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FINAL UNEXPLODED ORDNANCE 16 (UXO 16) WIDE AREA ASSESSMENT WORK PLAN ATLANTIC FLEET WEAPONS TRAINING AREA FORMER NAVAL AMMUNITION SUPPORT DETACHMENT AND FORMER VIEQUES NAVAL TRAINING RANGE VIEQUES ISLAND PUERTO RICO

12/01/2015

CH2M HILL

Final

UXO 16 Wide Area Assessment Work Plan
Atlantic Fleet Weapons Training Area - Vieques
Former Naval Ammunition Support Detachment and
Former Vieques Naval Training Range
Vieques, Puerto Rico

Contract Task Order 005

December 2015

Prepared for

Department of the Navy
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Atlantic

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Prepared by

Virginia Beach, Virginia

Executive Summary

This Work Plan (WP) presents the rationale and technical approach for the UXO 16 Wide Area Assessment (WAA) activities in Vieques, Puerto Rico (**Figure ES-1**). The UXO 16 WAA will assess the potential presence of areas of elevated anomaly densities (EADAs, essentially concentrated areas of metallic objects) that may represent munitions offshore of the former Naval Ammunition Support Detachment (NASD) and at the former Vieques Naval Training Range (VNTR) (**Figure ES-2**). These munitions may be present in the underwater environment as a result of past military training, open burn/open detonation (OB/OD), and from potential munitions offload and transport.

UXO 16 is approximately 11,500 acres and comprises former ship anchoring points and the area immediately surrounding Mosquito Pier where munitions offloading took place; areas where munitions may have been inadvertently fired into the water from Naval gunfire training, air-to-ground bombing, and artillery and training ranges; and areas where OB/OD activities may have ejected munitions into the water. The underwater area adjacent to Cayo La Chiva, adjacent to the Former OB/OD Area (Solid Waste Management Unit 4), and the underwater area adjacent to Mosquito Pier are part of separate investigations and are therefore not included in the WAA.

The WAA will identify EADAs using underwater digital geophysical mapping (DGM) and will also determine the relative density distribution across and between each EADA. The WAA is not intended as a full-scale study of the nature and extent of munitions or munitions constituents (MC) contamination; rather it is the first step in a phased approach to investigate UXO-16, and the findings of the WAA will be used to aid in the decision-making process and planning for future investigations and munitions response actions, as applicable, for UXO 16.

The specific objectives of the WAA are to identify and evaluate the anomaly density and lateral extent of EADAs within UXO 16; and provide recommendations for additional investigations and possible munitions response actions at UXO 16. This WP will help ensure that data collected during the WAA are scientifically sound, of known and documented quality, and suitable for the intended uses (i.e., characterization and path forward).

The WAA will be performed using a towed cesium vapor magnetometer array to measure distortion of the Earth's magnetic field in proximity to discrete metallic (ferrous) objects, such as munitions items. The magnetometer survey will map anomalies in the magnetic field and will provide an indication of the size and location of metallic objects on or buried beneath the sea floor. The magnetometer survey will be performed along transects with approximately 330 foot (100 meter) spacing throughout UXO 16 (**Figures ES-3 and ES-4**). Previously collected side scan sonar data will be used during the WAA to avoid obstacles and sensitive habitats.

Results of the WAA will be documented in the UXO 16 WAA Report following the completion of the field activities, which will provide an update to the conceptual site model (as applicable), document the technology used, data collection/processing/analysis, summarize the results of the data analysis and historical records evaluation, and identify operable units (OUs) and recommendations for future investigations and/or actions within UXO 16.

Resumen Ejecutivo

Este Plan de Trabajo (WP, por sus siglas en inglés) presenta el razonamiento y el enfoque técnico para las actividades relacionadas con la Evaluación de Área Amplia (WAA, por sus siglas en inglés) para UXO 16 en Vieques, Puerto Rico (**Figura ES-1**). El WAA para UXO 16 evaluará la presencia potencial de áreas con altas densidades de anomalías (EADAs, por sus siglas en inglés, áreas esencialmente concentradas de objetos metálicos) que pueden representar municiones fuera de la costa del antiguo Destacamento de Apoyo a Municiones Navales (NASD, por sus siglas en inglés) y en el antiguo Campo de Adiestramiento Naval de Vieques (VNTR, por sus siglas en inglés) (**Figura ES-2**). Estas municiones pudieran estar presentes en el ambiente submarino como resultado de pasados adiestramientos militares, quema abierta/detonación abierta (OB/OD, por sus siglas en inglés), y durante la descarga a otros barcos y transporte potencial de municiones.

UXO 16 contiene aproximadamente 11,500 acres e incluye antiguos puntos de anclaje de barcos y el área inmediatamente circundante a Mosquito Pier donde ocurrió descarga de municiones (a otros barcos); áreas donde se pudieron haber disparado municiones al agua por equivocación durante los adiestramientos de disparos Navales, bombardeo de aire-a-tierra, y campos de artillería y adiestramiento; y áreas donde actividades de OB/OD pudieron haber expulsado municiones hacia el agua. El área debajo del agua adyacente a Cayo La Chiva, el área adyacente a la Antigua Área de OB/OD (Unidad de Manejo de Desperdicios Sólidos 4), y el área debajo del agua adyacente a Mosquito Pier son parte de investigaciones separadas y por esto no están incluidas en el WAA.

El WAA identificará las EADAs usando cartografía geofísica digital (DGM, por sus siglas en inglés) y también determinará la distribución de densidad relativa a través y entre cada EADA. No se pretende que el WAA sea un estudio a gran escala para determinar la naturaleza y extensión de las municiones o de la contaminación con constituyentes de municiones (MC, por sus siglas en inglés); es sin embargo el primer paso en un enfoque por fases para investigar a UXO 16, y los resultados del WAA se usarán para ayudar en el proceso de toma de decisiones y planificación para futuras investigaciones y acciones de respuesta a municiones, como aplique, para UXO 16.

Los objetivos específicos del WAA son identificar y evaluar la densidad de anomalías y extensión lateral de las EADAs dentro de UXO 16; y proveer recomendaciones para investigaciones adicionales y posibles acciones de respuesta a municiones en UXO 16. Este Plan de Trabajo ayudará a asegurarse que los datos colectados durante el WAA son científicamente sólidos, de calidad conocida y documentada, y adecuados para los usos previstos (i.e. caracterización y acciones futuras).

El WAA será llevado a cabo usando un magnetómetro de vapor de cesio remolcado para medir la distorsión del campo magnético de la Tierra en proximidad a objetos metálicos discretos (ferrosos), como los artículos de municiones. El estudio con el magnetómetro trazará un mapa de anomalías dentro del campo magnético y proveerá una indicación del tamaño y la localización de los objetos metálicos en o enterrados debajo del suelo marino. El estudio con el magnetómetro será llevado a cabo a lo largo de transectos con aproximadamente 330 pies (100 m) de espacio entre ellos a través de UXO 16 (**Figura ES-3 y ES-4**). Los datos del escaneador (sonar) de barrido lateral previamente colectados serán usados durante el WAA para evitar obstáculos y hábitats sensitivos.

Los resultados del WAA serán documentados en el Informe del WAA para UXO 16 luego de que se completen las actividades de campo, las cuales proveerán una actualización del modelo conceptual del sitio (como aplique), documentará la tecnología usada, la colección de datos/procesamiento/análisis, resumirá los resultados del análisis de los datos y la evaluación de los records históricos, e identificará las unidades operables (OUs, por sus siglas en inglés) y recomendaciones para futuras investigaciones y/o acciones dentro de UXO 16.

R:\USNavFacEngCom405450\Vieques\MapFiles\Underwater_Wide_Area_Assessment_WP\Figure 1-1 - Regional Location Map.mxd2/25/2015CGauthier_ch2mhillen

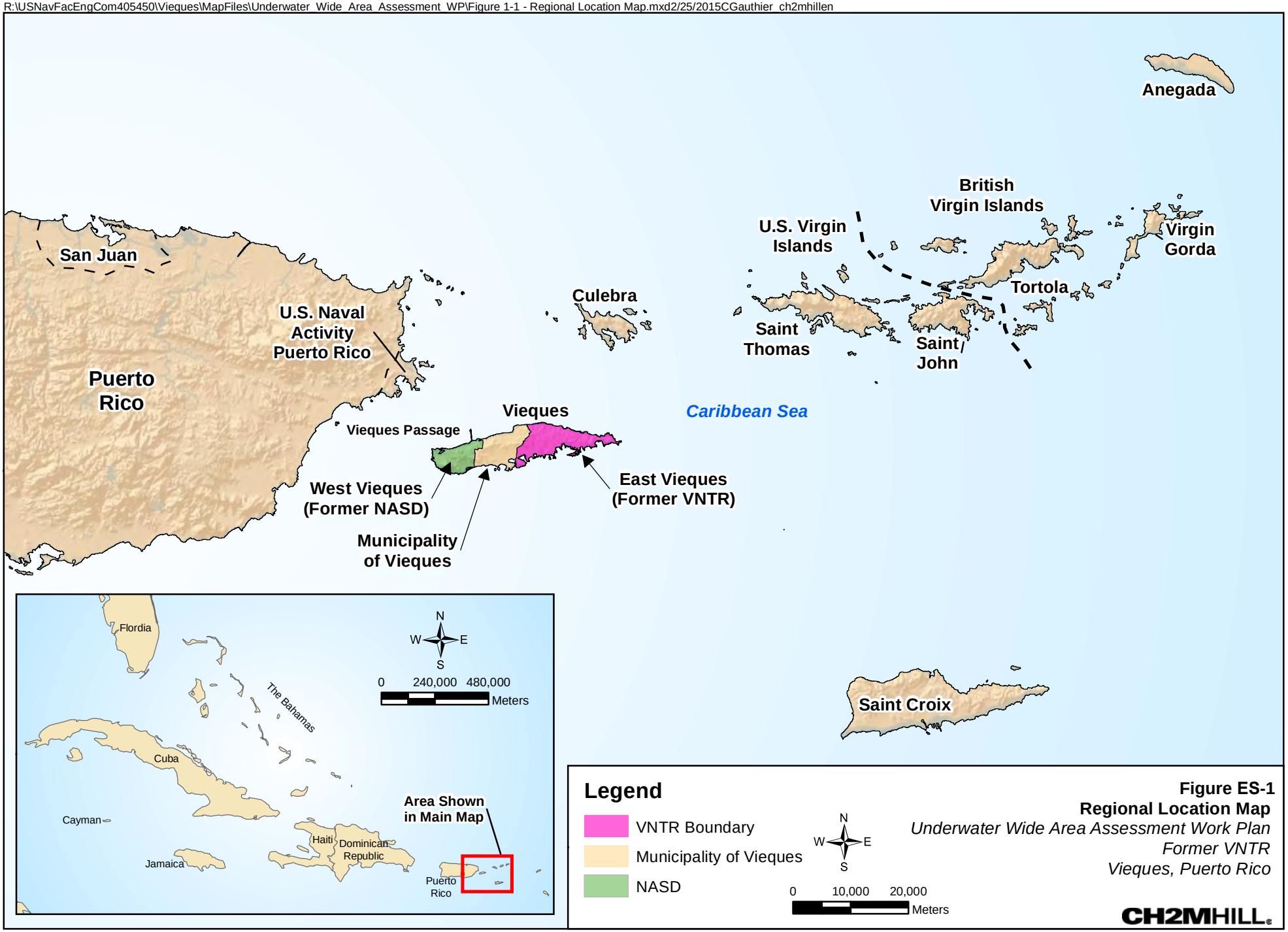

Figure ES-1
Regional Location Map
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

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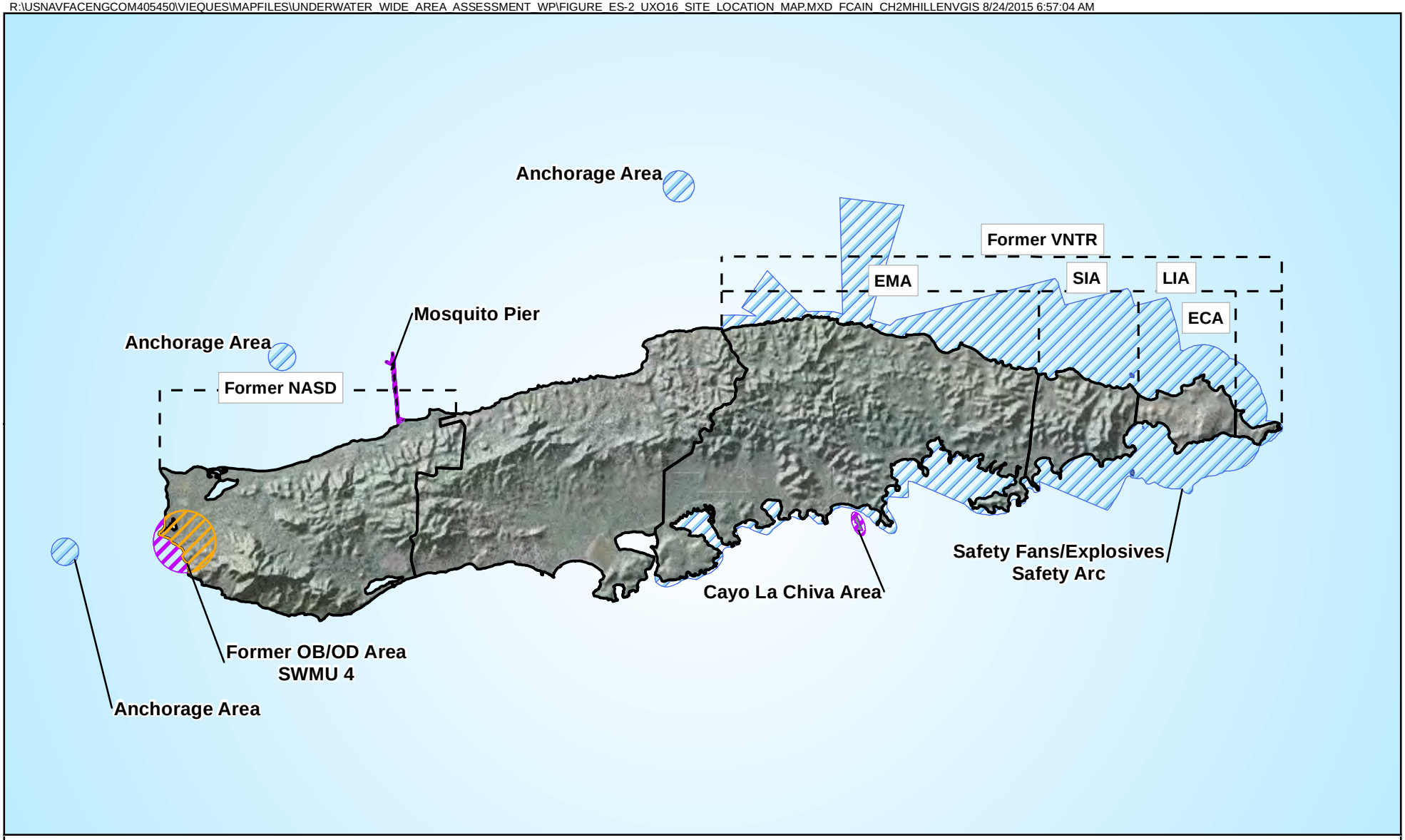

Legend

- Area Addressed under a Separate Investigation from this WAA
- SWMU 4
- UXO 16

ECA - Eastern Conservation Area
EMA - Eastern Maneuver Area
SIA - Surface Impact Area
LIA - Live Impact Area

N
W E
S

0 2.5 5 Miles

Figure ES-2
UXO 16 Site Location Map
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

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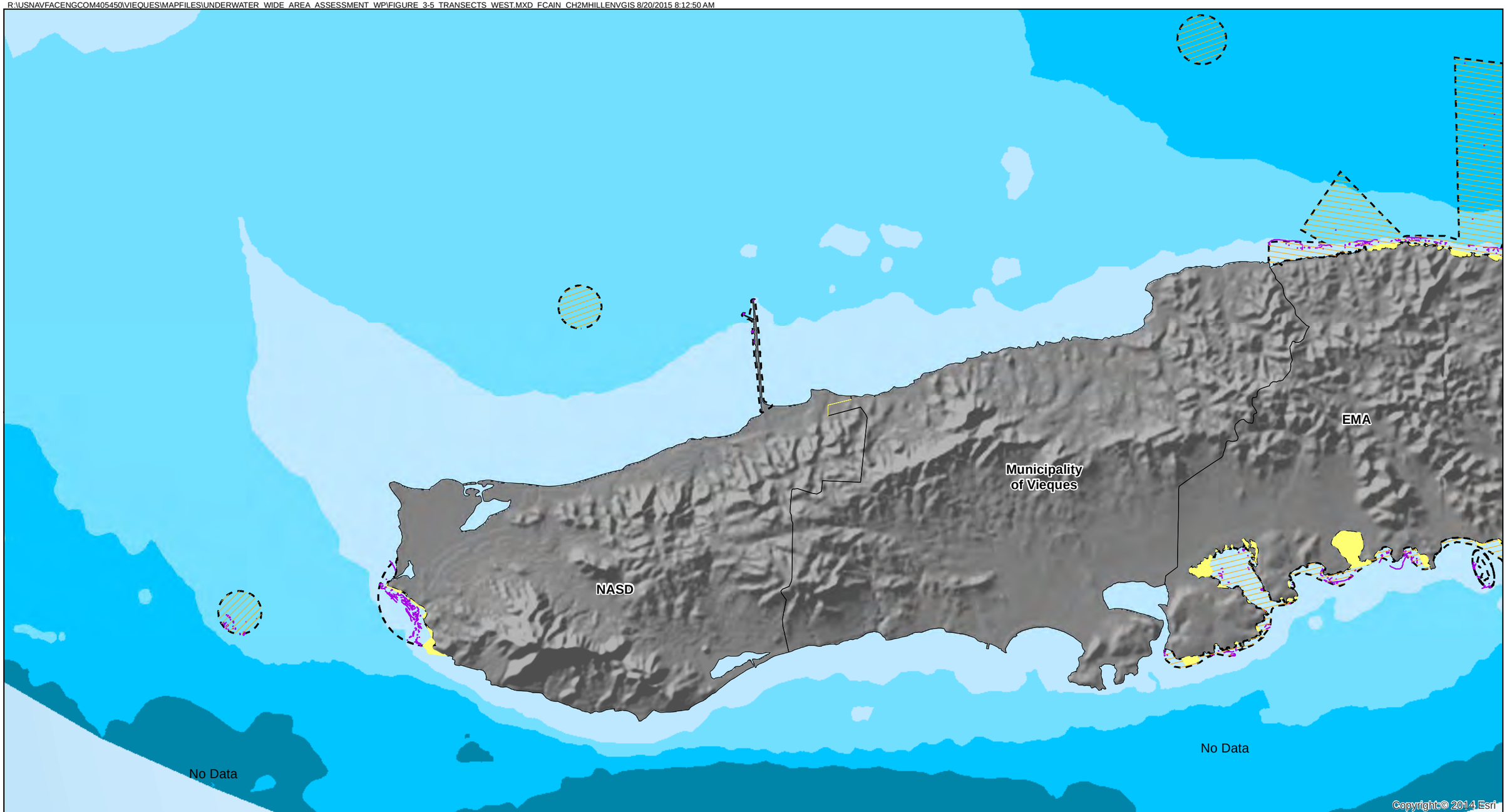

Legend

- Site Boundary
- UXO 16 Boundary
- Transects (100 meters)
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Side scan sonar survey could not be conducted in area due to shallow depth conditions, reefs, and/or rough sea conditions

Underwater Depth (feet)

- 0 - 30
- 30 - 60
- 60 - 120
- 120 - 164

N
W E
S

0 1.5 3 Miles

Figure ES-3
Conceptual Survey Design - West
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

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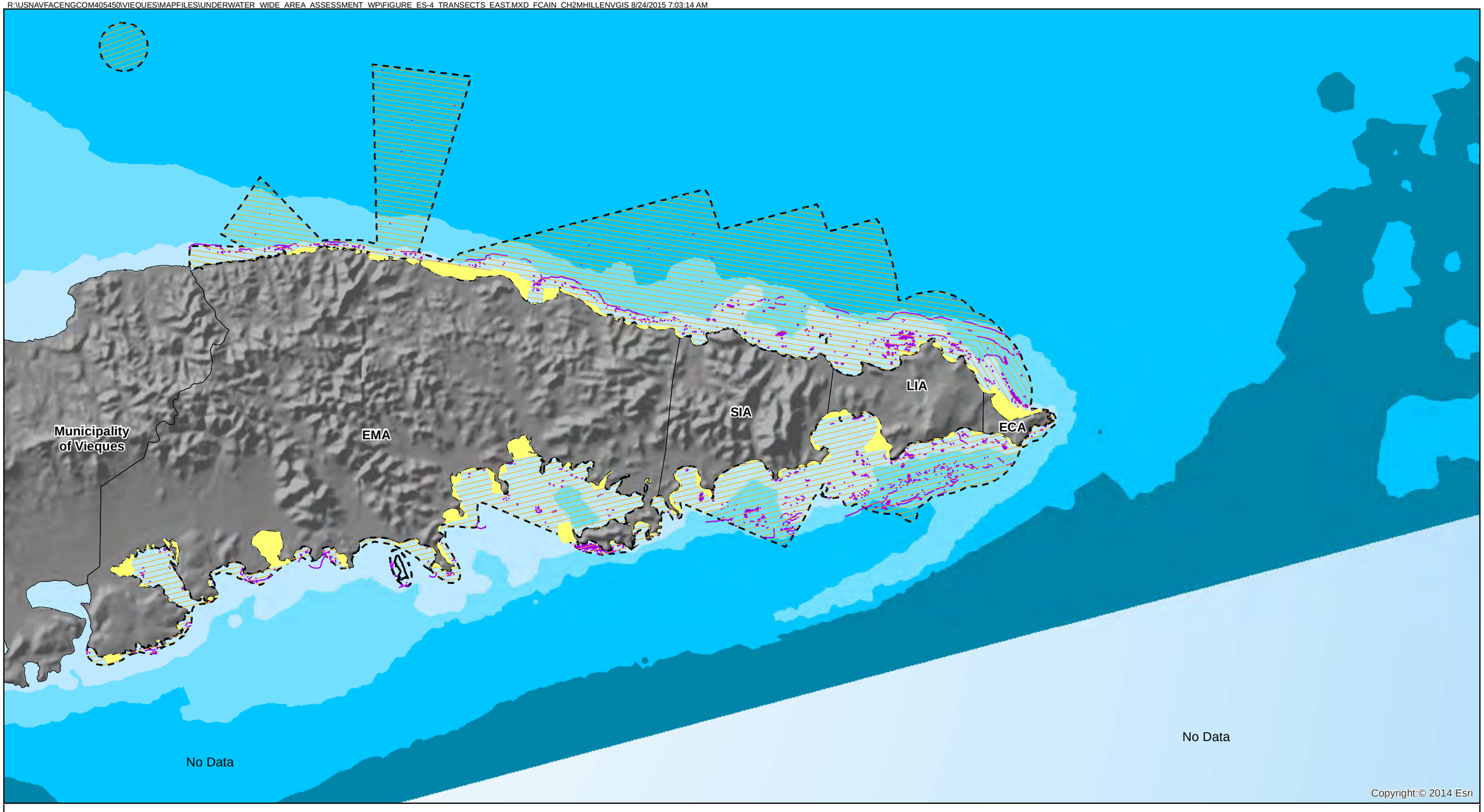

Legend

- Site Boundary
- UXO 16 Boundary
- Transects (100 meters)
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Side scan sonar survey could not be conducted in area due to shallow depth conditions, reefs, and/or rough sea conditions

Underwater Depth (feet)

- 0 - 30
- 30 - 60
- 60 - 120
- 120 - 164

N
W E
S

0 1.5 3
Miles

Figure ES-4
Conceptual Survey Design - East
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

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Contents

Appendixes

Tables

Figures (provided at the end of each section)

Acronyms and Abbreviations

AFWTA	Atlantic Fleet Weapons Training Area
AMS	aerial magnetometer survey
AUV	Autonomous Underwater Vehicle
CA	corrective action
CAP	Corrective Action Plan
CAR	Corrective Action Request
CariCOOS	Caribbean Coastal Ocean Observing System
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action
CSM	conceptual site model
DFOW	definable feature of work
DGM	digital geophysical mapping
DMM	discarded military munitions
DOI	Department of the Interior
EADA	elevated anomaly density area
ECA	Eastern Conservation Area
EMA	Eastern Maneuver Area
EMI	Magnetometer or Electromagnetic Induction
EOD	Explosive Ordnance Disposal
EPA	United States Environmental Protection Agency
ERP	Environmental Restoration Program
ESA	Endangered Species Act
ESTCP	Environmental Security Technology Certification Program
FFA	Federal Facility Agreement
FP	Follow-up Phase
ft	foot/feet
FTL	field team leader
FTP	file transfer protocol
GMI	Geo-Marine, Inc.
GPS	global positioning system
H&S	health and safety
IP	Initial Phase
IR	Installation Restoration
ISO	industry standard objectives
IVS	Instrument Verification Strip
kts	knots
lb	pound
LIA	Live Impact Area
m	meter/meters
MC	munitions constituents
MD	munitions debris
MEC	munitions and explosives of concern

mm	millimeter
MOV	Municipality of Vieques
MPC	measurement performance criteria
MPH	miles per hour
MPPEH	materials potentially presenting an explosive hazard
MR	munitions response
MRSIMS	Munitions Response Site Information Management System
MSL	mean sea level
MTA	Marine Towed Array
NAD	North American Datum
NASD	Naval Ammunition Support Detachment
NAVFAC	Naval Facilities Engineering Command
Navy	United States Navy
NGFS	Naval Gunfire Support
NOAA	National Oceanic and Atmospheric Administration
NOSSA	Naval Ordnance Safety and Security Activity
NPL	National Priority List
nT	nanotesla
OB/OD	open burn/open detonation
OR&R	Office of Response and Restoration
OU	Operable Unit
Pd	detection probability
PDA	personal digital assistant
PDF	Portable Document Format
PI	Photo Identified
PLS	professional land surveyor
PP	Preparatory Phase
PRCT	Puerto Rico Conservation Trust
PRDNER	Puerto Rico Department of Natural and Environmental Resources
PREQB	Puerto Rico Environmental Quality Board
QA	quality assurance
QC	quality control
RCA	root-cause analysis
ROV	remotely operated vehicle
RRD	range-related debris
SIA	Surface Impact Area
SNR	signal-to-noise ratio
SOP	Standard Operating Procedure
SSS	side scan sonar
SWMU	Solid Waste Management Unit
TOI	target of interest
USACE	United States Army Corps of Engineers
USBL	ultra short baseline
US	United States
USAE	USA Environmental
USFWS	United States Fish and Wildlife Service
UTM	Universal Transverse Mercator

UXO	unexploded ordnance
VNTR	Vieques Naval Training Range
VSP	visual sample plan
WAA	Wide Area Assessment
WP	Work Plan

SECTION 1

Introduction

This Work Plan (WP) presents the technical approach for the UXO 16 Wide Area Assessment (WAA) to assess the potential presence of munitions offshore of the former Naval Ammunition Support Detachment (NASD) and the former Vieques Naval Training Range (VNTR) in Vieques, Puerto Rico (**Figures 1-1** and **1-2**). Within this document, where the term "munitions" is used, it encompasses historically and/or currently used terms munitions and explosives of concern (MEC), material potentially presenting an explosive hazard (MPPEH), munitions debris (MD), unexploded ordnance (UXO), and discarded military munitions (DMM). Munitions and munitions constituents (MC) may be present in the underwater environment adjacent to the former NASD and the former VNTR as a result of past military training, open burn/open detonation (OB/OD), and from potential munitions offload and transport.

The WAA is the first step in a multi-step process to investigating and addressing underwater munitions around Vieques and as such it involves a broad evaluation of the underwater area. Information gathered from the WAA will be used to better plan more focused, localized investigations. Because the WAA is part of the initial, broad evaluation, its primary objective is to determine where the largest densities of munitions, referred to as elevated anomaly density areas (EADAs), may be located within UXO 16 and characterize the background anomaly density across the area. Digital geophysical mapping (DGM) will be used to determine the locations with high densities of potential munitions and the relative density distribution across and between the EADAs. This is an important step in the overall investigation process in order to: (1) prioritize areas for more focused follow-up investigations, and (2) determine the background density in order to be better-identify areas potentially containing high densities of munitions. Another objective of the WAA is to collect information that can be used in preparing a biological assessment and/or protocols to ensure protection of key marine species and habitats during the follow-up focused investigations and actions. The WAA is not intended as a full-scale study of the nature and extent of munitions or MC contamination, nor is it a WAA objective to detect individual munitions or even small clusters of munitions. Rather, as noted above, it is the first step in a phased approach to investigation of UXO 16 and the findings will be used to aid in the decision-making process and planning for future investigations and munitions response actions. In circumstances where identifying individual or small clusters of munitions is desirable (for example, in a localized area of particular interest based on anticipated use), focused studies using techniques and technologies appropriate for the study objectives will be planned.

The objectives of the WAA are to characterize sea floor conditions including obstructions, bathymetry, ecological regimes, and endangered species; identify and evaluate the anomaly density and lateral extent of EADAs within UXO 16; and provide recommendations for additional investigations and possible munitions response actions at UXO 16. UXO 16 will follow the full CERCLA process; the WAA results will not be used as the sole criteria for making a no further action decision for any area of UXO 16.

UXO 16 is approximately 11,500 acres and comprises former ship anchoring points and the area immediately surrounding Mosquito Pier where munitions may have been transferred; areas where munitions may have been inadvertently fired into the water from Naval gunfire training, air-to-ground bombing, and artillery and training ranges; and areas where OB/OD activities may have ejected munitions into the water. However, as shown in **Figure 1-2**, the underwater area adjacent to Cayo La Chiva, adjacent to the former OB/OD Area, and the underwater area adjacent to Mosquito Pier are part of separate investigations and are therefore not included in the WAA.

This WP was prepared under the United States Navy (Navy) Comprehensive Long-Term Environmental Action (CLEAN) Contract N62470-11-D-8012, Contract Task Order 0005, for submittal to Naval Facilities Engineering Command (NAVFAC) Atlantic, United States Environmental Protection Agency (EPA) Region 2, the Commonwealth of Puerto Rico Environmental Quality Board (PREQB), the Puerto Rico Department of Natural and Environmental Resources (PRDNER), and the United States Fish and Wildlife Service (USFWS). The Navy,

EPA, PREQB, PRDNER, and USFWS work jointly as the Vieques Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Environmental Restoration Program (ERP) Technical Subcommittee.

1.1 Site Background

Vieques is located in the Caribbean Sea approximately seven miles southeast of the eastern tip of the main island of Puerto Rico and 20 miles southwest of St. Thomas, United States (US) Virgin Islands (**Figure 1-1**). It is approximately 20 miles long and 4.5 miles wide, and has an area of approximately 33,088 acres (51 square miles).

The Navy purchased large portions of Vieques in the early 1940s to conduct activities related to military training. The Atlantic Fleet Weapons Training Area (AFWTA) was historically divided into two portions – the NASD and VNTR. Site operations on the western end of Vieques (former NASD), consisted mainly of ammunition loading and storage, vehicle and facility maintenance, and OB/OD. The eastern end of Vieques (former VNTR) was used for various aspects of naval gunfire training, including air-to-ground ordnance delivery and amphibious landings, as well as housing the main base of operations for these activities, Camp Garcia.

The former NASD was apportioned and transferred to the Department of the Interior (DOI), the Municipality of Vieques (MOV), and the Puerto Rico Conservation Trust (PRCT) in 2001, in accordance with Public Law 106-398. The property owned by DOI is managed by USFWS as part of the Vieques National Wildlife Refuge. The former VNTR was transferred to the DOI to be operated by USFWS as a National Wildlife Refuge in 2003, in accordance with Public Law 107-107. The offshore territorial waters are under the jurisdiction of the Commonwealth of Puerto Rico and extend nine nautical miles from the coast of Vieques.

On February 11, 2005, Vieques was placed on the National Priority List (NPL) as part of the former Atlantic Fleet Weapons Training Area - Vieques, which required all subsequent environmental restoration activities for Navy Installation Restoration (IR) sites on Vieques be conducted under CERCLA unless and until removed from CERCLA authority. The Navy, DOI, EPA, and PREQB executed a Federal Facility Agreement (FFA) on September 7, 2007 that established the procedural framework and schedule for implementing the CERCLA response actions for Vieques.

1.1.1 Former NASD and VNTR

The former NASD includes Solid Waste Management Unit (SWMU) 4, which was formerly used as an OB/OD area for the thermal destruction and open detonation of retrograde and surplus munitions, fuels and propellants from 1969 through 1979, and may have periodically been used as far back as the late 1940s (CH2M HILL, 2012). An explosive safety arc extends radially 2,100 feet (ft) from the center of the historical OB/OD area; the offshore portion of the arc is part of UXO 16 (**Figure 1-2**). As noted in **Figure 1-2**, this part of UXO 16 is part of a separate investigation and not included in the WAA.

The former VNTR consists of approximately 14,600 acres and is divided into four separate operational areas that from west to east comprise the 11,000-acre Eastern Maneuver Area (EMA), the 2,500-acre Surface Impact Area (SIA); the 900-acre Live Impact Area (LIA), and the 200-acre Eastern Conservation Area (ECA), as shown in **Figure 1-2**.

- Eastern Maneuver Area (EMA) – established in 1947 to provide military maneuvering areas and ranges for training in amphibious landings, small arms fire, artillery and tank fire, shore fire control, and combat engineering tasks. The ranges located in the northern portion of the EMA were used for the following activities: Small arms ranges (Range 1 and 2), Rifle Grenade Range (Range 3), Rocket Range (Range 4), and Grenade Range (Range 5).
- Surface Impact Area (SIA) – established in the 1950s when several Marine artillery targets were constructed; in 1969, a bulls-eye target was constructed and used for inert bombing.
- Live Impact Area (LIA) – established in 1965, where several targets were maintained for aerial bombing including old tanks and vehicles, a simulated railroad tunnel, simulated ammunition dump, simulated fuel

farm, a simulated airstrip, two simulated surface-to-air missile (SAM) sites, and a strafing target; several point and area targets were used for ships to practice naval gunfire support; one bulls-eye target used for inert bombing; and an OB/OD area was used for treatment of retrograde ordnance and open burning of propellants and pyrotechnics.

- Eastern Conservation Area (ECA) – established as a conservation area and not used as an operational area for munitions; however, the site is located adjacent to the LIA.

Following cessation of military operations on the former NASD and VNTR, the Navy subdivided the former operational areas into smaller parcels based on considerations such as historic use, geographic features, and land use. The parcels, referred to as UXO sites, were delineated in such a way to make them more manageable for the purposes of prioritization, munitions removal, site characterization, and decision making (**Figure 1-3**).

1.1.2 UXO 16

UXO 16 comprises the waters surrounding the former VNTR and NASD where the Navy historically conducted operations (**Figures 1-2 and 1-3**). The UXO 16 site boundary was designated by the Navy, EPA, PREQB, and DOI as an "Agreed Area" where evaluations under CERCLA would be focused. The UXO 16 site boundary was defined in the Federal Register on August 13, 2004 (Federal Register, 2004), in a letter from the PREQB to the EPA dated May 26, 2004 (Cotto), and in the Vieques Site Management Plan (CH2M HILL, 2014). **Figures 2-1 and 2-2** present the conceptual site model (CSM). The historical site operations and the Naval gunfire support (NGFS) targets shown conceptually illustrate site operations and impacted areas. The NGFS are placed in locations consistent with the current understanding of the CSM. Following the WAA, the CSM will be re-evaluated to confirm that the WAA findings are appropriately reflected. Each of the component areas of UXO 16 are summarized below.

Anchorage Areas

Navy ships containing munitions used during the training activities at the former AFWTA would temporarily anchor at three anchoring locations in the Vieques Passage and Vieques Sound while waiting to be unloaded (**Figure 1-2**). When the anchorage areas were operational, explosives in quantities no greater than 1,625 short tons were handled in any area at one time.

The boundary of each anchorage area was defined by the area in which the ammunition supply ship would rotate around a single anchorage point. Each anchorage area radius was established using the depth of water, the ship horizontal offset from its anchor line, the length of the largest ammunition supply ship, and a distance buffer from the designated anchorage point (Naval Ordnance Safety and Security Activity [NOSSA], 2004). The two westernmost anchorage areas were defined with a maximum radius of 440 yards and the other anchorage area with a maximum radius of 500 yards.

The National Oceanic and Atmospheric Administration (NOAA) nautical chart indicates that wire dragging had been performed in some of the anchorage areas. Wire dragging refers to the practice of hanging a wire at a specific depth between two vessels. The wire is then dragged between two points to identify submerged rocks or other obstructions. Wire dragging would be performed to ensure that ships could safely navigate in those areas and avoid obstructions. This historical practice will not affect the planned WAA activities.

Mosquito Pier

Mosquito Pier was used for loading and unloading ordnance from Navy ships. The boundary of this area is defined as a 100 foot radius around the perimeter of the pier to account for any munitions that may have been dropped during loading and unloading (**Figure 1-2**). This area of UXO 16 will be addressed separately from the WAA and therefore is not discussed further in this document.

Offshore of SWMU 4

The explosives safety arc of the OB/OD operations at SWMU 4 extends approximately 2,000 feet offshore to the west of the former OB/OD area; the offshore area is part of UXO 16 (**Figure 1-2**). Over 90 percent of the munitions recovered during investigation and interim actions within SWMU 4 were 20-millimeter (mm)

projectiles. Significantly lower quantities of high explosive, low explosive, incendiary, white phosphorous, fuzes, and other items were also identified at SWMU 4.

As noted previously, this area of UXO 16 is being addressed separately from the WAA and therefore is not discussed further in this document.

Explosives Safety Arcs and Artillery Safety Fans adjacent to the Former VNTR

A series of explosives safety arcs and artillery safety fans associated with the historical ranges, gun emplacements, and OB/OD area were developed for the former VNTR as part of the Vieques Land Use Plan (Department of the Navy, 1999) and the Preliminary Range Assessment (NAVFAC, 2003). The safety fans provide an estimate of the lateral extent of the potential munitions impact area extending from the ranges and artillery gun positions. The areas where the explosives safety arcs and artillery safety fans extend offshore of the former VNTR are shown in **Figures 1-2 and 1-3**.

The explosives safety arc provides a maximum primary fragment distance (3,219 feet as measured from the shoreline) for an MK 83 high explosive filled bomb, primarily in the area of the LIA (**Figure 1-3**). This area also includes documented water hits based on air-to-ground bombing and naval gunfire support rounds that were recorded by the Navy (Department of the Navy, 1999). From 1989 to 1999, a total of 811 munitions were observed entering the water. Following 1999, all air-to-ground bombing (25-pound practice bombs [MK76] to 1,000 pound (lb) bombs [MK83] and naval gunfire support rounds [5-inch projectiles]) were non-explosive.

The marine artillery fans from former gun positions were based on 175 mm marine artillery fire (**Figure 1-3**). The area of the safety fans are based on historical ordnance use records and the projected safety fans documented in the Preliminary Range Assessment Report (NAVFAC, 2003).

Other Offshore Areas

For extra caution at shorelines, all offshore areas to a depth of 10 feet surrounding the former VNTR (outside the explosives safety arcs and artillery safety fans) were included as part of UXO 16 (**Figure 1-2**). The majority of this area is contained within the safety arcs and fans described above; outside of these areas, coverage is primarily along the southern portion of Vieques from Puerto Ferro to the eastern portion of Playa La Chiva (Blue Beach), as well as the eastern tip of the ECA.

Cayo La Chiva

Cayo La Chiva (UXO 18) is a 12-acre island located south of the EMA (**Figure 1-2**). A simulated machine gun nest was located on Cayo La Chiva during Operation Portrex conducted in 1950 (Sibert, 1993). No additional training activities are documented to have occurred in the UXO 18 area; however, fired 5-inch rockets were identified both on and offshore of Cayo La Chiva, which indicates the area may have been used for live fire training, albeit potentially in a single event. In 2010, the Navy conducted a visual underwater survey within approximately 100 feet offshore of Cayo La Chiva and covered the remainder of Bahía de la Chiva using 200-foot spacing transects. Nine potential munitions were identified just west and south of the island (CH2M HILL, 2014).

As noted previously, this area of UXO 16 is being addressed separately from the WAA and therefore is not discussed further in this document.

1.2 Previous Investigations

Below is a brief summary of the previous munitions investigations and pilot tests conducted within UXO 16 (**Figure 1-4)**. Where there is an associated report, the report author and date are cited in **Figure 1-4**; where no associated report was produced, the date(s) of the investigation are cited in the figure.

1.2.1 Side Scan Sonar Pilot Test and Underwater Magnetometer Survey

During November 2006, a joint pilot test between NOAA Office of Response and Restoration (OR&R), the Office of Coast Survey, the Navy, and the University of New Hampshire's Joint Hydrographic Center was conducted using high resolution side scan and multibeam sonar to identify the distribution of potential munitions and other objects on the seafloor and the associated habitats at Bahía Salina del Sur and Bahía Icacos (**Figure 1-4**). Four

individual surveys were carried out to identify locations of possible UXO. These surveys were: 1) a high-resolution bathymetric survey using a multibeam sonar system; 2) a high-resolution side scan sonar survey; 3) a magnetometer survey and finally; 4) a ground truth survey performed by a remotely operated vehicle (ROV) with video camera and divers with still cameras. Many targets were selected from the bathymetry, side scan sonar (SSS), and magnetometer data sets (NOAA, 2007).

During June 2007, the Autonomous Underwater Vehicle (AUV) project area was located north of Bahiá Icacos and Bahiá Salinas, and covered an area of approximately three square nautical miles. Water depths ranged from six feet to approximately 50 feet. NOAA used a REMUS 100 AUV to conduct a high-resolution side scan survey on the northern shores of the LIA. Hydrographers selected targets from the side scan imagery and performed a ground truth survey using an ROV equipped with a video camera.

In addition, a pilot test using a Marine Towed Array (MTA) equipped with an underwater magnetometer was conducted in 2007 within 195 acres of Bahiá Salinas del Sur to identify geophysical anomalies that may be potential munitions items (**Figure 1-4**). The survey identified locations of 603 magnetic anomalies (SAIC, 2009).

Based on the results of the SSS pilot test and the MTA magnetometer pilot test, divers/snorkelers conducted an underwater visual survey of 42 anomalies identified at Bahiá Salina Del Sur and Bahiá Icacos to determine if the sources of the anomalies were munitions or only had the general appearance (shape and size) of potential munitions. Additionally, 20 of the targets were investigated by ROV video. All targets were photographed from different view directions and positions, and bottom type and associated habitats were documented. A metal detection survey was also conducted within a small portion of Bahiá Icacos to evaluate the potential for munitions north of the LIA (GMI, 2007). MEC was confirmed in these areas during the underwater visual inspection performed by the divers. Only items present on the surface of the seafloor were inspected by the divers. Buried anomalies and anomalies obscured by coral could not be observed during the survey.

1.2.2 Aerial Magnetometer Survey

In November and December 2008, an aerial magnetometer survey (AMS) was conducted to assess potential munitions locations over the entire VNTR terrestrial portion, extending into the near shore areas (**Figure 1-4**). The AMS identified 12 EADAs that lie wholly or partially in the water (**Figure 1-5**). These EADAs represent areas of large clusters/groupings of magnetic anomalies and are described in detail in the *HeliMag Survey Report, Aerial Magnetometer Survey, Former Vieques Naval Training Range* (Sky Research, Inc., 2009). However, aerial magnetometer surveys would not be an appropriate approach for this WAA due to limitations associated with surveying in water depths associated with UXO 16.

1.2.3 Remotely Operated Vehicle Pilot Test

In January 2009, the Navy conducted a pilot test of a VideoRay Miniature ROV within the underwater areas at Bahiá Salinas. The pilot test demonstrated specifically that the ROV was able to locate specific targets located on the surface of the sea floor identified from previous geophysical surveys and identify those targets as munitions (USA Environmental [USAE], 2009). In addition, subsequent ROV surveys were conducted to identify underwater munitions offshore of UXO 15 (USAE, 2010), and at the three anchorage areas, Bahiá Icacos, and Bahiá Salina Del Sur (**Figure 1-4**) (USAE, 2012).

1.2.4 Navy Explosive Ordnance Disposal Diver Surveys

The Navy conducted several visual surveys using Navy explosive ordnance disposal (EOD) divers/snorkelers to identify locations of underwater munitions. As part of the Preliminary Range Assessment (NAVFAC, 2003), a transect inspection was conducted in the shallow waters adjacent to Blue Beach and Red Beach in 2003 (**Figure 1-4**). No munitions were identified in these areas. In 2010, Navy EOD divers/snorkelers conducted visual underwater surveys at Puerto Diablo, within Bahiá de la Chiva, and at UXO 15. Navy EOD divers identified MEC at Puerto Diablo. Additionally nine potential MEC/MPPEH were identified within Bahiá de la Chiva just west and south of the island, five MEC items were identified as 5-inch rockets and four other as unidentified items. No MEC were identified near UXO-15.

1.2.5 Underwater Munitions Mobility Modeling

Under the Environmental Security Technology Certification Program (ESTCP) demonstration project by the Scripps Institution of Oceanography: UXO Mobility Model for Reef-Type Range Environments (MR-201003), a process-based model was developed that uses vortex lattice computational methods to generate three-dimensional simulations of burial, exposure, and migration specific to underwater munitions. The model was implemented at two underwater high-density UXO areas located at the eastern end of Vieques; one north of the LIA (Bahiá Salinas) and one area south of the LIA (Bahiá Salina del Sur). The modeling results, issued in 2012, predicted that over a 30-year period, UXO surrogates may remain stationary (in deeper, offshore areas) or migrate (in more in-shore areas) from the reef platform a maximum of only about 10 feet (3 meters) into adjacent sand channels and, in some cases, become buried in sand. Field measurements using UXO surrogates confirmed the modeling results (surrogates remained stationary in deeper, offshore areas and migrated a maximum of about 13 feet [4 meters] in the in-shore areas) (Scripps Institution of Oceanography, 2012). These high-density areas, as well as where the model predicted and field measurements confirmed munitions would migrate are within the planned WAA study area.

1.2.6 Bathymetry Data Review

In 2013, existing bathymetry data offshore of Vieques was evaluated to determine if the data was sufficient to support the UXO 16 WAA. It was determined that extensive bathymetry data coverage exists around Vieques and within UXO 16, and that this data coverage, resolution, and overall quality are sufficient for the WAA. A Technical Memorandum summarizing the results of the desktop evaluation is included in **Appendix A**.

1.2.7 Bathymetry Side Scan Sonar Survey

From November 2013 through January 2014, an SSS survey was conducted across UXO 16 (with the exception of a few localized areas immediately adjacent to the shore), to identify potential underwater obstacles and environmentally sensitive areas (such as coral reefs), such that additional aspects of the UXO 16 WAA could be appropriately designed. A Technical Memorandum summarizing the results of the SSS survey is included in **Appendix B**.

In total, 1,622 potential hazards to underwater DGM equipment (i.e., locations where a one-meter or more vertical change on the seafloor) were identified. The one-meter rise is independent of any horizontal distances; it is relative to the area immediately adjacent. Although one meter is arbitrary, it was conservatively selected to ensure protection of both the underwater ecological regime and the DGM equipment during the survey described in this WAA WP. The hazards observed were primarily within shallow water along the shoreline, islands, reefs, and shoals (**Figure 1-6**). The limitations to the investigation with respect to survey altitude (or other avoidance measures) imposed by obstructions such as sunken ships are the same as those posed by coral reefs. In addition, the magnetic signature of the ships will essentially mask any smaller targets in close proximity to the ships. However, the relatively small gaps in coverage imposed by the spatial extent of these ships will not adversely affect the survey results and the regions in close proximity to these ships will be considered for follow on, focused investigations as warranted.

1.3 Objectives and Approach

Munitions and MC may be present in the underwater environment surrounding the former NASD and former VNTR as a result of munitions transport, OB/OD, and firing activities related to past military training. The extent of munitions and associated MC is unknown.

1.3.1 UXO 16

The overall objectives for UXO 16 (not specifically the WAA) are as follows:

- Delineate the nature and extent of underwater munitions such that the explosive safety hazard can be assessed

- Delineate the nature and extent of MC, as warranted, such that the human health and ecological risks can be assessed
- Address hazards and risks

Due to the complexity and size of UXO 16, a multi-phased approach is warranted. Therefore, the general approach to evaluate UXO 16 is as follows:

- Develop a CSM that will be updated as new data is available (Section 2)
- Conduct an underwater WAA (as defined in this WP)
- Identify Operable Units (OUs) within UXO 16
- Perform OU characterization to delineate the nature and extent of munitions and MC
- Evaluate the potential risks to human health and the environment
- Evaluate remedies to address potential risk and explosive hazards, as applicable

1.3.2 Wide Area Assessment

The WAA is a reconnaissance process intended to identify potential areas of concentrated munitions and to aid in the decision-making process for the future investigations and munitions response actions at UXO 16. This WAA is not a means of developing technology, equipment, or to be used for training at other facilities, but is a vital step in the overall remedial investigation approach. The data generated by the WAA will be used by the Environmental Technical Subcommittee to identify, delineate, and prioritize OUs within UXO 16.

The objectives of the UXO 16 WAA are to:

- Characterize the general physical sea and sea floor conditions including, as warranted, obstructions, bathymetry, and benthic habitats, including endangered species
- Evaluate the anomaly density conditions to aid in the planning of focused investigations
- Identify and delineate EADAs within UXO 16
- Provide recommendations for additional investigations and, as applicable, munitions response actions at UXO 16

It is noted here that underwater obstructions (via side scan sonar survey) and bathymetry have already been characterized, as discussed in Section 1.2.

In order to minimize impacts to benthic habitats and species, the WAA investigation methods are designed to avoid direct contact with the sea floor as well as potential munitions. Based on this and the aforementioned objectives, the specific approach of the WAA within UXO 16 is as follows:

- Incorporate information of the physical sea floor conditions from the bathymetry characterization
- Incorporate results of existing remote sensing data (e.g., SSS) used to characterize underwater structures and water depth
- Perform near sea floor surveys using a transect approach to delineate density distribution of potential munitions and benthic habitats

As warranted and practical, couple the use of physical measurement tools (e.g., Global Positioning System [GPS], cameras, sensors, drifters, etc.) with the surveys to measure ocean currents and transport and to document physical features.

R:\USNavFacEngCom405450\Vieques\MapFiles\Underwater_Wide_Area_Assessment_WP\Figure 1-1 - Regional Location Map.mxd2/25/2015CGauthier_ch2mhillen

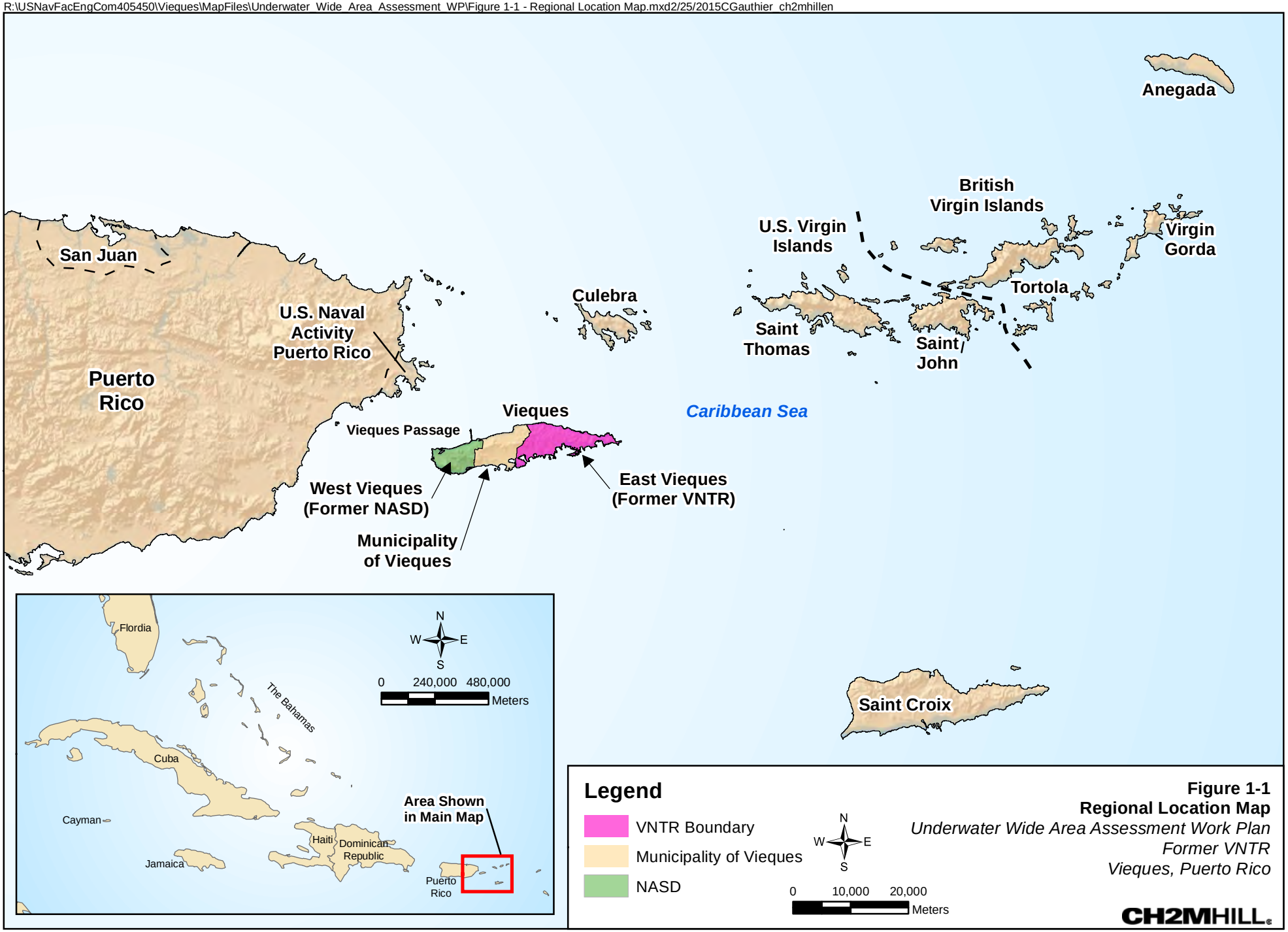

Figure 1-1
Regional Location Map
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

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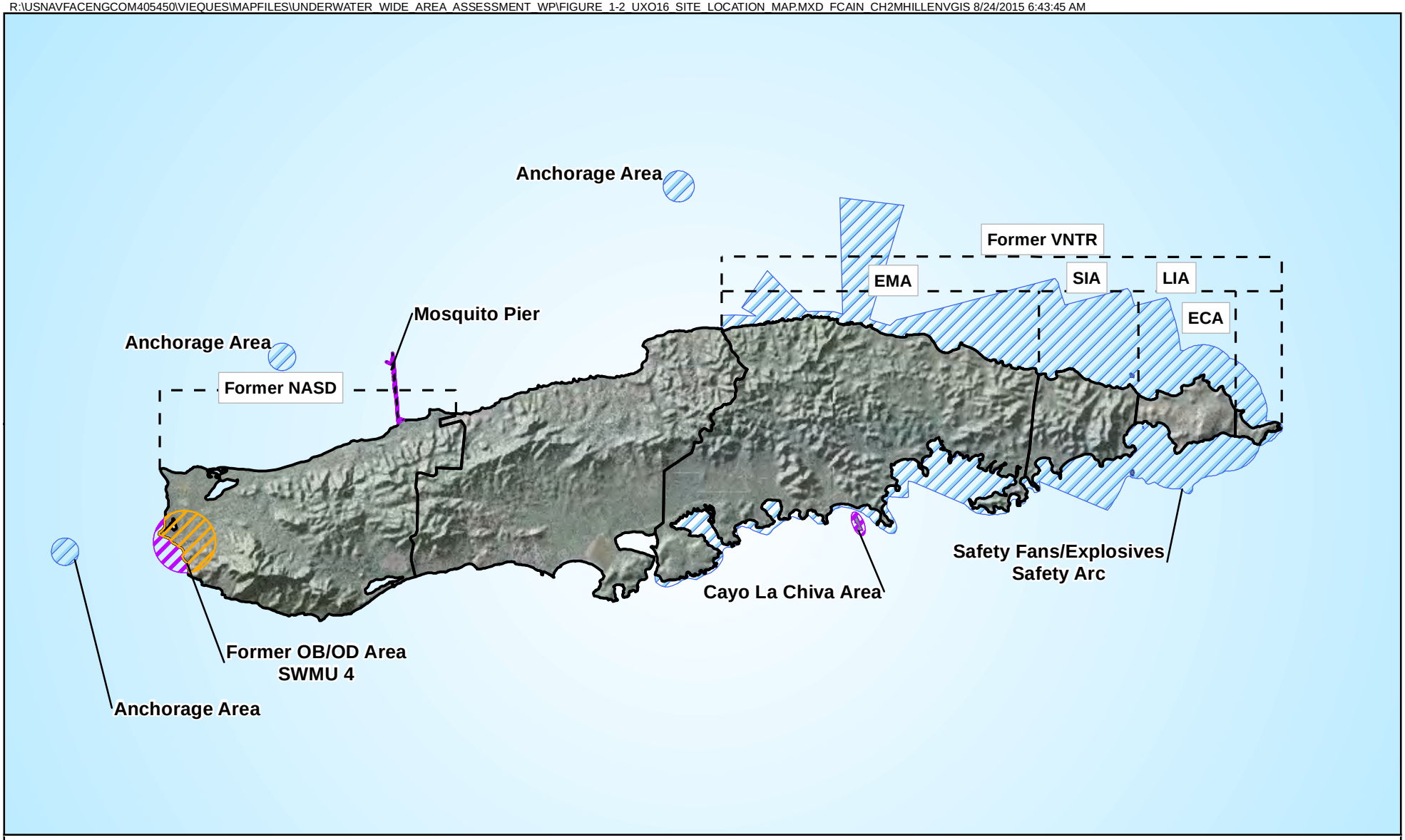

Legend

- Area Addressed under a Separate Investigation from this WAA
- SWMU 4
- UXO 16

ECA - Eastern Conservation Area
EMA - Eastern Maneuver Area
SIA - Surface Impact Area
LIA - Live Impact Area

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Figure 1-2
UXO 16 Site Location Map
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

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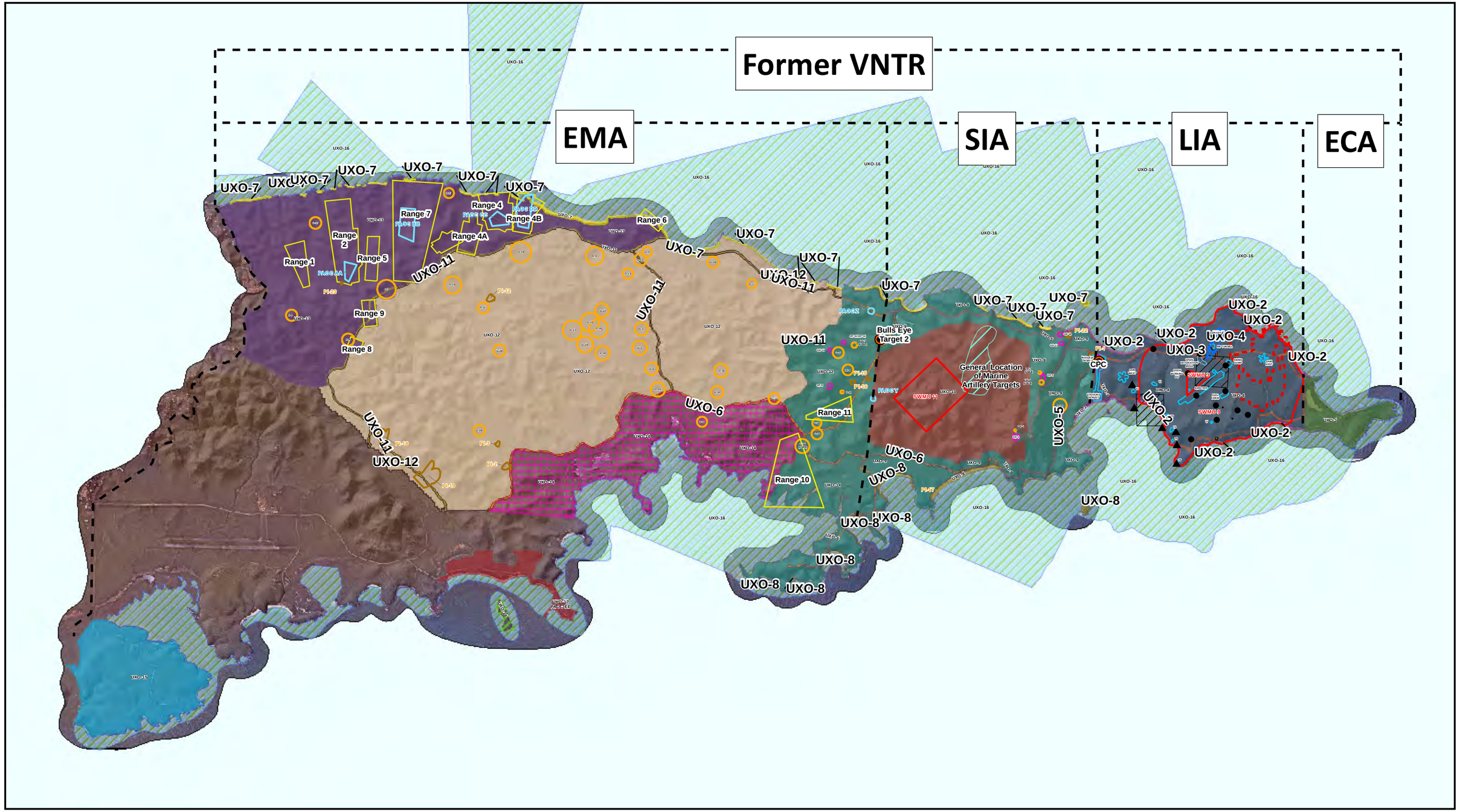

Historical Air-To-Ground (ATG) Target
Historical Naval Gunfire Support (NGFS) Target
Bulls Eye Target
General Location of Marine Artillery Targets
North Convoy Target Area
LIDAR (Light Detection and Radar) Identified Target Feature
Central Processing Center
Gun Positions
Target Area
Observation Point

Photo Identified Area
Preliminary Area of Concern
Solid Waste Management Unit
Range
Open Burn Pit
Open Detonation Area
Naval Gunfire Support (NGFS) Target Area
Dense Submunitions Area

2005 Aerial Imagery
2005 Hillshade

Munitions Response Sites

UXO 1 - ECA
UXO 2 - LIA Beaches
UXO 3 - LIA Roads
UXO 4 - LIA Interior
UXO 5 - SIA Restricted Roads
UXO 6 - EMA/SIA Public Roads
UXO 7 - EMA/SIA North Beaches
UXO 8 - SIA South Beaches
UXO 9 - SIA Exterior
UXO 10 - SIA Interior
UXO 11 - EMA Public Roads
UXO 12 - EMA Interior
UXO 13 - EMA West
UXO 14 - EMA South
UXO 15 - Puerto Ferro
UXO 16 -Underwater Areas
UXO 17 - PAOC-EE
UXO 18 - Cayo de la Chiva

Sources of Former Military Features:

Ranges, Gun Positions, and Observation Points – Aerial Photographic Analysis by Environmental Research Inc. 2000 and the Environmental Impact Statement prepared by the Naval Facilities Engineering Command 1979.

Target Features – Environmental Impact Statement prepared by the Naval Facilities Engineering Command 1979 and by LIDAR/Orthophotography Survey by SKY Research Inc.

Submunitions Area – Area delineated by CH2MHILL based on high density of submunitions found.

Open Burning Pit and Open Detonation Area - Aerial Photographic Analysis by Environmental Research Inc. 2000.

Figure 1-3
UXO Sites and Former Military Operations
Underwater Wide Area Assessment Work Plan
Former Vieques Naval Training Rrange
Vieques, Puerto Rico

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R:\USNavFacEngCom405450\Vieques\MapFiles\Underwater_Wide_Area_Assessment_QAPP\Figure 1-3 Former Military Operations.mxd 8/20/2015 FCain_ch2mhillenvgis

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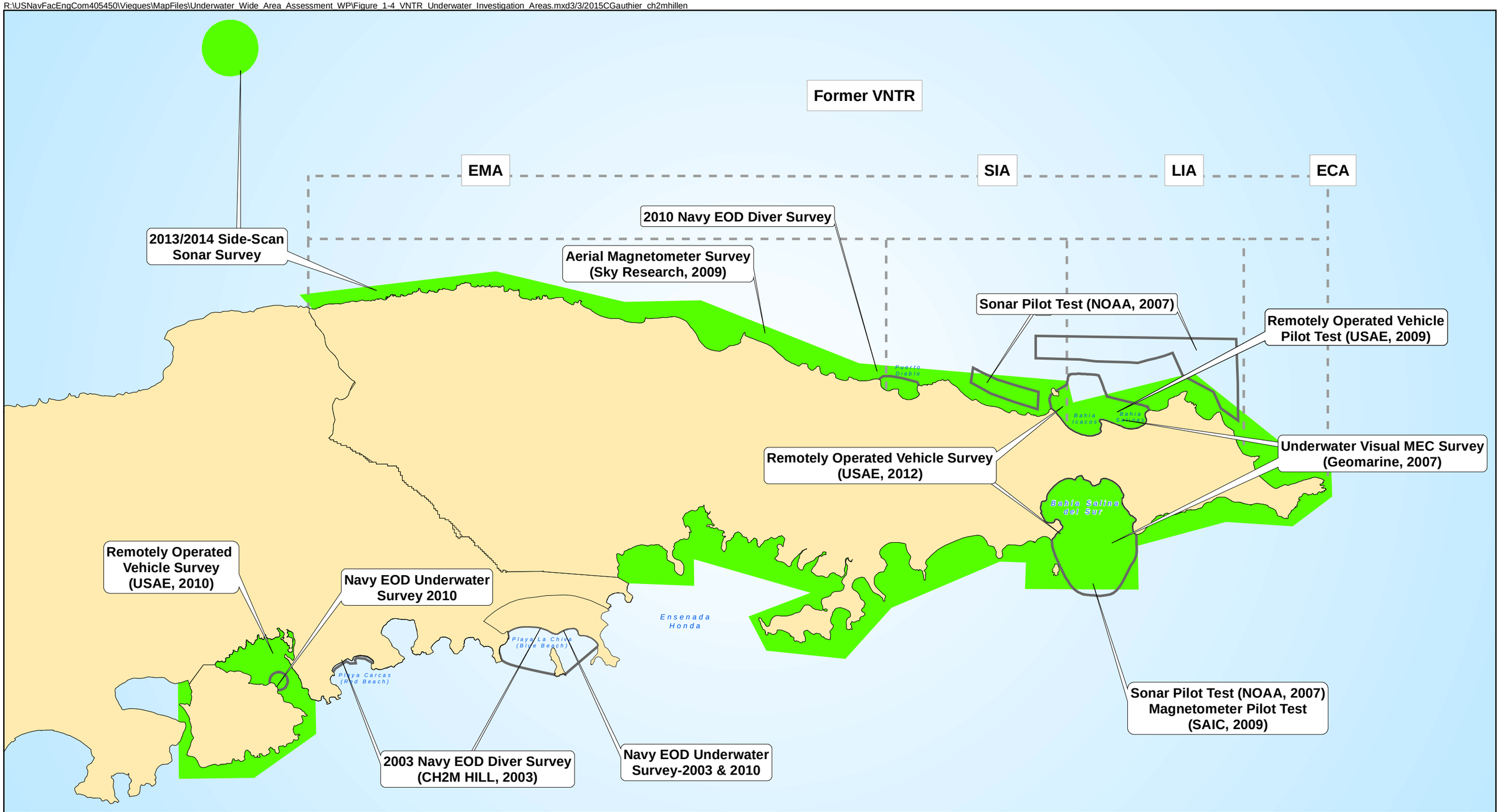

Legend

Aerial Magnetometer Survey - Offshore Area

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Figure 1-4
Previous Underwater Investigations at the Former VNTR
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

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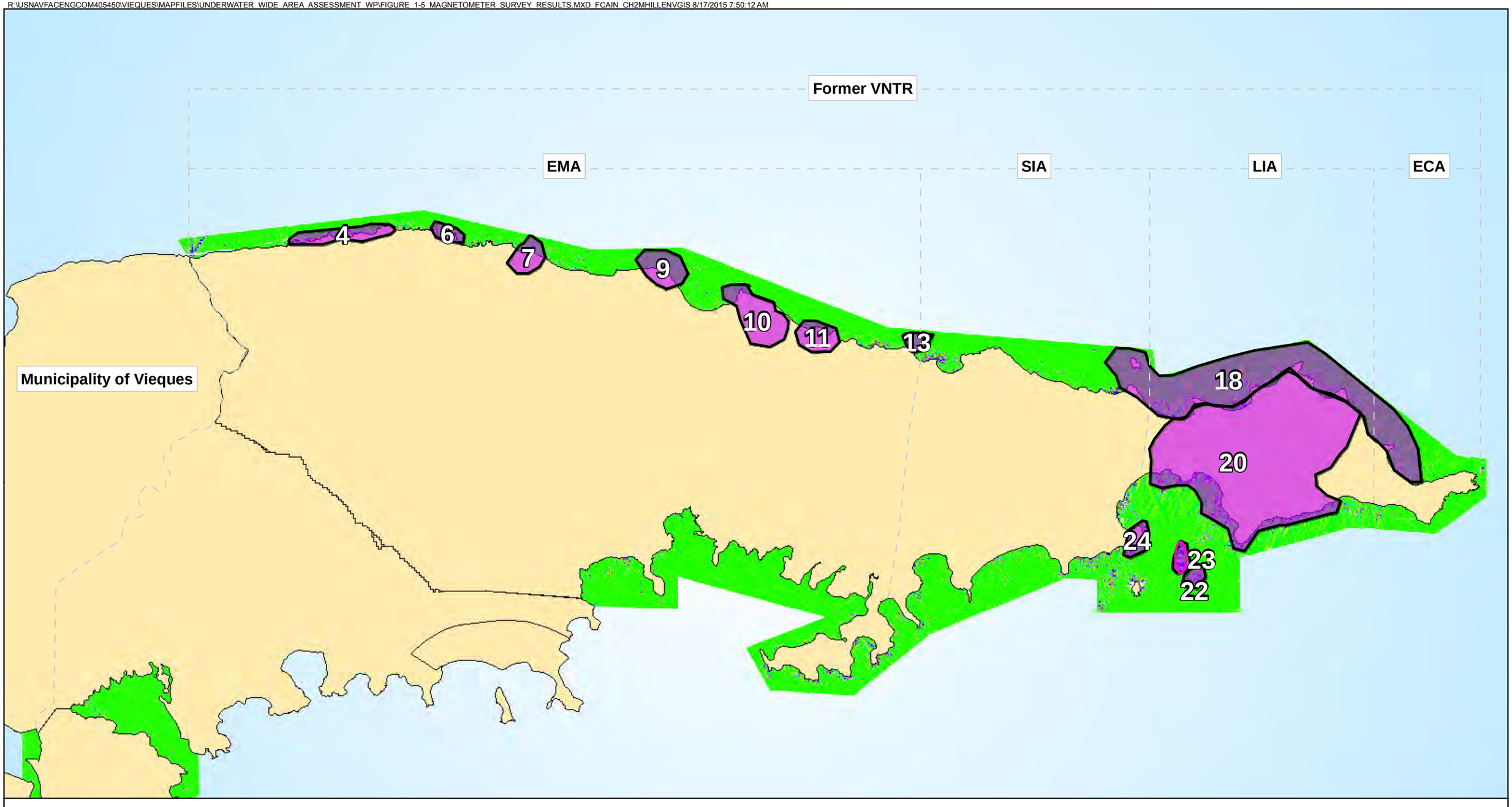

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Aerial Magnetometer Survey – Offshore Area

EADA

Total Magnetic Field - Demedian Filtered (nT)

-4.6 -2.3 0.0 1.9 3.8 5.8 7.7 9.6

Note: A total of 46 EADAs were identified during the aerial magnetometer survey. The 12 EADAs located wholly or partially in UXO 16 are included on this figure. The number associated with each EADA corresponds with the EADA number assigned based on the aerial magnetometer survey results.

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Figure 1-5
Magnetometer Survey Results
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

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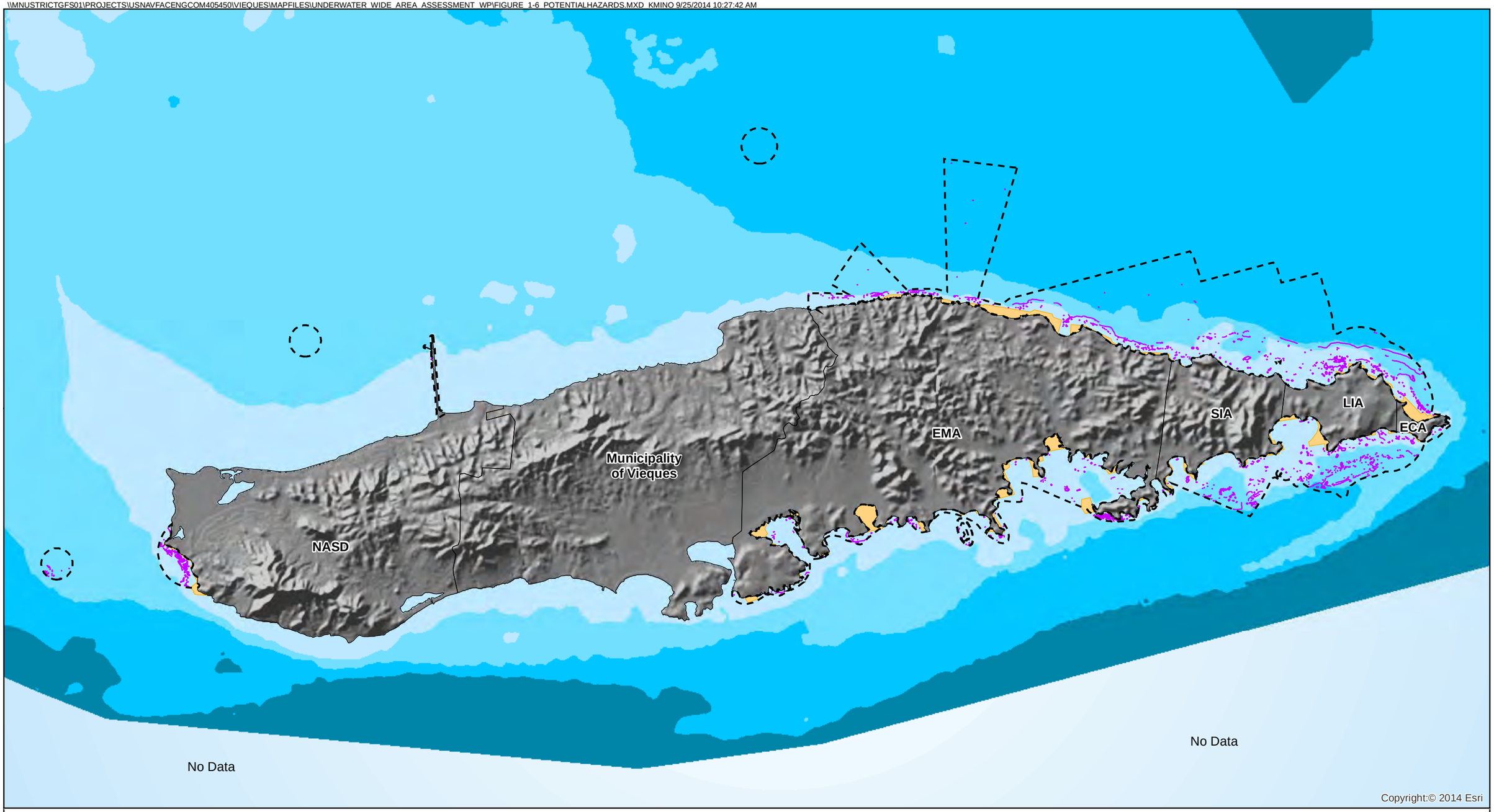

Legend

- Site Boundary

Underwater Depth (feet)

- 0 - 30
- 30 - 60
- 60 - 120
- 120 - 164

- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Side scan sonar survey could not be conducted in area due to shallow depth conditions, reefs, and/or rough sea conditions
- UXO 16 Boundary

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Figure 1-6
Potential Hazards Identified during Side Scan Sonar Survey
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

CH2MHILL

SECTION 2

Conceptual Site Model

This section provides a summary of the key elements of the CSM, including release history, physical characteristics, land use, and potential receptors at UXO 16. **Figures 2-1 and 2-2** present the generalized CSM of UXO 16.

2.1 Release History

Munitions and munitions-related items identified within the former NASD and former VNTR are generally classified as MEC, MPPEH, MD, or range-related debris (RRD). MEC is further subcategorized into UXO, DMM, and MC. A brief definition of each is summarized below:

- MEC – distinguishes specific categories of military munitions that may pose unique explosive safety risks
- UXO – munitions that have been primed, fused, and armed, or otherwise prepared for action; have been placed in such a manner as to constitute a safety hazard; and remain unexploded
- DMM – munitions that have been abandoned or removed from storage without proper disposal
- MC – any materials originating from UXO, discarded military munitions, or other military munitions, including explosive and non-explosive materials, and emission, degradation, or breakdown elements of such munitions
- MPPEH – material that, prior to determination of its explosives safety status, potentially contains explosives or munitions, or potentially contains a high enough concentration of explosives that the material presents an explosive hazard
- MD – remnants of munitions remaining after munitions use, demilitarization, or disposal
- RRD – debris, other than munitions debris, collected from ranges (such as targets and fragments of metal)

The sources of MEC within UXO 16 include: Naval gunfire and air-to-ground bombing of munitions intended for offshore targets south of the LIA and targets on cliff faces along the southern portion of the LIA; Naval gunfire and air-to-ground bombing that may have missed their intended targets in the LIA and SIA or deflected from land to offshore; overshooting of Marine artillery at the ranges and gun positions in the EMA; kick-outs of munitions from the OB/OD areas at the LIA and at the western end of Vieques; and inadvertent release of munitions during their transfer at the anchorage areas and Mosquito Pier. MC may be/may have been released into the marine environment due to historical site activities. However, studies indicate that any impact from MC is localized to the area immediately at and adjacent to munitions (USACE, 2013).

2.2 Physical Characteristics

This subsection summarizes the physical characteristics of UXO 16, including wind, bathymetry, tides, currents, benthic habitats, and waves; this information was obtained from three sources: Bauer et al. (2008), GMI (2005), and Morelock et al. (2014).

2.2.1 Wind

Vieques lies along the northern edge of the Trade Wind belt which circles the globe from east to west. Locally, these surface winds are associated with the mid-latitude high-pressure cell, whose center is periodically displaced along the Bermudas-Azores latitude band. This clockwise rotating, high surface pressure system generates easterly winds over the Caribbean. The wind direction varies from northeast to southeast, depending on the season, but is predominantly from the east all year round. In the winter months, easterly and northeasterly 10 to 15-knot winds are typical. In the summer, the typical wind is from the east at five to 10 knots (kts).

Coastal processes associated with winds due to episodic storms (e.g., tropical storms and hurricanes) may affect the migration of munitions. Vieques is on the path of Atlantic tropical storms and hurricanes, and it has been affected by both in recent history. From June to November, the high sea surface temperatures and favorable atmospheric conditions in the Atlantic Ocean allow the development of tropical lows into tropical depressions, tropical storms, and hurricanes. These storms track from east to west, and southeast to northwest. In recent history, Hurricanes David and Frederic in 1979, and Hurricane Hugo in 1989, were violent hurricanes that severely impacted Vieques coastline and marine habitats. According to Lizano (1991), Hurricane David passed approximately 90 nautical miles to the south of Vieques in an east to west direction with winds in the order of 90 miles per hour (mph). Rodriguez et al. (1994) reports that Hugo, with winds greater than 150 mph, was the most intense hurricane to impact Puerto Rico since 1956.

Figure 2-3 shows the tracks of 18 tropical storms and hurricanes (both referred to as storms herein) for the period from 1900 to 2012, and passing within a 25 nautical mile radius of Vieques. For the 113 years of record, the frequency is approximately an average of one storm every six years, with nearly 50 percent occurring in the month of September and 25 percent in August.

2.2.2 Bathymetry

The bathymetry around Vieques differs markedly between the north and south shore (**Figure 2-4**). North of the island, the seafloor is generally uniform and shallow, interrupted only by patch reefs and a sand and gravel shoal denoted as the Escollo de Arenas on the northwestern end of the island. The sea floor in this area slopes gently (e.g. 1:100) from the shore to a depth of approximately 50 feet, with a broad 80 foot deep shelf that extends to the north and west. The south side of Vieques is characterized by numerous small inlets and lagoons, and a shore-parallel coral reef at a depth of 50 to 65 feet approximately one to two miles offshore. South of the reef, there is a steep slope (e.g. 1:10) where the seafloor drops abruptly to depths over 3,000 feet. The bathymetry to the east of the island features an 80 to 150 foot depth transition between the shallow shelf on the north and the edge of the steep slope to the south.

The majority of UXO 16 is less than 60 feet deep. The deepest portion is approximately 80 feet within the northern portion of the site near the site boundary.

2.2.3 Water Levels

Water levels in Vieques are typically dominated by the tide. However, during storms, the storm surge would be the dominant component of high water levels.

Throughout the northeastern Caribbean, tides exhibit a complex behavior. Along the south coast of Vieques the tide is principally diurnal (one cycle per day) while along the north coast the tide is semidiurnal (two cycles per day). The tide range along both coasts is relatively small and on the order of 0.7 and 1.3 feet, respectively.

Limited data make it difficult to estimate extreme water levels around Vieques. However, Rodriguez et al. (1994) reports that observations of storm-swash debris post Hurricane Hugo indicated that six to 10 foot water levels in the Vieques Passage were reached. On the southeast end of Vieques the estimated storm surge was in the order of three feet, the wave runup approximately eight feet, generating a total water level of approximately 11.5 feet relative to mean sea level (MSL). **Table 2-1** shows estimates of storm surges, for various return periods, according to the Caribbean Disaster Mitigation Project (2000).

TABLE 2-1
Storm Surge at Vieques for Various Return Periods

Return Period (years)	Storm Surge (feet)
10	1.3
25	2.0
50	3.3
100	3.9

2.2.4 Currents

Current patterns in the Caribbean are highly variable, both spatially and temporally. This variability is a function of bottom topography, wind, and the tide. The general current pattern around Puerto Rico and the US and British Virgin Island archipelago is an east to west direction (**Figures 2-1**, **2-2**, **and 2-4**); these waters join the general western flow of the Caribbean Current towards Yucatan Strait.

Previous studies (GMI, 2005) have indicated that surface currents around Vieques are driven mainly by the prevailing trade winds. Prevailing surface currents at the eastern end of Vieques flow east to west at approximately 0.10 meter/second (0.20 knot) along the north and south coastlines. This is consistent with rule-of-thumb estimates of two to three percent of the wind speed which would result in wind-induced currents in the order of 0.20 to 0.45 knots for the typical 10 to 15-knot easterly winds.

The Vieques north and south shores are relatively broken and consist of a series of rocky headlands separating pocket beaches and bays. This particular coastal morphology is not conducive to the establishment of spatially and temporally constant wave-induced longshore currents. Instead, longshore currents are a function of the specific bathymetry and wave conditions within bays and along pocket beaches. The tide is not expected to contribute significantly to the current given its relatively low range.

The east to west wind-induced current sets a longshore drift that moves suspended sediments in the same direction. At the northwest end of Vieques, the convergence of the westward current with the northward currents along the Vieques Passage formed the Escollo de Arenas shoal (**Figure 2-4**).

In storm conditions, wind- and wave-induced currents could produce significant sediment transport and alter shorelines and marine habitats. According to Rodriguez et al. (1994) bottom currents generated by Hugo were sufficiently strong to scour out sediments from around seagrass roots and waves tore up extensive areas of seagrass and deposited the debris on the south coast of Vieques.

2.2.5 Benthic Habitats

The contrasting bathymetric profiles on the north and south sides of Vieques are reflected in the distribution of benthic habitats and associated biological communities. **Figures 2-5** through **Figure 2-8** illustrate the coral and non-coral biological cover surrounding the island. Seagrass communities, which are generally limited to shallow depths and protected, low-energy regions, are widespread northwest of Vieques where depth is shallow and conditions are relatively calm. In contrast, hard bottom habitats are typified by higher topographic complexity than seagrass and other soft bottom habitats. For example, the areas of highest complexity around Vieques highlight slopes and areas of reef and hard bottom. These features include numerous patch reefs north of Vieques, and barrier reefs extending along the edge of the steep slope on the south side of the island.

2.2.6 Waves

The most frequent wave climate around Vieques consists of easterly waves generated by the Trade Winds. Deep-water waves due to the Trade Winds are in the order of three to six feet with periods in the range of five to 10 seconds. **Figures 2-10 and 2-11** show typical significant wave heights (shown in meters) and periods (shown in seconds), respectively, measured east of Vieques and offshore and to the south of St. Thomas. Windward facing coastlines are fully exposed to these waves, but the west coast of Vieques generally exhibits smaller waves.

From November to February/March, winds are more predominant and stronger from the northeast, and therefore the northern coast of Vieques is more exposed to waves and the southern coast is protected. During these winter months, storms and cold fronts farther north produce stronger than usual 25 to 30-knot winds from the northeast which can contribute to the generation of 10 to 11 foot waves with 12 to 16-second waves that often reach Vieques.

As these waves approach the coast they are transformed due to the proximity of the bottom, refracting and gradually aligning their fronts with the depth contours, and shoaling and breaking in shallow water. **Figure 2-9** shows typical wave refraction patterns around Vieques for easterly waves. Wave breaking is a

function of wave height and water depth, and it is generally accepted that waves will break when the wave height to water ratio is approximately 0.78. While the bathymetry of the locations of interest is known, wave conditions are variable and therefore locations of wave breaking are also variable. The Beach Dynamics Investigation, currently being performed, will be evaluating these areas (via transects) at various beaches and will produce wave measurements which, in combination with wave modeling, will assist in the definition of area of potential MEC mobility.

The many and different coastal features existing around Vieques will modify incoming wave height and direction in various degrees. The Vieques shoreline is extensive and, at the conceptual level of this assessment, it is not possible to assess how particular areas might affect wave refraction and breaking. Nevertheless, a description for a Puerto Ferro on the south shore of Vieques is provided as representative of other locations along this shore.

Puerto Ferro is essentially a natural, generally shallow six to 10 ft (2 to 3 m) MSL deep bay, featuring a low shoreline consisting of mangroves. It is connected to the sea through an approximately 2,800 ft (850 m) long, 820 ft (250 m) wide natural channel, oriented in a northwest-southeast direction. The channel is sided by rocky shores with few sandy pockets on each side which slope up to 65 ft to 98 ft (20 m and 30 m) high headlands to the east and west, respectively. Just offshore Puerto Ferro, the bottom is approximately 26 ft (8 m) MSL deep, and gently slopes up to a 10 ft (3 m) MSL deep shoal midway in the channel, to then drop into a 13 to 16 ft (4 to 5 m) MSL deep depression in the center the bay. The bottom of the channel consists of sand covered by patches of seagrass, while the bay is predominantly covered by unconsolidated mud also covered by patches of seagrass. PI-9 East is an area within Puerto Ferro where MEC has been found, likely as a consequence of wave transport. PI-9 East is located at the northwest edge of the channel where the bottom conditions and shoreline features of the bay transition. **Figure 2-12** shows the Puerto Ferro bathymetry, bottom constituents, shoreline characteristics, and PI-9 East. **Figure 2-9** shows typical wave refraction patterns around Vieques for easterly waves. At Puerto Ferro, waves would be approximately aligned with the channel.

The southeast approaching waves would penetrate into the bay through the channel and refract around PI-9 East, turning to the west and significantly reducing their height. **Figure 2-13** shows bathymetry, wave fronts, and refraction patterns at Puerto Ferro.

Table 2-2 summarizes the estimates of significant wave heights and surges due to storms for various return periods according to the Caribbean Disaster Mitigation Project (2000).

TABLE 2-2
Significant Wave Heights and Surge at Vieques for Various Return Periods

Return Period (years)	Significant Wave Height (feet)	Storm Surge (feet)
10	15.5	1.3
25	17.1	2.0
50	19.7	3.3
100	24.6	3.9

According to Lizano (1991) Hurricane David passed approximately 90 nautical miles to the south of Vieques in an east to west direction and generated southeasterly 10 foot significant wave heights along the southern shore of Vieques. Rodriguez et al. (1994) reports that Hurricane Hugo, with winds greater than 150 mph, traveled in a southeast to northwest direction and made landfall in Vieques. It generated an estimated storm surge on the southeast end of Vieques of three feet. Rodriguez et al. (1994) did not provide information about wave heights, but correlating Hugo's estimated three foot storm surge along Vieques south shore with the significant wave heights in **Table 2-2** it can be inferred that waves in deep water may have reached 19 to 23 feet.

2.3 Potential Munitions Transport Pathways

The mobility of munitions within UXO 16 is dependent on munitions shape, size, weight, and surface roughness, relative orientation of munitions to the wave-induced and current flows, water depths, wave and current conditions, and its degree of burial in bottom sediments.

Figure 2-14 and Figure 2-15 show areas of potential munitions presence on the north and south shores of Vieques, respectively, bottom characteristics, and typical wave directions. While bottom characteristics could be classified in a very detailed manner, including type and percentage of bottom coverage, only a) coral and hard bottom and b) unconsolidated sediment bottom types were used for this assessment.

In areas with coral and a hard bottom, munitions would be expected to remain in place due to the relatively large changes in elevation and because munitions would be trapped in place by the coral reef. Areas covered by unconsolidated sediment with gentle slopes would be conducive for munitions mobility if hydrodynamic (depth, waves, and currents) and munitions characteristics (shape, size, weight, condition, and relative orientation) are suitable. Waves in shallow water induce on the fluid particles oscillatory, elliptical orbits where the velocity induced at the crest of the wave is larger than the velocity at the through. The net result of this is drift in the wave direction. Consequently, munitions in unconsolidated sediment areas are expected to migrate in the direction of the waves, provided that waves induce large enough hydrodynamic loads

Along the north shore, there is a narrow area of unconsolidated sediment. This area is bounded by coral and hard bottom to the north and south, along the (20 and 10 m) depth contours, respectively. Munitions in this narrow area, if not buried, are expected to migrate in the predominant wave direction and accumulate along the 10 m depth contour. In this narrow area of unconsolidated sediment, typical 1 to 2 m, 5 to 10-second waves would generate bottom flow velocities in the order of 0.75 knots, while 3 to 3.5 m, 12 to 16-second storm waves in the winter would generate velocities in the order of 1 knot. These wave conditions depending on shape, size, weight, condition, and relative orientation of munitions could induce transport. Between the shore and the 10 m depth contour, there are a few pockets of unconsolidated sediment where munitions are expected to migrate similarly (e.g., toward the shore and in the predominant wave direction). Provided that waves do not break over the reefs, bottom wave-induced velocities in this area would increase due to shallower water and could reach 1 to 3 knots.

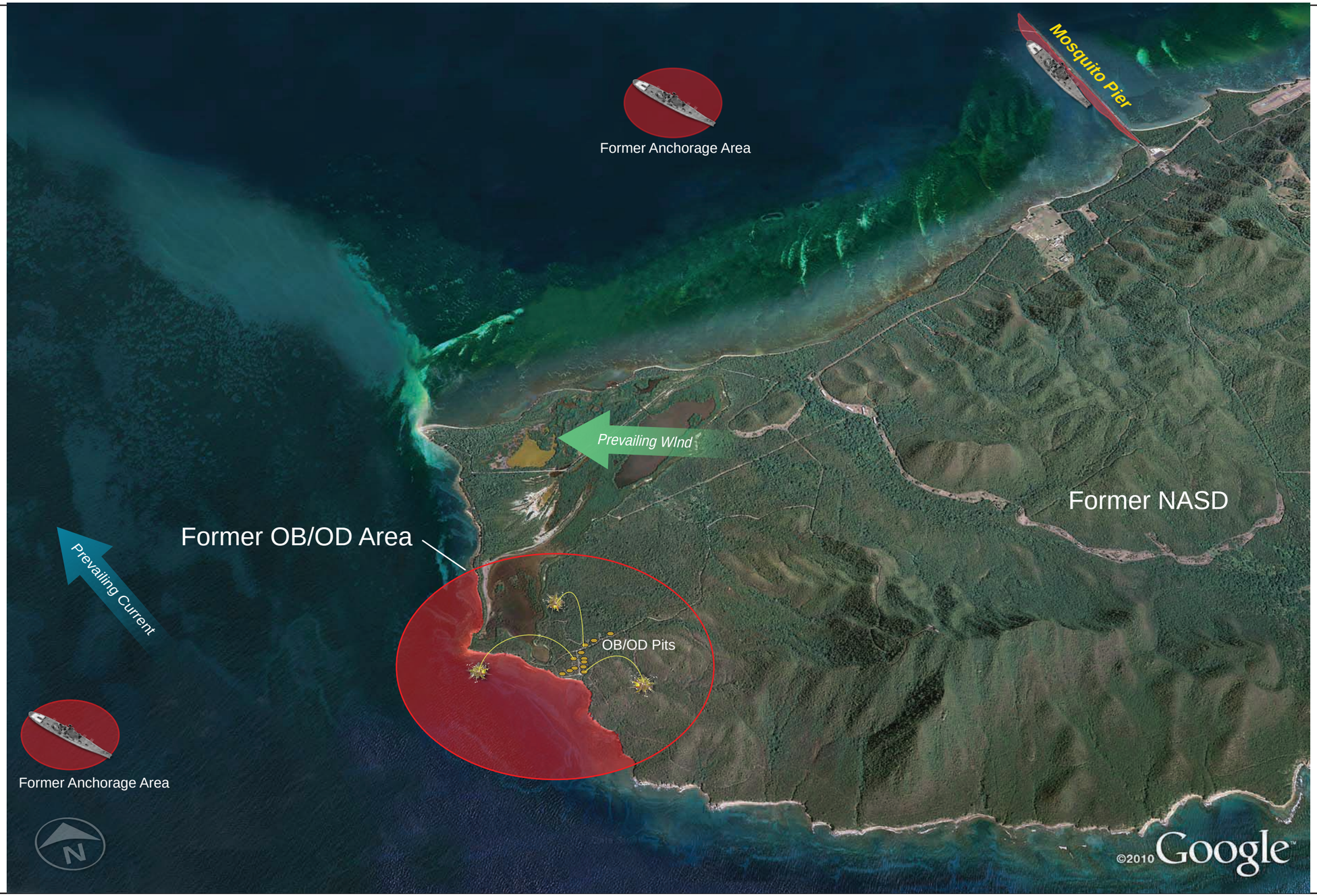
On the south shore the predominant bottom condition in the area of potential munitions presence is unconsolidated sediment. In principle, a similar behavior to what was described for munitions on the north shore on unconsolidated sediment should be expected. It is important to note, however, that the south shore features a broken coastline with pocket beaches bounded by headlands and fronted by islands, reefs, and shoals that offer wave protection. These features significantly transform the deep water waves as they travel to the shore, decreasing the potential of waves to transport munitions. Therefore, low mobility of munitions could be expected in this area in typical conditions.

2.4 Future Land Use and Potential Receptors

The offshore territorial waters are under the jurisdiction of the Commonwealth of Puerto Rico. Code of Federal Regulations (CFR) Title 33 has been established to address navigation and navigable waters and the anchor sites off the coast of Vieques, as described in 33 CFR Sections 110.1, 110.245, 334.1470, and 334.1480. These areas are shown in the NOAA nautical charts.

Potential human receptors are recreational users (boaters, divers, snorkelers, and swimmers) and fishermen who may come into contact with munitions and MC. Potential ecological receptors are those associated with coastal benthic marine habitats within UXO 16, which are primarily coral reef and colonized hardbottom, submerged vegetation (seagrass and algae), and fringing mangroves. Aquatic organisms in these habitats could potentially be exposed to MC in site media. The diversity of aquatic organisms in these coastal habitats is high and includes approximately 50 species of corals, large numbers of benthic and epibenthic invertebrates (e.g., polychaetes, mollusks, crustaceans), over 30 seagrass and macroalgae species, over 200 species of fish,

28 species of aquatic mammals (mostly cretaceans), and four species of sea turtles. At least 16 species of seabirds are dependent on the coastal and oceanic environment for important life history requirements, such as foraging. Multiple species of corals, aquatic mammals, sea turtles, fish, and seabirds in the vicinity of Vieques are currently protected (or proposed) under the Endangered Species Act (ESA) and analogous territorial Acts.



LEGEND

- Fomer OB/OD/Anchorage Area
- Prevailing Wind Direction
- Prevailing Currents
- OB/OD Pits

Figure 2-1
UXO 16 Conceptual Site Model – West
Underwater Wide Area Assessment Work Plan
Former NASD
Vieques, Puerto Rico

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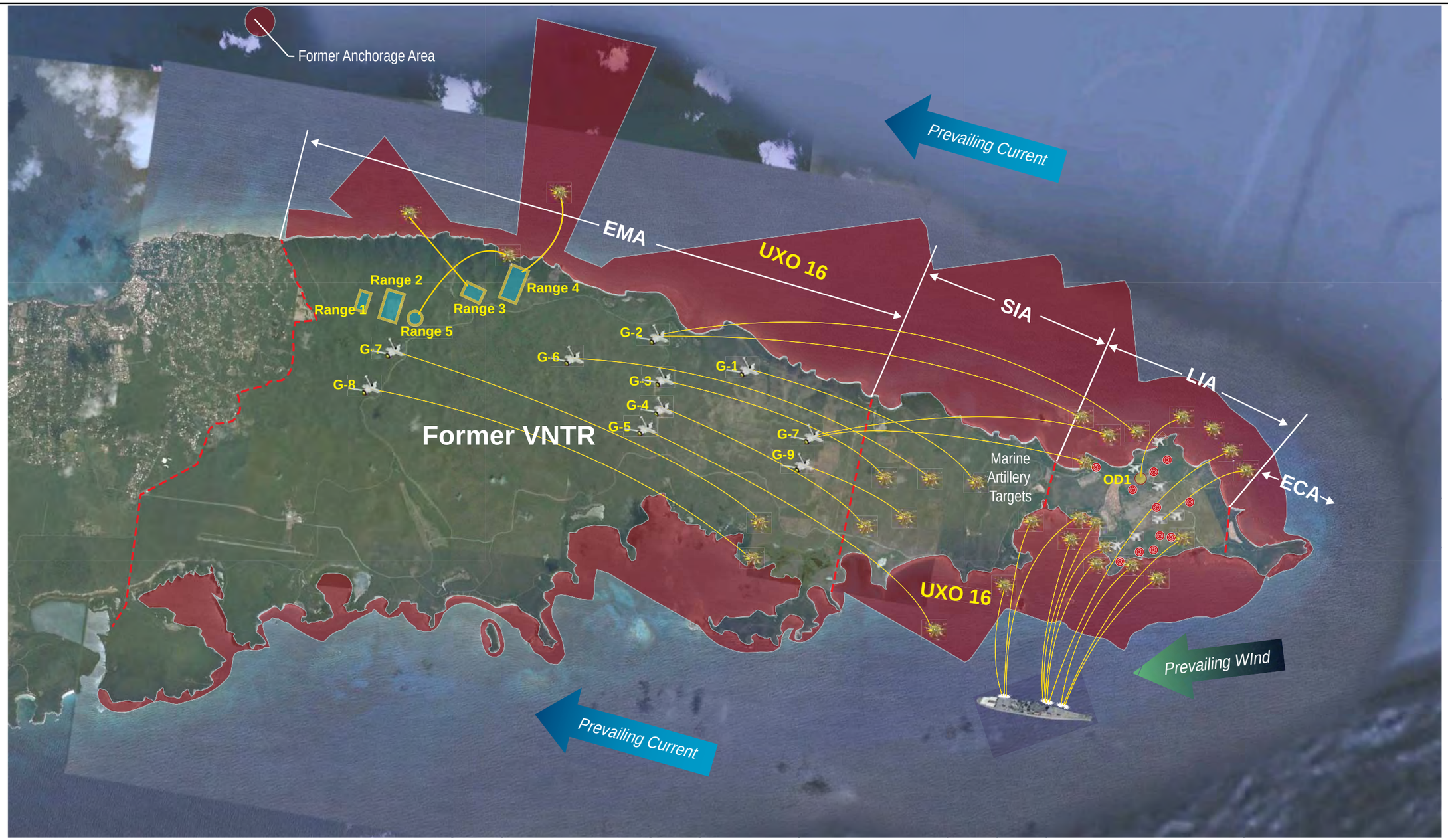

LEGEND

- Air-To-Ground (ATG) Target
- Naval Gunfire Support (NGFS) Target
- Gun Position
- Range
- Property Line
- UXO 16 Boundary
- Fighter/Bomber Plane
- Prevailing Wind Direction
- Prevailing Currents
- OD Area

Figure 2-2
UXO 16 Conceptual Site Model – East
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

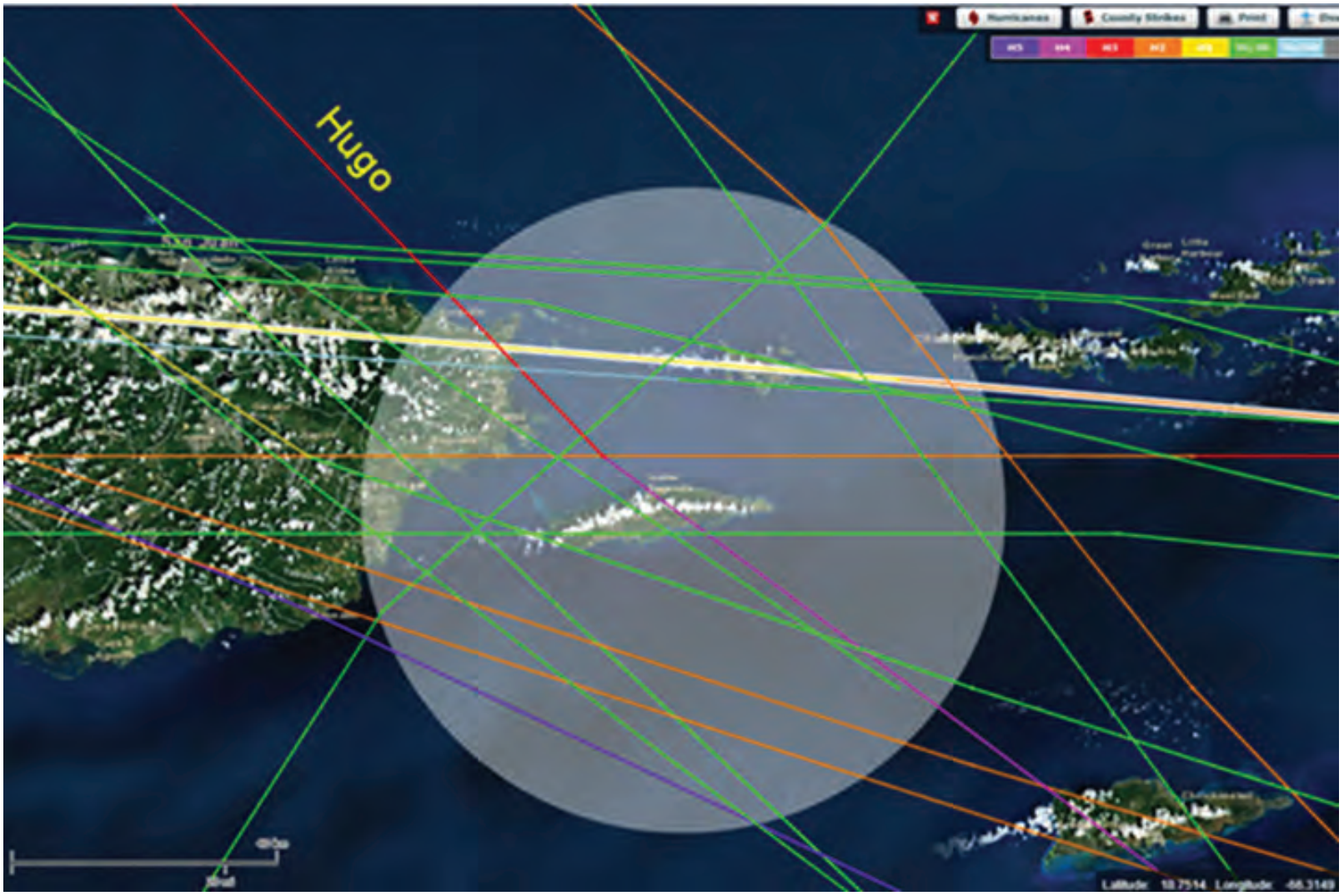

FIGURE 2-3
Tracks of Historical Tropical Storms and Hurricanes from 1900 to Date Within a 25 Nautical Mile Radius of Vieques
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

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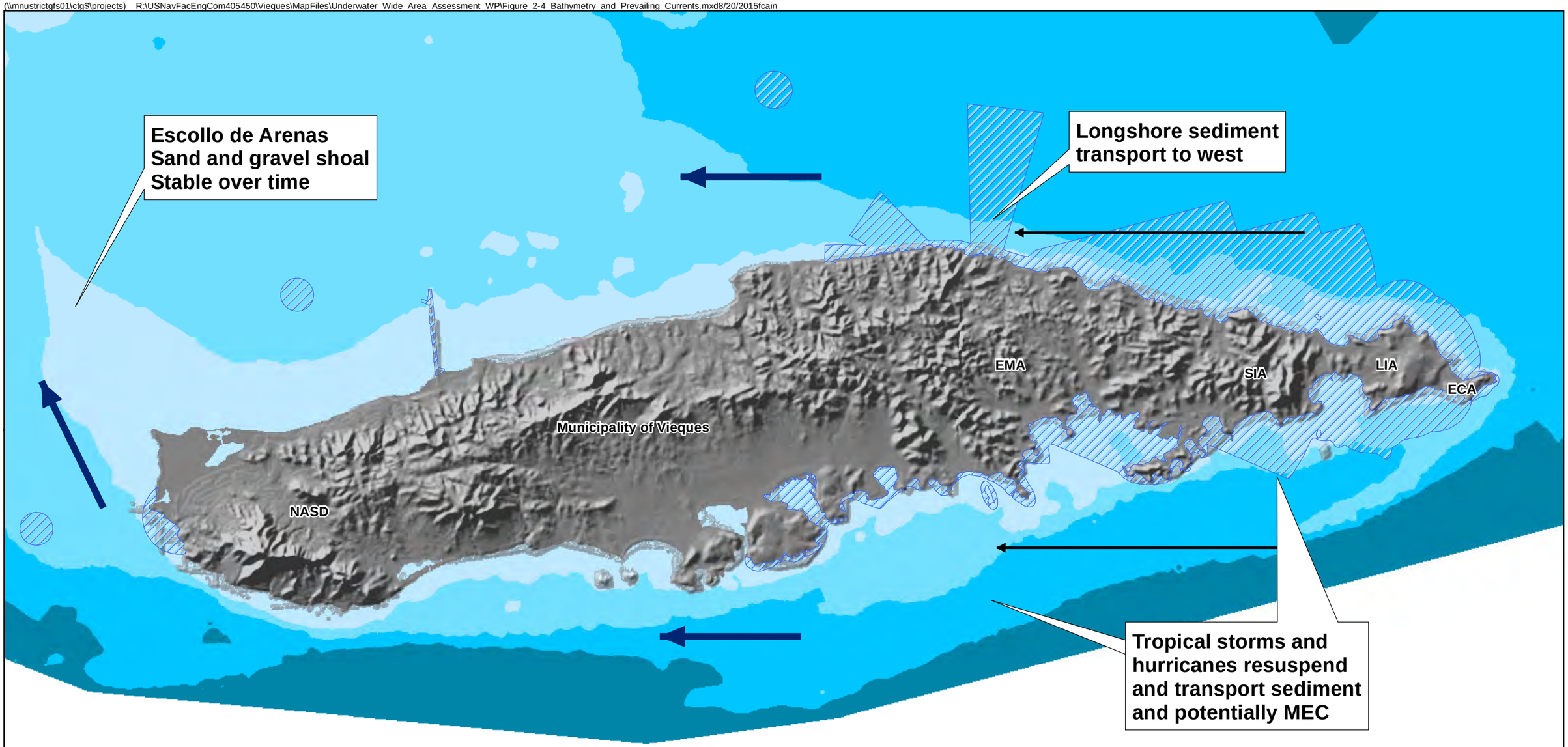

Legend

- Prevailing Winds
- Prevailing Currents
- UXO 16

Underwater Depth (feet)

- 0 - 30
- 30 - 60
- 60 - 120
- 120 - 164

N
W E
S

0 0.75 1.5
Miles

Figure 2-4
Bathymetry and Prevailing Currents
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

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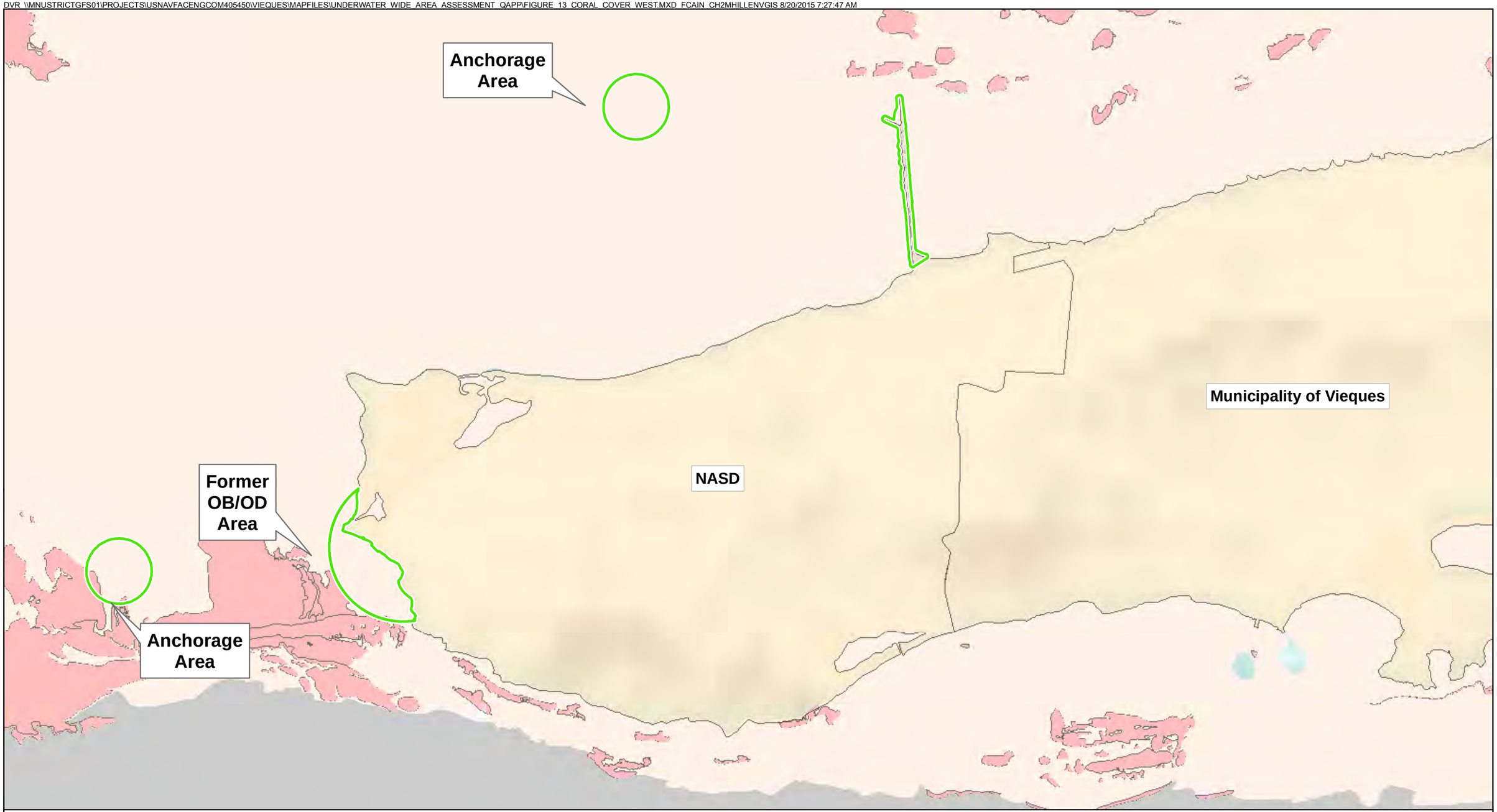

Legend

Percent Coral Cover

- UXO 16
- 0% - <10%
- 10% - <50%
- 50% - <90%
- Unknown

Source – Geospatial data from NOAA's Ocean Service, National Centers for Coastal Ocean Science (NCCOS) at http://ccma.nos.noaa.gov/ecosystems/coralreef/vieques/data.aspx, and documented in Bauer, L.J., M.S. Kendall, A.G. Zitello, and T. Battista. 2010. Benthic Habitats of Vieques, Puerto Rico.

N W E S

0 1 2 Miles

Figure 2-5
Coral Cover - West
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

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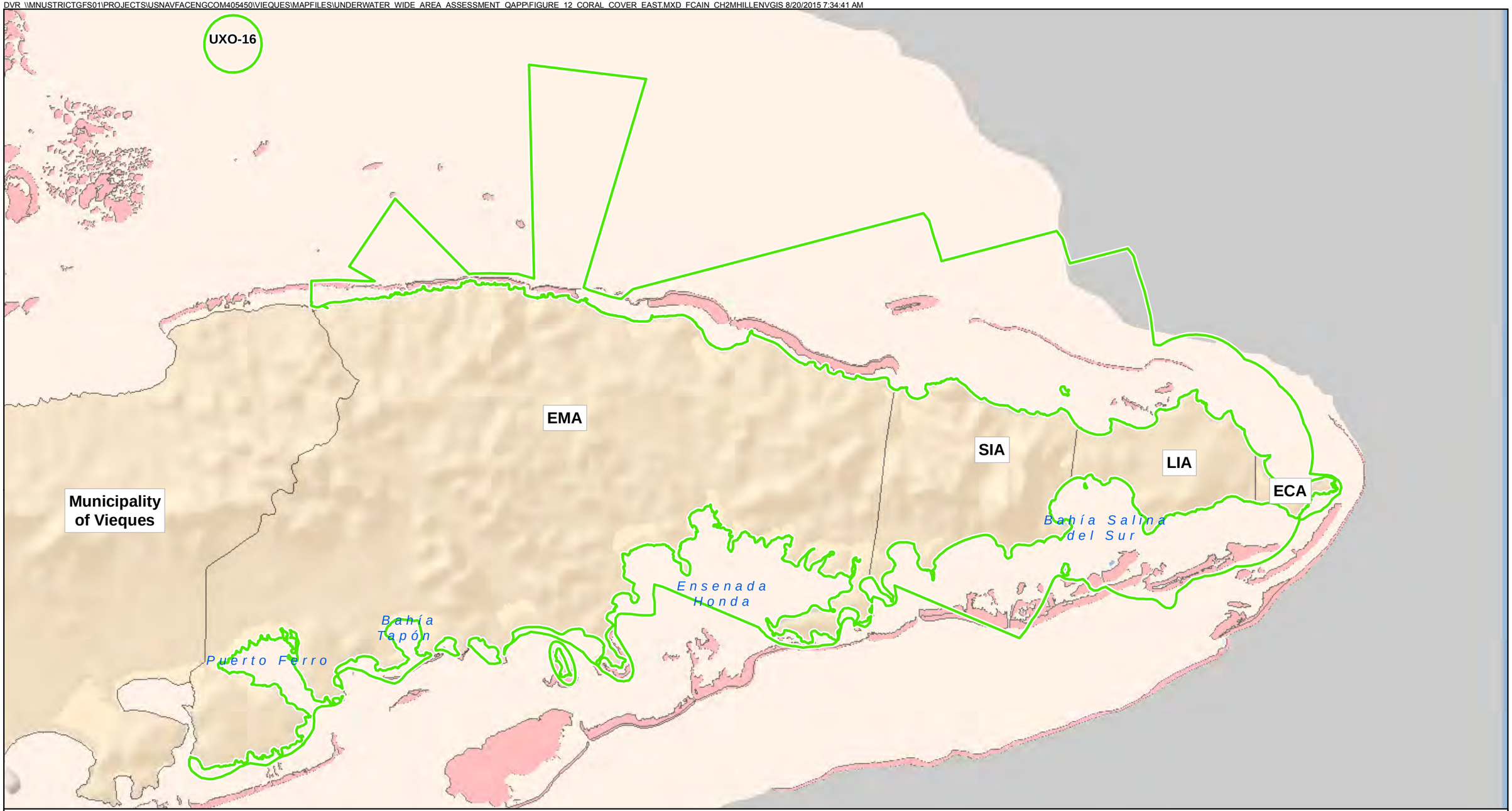

Legend

Percent Coral Cover

- UXO 16
- 0% - <10%
- 10% - <50%
- 50% - <90%
- Unknown

Source – Geospatial data from NOAA's Ocean Service, National Centers for Coastal Ocean Science (NCCOS) at http://ccma.nos.noaa.gov/ecosystems/coralreef/vieques/data.aspx, and documented in Bauer, L.J., M.S. Kendall, A.G. Zitello, and T. Battista. 2010. Benthic Habitats of Vieques, Puerto Rico.

N
W E
S

0 1 2 Miles

Figure 2-6
Coral Cover - East
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

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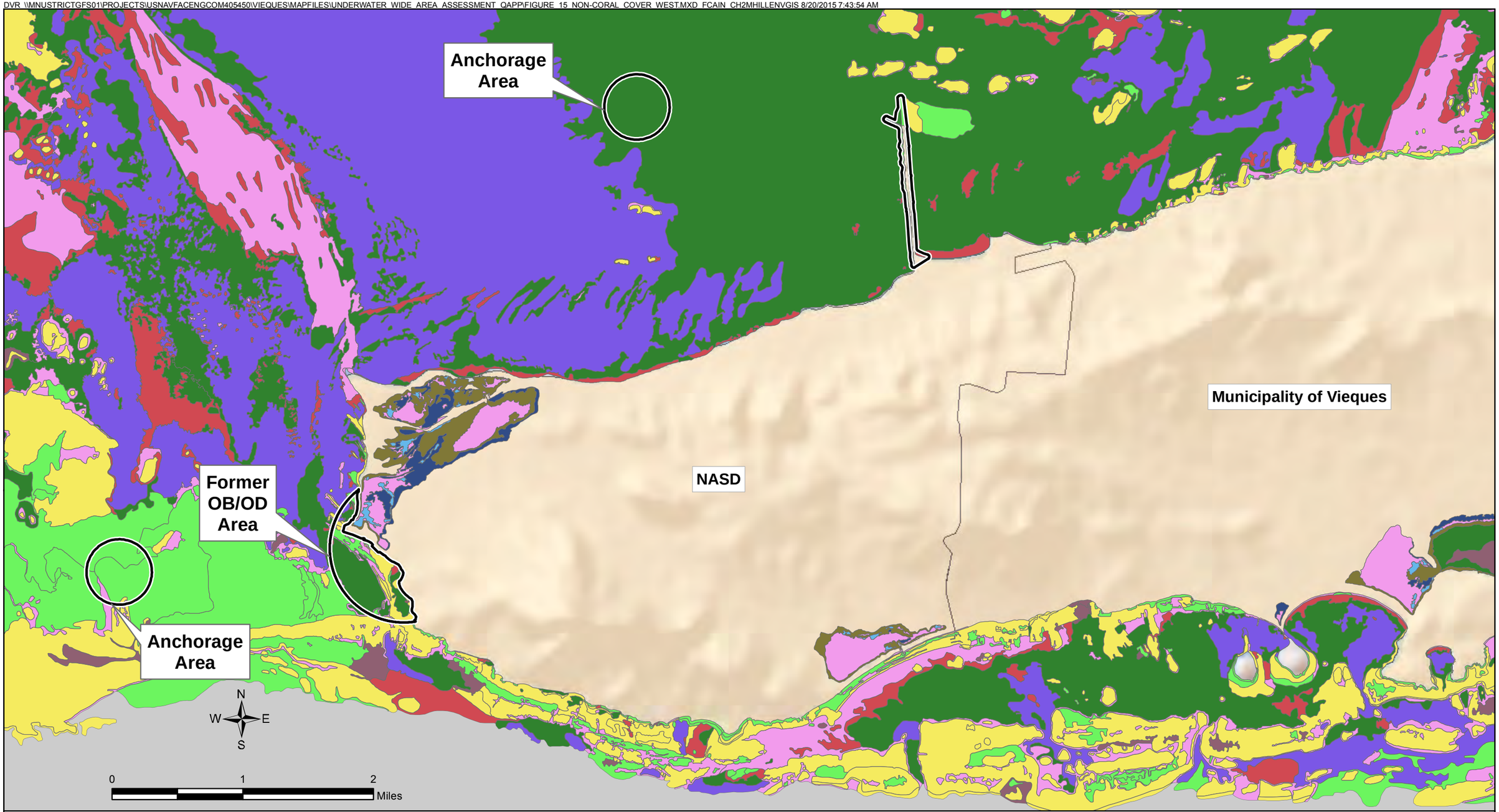

Legend

Non-Coral Biological Cover

- Algae 10% - <50%
- Algae 50% - <90%
- Algae 90% - 100%
- Mangrove 10% - <50%
- Mangrove 50% - <90%
- Mangrove 90% - 100%
- No Cover 90% - 100%
- Seagrass 10% - <50%
- Seagrass 50% - <90%
- Seagrass 90% - 100%
- Unknown
- UXO 16

Source – Geospatial data from NOAA's Ocean Service, National Centers for Coastal Ocean Science (NCCOS) at http://ccma.nos.noaa.gov/ecosystems/coralreef/vieques/data.aspx, and documented in Bauer, L.J., M.S. Kendall, A.G. Zitello, and T. Battista. 2010. Benthic Habitats of Vieques, Puerto Rico.

Figure 2-7
Non-Coral Biological Cover - West
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

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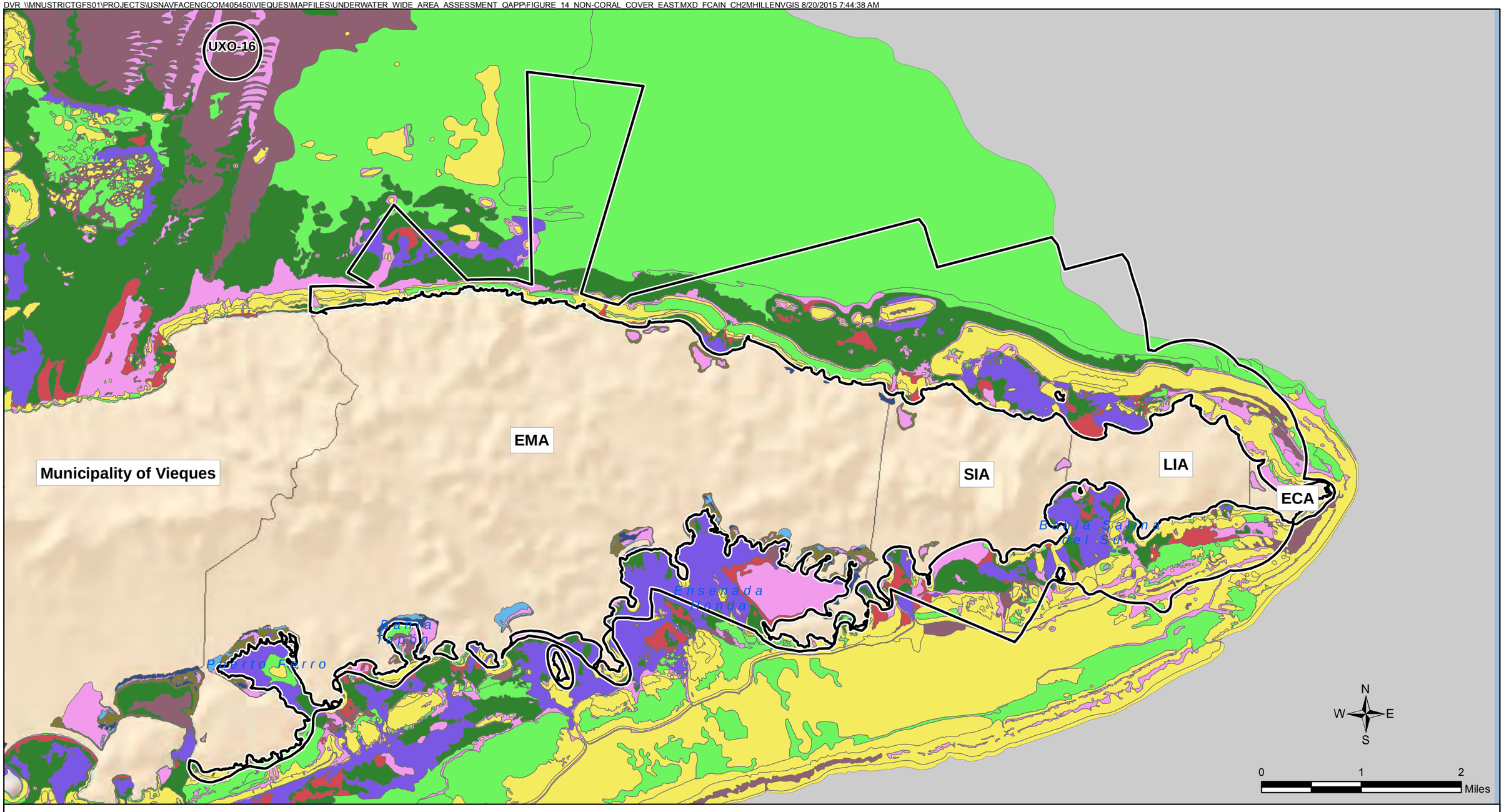
DVR \\MNUSTRICTGFS01\PROJECTS\USNAVFACENGCOM405450\VIEQUES\MAPFILES\UNDERWATER_WIDE_AREA_ASSESSMENT_QAPP\FIGURE_14_NON-CORAL_COVER_EAST.MXD FCAIN_CH2MHILLENVGIS 8/20/2015 7:44:38 AM



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Non-Coral Biological Cover

- Algae 10% - <50%
- Algae 50% - <90%
- Algae 90% - 100%
- Mangrove 10% - <50%
- Mangrove 50% - <90%
- Mangrove 90% - 100%
- No Cover 90% - 100%
- Seagrass 10% - <50%
- Seagrass 50% - <90%
- Seagrass 90% - 100%
- Unknown
- UXO 16

Source – Geospatial data from NOAA's Ocean Service, National Centers for Coastal Ocean Science (NCCOS) at http://ccma.nos.noaa.gov/ecosystems/coralreef/vieques/data.aspx, and documented in Bauer, L.J., M.S. Kendall, A.G. Zitello, and T. Battista. 2010. Benthic Habitats of Vieques, Puerto Rico.

Figure 2-8
Non-Coral Biological Cover - East
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

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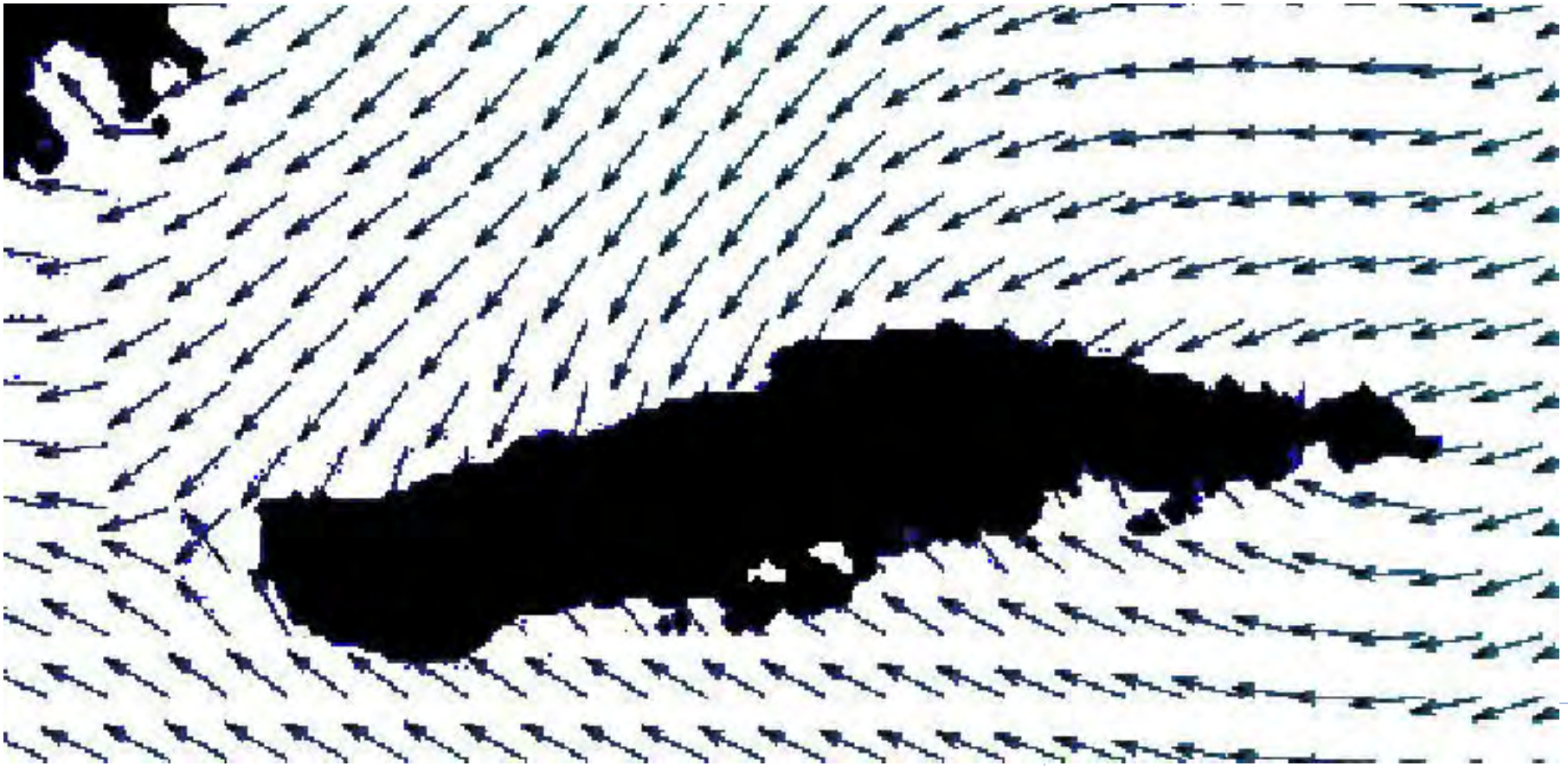

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0.7" Right Margin

(source: Caribbean Coastal Ocean Observing System [CariCOOS]).

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Figure Title - Calibri, initial caps, bold, 10/11
Figure Caption or Project Name - Calibri, initial caps, italics, 10/11

FIGURE 2-9
Wave Refraction Pattern Around Vieques for Easterly Waves
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

space = height of logo

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Will ALWAYS include the JETT number, Project Acronym and FileName.

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AA=Designer Initials
BB=Date example: 10.01.11

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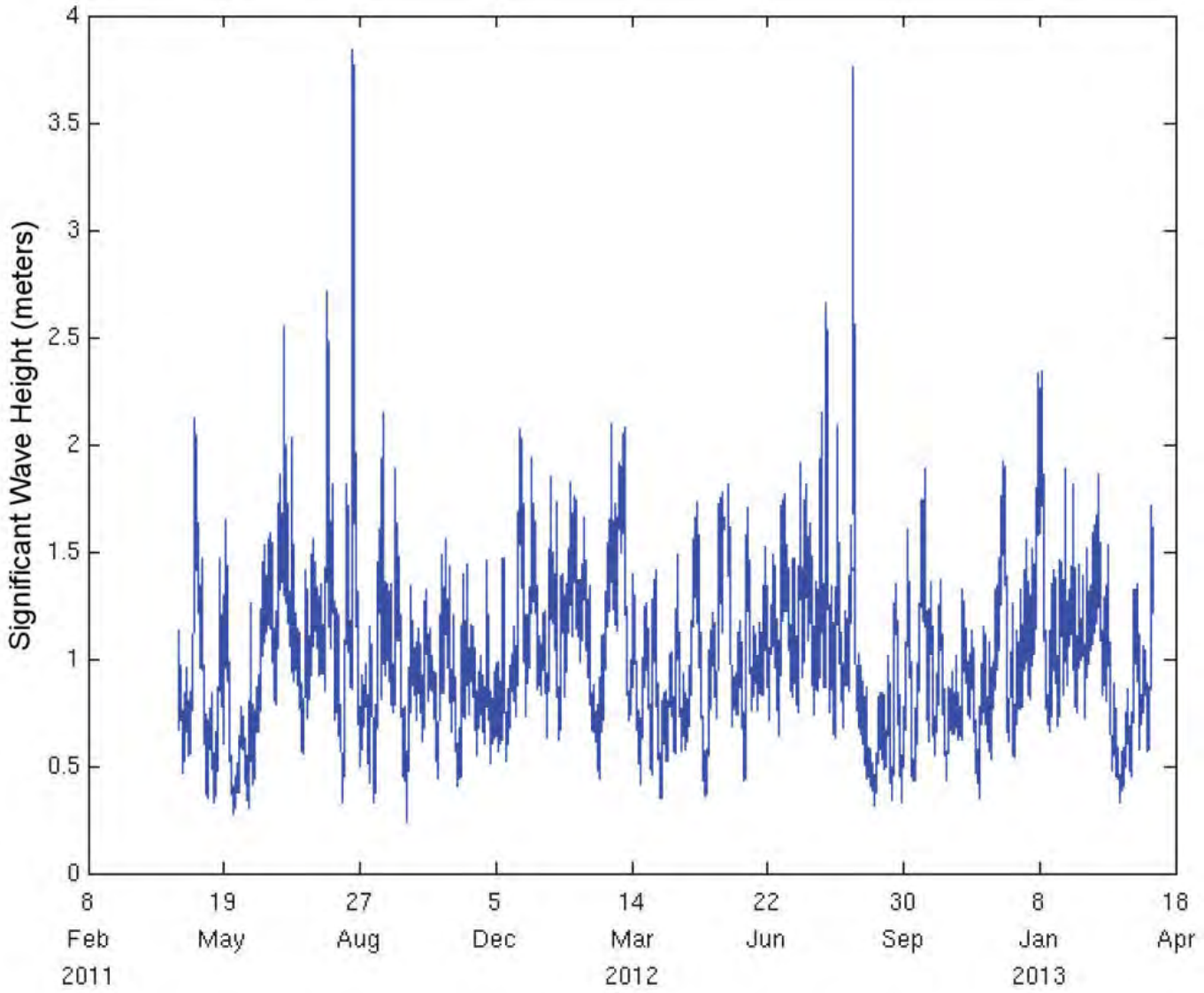

FIGURE 2-10
Typical Significant Wave Heights Offshore East of Vieques
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

Source: CariCOOS, accessed in March 2013

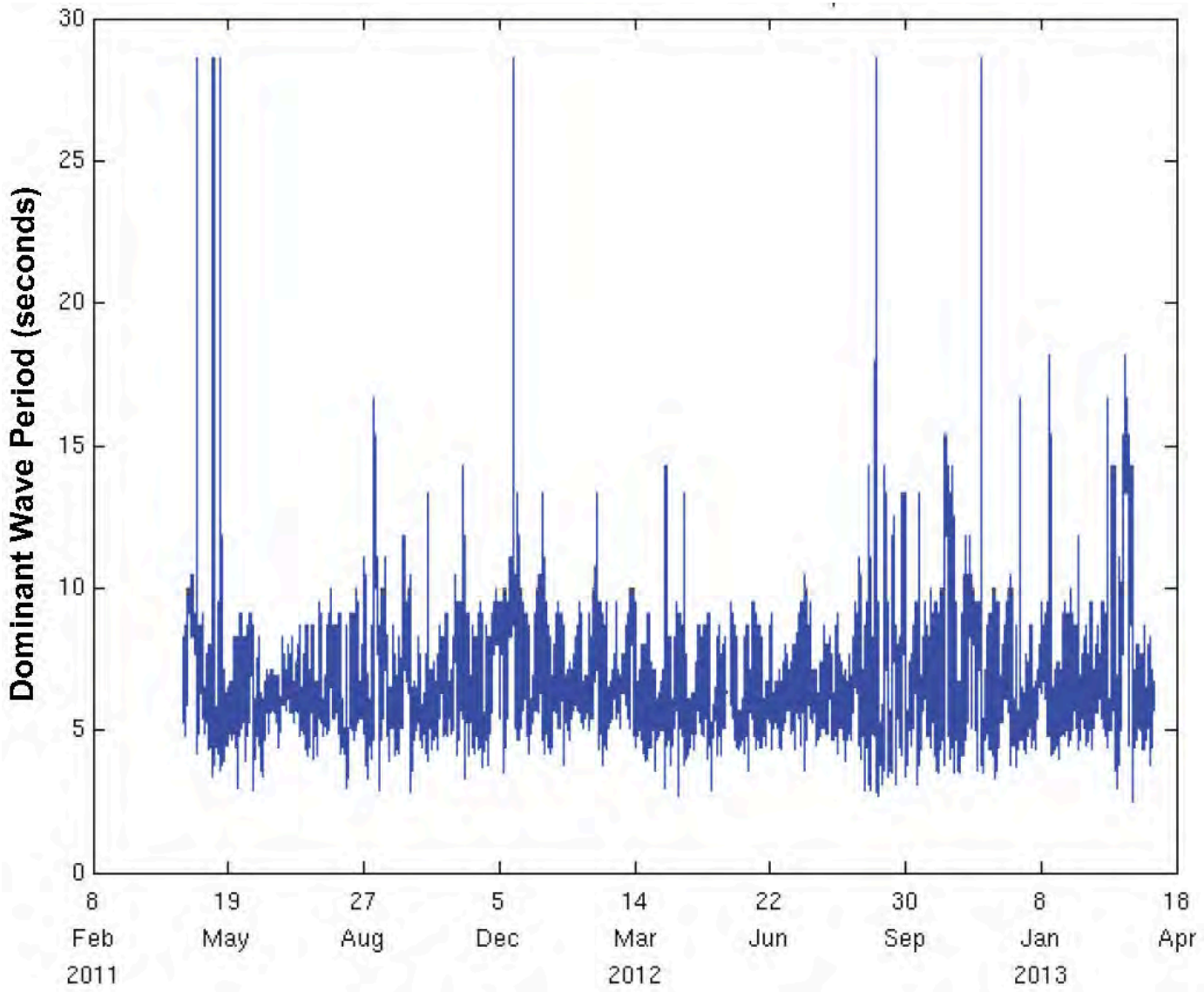

FIGURE 2-11
Typical Dominant Wave Periods Offshore East of Vieques
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

Source: CariCOOS, accessed in March 2013

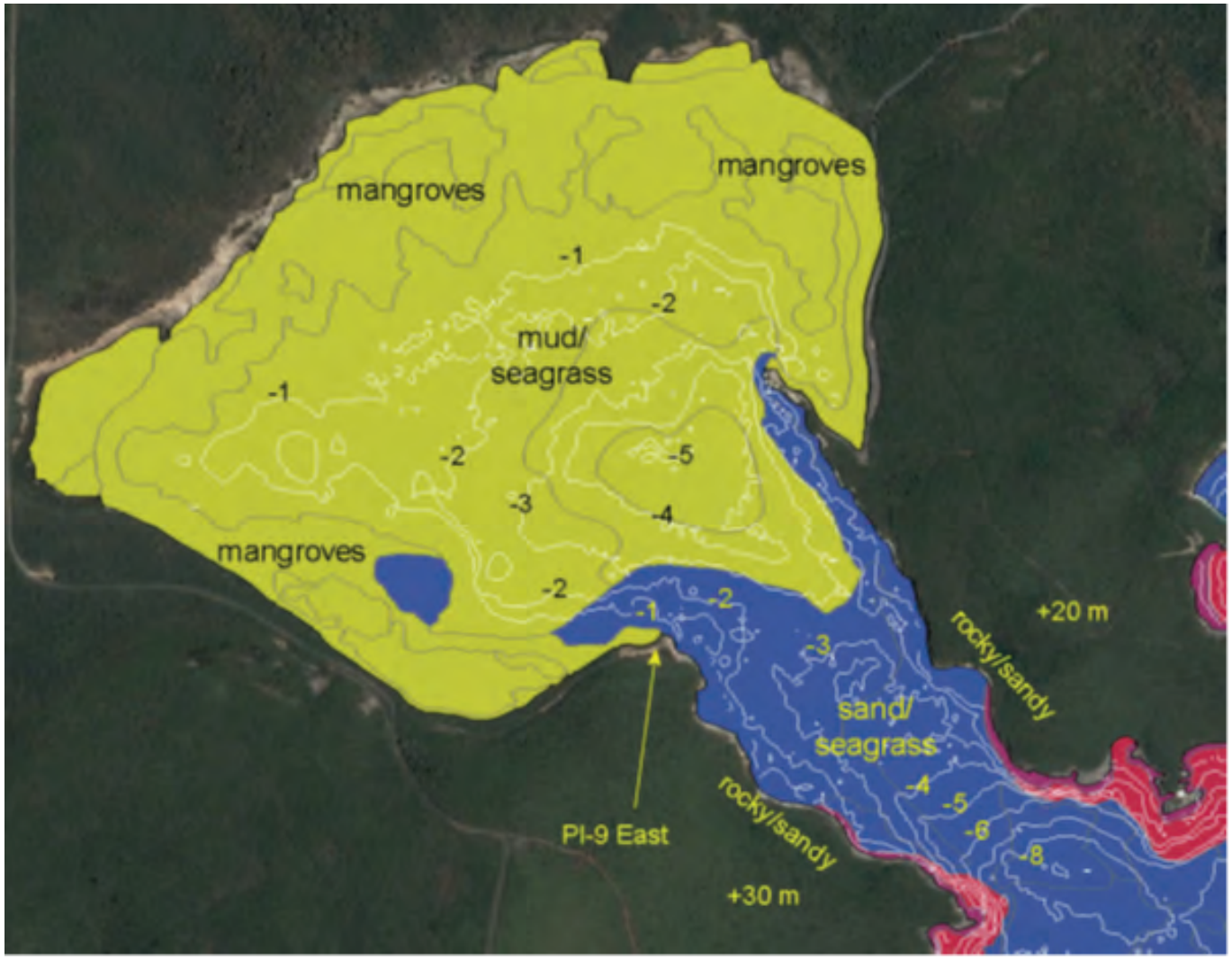

FIGURE 2-12
Puerto Ferro Bathymetry (m, MSL), Bottom Constituents, and Shoreline Characteristics
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

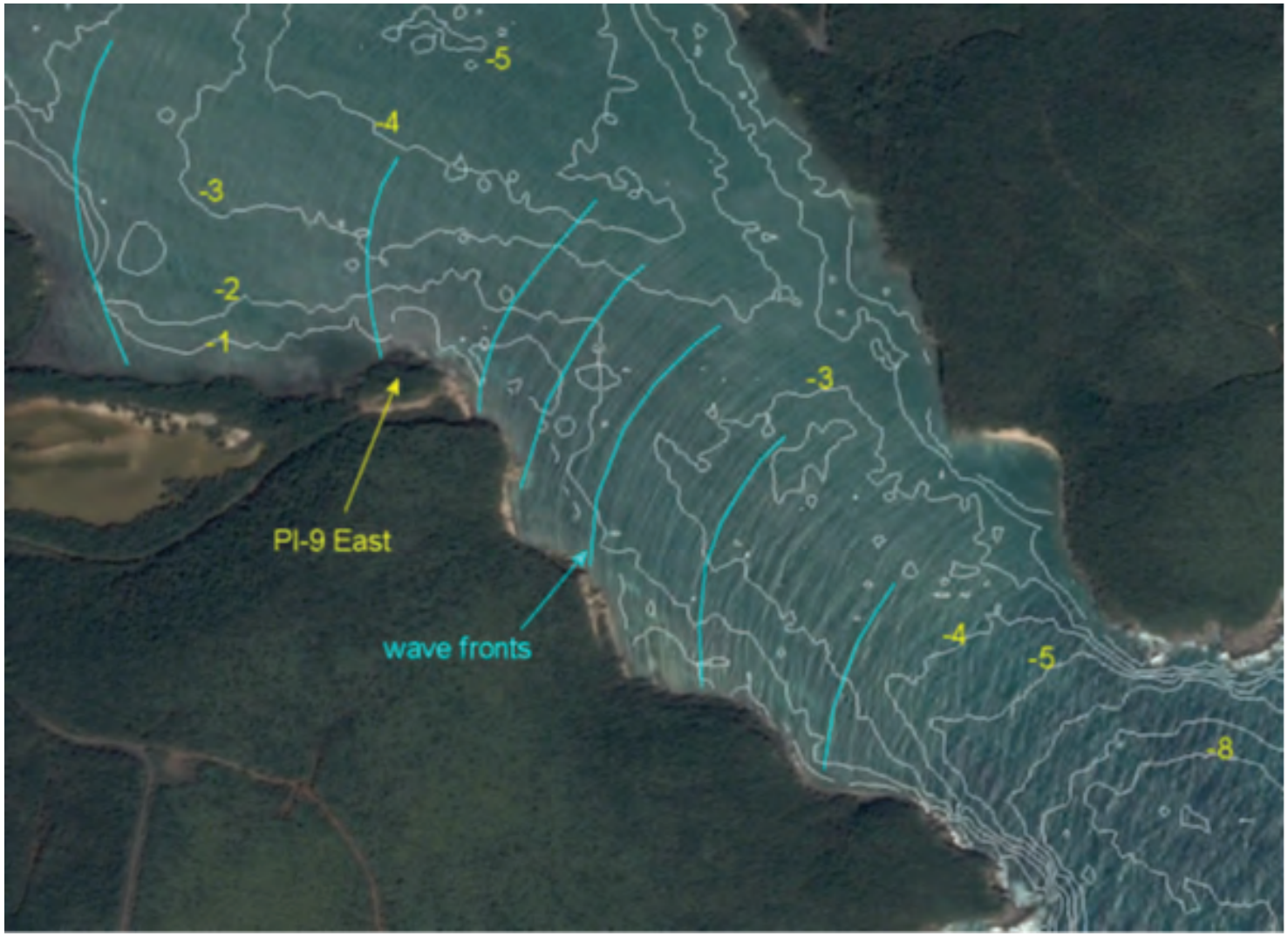

FIGURE 2-13
Puerto Ferro Bathymetry, Wave Fronts, and Refraction Patterns
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

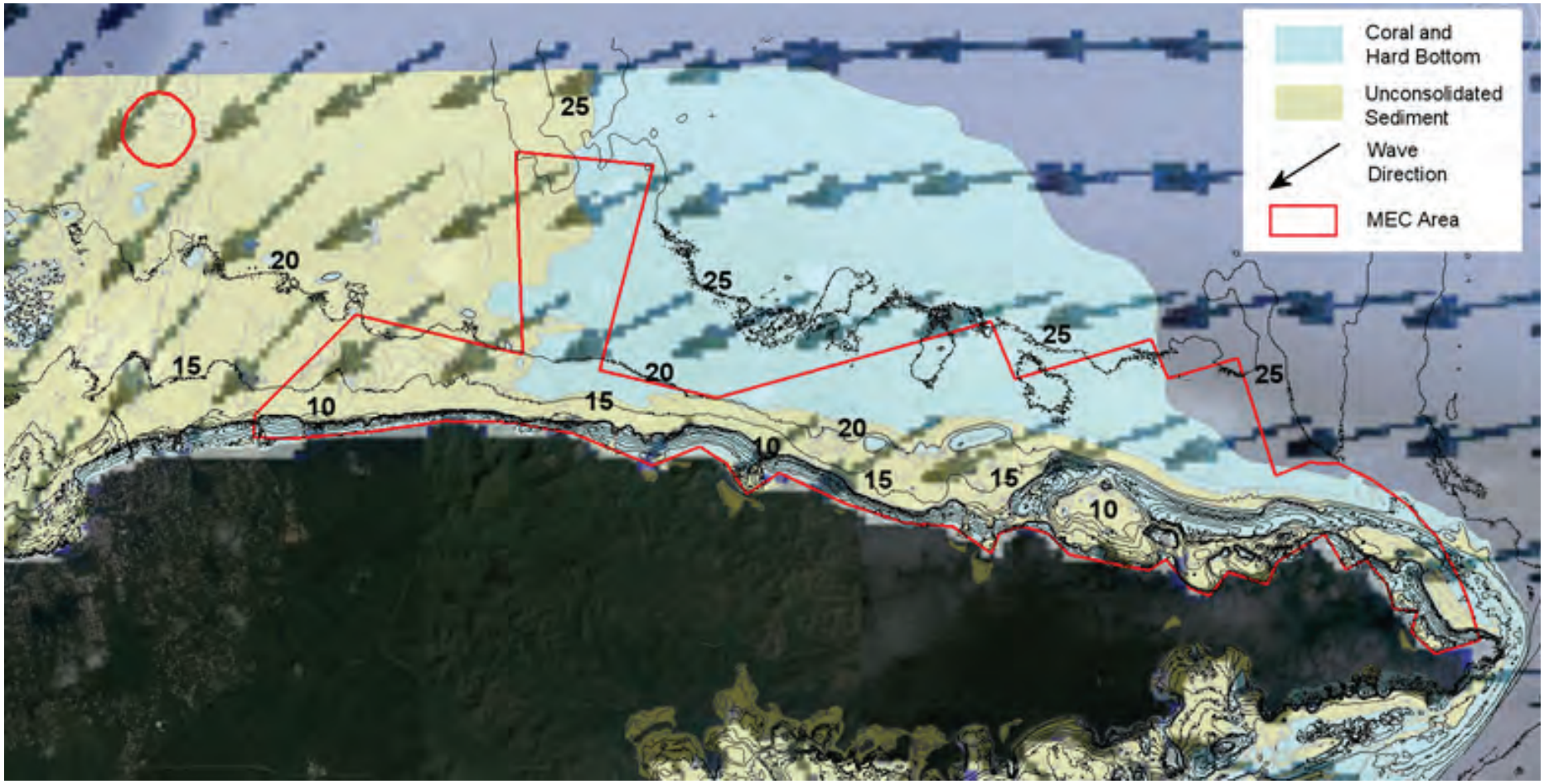

FIGURE 2-14
North Shore Bottom Characteristics, Typical Wave Directions, MEC Areas, and Bathymetry (m, MSL)
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

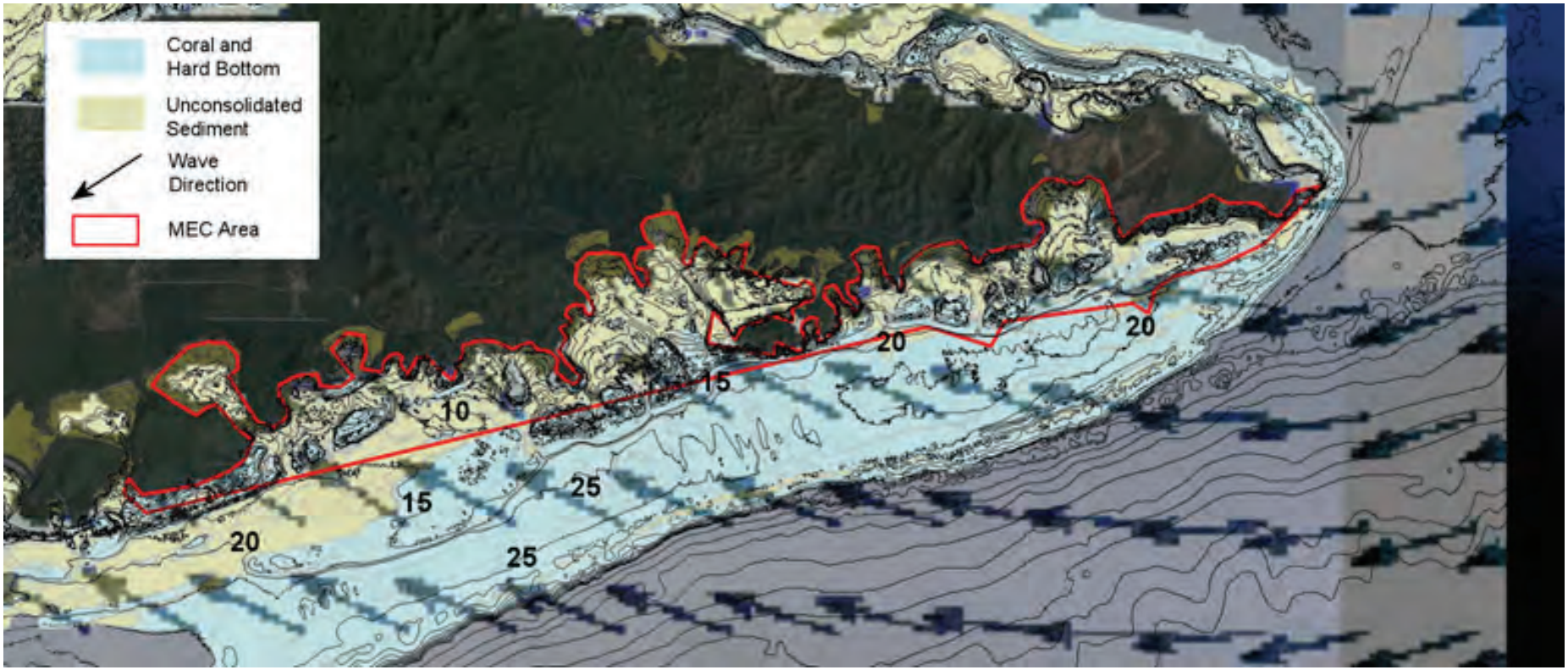

FIGURE 2-15
South Shore Bottom Characteristics, Typical Wave Directions, MEC Areas, and Bathymetry (m, MSL)
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

SECTION 3

Technical Approach

This section presents a description of the underwater WAA approach, including the technology planned, survey design, scope of work, and quality control.

3.1 Technology Description

Options available for underwater munitions detection include DGM arrays (Magnetometer or Electromagnetic Induction [EMI] sensors), visual surveys (using divers), and acoustic techniques (high-resolution acoustic imagery). For reasons explained in the following text, the technology selected for the WAA of UXO 16 is a towed array of magnetometers.

Visual surveys are precluded due to the fact that their effectiveness is limited to targets that are not buried beneath the sea floor. Commercially available acoustic systems are also limited to investigation of targets that are located on the surface of the sea floor. Very high-resolution acoustic technologies are not commercially available and are more expensive to deploy and interpret than magnetometer arrays. Although acoustic technologies are being developed to investigate the subsurface with appropriate resolution and automated interpretation algorithms to detect munitions, these are not yet commercially available, nor are they appropriate for large scale, WAA investigations such as the one to be performed for UXO 16. Visual surveys and/or acoustic techniques may be considered for future OU-specific investigations at UXO 16.

DGM surveys using terrestrial EMI sensors have been performed in the marine environment but, compared to magnetometer sensors, the efficacy of these sensors is more sensitive to the restrictions imposed by the standoff distance between the sensor and the seafloor. This is because the EMI response of a potential target of interest will decay with distance (d) at a rate of the $1/d^5$. The total magnetic field response, on the other hand, decays at a rate of $1/d^3$. The detection performance of the two technologies as a function of depth is presented as **Figure 3-1.** The noise assumptions for the data presented on this figure are consistent with terrestrial deployment (1 nanotesla [nT] for the magnetometer and 0.5 mV for the EMI sensor). While it is anticipated that the signal-to-noise ratio (SNR) performance will improve slightly in the marine environment, this improvement will occur with both systems, and the comparison between the systems remains valid. One of the challenges associated with performing DGM in the marine environment is controlling the altitude of the sensors over the sea floor – the deeper the water depth of investigation, the more difficult. Because the water depth of the investigation is as deep as approximately 80 feet (bathymetry data [Section 2.2.2] showed the maximum water depth within UXO 16 is 80 feet), use of total field magnetometry (i.e., DGM using total magnetic field sensors to map the localized distortions, or anomalies, in the Earth's magnetic field caused by discrete ferrous objects) is selected to minimize the impact of the sensor altitude. Towed magnetometer arrays have been deployed previously in UXO 16 and have shown to be effective at detecting individual targets and delineating EADAs. In addition, magnetometers are appropriate for detecting ferrous (iron/steel) metal; the vast majority of munitions used on Vieques were constructed with ferrous metal.

Total magnetic field surveys designed to map geologic structures typically have to be corrected for diurnal geomagnetic activity. In this application, the periodicity (i.e., time footprint) of the anomalous response to a target of interest (TOI) is much lower (1 second) than the periodicity of geomagnetic activity. The total magnetic field signal due to diurnal magnetic activity is removed using a de-median filter that removes all signals of a higher periodicity (lower frequency) than the TOI. The proposed method (DGM using a magnetometer array) has been used successfully for the past decade in terrestrial, airborne, and marine application without being adversely affected by diurnal magnetic activity.

There are a limited number of commercially available marine towed array systems available. All of these systems use similar total magnetic field sensors, but they differ with respect to the number of sensors, navigation control (including survey altitude), and positioning accuracy. Furthermore, the capabilities of the system vendors vary

with respect to open ocean survey experience, deployment vessel characteristics, and anomaly analysis sophistication. The following descriptions describe the technology from a generic standpoint. Details regarding final array geometry and positioning methodology that are specific to the commercial provider will be determined once a subcontractor is identified. The information will then be provided to the agencies.

The survey vessel used will be suitable for the survey task with respect to the expected ocean conditions.

3.2 Total Magnetic Field Sensors

Cesium Vapor magnetometers are designed to precisely measure the magnitude of the Earth's magnetic field. The magnitude of the Earth's field is distorted in proximity to discrete ferrous objects such as munitions items. A magnetometer survey maps these localized distortions (anomalies) and evaluation of the nature of these anomalies provides an indication of the size and location of ferrous objects on or buried under the sea floor.

An array of four to eight magnetometers will be deployed in a towed platform so that a broad swath (up to 19 feet [6 meters] depending upon the system geometry) can be surveyed for each single transect. This swath width is dependent upon the width of the array and does not vary with altitude. In addition to the obvious advantage of expanded coverage, the array also provides a rich and precisely positioned data set that will support analysis of individual targets.

3.3 Positioning/Navigation

Positioning of the sensor data is achieved by a combination of GPS technology coupled with ancillary systems used to translate the GPS antenna position to the sensors. In shallow water, systems using combinations of tow angle sensors, depth sensors and vessel/platform attitude sensors have been shown to provide better than 0.5 meter accuracy. Positioning of the data gets more challenging in deeper water (greater than 49 feet [15 meters]) because this method relies on precise measurement of the tow cable angle, depth, and catenary. As a result, positioning technologies, such as ultra-short baseline (USBL) acoustic tracking systems, are used to provide sub-meter sensor position accuracies. Schematics of the two methods are shown on **Figure 3-2**. The top figure depicts a system positioned using USBL and the bottom figures show a side view (left) and plan view (right) of the geometry involved using combinations of tow angle sensors, depth sensors and vessel/platform attitude sensors. It is anticipated that the USBL system would be used at depths greater than approximately 32 to 50 feet (10 to 15 meters), although this determination is dependent upon the subcontractor-specific equipment and will be made during field activities.

Horizontal navigation of the sensor array is performed using commercially available GPS based navigation systems. Vertical navigation, required to maintain the sensor altitude above the sea floor, can be achieved manually or automatically, using elevators mounted to the sensor platform, or using a winch to modify system depth. Examples of two of these systems are provided in **Figure 3-3**. The system on the left uses a combination of winches and floats to control the altitude. The system on the right uses autopilot controlled actuators to control platform altitude and attitude. Both manual and autopilot controlled approaches require continuous control to maintain optimal survey altitude. Regardless of the vertical navigation methodology, survey altitude will be maintained in accordance with the Measurement Performance Criteria (MPC) presented **Table 3-4** (Section 3.8).

Survey speeds will be nominally between two and four knots – the equivalent of 3 to 6.5 feet per second (1 to 2 meters per second [m/s]). At a 10 Hz sample rate this corresponds to samples every 0.3 to 0.6 feet (0.1 to 0.2 meters). The final combination of sample rate and survey speed will require that sample intervals do not exceed 1 foot (0.3 meters).

3.4 Ancillary Sensors

Attitude measurement of the vessel and towed platform are used with GPS and system geometry to derive the sensor positions.

Acoustic altimeters mounted on the survey vessel as well as the towed platform, and depth sensors mounted on the platform, are used as input for navigation as well as to verify the usability of the collected data with respect to standoff distance.

A marine video system will be used to collect video imagery of the sea floor. This imagery will serve a variety of uses including providing an opportunity to visually investigate and identify targets that are located on the surface of the sea floor, and provide information about the benthic habitat in the survey area. The imagery will be georeferenced and/or time stamped to facilitate mapping of identified features. Because a subcontractor and system has not yet been procured, the procedures will be provided in a Standard Operating Procedure (SOP) to be added to the Work Plan prior to finalization.

3.5 Data Processing and Analysis

Data processing/analysis is performed using a geophysical processing environment, such as Geosoft Oasis Montaj. The processing involves importing the data, positioning the geophysical measurements, removing the unwanted signal from these measurements, and mapping the results. The analysis of the geophysical data involves target selection to identify locations of discrete ferrous objects, dipole fit analysis of individual targets to extract information about the likely source of these targets, and target density distribution analysis to delineate EADAs that may require future investigation.

3.5.1 Data Processing

The raw total magnetic field data (measurements between 20,000 and 70,000 nT) are transcribed into the database and are time aligned and merged with the positioning data. System geometry, vessel and platform attitude, and ancillary sensor measurements (angle encoders and/or USBL data) are used to translate the GPS antenna coordinates to each geophysical sensor measurement. A set of site-specific filters are used to isolate the target responses by removing unwanted 'background' signal (geology, diurnal variations and sensor heading effects) resulting in a 'leveled' data set where the data are essentially at 'zero' unless there is an anomalous response due to a proximal ferrous object. These results are interpolated to a regularly sampled grid covering the survey area using Geosoft's standard gridding software. The interpolations are limited to the effective horizontal range of the sensors (nominally 1 to 2 meters, depending on the size of source objects). The resolution of the regularly sampled grid will be 0.5m – measurements falling within a grid cell will be averaged to provide a value for that grid cell. Grid cells with no measurements will be assigned null values. The final distribution of grid cells populated with values will depend upon the final system geometry and sample rate.

Total magnetic field surveys designed to map geologic structures typically have to be corrected for diurnal geomagnetic activity. In this application, the periodicity (i.e., time footprint) of the anomalous response to a TOI is much lower (1 second) than the periodicity of geomagnetic activity. The total magnetic field signal due to diurnal magnetic activity is removed using a de-median filter that removes all signals of a higher periodicity (lower frequency) than the TOI. The proposed method (DGM using a magnetometer array) has been used successfully for the past decade in terrestrial, airborne, and marine application without being adversely affected by diurnal magnetic activity.

3.5.2 Data Analysis

The total magnetic field response to a discrete ferrous object is dipolar in nature. Depending upon the orientation of the object, the response can be positive, negative, or most prevalently, a combination of the two. Additionally, the peaks of the positive and negative responses are spatially offset from the position of the source object. To simplify the target selection process, the total magnetic field response is used to derive the analytic signal (the square root of the sum of the total magnetic field gradients). Analytic signal has the advantage of being unipolar with the peak response located over the source of the anomaly. In other words, the analytic signal will be used to locate the anomalies instead of utilizing the positive and negative responses due to the spatial offset. By utilizing analytic signal, the location of each object will be accurately identified.

Target selection is achieved by running an automatic 'peak detection' routine on the mapped analytic signal data. The target list is inspected by the geophysicist and deletions/additions are made to account for multiple selections on a single target as well as missed targets that may be slightly under the threshold used for the peak detection routine.

The spatial distribution of all of the detected anomalies will be examined to identify EADAs and thus potential OUs requiring detailed investigations. This process will involve deriving density distribution maps (i.e., maps of anomalies/acre) and using Visual Sample Plan (VSP) to identify EADAs within the survey region. The appropriate VSP parameters used for this investigation will be based in part on the character of the anomaly density data. Background anomaly density will be derived from the survey data and, based upon this and the line spacing used, the supporting statistical basis for conclusions drawn from the survey results will be provided. For example, for a given minimum size and shape (e.g., 250 meter diameter circle) these data will allow determination of what density above background can be claimed to have been detected with close to 100 percent probability. Conversely, for a given anomaly density elevation above the background, the minimum size of area that was detected can be determined with close to 100 percent probability. The VSP report is provided in **Appendix C**.

In an effort to further characterize the population of anomalies and/or populations of EADAs, each selected target will be subjected to a 'dipole fit' analysis routine whereby seven parameters describing a dipole model are iteratively modified to find the model response that best fits the observed responses. These parameters include extrinsic parameters of target location (x,y,z) and orientation (pitch, roll, and yaw) as well as the intrinsic parameter of dipole size. While the dipole size parameter is intrinsic to the target, this value is non-unique for a given target because it will vary depending upon the orientation of the object relative to the Earth's magnetic field. For this reason, the dipole size estimate can only be used as a coarse classifier to characterize anomaly sources as small, medium, or large. Due to the range in size of TOI (up to MK83 1,000 lb bombs) the size estimates will not be used to exclude anomalies from the anomaly density analysis, but the dipole analysis results may prove instructive to help characterize the populations of the identified EADAs. For each identified EADA, the relative proportion of small, medium, and large anomaly sources, as well as the average estimated burial depth of these sources will be used to plan any potential follow on investigations.

3.6 Survey Design

The WAA for UXO 16 is the first step in a phased, iterative approach. The results of the WAA will be used to guide the planning for the next phase. WAA surveys are designed to look for EADAs, indicating a possible concentration of targets of interest as well as to provide general background density information that can be used to inform the planning process for future investigations. As outlined above, the WAA survey results will be used to identify and delineate EADAs for future investigation activities, which may include 100 percent DGM coverage, high resolution acoustic surveys, and visual diver inspections of focus areas. The water depths where the survey will occur range from several feet to approximately 80 feet, the deepest depth within the UXO 16 boundary. Due to practical limitations of equipment access and the need to maintain the array off the seafloor to avoid contacting potential munitions, ESA-listed coral species, and other obstructions, it may not be possible to survey all areas. Additional detail is provided in the remainder of this subsection.

A helicopter borne magnetometer array survey conducted in 2009 identified a number of EADAs in the shallow, near shore areas of UXO 16. The smallest of these EADAs is approximately 820 ft x 820 ft (250 m x 250 m). VSP was used to confirm that, using a minimum swath width of 13 ft (4 m), 330 ft (100 m) line spacing would detect all 250 m diameter (125 m radius) areas with an elevated anomaly density of 25 targets/acre above a background of five targets per acre (**Figure 3-4**). Without prior knowledge of the target densities, these initial estimates were used to create a conservative line spacing. It is important to note that these estimates are not actionable thresholds and will not be used as a basis for identification of elevated anomaly density areas – they are only used as starting estimates for the sole purpose of deriving a conservative line spacing. Also, although a 'bivariate' density distribution was used, a normal distribution was found to give essentially the same results (Pd = 1.00 vs .993 respectively). The actual shape of an EADA is not predictable due to the myriad of factors

affecting the final resting positions of TOI. However, the actual shape of an EADA does not need to be circular for the statistics obtained with a circular assumption to be valid. The circle is just used to estimate the smallest dimension of an EADA. By using a 250 m circle as the input, the implication is that 250 m is the minimum size in any direction that will be detected with a probability of close to 100 percent (i.e. any area that has a minimum dimension of 250 m or greater will be detected). Assuming the final array geometry provides a 13 ft to 20 ft (4 m to 6 m) swath width (the final array configuration will depend upon the subcontractor selected), the 328 ft (100 m) line spacing will result in four to six percent coverage of the survey area. The resolution of the geophysical survey data (both marine and airborne) is sufficiently small to be a non-factor in the identification of EADAs. The 'resolution' of the helicopter magnetometer surveys was 0.5 m – less than one percent of the size of the EADAs. The resolution of the marine surveys will be the same order of magnitude as the airborne data.

Given that there is not prior knowledge of the background anomaly densities across the site, the VSP analysis provided above is appropriate as a starting point but is not conclusive with respect to EADA detection performance, nor is that necessary. The VSP analysis as presented uses fixed background anomaly density, EADA target density threshold and minimum EADA dimension values to produce a suggested line spacing as a function of detection probability (Pd). A post hoc analysis (using VSP) of the survey results will be performed to determine what conclusions the data will support with respect to minimum dimension of detectable EADAs as a function of EADA density threshold. This will be done by using the 100 meter line spacing, 100 percent Pd, and measured background anomaly levels as fixed values to determine the minimum EADA dimension as a function of EADA anomaly density threshold.

In addition to the areas of clustered munitions due to firing activities, the Vieques conceptual site model also includes three anchorage areas where DMM may have fallen off a ship (note, Mosquito Pier is not included in the WAA). While it is possible the line spacing derived from VSP for these areas may not be appropriate for finding DMM (unless the numbers and distribution of DMM are sufficient to result in an elevated anomaly density footprint greater than 250 meter diameter), because there is not knowledge regarding the expected anomaly densities in these areas and they total over 400 acres in size, the survey as planned will provide the background information required to design a statistically valid, focused investigation for these areas.

Due to the suspected presence of munitions as well as sensitive benthic habitats, the DGM system will not intentionally make contact with the sea floor. In 2013, an SSS survey was performed to identify obstacles and sensitive corals that the DGM survey must avoid (**Figure 1-6** and **Appendix A**). The nominal line spacing of 330 feet (100 meters) will be modified as required to avoid items identified from this survey. **Figures 3-5** and **3-6** present the conceptual survey design and transect spacing for the UXO 16 WAA. The subcontractor will utilize the previously collected SSS data to identify obstacles and sensitive habitats when establishing transects and programming, as applicable, into the vessel navigation system prior to commencing the survey. Any area without SSS coverage will not be surveyed by the DGM system. Additionally, procedures for protection of federally listed species and habitat are detailed in **Appendix E**.

Gaps in coverage due to obstacle/sensitive habitat avoidance will be unavoidable. Additionally, real-world conditions such as currents, wind, and wave action will results in some deviation of the array from its intended transect. Significant gaps in coverage (defined as gaps between lines greater than 410 feet [125 meters] for distances of 1640 feet [500 meters]) will be re-collected unless they were incurred for obstacle/sensitive habitat/wildlife avoidance. Due to the conservative line spacing, gaps up to this size will have a minimal effect on the usability of the survey data to detect EADAs. Gaps greater than this size that are unavoidable will be identified and their effect on the survey results will be discussed in the final report.

The proposed technology will detect targets buried in the sediment as well as on the seafloor. Detection performance is a function of the sensor to target separation distance and is degraded as this distance increases. Control of survey altitude becomes more challenging at greater depths, and limitations on acceptable altitudes are a trade-off between detection performance and the requirement to avoid contact with the sea floor. Depending upon the aspect ratio of the object, its orientation with respect to the Earth's magnetic field will have a large effect on the magnitude of the total magnetic field response. Where a sphere will produce a response

that does not vary with orientation of the Earth's field, an object like a 37 mm projectile will produce a maximum response (oriented parallel the Earth's field) that is more than double its minimum response (oriented normal to the Earth's field). **Figure 3-7** presents the minimum expected total magnetic field response as a function of sensor offset distance. With an assumed detection threshold of 0.5 nT, small targets lying on the surface of the seafloor can be detected at survey altitudes up to 1.5 meters and medium targets on the seafloor will be detected at altitudes approaching three meters. This detection threshold assumes system and site-specific noise levels of 0.1 nT (a reasonable assumption given the sensor noise levels are below 0.001 nT).

The survey will be conducted with the array as close to the sea floor as possible, without contacting the sea floor. The sensor altitudes will be nominally between 3.3 feet (1 meter) and 6.6 feet (2 meters). The altitude will be maintained as close to one meter as possible (maintaining an exact altitude is not possible). At 3.3 foot (1 meter) altitude, targets as small as 37 mm projectiles on the sediment surface should be reliably detected. However at 6.6 foot (2 meter) altitude, objects less than the size of 60 mm mortars on the sediment surface will not be reliably detected. Because the WAA is intended to identify EADAs, the reliable detection of small ordnance classes is not critical to the success of the survey. Although detection performance will vary with altitude, the altitude variations typically occur over much smaller spatial scales than the >250 meter diameter EADAs being targeted and are assumed to be uncorrelated with the density distribution of ferrous material (this has been the case for many helicopter-borne, terrestrial surveys that have similar altitude challenges). A qualitative review of survey altitude versus density will be performed to ensure that there were no artificial density lows or highs caused by altitude variations. Once the density results are correlated with altitude, dipole size estimates will be used to exclude targets that may be undetectable at higher altitudes. The survey altitude data and its effect on detection performance will be evaluated during the data analysis.

3.7 Definable Features of Work

A definable feature of work (DFOW) is a project task that is separate and distinct from other tasks and has control requirements and project team requirements unique to that task. The DFOWs for the WAA include pre-survey activities, DGM data collection, DGM data processing and analysis, and reporting of the survey activities and results. **Table 3-1** describes and summarizes the DFOW and associated activities.

TABLE 3-1
DFOW and Associated Activities

DFOW	Activities
Pre-mobilization Activities	Survey planning including logistics, mobilization, survey planning documents (site specific WPs, standard operating procedures, safety plans), and coordination with local infrastructure, as needed.
Mobilization/Site Preparation	Mobilization of personnel and equipment to the site and preparation activities.
DGM Survey	Instrument Verification Strip [IVS] surveys, daily quality control (QC) checks, data collection including geophysical data, video imaging, and ancillary data.
DGM Data Evaluation and Documentation	Positioning and filtering the geophysical data, target selection, discrete target analysis, density distribution analysis, video review.
Demobilization	Demobilization of personnel and equipment from the site.
Reporting	Documentation of all data collection, QC, data processing/analysis activities.
	Discussion and summary of the survey results.
	Delivery of data archives.

3.7.1 Pre-mobilization Activities

Before mobilization to the site occurs, all appropriate subcontractors will be procured. All subcontractors will provide qualifications, certifications, license, and the SOPs for underwater DGM for review and inclusion in this WP. DGM survey personnel will have reviewed data from SSS surveys conducted prior to the start of DGM as well as other available information that may be useful in the safe operation of the DGM instrument. Appropriate site-specific training, including health and safety (H&S) review of site activities, emergency response, and communication, will be conducted before the start of work. Additionally, a morning safety meeting will be conducted each day to review the tasks to be performed that day as well as any potential hazards.

The survey vessel will be operated by personnel familiar with the safe operation of the vessel in open water. Nautical charts will also be reviewed to locate potential navigational hazards that may be encountered during the survey. Anchoring within the prohibited/danger areas is not permitted unless otherwise approved by NOSSA prior to site activities.

All equipment will be inspected upon arrival at the site, tested for functionality, and repaired or replaced as necessary for quality performance. Equipment inspections will also be performed daily throughout the project to ensure proper functionality and to prevent damage. Good housekeeping procedures will be followed to further reduce the risk of equipment damage.

The CH2M HILL field team leader (FTL) will ensure that onsite communications (such as mobile phones and two-way radios) have been established between team members.

3.7.2 Mobilization/Site Preparation

A mobilization period will include mobilizing staff and securing and deploying equipment. Mobilization activities will include general activities and a kickoff and safety meeting.

Mobilization

General Activities

The general activities to be performed as part of mobilization include the following:

- Identify/procure, package, ship, and inventory project equipment
- Coordinate with local agencies, including police, hospital, and fire department, as appropriate
- Coordinate communications with logistical support
- Finalize operating schedules
- Assemble and transport the work force
- Conduct site-specific training on the WP procedures and hazards
- Verify that all forms and project documentation are in order and CH2M HILL team members understand their responsibilities with regard to completion of project reporting requirements

Kickoff/Safety Meeting

During mobilization, a kickoff and site safety meeting will be conducted. This meeting will include a review of this WP and review and acknowledgment of the Health and Safety Plan by all site personnel. Additional meetings will occur as needed, as new personnel, visitors, and/or subcontractors arrive at the site.

Control Points Survey

A professional land surveyor (PLS) will locate/establish at least two control points for use during the project. A local benchmark will be used as survey control for establishing the additional control points in locations convenient to the survey operations (to be determined in conjunction with the subcontractor selected to perform the DGM surveys).

3.7.3 DGM Survey

After site setup activities and prior to commencement of data collection activities, initial testing of the system to validate proper function will be performed. These tests will verify that all of the system components are operating properly and will include function tests of each magnetometer, static position accuracy tests for the GPS, and a test run over a modified IVS to ensure that the system as a whole is functioning properly.

Establishment of an IVS in the marine environment poses many challenges. The costs of emplacing targets, mobility of emplaced targets and time required to get to and from the IVS are all challenges that are not typically encountered on land-based projects. For the purposes of the WAA a modified approach to the initial and daily IVS surveys will be required. Where practical, existing submerged targets (with independently known positions) may be used as a single target IVS. If required one or more targets may be emplaced in convenient locations to act as a single or multi target IVSs.

Prior to deployment initial function tests will be performed on all magnetometers to ensure that they are responding properly and the array configuration is properly labeled (e.g. 'sensor 1' data exhibits a response when the sensor in 'sensor 1' location is challenged with a source). The physics governing the operation of cesium vapor magnetometers is such that these sensors do not require calibration (there is no 'gain' adjustment). Obtaining responses in the 20,000 to 70,000 nT range that vary when the sensor is challenged with a ferrous object is sufficient to show that the sensor itself is operational.

Static testing of the GPS against a known position will be used to verify that the GPS is set up properly.

The initial IVS survey will be used to verify the capability of the system to detect and accurately locate a ferrous object. This IVS test will be comprised of a number of passes over the intended object in opposing directions so that both the accuracy and precision of the target location capabilities may be assessed. At this point any measurement latency corrections will be identified. Daily IVS surveys will be used to monitor and verify the precision of the system target location performance.

After site setup activities have been completed, the DGM survey will be performed along transects at a nominal 330 foot (100 meter) line spacing across UXO 16. The transect spacing will be modified such that obstructions, sensitive benthic features, and other targets identified from the SSS are avoided for protection of the sensitive environment, vessel, and DGM equipment and in areas that can be completed safely. In addition, the DGM system will not be permitted to intentionally encounter the sea floor because of the possible presence of environmentally sensitive habitat and underwater munitions within the survey area. The investigation area location is approximate and the boundaries are subject to adjustment based on field conditions in order to accommodate unanticipated site conditions, support data collection, and improve productivity and efficiency. The survey is not anticipated to be conducted in water depths shallower than four to six feet. As with the SSS survey, the nearshore areas will not be accessible due to the WAA equipment configuration. Investigation of nearshore areas will be evaluated for future investigations.

The instrument footprint along each transect will have a minimum swath width of 13 feet (4 meters). Efforts will be made to maintain approximately straight, evenly spaced transects (consistent with the MPCs presented in **Table 3-4)** to the extent that the ocean conditions permit. It is important to note that the study objectives can be met even if transects are not straight and evenly spaced. The final spacing and orientation of the transects will be presented in the WAA report and any potential impact on the study objectives will be discussed.

Video imaging of the sea floor will be collected with sufficient resolution and clarity (when/where sea conditions allow) to identify potential anomaly sources located on the surface of the sea floor as well as characterize the benthic environment. Underwater obstructions and hazards may make data collection in certain areas impossible or impractical and present safety issues to those conducting the investigation; these locations will be noted by the field team.

The field team, which will consist of a CH2M HILL FTL and subcontractors will collect the DGM data. Raw data will be provided to CH2M HILL from the subcontractor on a daily basis. All geophysical data will be accompanied

by a field data sheet documenting the field activities associated with the data and the processing performed. An example field data sheet is provided in **Table 3-2**.

Performance functionality QC testing will be conducted for all geophysical equipment on a daily basis to ensure detection capabilities. The QC tests will include repeatability tests, standard response tests, background noise level evaluation, and positioning evaluation. Because a subcontractor and system has not yet been procured, QC testing and reporting procedures will be provided in a SOP to be added to the Work Plan prior to finalization. Data obtained from the survey and field logbooks will be available for QC. The QC review of the field logbooks will allow the reviewer to verify that equipment functionality tests are being conducted at least once a day and that other details pertaining to the investigation have been recorded. Quality control data to be collected are summarized in Section 3.8.

TABLE 3-2
Example DGM Field Data Sheet

Site identification
Grid identification (or other identifier of surveyed area)
FTL name
Field team members' names
Date of data collection
Instrument used
Positioning method used
Instrument serial numbers
File names in data recorders
Data collection sampling rate
Line numbers, survey direction, fiducial locations, start and end points
Weather conditions
Grid conditions (if applicable)
Survey area sketch (if applicable)
Associated base station data file names (magnetometer)
Associated QC data file names
Field notes (other)

3.7.4 DGM Data Evaluation and Documentation

On a daily basis, the DGM subcontractor will provide each day's data for QC inspection. Such data are considered to be in raw form. These data will be corrected for sensor offsets, and latency. The sensor offsets are a fixed value dependent on the system geometry. Latency is a term that refers to the difference between the time of applicability of the geophysical data and that of the positioning data. This time adjustment is relatively small (0.1 to 0.2 seconds) and is determined by comparing the initial IVS data collected on reciprocal headings. The latency correction will be equal to half of the measured offset (in time) between the anomaly peaks over the IVS target(s).

Also provided will be a digital planimetric map, in Geosoft format and coincident with the location of the geophysical survey, so that each day's geophysical data set can be registered within the original mission plan survey map. Geophysical field data will be provided in delineated fields as x, y, z, d, v1, v2, and so on, where x and y are the North American Datum (NAD) 83 (1986), Universal Transverse Mercator (UTM) Zone 20 north (meters) in Easting and Northing directions, z (altimeter reading), d (depth sensor reading), and v1, v2, and so on as the geophysical response readings. The last data field will be a time stamp. Each data field will be separated by a comma or tab. Each file containing data will be logically and sequentially named so that the file name can be easily correlated with the area surveyed. Information to be provided is summarized in **Table 3-3**.

Once QC inspection of all geophysical data has been performed, the data will be evaluated to determine the potential presence of EADAs that may represent areas impacted by munitions and to determine the relative density distribution across and between each EADA. The data will be reviewed by munitions-experienced data processing geophysicists. The geophysicists will use the following criteria for selecting anomalies:

- Maximum amplitude of the response with respect to local background conditions
- Lateral extent (plan size) of the area of response
- Shape of the response
- Location of the response with respect to the edge of the transects, unsurveyable areas, and underwater areas

Instrument-specific software will be used for initial data processing and the output will be imported into Geosoft Oasis Montaj for additional processing, graphical display, anomaly selections, and Quality Assurance (QA)/QC. Types of processing will be system-specific, but the general processing steps that may be performed to ensure quality data include the following:

- Positional offset correction
- Sensor bias, background leveling, and/or standardization adjustment
- Latency or lag correction
- Geophysical noise identification and removal
- Contour level selection with background shading
- Digital filtering and enhancement (such as low pass, high pass, band pass, convolution, correlation, and non-linear)

TABLE 3-3
DGM Data Processing Documentation Requirements

Information Type	Raw/Pre-processed Data Delivery	Final Data Delivery	Will be in File Headers
Site identification	X	X	X
Geophysical instrument type used	X	X	X*
Positioning method used	X	X	X*
Instrument serial numbers (geophysical and positioning)	X	X	
Coordinate system and unit of measure	X	X	X*
Grid identification (or other identifier of surveyed area)	X	X	X
Date of data collection	X	X	X
Raw data file names associated with delivery	X	X	X*

TABLE 3-3
DGM Data Processing Documentation Requirements

Information Type	Raw/Pre-processed Data Delivery	Final Data Delivery	Will be in File Headers
Processed data file names associated with delivery	X	X	X*
Name of project geophysicist	X	X	
Name of site geophysicist	X	X	
Name of data processor	X	X	X*
Data processing software used	X	X	
De-spiking method and details	X	X	
Latency/lag correction and details	X	X	
Heading correction and details (magnetometer data)	X	X	
Sensor bias, background leveling and/or standardization adjustment method and details		X	
Diurnal correction (magnetometer data)	X	X	
Portable Document Format (PDF) document showing graphical results of each field QC test	X	X	
Geophysical noise identification and removal (spatial, temporal, motional, terrain induced) and details		X	
Other filtering/processing performed and details		X	
Gridding method		X	
Anomaly selection and decision criteria details		X	
Geosoft ".xyz" file for unit of survey being delivered (grid or area agreed upon with Munitions Response [MR] Geophysicist)		X	
Geosoft ".grd" file for unit of survey being delivered		X	
Geosoft ".map" file for unit of survey being delivered		X	
PDF of Geosoft map for unit of survey being delivered		X	
Geosoft ".map" mosaic of all processed data to date		X	
PDF mosaic of Geosoft map of all processed data to date		X	
Other processing comments		X	
Date data processing is completed	X	X	
Data delivery date	X	X	
Scanned copy of field notes and field PDA notes (if applicable)	X		

*If CH2M HILL's Munitions Response Site Information Management System (MRSIMS), MRP Enterprise, or other database accepted by CH2M HILL's MR Geophysicist is used then the fields marked with an asterisk are not required in the file headers.

3.7.5 Demobilization

After completion of all field operations all equipment and personnel will be demobilized from the project site.

3.7.6 Reporting

A UXO 16 WAA report will be developed following the completion of the field activities and submitted to the Vieques ERP Technical Subcommittee for review. This report will include the following information:

- The findings of additional archival records searches and interviews
- An update to the CSM (as applicable)
- Documentation of the technical investigation approach
- Data collection/processing/analysis methods
- Data quality evaluation
- Results of the data analysis
- Identify OUs and EADAs
- Recommendations for future investigations and/or actions within UXO 16
- Archives of the raw data and final processed data

3.8 Measurement Performance Criteria

The usability of the DGM data set with respect to achievement of the stated WAA objectives will depend upon the following project level MPC in terms of precision, bias, representativeness, and completeness (**Table 3-4**).

TABLE 3-4
Measurement Performance Criteria

Data Quality Indicator	DFOW	Measurement Performance Criterion	Activity to Assess Measurement Performance	Failure Response
Representativeness/ Completeness (Transect Layout)	Pre-mobilization Activities	Transects will be planned at an average 100 m line spacing, modified such that obstructions and sensitive benthic features area are avoided.	Planned transect paths will be evaluated prior to commencement of work.	Revise until acceptable.
Completeness (DGM Survey Coverage)	DGM Survey (Transect Data Collection)	All transects will be surveyed within 33 ft (10 m) (cross-track) of the planned transect path. Gaps between survey lines will not exceed 410 ft (125 m) for greater than 1,600 ft (500 m) along the survey line. Exceptions required to maintain safety of survey equipment, crew and benthic environment are acceptable. 95% of the along-track (on the same transect) measurement spacing for each transect will not exceed 1.0 ft (0.3 m). The maximum allowable along track gap will be 5.0 m.	Transect path will be inspected and deviations identified; transect gap distance calculation using US Army Corps of Engineers (USACE) utility in Geosoft Oasis Montaj (or equivalent). Sample distance calculation using USACE utility in Geosoft Oasis Montaj (or equivalent).	Root-cause Analysis (RCA)/ Corrective Action (CA) (forms and instructions provided in **Appendix D**). Presumptive CA: recollect portions of transect affected by failure.
Representativeness/ Completeness (DGM Survey Altitude)	DGM Survey (Initial IVS Survey, Daily IVS, and Transect Data Collection)	The geophysical data will be collected with survey altitude between 3.3 ft and 6.6 ft above the sea floor. Exceptions required to maintain safety of survey equipment, crew, and benthic environment are acceptable. 95% of measurement altitude above the sea floor will be <6.6 ft (2.0 m).	Statistical summary of survey altitudes will be provided with transect data.	RCA/CA Presumptive CA: recollect portions of transect affected by failure.

TABLE 3-4
Measurement Performance Criteria

Data Quality Indicator	DFOW	Measurement Performance Criterion	Activity to Assess Measurement Performance	Failure Response
Representativeness, Accuracy (DGM Sensor Measurements)	DGM Survey (Initial IVS Survey, Daily IVS, and Transect Data Collection)	All magnetometers will be operational and providing valid data – i.e. values will be between 20,000 nT and 70,000 nT.	Evaluation of magnetometer measurements.	RCA/CA Presumptive CA: All values out of range are defaulted (rejected) – recollect portions of transect affected by failure if the results fail the along track density specification.
Accuracy (DGM Topside Positioning)	DGM Survey (Initial IVS Survey, Daily IVS)	The GPS antenna positioning errors associated with bias and precision will be less than 1 ft.	Measurement of the GPS antenna position placed at an independently measured location (to be selected at mobilization and established by a PLS).	RCA/CA Presumptive CA: reject data affected by failure, repair/replace equipment, and recollect affected data.
Accuracy (Target Positioning)	DGM Survey (Initial IVS Survey, Daily IVS)	The submerged target positioning errors associated with bias and precision will be less than 5 ft.	IVS survey over known ground truth target.	RCA/CA Presumptive CA: reject data affected by failure, repair/replace equipment, and recollect affected data.
Accuracy, Comparability (DGM Sensor Response)	DGM Survey (Magnetometer Response Amplitudes) (Initial IVS Survey, Daily IVS)	Sensor response values will be demonstrably consistent with expected values for IVS target(s).	IVS survey over known ground truth target.	RCA/CA Presumptive CA: reject data affected by failure, repair/replace equipment, and recollect affected data.
Representativeness, Comparability (DGM Sensor Noise Levels)	DGM Survey (Initial IVS Survey, Daily IVS, and Transect Data Collection)	Standard deviation of non-anomalous sensor response values <.25 nT.	Collection of 'background' data with sensors out of ground effect (at or near surface) in magnetically quiet region.	RCA/CA Presumptive CA: reject data affected by failure, repair/replace equipment, and recollect affected data.

TABLE 3-4
Measurement Performance Criteria

Data Quality Indicator	DFOW	Measurement Performance Criterion	Activity to Assess Measurement Performance	Failure Response
Completeness (Video Image Collection)	DGM Survey (Initial IVS Survey, Daily IVS, and Transect Data Collection)	Video imaging of the sea floor will be collected with sufficient resolution and clarity to identify potential anomaly sources located on the surface of the sea floor as well as characterize the benthic environment. The video will be time stamped so that it can be aligned with position information.	A qualitative review of the video images will be performed daily.	RCA/CA Presumptive CA: if failure is due to equipment failure, reject data affected by failure, repair/replace equipment, and recollect affected data.
Completeness/ Representativeness (Data Evaluation and Documentation)	DGM Data Evaluation and Documentation	Data will be appropriately processed, interpreted, and documented.	The data processing, interpretation, and documentation will undergo senior technical review.	RCA/CA Presumptive CA: data processing, interpretation, or documentation that does not pass senior technical review will be redone.
Completeness	Reporting	The final report will summarize the data collection and QC activities and results. It will also summarize the data processing and data analyses and results. All collected and processed data shall be properly archived and delivered to the project team.	The report will undergo senior technical review.	RCA/CA Presumptive CA: Portions of the report not accepted by senior technical review will be rewritten.

Transect Layout: The MPC for the transect layout is that the boundary is correct and the transect line spacing is correct. These are the theoretical transect lines that the survey crew will attempt to follow.

DGM Survey Coverage: The MPC for survey coverage is established to ensure that the survey area has been fully investigated. Wind, currents, and wave action will cause the vessel and array to deviate from the planned transects. The stated cross-track tolerance of 410 feet (125 meters) between survey lines for no more than 1640 feet (500 meters) will provide sufficient coverage to ensure that the survey goals are met. Deviations required to avoid obstacles/sensitive habitats, or wildlife are anticipated and acceptable. The down-line sample spacing of 1 foot (0.3 meters) is established to ensure that the sample density is sufficient to detect discrete ferrous objects that are potential TOI.

DGM Survey Altitude: The MPC for DGM survey altitude is established to minimize the sensor offset from the sea floor while maintaining a safety buffer to avoid contact with the sea floor. A survey altitude between 3.3 feet and 6.6 feet above the sea floor is sufficient to meet the goals of the survey. Deviations required to avoid obstacles/sensitive habitats are anticipated and acceptable.

DGM Sensor Measurements: This MPC is established to verify that valid total magnetic field data are being measured by the magnetometers. The physics governing the operation of cesium vapor magnetometers is such that these sensors do not require calibration (there is no 'gain' adjustment). Obtaining raw total magnetic field measurements in the 20,000 to 70,000 nT range that vary when the sensor is challenged with a ferrous object is sufficient to show that the sensor itself is operational. Note that this large 'background field' is removed during the levelling process to isolate the nT level responses used for detection of ferrous objects.

DGM Topside Positioning: The MPC for DGM topside positioning is that the accuracy of the GPS antenna above the surface of the water be less than one foot. A test location will be established by a professional land surveyor.

Target Positioning: The MPC for target positioning is established to ensure that the submerged targets are being detected with an accuracy of less than five feet. This check is accomplished with the use of the IVS, a twice-daily survey over one or more objects at a fixed, known location.

DGM Sensor Response: The MPC for DGM sensor response is established to verify that the response values are consistent with the expected values for the item(s) located in the IVS. If the IVS uses a previously emplaced target where the expected response is unknown, the initial IVS survey will be used to establish the expected response. Prior to the initial IVS survey, the sensor responses will be verified with a static test using a known object (typically and industry standard object [ISO]).

DGM Sensor Noise Levels: The MPC for the DGM sensor noise levels are established in to enable monitoring of sensor noise levels. Typical noise levels in the marine environment are less than 0.1 nT (rms) but will vary depending upon the system configuration. Noise levels above 0.25 nT may indicate a problem with the sensors or a proximal noise source that will impact the sensitivity of the system.

Video Image Collection: The MPC for video image collection is that the video footage of the sea floor is clear enough to identify the environment and objects along the sea floor, and that it can be time stamped and matched to the GPS data. Environmental factors such as turbidity or dense vegetation may obstruct video clarity and are anticipated and acceptable.

Data Evaluation and Documentation: The MPC for data evaluation and documentation is established so that all data passes through the review process. A senior technical review will determine that data has been processed and presented appropriately.

Reporting: The MPC for reporting is the delivery of the final report. It will summarize all field and data processing activities and documentation, including analysis of the data and final results. Archived data will be maintained by the project team.

3.9 Quality Control Plan

QC inspections will be implemented for each DFOW per the three-phase inspection control process described in this section. The DFOWs and corresponding inspections and pass/fail criteria are provided in **Table 3-4**. **Appendix D** contains the following forms for use in performing the QC activities discussed in this section:

Contractor Production Report

Contractor QC Report

Daily QC Form

Preparatory Phase Inspection Checklist

Corrective Action Request

Non-Conformance Form

Root Cause Analysis Form

3.10 Three-Phase Inspection Control Process

Compliance of the WAA WP will be verified using implementation of the three-phase inspection control process (**Table 3-5**). This process provides sufficient redundancy to ensure project activities comply with the approved plans and procedures. Each phase is considered relevant for obtaining necessary product quality. However, the preparatory and initial inspections are particularly invaluable in preventing project pitfalls. Work will not be performed on a DFOW until the preparatory and initial phase inspections have been completed and any non-conformance issues have been resolved.

- **Preparatory Phase Inspection** will be performed before beginning each DFOW. The purposes of this inspection are to review applicable specifications and plans to verify that the necessary resources, conditions, and controls are in place and compliant before work activities start. To complete this inspection, WPs and operating procedures will be reviewed. The FTL and project geophysicist will verify that required plans and procedures have been approved and are available to the field staff; field equipment is appropriate, available, functional, and properly calibrated for its intended/stated use; staff responsibilities have been assigned and communicated; staff have reviewed the Work Plan and associated SOPs; arrangements for support services have been made; and prerequisite site work has been completed. Project staff must correct or resolve discrepancies between existing conditions and the approved plans/procedures identified by the FTL or project geophysicist during the Preparatory Phase Inspection. Upon completion of the inspection, the FTL will complete the Preparatory Phase Inspection Checklist provided in **Appendix D**.

- **Initial Phase Inspection** will be performed at the onset of conducting a particular DFOW. The objectives of this inspection are to check preliminary work for compliance with process, procedures, and specifications; establish the acceptable level of workmanship; check for omissions; and resolve differences of interpretation. The FTL or project geophysicist will ensure that discrepancies between site practices and approved plans or specifications are identified and resolved. Discrepancies between site practices and approved plans/procedures will be resolved and corrective actions for unsatisfactory and nonconforming conditions or practices will be resolved by the FTL or project geophysicist before continuing the work. Upon completion of the inspection, the FTL will complete the Initial Phase Inspection information in the Contractor Quality Control Report provided in **Appendix D**.

- **Follow-up Phase Inspection** will be completed at regular intervals while a particular DFOW is performed. This phase ensures continuous compliance and an acceptable level of workmanship. The FTL or project geophysicist will monitor onsite practices and operations taking place and verify continued compliance with the specifications and requirements of the Quality Control Plan and approved amendments. The FTL will also verify that daily health and safety inspections are performed and documented as prescribed in the H&S Plan.

Discrepancies between site practices and approved plans/procedures will be resolved and corrective actions for unsatisfactory and nonconforming conditions or practices will be resolved by the FTL or project geophysicist before continuing work. Upon completion of the inspection, the FTL will complete the Follow-up Phase Inspection information in the Contractor Quality Control Report provided in **Appendix D**.

Additional inspections performed on a particular DFOW may be required at the discretion of the Navy, the FTL, or the project geophysicist.

TABLE 3-5
Definable Features of Work Auditing Procedure

DFOW	Task with Auditable Function	Audit Procedure	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
Pre-mobilization Activities	GIS Setup	Verify GIS system has been setup	Preparatory Phase (PP)	Once	GIS system has been set up and is ready for site data, including: • GIS technician has prepared a GIS project with all available GIS information • System is ready for import of new data	Do not proceed with field activities until criterion is passed
	Document Management and Control	Verify appropriate measures are in place to manage and control project documents	PP	Once	Appropriate measures are in place to manage and control project documents, including: • Project SharePoint site is set up and user permissions have been established • Project folders have been established on the CH2M HILL servers and backup processes are in place • File naming conventions for project documents have been established and shared with the project team • Version control procedures and naming conventions have been established and shared with the project team • Electronic templates for field forms have been provided to field personnel as appropriate	Do not proceed with field activities until criterion is passed
	Data Management	Verify appropriate measures are in place to manage and control project data	PP	Once	Appropriate measures are in place to manage and control project data, including: • File Transfer Protocol (FTP) site has been set up and is ready for data transfer from subcontractors • Project SharePoint site is set up and user permissions have been established • File naming conventions for data files has been established and shared with the project team	Do not proceed with field activities until criterion is passed
	Subcontractor Procurement	Ensure procurement of subcontractors and verify qualifications, training, licenses • Qualifications include proper educational or work background to perform assigned tasks • Training includes health and safety training appropriate to perform assigned tasks • Licenses include licenses to perform assigned tasks, such as a Captain's license for the boat operator	PP/ Initial Phase (IP)	Once	Subcontractors' qualifications, training, and licenses are up to date and acceptable	Ensure subcontractor provides qualifications, training, and licenses or change subcontractor
	Pre-Mobilization Process	Ensure individual tasks associated with pre-mobilization are performed and completed	PP/IP/ Follow-up Phase (FP)	As required	Each of the individual tasks associated with the pre-mobilization DFOW has been completed and associated criteria passed	Return to performance of tasks until all criteria pass

TABLE 3-5
Definable Features of Work Auditing Procedure

DFOW	Task with Auditable Function	Audit Procedure	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
Mobilization/ Site Preparation	Onsite Document Review	Verify Project Plans are approved and review with project team and get appropriate signatures	PP/IP	Once	Document is approved and has been reviewed and acknowledged by appropriate project team members	Personnel who are not familiar with the Project Plans may not proceed with field activities until criterion are passed
	Establish Communication and Logistics	Verify functionality of communications equipment and logistical support is coordinated	PP/IP	Once	Communications and other logistical support are coordinated	Do not proceed with field activities until criterion is passed
	Site Boundary and Transect Establishment	Verify area/boundary and transects	PP/IP	Once	Area/boundary is defined correctly and transect spacing is correct	Stop activities until area/boundary/transect approach is verified
	Mobilization/ Site Preparation Process	Ensure individual tasks associated with Mobilization/Site Preparation are performed and completed	PP/IP/FP	As required	Each of the individual tasks associated with the Mobilization/Site Preparation DFOW has been completed and associated criteria passed	Return to performance of tasks until all criteria pass
DGM Survey	Equipment Testing	Verify initial and daily IVS surveys are performed and applicable MPCs are being met	IP/FP	Once/daily/as required	Equipment passed functionality test as required by this WP and associated SOPs	Repair or replace instrument
	Work Methods	Verify work methods are established and communicated	IP/FP	Daily	Work methods are established and communicated and being performed in accordance with this WP and SOPs	Stop activities until the WP and SOPs can be followed and any activities not performed within compliance are re-evaluated and re-performed, if necessary
	Geophysical Survey (Towed-array)	Verify DGM survey of the area is performed as detailed in this WP and associated SOPs	IP/FP	Daily	DGM activities are being performed in accordance with this WP and associated SOPs	Stop work until DGM activities are corrected and in compliance with the WP and SOPs
	Data Transfer/Upload to FTP	Verify data are transferred for review	IP/FP	Per data collection set	Data has been transferred as required by this WP and SOPs	Request transfer of data
	Documentation/Recording of Functionality Tests and Other Investigation Details	QC Geophysicist to verify Equipment functionality tests are being conducted at least once a day and other investigation details are being recorded through review of field log books and/or digital logs	IP/FP	Daily	Equipment functionality tests are being conducted at least once a day and other investigation details are being recorded	Stop activities until functionality tests are being conducted at least once a day RCA/CA
	Inspect QC Data	QC Geophysicist to verify QC tests meet MPC requirements	IP/FP	Daily	QC tests meet MPCs	Stop activities until QC tests demonstrate MPCs are being met and perform RCA/CA
	DGM Survey Process	Ensure individual tasks associated with pre-mobilization are performed and completed	PP/IP/FP	As required	Each of the individual tasks associated with the DGM Survey DFOW has been completed and associated criteria passed	Return to performance of tasks until all criteria pass
DGM Data Evaluation and Documentation	Geophysical Data Processing and Interpretation	Verify data processing is adequately performed and interpretation/anomaly selection is appropriate	IP/FP/FP	Per data package	Data are appropriately processed, interpreted, and documented and anomaly selection has been made as detailed in this WP	Request data be resubmitted or recollected, as necessary, for adequate review

TABLE 3-5
Definable Features of Work Auditing Procedure

DFOW	Task with Auditable Function	Audit Procedure	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
Demobilization	Demobilize from the Site	Verify equipment and personnel have been demobilized from the site and the site is returned to pre-mobilization condition	IP/FP/FP	Once	All personnel and equipment have been demobilized and the site is in pre-construction condition	Restore site to pre-construction condition, package and ship all equipment offsite, demobilize crew
Reporting	Prepare and Provide Report on WAA Operations and Results	Verify report contains the information identified as needing to be included (per Section 3.7.6 of this WP) and accurately describes all field operations, data analysis and data interpretation performed	IP/FP/FP	Once	Document has been reviewed by appropriate technical staff and review signatures have been obtained	Ensure that document is reviewed by appropriate technical staff and review signatures are obtained

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3.11 Preventative and Corrective Actions

The preventative and corrective actions incorporated within this WP are designed to prevent and correct quality problems that may arise during the WAA. The procedures facilitate process improvements and describe the available mechanisms to identify, document, and track discrepancies until a corrective action has been verified.

3.11.1 Continual Improvement

A continual improvement process will be implemented for the project. Project staff at all levels will be encouraged to provide recommendations for improvements in established work processes and techniques. The intent is to identify activities that are compliant but can be performed in a more efficient or cost-effective manner. Typical quality improvement recommendations include identifying an existing practice that can and should be improved (e.g., a bottleneck in production) and/or recommending an alternative practice that provides a benefit without compromising prescribed standards of quality. Project staff should bring their recommendations to the attention of the FTL or Project Manager through verbal or written means.

Deviations from established protocols will not to be implemented without prior written approval.

3.11.2 Deficiency Identification and Resolution

While deficiency identification and resolution occurs primarily at the operational level, QC audits provide a backup mechanism to address problems that either are not identified or cannot be resolved at the operational level. Through implementation of the project, the CH2M HILL team is responsible for verifying that deficiencies are identified and documented as prescribed herein and corrected in a timely manner. Deficiencies identified by the CH2M HILL team are to be corrected by operational staff and documented by the QC Geophysicist or his designee.

3.11.3 Corrective Action Request

A Corrective Action Request (CAR) (**Appendix D**) can be issued by any member of the CH2M HILL team, including subcontractor employees. If the individual issuing the CAR is also responsible for correcting the problem, then he/she should document the results on Part B of the CAR. Otherwise, the CAR should be forwarded to the Project Manager who is then responsible for evaluating the validity of the request, formulating a resolution and developing a corrective strategy, assigning personnel and resources, and specifying and enforcing a schedule for corrective actions. Once a corrective action has been completed, the CAR and supporting information will be forwarded to the Program QC Manager for closure. Sufficient information will be provided to allow the QC reviewer to verify the effectiveness of the corrective actions.

The recommendations provided in the CARs and implemented on the project will be reviewed during follow-up QC inspections. The purposes of this CAR review are to ensure that established protocols are implemented properly; verify that corrective action commitments are met; ensure that corrective actions are effective in resolving problems; identify trends within and among similar work units; and facilitate system root cause analysis of larger problems.

The Program QC Manager will determine whether a written Corrective Action Plan (CAP) (**Appendix D**) is necessary, based on whether or not any of the following are met: the CAR priority is high; deficiency requires a rigorous corrective action planning process to identify similar work product or activities affected by the deficiency; or deficiency requires extensive resources and planning to correct the deficiency and to prevent recurrence. The CAP will be developed by the Project Manager and approved and signed by the Program QC Manager. The CAP will indicate whether it is submitted for informational purposes or for review and approval. In either event, operational staff are encouraged to discuss corrective action strategy with the QC Geophysicist throughout the process.

3.11.3.1 Corrective Action Request Tracking

Each CAR will be given a unique identification number and tracked until corrective actions have been implemented in the field, documented in Part B of the CAR form (**Appendix D**), and the CAR is submitted to the Project Manager for verification and closure.

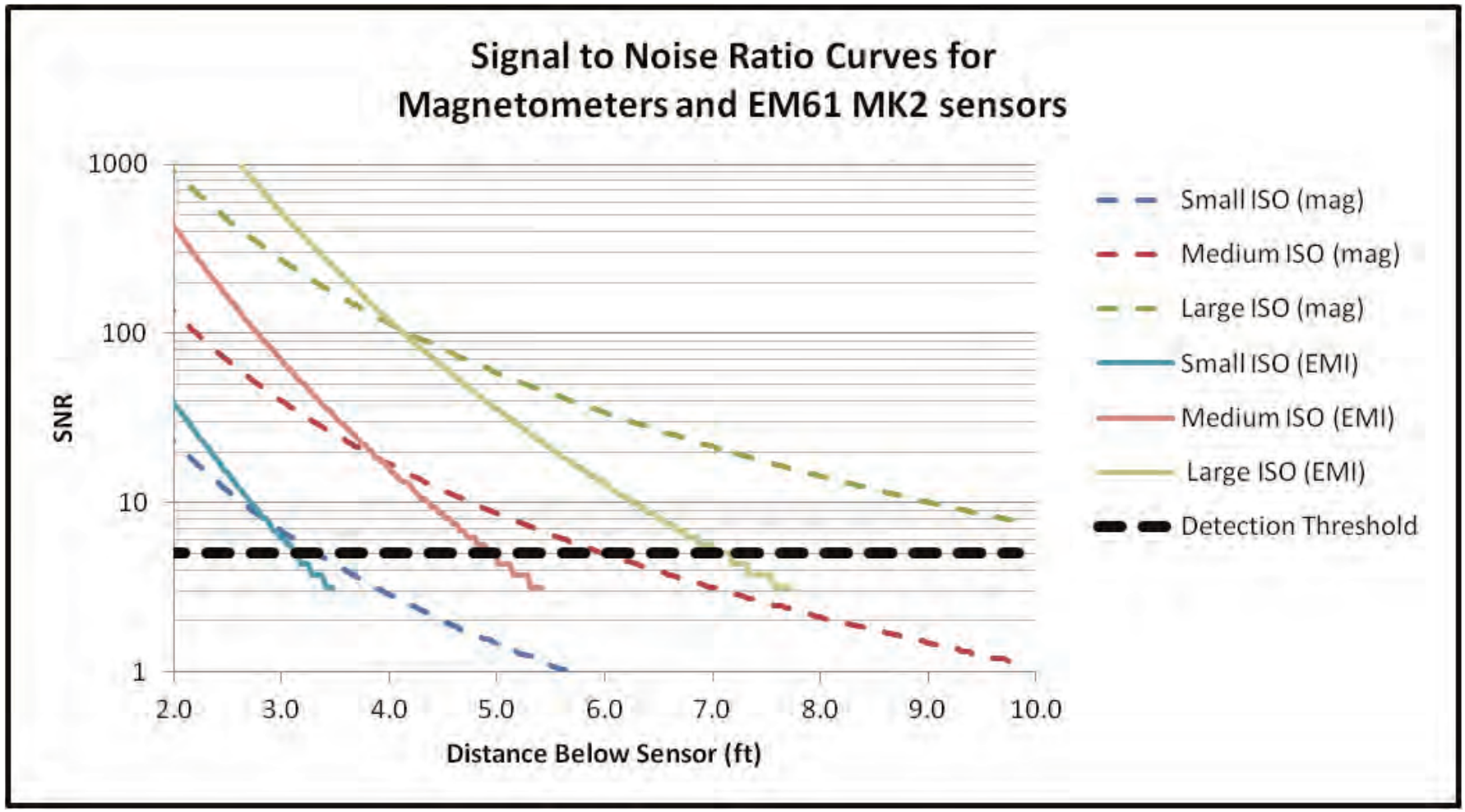


FIGURE 3-1
Signal to Noise Ratio Curves for Magnetometers and EM61-MK2 Sensors
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

Signal to noise ratio curves for magnetometers and EM61-MK2 sensors to industry standard objects (ISOs) of various sizes.
The ISOs are welded steel, schedule 40 pipe nipple with the following sizes: Small = 1-in x 4-in; Medium = 2-in x 8-in; Large = 4-in x 12-in.

CH2MHILL

ES090814102429TPA FILENAME F_4-1_Signal to noise ration curves for magnetometers and EM61-MK2 sensors.WAA.ai

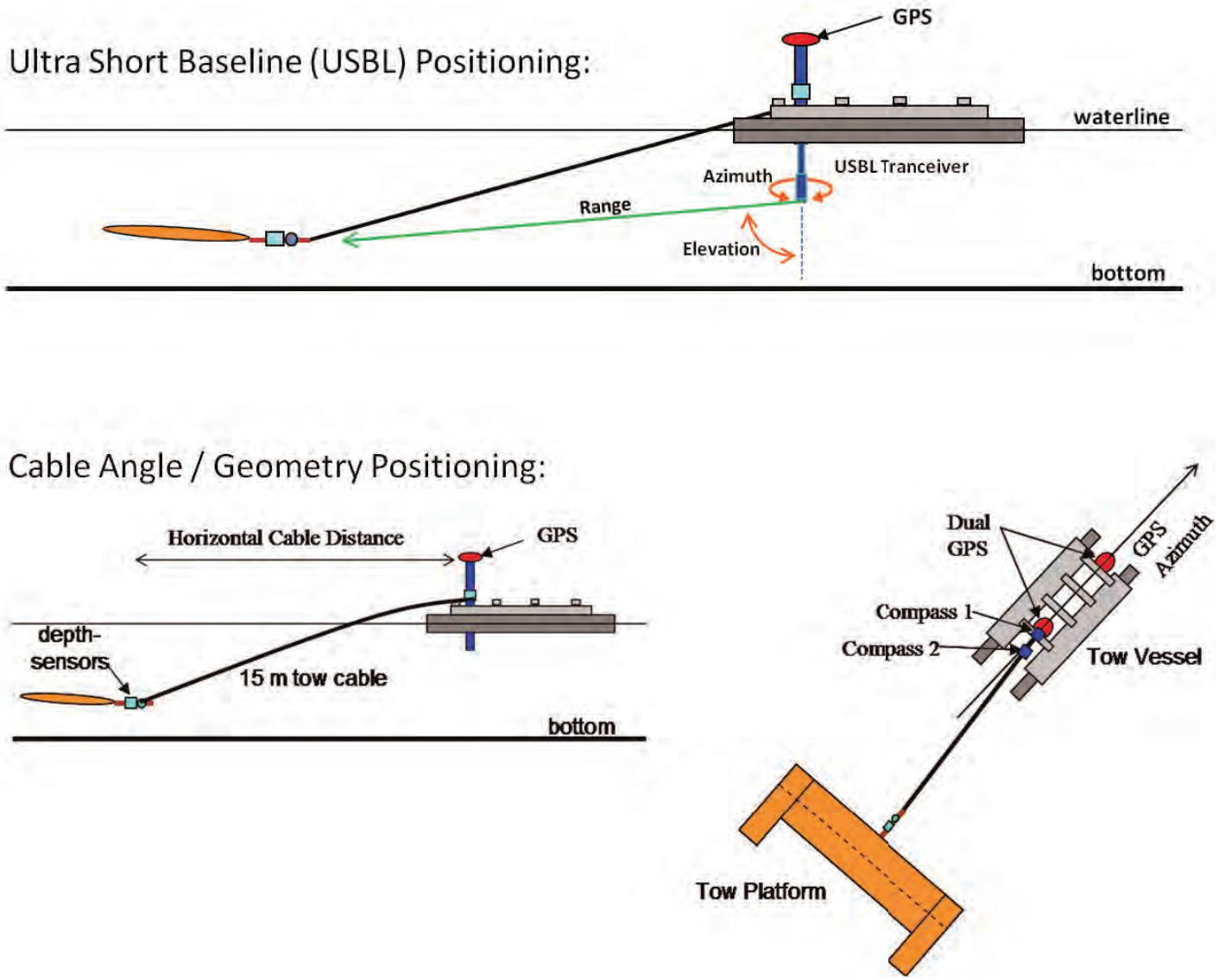


FIGURE 3-2
Positioning Sensor Schemes
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

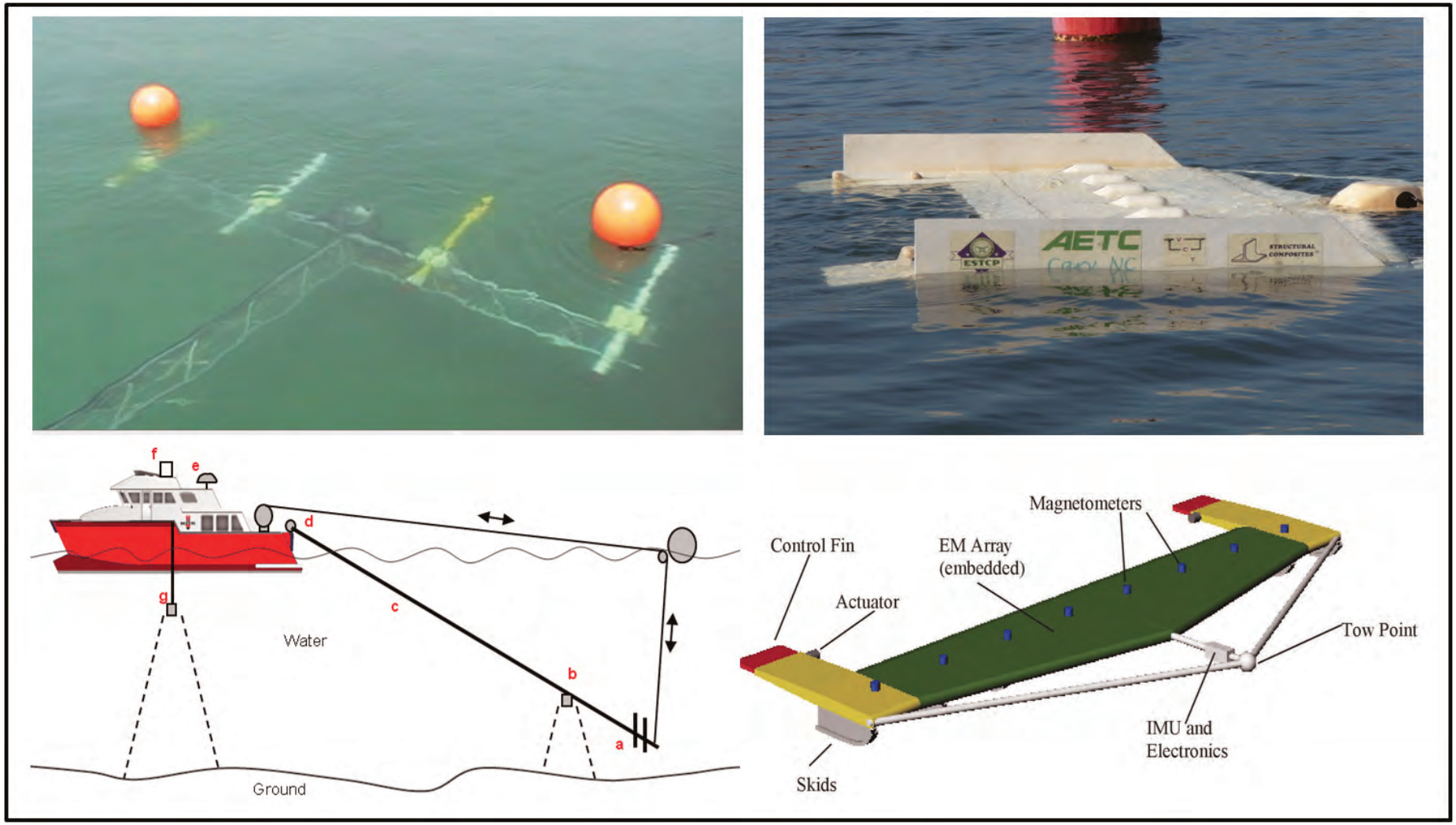


FIGURE 3-3
Altitude Control
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

CH2MHILL

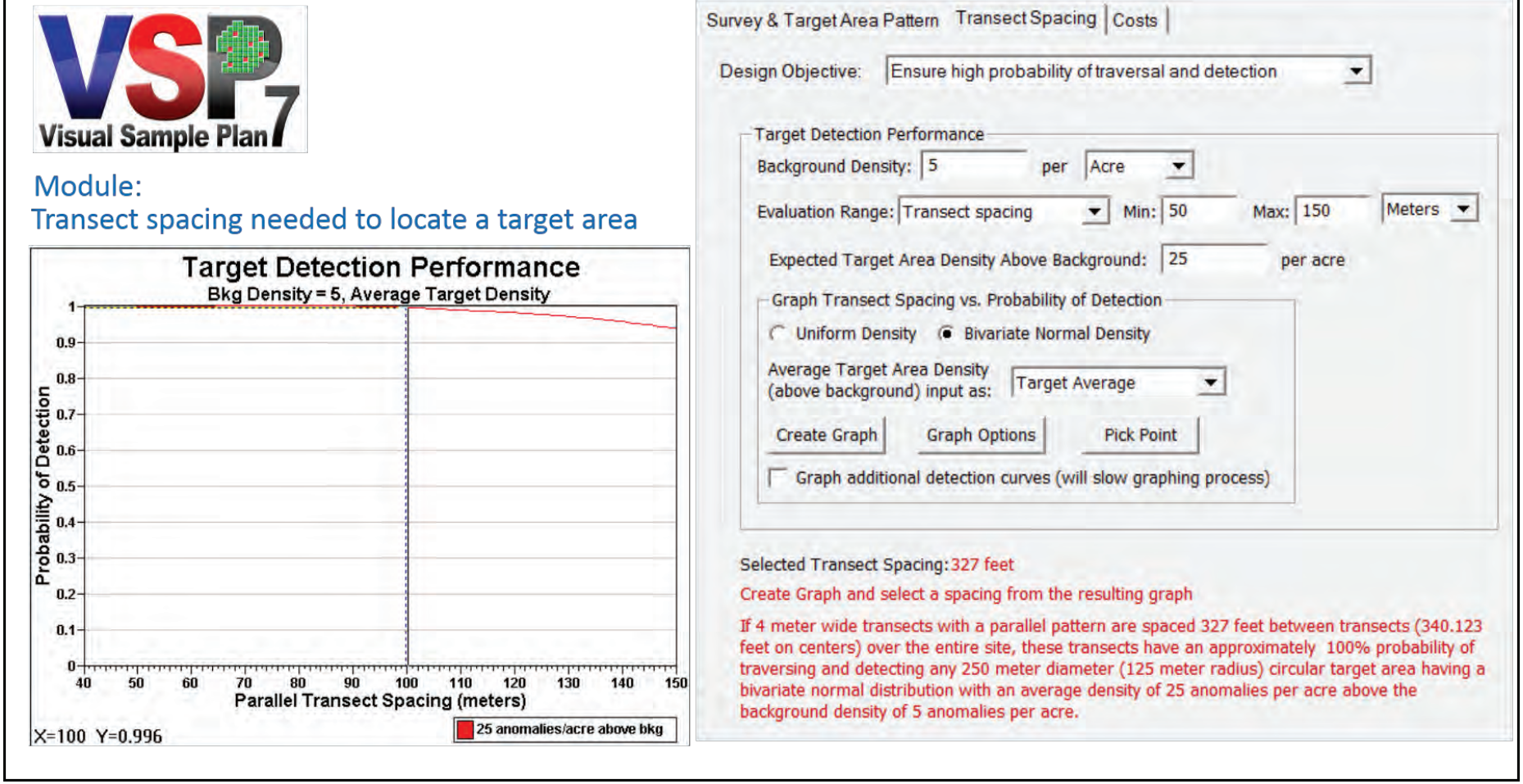
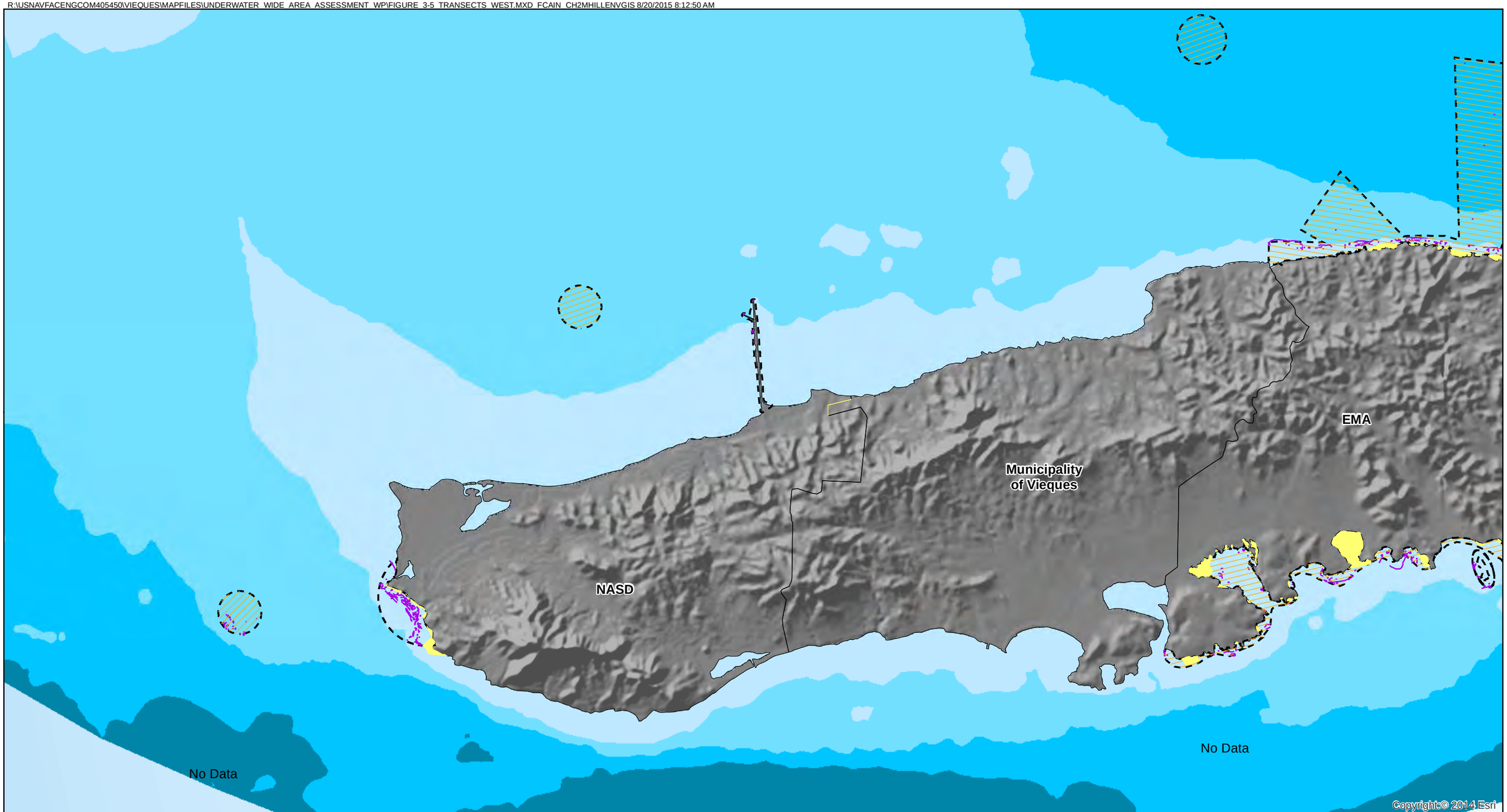


FIGURE 3-4
Visual Sample Plan (VSP) Results
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

R:\USNAVFACENGCOM405450\VIEQUES\MAPFILES\UNDERWATER_WIDE_AREA_ASSESSMENT_WP\FIGURE_3-5_TRANSECTS_WEST.MXD FCAIN_CH2MHILLENVGIS 8/20/2015 8:12:50 AM



Legend

- Site Boundary
- UXO 16 Boundary
- Transects (100 meters)
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Side scan sonar survey could not be conducted in area due to shallow depth conditions, reefs, and/or rough sea conditions

Underwater Depth (feet)

- 0 - 30
- 30 - 60
- 60 - 120
- 120 - 164

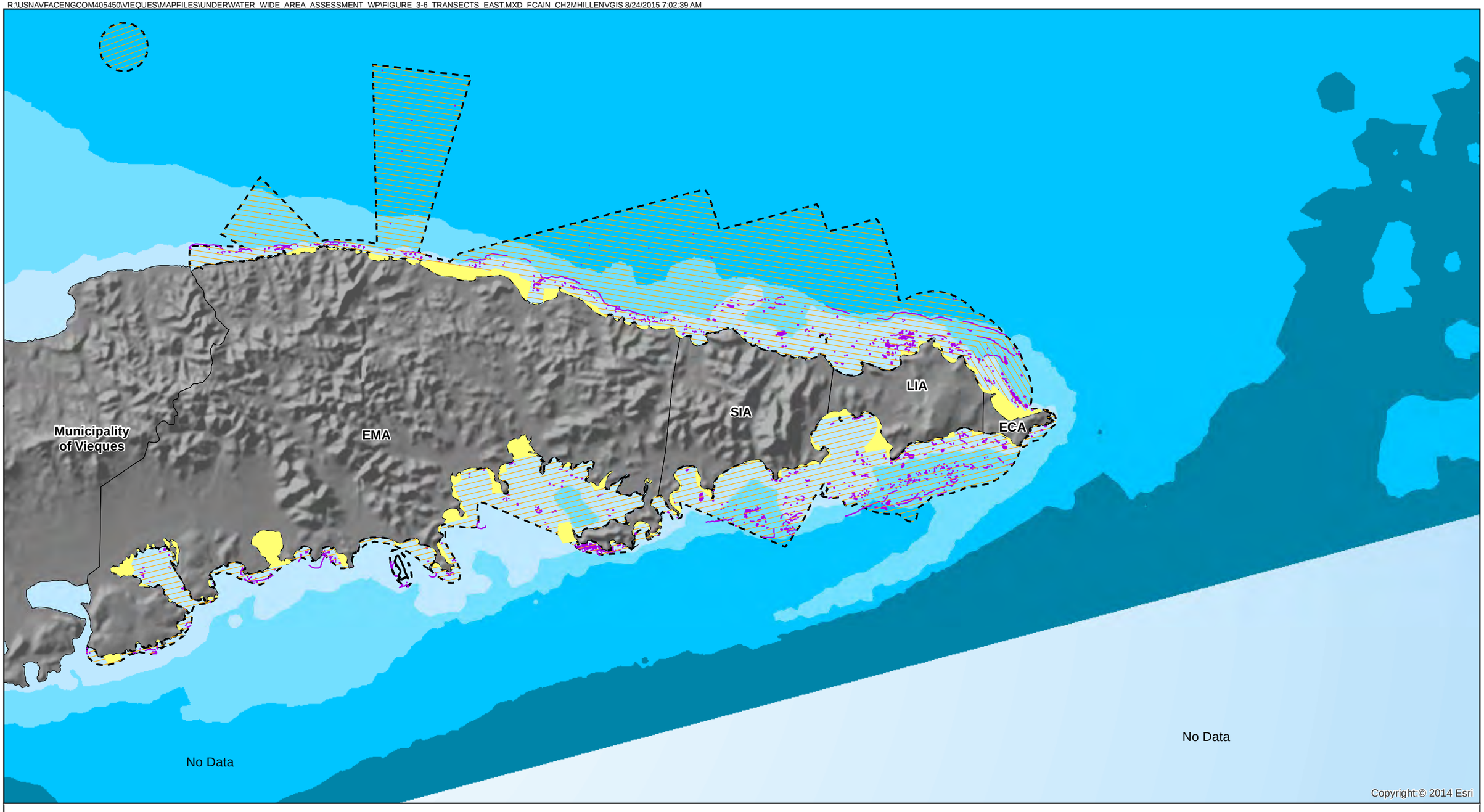
N
W E
S

0 1.5 3 Miles

Figure 3-5
Conceptual Survey Design - West
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

CH2MHILL

R:\USNAVFACENGCOM405450\VIEQUES\MAPFILES\UNDERWATER_WIDE_AREA_ASSESSMENT_WP\FIGURE_3-6_TRANSECTS_EAST.MXD_FCAIN_CH2MHILLENVGIS 8/24/2015 7:02:39 AM



Legend

- Site Boundary
- UXO 16 Boundary
- Transects (100 meters)
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Side scan sonar survey could not be conducted in area due to shallow depth conditions, reefs, and/or rough sea conditions

Underwater Depth (feet)

- 0 - 30
- 30 - 60
- 60 - 120
- 120 - 164

N
W E
S

0 1.5 3
Miles

Figure 3-6
Conceptual Survey Design - East
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

CH2MHILL

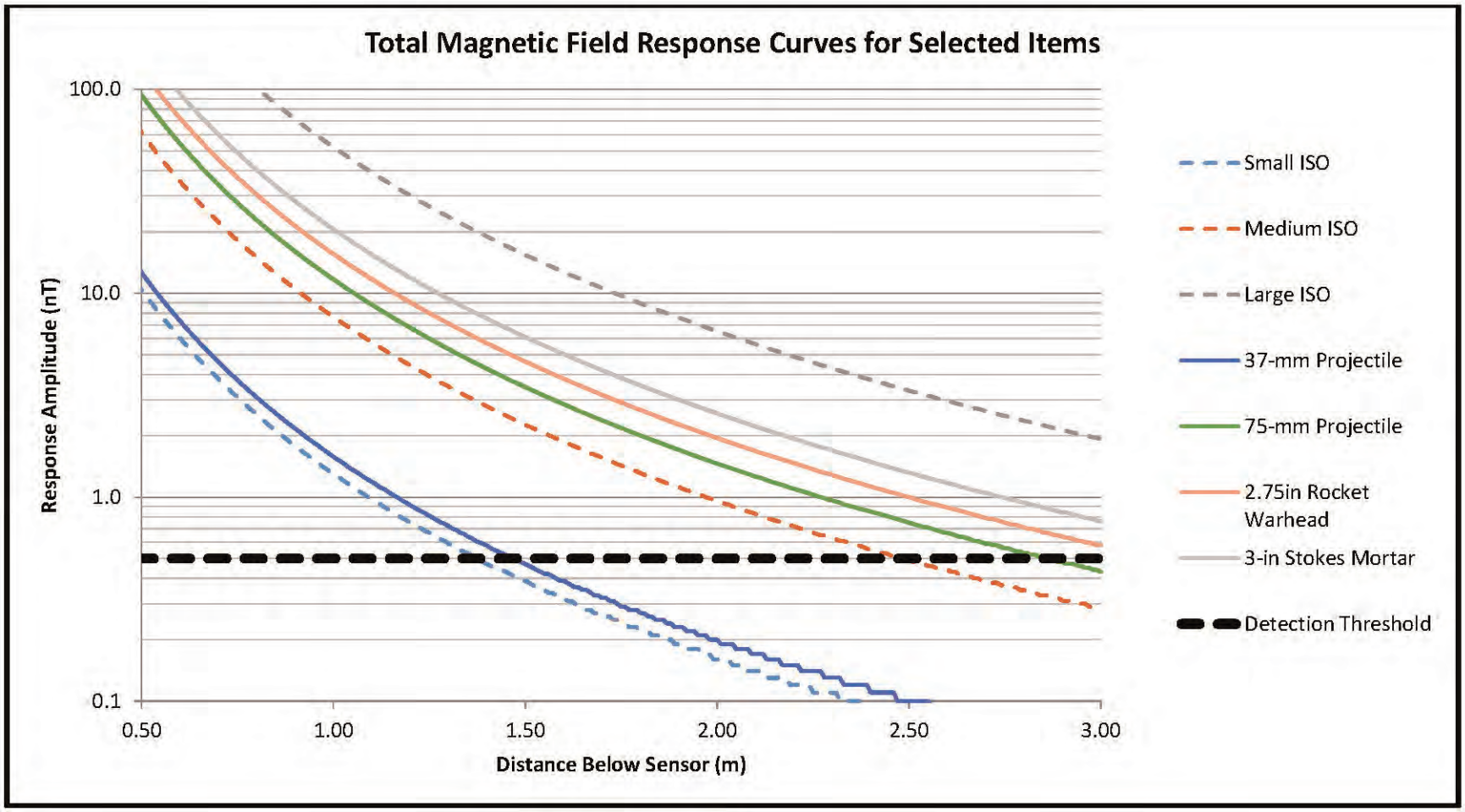


FIGURE 3-7
Minimum Expected Total Magnetic Field Response As a Function of Sensor Offset Distance
Underwater Wide Area Assessment Work Plan
Former VNTR
Vieques, Puerto Rico

SECTION 4

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Appendix A
Bathymetry Data Review

Review of Existing Bathymetry Data for Vieques, Puerto Rico

PREPARED FOR: NAVFAC Atlantic

PREPARED BY: CH2M HILL

DATE: April 16, 2003

This memorandum summarizes the existing bathymetry data review for Vieques performed by CH2M HILL. The data review was conducted on behalf of the Department of the Navy, Naval Facilities Engineering Command (NAVFAC), Atlantic in support of initial preparations for the Wide Area Assessment (WAA) and Beach Dynamics Investigation.

Purpose of Data Review

The Navy has adopted an iterative approach for both the WAA and the Beach Dynamics Investigation. Each component of these investigations requires supporting data and information from the previous stage(s) to be used during planning of subsequent stages and refinement of the Conceptual Site Model (CSM). For the WAA, Beach Dynamics Investigation, and CSM, knowledge of water depth was identified as an initial planning necessity.

For the WAA of Site UXO 16, bathymetry data will be used primarily to help plan the side scan sonar survey. The objective of the side scan sonar survey is to map environmentally sensitive areas and underwater navigational obstructions (e.g., reefs, shipwrecks) to be used for planning the follow-up underwater digital geophysical mapping (DGM). The objective of the DGM is to identify anomalies consistent with underwater munitions.

For the Beach Dynamics Investigation, the bathymetry data will be used for various purposes during planning and data analysis. During the planning stage, nearshore bathymetry will be used to help determine the locations of the beach transects that will be surveyed to monitor the evolution of the beaches throughout the investigation. Offshore bathymetry data will be used to help determine the location of sensors that will collect wave, current, and water level data for the purpose of correlating these parameters with the beach evolution. During the analysis stage, bathymetry data around the island will be used to help develop wave and sediment transport models that will be used to predict beach changes in a wide range of conditions.

CH2M HILL conducted a review of existing bathymetry data obtained from a variety of sources in order to determine whether existing bathymetry data are sufficient to satisfy the aforementioned objectives or whether a new, stand-alone bathymetry survey is warranted as the first phase of the WAA and Beach Dynamics Investigation. The data were reviewed for resolution, Site UXO 16 coverage, ability to incorporate the data into the Vieques program GIS, and overall usability.

Data Sources

Table 1 presents the data sources and metadata compiled to produce the comprehensive bathymetric dataset for Vieques.

TABLE 1
Existing Bathymetry Data Sources and Metadata
Vieques, Puerto Rico

Data Source	Date	Data Type	Spatial Resolution	Horizontal Accuracy	Vertical Accuracy	Original Horizontal Datum	Original Vertical Datum	Publisher
NOAA[a]	2007	Digital Elevation Model / Bathymetry	1 arc-second (~30m)	Dependent on DEM cell size of data inputs	Dependent on DEM cell size of data inputs	WGS 84	MHW	NOAA
NOAA[b]	2007	Digital Elevation Model / Bathymetry	1/3 arc-second (~10m)	Dependent on DEM cell size of data inputs	Dependent on DEM cell size of data inputs	WGS 84	MHW	NOAA
JALBCTX/USACE (SHOALS)	2001	Airborne LiDAR Bathymetry	5m posting	~3m	~15cm	WGS 84	MLLW	JALBCTX/ USACE

TABLE 1
Existing Bathymetry Data Sources and Metadata
Vieques, Puerto Rico

Data Source	Date	Data Type	Spatial Resolution	Horizontal Accuracy	Vertical Accuracy	Original Horizontal Datum	Original Vertical Datum	Publisher
JALBCTX/USACE (SHOALS)	2000	Airborne LiDAR Bathymetry	5m posting	~3m	~15cm	WGS 84	MLLW	JALBCTX/ USACE
NOAA Nautical Chart 25650 – Edition 36[c]	2011	Soundings	N/A	N/A	N/A	NAD83	MLLW	NOAA
NOAA Nautical Chart 25663 – Edition 28[c]	2012	Soundings	N/A	N/A	N/A	NAD83	MLLW	NOAA
NOAA Nautical Chart 25664 – Edition 17[c]	2011	Soundings	N/A	N/A	N/A	NAD83	MLLW	NOAA

Table Notes:
[a] Reference/URL: http://www.ngdc.noaa.gov/dem/squareCellGrid/download/1561
[b] Reference/URL: http://www.ngdc.noaa.gov/dem/squareCellGrid/download/689
[c] Charts used for quality control purposes; Reference/URLs:
http://www.charts.noaa.gov/OnLineViewer/25650.shtml
http://www.charts.noaa.gov/OnLineViewer/25663.shtml
http://www.charts.noaa.gov/OnLineViewer/25664.shtml

Table Abbreviations:
cm = centimeter
DEM = Digital Elevation Model
ft = foot
JALBCTX = Joint Airborne LiDAR Bathymetry Technical Center of Expertise
LiDAR = Light Detection and Ranging
m = meter
MHW = Mean High Water
MLLW = Mean Low Low Water
NAD83 = North American Datum 1983
NOAA = National Oceanic and Atmospheric Administration
USACE = United States Army Corps of Engineers
UTM = Universal Transverse Mercator
WGS = World Geodetic System

Additional data sets were reviewed as part of this effort. They are not presented in **Table 1** because they were determined to be redundant, did not meet general usability requirements, or were of coarser resolution or lesser quality than those in **Table 1**. These included the following:

- University of Puerto Rico: Digitization of National Ocean Survey Hydrographic Survey "Smooth" Sheets for Puerto Rico and the U.S. Virgin Islands
- C-MAP: soundings from digital charts
- NOAA: Vieques Bathymetry Survey W00235 2012
- NOAA: Vieques Bathymetry Survey W00207 2008
- NOAA: Vieques Bathymetry Survey W00214 2009

Review Findings

CH2M HILL obtained the actual data for each data set listed in **Table 1** and compiled the information in GIS to assess the coverage and usability. Based on evaluation of the compiled data, the data sets listed in **Table 1** were determined to meet the initial planning needs for the WAA and Beach Dynamics Investigation.

The results of the compilation are presented as **Figures 1 through 3**. **Figure 1** presents a comparison of each data set listed in **Table 1**. This figure is intended to demonstrate that extensive data coverage exists around Vieques and, in the case of the NOAA digital elevation model (DEM) data, all of Puerto Rico. However, for purposes of evaluating the suitability of the data for the WAA and Beach Dynamics Investigation, Site UXO 16 is the focus. Therefore, the Site UXO16 boundary is shown in red on each of the four maps presented as **Figure 1**.

Figure 2 presents the compilation of the bathymetry data for Vieques performed by CH2M HILL. The Site UXO 16 boundary is also shown in red. Depths are presented in reference to mean seal level (MSL). Coordinates and datum were translated to UTM Zone 20 North, NAD83, meters, because this coordinate system adopted for the project.

Because the data sets were of varying resolution, the contour interval used to generate the map in **Figure 2** varies depending on the resolution of the existing data. In general, the nearshore data are of the highest resolution (e.g., 5 meters) whereas the offshore data are of generally coarser resolution (e.g., 10 – 30 meters). It is important to note that in **Table 1**, references to "posting" in the LiDAR data refers to the smallest anticipated distance between data points during acquisition. It specifically refers to the distance between LiDAR pulses during the survey, although it does not necessarily equate to the data point station at the ground surface due to effects from aircraft altitude changes, clouds, and other factors that may impact actual data point spacing at the ground surface when performing airborne LiDAR surveys. CH2M HILL determined that it was possible to present both of the airborne LiDAR data sets using a 5-meter grid (**Figure 2**) and minimize data gaps in coverage within these data sets, which is sufficient for the current needs of the WAA and Beach Dynamics Investigation.

NOAA nautical charts were used as a quality control (QC) check during the data compilation. The QC check essentially consisted of comparing interpolated water depths on a random basis to the NOAA nautical chart data using an acceptance criterion of ±0.5 meters. In addition, spot soundings collected by CH2M HILL during a site visit the week of March 11, 2013 were also used for QC. The average difference between the 2000 and 2001 LiDAR data and the spot soundings was determined to be ±0.3 meters and ±0.5 meters, respectively. All QC efforts were performed using tide-adjusted data and information.

As evidenced in **Figure 3**, the majority of Site UXO 16 is covered by the available data with the highest resolution. Locations within Site UXO 16 that are covered only by available coarser resolution data are still deemed acceptable for purposes of planning the WAA and Beach Dynamics Investigation because these areas constitute a relatively small percentage of Site UXO 16 and include primarily the outermost extents of the site. If it is determined at a later phase of the WAA or Beach Dynamics Investigation that higher resolution data are desired in a specific location than what is currently available, small, focused bathymetry surveys can be performed in conjunction with other data collection efforts. In so doing, overall costs will be reduced by eliminating the need for new site-wide coverage or separate mobilizations for just bathymetry data collection. **Table 2** presents the estimated percent coverage by each of the reviewed data sets within Site UXO 16 depicted on **Figure 3**.

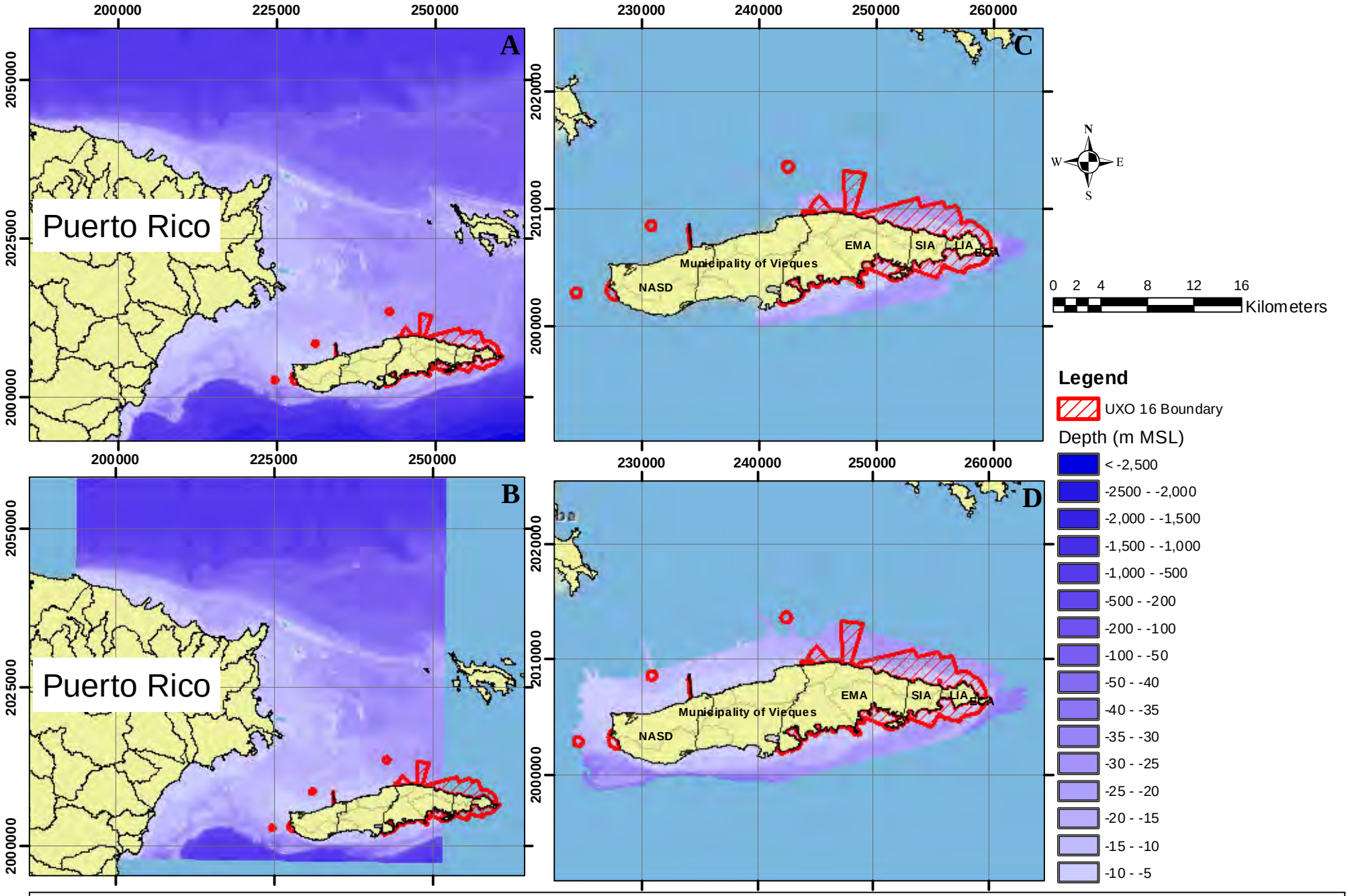
TABLE 2
Existing Bathymetry Data and Estimated Coverage Within Site UXO 16
Vieques, Puerto Rico

Data Set	Spatial Resolution	Estimated UXO16 Coverage
NOAA 1 arc-second DEM Bathymetry	~30m	1%
NOAA 1/3 arc-second DEM Bathymetry	~10m	5%
2000 Airborne LiDAR	5m posting	76%
2001 Airborne LiDAR	5m posting	18%

The review of existing data also determined that the maximum water depth within Site UXO 16 is less than 37 meters (120 feet).

Conclusions

CH2M HILL has determined that existing bathymetry data coverage, resolution, and overall quality are sufficient for planning the side scan sonar survey for the Site UXO 16 WAA and Beach Dynamics Investigation. In addition, the existing bathymetry data will be incorporated into the program GIS.



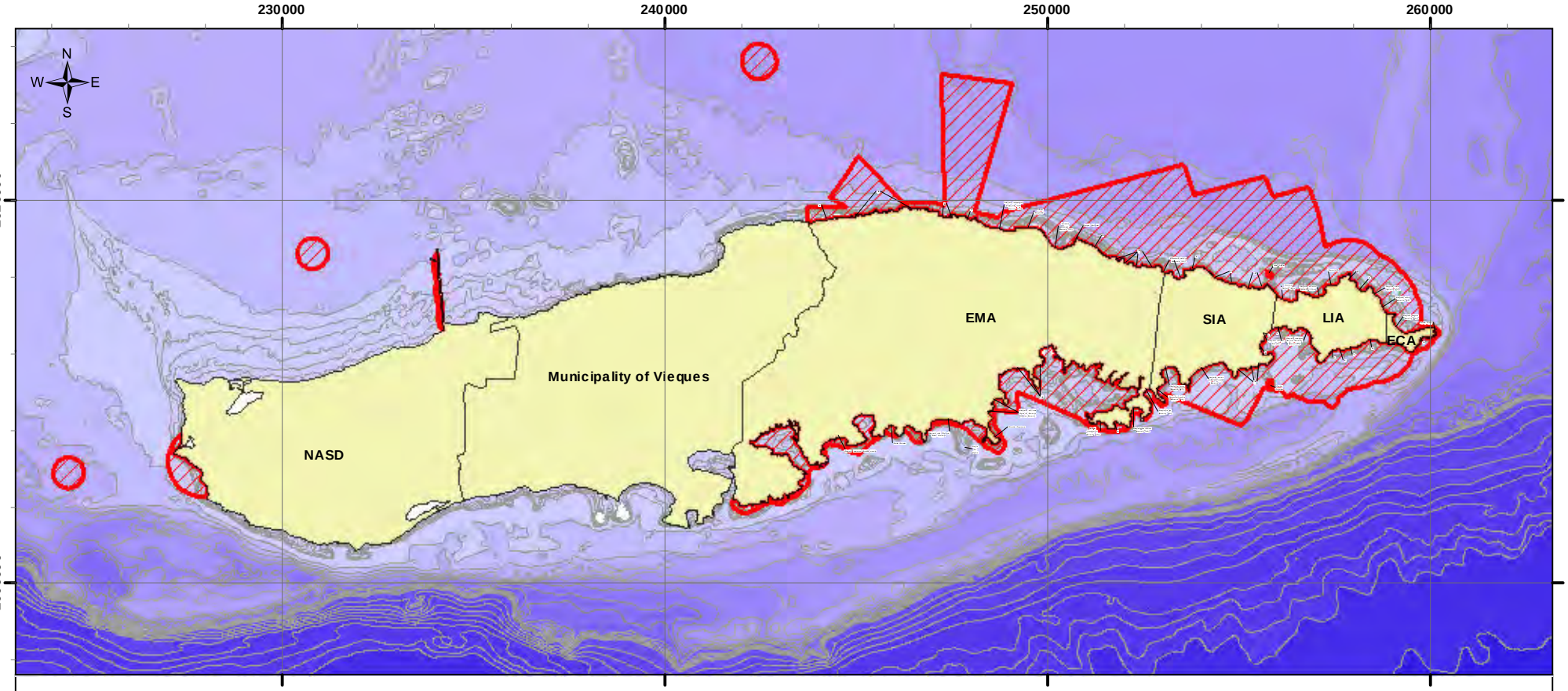
A. NOAA 1 arc-second DEM - 06/22/2007
B. NOAA 1/3 arc-second DEM - 06/22/2007
C. USACE LiDAR 5 m posting- 08/2000
D. USACE LiDAR 5 m posting- 08/2001

Notes:
1. All dimensions are in meters unless otherwise noted

2. Horizontal datum : NAD 1983 UTM 20N
Vertical datum : meters Mean Sea Level (MSL)

Figure 1
Availble Bathymetric Data Coverage
Vieques Puerto Rico

CH2MHILL



0 1.25 2.5 5 7.5 10 Kilometers

Legend

UXO 16 Boundary

Bathymetry Contours

Depth (m MSL)

- < -2,500
- -2500 - -2,000
- -2,000 - -1,500
- -1,500 - -1,000
- -1,000 - -500
- -500 - -200
- -200 - -100
- -100 - -50
- -50 - -40
- -40 - -35
- -35 - -30
- -30 - -25
- -25 - -20
- -20 - -15
- -15 - -10
- -10 - -5

Notes:

1. All dimensions are in meters unless otherwise noted

2. Horizontal datum : NAD 1983 UTM 20N
   Vertical datum : meters Mean Sea Level (MSL)

3. The bathymetry contours are shown as follows:
   From 0 m to 5 m - 1 m intervals
   From 5 m to 50 m - 5 m intervals
   From 50 m to 100 m - 10 m intervals
   From 100 m to 1000 m - 100 m intervals
   From 1000 m to 2000 m - 500 m intervals

Figure 2
Bathymetric Contours
Vieques Puerto Rico

CH2MHILL

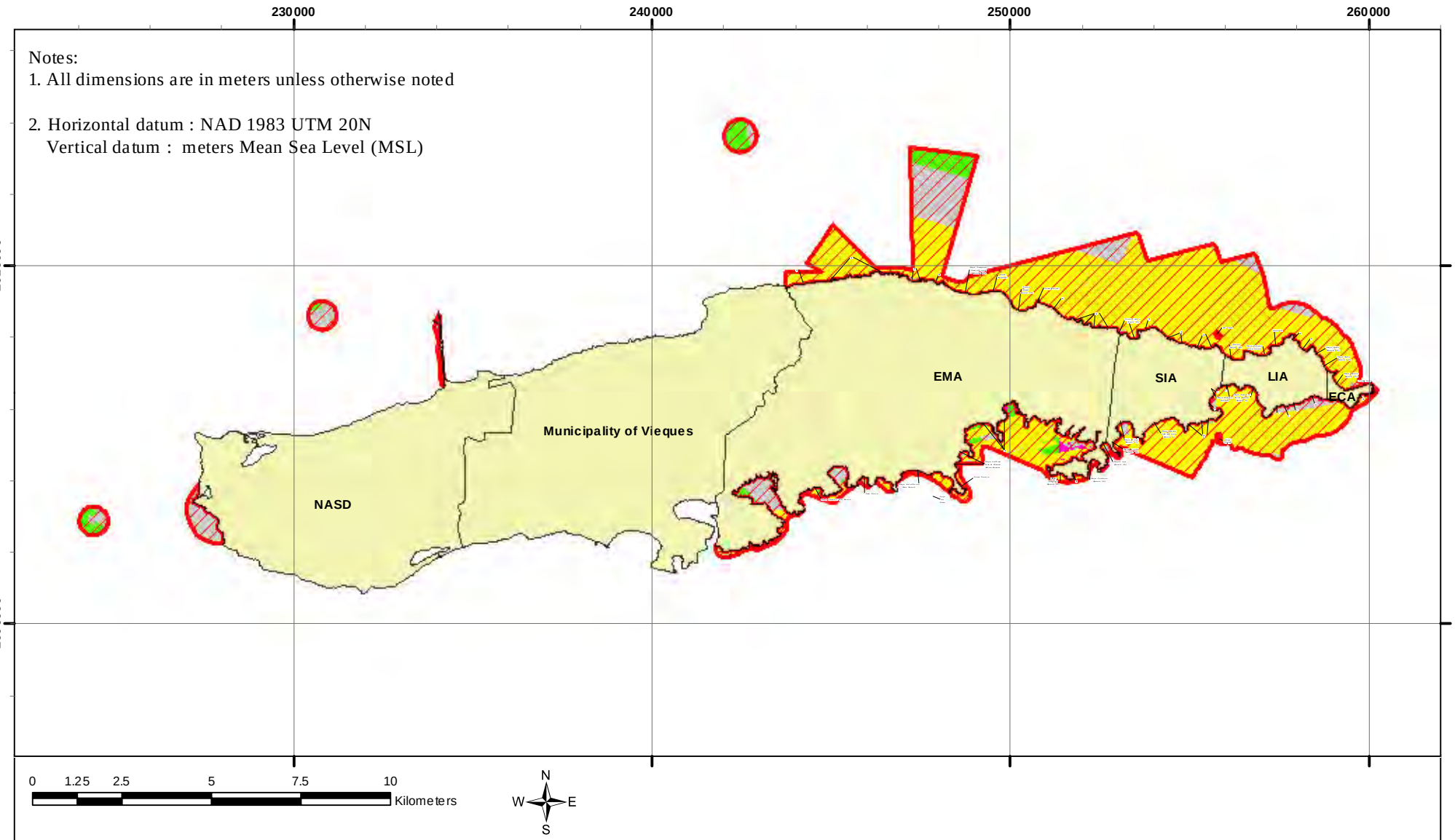


Figure 3
UXO 16 Bathymetric
Coverage and Resolution
Vieques Puerto Rico

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Appendix B
Bathymetry Side Scan Sonar Survey

Side-scan Sonar Survey of UXO 16 Former Atlantic Fleet Weapons Training Area – Vieques Vieques, Puerto Rico

PREPARED FOR:	NAVFAC Atlantic
PREPARED BY:	CH2M HILL
DATE:	August 25, 2015

Introduction

This Technical Memorandum summarizes the side-scan sonar survey activities conducted in support of the Underwater Wide Area Assessment at UXO 16, located at both the Former Naval Ammunition Support Detachment (NASD) and the Former Vieques Naval Training Range (VNTR) in Vieques, Puerto Rico (**Figure 1**). UXO 16 is approximately 11,500 acres in size and includes the underwater areas adjacent to the range and operational areas on East and West Vieques that are known to be or are potentially impacted by munitions. The side-scan sonar survey identified potential underwater obstacles and environmentally sensitive areas (such as coral reefs) across UXO 16, such that the Wide Area Assessment can be appropriately designed; it was not intended to detect individual items or the nature of the obstacles or objects on the sediment surface.

This Technical Memorandum was prepared under the Navy Comprehensive Long-Term Environmental Action (CLEAN) Contract N62470-11-D-8012, Contract Task Order (CTO) 0005, for submittal to the Naval Facilities Engineering Command (NAVFAC) Atlantic Division.

Arc Surveying & Mapping, Inc. of Jacksonville, Florida and Sonographics, Inc. of Wilton Manors, Florida conducted the side-scan survey under the technical oversight of CH2M HILL.

Site Background

Vieques is located in the Caribbean Sea approximately 7 miles southeast of the eastern tip of the main island of Puerto Rico and 20 miles southwest of St. Thomas, U. S. Virgin Islands. Vieques is the largest offshore island of the Commonwealth of Puerto Rico. It is approximately 20 miles long and 4.5 miles wide, and has an area of approximately 33,088 acres (51 square miles) (**Figure 1**).

The Navy purchased portion of Vieques in the early 1940s to conduct military training activities. Operations within the Former VNTR comprised various aspects of naval gunfire training, including air-to-ground ordnance delivery and amphibious landings, as well as housing the main base of operations for these activities at Camp Garcia. Operations within the former NASD consisted mainly of ammunition loading and storage, vehicle and facility maintenance, and general support activities.

UXO 16 comprises the waters surrounding the former VNTR and NASD and several anchoring and offloading areas (**Figure 2**) that are to be assessed under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as agreed to by the United States Navy (Navy), United States Environmental Protection Agency (EPA), the Department of the Interior (DOI), and the Commonwealth of Puerto Rico Environmental Quality Board (PREQB). The areas of assessment include:

- Ship anchoring points and the area immediately adjacent to Mosquito Pier where munitions may have been transferred and offloaded

- Areas where munitions may have been inadvertently fired into the water from naval gun fire or air-to-ground bombing
- Areas where the explosive safety arc from open burning/open detonation activities may have extended into the water.

Limited investigation data have been collected at UXO 16; however, based on the historical information, a remedial investigation (RI) will be conducted for the underwater areas of UXO 16. The initial phase of the underwater investigation was compiling bathymetry data throughout the UXO 16 area. This was followed by conducting a side-scan sonar survey, which is the subject of this Technical Memorandum. The bathymetry data and the side-scan sonar data will be used to plan a wide area assessment to provide a preliminary evaluation of the nature and extent of the underwater munitions.

Water depths in UXO 16 range from approximately 2 feet in near shore areas to approximately 85 feet at the outer boundary of UXO 16 (depths are based on the mean low low water level [MLLW]).

Summary of Field Activities

The side-scan sonar activities were conducted from November 3, 2013 through January 21, 2014 and covered the accessible portion of UXO 16 (nearly 100 percent of UXO 16), along with additional areas to improve productivity and efficiency and support the data collection (**Figure 3)**. The total area surveyed was approximately 13,500 acres. Photographs from the side-scan sonar survey are provided in **Attachment A**.

Equipment

Data positioning was achieved using the Differential Global Positioning System (DGPS) system, using a Hemisphere GPS model VS111. The system is a 12-channel survey-quality unit that receives the United States Coast Guard Beacon transmitted differential corrections to provide sub-meter positions.

The side-scan sonar system employed was the EdgeTech 4200-FS tow-fish, a digital “chirp” simultaneous dual frequency unit. This unit is the stainless steel model and employs the 300 kilohertz (kHz) and 600 kHz frequencies (**Attachment A**). The low frequency channels were turned off to avoid potential impacts with marine mammals. The survey was conducted using the High Speed Mode (HSM).

The position of the tow-fish was calculated using Hypack software and supplied to the side-scan computer by the Hypack computer. A National Oceanic and Atmospheric Administration (NOAA) navigation chart was underlain on the Hypack navigation display with potential hazards highlighted (i.e., coral reefs).

Survey Grids

Due to the size and shape of UXO 16, 11 survey grids were set up that comprised the following (**Figure 3**):

- Southwest Anchorage Area
- Northwest Anchorage Area
- Northeast Anchorage Area
- Punta Boca Quebrada
- Mosquito Pier
- Southeast Area 1
- Southeast Area 2
- Bahia Fanduca
- Northeast Area 1
- Northeast Area 2
- Northeast Area 3

Each survey grid was generally aligned with the coastline in each area with transect spacing 150 feet apart. Where feasible, the horizontal range scale was 100 meters (m) (328 feet) to each side of the sensor, providing a swatch of coverage 200 m (656 feet) wide on each survey line. Line spacing was alternated at 150 feet and 450 feet to provide at least 100 percent redundancy of coverage; this procedure resulted in 200 percent

coverage of the bottom and provided coverage of the nadir area (shadow area under the tow-fish where measurements cannot be provided). Extra transects were run in very shallow areas and where an adjacent line required nadir area coverage or where coverage was less than 200 percent.

The side-scan sonar survey was moved across various survey grids rather than methodically working through one area until completion due to weather conditions and state of the seas. If the swells were low on the north side on a particular day, the shallow areas on the north side became a priority. This efficiently completed the side-scan sonar survey with minimal weather delays.

Areas that could not be surveyed due to shallow depth conditions, coral reefs, and rough sea conditions are shown in **Figure 3**.

Methodology

A 27-foot Mako center console boat was used for the survey with the tow-fish connected to a nylon line that was tied off to a cleat on the boat. The amount of line deployed controlled the depth of the tow-fish so that the altitude above the seafloor was maintained within 10 to 20 % of the sonar range (nominally 10m to 20m), thus providing the optimal 'grazing angle.'

The side-scan sonar survey area included numerous reefs, shoals, and shore lines along the pre-plotted survey lines. The vessel captain observed the bottom conditions from the bow of the vessel as the navigator slowed the progress upon approach to sensitive or otherwise dangerous underwater features. The expertise and caution of the captain and crew resulted in no accidents or instances of grounding either the vessel or the equipment. In addition, no fish traps were caught or run over.

The Navigation Computer with Hypack software provided the helm display to guide the helmsman with the preloaded survey grids. The Hypack program was set up to receive the DGPS antenna positions and output the side-scan tow-fish positions to the side-scan topside computer. The offsets from the antenna to the transducers were measured and entered into the Hypack software. After making these entries, the positions of the antenna and the tow-fish were monitored on the display to confirm that they were positioned properly.

As the vessel docked, a cleat was selected as a reference point to verify the repeatability and integrity of the DGPS and grid data. This verification was performed at the beginning and end of each survey day. Quality control (QC) readings were observed and noted to the QC log including the rub test and wet test of the sonar (discussed in the Quality Control section below). Nearby piers were selected at Esperanza and Fajardo, PR for QC passes with the sonar. At least two passes in opposite directions were performed each day prior to and after survey operations to confirm repeatability of sonar data.

Data Processing and Interpretation

The side-scan sonar data were recorded as native EdgeTech (.jsf) files to hard disk on the computer and backed up on external hard drives. The individual line files were imported into the Chesapeake Technologies SonarWizMap program where they were smoothed navigationally and adjusted with time variable gain and bottom tracking. The water column was removed and formed into geo-referenced tiff images. Features of 1 meter or more in height were marked, measured and added to DXF files. QC passes by the pier were processed in the same manner and a common point position on the pier was recorded to the QC logs. All maps and images were projected using WGS84, Universal Transverse Mercator (UTM), Zone 20 north, meters.

Summary of Results

Sonar mosaics (geo-tiffs) with the targets identifying the 1 meter or greater vertical change on the seafloor for UXO 16 are included in **Attachment B**; these features are shown in **Figure 4**. Most target features were observed along the shoreline, islands, reefs, and shoals primarily in shallow water. Several known shipwrecks and sunken boats were also mapped. The mid to deep water was generally devoid of bottom relief. In total, 1,622 potential hazards to the underwater digital geophysical mapping (DGM) equipment

were observed; each of these were classified as “ledges, ridges, and/or shoals, and miscellaneous features (indistinguishable between natural or man-made features), as follows:

Survey Area	Total Potential Hazards
Southwest Anchorage Area	24
Northwest Anchorage Area	0
Northeast Anchorage Area	0
Punta Boca Quebrada	175
Mosquito Pier	7
Southeast Area 1	314
Southeast Area 2	456
Bahia Fanduca	5
Northeast Area 1	153
Northeast Area 2	363
Northeast Area 3	125

Quality Control

Each daily pre and post survey position taken at the cleat on the dock in Esperanza and Fajardo was recorded in the Daily Quality Control Report (**Attachment C**) along with a running average of the previous positions. The side-scan sonar system tests and acceptance criteria used are summarized in **Table 1**.

TABLE 1
Side-Scan Sonar System Tests and Acceptance Criteria

Test	Test Description	Acceptance Criteria	Beginning of Day	During Survey
1	GPS Position Test	Positions are repeatable to better that 1.0 m	x	
2	GPS Differential Corrections Suitability	Age of Differential corrections will be <20 seconds		x
3	GPS Dilution of Precision (DOP)	Dilution of Precision will be <2.5		x
4	Side-scan Maintenance and Calibration checks	Pursuant to system manual	X	
5	Wet Test	Starboard and port channels are operating properly	x	x
6	Confidence checks	Qualitative repeatability of response to targets approaching range scale limits		X

Navigation System

The following specifications were met for the DGPS:

- The DGPS receiver aboard the vessel was configured such that satellites below 8 degrees above the horizon were not used for positional computations.
- The age limit of pseudo-range corrections was set to 20 seconds such that if the limit were exceeded, the DGPS data string would report “stand alone” vs. “differential” position to the Hypack computer; the Hypack computer was set to show an alarm and ignore non-differential positions.
- HDOP was monitored and recorded and an alarm was set to not exceed 2.5 nominally; satellite geometry alone is not a sufficient statistic for determining horizontal positioning accuracy. A low HDOP value represents a better positional precision due to the wider angular separation between the satellites used to calculate the position. A nominal value of 2.5 or below is appropriate precision for the data collected. There were two instances of the HDOP exceeding 2.5 nominally; in the first instance, work was stopped and the survey line was restarted after the HDOP returned to an acceptable state; in the other instance, the start of a line was delayed until an acceptable state was achieved.
- A minimum of five satellites were used to compute all positions, which was monitored by the Hypack program.

The HDOP, number of satellites and DGPS mode were all continuously recorded in the Hypack throughout the survey.

Side Scan Sonar System

The following specifications were met for the side-scan sonar system:

- Side-scan maintenance and calibration checks were performed prior to the start of the survey. There were no instances of the side-scan sonar system out of specifications, including the Data Link, 48 volt tow-fish power, 400 volt tow-fish power, Ambient tow-fish temperature, cable current, error count, and CPU activity.
- A rub test and wet test were performed at the dock prior to departure to ensure all channels are operating and detecting targets; the side-scan system is turned on and lightly rubbed by hand until a dark line appears on the monitor screen. In this manner, the system circuitry is checked, confirming that the system is functioning properly. All rub and wet tests passed.
- Two confidence check targets were selected near the range limit each day and their positions were recorded in the Data Quality Control Report. The sonar output was continuously monitored for interference with data quality such as from sea state, surface clutter, thermal layering, and other possible sources of interference with data quality.

The tow-fish position was displayed on the screen for both the helmsman and the sonar operator. The distance off line, which was prominently displayed, was the full time task of the helmsman to keep it within 8 meters of the track-line. The track-lines were reviewed at the end of each day to determine if any gaps needed to be covered. Several intermediate lines were run to fill in any areas that appeared as potential gaps in the 100 percent coverage.

Figures

R:\USNAVFACENGCOM405450\VIEQUES\MAPFILES\SIDE_SCAN_SONAR_INVESTIGATION\FIGURE 1 - REGIONAL LOCATION MAP.MXD CELEFTHERIADIS 10/10/2013 4:16:50 PM

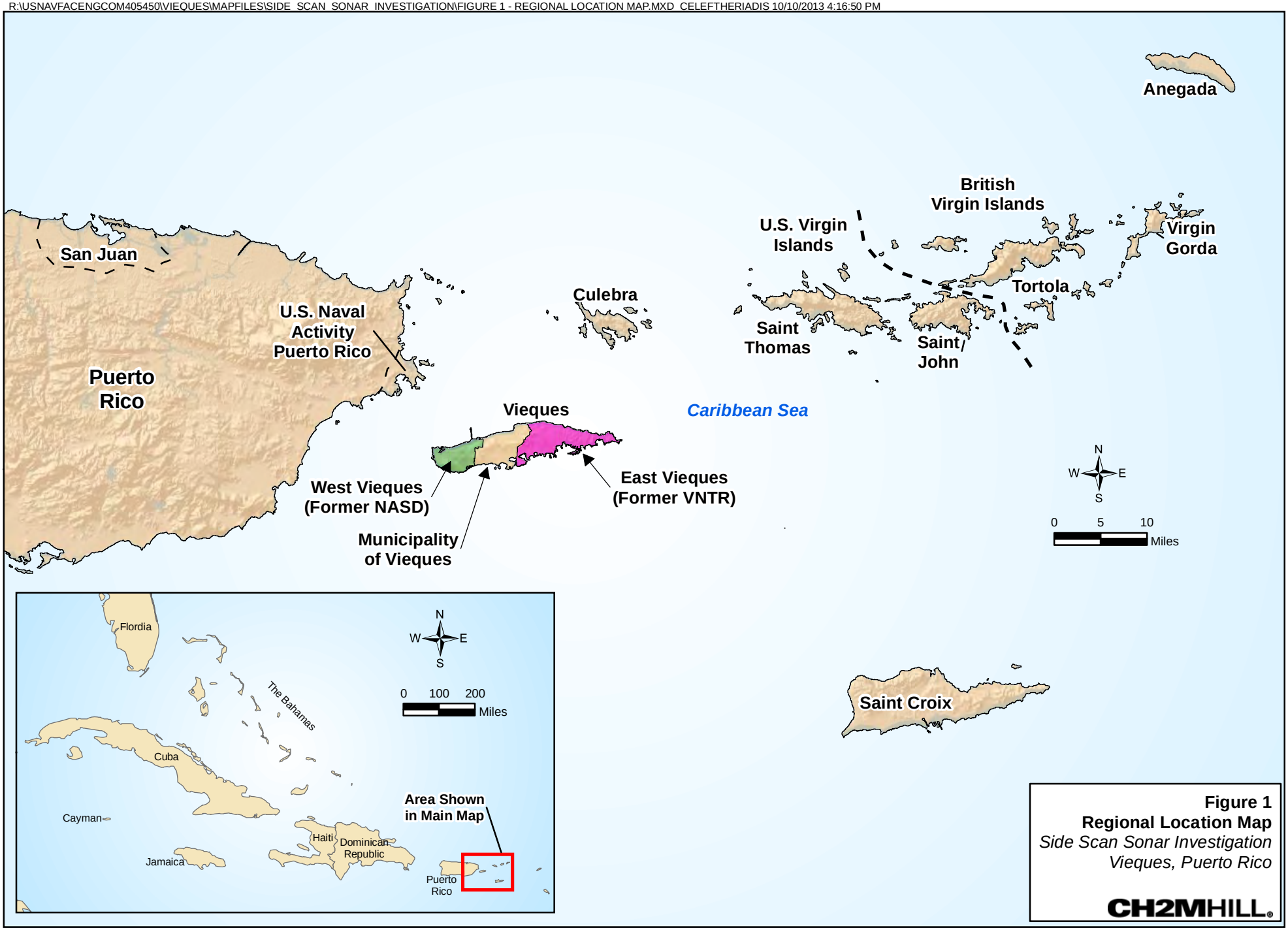

Figure 1
Regional Location Map
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

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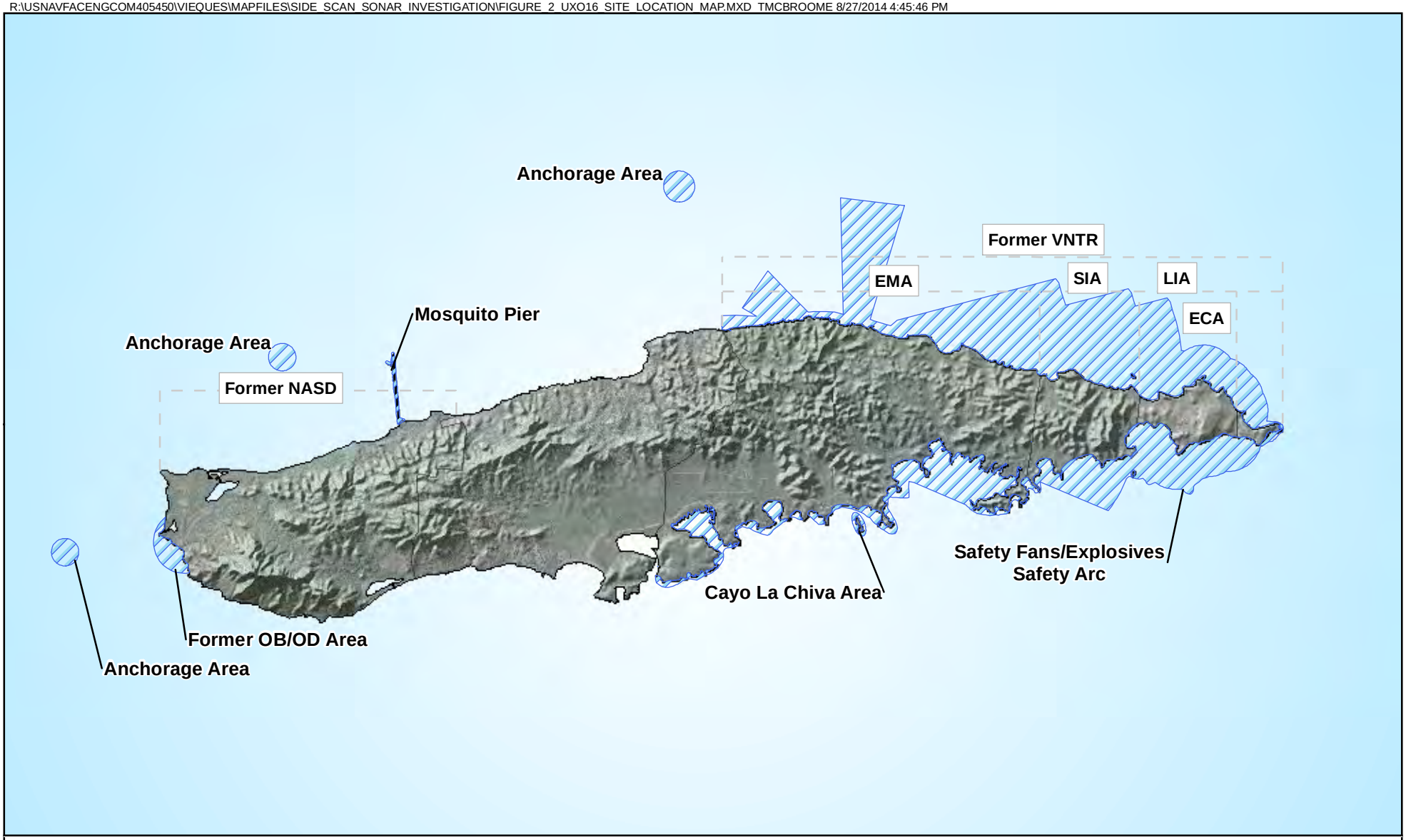

Legend

UXO 16

ECA - Eastern Conservation Area
EMA - Eastern Maneuver Area
SIA - Surface Impact Area
LIA - Live Impact Area

N
W E
S

0 2.5 5
Miles

Figure 2
UXO 16 Site Location Map
Side Scan Sonar Investigation
Vieques, Puerto Rico

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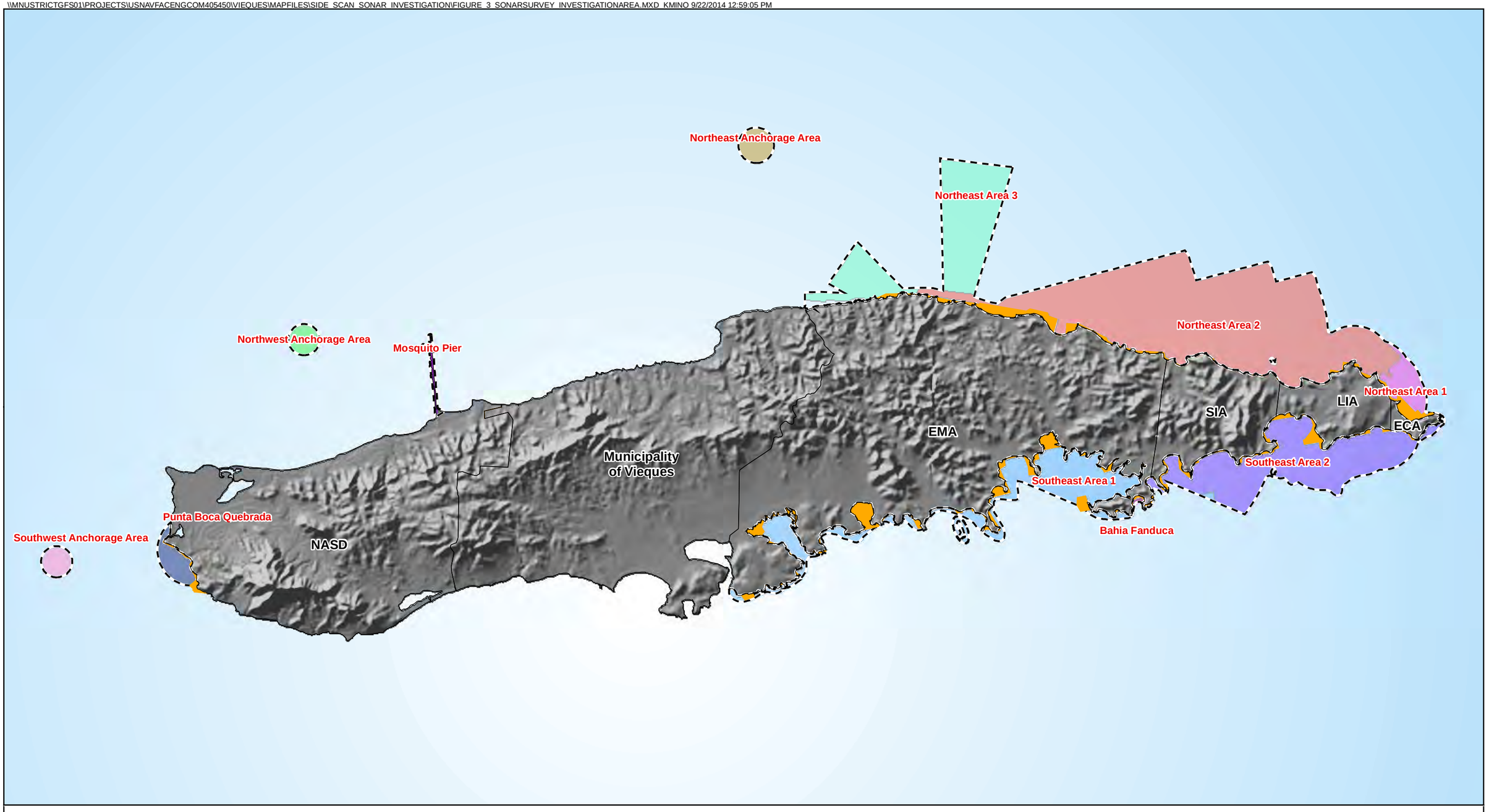
\\MNUSTRICTGFS01\PROJECTS\USNAVFACENGCOM405450\VIEQUES\MAPFILES\SIDE_SCAN_SONAR_INVESTIGATION\FIGURE_3_SONARSURVEY_INVESTIGATIONAREA.MXD KMINO 9/22/2014 12:59:05 PM



Legend

- Site Boundary
- UXO 16 Boundary
- Side scan sonar survey could not be conducted in area due to shallow depth conditions, reefs, and/or rough sea conditions

N
W E
S

0 1.5 3
Miles

Figure 3
Side Scan Sonar Survey Investigation Area
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

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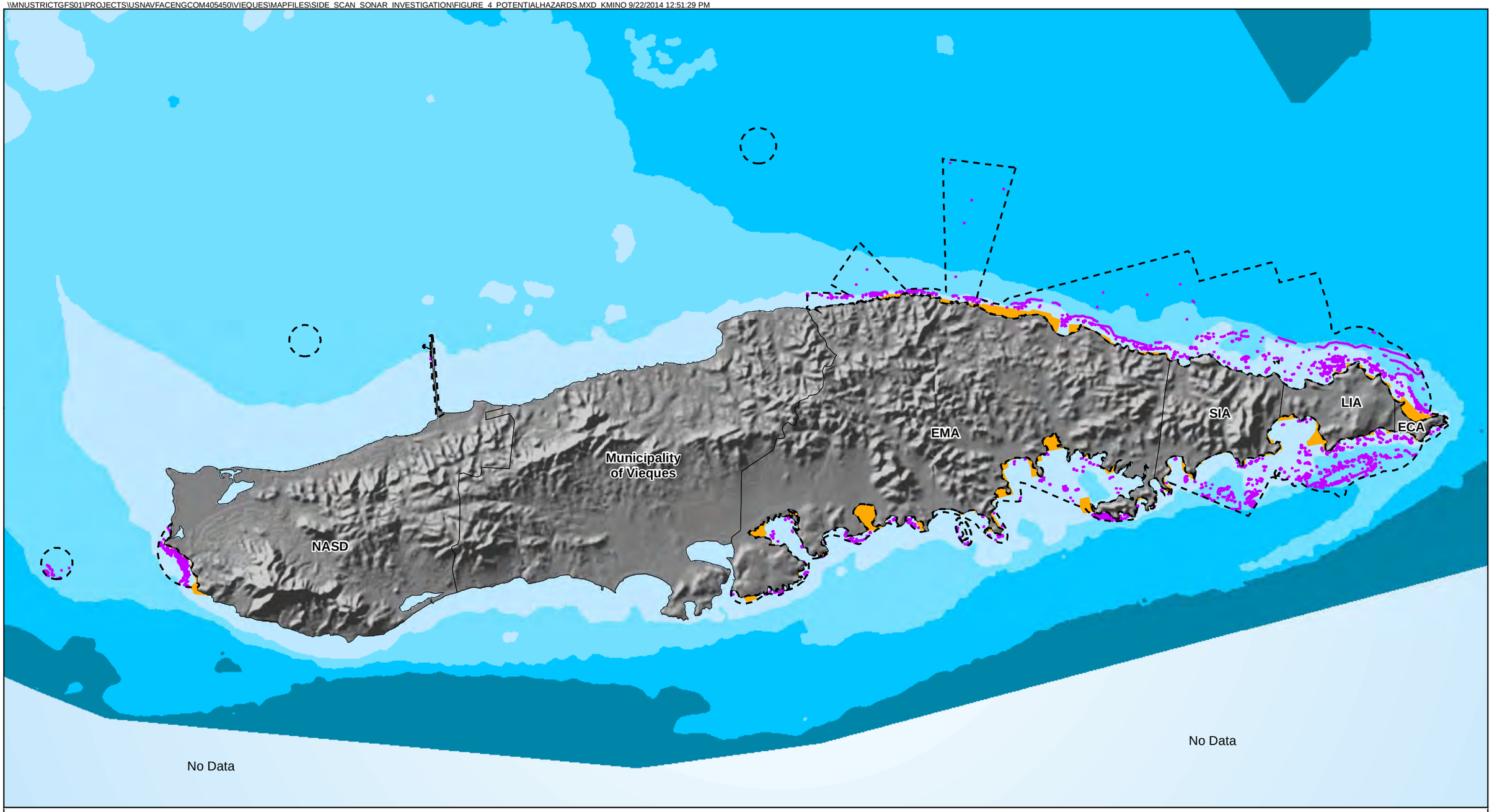

Legend

Site Boundary

Underwater Depth (feet)

0 - 30
30 - 60
60 - 120
120 - 164

Areas Identified with 1 meter or Greater Vertical Change on the Seafloor

Side scan sonar survey could not be conducted in area due to shallow depth conditions, reefs, and/or rough sea conditions

UXO 16 Boundary

N
W E
S

0 1.5 3
Miles

Figure 4
Potential Hazards Identified during Side Scan Sonar Survey
Side Scan Sonar Investigation
Vieques, Puerto Rico

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Attachment A
Photos

Photo 1 – EdgeTech 4200-FS side scan sonar system

Photo 2 – Side scan sonar tow-fish

Photo 3 – Survey vessel at pier in Esperanza

Photo 4 – Deployment of the side scan sonar tow-fish

Photo 5 – Side scan sonar computer in foreground and navigation computer in background

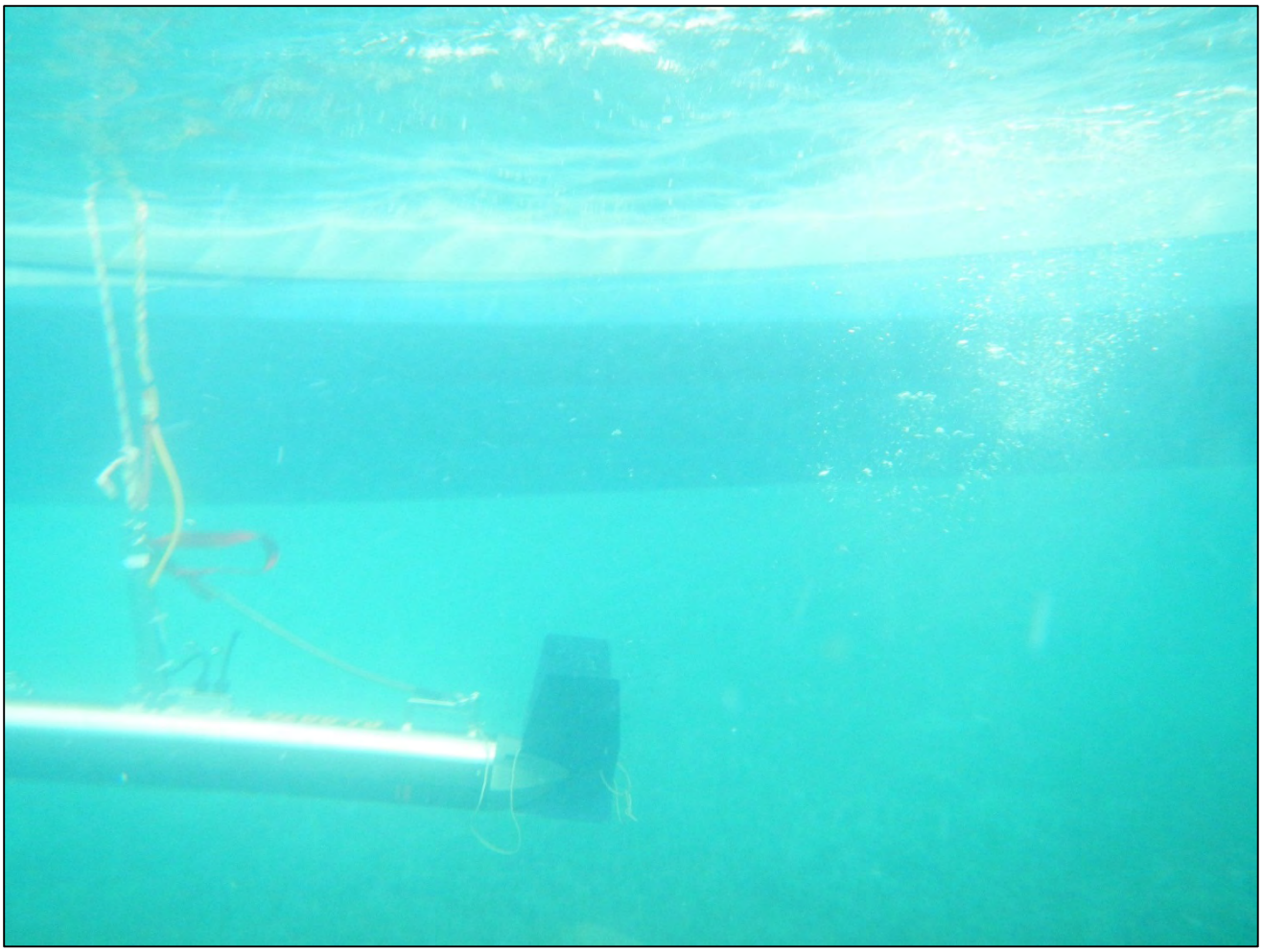


Photo 6 – Side scan sonar tow-fish underwater


YAMAHA
250
HONDA
EdgeTech

Attachment B
Sonar Mosaics

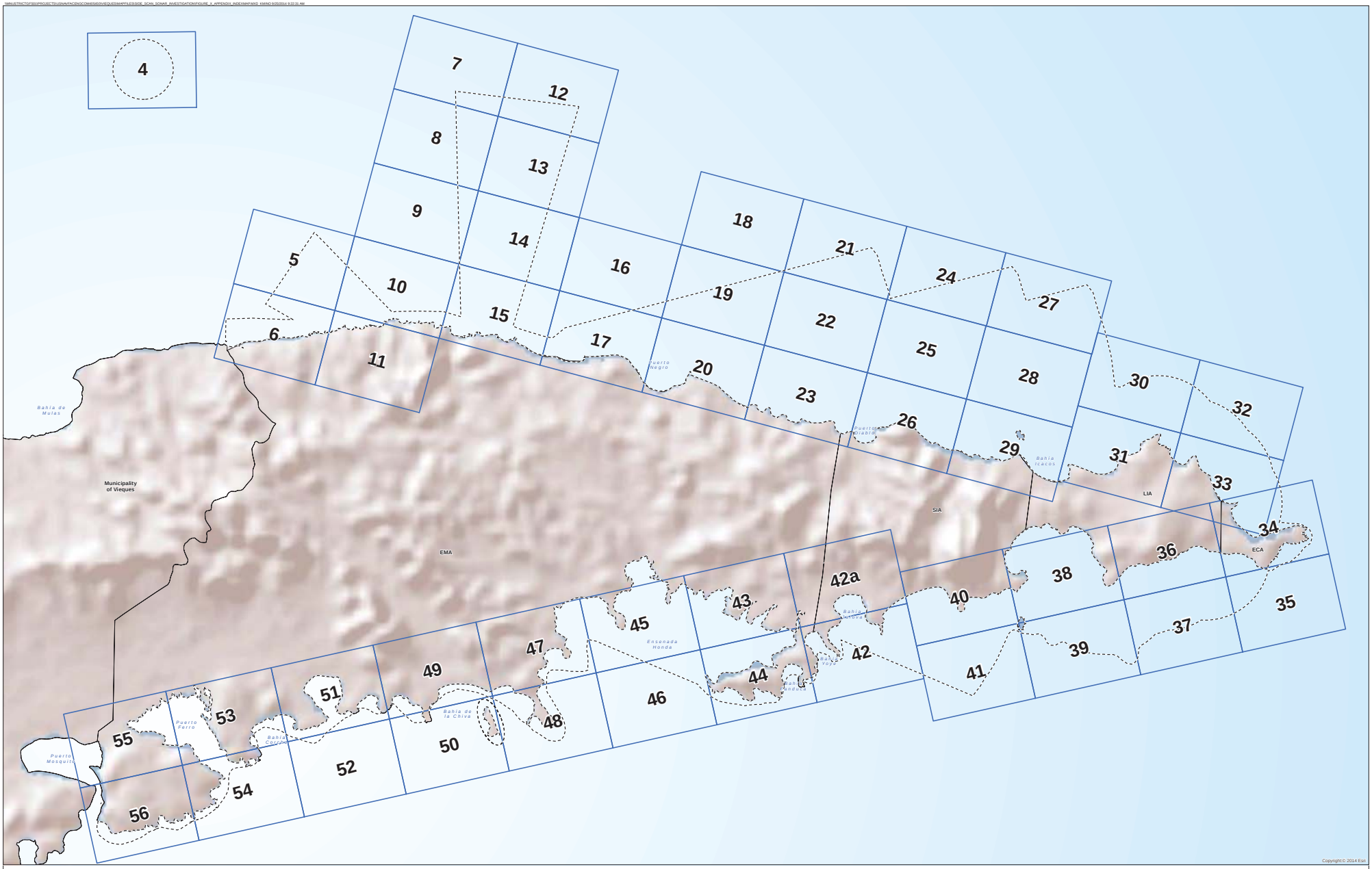
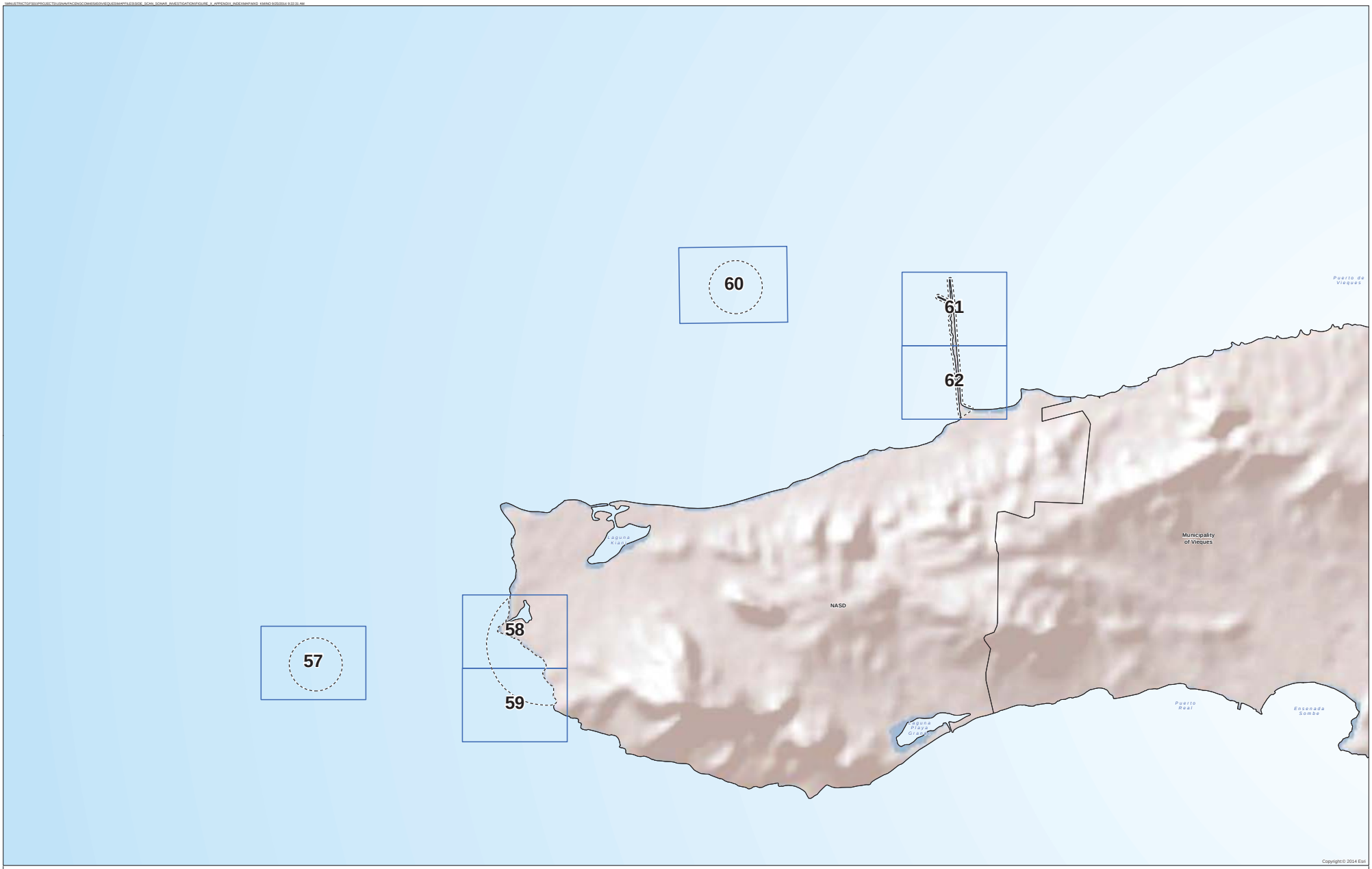


Figure 1
Map Index – Former VNTR
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Map Sheet

N
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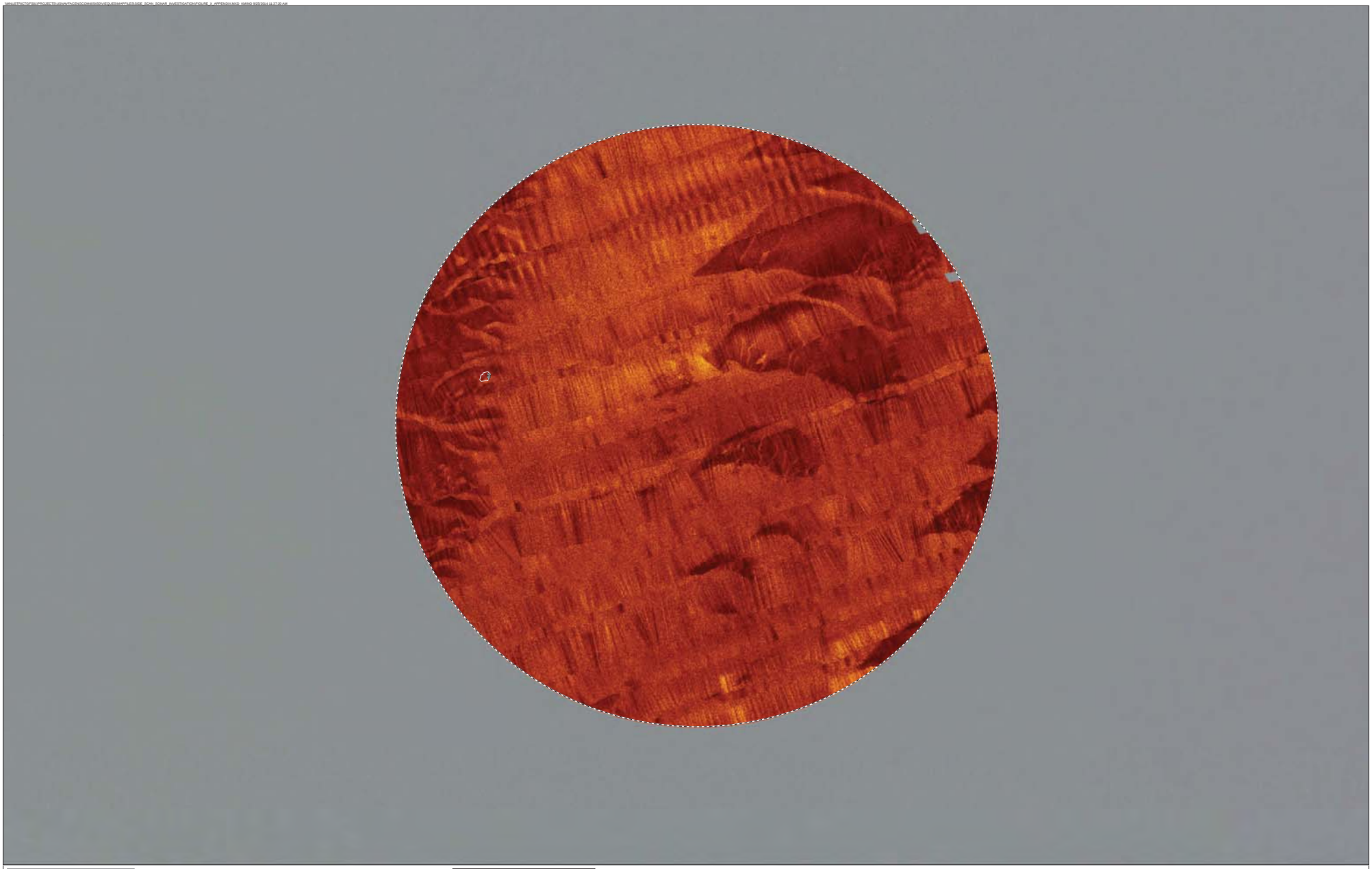
0 2,000 4,000
Feet

Figure 2
Map Index – Former NASD
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

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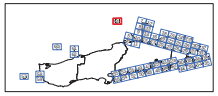
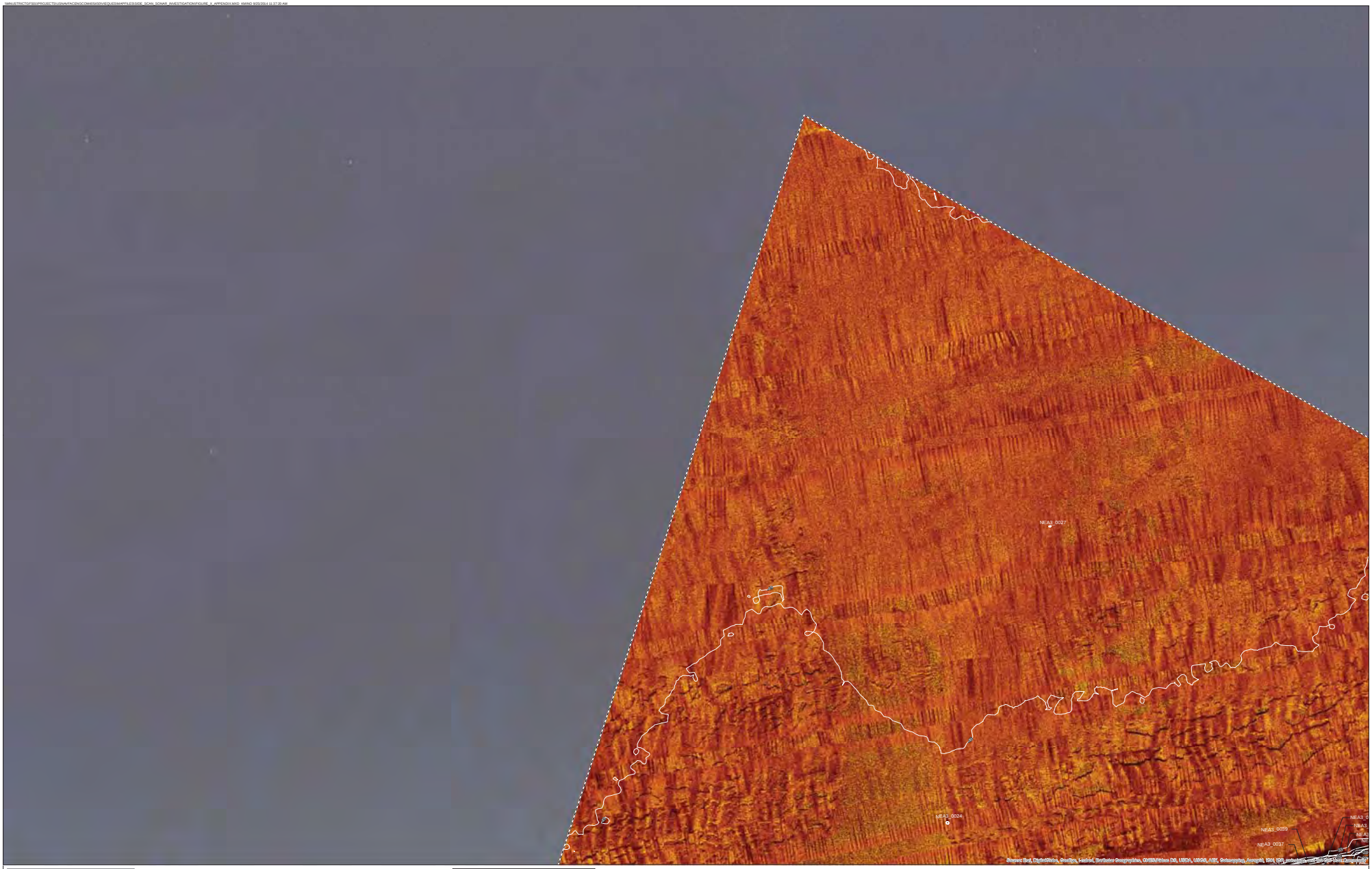
0 200 400
Feet



Side Scan Sonar Survey - Map 4
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

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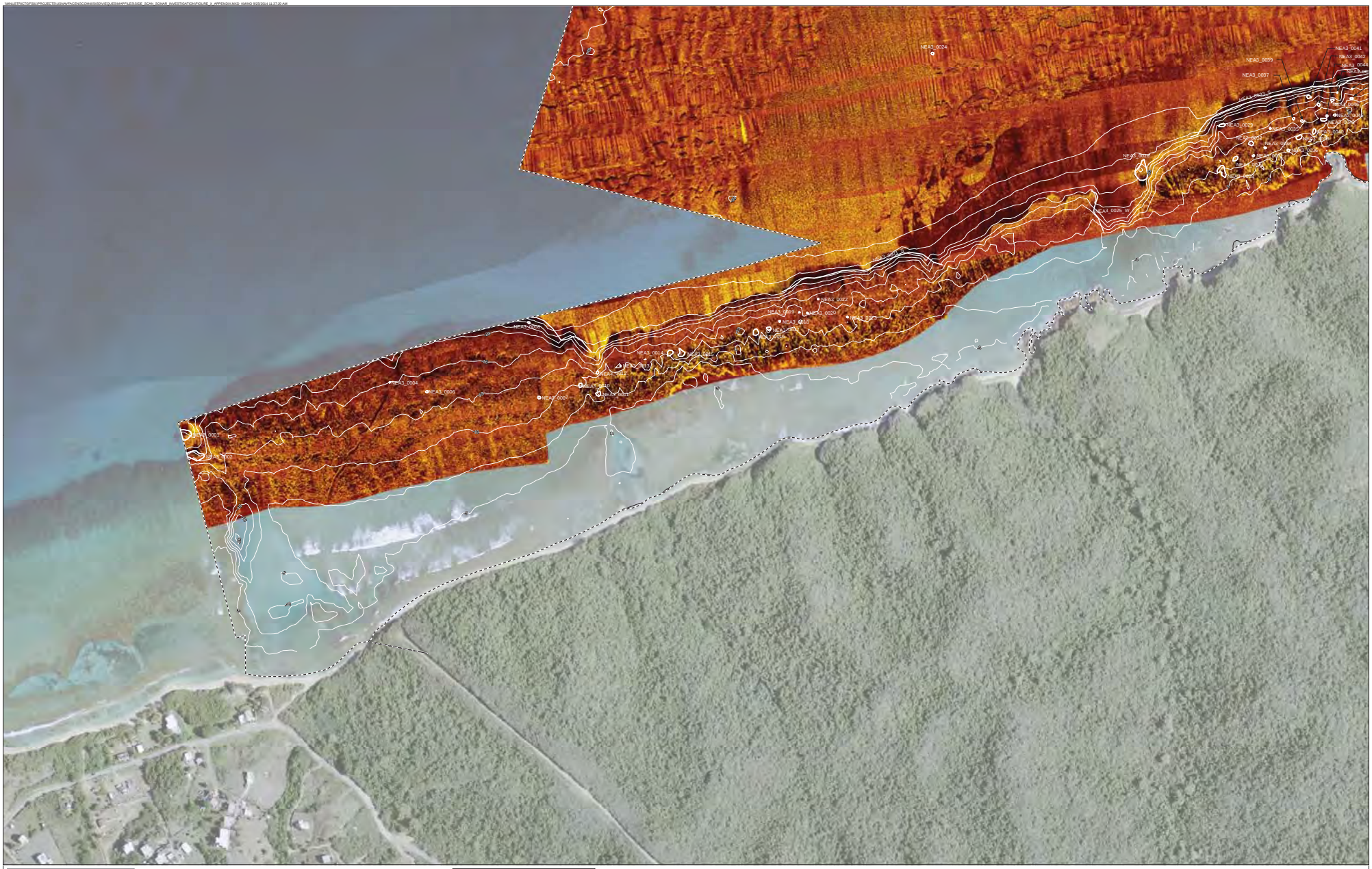
0 200 400
Feet

Side Scan Sonar Survey - Map 5
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Side Scan Sonar Survey - Map 6
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
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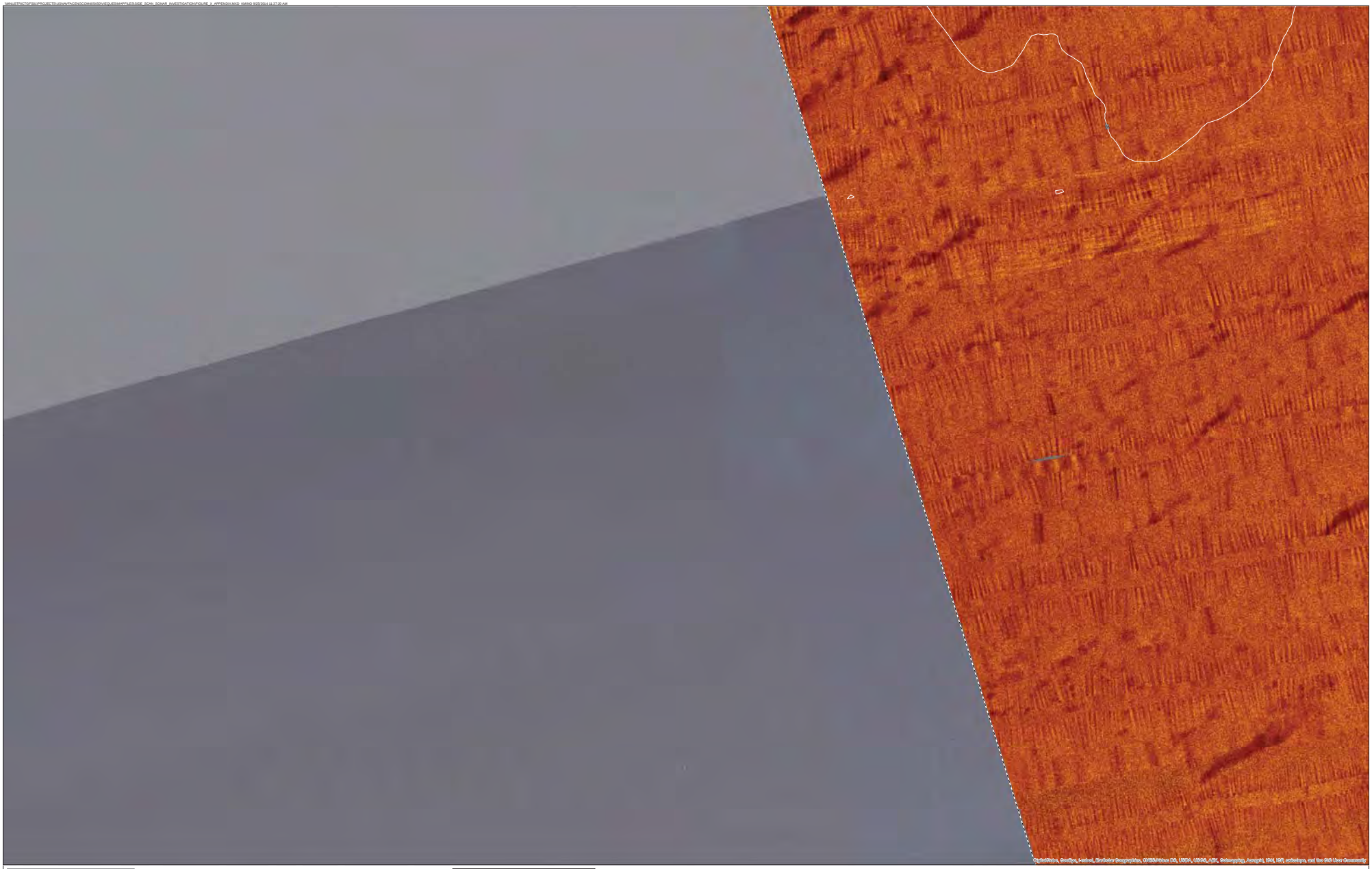
0 200 400
Feet

Side Scan Sonar Survey - Map 7
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Side Scan Sonar Survey - Map 8
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

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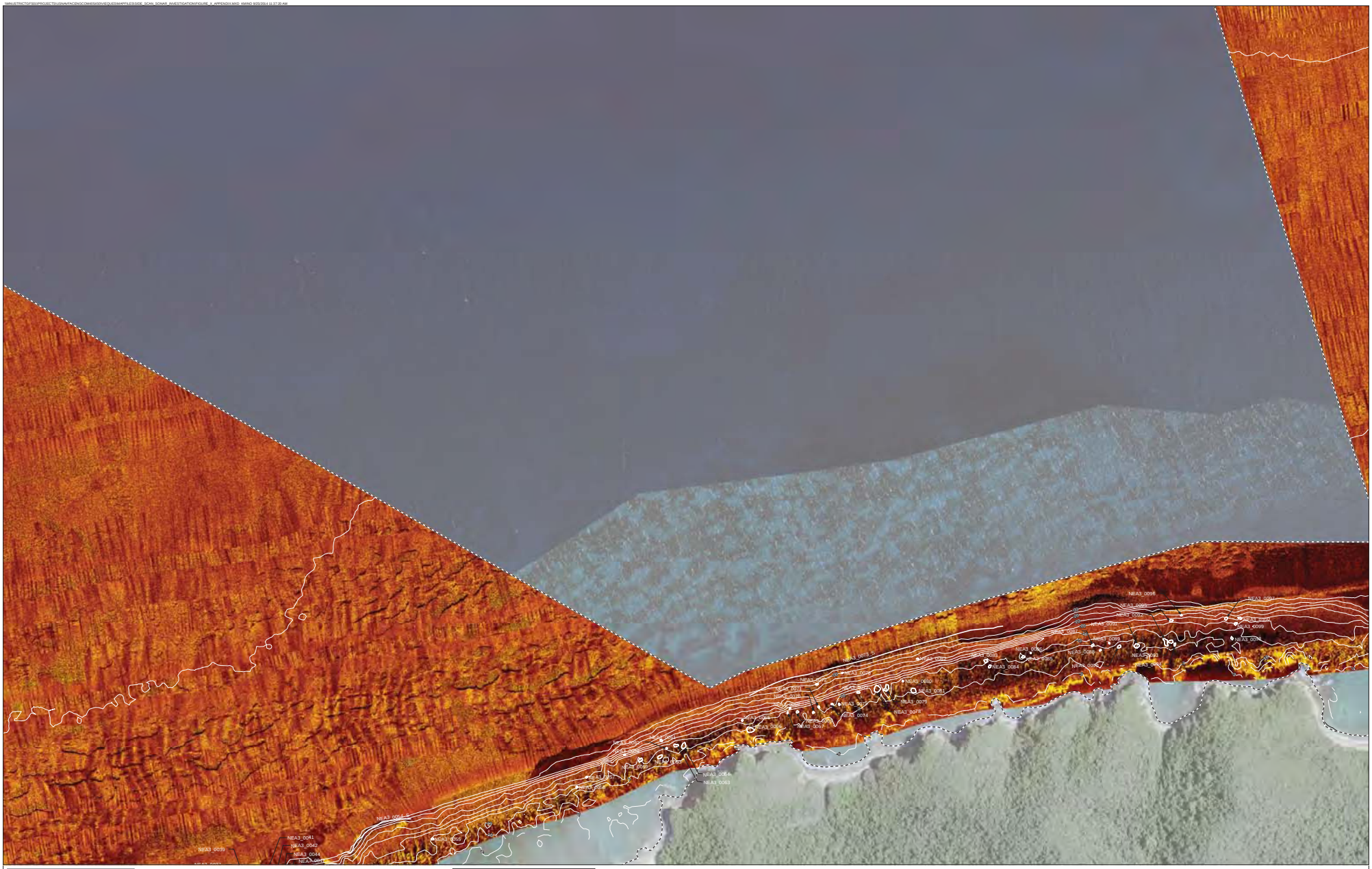
0 200 400
Feet

Side Scan Sonar Survey - Map 9
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

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W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 10
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

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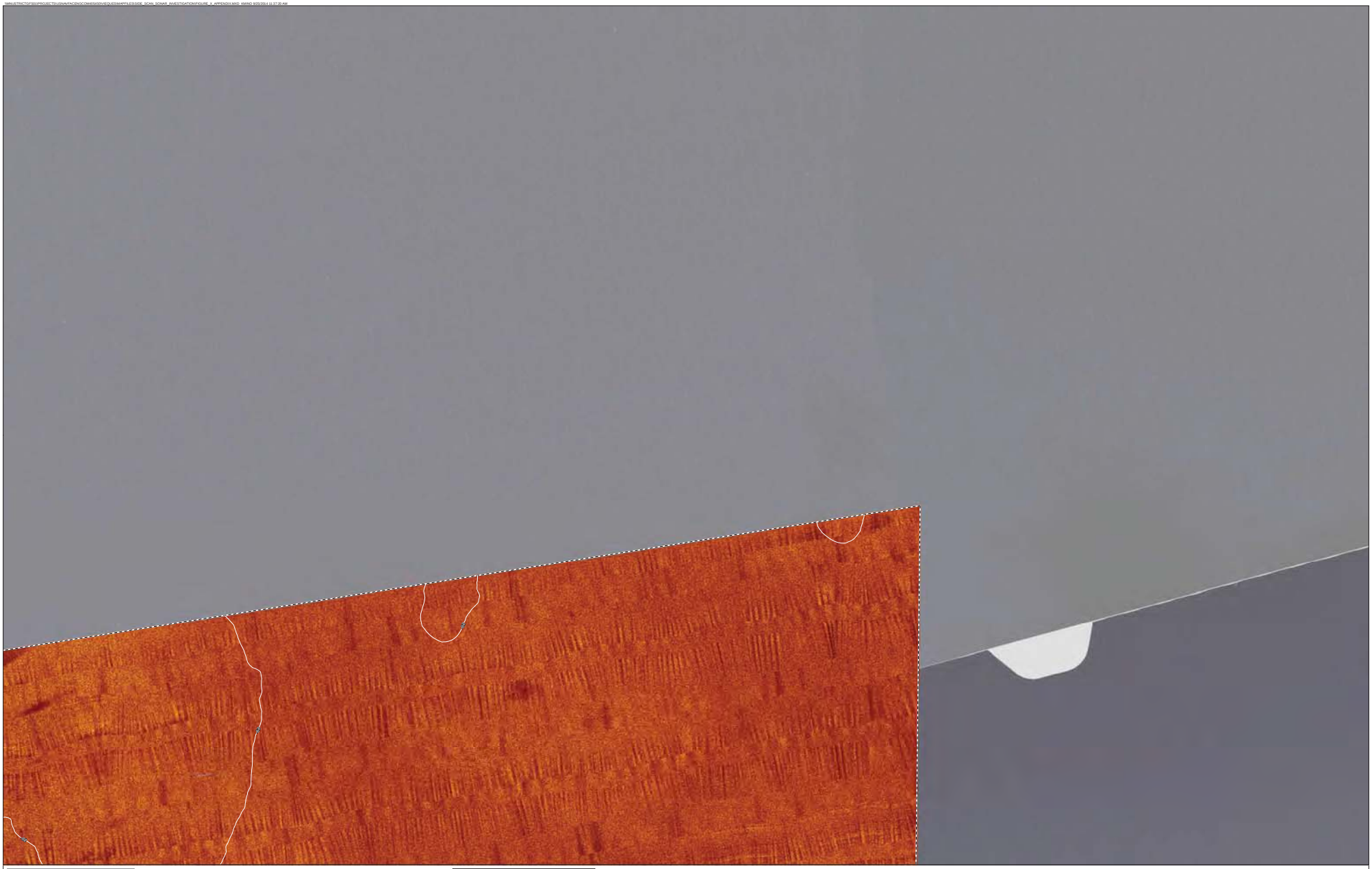
Feet

Side Scan Sonar Survey - Map 11
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

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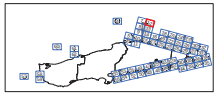
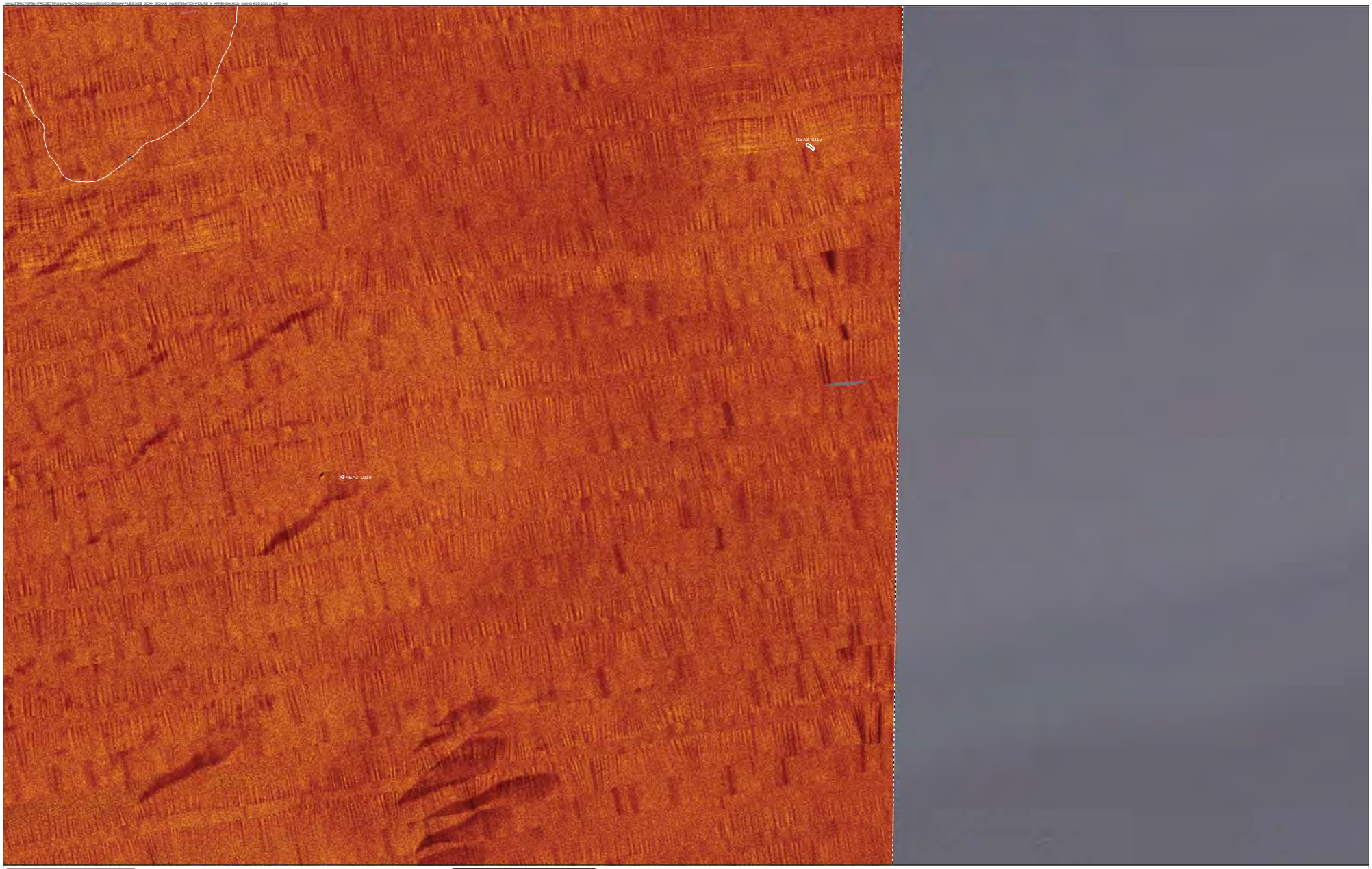
Feet



Side Scan Sonar Survey - Map 12
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

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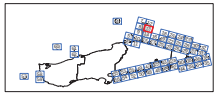
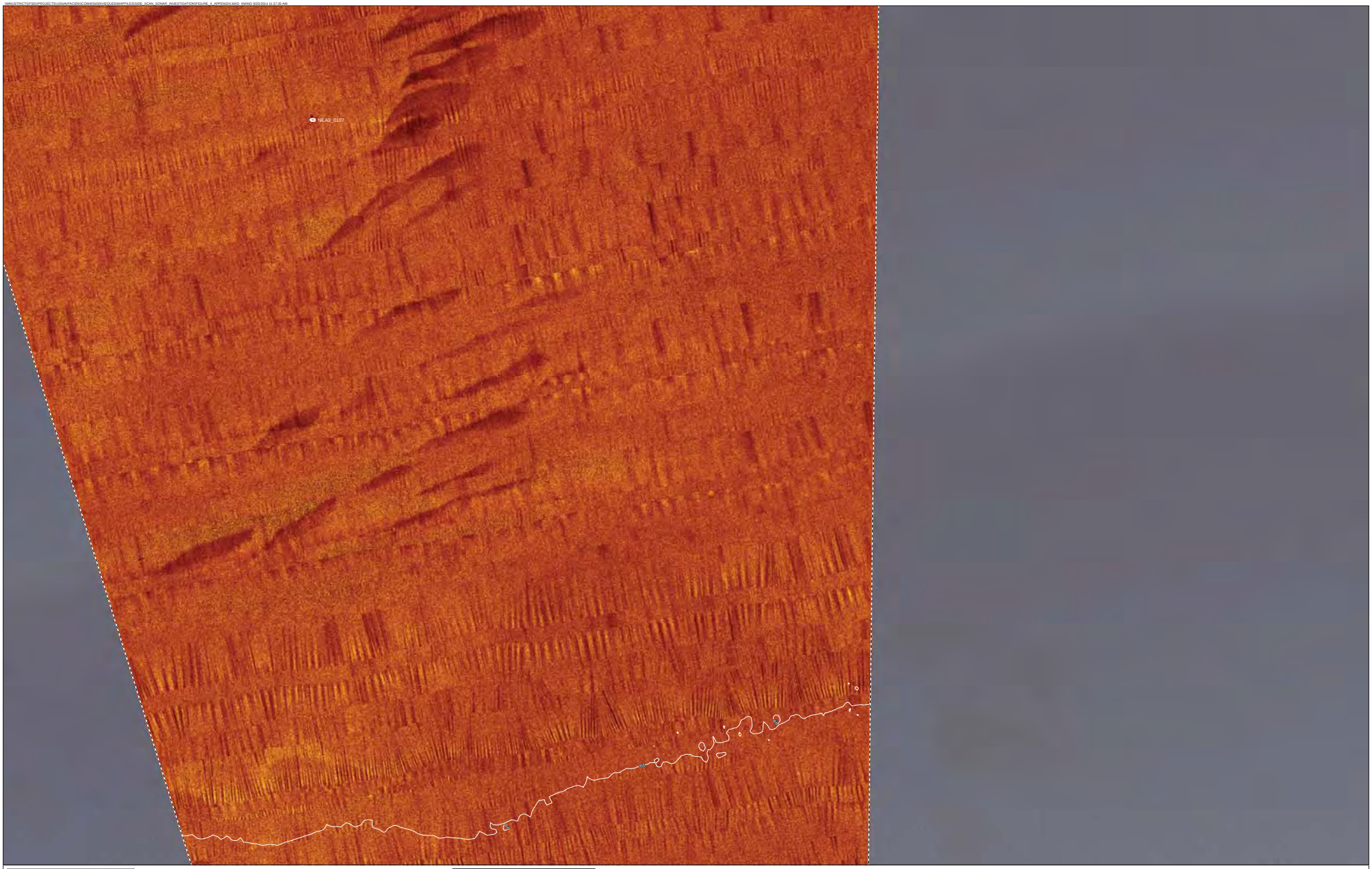
Feet



Side Scan Sonar Survey - Map 13
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

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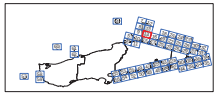
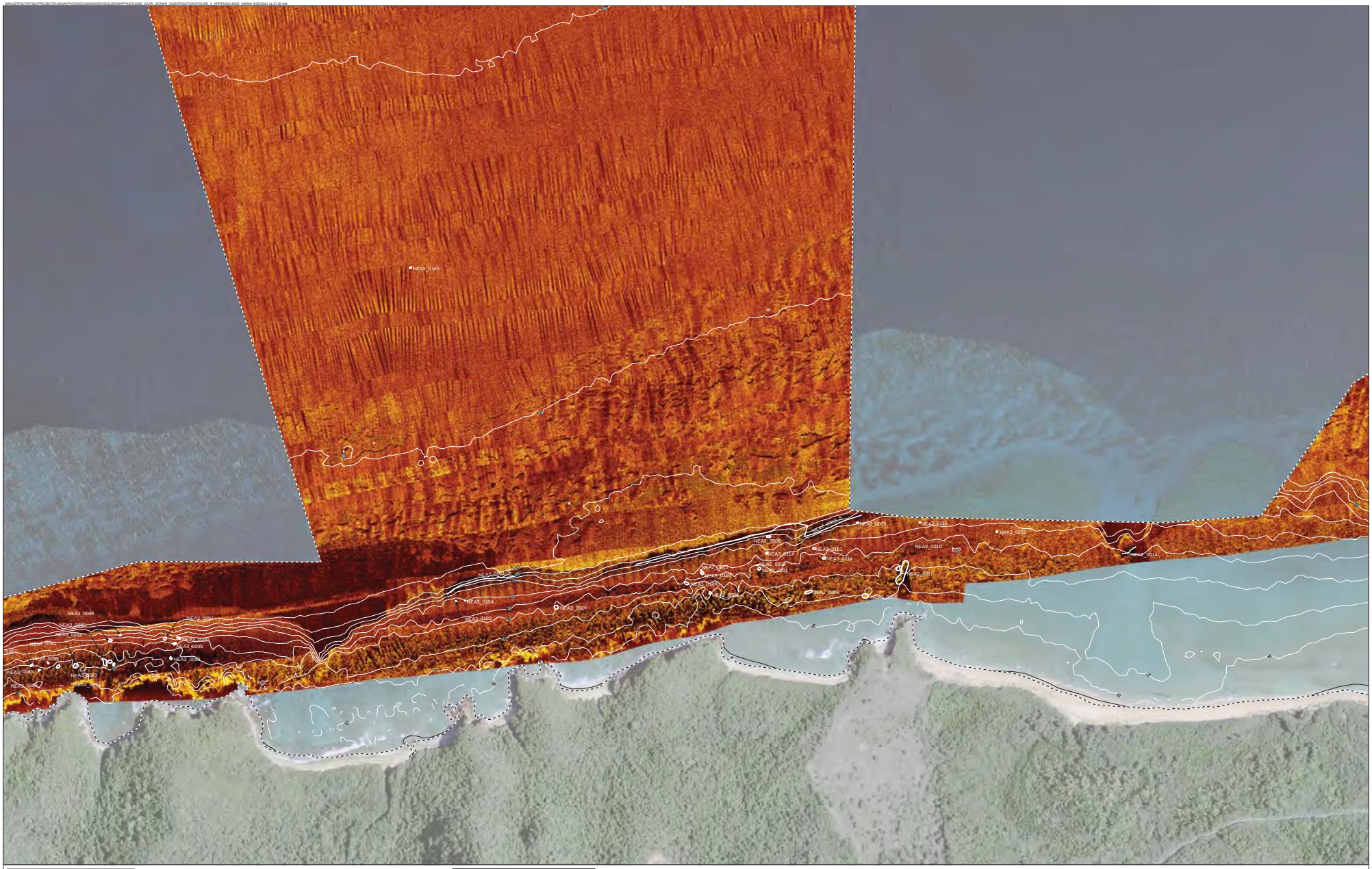
Feet



Side Scan Sonar Survey - Map 14
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
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0 200 400
Feet

Side Scan Sonar Survey - Map 15
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

N
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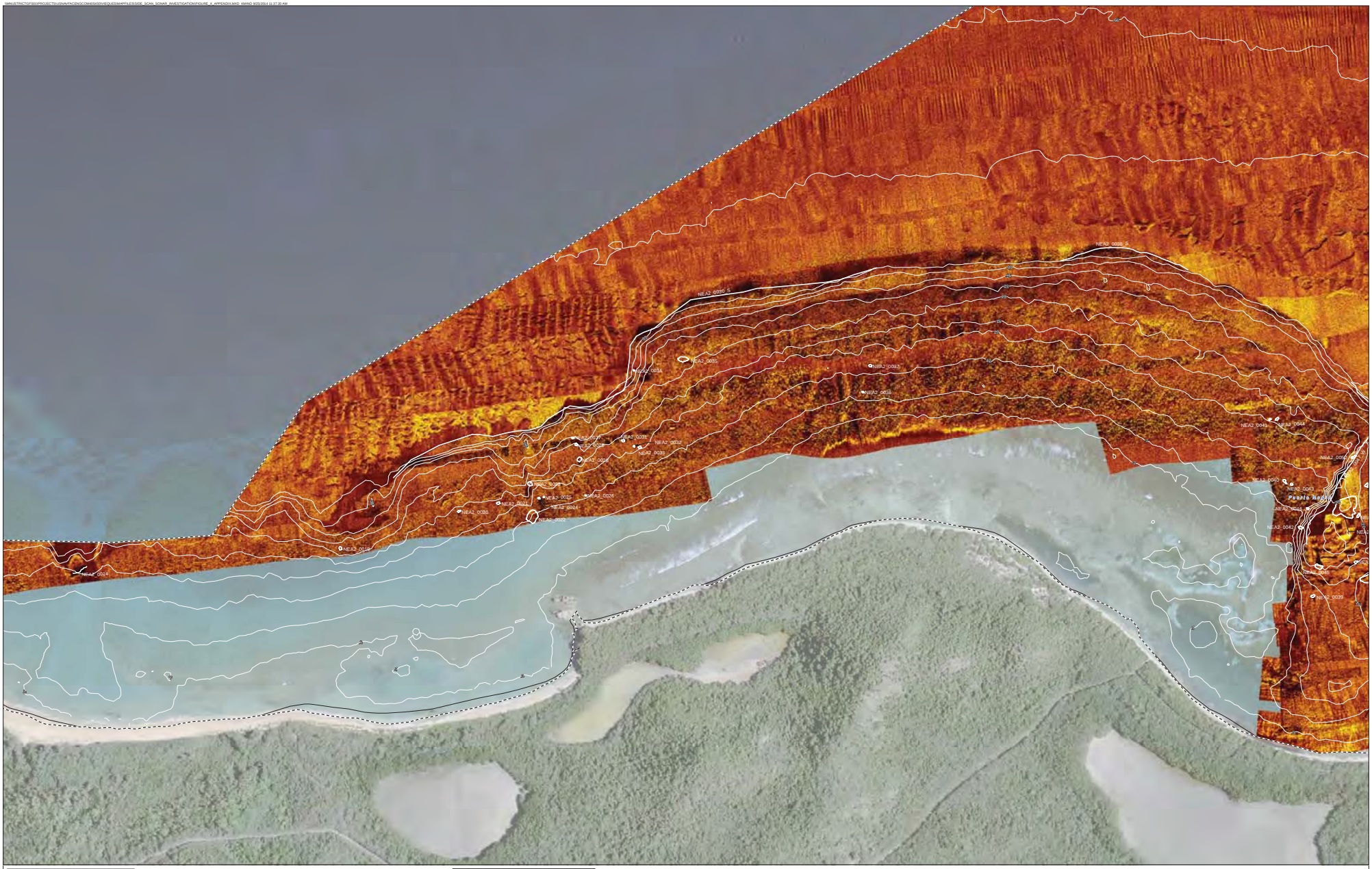
0 200 400
Feet

Side Scan Sonar Survey - Map 16
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Side Scan Sonar Survey - Map 17
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
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Feet

Side Scan Sonar Survey - Map 18
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

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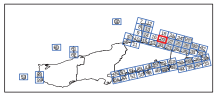
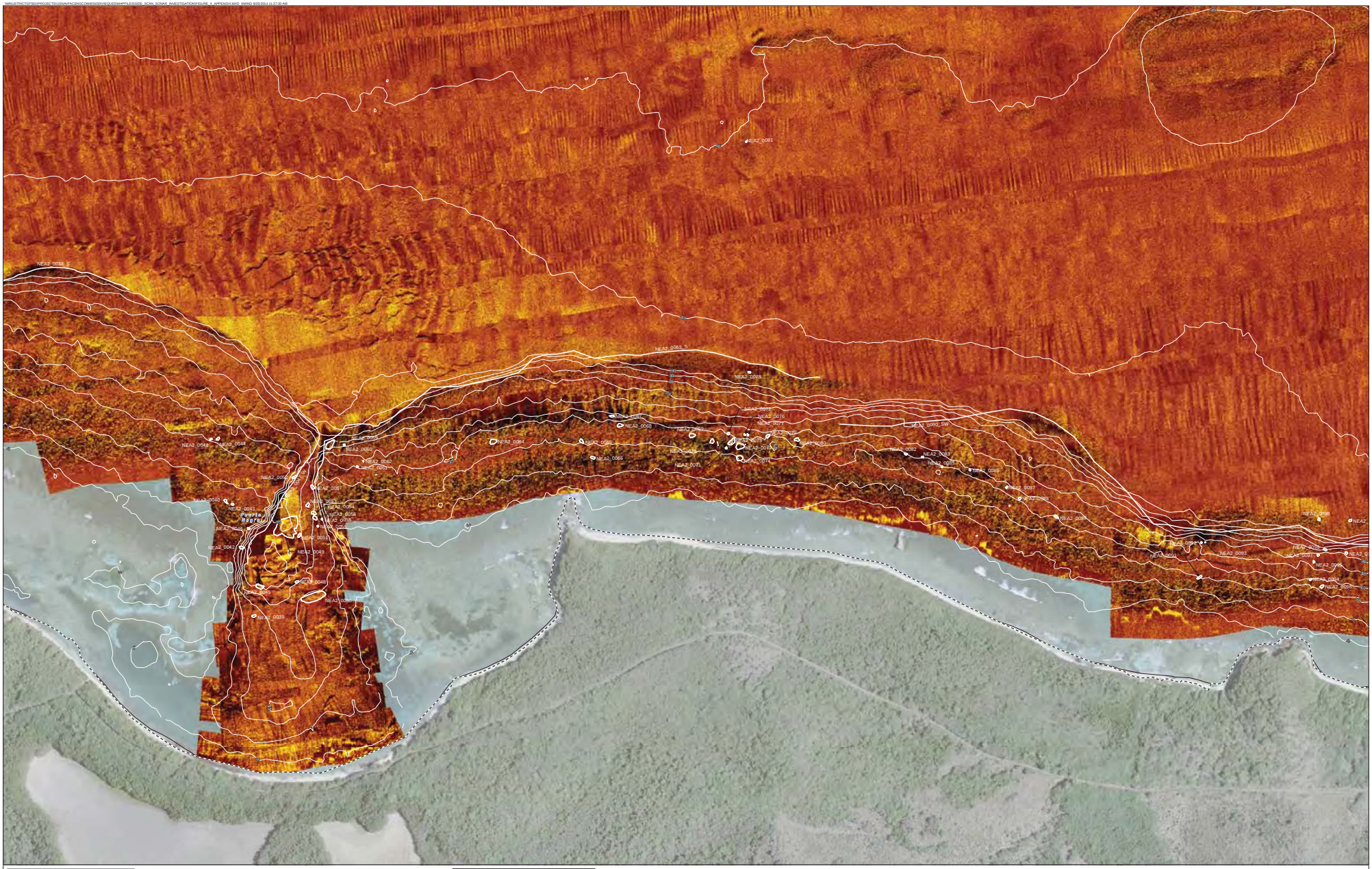
0 200 400
Feet



Side Scan Sonar Survey - Map 19
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL


NEA2_0038_S
NEA2_0081
NEA2_0063_S
NEA2_0078
NEA2_0073
NEA2_0077
NEA2_0092_SW
NEA2_0049
NEA2_0044
NEA2_0060
NEA2_0062
NEA2_0064
NEA2_0085
NEA2_0071
NEA2_0082
NEA2_0083
NEA2_0095
NEA2_0087
NEA2_0065
NEA2_0010
NEA2_0013
Puerto Negro
NEA2_0058
NEA2_0055
NEA2_0042
NEA2_0053
NEA2_0049
NEA2_0048
NEA2_0039
NEA2_0090
NEA2_0091
NEA2_0093
NEA2_0096
NEA2_0097
NEA2_0098
NEA2_0094
NEA2_0099
Legend
UXO 16 Boundary
Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
Bathymetry Contour (ft)
Source: Arc Surveying & Mapping & Sonographics, Inc.
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Feet
Side Scan Sonar Survey - Map 20
Side Scan Sonar Investigation
Vieques, Puerto Rico
CH2MHILL

Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

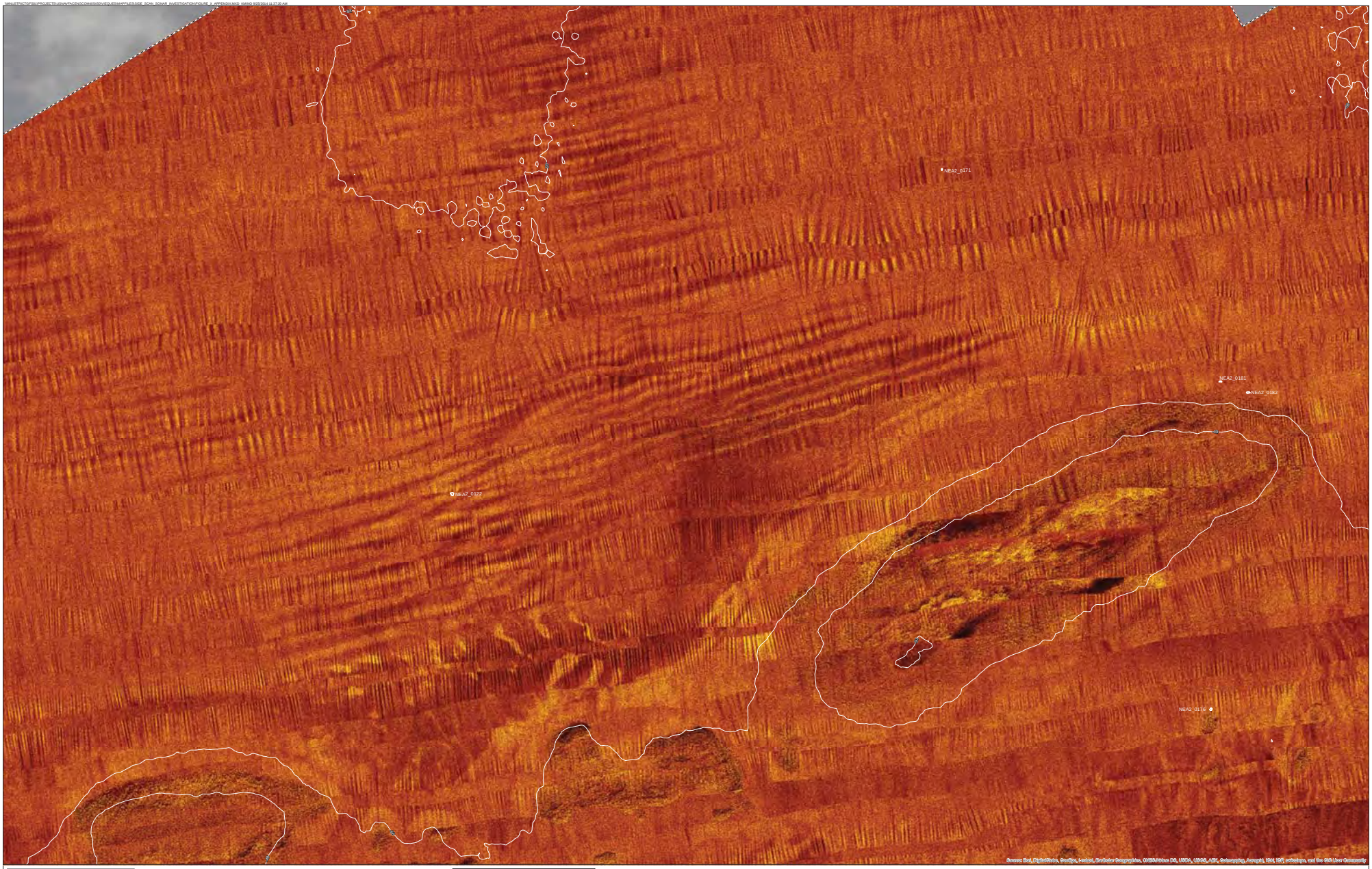
Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 21
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

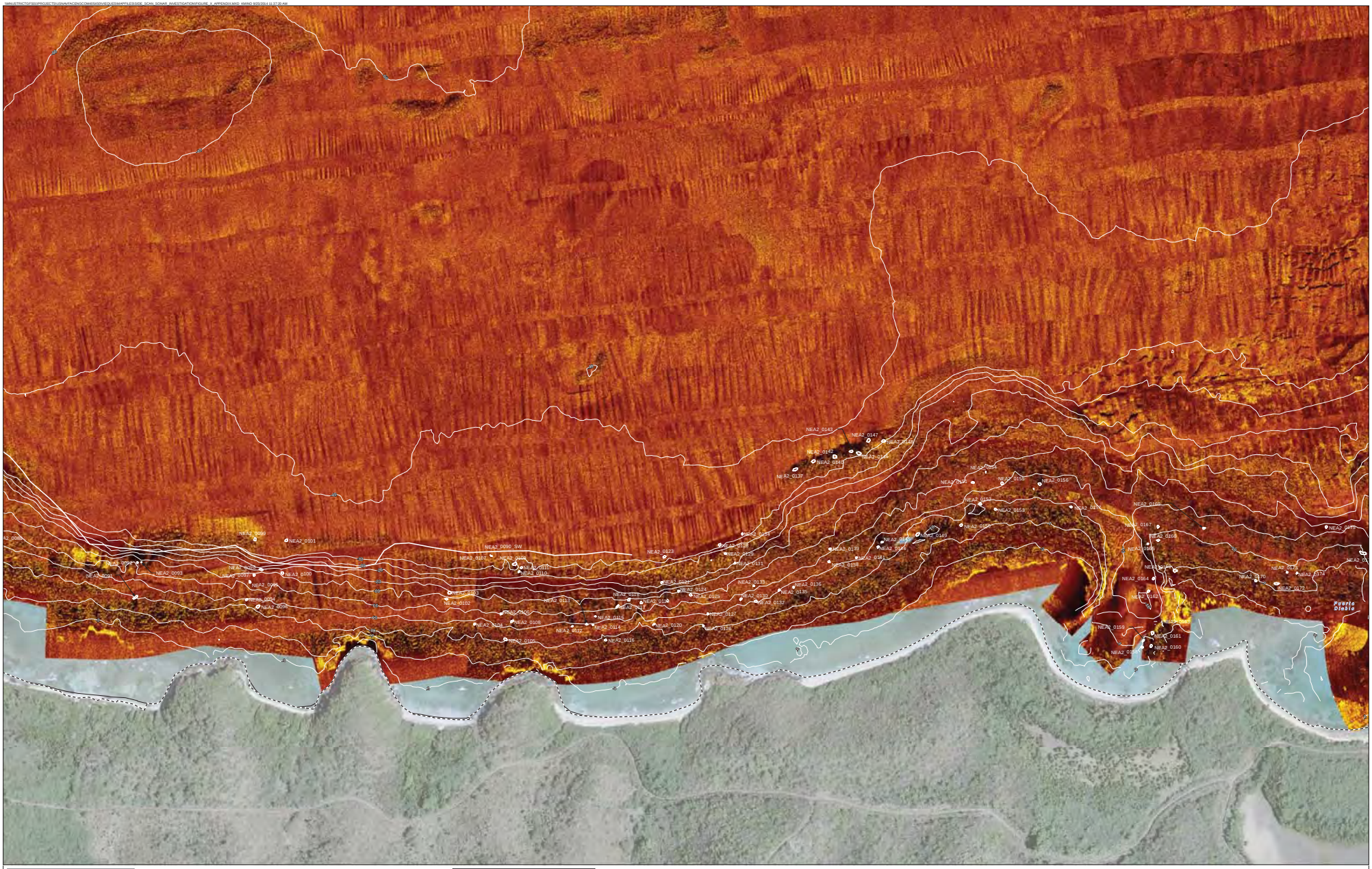
Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 22
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
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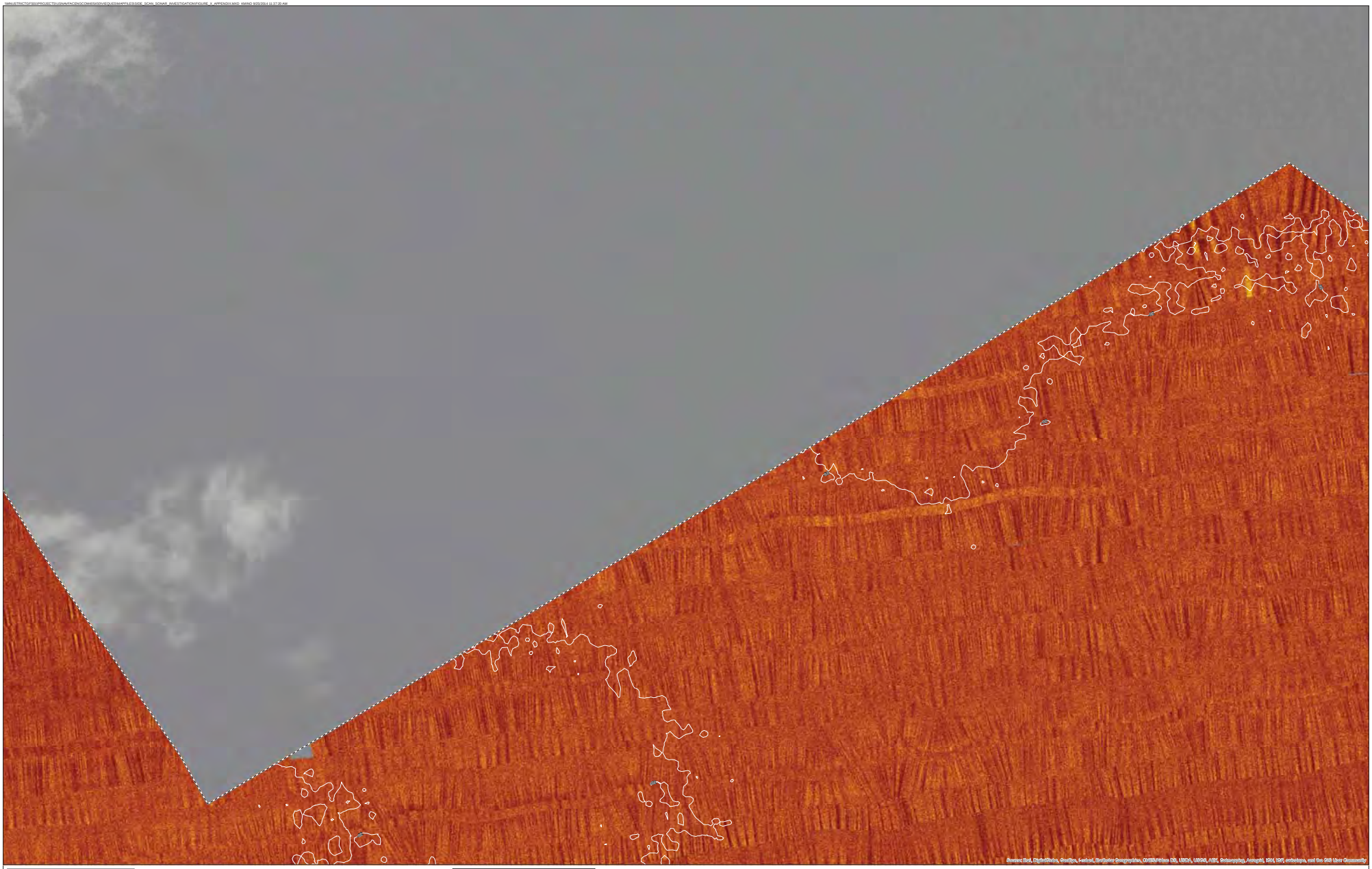
0 200 400
Feet

Side Scan Sonar Survey - Map 23
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

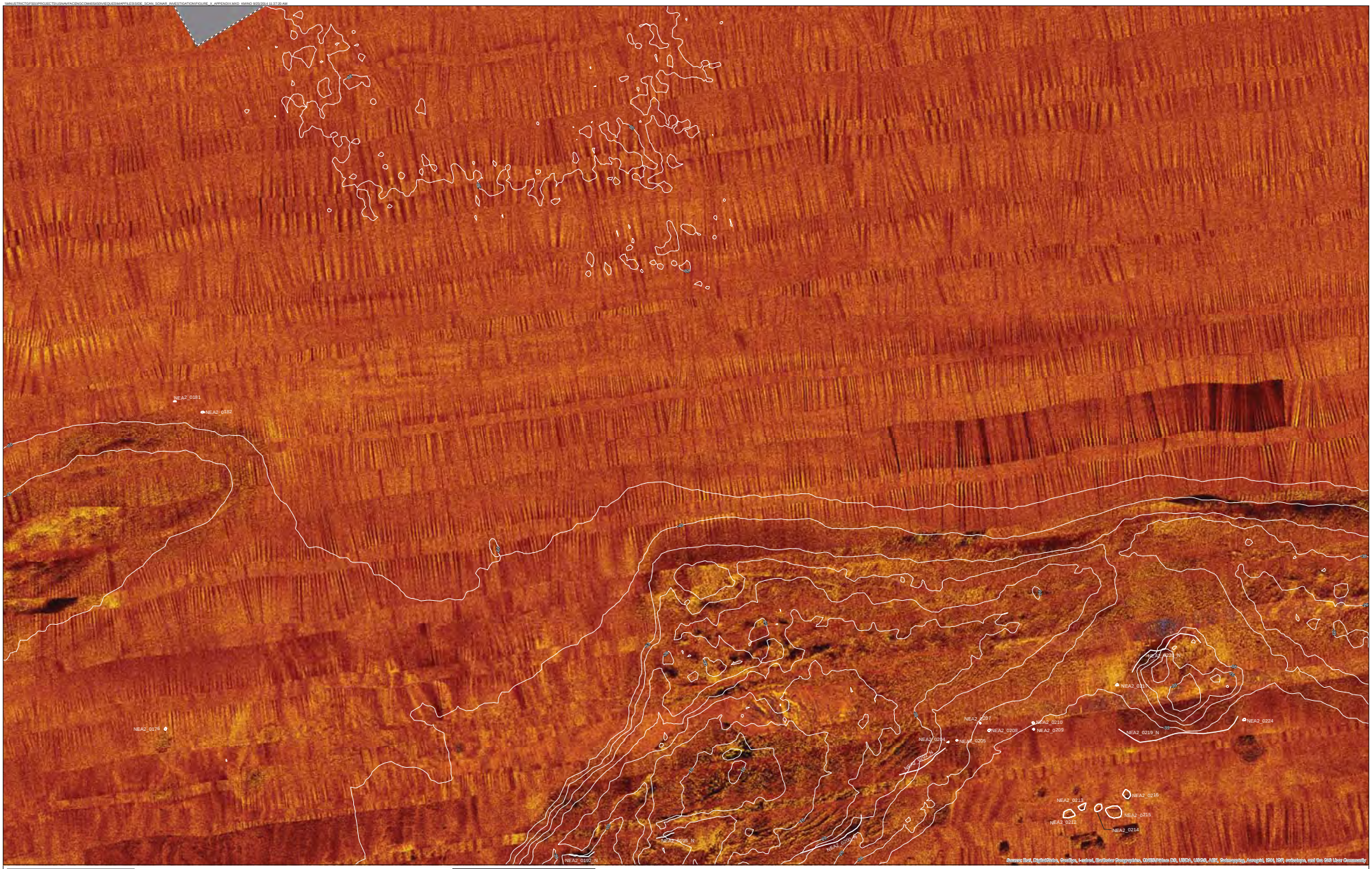
Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 24
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

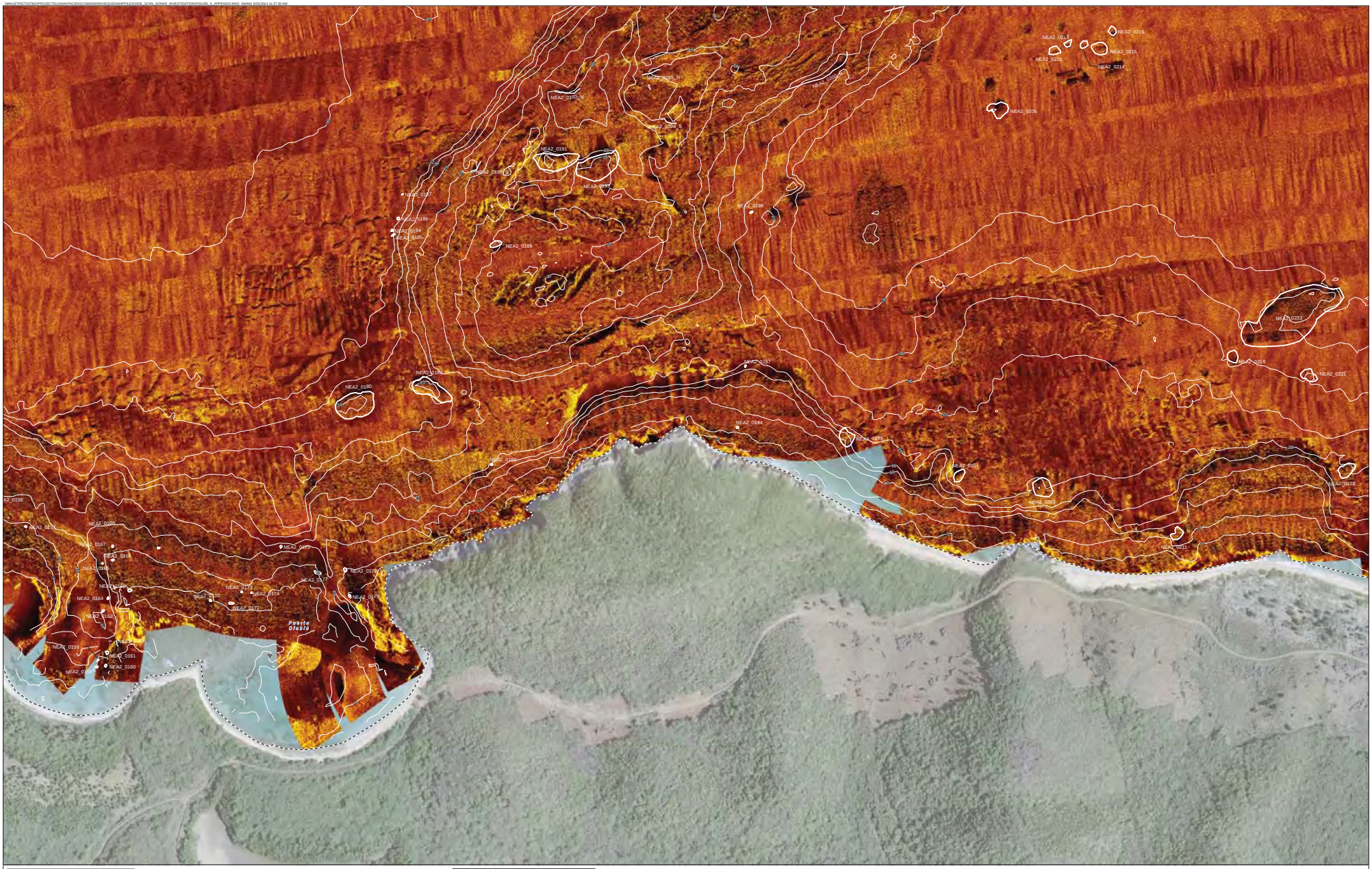
Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 25
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

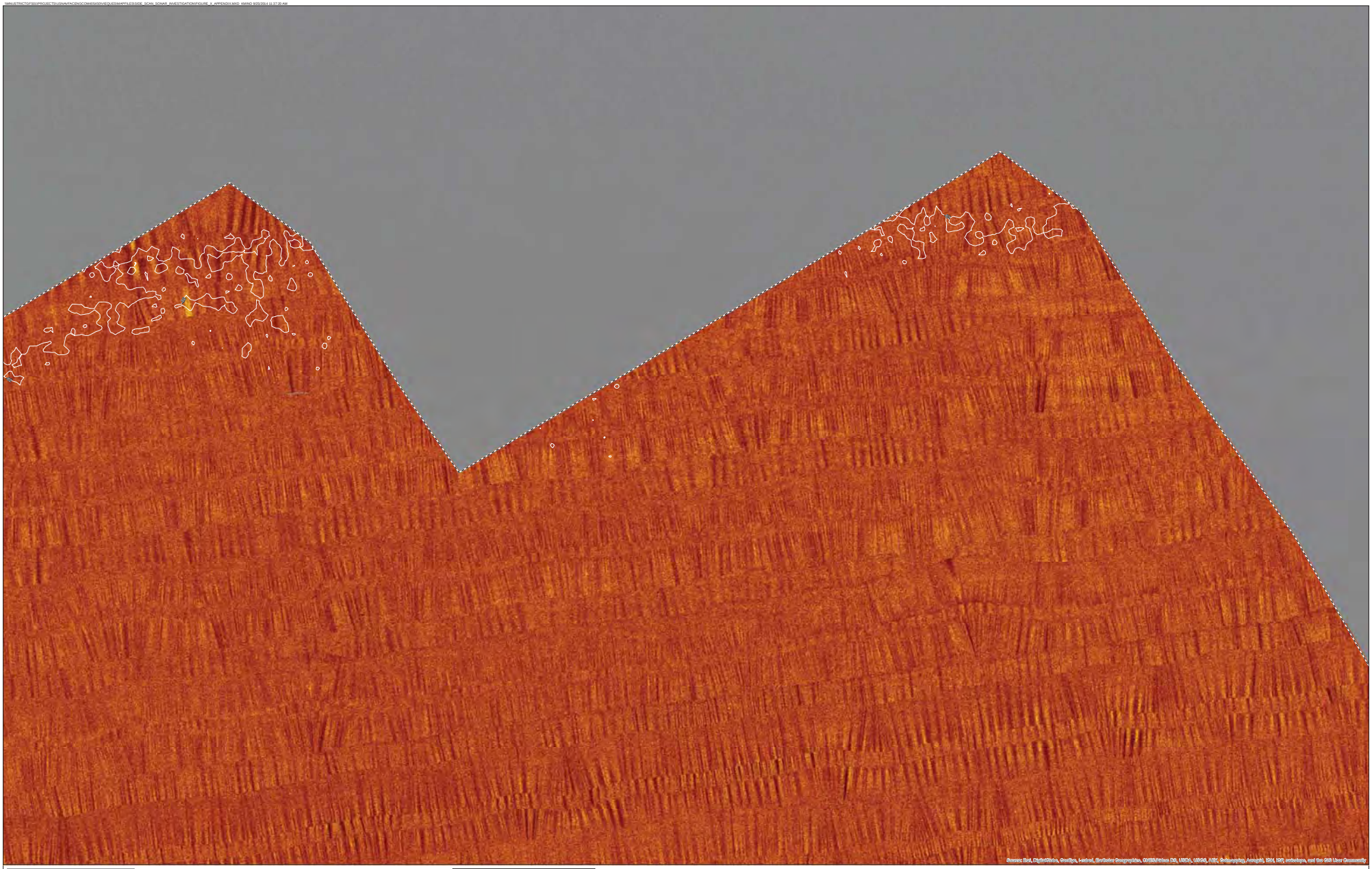
Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 26
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

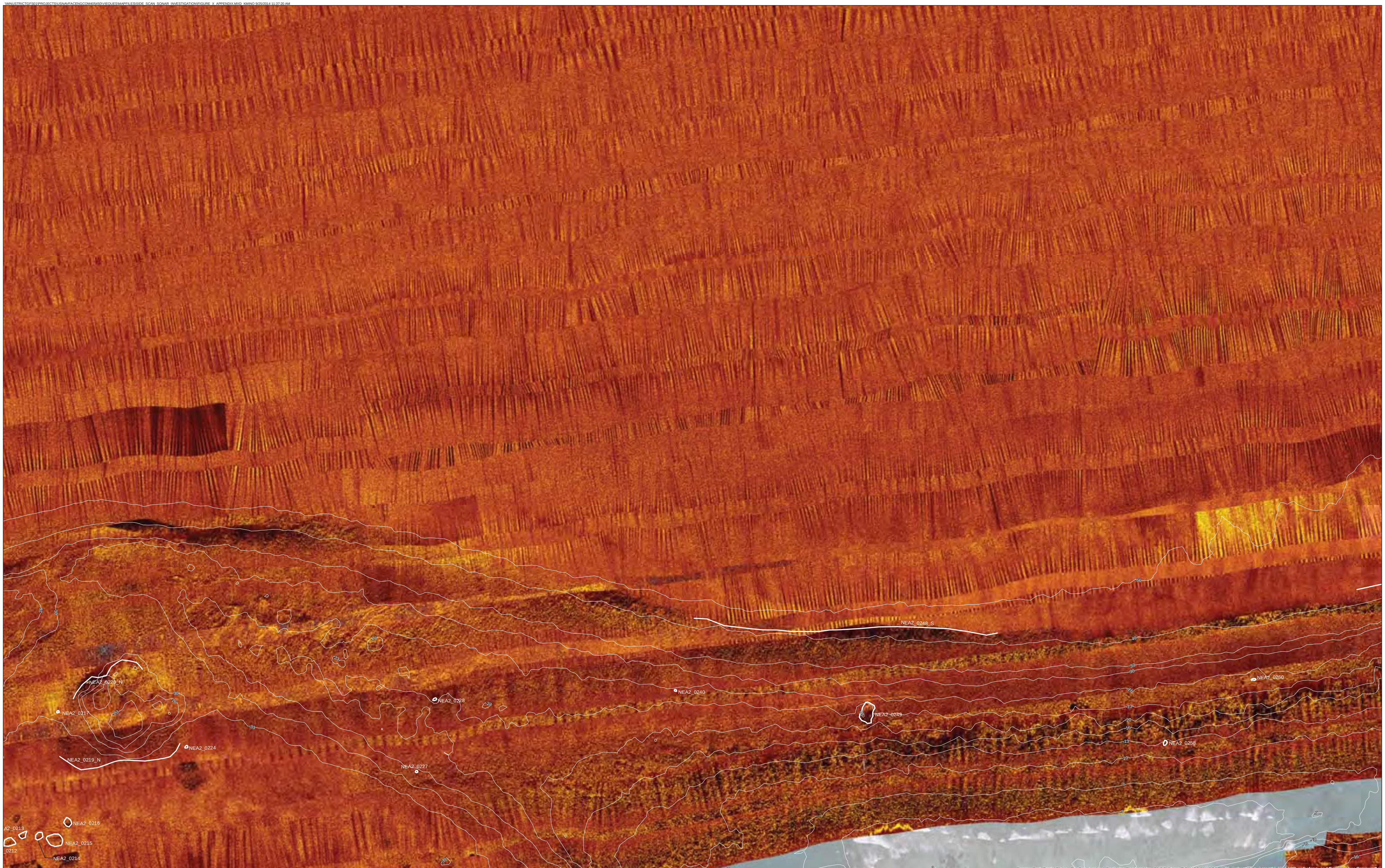
Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 27
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



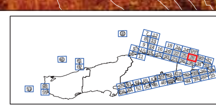
Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

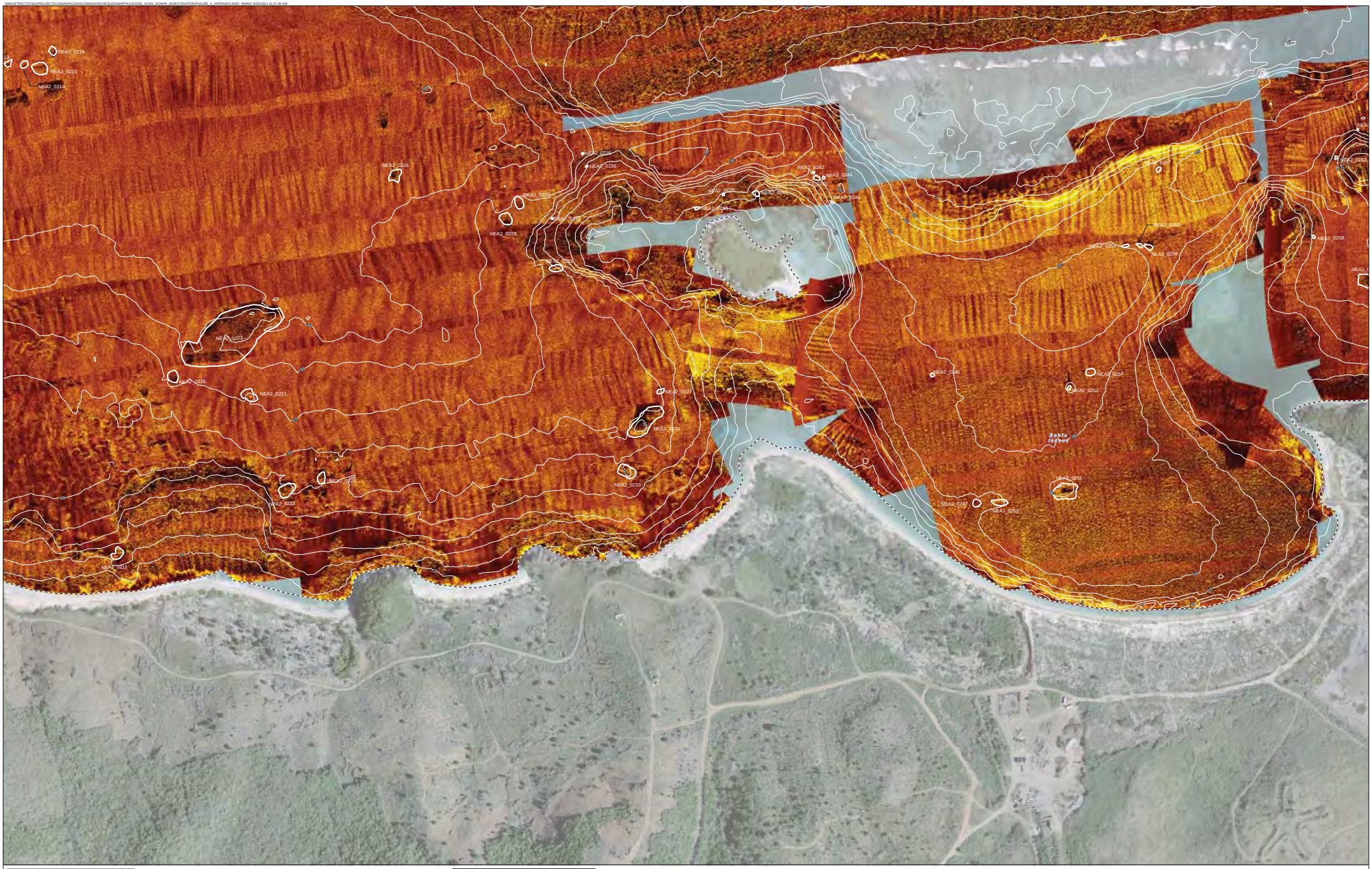
N / E / S / W

0 200 400 Feet



Side Scan Sonar Survey - Map 28
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL


NEA2_0216
NEA2_0215
NEA2_0214
NEA2_0226
NEA2_0230
NEA2_0229
NEA2_0223
NEA2_0218
NEA2_0221
NEA2_0222
NEA2_0219
NEA2_0237
NEA2_0234
NEA2_0233
NEA2_0236
NEA2_0242
NEA2_0244
NEA2_0245
NEA2_0255
NEA2_0256
NEA2_0259
NEA2_0246
NEA2_0253
NEA2_0252
NEA2_0251
NEA2_0247
NEA2_0250
Bahia Tejhor
Legend
UXO 16 Boundary
Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
Bathymetry Contour (ft)
Source: Arc Surveying & Mapping & Sonographics, Inc.
N
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200
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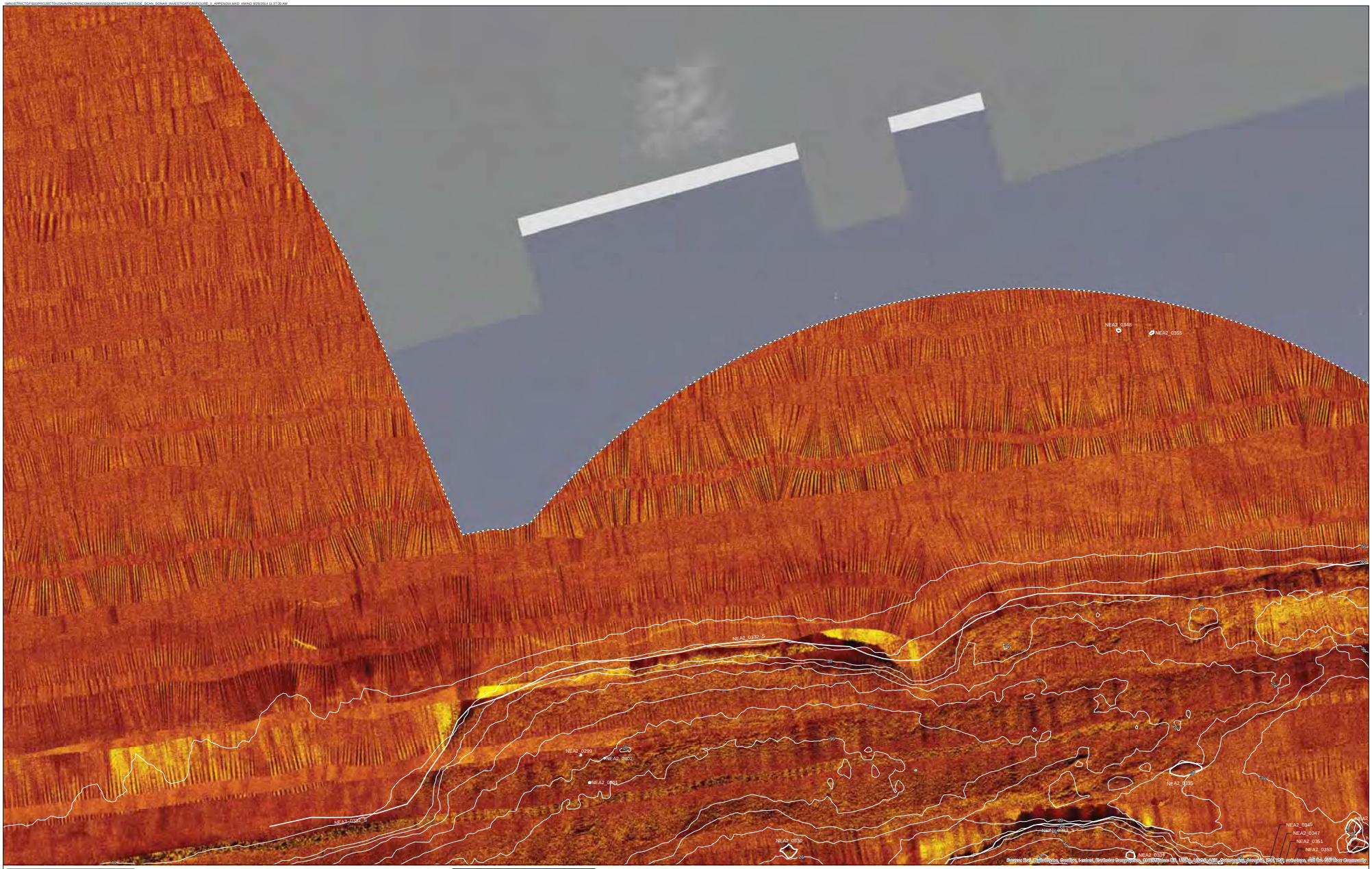
Feet
Side Scan Sonar Survey - Map 29
Side Scan Sonar Investigation
Vieques, Puerto Rico
CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

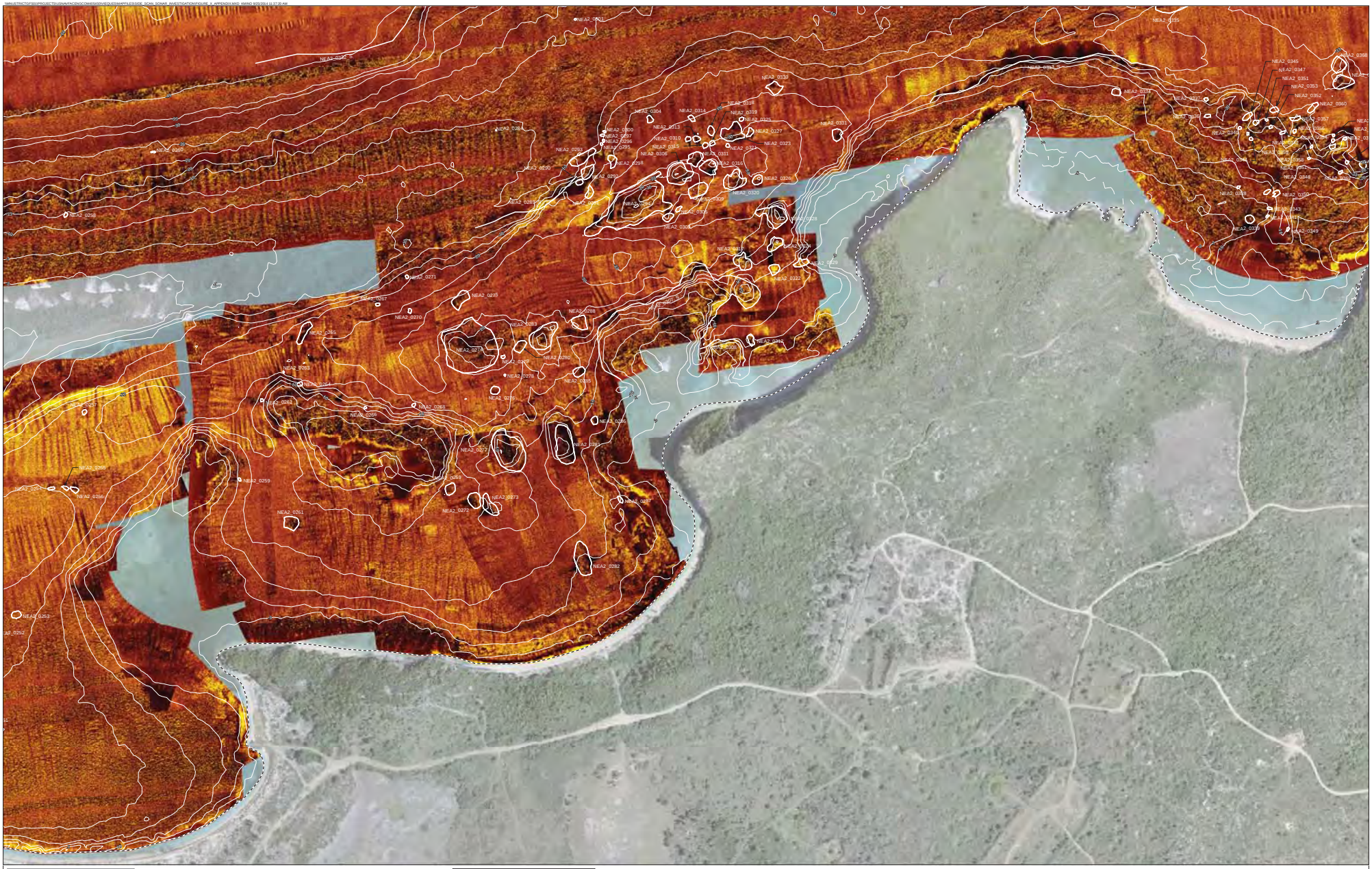
Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

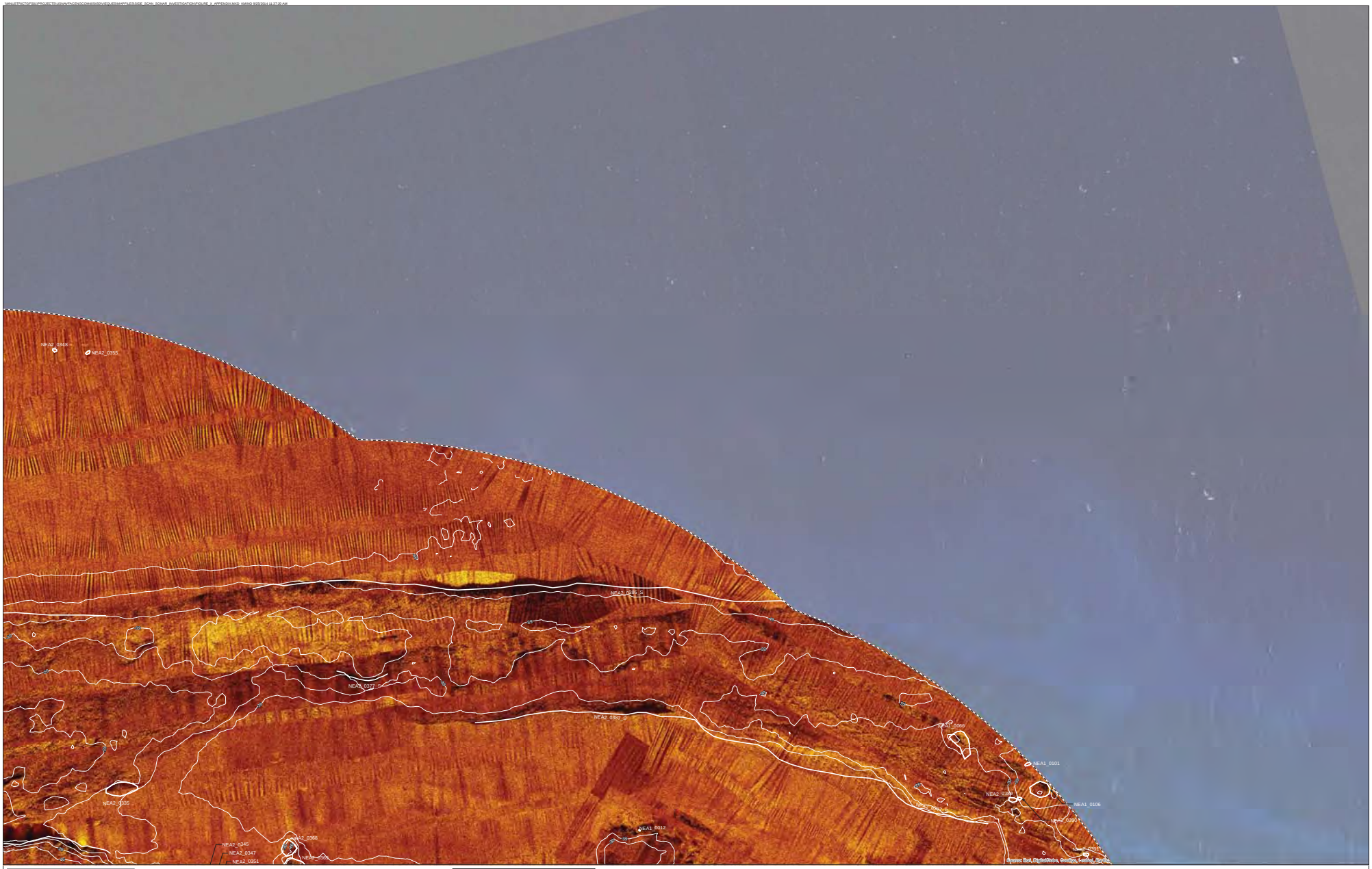
Side Scan Sonar Survey - Map 30
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Side Scan Sonar Survey - Map 31
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

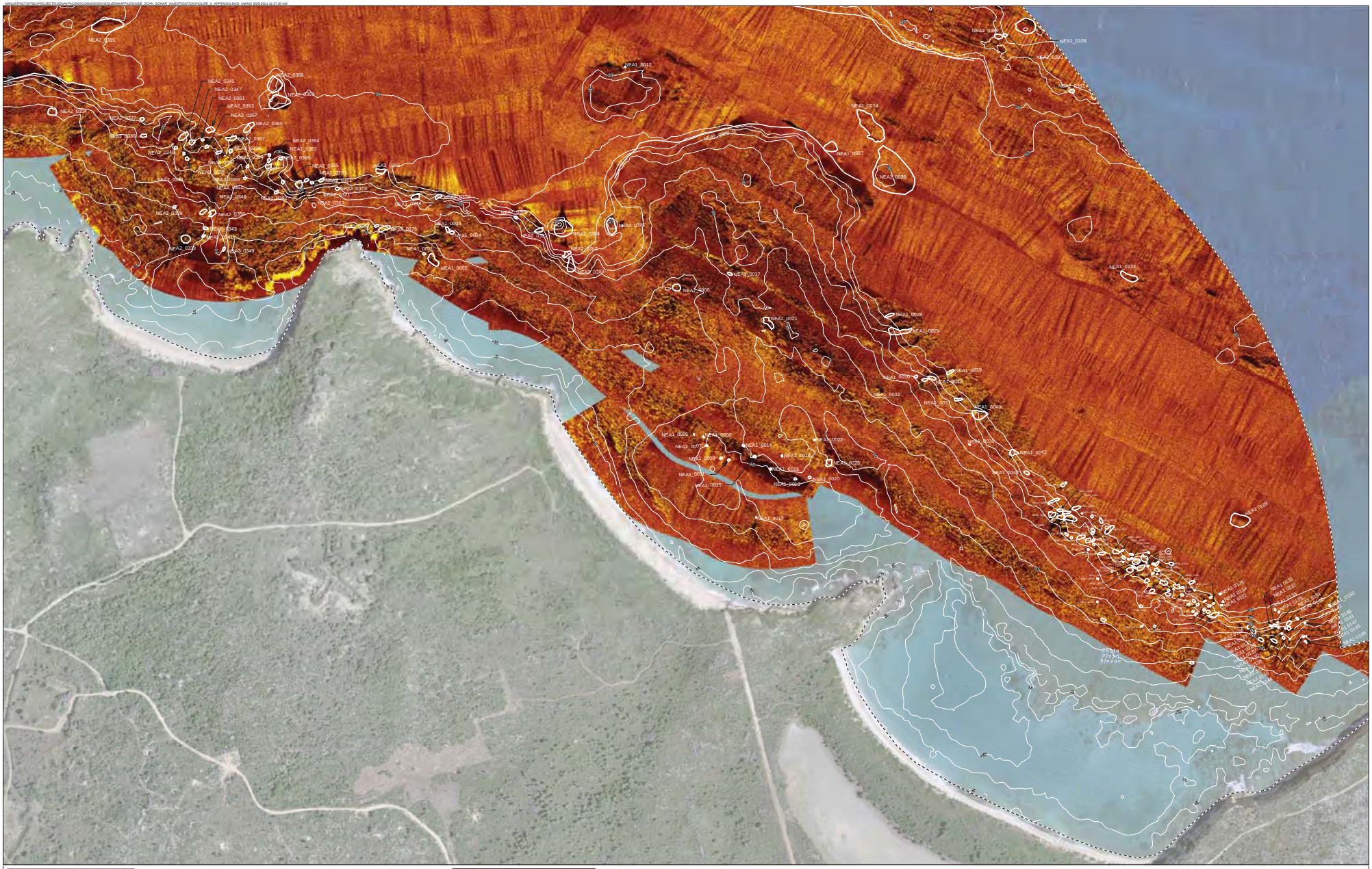
Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 32
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Side Scan Sonar Survey - Map 33
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

\\MNUSTRICTGFS01\PROJECTS\USNAVFACENGCOM405450\VIEQUES\MAPFILES\SIDE_SCAN_SONAR_INVESTIGATION\FIGURE_X_APPENDIX.MXD KMINO 9/25/2014 11:37:20 AM

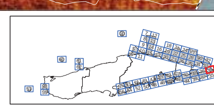
Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

N / W / E / S

0 200 400 Feet



Side Scan Sonar Survey - Map 34
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

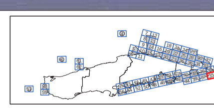
Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

N W E S

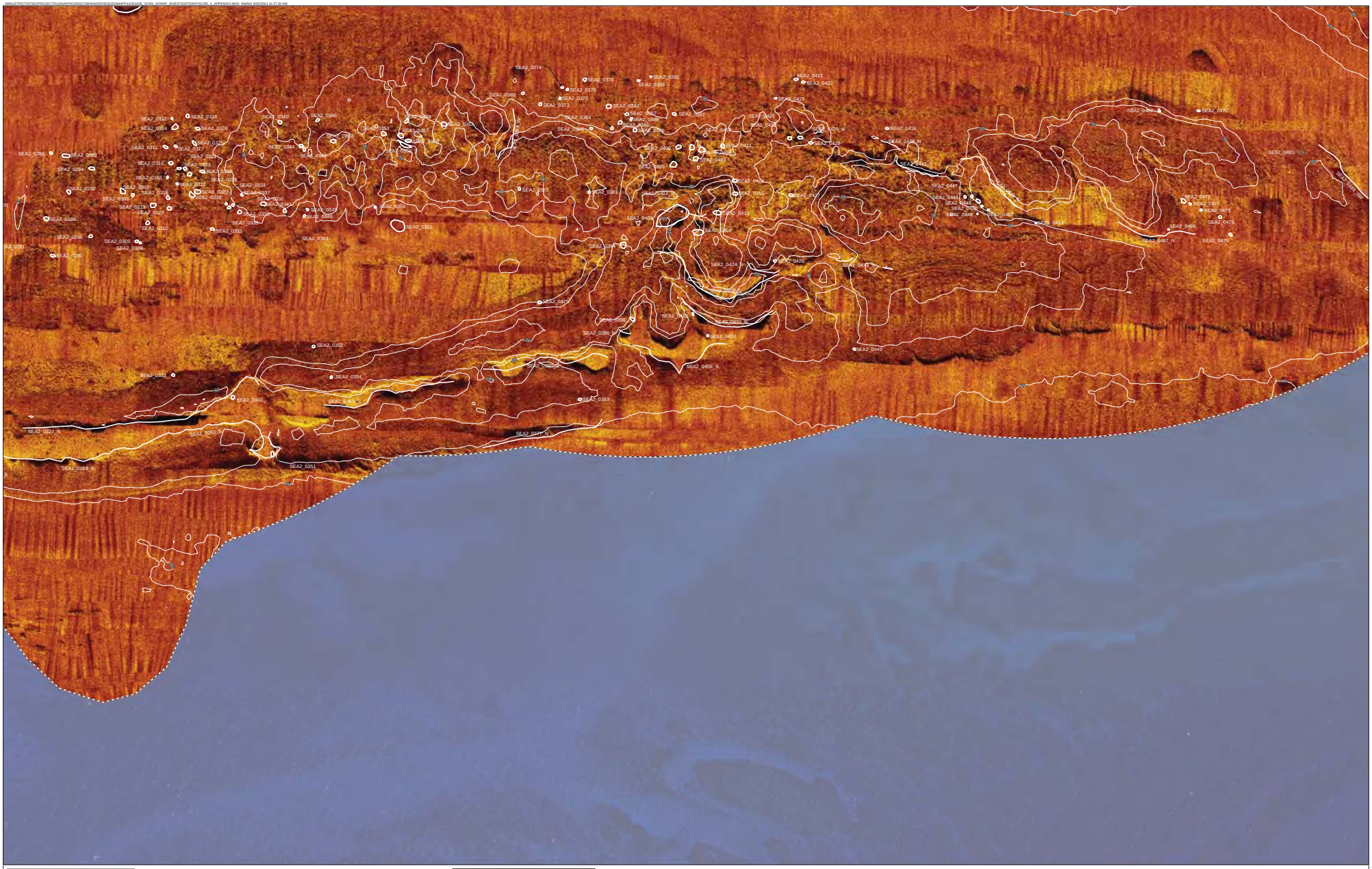
0 200 400 Feet



Side Scan Sonar Survey - Map 35
Side Scan Sonar Investigation
Vieques, Puerto Rico

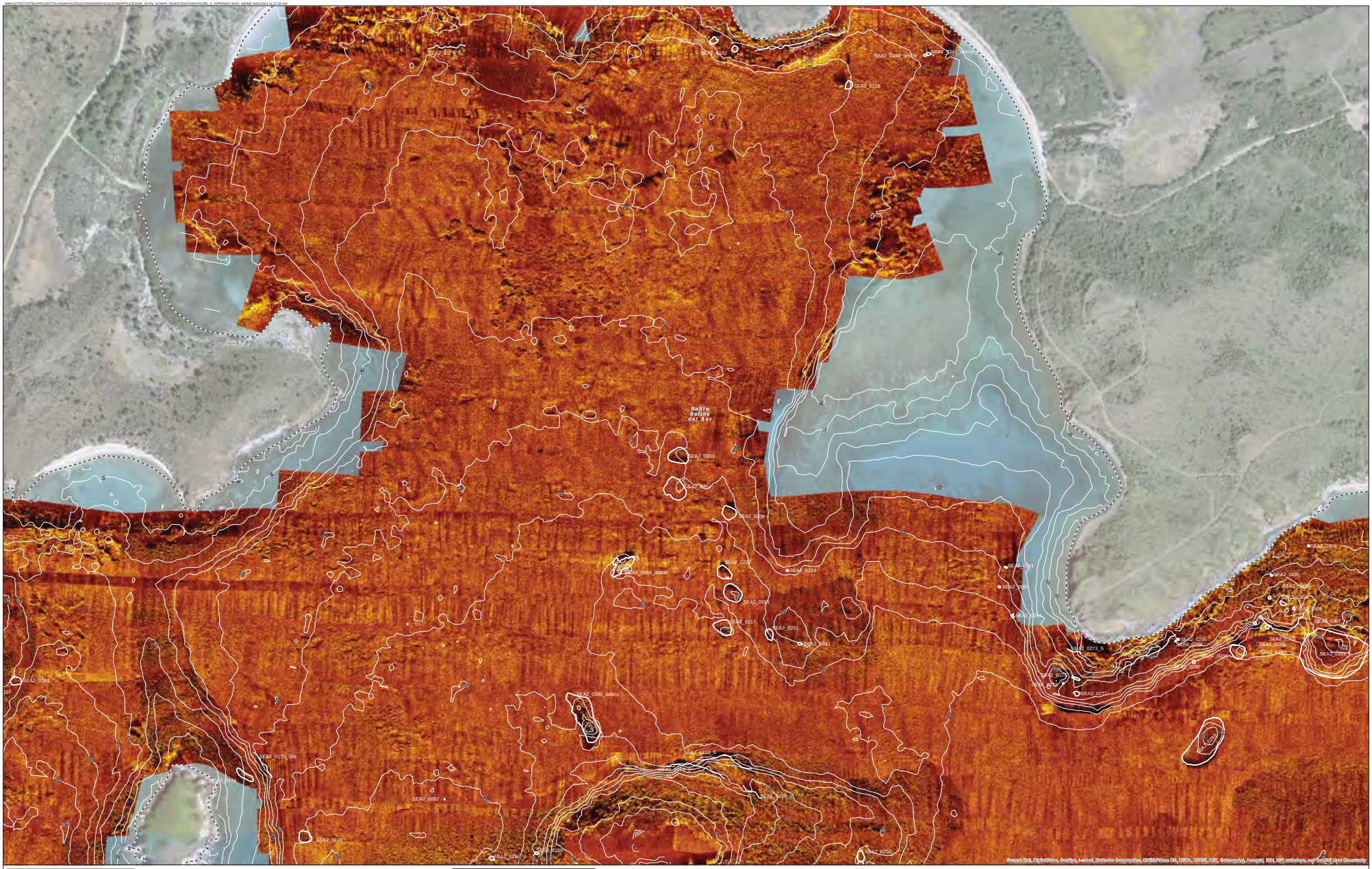
CH2MHILL


Legend
UXO 16 Boundary
Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
Bathymetry Contour (ft)
Source: Arc Surveying & Mapping & Sonographics, Inc.
N
W
E
S
0
200
400
Feet
Side Scan Sonar Survey - Map 36
Side Scan Sonar Investigation
Vieques, Puerto Rico
CH2MHILL



Side Scan Sonar Survey - Map 37
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 38
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

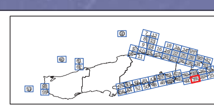
Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

N / W / E / S

0 200 400 Feet

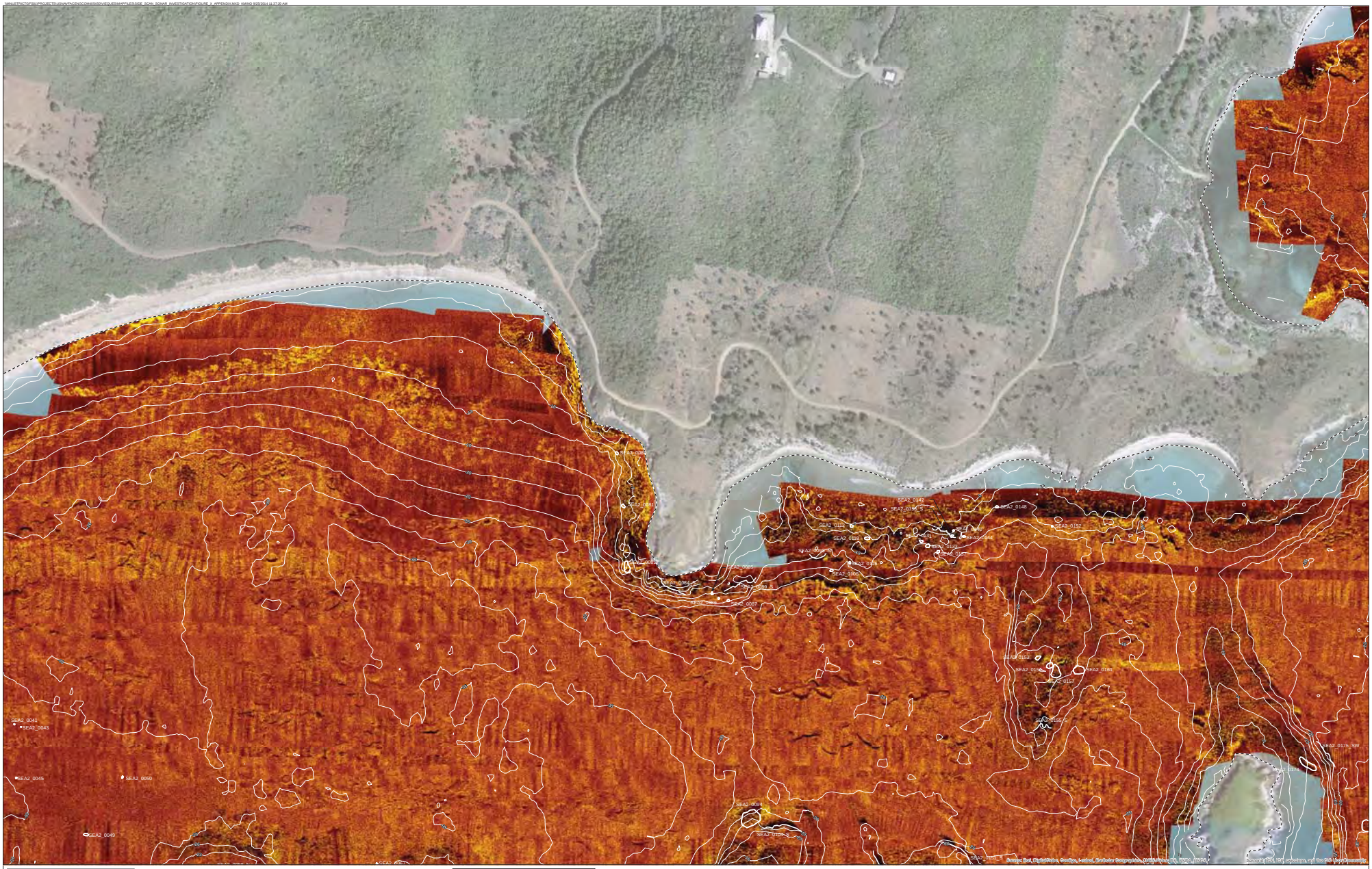


Side Scan Sonar Survey - Map 39

Side Scan Sonar Investigation

Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

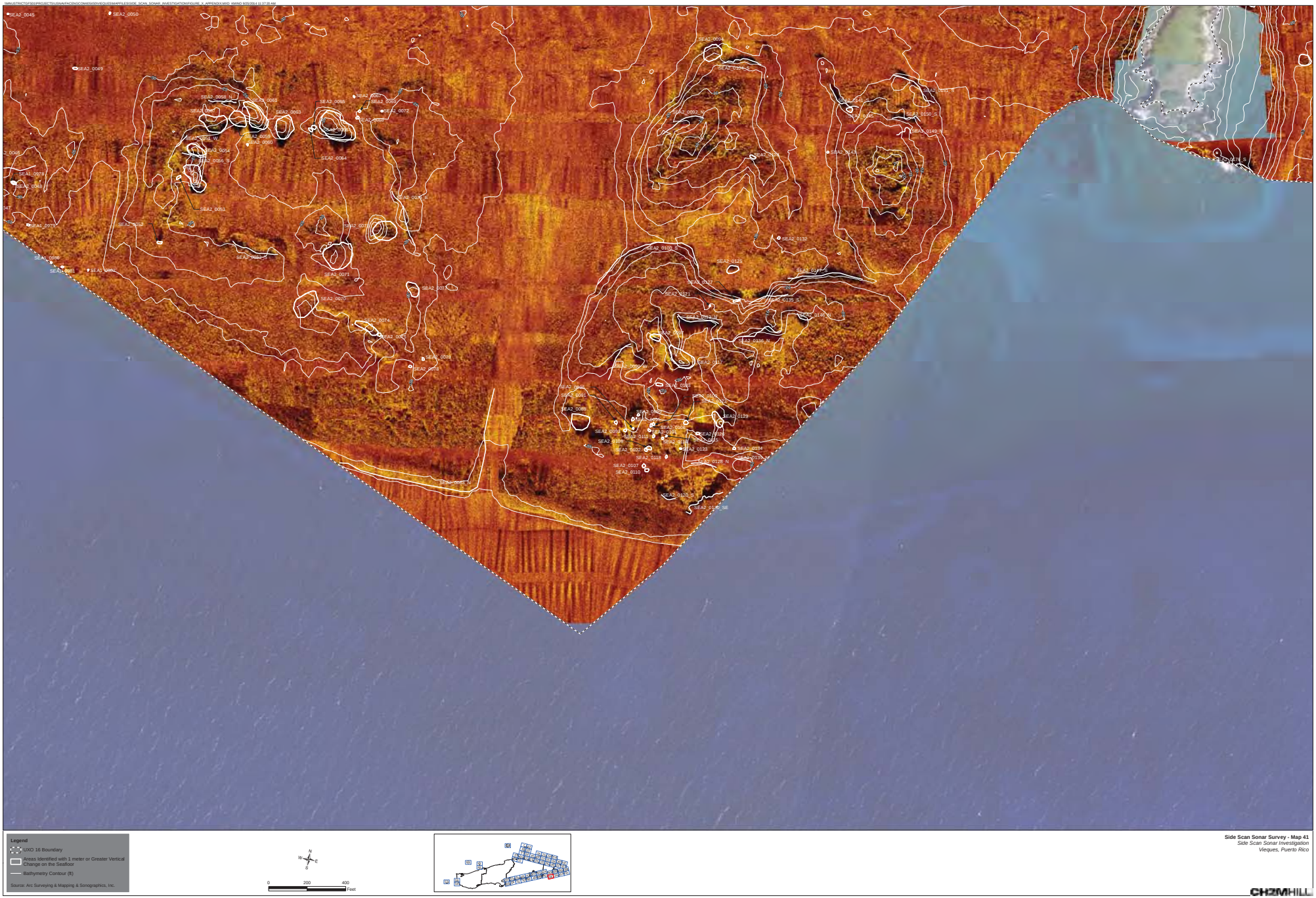
Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 40
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Side Scan Sonar Survey - Map 41
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

N W E S

0 200 400 Feet

Side Scan Sonar Survey - Map 42
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

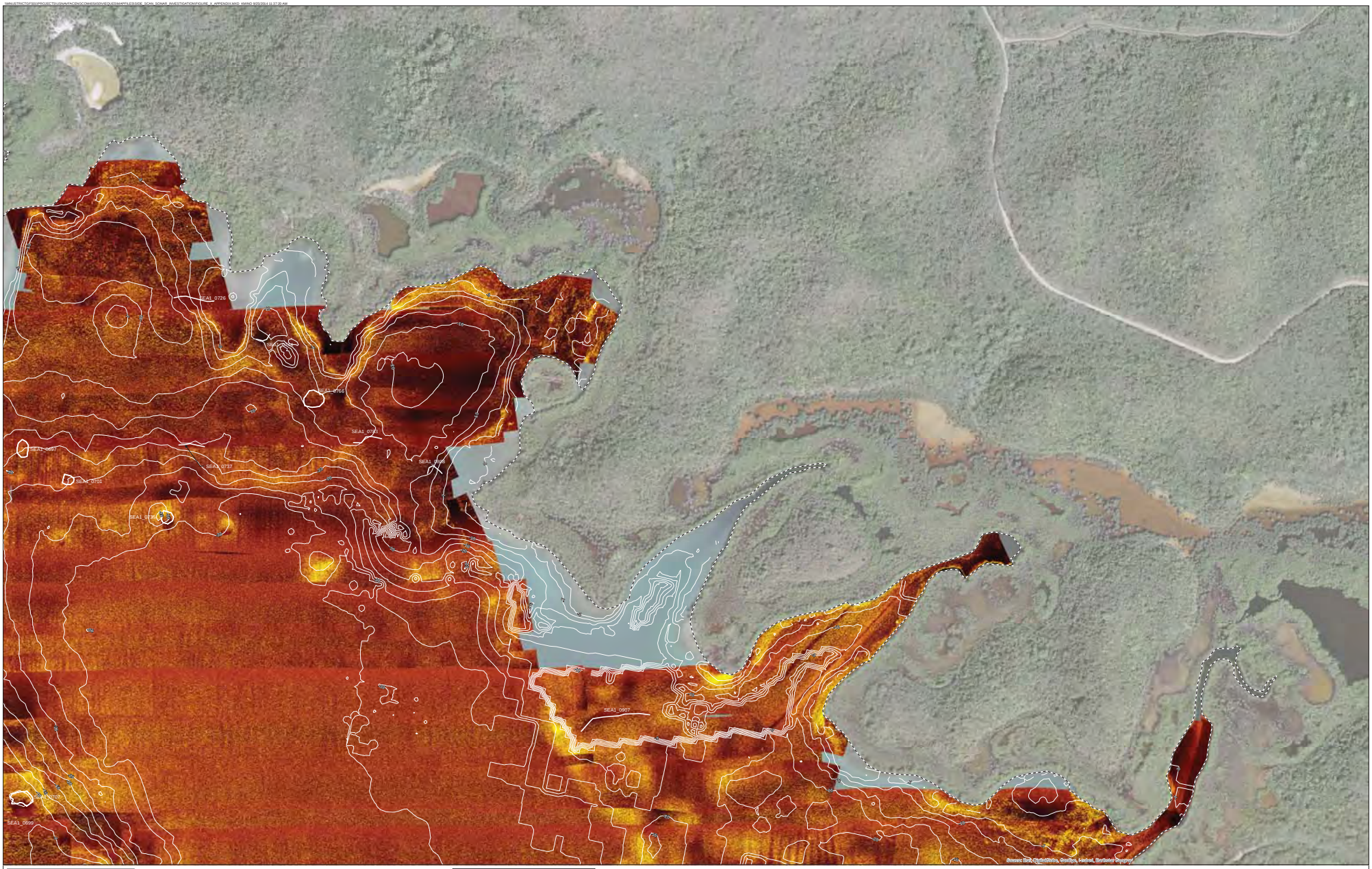
Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 42a
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

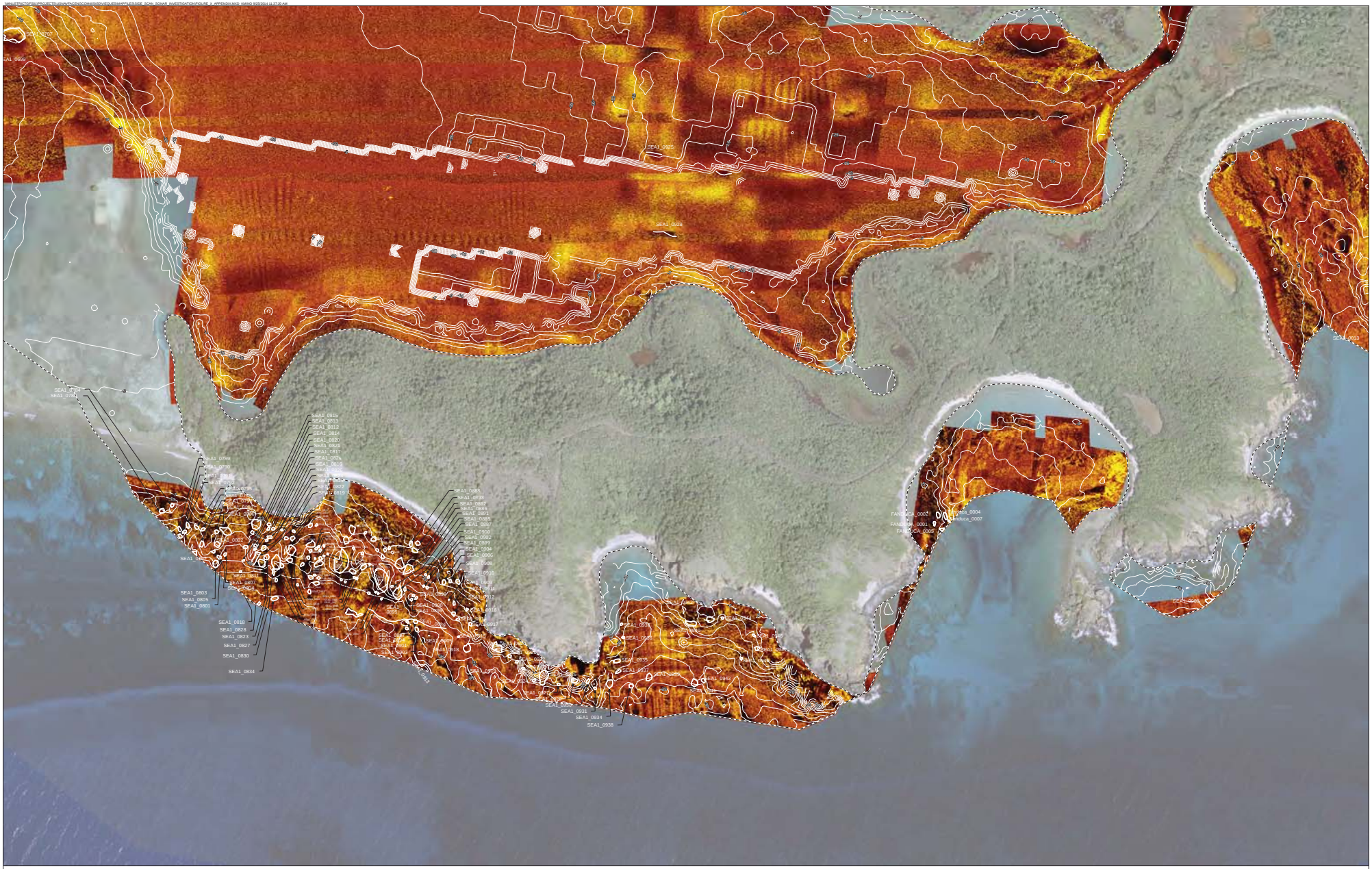
Source: Arc Surveying & Mapping & Sonographics, Inc.

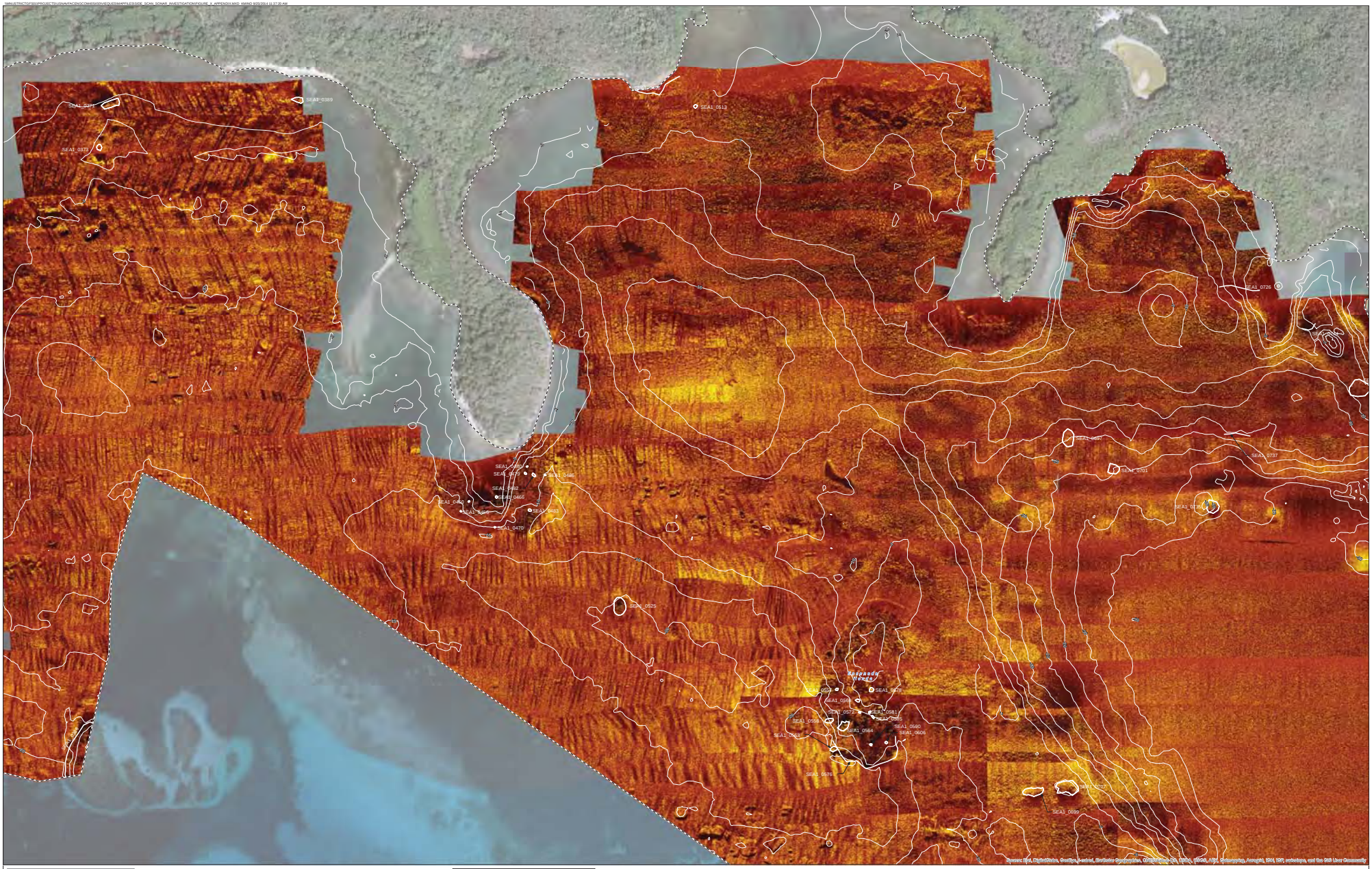
N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 43
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL


Legend
UXO 16 Boundary
Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
Bathymetry Contour (ft)
Source: Arc Surveying & Mapping & Sonographics, Inc.
0
200
400
Feet
Side Scan Sonar Survey - Map 44
Side Scan Sonar Investigation
Vieques, Puerto Rico
CH2MHILL



Side Scan Sonar Survey - Map 45
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

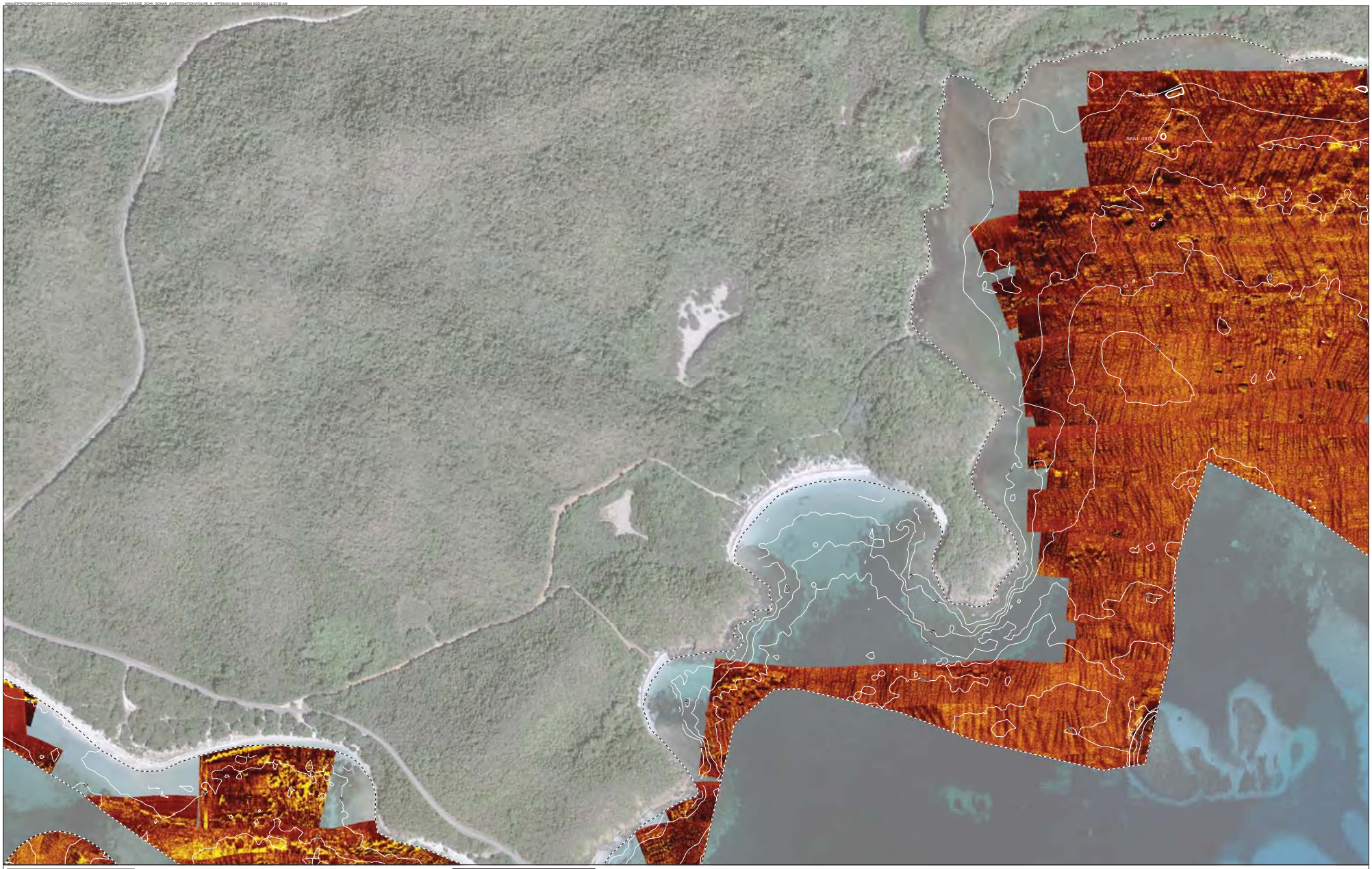
Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 46
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 47
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

Side Scan Sonar Survey - Map 48
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

\\MNUSTRICTGFS01\PROJECTS\USNAVFACENGCOM405450\VIEQUES\MAPFILES\SIDE_SCAN_SONAR_INVESTIGATION\FIGURE_X_APPENDIX.MXD KMINO 9/25/2014 11:37:20 AM

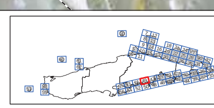
Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

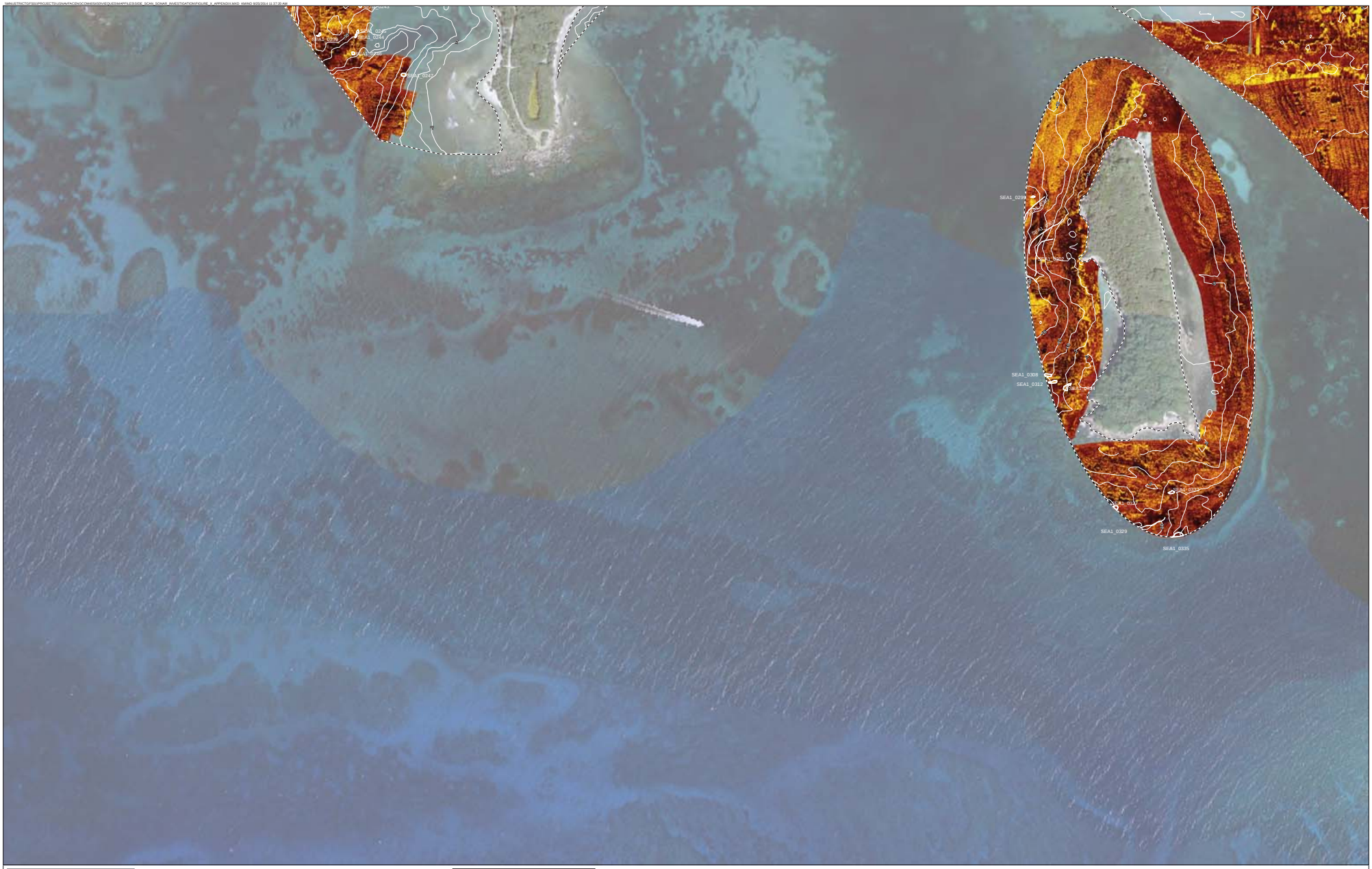
N W E S

0 200 400 Feet



Side Scan Sonar Survey - Map 49
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

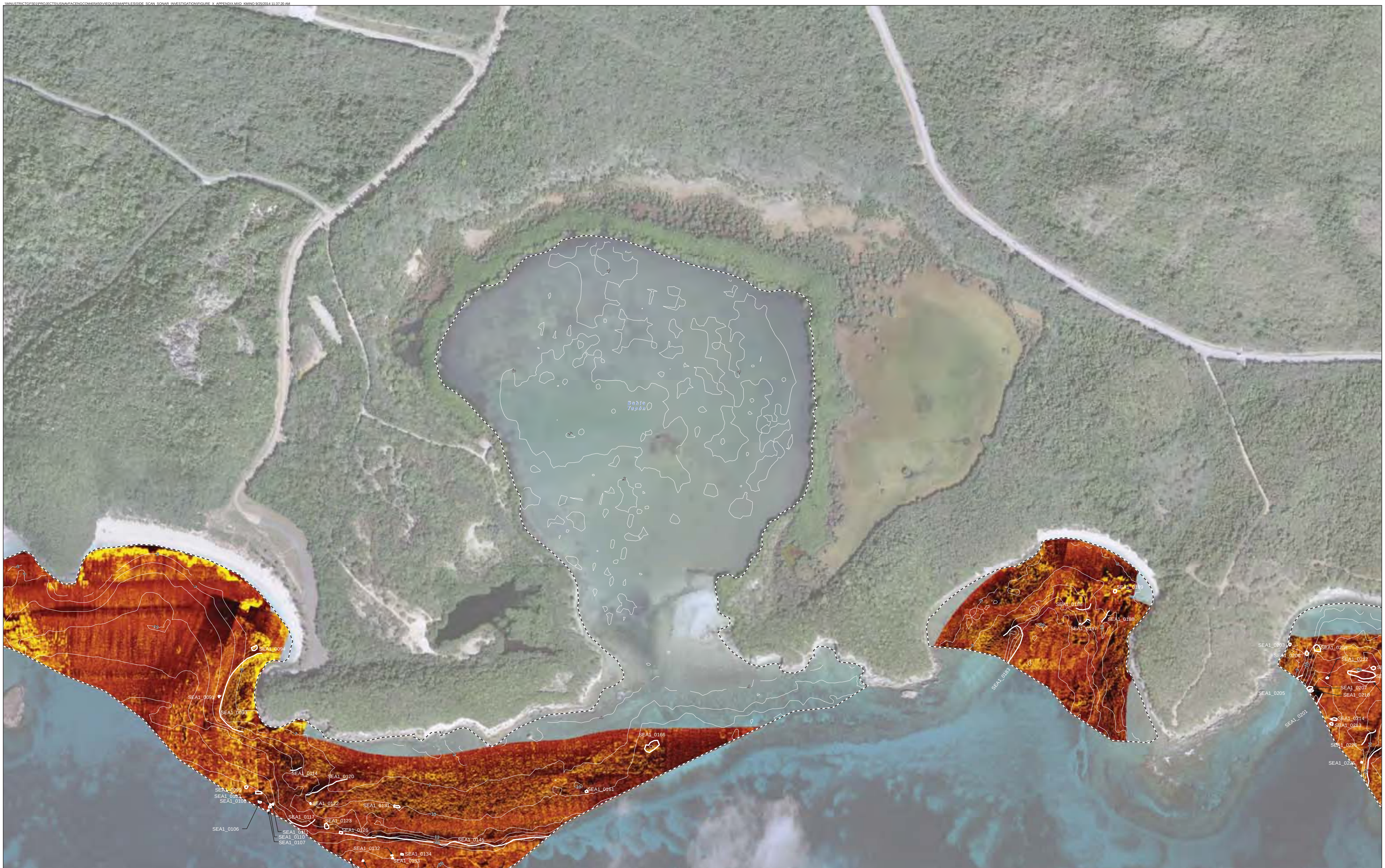
Source: Arc Surveying & Mapping & Sonographics, Inc.

N W E S

0 200 400 Feet

Side Scan Sonar Survey - Map 50
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

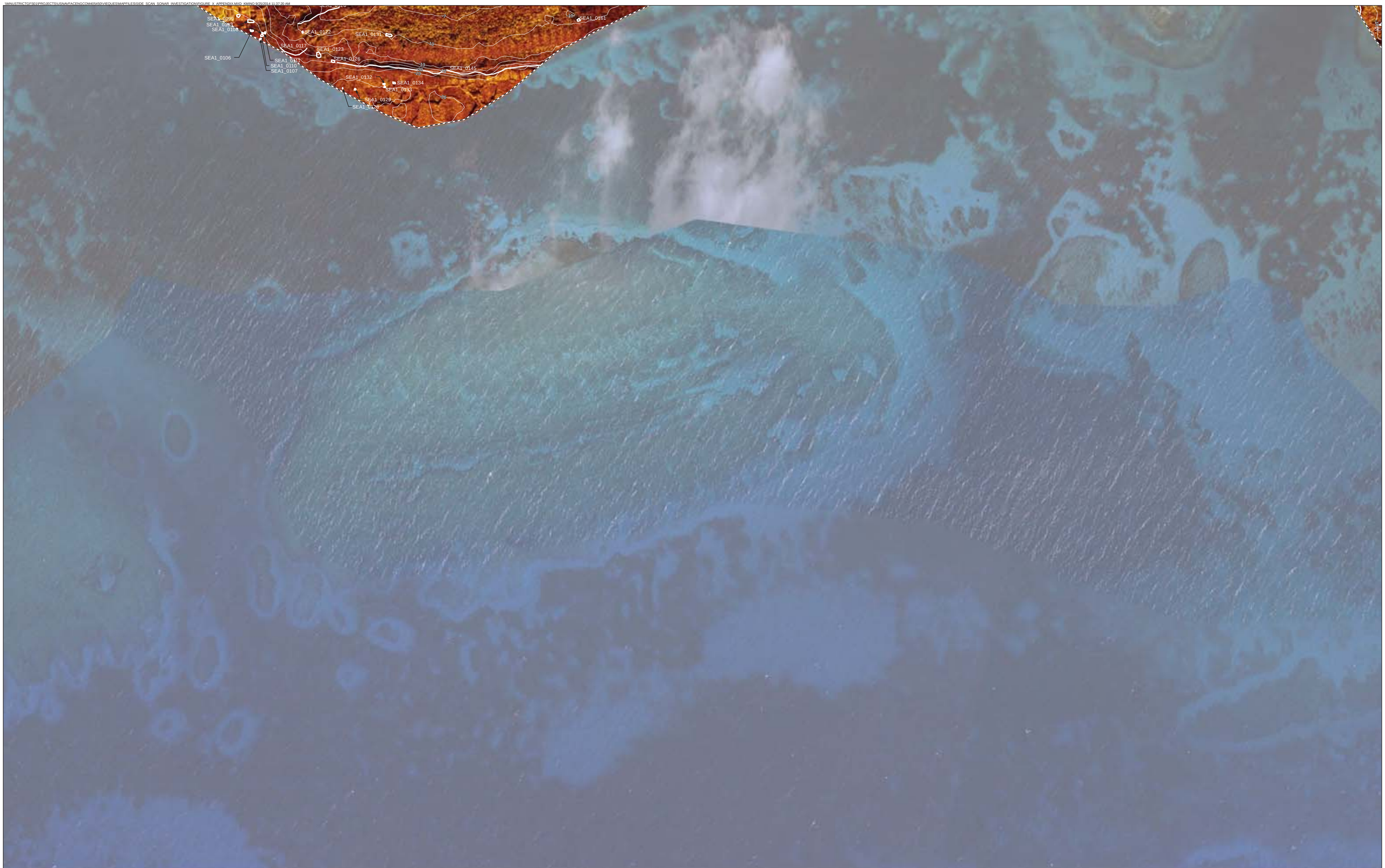
N W E S

0 200 400 Feet

Side Scan Sonar Survey - Map 51
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

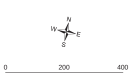
\\MNUSTRICTGFS01\PROJECTS\USNAVFACENGCOM405450\VIEQUES\MAPFILES\SIDE_SCAN_SONAR_INVESTIGATION\FIGURE_X_APPENDIX.MXD KMINO 9/25/2014 11:37:20 AM

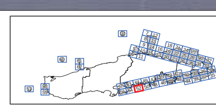


Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

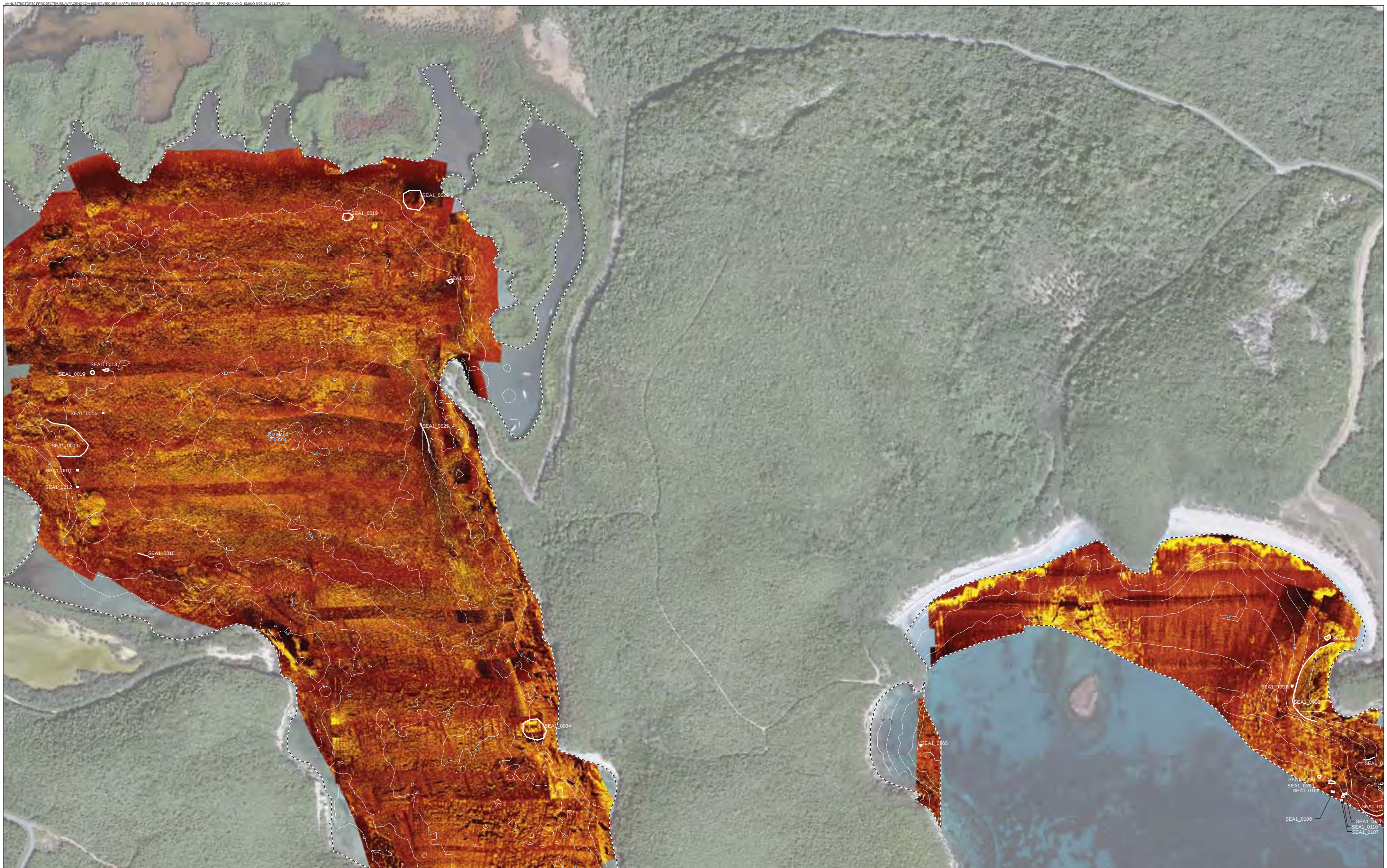




Side Scan Sonar Survey - Map 52
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

\\MNUSTRICTGFS01\PROJECTS\USNAVFACENGCOM405450\VIEQUES\MAPFILES\SIDE_SCAN_SONAR_INVESTIGATION\FIGURE_X_APPENDIX.MXD KMINO 9/25/2014 11:37:20 AM



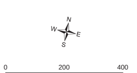
Legend

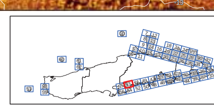
UXO 16 Boundary

Areas Identified with 1 meter or Greater Vertical Change on the Seafloor

Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.



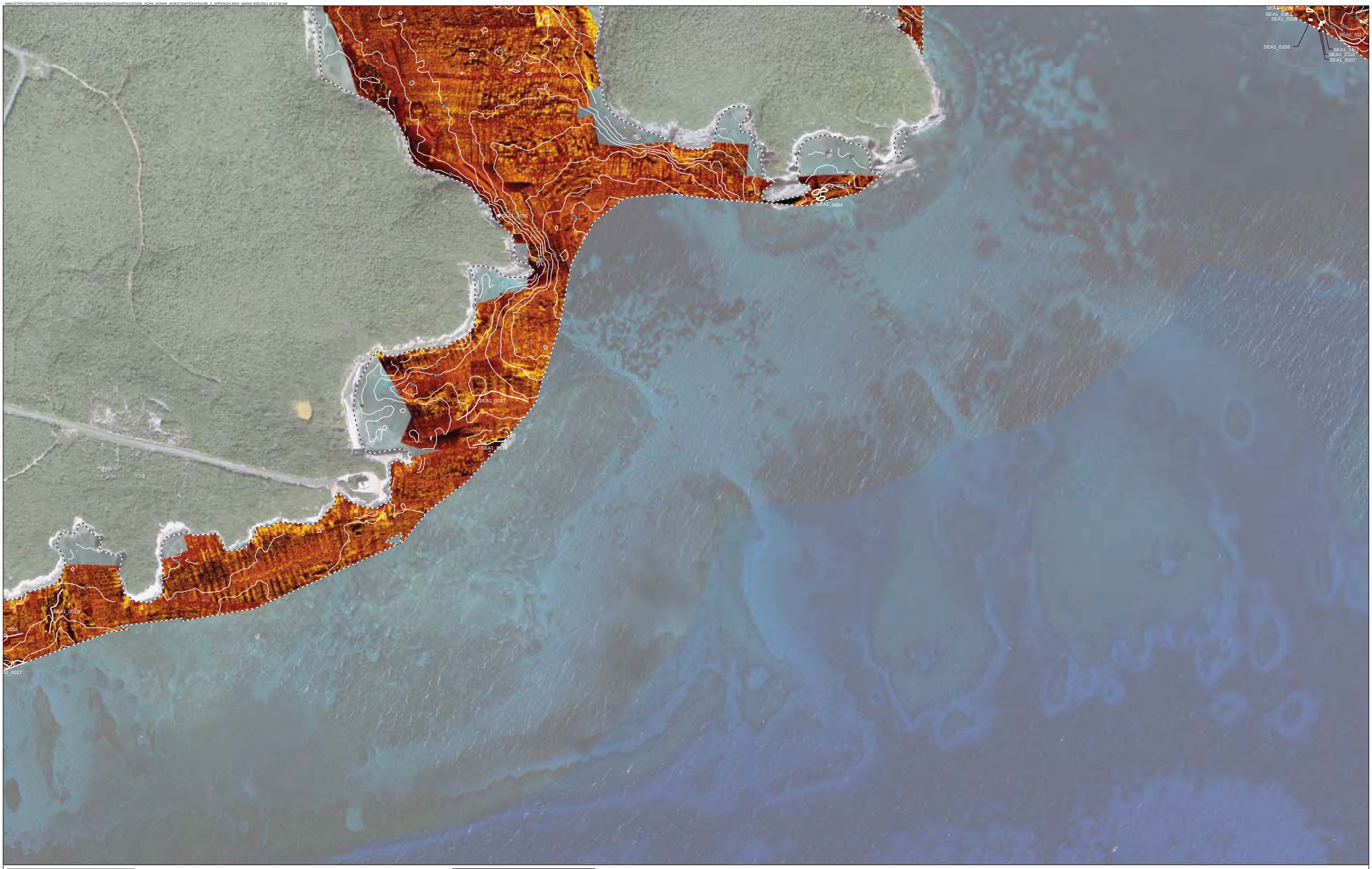


Side Scan Sonar Survey - Map 53

Side Scan Sonar Investigation

Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

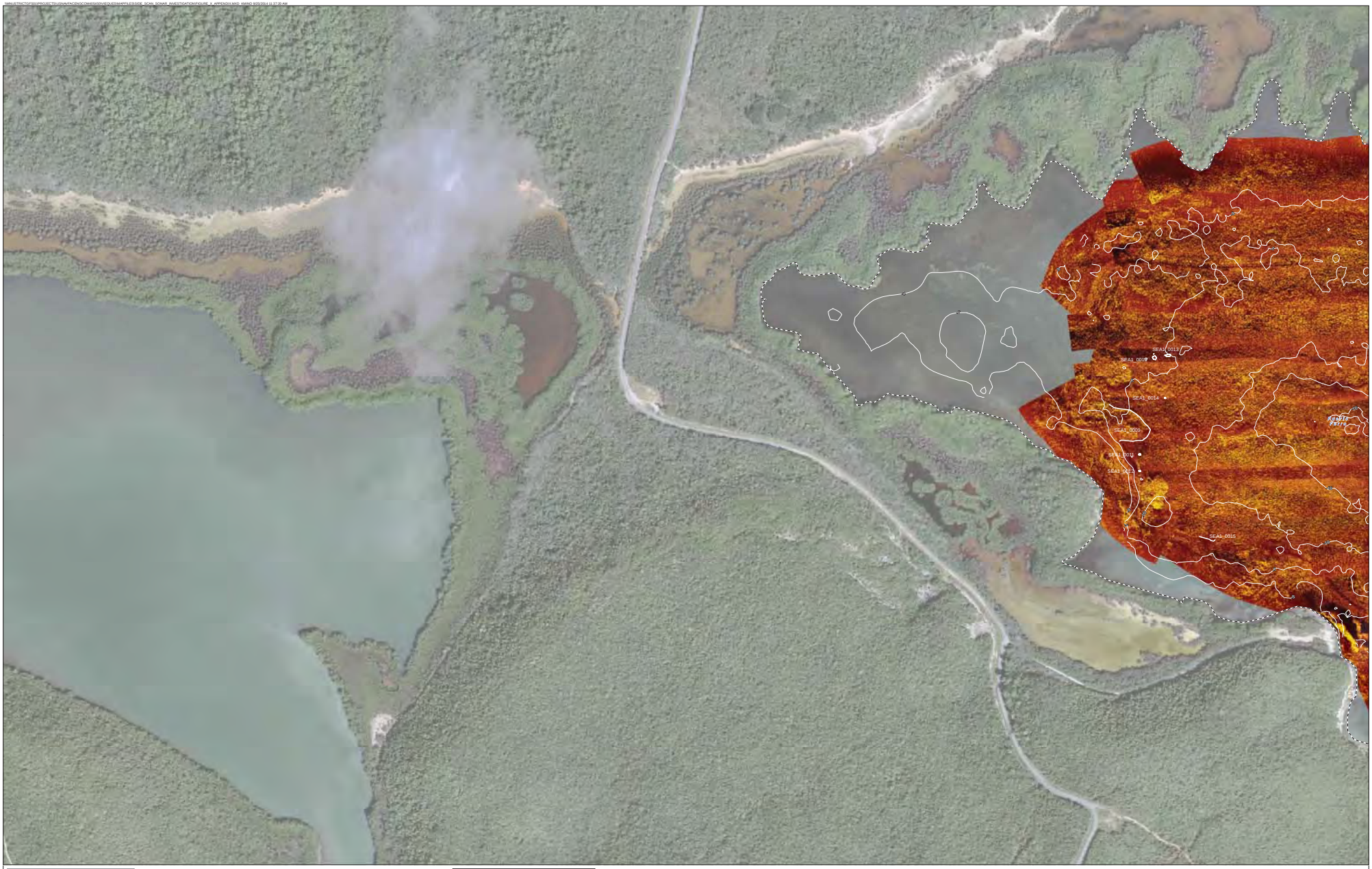
Source: Arc Surveying & Mapping & Sonographics, Inc.

N W E S

0 200 400 Feet

Side Scan Sonar Survey - Map 54
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 55
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

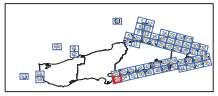
Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

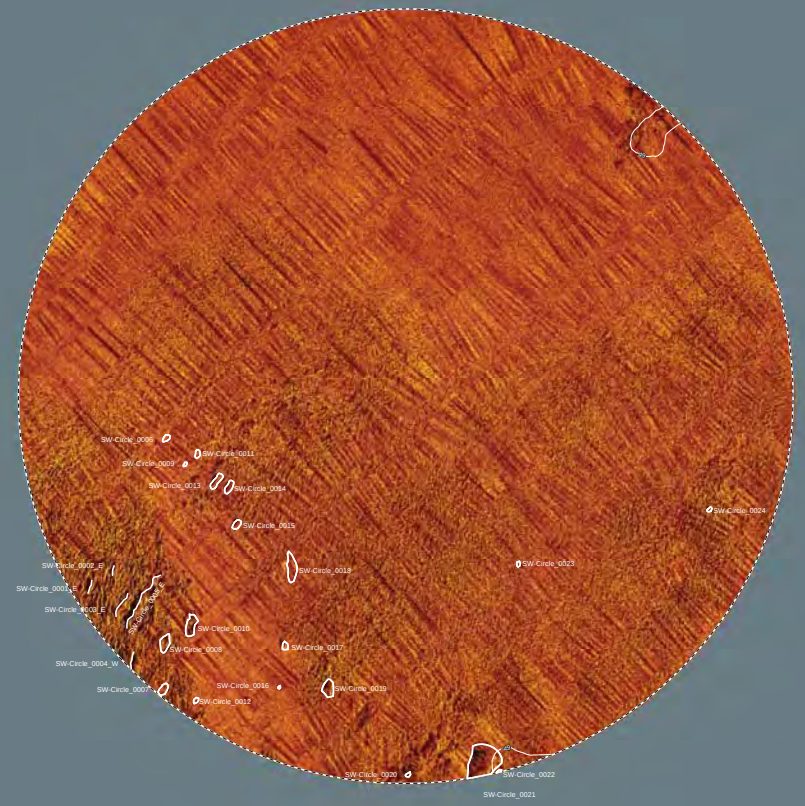
N W E S

0 200 400 Feet



Side Scan Sonar Survey - Map 56
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

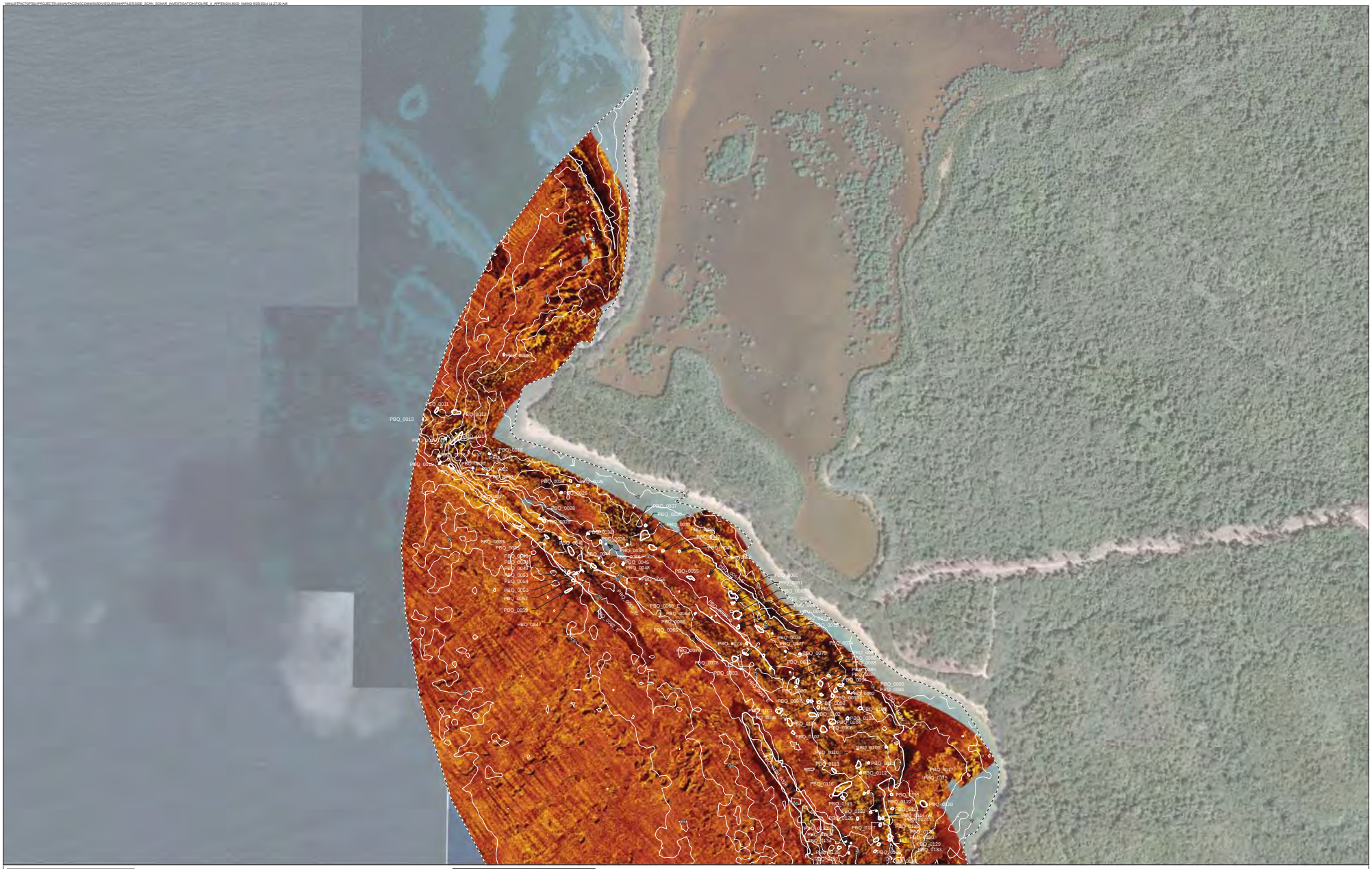
Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

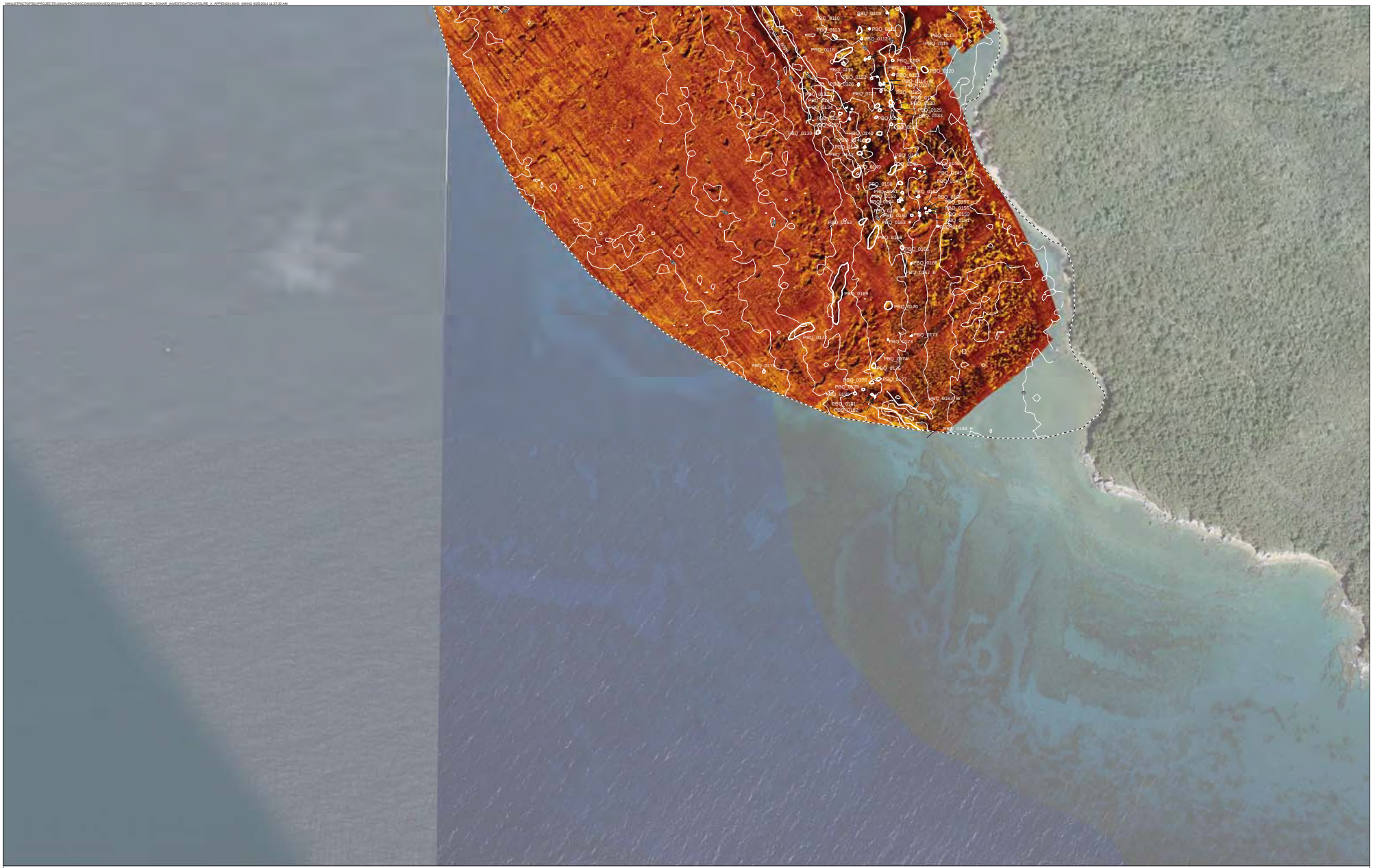
Side Scan Sonar Survey - Map 57
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



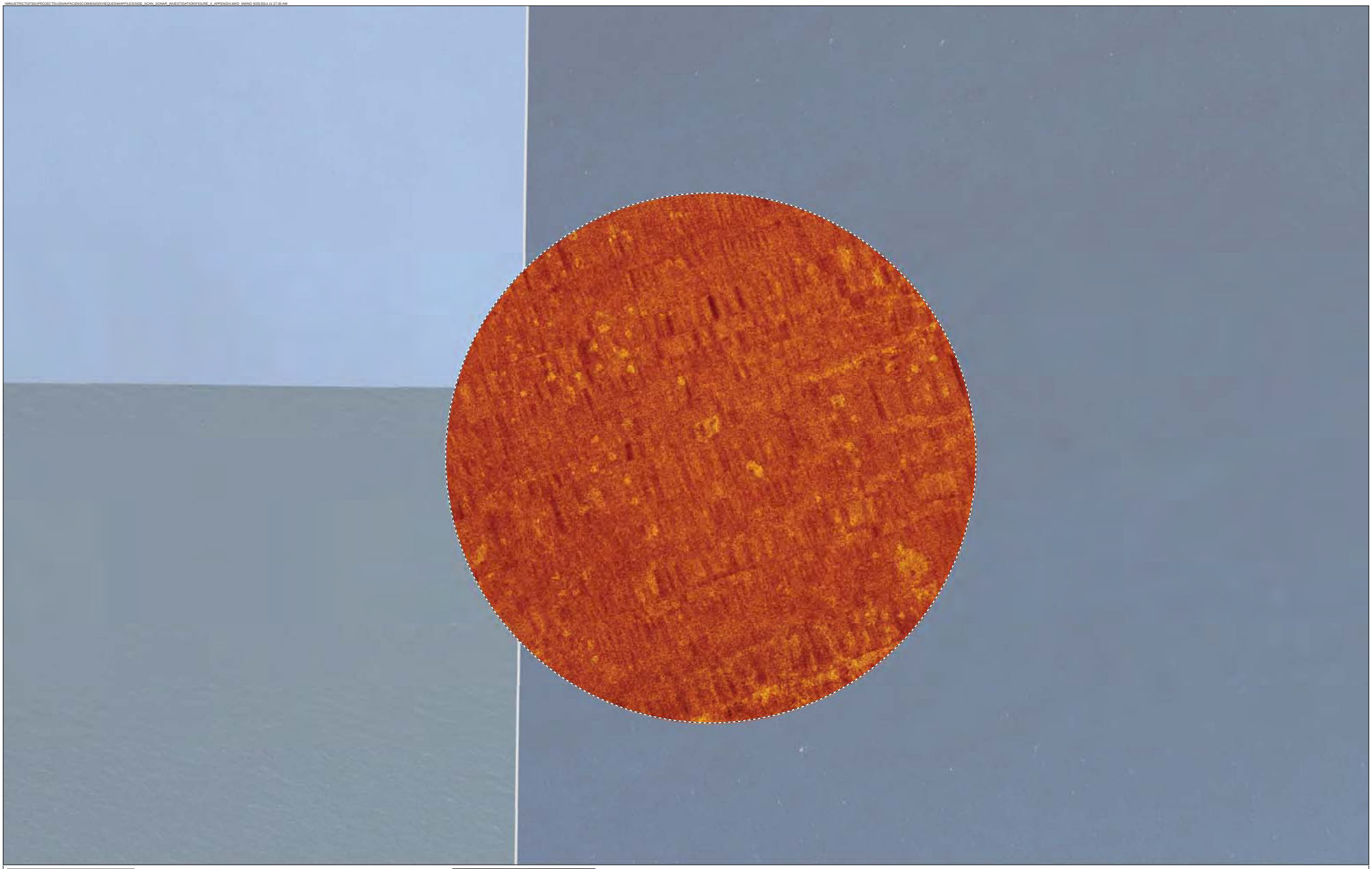
Side Scan Sonar Survey - Map 58
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Side Scan Sonar Survey - Map 59
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL



Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 60
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

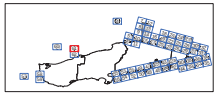
Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet



Side Scan Sonar Survey - Map 61
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

Legend

- UXO 16 Boundary
- Areas Identified with 1 meter or Greater Vertical Change on the Seafloor
- Bathymetry Contour (ft)

Source: Arc Surveying & Mapping & Sonographics, Inc.

N
W E
S

0 200 400
Feet

Side Scan Sonar Survey - Map 62
Side Scan Sonar Investigation
Vieques, Puerto Rico

CH2MHILL

Attachment C
Data Quality Control Report

Vieques Island Side Scan Sonar Survey

Daily Quality Control Report

DATE January 21, 2014

	Check Description	Acceptance							TIME	Ckd by	Comments
Check #1	**GPS Repeatablity**		**Distance from running avg.**								
			Start of day	**End of day**	**X**	**Y**	**Sats**				
		Within 1 meter	0.4227	N/A	221603.5	2030732	7		06:47	Erick	
			N/A	0.3453	221603.8	2030732	6		13:13	Erick	
	Check Description	**Acceptance**	**Start of day**	**End of day**	**During Sur**	**Post Processing**					
Check #2	**Pseudo-range Age Limit**	set to 20 Sec.	yes	yes	yes					Erick	
Check #3	**HDOP**	< 2.5	1.0	1.3	1.0					Erick	
Check #4	**Side-Scan Health**										
	Data Link	Net On Light on	yes	yes	yes					Rick	
	48 volt Power in towfish	>44VDC, <52VDC	ok	ok	ok					Rick	
	400 volts in towfish	400v indicator on	yes	yes	yes					Rick	
	Ambient Temp. C	>0 C , <60 C	ok	ok	ok					Rick	
	Cable Current	80 - 180 mA	ok	ok	ok					Rick	
	Error Count	Not increasing	yes	yes	yes					Rick	
	CPU Activity	Increasing	yes	yes	yes					Rick	
Check #5	**Side-Scan Rub Test**	Rub Xdcr display port/stbd	Pass	Pass	N/A				08:05	Rick	
Check #6	**Side-Scan Wet Test**	imagery both sides in water	Pass	Pass	Pass				12:05	Rick	
Check #7	**Pier Passes**		**Distance from running avg.**								
	End of Pier pass E to W	Ref. Point within 3 meters	0.9m	N/A	N/A	yes			07:01	Chris	Good repeatability, imagery and range coverage
	End of Pier pass W to E	Ref. Point within 3 meters	1.5m	N/A	N/A	yes			07:04	Chris	Good repeatability, imagery and range coverage
	End of Pier pass E to W	Ref. Point within 3 meters	N/A	0.9m	N/A	yes			12:49	Chris	Good repeatability, imagery and range coverage
	End of Pier pass W to E	Ref. Point within 3 meters	N/A	0.8m	N/A	yes			12:51	Chris	Good repeatability, imagery and range coverage
Check #8	**Confidenc Checks**		**Line Name**	**Target Name**	**X**	**Y**					
	Confidence Check 1	targets near range limits	NEA2_2E	QC0121_port	253034.40	2011035.80			11:10:35	Rick/Chris	Good range coverage
	Confidence Check 2	targets near range limits	NEA2_3W	QC0121_stbd	253308.00	2010949.99			11:21:33	Rick/Chris	Good range coverage
Check #9	**Data Quality Issues**	Sufficient lack of interference	**Pass/Fail** Pass							Rick	fading intensity streaks due to sea state on most lines. Feature Detection and resolution unaffected.

Appendix C
Visual Sample Plan Report

Transect Sampling for Unexploded Ordnance (UXO) Target Detection

Summary

This report summarizes the probability of traversing and detecting a target area of specific size and shape for different transect spacings. Simulation details and a power curve estimate how well the specified design would detect the target. The selected design statement is:

> If 4 meter wide transects with a parallel pattern are spaced 328 feet between transects (341.123 feet on centers) over the entire site, these transects have an approximately 99% chance of traversing and detecting any 250 meter diameter (125 meter radius) circular target area having a bivariate normal distribution with an average density of 25 anomalies per acre above the background density of 5 anomalies per acre. This assumes the instrument false negative rate is 0% and flagged windows have at least 95% confidence they have density greater than background.

The following table summarizes the sampling design developed.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Ensure high probability of traversing and detecting a target area that has a specified size and shape
Required Probability of Traversing the Target	100%
TARGET AREA AND TRANSECT INPUTS	
Type of Sampling Design	**Transects**
Transect Pattern	**Parallel**
Transect Width	**4 meters**
Target Area Definition	**User Specified**
Area of target area	**528372.22 ft^2**
Shape of target area of concern	**Circular**
Radius of target area of concern	**125 meters**
SIMULATION PARAMETERS FOR PROBABILITY OF DETECTION	
Formula for calculating the probability of traversing and detecting target area	Monte Carlo Simulation (method described below)
Background Density of the Site	5 anomalies / acre
Expected Target Area Density Above Background	25 anomalies / acre Target average
Distribution of target area density above background	Bivariate Normal
Transect spacing evaluation range	50 to 150 feet
Minimum precision	0.03
Maximum error	0.01
Search Window Diameter	738.189 feet

PROPOSED TRANSECT DESIGN AND COST INFORMATION	
Number of selected sample areas [a]	0
Specified sampling area [b]	0.00 acres
Computed spacing between transects	328 feet
Computed spacing between transect centers	341.123 feet
Number of transects to be surveyed	0
Transect Coverage	0.00% of total site area
Linear transect coverage	0.00 km
Area of transect coverage	0.0000 acres
Total cost of sampling [c]	N/A

[a] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.

[b] The sampling area is the total surface area of the selected colored sample areas on the map of the site.

[c] See the Cost of Sampling section for an explanation of the costs presented here.

Site Map With Proposed Transect Design

No map within VSP project.

Primary Sampling Objective

The primary purpose of sampling at this site is to traverse and detect target areas of a given size and shape with required high probability. The transect design tools provide a statistically defensible method to use transect survey data that covers only a small proportion of the total study area.

Selected Sampling Approach

The specified sampling approach was random parallel transect sampling. If parameters change from those specified in the table above, then the probability of detecting the target area will be different from those computed by VSP and reported here.

Simulation Details

To generate an estimated probability on a graph, VSP runs a Monte Carlo simulation based on the entered parameters. For each iteration, VSP creates a square site with the target area centered at the origin and rotated at a random angle. A parallel transect pattern is placed randomly so that 4 meters wide transects are parallel to the x axis.

VSP calculates the total area of the site traversed by transects, A_b, which can vary for each iteration. The expected number of detected background anomalies, λ_b, is calculated as $\lambda_b = D_b A_b (1 - P_{fn})$ where D_b is the background density of 5 anomalies / acres and P_{fn} is the instrument false negative rate of 0. A random number of detected background anomalies is generated using a Poisson distribution with parameter λ_b. VSP randomly places these anomalies within the traversed areas of the site.

To simulate the number of additional anomalies in the target area, VSP uses an approximation technique to randomly place additional detected anomalies in the traversed areas of the target area. Portions of transects overlapping the target area are divided into small sections. For each section, the quantile of the target area in which it lies is determined, the expected number of additional anomalies is determined, and a random number of detected anomalies is determined using a Poisson distribution and placed within the section.

VSP uses a moving window along each transect to determine which areas have density significantly greater than background density. The window moves 1/6 of the search window diameter for each iteration. Where D_a is the actual density for the current window, the null and alternative hypotheses for determining if the area inside the window has density significantly greater than background density, D_b, are as follows:

Null Hypothesis: $H_o : D_a \leq D_b$

Alternative Hypothesis: $H_a : D_a > D_b$

VSP checks each window to see if the actual number of detected anomalies is significantly greater than the expected number of anomalies for a Poisson distribution. If any windows intersecting the target area are flagged as significant, then we determine the target area has been detected.

250 iterations are run to begin the simulation to estimate a probability of detection. If the specified Maximum Error has not been achieved, additional iterations are run until the Maximum Error is met. If the total number of iterations is *n* and the proportion of target areas detected is *p*, then another iteration is run if

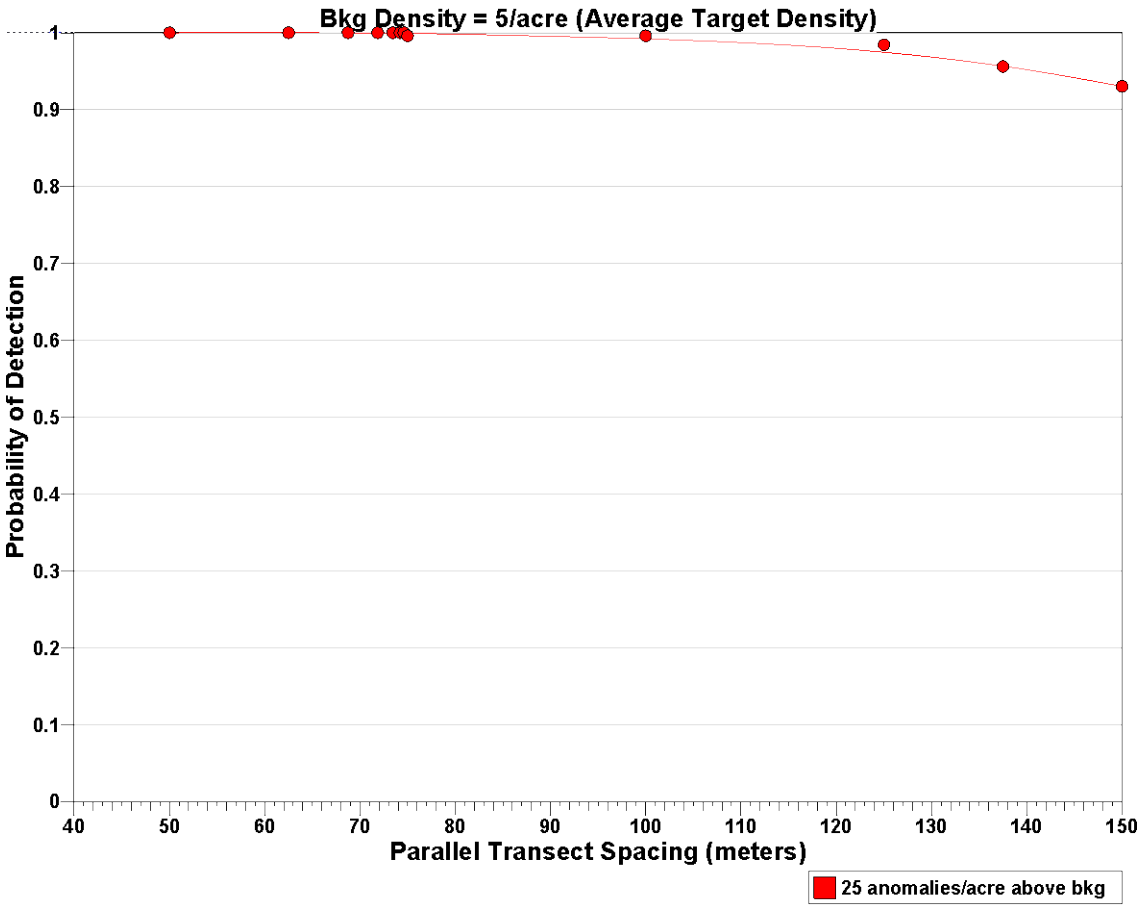
Maximum Error $< 1.96 * \sqrt{\frac{p(1-p)}{n}}$

The quantity $1.96 * \sqrt{\frac{p(1-p)}{n}}$ is the 95th percentile of the standard error of the mean for a binomial distribution. We are 95% certain that the estimated probability is close to the true probability (within the maximum error). When all iterations are completed, VSP tabulates the estimated probability the target area has been detected, *p* / *n*. VSP repeats this process for a number of transect spacings determined by simulation results and the minimum precision specified. The results are plotted in the power curve below.

Target Detection Power Curve

The following figure is a target detection performance diagram. It shows the probability of detecting the specified target area for a range of transect spacings. The estimated probability of detecting the target area is on the vertical axis, and a range of possible transect spacings are shown on the horizontal axis.

The legend at the bottom of the graph indicates the color of the line representing the target area densities above background used. Lines are fit by first smoothing the points using a moving average, then fitting the line using a cubic spline.



The transect spacings and the simulated probabilities of detecting the target area are shown in the table below:

Curve	Transect Spacing	Estimated Probability of Detecting the Target Area
1	50	1
1	62.5	1
1	68.75	1
1	71.875	1
1	73.4375	1
1	74.2188	1
1	74.6094	1
1	75	0.996094
1	100	0.996094
1	125	0.984536
1	137.5	0.95634
1	150	0.930275

Cost of Sampling

N/A

This report was automatically produced* by Visual Sample Plan (VSP) software version 7.0.

Software and documentation available at http://vsp.pnnl.gov

* - The report contents may have been modified or reformatted by end-user of software.

Appendix D
Quality Control Forms

CONTRACTOR PRODUCTION REPORT

(ATTACH ADDITIONAL SHEETS IF NECESSARY)

DATE OF REPORT:
REVISION NO:
REVISION DATE:

CTO NO:	PROJECT NAME/LOCATION:		REPORT NO:
PROJECT NO:	SUPERINTENDENT:	SITE H&S SPECIALIST:	
AM WEATHER:	PM WEATHER:	MAX TEMP: F	MIN TEMP: F

SUMMARY OF WORK PERFORMED TODAY

JOB SAFETY

Was A Job Safety Meeting Held This Date?	☐ Yes ☐ No	**TOTAL WORK HOURS ON JOB SITE THIS DATE** (Including Continuation Sheets)	
Were there any lost-time accidents this date? (If Yes, attach copy of completed OSHA report)	☐ Yes ☐ No	CH2MHILL On-Site Hours	
Was a Confined Space Entry Permit Administered This Date? (If Yes, attach copy of each permit)	☐ Yes ☐ No	AGVIQ On-Site Hours	
Was Crane/Manlift/Trenching/Scaffold/HV Elec/High Work/Hazmat Work Done?? (If Yes, attach statement or checklist showing inspection performed)	☐ Yes ☐ No	Subcontractor On-Site Hours	
		Total On-Site Hours This Date	
Was Hazardous Material/Waste Released into the Environment? (If Yes, attach description of incident and proposed action)	☐ Yes ☐ No	Cumulative Total of Work Hours From Previous Report	
		Total Work Hours From Start of Construction	

SAFETY ACTIONS TAKEN TODAY/SAFETY INSPECTIONS CONDUCTED (Include Safety Violations, Corrective Instructions Given, Corrective Actions Taken, and Results of Safety Inspections Conducted):

EQUIPMENT/MATERIAL RECEIVED TODAY TO BE INCORPORATED IN JOB

DESCRIPTION OF EQUIPMENT/MATERIAL RECEIVED	MAKE/ MODEL/ MANUFACTURER	EQUIPMENT/ LOT NUMBER	INSPECTION PERFORMED BY	NUMBER/ VOLUME/ WEIGHT

EQUIPMENT USED ON JOB SITE TODAY.

EQUIPMENT DESCRIPTION	EQUIPMENT MAKE/MODEL	SAFETY CHECK PERFORMED BY	NUMBER OF HOURS		
			USED	IDLE	REPAIR

CHANGED CONDITIONS/DELAY/CONFLICTS ENCOUNTERED (List any conflicts with the delivery order [i.e., scope of work and/or drawings], delays to the project attributable to site and weather conditions, etc.)**:**

VISITORS TO THE SITE:

LIST OF ATTACHMENTS (OSHA report, confined space entry permit, incident reports, etc.):

SAFETY REQUIREMENTS HAVE BEEN MET ☐

SUPERINTENDENT'S SIGNATURE _____ DATE _____

CH2MHILL	**CONTRACTOR PRODUCTION REPORT** (ATTACH ADDITIONAL SHEETS IF NECESSARY)	DATE OF REPORT: REVISION NO: REVISION DATE:
CTO NO:	PROJECT NAME/LOCATION:	REPORT NO:
PROJECT NO:	SUPERINTENDENT:	SITE H&S SPECIALIST:

WORK PERFORMED TODAY

EMPLOYEE	WORK PERFORMED	EMPLOYER	FEMALE?	MINORITY?	TITLE/TRADE	HRS

INCLUDE ALL PERSONNEL WORK HOURS IN THE TOTAL WORK HOURS ON JOB SITE

SAFETY REQUIREMENTS HAVE BEEN MET ☐

SUPERINTENDENT'S SIGNATURE _____ DATE _____

CH2MHILL	**CONTRACTOR QUALITY CONTROL REPORT** (ATTACH ADDITIONAL SHEETS IF NECESSARY)	REPORT DATE: REVISION NO: REVISION DATE:
CTO NO:	PROJECT NAME/LOCATION:	REPORT NO:
PROJECT NO:	PROJECT QC MANAGER:	SITE H&S SPECIALIST:

SAFETY MEETINGS AND INSPECTIONS

WAS A SAFETY MEETING HELD THIS DAY?	☐ YES ☐ NO	IF YES, ATTACH SAFETY MEETING MINUTES
WAS CRANE USED ON THE SITE THIS DAY?	☐ YES ☐ NO	IF YES, ATTACH DAILY CRANE REPORT OF INSPECTION AND CONTRACTOR CRANE OPERATION CHECKLIST

DEFINABLE FEATURES OF WORK STATUS

DFOW No.	Definable Feature Of Work	Preparatory	Initial	Follow-Up
1		☐	☐	☐
2		☐	☐	☐
3		☐	☐	☐
4		☐	☐	☐
5		☐	☐	☐
6		☐	☐	☐
7		☐	☐	☐
8		☐	☐	☐
9		☐	☐	☐
10		☐	☐	☐
11		☐	☐	☐
12		☐	☐	☐
13		☐	☐	☐
14		☐	☐	☐
15		☐	☐	☐

PREPARATORY

WAS PREPARATORY PHASE WORK PERFORMED TODAY? ☐ YES ☐ NO

IF YES, FILL OUT AND ATTACH SUPPLEMENTAL PREPARATORY PHASE CHECKLIST.

DFOW No.(from list above).	TASK/ACTIVITY	PREPARATORY PHASE REPORT NO.

INITIAL AND FOLLOW-UP FEATURE OF WORK COMMENTS

DFOW No.(from list above)	Phase	Comment/Finding/Action
	Initial ☐ Follow up ☐	
	Initial ☐ Follow up ☐	
	Initial ☐ Follow up ☐	
	Initial ☐ Follow up ☐	
	Initial ☐ Follow up ☐	
	Initial ☐ Follow up ☐	
	Initial ☐ Follow up ☐	
	Initial ☐ Follow up ☐	
	Initial ☐ Follow up ☐	
	Initial ☐ Follow up ☐	
	Initial ☐ Follow up ☐	

REWORK ITEMS IDENTIFIED TODAY (NOT CORRECTED BY CLOSE OF BUSINESS)			**REWORK ITEMS CORRECTED TODAY (FROM REWORK ITEMS LIST)**	
TASK/ACTIVITY	DATE ISSUED	DESCRIPTION	TASK/ACTIVITY	CORRECTIVE ACTION(S) TAKEN

CH2MHILL	**CONTRACTOR QUALITY CONTROL REPORT** (ATTACH ADDITIONAL SHEETS IF NECESSARY)	REPORT DATE: REVISION NO: REVISION DATE:
CTO NO:	PROJECT NAME/LOCATION:	REPORT NO:
PROJECT NO:	PROJECT QC MANAGER:	SITE H&S SPECIALIST:

SAMPLING/TESTING PERFORMED

SAMPLING/TESTING PERFORMED	SAMPLING/TESTING COMPANY	SAMPLING/TESTING PERSONNEL

MATERIALS/EQUIPMENT INSPECTION (Materials received and inspected against specifications)

MATERIAL/EQUIPMENT DESCRIPTION	SPECIFICATION	MATERIAL ACCEPTED?	COMMENT/REASON/ACTION
		YES ☐ NO ☐	
		YES ☐ NO ☐	
		YES ☐ NO ☐	
		YES ☐ NO ☐	
		YES ☐ NO ☐	
		YES ☐ NO ☐	
		YES ☐ NO ☐	

SUBMITTALS INSPECTION / REVIEW

SUBMITTAL NO	SUBMITTAL DESCRIPTION	SPEC/PLAN REFERENCE	SUBMITTAL APPROVED?	COMMENT/REASON/ACTION
			YES ☐ NO ☐	
			YES ☐ NO ☐	
			YES ☐ NO ☐	
			YES ☐ NO ☐	

OFF-SITE SURVEILLANCE ACTIVITIES, INCLUDING ACTIONS TAKEN:

ACCUMULATION/STOCKPILE AREA INSPECTION

INSPECTION PERFORMED BY:				SIGNATURE OF INSPECTOR:			
ACCUMULATION/ STOCKPILE AREA LOCATION							
NO OF CONTAINERS:		NO OF TANKS:		NO OF ROLL-OFF BOXES:		NO OF DRUMS:	

INSPECTION RESULTS:

TRANSPORTATION AND DISPOSAL ACTIVITIES/SUMMARY/QUANTITIES:

GENERAL COMMENTS (rework, directives, etc.):

LIST OF ATTACHMENTS (examples, as applicable: preparatory phase checklist, QC meeting minutes, safety meeting minutes, crane inspections, crane operation checklist, COCs, weight tickets, manifests, profiles, rework item list, testing plan and log, etc.):

On behalf of the contractor, I certify that this report is complete and correct and equipment and material used and work performed during this reporting period is in compliance with the contract drawings and specifications to the best of my knowledge except as noted in this report.

PROJECT QC MANAGER'S SIGNATURE DATE

On behalf of the contractor, I attest that the work for which payment is requested, including stored material, is in compliance with contract requirements.

PROJECT QC MANAGER'S SIGNATURE DATE

FORM 6-3

DAILY QC REPORT

PROJECT: _____ Date: _____

LOCATION OF WORK (SITE/AOI): _____

DESCRIPTION OF WORK: _____

WEATHER: ☐(CLEAR) ☐(FOG) ☐(P.CLOUDY) ☐(RAIN) ☐(WINDY)

TEMPERATURE: MIN: _____°F MAX: _____°F

1. Project work completed today:

2. Work completed today by QC inspection staff :

3. All work performed in conformance with Work Plan/QCP requirements?

If not, explain:

4. Are team leader log entries current and legible, and include documentation of morning

And tail-gate safety brief and relevant information regarding daily functions?

Comments:

CERTIFICATION: I certify that the above report is complete and correct and that I, or my representative, have inspected all work identified on this report and have determined to the best of my knowledge and belief that noted work activities are in compliance with work plans and specifications, except as may be noted above.

_____

Project QC Specialist

CH2MHILL	**PREPARATORY PHASE REPORT**	REPORT NO:	REPORT DATE: REVISION NO: REVISION DATE:
PROJECT NO:	DEFINABLE FEATURE OF WORK:	SITE/ACTIVITY:	

PERSONNEL PRESENT

NAME	POSITION	COMPANY/GOVERNMENT

SUBMITTALS

REVIEW SUBMITTALS AND/OR SUBMITTAL REGISTER.	HAVE ALL SUBMITTALS BEEN APPROVED? YES ☐ NO ☐
IF NO, WHAT ITEMS HAVE NOT BEEN SUBMITTED?	
ARE ALL MATERIALS ON HAND? YES ☐ NO ☐	
IF NO, WHAT ITEMS ARE MISSING?	
CHECK APPROVED SUBMITTALS AGAINST DELIVERED MATERIAL. (THIS SHOULD BE DONE AS MATERIAL ARRIVES).	
COMMENTS:	

MATERIAL STORAGE

ARE MATERIALS STORED PROPERLY? YES ☐ NO ☐	
IF NO, WHAT ACTION IS TAKEN?	

SPECIFICATIONS

REVIEW EACH PARAGRAPH OF SPECIFICATIONS.
DISCUSS PROCEDURE FOR ACCOMPLISHING THE WORK.
CLARIFY ANY DIFFERENCES.

PRELIM WORK & PERMITS

ENSURE PRELIMINARY WORK IS CORRECT AND PERMITS ARE ON FILE.	
IF NO, WHAT ACTION IS TAKEN?	

CH2MHILL	**PREPARATORY PHASE REPORT**	REPORT NO:	REPORT DATE: REVISION NO: REVISION DATE:
PROJECT NO:	DEFINABLE FEATURE OF WORK:	SITE/ACTIVITY:	

TESTING

IDENTIFY TEST TO BE PERFORMED, FREQUENCY, AND BY WHOM.

TEST	FREQUENCY	PERFORMER

WHEN REQUIRED?

WHERE REQUIRED?

REVIEW TESTING PLAN.

HAVE TEST FACILITIES BEEN APPROVED?

TEST FACILITY	APPROVED?
	YES ☐ NO ☐
	YES ☐ NO ☐

SAFETY

ACTIVITY HAZARD ANALYSIS APPROVED? YES ☐ NO ☐

REVIEW APPLICABLE PORTION OF EM 385-1-1 AND AHA.

MEETING COMMENTS

NAVY/ROICC COMMENTS DURING MEETING.

OTHER ITEMS OR REMARKS

OTHER ITEMS OR REMARKS:

QC REPRESENTATIVE'S NAME	QC REPRESENTATIVE'S SIGNATURE		DATE	

FORM 4-9

CORRECTIVE ACTION REQUEST

(2)CAR #:	(3)PRIORITY: ☐HIGH ☐NORMAL	(4)DATE PREPARED:

PART A: NOTICE OF DEFICIENCY

(5)PROJECT:	
(6)PROJECT MANAGER:	(7)MEC QCS:
(8)WORK UNIT:	(9)WORK UNIT MANAGER:
(10)ISSUED TO (INDIVIDUAL & ORGANIZATION):	
(11)REQUIREMENT & REFERENCE:	
(12)PROBLEM DESCRIPTION & LOCATION: (4)CAP REQUIRED? ☐YES ☐NO (14)RESPONSE DUE:	
(15)ISSUED BY (PRINTED NAME & TITLE): SIGNATURE: DATE:	(16)MANAGEMENT CONCURRENCE:

PART B: CORRECTIVE ACTION

(17)PROPOSED CORRECTIVE ACTION/ACTION TAKEN: NOTE: SUPPORTING DOCUMENTATION MUST BE LISTED ON THE BACK OF THIS FORM AND ATTACHED.	
(18)PART B COMPLETED BY (NAME & TITLE): SIGNATURE: DATE:	(19)QC CONCURRENCE:

CORRECTIVE ACTION REQUEST

PART C: CORRECTIVE ACTION VERIFICATION

(20)CAR VERIFICATION AND CLOSE-OUT: (CHECK ONLY ONE & EXPLAIN STIPULATIONS, IF ANY)

☐APPROVED FOR CLOSURE WITHOUT STIPULATIONS

☐APPROVED FOR CLOSURE WITH FOLLOWING STIPULATIONS

COMMENTS/STIPULATIONS:

(21)CLOSED BY (PRINTED NAME & TITLE):

SIGNATURE: DATE:

CORRECTIVE ACTION REQUEST (CAR) INSTRUCTION SHEET

(1) **MEC QCS**: Verify that the total number of pages includes all attachments.

(2) **MEC QCS**: Fill in CAR number from CAR log.

(3) **MEC QCS**: Fill in appropriate priority category. **High** priority indicates resolution of deficiency requires expediting corrective action plan and correction of deficient conditions noted in the CAR and extraordinary resources may be required due to the deficiency's impact on continuing operations. **Normal** priority indicates that the deficiency resolution process may be accomplished without further impacting continuing operations.

(4) **CAR Requestor**: Fill in date CAR is initiated.

(5) **CAR Requestor**: Identify project name, number, CTO, and WAD.

(6) **CAR Requestor**: Identify Project Manager

(7) **CAR Requestor**: Identify CQC System Manager.

(8) **CAR Requestor**: Identify project organization, group, or discrete work environment where deficiency was first discovered.

(9) **CAR Requestor**: Identify line manager responsible for work unit where deficiency was discovered.

(10) **MEC QCS**: Identify responsible manager designated to resolve deficiency (this may not be work unit manager).

(11) **CAR Requestor**: Identify source of requirement violated in contract, work planning document, procedure, instruction, etc; use exact reference to page and, when applicable, paragraph.

(12) **CAR Requestor**: Identify problem as it relates to requirement previously stated. Identify location of work activities impacted by deficiency.

(4) **MEC QCS**: Identify if Corrective Action Plan (CAP) is required. CAP is typically required where one or more of the following conditions apply: CAR priority is **High**; deficiency requires a rigorous corrective action planning process to identify similar work product or activities affected by the deficiency; or deficiency requires extensive resources and planning to correct the deficiency and to prevent future recurrence.

(14) **MEC QCS**: Identify date by which proposed corrective action is due to QC for concurrence.

(15) **MEC QCS**: Sign and date CAR and forward to responsible manager identified in (10) above.

(16) **Responsible Manager**: Initial to acknowledge receipt of CAR.

(17) **Responsible Manager**: Complete corrective action plan and identify date of correction. Typical corrective action response will include statement regarding how the condition occurred, what the extent of the problem is (if not readily apparent by the problem description statement in [12]), methods to be used to correct the condition, and actions to be taken to prevent the condition from recurring. If a CAP is required, refer to CAP only in this section.

(18) **Responsible Manager**: Sign and date corrective action response.

(19) **MEC QCS**: Initial to identify concurrence with corrective action response from responsible manager.

(20) **MEC QCS**: Check appropriate block to identify if corrective action process is complete so that CAR may be closed. Add close-out comments relevant to block checked.

(21) **MEC QCS**: Indicate document closeout by signing and dating.

CH2MHILL

NON-CONFORMANCE REPORT

A non-conformance has been identified on the project listed below. An investigation and root cause analysis must be performed by the personnel designated below and corrective actions proposed to the Program QA/QC Manager by the "Reply Due Date". When the investigative findings, root cause analysis results, and corrective actions are accepted by the Program Manager and the Program QA/QC Manager, the NCR will considered closed.

PART 1 – General Information

Date Submitted:	NCR Number:
Submitted To:	Company/ Title/Position:
Prepared By:	Company/ Title/Position:
Project Name:	Project Number:
TO Number:	Contract Number:

PART 2 – Non-Conformance Report

Description of Non-Conforming Item or Condition				
Contract Requirement or Project Specification/Drawing				
Test/Inspection/Audit Identifying Non-Conformance				
Reportable Release?	Yes ☐		No ☐	
Material Name:	N/A		Quantity: N/A	
Disposition:	Repair ☐	Rework ☐	Use-As-Is ☐	Reject ☐

PART 3 – Investigation/Root Cause Determination

Personnel Responsible for Investigative Process:
Investigative Process Findings:
Probable Root and Contributing Cause(s):

PART 4 – Corrective Actions

Proposed Corrective Actions and Completion Dates:		
Personnel Responsible for Implementation of Corrective Actions:		
Resulting Actions and Effectiveness of Those Actions:		
Personnel Responsible for Monitoring Effectiveness of Corrective Actions:		
Corrective actions have been completed and monitored for effectiveness.		
Signature	Company/Title	Date

PART 5 – Response Approval

Responses Accepted By		
Signature	Company/Title	Date
Signature	Company/Title	Date

PART 6 – Quality Control Follow-Up

Comments/Findings of Follow-Up Observation / Inspection / Audit:			
Verification Results	Satisfactory ☐	Unsatisfactory ☐	

PART 7 – NCR Closure

NCR Closed		
	Sector Quality Manager	
Signature	Company/Title	Date

Root Cause Analysis Form

Root Cause Analysis (RCA)

Root Cause Categories (RCC): Select the RCC numbered below that applies for the root cause (RC) and/or contributing factor (CF) in the first column, then describe the specific root cause and corrective actions in each column.

1. **Lack of skill or knowledge**
2. **Lack of or inadequate operational procedures or work standards**
3. **Inadequate communication of expectations regarding procedures or work standards**
4. **Inadequate tools or equipment**
5. **Correct way takes more time and/or requires more effort**
6. **Short cutting standard procedures is positively reinforced or tolerated**
7. **Person thinks there is no personal benefit to always doing the job according to standards**

RCC #	Root Cause(s)	Corrective Actions	RC[1]	CF[2]	Due Date	Completion Date	Date Verified

[1] RC = Root Cause; [2] CF = Contributing Factors (check which applies)

Investigation Team Members

Name	Job Title	Date

Results of Solution Verification and Validation

Reviewed By

Name	Job Title	Date

Determination of Root Cause(s)

For minor losses or near losses the information may be gathered by the supervisor or other personnel immediately following the loss. Based on the complexity of the situation, this information may be all that is necessary to enable the investigation team to analyze the loss, to determine the root cause, and to develop recommendations. More complex situations may require the investigation team to revisit the loss site or re-interview key witnesses to obtain answers to questions that may arise during the investigation process.

Photographs or videotapes of the scene and damaged equipment should be taken from all sides and from various distances. This point is especially important when the investigation team will not be able to review the loss scene.

The investigation team must use the Root Cause Analysis Flow Chart to assist in identifying the root cause(s) of a loss. Any loss may have one or more "root causes" and "contributing factors". The "root cause" is the primary or immediate cause of the incident, while a "contributing factor" is a condition or event that contributes to the incident happening, but is not the primary cause of the incident. Root causes and contributing factors that relate to the *person* involved in the loss, his or her peers, or the supervisor should be referred to as "personal factors". Causes that pertain to the *system* within which the loss or injury occurred should be referred to as "job factors".

Personal Factors

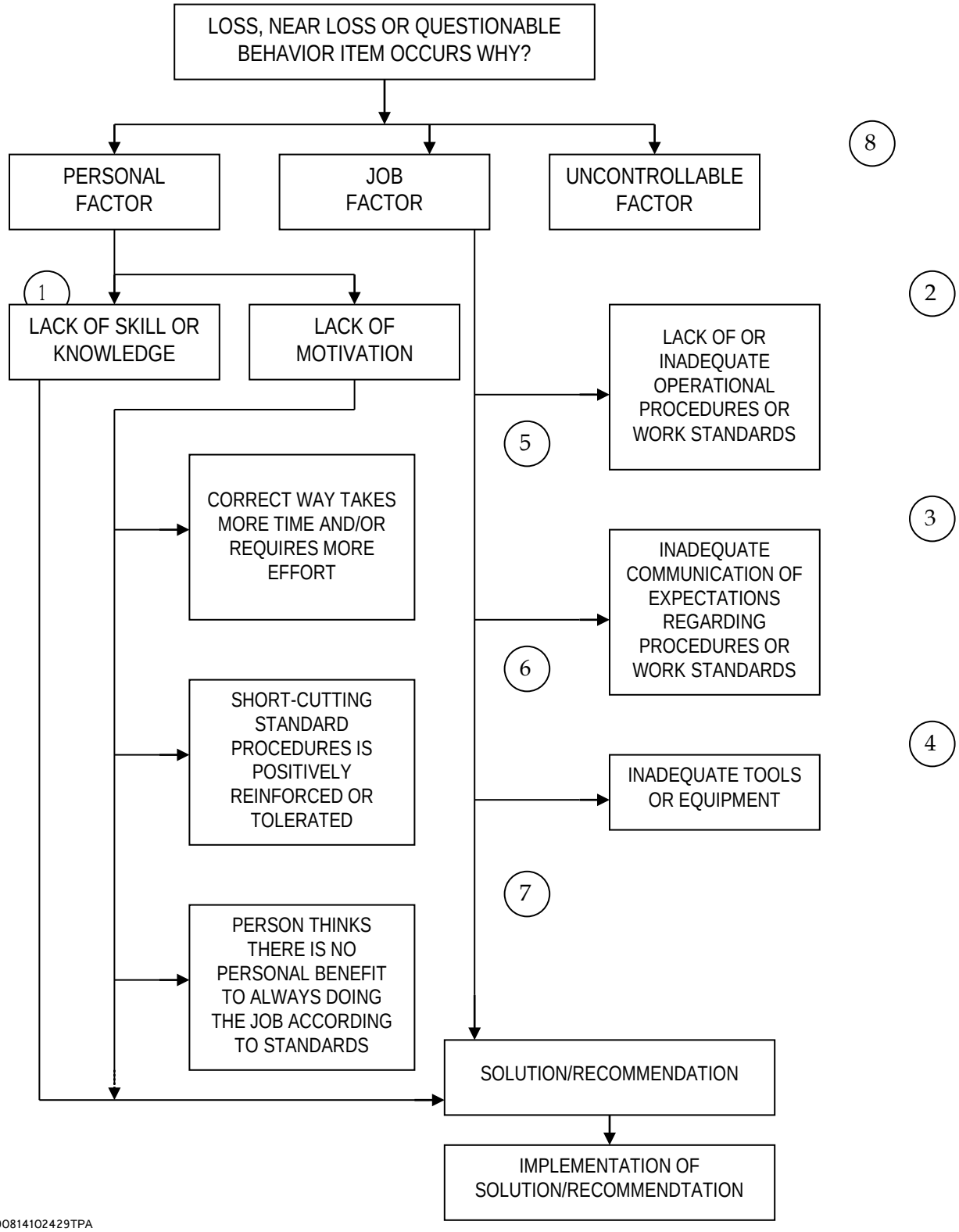
- Lack of skill of knowledge
- Correct way takes more time and/or requires more effort
- Short-cutting standard procedures is positively reinforced or tolerated
- Person thinks that there is no personal benefit to always doing the job according to standards

Job Factors

- Lack of or inadequate operational procedures or work standards.
- Inadequate communication of expectations regarding procedures or standards
- Inadequate tools or equipment

The root cause(s) could be any one or a combination of these seven possibilities or some other "uncontrollable factor". In the vast majority of losses, the root cause is very much related to one or more of these seven factors. Uncontrollable factors should be used rarely and only after a thorough review eliminates "all" seven other factors.

Root Cause Analysis Flow Chart



Appendix E
Standard Operating Procedures

Standard Operating Procedures for Protection of Federally Listed Species and Sensitive Habitat

UXO 16 Wide Area Assessment

Former Naval Ammunition Support Detachment and Former Vieques Naval Training Range Vieques, Puerto Rico

These Standard Operating Procedures (SOPs) apply to the underwater digital geophysical mapping (DGM) surveys to be conducted as part of the UXO 16 Wide Area Assessment (WAA) to assess the potential presence of munitions and explosives of concern (MEC) and munitions constituents (MC) offshore of the former Naval Ammunition Support Detachment (NASD) and the former Vieques Naval Training Range (VNTR) in Vieques, Puerto Rico. The DGM surveys will be conducted using a vessel-towed array of 4 to 8 magnetometers. In addition to the magnetometers, the towed array will include GPS equipment, various sensors, video equipment, and other instrumentation. These SOPs are required to be implemented in conjunction with the Work Plan and Project Instructions prepared for the project. These SOPs are required to be posted onboard all work vessels.

Vessel Operations

- All project related watercrafts should travel at no wake speed within shallow waters (10 feet or less) and/or when 150 feet from the coastline.
- All vessels will preferentially follow deep water routes whenever possible.
- Vessel operators will use nautical charts, data on underwater obstructions collected during the UXO 16 side-scan sonar survey, onboard depth sounders, and sensors on the towed area to prevent the vessel and towed array from contacting the seafloor and underwater obstacles, including coral colonies. The survey is not anticipated to be conducted in water depths shallower than 4 - 6 feet.
- Vessels will be anchored preferentially on sandy bottom whenever possible. If anchoring on sandy bottom is not possible, vessels may be anchored on vegetated bottom that consists of seagrass and/or algae (seaweed). Vessels will not be anchored on hardbottom that contains hard and/or soft coral, regardless of the percentage of coral cover present. The type of bottom present will be confirmed by divers, onboard using a glass-bottom bucket, or by other appropriate means, prior to anchoring.
- If the vessel is anchored on vegetated bottom (seagrass/algae), the anchor will be removed from the seafloor in a manner that minimizes disturbance to the vegetation, for example, by attaching a secondary anchor line to the rear of any plow-type anchor (danforth, union, bruce) and pulling the anchor free from the seafloor before lifting to the surface.

Protection of Sea Turtles and Marine Mammals

- All work personnel will be familiar with the identification of federally listed sea turtle and marine mammal species that have the potential to occur in the work areas; Endangered Species Act (ESA) policy and associated civil/criminal penalties for violations; and the procedures to be followed to prevent impacts to sea turtles and marine mammals during work activities.
- The following federally listed sea turtle species have the potential to occur in the work areas:
  - Loggerhead sea turtle (*Caretta caretta*)
  - Green sea turtle (*Chelonia mydas*)
  - Leatherback sea turtle (*Dermochelys coriacea*)

  - Hawksbill sea turtle (*Eretmochelys imbricata*)

- The following federally listed marine mammal species have the potential to occur in the work areas:

  - West Indian manatee (*Trichechus manatus*)
  - Humpback whale (*Megaptera novaeangliae*)
  - Sperm whale (*Physeter macrocephalus*)
  - Sei whale (*Balaenoptera borealis*)
  - Blue whale (*Balaenoptera musculus*)
  - Finback whale (*Balaenoptera physalus*)

- All sightings of the above federally listed sea turtle and marine mammal species will be documented in a log to be provided to the Navy, National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), and Puerto Rico Department of Natural and Environmental Resources (DNER) at the end of the project. The following information shall be collected and recorded:

  - Sighted species
  - Date and time of sighting
  - GPS coordinates of sighting location
  - One or more photographs if possible
  - Any action taken to minimize potential impacts to species (see below)

- All personnel onboard work vessels are responsible for observing for the presence of sea turtles and marine mammals. The work areas will be routinely monitored for the presence of sea turtles and marine mammals.

- If a whale is sighted, maintain a distance of 100 yards or greater between the whale and the vessel whenever possible.

- If a sea turtle or manatee is sighted, maintain a distance of 50 yards or greater between the animal and the vessel whenever possible.

- If a whale is sighted while a vessel is underway (e.g., bow-riding), attempt to remain parallel to the animal's course. Avoid excessive speed or abrupt changes in direction until the whale has left the area.

- Reduce vessel speed to 10 knots or less when mother/calf pairs, groups, or large assemblages of whales are sighted near an underway vessel, when safety permits. A single whale at the surface may indicate the presence of submerged animals in the vicinity. The vessel should attempt to route around the animals, maintaining a minimum distance of 100 yards whenever possible.

- Sea turtles and marine mammals may surface in unpredictable locations or approach slowly moving vessels. When an animal is sighted in the vessel's path or in close proximity to a moving vessel, reduce speed and shift the engine to neutral. Do not engage the engines until the animal is clear of the area.

- Any collision with and/or injury to a sea turtle or marine mammal will be reported immediately to NMFS and DNER. Work personnel should report sightings of any injured or dead sea turtle or marine mammal immediately to NMFS, regardless of whether the injury/death is caused by the work personnel.

  - Report sea turtles to the NMFS Southeast Regional Office: (727) 824-5312 and to the DNER Ranger Corps 787-724-5700 or 787-771-1124.

  - Report marine mammals to the Southeast U.S. Stranding Hotline: (877) 433-8299 and the DNER Marine Mammal Rescue Program (787) 645-5593 or (787) 538-4684. Any incidents involving manatees must be reported immediately to the DNER Manatee Stranding Coordinator at 787 645-5593, the USFWS Caribbean Field Office at 787 851-7297 ext. 220, and to the Vieques National Wildlife Refuge at (787) 741-2138.

- If the injury or death of a sea turtle or marine mammal is caused by a vessel collision or other work activity, the responsible parties will remain available to assist the respective response personnel as needed.

Protection of Coral and Benthic Habitats

- All work personnel will be familiar with the identification of federally listed coral species, hardbottom habitat, and vegetated bottom habitat that have the potential to occur in the work areas; ESA policy and associated civil/criminal penalties for violations; and the procedures to be followed to prevent impacts to listed coral species, hardbottom habitat, and vegetated bottom habitat during work activities.
- The following federally Threatened coral species have the potential to occur in the work areas:
  - Staghorn coral (*Acropora cervicornis*)
  - Elkhorn coral (*Acropora palmata*)
  - Pillar coral (*Dendrogyra cylindrus*)
  - Lobed star coral (*Orbicella annularis*)
  - Mountainous star coral (*Orbicella faveolata*)
  - Boulder star coral (*Orbicella franksi*)
  - Rough cactus coral (*Mycetophyllia ferox*)

  The seven threatened coral species are protected by the ESA; currently elkhorn and staghorn corals have "take" prohibitions established, while the remaining five species may have "take" prohibitions in the future. If during the underwater investigation any ESA-listed corals are inadvertently impacted, whatever activity causing the impact will be stopped. Information will be gathered including the following:
  - Time, date, and coordinates of the impact
  - Name and type of vessel involved, and vessel speed
  - A description of the incident
  - Water depth
  - Environmental conditions (such as visibility, waves, wind speed and direction)
  - The coral species impacted and description of the damage

  This information will be immediately reported to the NOAA Office of Law Enforcement at (800) 853-1964, NMFS in Boquerón at (787) 851-3700, and DNER at (787) 645-5593.
- As standard practice, impacts to any hard or soft coral species should be avoided.
- The potential for vessels or the towed array to impact seagrass or coral is very low as the above impact avoidance measures identified for vessel operations will be strictly followed. In the event that seagrass or coral is inadvertently impacted by vessel operations, the restoration measures identified below will be implemented. Any impacts to seagrass or coral will be immediately reported to NMFS.
- Any seagrass that is inadvertently impacted during the project will be inspected by scientific divers who will determine the type of restoration measures, if necessary, that should be implemented. All seagrass restoration will occur in the area impacted and will be conducted by scientific divers who have experience in seagrass restoration techniques. Any void created on the seafloor by an inadvertent impact will be backfilled with adjacent sediment so the grade of the impacted area is flush with the surrounding grade. The methods used to restore seagrass will be specific to the condition of the impacted seagrass and the seagrass species involved. Turtle grass (*Thalassia testudinum*) has deeper rhizomes/roots than shoal grass (*Halodule wrightii*), manatee grass (*Syringodium filiforme*), and paddle grass (*Halophila decipiens*). Divers will attempt to maintain the integrity of the root/rhizome structure of any seagrass that is uprooted or otherwise impacted; the techniques used will depend on the impact condition and species involved. Use of biodegradable stakes to secure replanted seagrass will be evaluated in the field with respect to its suitability based on field conditions

- Any hard or soft corals that are inadvertently impacted during the project will be inspected by scientific divers who will determine the type of restoration measures, if necessary, that should be implemented. All coral restoration will be conducted by scientific divers who have experience in coral restoration techniques. The overall potential for impacts to coral, especially federally listed coral species, is very low. Restoration measures would primarily involve reattaching any coral that is inadvertently broken. The affected coral would be relocated to a suitable nearby location and reattached onto suitable substrate via cement or marine epoxy using established NOAA methodology. General guidance on coral reattachment is provided in the following two videos: http://www.youtube.com/watch?v=_XaUttAUHv4 (NOAA, 2009) and http://www.youtube.com/watch?v=qRlfOu7fERw (NOAA, 2011).
- If an underwater item that may have historic or archaeological value is encountered, the item will not be disturbed in any way. The item will be photographed, GPS coordinates of the location will be collected, and the Navy will be notified. The Navy will coordinate the collected information with the Puerto Rico State Historic Preservation Office in compliance with the National Historic Preservation Act.

Appendix F
Final Responses to Regulatory Comments

Final Responses to EPA Comments
on the Draft UXO 16 Wide Area Assessment Work Plan
Former Naval Ammunition Support Detachment And Vieques Naval Training Range, Vieques, Puerto Rico
Dated September 2014

Presented below are review comments on the *Draft UXO 16 Wide Area Assessment Work Plan, Vieques, Puerto Rico*; dated September 2014 (the UXO 16 Work Plan).

GENERAL COMMENTS

1. The Navy should expand the boundary of UXO 16 to include the water portion of the area define as the Inner Range as a component of the UXO 16 Work Plan.

   Navy Response: The UXO 16 site boundary was designated in the National Priorities List (NPL) listing (Federal Register, Vol. 69, No. 156, August 13, 2004) via reference to a letter from the Commonwealth of Puerto Rico (May 26, 2004) summarizing consensus on the "Agreed Area" by representatives of, among others, the Navy, EPA, and Commonwealth of Puerto Rico. As such, this will be the boundary for the WAA. It should be noted that the WAA is an initial reconnaissance to guide future investigations at UXO 16. The need for characterization beyond the UXO 16 boundary will be based on the findings of the WAA and, potentially, subsequent investigations. This information has been added to Section 1.1.2.

   EPA Response: The investigation of an area used for range activities should not be excluded because of an "Agreed Area" map. The areas presented on the "Agreed Areas" map was for a visual illustration of the site. The agencies could not have agreed that the final layout of the site was the representation of the "Agreed Area" map without having yet performed the Preliminary Assessment/Site Investigation.

   Navy records identifies a broader area where military training activities could have taken place as the Inner Range. The type of activities that could have occurred within the Inner Range, unrelated to the areas already identified (safety fans, etc.) could present areas of contamination from activities that are non-contiguous to the current proposed boundary. Therefore, we cannot rely on the need for characterization beyond the proposed Navy UXO 16 boundary on findings from WAA efforts. Areas where Navy activities took place could be missed.

   There is information that identifies the sinking of four (4) ships off the coast of Vieques, which includes the USS Killen, as part of the military training exercises on Vieques. The UXO 16 Work Plan does not mention the following as target, USS Barr (DE-576/ APD39), USS Darby (DE-218), and USS Otter (DE-210 It is reasonable to assume that military activities may have taken place beyond the proposed WAA boundaries.

   Attached you will find a list of other vessels sunk around the island of Puerto Rico (possible around Vieques and Culebra, where Navy training took place).

   Navy Response to Evaluation: There is no known information that indicates there were targets outside the current UXO 16 boundary. As stated in the original response, the WAA included in this Work Plan will be conducted within the current UXO 16 boundary. However, it is recognized that adjustments to the boundary may be warranted based on the findings of the WAA or other information identified that suggests the need to investigate beyond that boundary. Upon completion of the WAA within the existing UXO 16 boundary, a report will be produced that provides the findings and recommendations for additional investigation, potentially including areas outside of the existing UXO 16 boundary.

EPA Response: The Navy has not satisfactorily addressed EPA's comment. The investigation of the underwater portions of this area of concern should be conducted in a manner consistent with the investigation of land-based areas, e.g., the EMA, SIA, LIA, and ECA. During the performance of the PA/SI, the Navy conducted a Range Assessment on these areas and did not limit this assessment solely to areas where records showed potential for munitions and explosives of concerns (MEC) to be located, such as gun positions or ranges. A similar approach should be followed for the Inner Range. We cannot rely solely on the Navy's records to determine the boundaries of an investigation, as it has been demonstrated that there are areas where no records exist that document the use of munitions but that, nonetheless, the area did contain MEC. Such an example is UXO 18, Cayo La Chiva.

In addition, EPA does not concur with the statement that, "[t]he UXO 16 site boundary was designated in the National Priorities List (NPL) listing (Federal Register, Vol. 69, No. 156, August 13, 2004) via reference to a letter from the Commonwealth of Puerto Rico (May 26, 2004) summarizing consensus on the 'Agreed Area.'" In fact, a review of the above referenced Federal Register notice indicates that immediately below the text that you cite is the following statement: "The description of the facility may change as more information is gathered on the nature and extent of contamination." EPA also notes that this federal register notice (see I.F) specifically indicates that the "NPL does not describe releases in precise geographical terms; it would be neither feasible nor consistent with the limited purpose of the NPL (to identify releases that are priorities for further evaluation), for it to do so."

Also, EPA notes that the term 'site', as defined in the Federal Facilities Agreement, states the following: "Site" shall include those areas where a hazardous substance, hazardous waste, hazardous constituent, pollutant, or contaminant from the Facility has been released, deposited, stored, disposed of, or placed, or has migrated or otherwise come to be located." Therefore, we believe that the Navy's interpretation of the site as being limited to an agreed upon map prior to the listing of the site on the NPL is inconsistent with that described in the NCP, the Federal Register notice, and the Federal Facilities Agreement.

That being said, EPA recognizes that the Inner Range is a vast expanse and therefore, an iterative approach could be used to conduct an appropriate investigation of such an area. The WAA would be an initial step, but it is EPA's position that additional work will need to be performed outside the boundaries proposed in the WAA work plan, as written, regardless of the outcome of that work. The purpose of the PA/SI was to identify potential areas that could have been impacted from past activities. Therefore, the Navy should either include the Inner Range in the proposed WAA work plan or provide a separate plan describing how the investigation of this area will proceed. Additionally, please confirm that the Navy has no records of the ships that were sunk off the coast of Vieques.

Navy Response: As previously stated, the WAA covered by this Work Plan will be conducted within the current UXO 16 study area. It is recognized that this study area is a starting point and that additional investigation outside this area may be warranted. However, the need for investigation within the Inner Range should be based on the conceptual site model of potential sources, release mechanisms, and transport/exposure pathways, just as it is for any CERCLA site. As stated previously, the Navy will conduct further evaluation of historical information, evaluation of the WAA findings, and hold further discussion with the regulatory agencies to determine if investigation of the Inner Range is warranted and, if so, the limitations of and means to perform that investigation. Therefore, the Inner Range will not be added to the current WAA Work Plan, but instead will be added as an addendum or as a separate work plan, if warranted, based on the above activities and further discussion with the regulatory agencies.

Publically-available records indicate the USS Barr, the USS Darby, and the USS Otter were used as targets and sunk off the coast of Vieques. As noted above, additional historical Navy records evaluation will be conducted. Of not, other than the Killen, the side-scan sonar survey conducted within UXO 16 did not identify any features positively identified as a ship.

2. The UXO 16 Work Plan does not discuss conditions under which magnetic surveys should not be conducted. Magnetic surveys should not be conducted during periods of high geomagnetic activity (e.g., when magnetic

storms, high sunspot activity, or solar flares occur). Revise the UXO 16 Work Plan to discuss conditions under which magnetic surveys should not be conducted and how it will be determined whether these conditions exist.

Navy Response: In practice, the periodicity (i.e., time footprint) of the anomalous response to a target of interest (TOI) is much lower (1 second) than the periodicity of geomagnetic activity. The total magnetic field signal due to diurnal magnetic activity is removed using a de-median filter that removes all signals of a higher periodicity (lower frequency) than the TOI. The proposed method (DGM using a magnetometer array) has been used successfully for the past decade in terrestrial, airborne, and marine application without being adversely affected by diurnal magnetic activity. This information has been added to the Work Plan.

3. The UXO 16 Work Plan does not include standard operating procedures (SOPs) for operating and testing the magnetometer, conducting the magnetic survey using boats, use of the Global Positioning System (GPS), establishing the instrument verification strip (IVS), data processing, etc. For example, Table 3-5, Definable Features of Work Auditing Procedure, includes verifying that equipment testing has been performed and that equipment is functional, but procedures for equipment testing, criteria for evaluating the results of the tests, etc. are not included in the UXO 16 Work Plan. Revise the UXO 16 Work Plan to include SOPs or revise the UXO 16 Work Plan to include sufficient details to conduct all of the necessary tasks.

   Navy Response: Table 3-4 presents the measurement performance criteria for transect layout, conducting the DGM survey, and data evaluation that must be met to meet the project goals. Additional detail has also been included throughout Section 3 to detail the requirements for each task. Any subcontractor selected will be able to meet these requirements. Because equipment-specific procedures are unique to each potential subcontractor, SOPs will be appended to the Work Plan once the subcontractor has been selected.

4. The UXO 16 Work Plan does not discuss how transects will be established in the field. For example, it is unclear if the beginning and end of each transect will be determined prior to the survey using GPS coordinates to ensure that transects are no more than 100 meters apart. Table 3-5, Definable Features of Work Auditing Procedure, includes “verifying area/boundary and transects,” but the UXO 16 Work Plan does not discuss how areas/boundaries and transects will be established. Revise the UXO 16 Work Plan to discuss how areas/boundaries and transects will be established.

   Navy Response: The transects will be established by the subcontractor prior to the field effort using CAD tools or purpose-built software utilities. The investigation area boundary and the transect locations will be identified in the field using commercially available GPS-based navigation systems system as detailed in Section 3.3. The DFOW audit will ensure that the proposed transects (used as input for navigation systems) are properly established prior to mobilization by checking the survey boundary and line spacing used.

   EPA Response: The response partially addresses the comment. Specifically, it is unclear if the proposed transects will be submitted to EPA for review after the survey design is complete. Revise the Draft Work Plan to specify submission of the transect design to EPA for review.

   Navy Response to Evaluation: Because the transects will be established in the field, the final transect design will be provided in the WAA Report. As noted previously, the transect design will meet the specifications established in the Work Plan. In addition, all regulatory agencies will have the opportunity to provide comment on how the WAA was conducted and whether it met the stated objectives. Establishing all transects in advance and providing the design for review in advance of the WAA would cause significant delays. As with the recent UXO 16 Expanded Site Inspection, transects were not provided for review. Instead, the objectives and specifications of areal coverage were provided, reviewed, and concurred upon in the Work Plan. Actual transect locations were established in the field during the ESI to ensure the mutually agreed upon objectives and specifications were met.

   EPA Response: The response is acceptable. However, EPA request that the Navy keeps the regulatory agencies informed on the progress of the design of the transects providing opportunities for discussion by

conference calls, project technical meetings, and field oversight activities and not waiting until the WAA Report.

Navy Response: The Navy will provide the transect design to the regulatory agencies as soon as it is available.

5. Information presented in Section 1.2, Previous Investigations, is not consistently presented on Figure 1-4, Previous Underwater Investigations at the Former VNTR, including but not limited to:

   - Bahia Icacos is not labeled on Figure 1-4 as stated in the first paragraph of Section 1.2.1, Side Scan Sonar Pilot Test and Underwater Magnetometer Survey.
   - Puerto Diablo is not labeled on Figure 1-4 as stated in Section 1.2.4, Navy Explosive Ordnance Disposal (EOD) Diver Surveys.

   Revise Figure 1-4 to include labels for all of the locations discussed in Section 1.2.

   Navy Response: Figure 1-4 has been modified to include location labels for sites discussed in Section 1.2.

6. The UXO 16 Work Plan indicates that Visual Sample Plan (VSP) was used in the survey design. However, the UXO 16 Work Plan does not provide the version of VSP used, the VSP module used, or the VSP report. Therefore, the adequacy of the proposed survey design and whether project data quality objectives (DQOs) will be met using the proposed design cannot be evaluated. Revise the UXO 16 Work Plan to provide the full VSP report as well as the VSP version and module used.

   Navy Response: VSP does not produce a report summarizing the evaluation results, but the results of the VSP evaluation are presented in Figure 3-4. Additionally Figure 3-4 has been updated to include the VSP version, module, and input parameters used for UXO 16.

   EPA Response: The response partially addresses the comment. The response states that Visual Sampling Plan (VSP) does not produce a report. However, a VSP report can be produced by choosing “View” and “Report.” This report along with Figure 3-4 should be provided in the Draft Work Plan. Revise the Draft Work Plan to provide the VSP report.

   Navy Response to Evaluation: The VSP report is now included as Appendix C.

7. Potential issues and concerns with the use of VSP for the underwater environment:

   a. Based upon the available information, to the best of our knowledge the VSP software is used to determine transect spacing within an anomaly area of concern (AOC) to identify anomaly splatters of circular/elliptical shapes. Transect spacing is computed based upon certain assumptions such as: anomaly scatter pattern is circular/elliptical in shape; reasonable estimates of dimensions of circular/elliptical AOCs are known, and some estimates of anomaly densities in AOCs and background areas are also known. When these assumptions are not satisfied, survey design may miss an underwater AOCs and computed anomaly detection probabilities may be quite off from reality.

      Navy Response: Because detailed anomaly density information is not yet available for UXO 16, the VSP input parameters were selected to be very conservative with respect to the final derived line spacing (i.e., biased toward a tighter line spacing). The following text has been added to Section 3.6 for clarification: “Without prior knowledge of the target densities, these initial estimates were used to create a conservative line spacing. It is important to note that these estimates are not actionable thresholds and will not be used as a basis for identification of elevated anomaly density areas – they are only used as starting estimates for the sole purpose of deriving a conservative line spacing. Also, although a ‘bivariate’ density distribution was used, a normal distribution was found to give essentially the same results (Pd = 1.00 vs .993 respectively). The actual shape of an EADA is not predictable due to the myriad of factors affecting the final resting positions of TOI. However, the actual shape of an EADA does not need to be circular for the statistics obtained with a circular assumption to be valid. The circle is just used to estimate the smallest dimension of an EADA. By using a 250 m circle as the input, the

implication is that 250 m is the minimum size in any direction that will be detected with a probability of close to 100% (i.e. any area that has a minimum dimension of 250 m or greater will be detected)."

b. Anomaly splatter in an AOC on land (e.g., with historical training activities) may follow an elliptical or a circular pattern; however, it is hard to justify that an underwater anomaly splatter pattern in an area of interest (e.g., AOCs in UXO 16) will be circular/elliptical or will follow some other known shape. Under these circumstances, detection probabilities (as derived in the Draft UXO 16 WAA Work Plan) computed based upon untenable probability distributions (normal or otherwise) will be meaningless/unreliable.

Navy Response: The actual shape of the anomaly pattern does not need to be circular or elliptical for the statistics obtained with a circular assumption to be valid. By using a 250-meter circle as the input, the implication is that 250 meters is the minimum size in any direction that will be detected with a probability of close to 100% (i.e., any area that has a minimum dimension of 250 meters or greater will be detected).

The following text has been added to Section 3.6 for clarification: "Without prior knowledge of the target densities, these initial estimates were used to create a conservative line spacing. It is important to note that these estimates are not actionable thresholds and will not be used as a basis for identification of elevated anomaly density areas – they are only used as starting estimates for the sole purpose of deriving a conservative line spacing. Also, although a 'bivariate' density distribution was used, a normal distribution was found to give essentially the same results (Pd = 1.00 vs .993 respectively). The actual shape of an EADA is not predictable due to the myriad of factors affecting the final resting positions of TOI. However, the actual shape of an EADA does not need to be circular for the statistics obtained with a circular assumption to be valid. The circle is just used to estimate the smallest dimension of an EADA. By using a 250 m circle as the input, the implication is that 250 m is the minimum size in any direction that will be detected with a probability of close to 100% (i.e., any area that has a minimum dimension of 250 m or greater will be detected)."

c. As described in the various Sections (Sections 1 through 3) of the UXO 16 Work Plan, the UXO 16 is a very large area and most of the munitions present underwater are because of over and under shoot, skipped, or dropped (from gun positions, planes, boats or munitions transfers). Additionally, natural occurrences and disturbances (e.g., routine tides, waves and currents, wind directions, storms, hurricanes) cause munitions to be mobile. Due to these complexities and unknown factors (e.g., munitions shape, size, weight and surface roughness, relative orientation of munitions to the wave-induced and current flows, water depths, and its degree of burial in bottom sediments), it is hard to justify/assume that underwater anomaly scatter in areas of interest (including a direct target Bahia Salinas del Sur area) will be elliptical or circular.

Navy Response: See response to General Comment 7b.

d. Due to the reasons described above, it is highly likely that anomaly scatter in the various AOCs of UXO 16 will be random (without any pattern) and may not satisfy any of the underlying assumptions needed to able to use VSP to determine reasonably reliable detection probabilities. Consequently, VSP based survey design (based upon untenable assumptions) may not be able to detect underwater anomalies with computed detection probabilities (e.g., 1.0 or 0.993). Actually, depending upon the random splatter pattern(s) of munitions, a survey design may miss an AOC with high probability.

Navy Response: See response to General Comment 7b.

e. Given so many uncertainties coupled with natural causes, a phased iterative approach is desirable. Knowledge at each iteration will help refine the CSM which will help in deriving more reliable sampling designs to identify AOCs with reasonably reliable PDs.

Navy Response: The WAA for UXO 16 is the first step in a phased, iterative approach. The results of the WAA will be used to guide the planning for the next phase.

f. The project team with all available site knowledge should be able to determine if the assumptions made (needed to be able to use VSP) are tenable for UXO 16.

Navy Response: See response to General Comment 7a.

g. One can use transect spacing to survey underwater anomalies using an iterative approach, but it is highly likely that VSP computed high detection probabilities are meaningless as assumptions (e.g., distribution, shape) needed to compute those probabilities may not be justified/verified.

Navy Response: See responses to General Comments 7a and 7b.

EPA Response: The response partially addresses the comment. The response indicates that VSP input parameters were selected to be very conservative with respected to the final derived line spacing. However, no supporting information has been provided to support this position. For example, neither the input parameters nor the rationale for selecting these parameters have been provided in the Draft Work Plan. Therefore, it is not possible to determine if the proposed survey design is sufficient to accomplish the project goals. Additionally, as stated in 7g, the high detection probabilities computed by VSP are likely incorrect and could be potentially misleading to data users. Revise the Draft Work Plan to discuss the high detection probabilities computed by VSP. Further, ensure that the rationale for the proposed VSP input parameters (i.e., to be provided in response to General Comment 8) includes sufficiently detailed information to support the proposed sampling design and discuss why these assumptions were deemed conservative. Finally, the language provided in response to General Comment 7e appears to address the concern raised in the comment. However, it is recommended that the text of the response to this comment be added to Section 3.6, Survey Design.

Navy Response to Evaluation: The input parameters are provided in the Work Plan (and also in the VSP report included as Appendix C). As stated in Section 3.6, a helicopter borne magnetometer array survey conducted in 2009 identified a number of EADAs in the shallow, near shore areas of UXO 16. The smallest of these EADAs is approximately 820 ft x 820 ft (250 m x 250 m). VSP was used to confirm that, using a minimum swath width of 13 ft (4 m), 330 ft (100 m) line spacing would detect all 250 m diameter (125m radius) areas with an elevated anomaly density of 25 targets/acre above a background of 5 targets per acre (Figure 3-4).

The following text has been added to beginning of Section 3.6 as suggested: “The WAA for UXO 16 is the first step in a phased, iterative approach. The results of the WAA will be used to guide the planning for the next phase.”

Additionally, the following text has been added to later portion of Section 3.6 to clarify that the VSP analysis and predicted detection performance are not conclusive: “Given that there is not prior knowledge of the background anomaly densities across the site, the VSP analysis provided above is appropriate as a starting point but is not conclusive with respect to EADA detection performance, nor is that necessary.”

8. The UXO 16 Work Plan discusses various VSP input parameters, including line spacing, the size of areas that would be detected, anomaly density, and background anomaly density. However, the UXO 16 Work Plan does not discuss the rationale for why these VSP inputs were chosen, or why these inputs are sufficient to meet project DQOs. Therefore, it is not possible to evaluate the adequacy of the proposed investigations. Revise the UXO 16 Work Plan to discuss the rationale for all VSP inputs, including why the proposed values are sufficient to meet project DQOs for this investigation.

Navy Response: Sections 3.5.2 and 3.6 have been modified to provide clarification on the VSP input parameters rationale to meet project DQOs.

9. The UXO 16 Work Plan does not indicate that the VSP inputs will be evaluated as part of a post-hoc data assessment. For example, the assumption that the proposed line spacing will be sufficient to detect a target area 250 meters in diameter with an anomaly density of 25 targets/acre above the background of five

targets per acre should be assessed based upon the data collected. Revise the UXO 16 Work Plan to indicate that all of the VSP statistical assumptions will be assessed and discussed in the associated report, and that the report will present sufficient information to evaluate the statistical assumptions.

Navy Response: VSP shows that "the proposed line spacing will be sufficient to detect a target area 250 meters in diameter with an anomaly density of 25 targets/acre above the background of five targets per acre." It is not necessary to assess this assumption (i.e., the objective is not to validate VSP, nor is it necessary). The assumptions are simply a starting point and serve no purpose post-hoc. As discussed in the revised Section 3.5.2, after collection of the data, VSP can be used to determine what conclusions the data will support with respect to the identification of EADAs.

EPA Response: The response does not address the comment. Assumptions have been made in developing the proposed survey approach, including but not limited to, use of VSP to design the survey approach. However, from the information presented it is unclear if VSP is an appropriate tool for designing a reliable survey of these areas. For example, VSP only has two choices of distribution (i.e., bivariate or uniform density), and it is unclear if either distribution is acceptable for UXO 16. If the site data show that the anomaly distribution is neither uniform nor bivariate (e.g., a bimodal distribution found), use of VSP may not be acceptable as it does not allow for a bimodal or other distributions. Further, Section 3.6 of the Work Plan states that VSP was used to confirm that 100 meter line spacing would detect all (emphasis added) 250 meter diameter areas with an elevated anomaly density of 25 targets per acre above a background of 5 targets per acre. However, since prior knowledge of anomaly densities does not exist as stated in the Response to General Comment 7, it is unclear if the proposed survey design will be sufficient to detect all such areas. Therefore, a post hock analysis of the findings is necessary. Revise the Draft Work Plan to indicate that the survey results will be reviewed and compared to the assumptions, and that if the assumptions were found to be inaccurate or varied significantly, this will be discussed in the associated report. Also, ensure that this report will provide sufficient information to support this assessment.

Navy Response to Evaluation: Given that the distribution is unknown (e.g., whether it is 'bimodal), VSP has been selected as the best method for this phase of the approach. It is recognized that it is not necessarily appropriate for anchorage areas where there is suspected DMM, but given the size of UXO 16 and the release mechanisms across the vast majority of the UXO site, it is appropriate to guide the first phase of investigations and provide the background density data required to inform the planning of future investigations.

For clarification the following text has been added to Section 1.3.2 to further define the Wide Area Assessment Objectives: "Evaluate the anomaly density conditions to aid in the planning of focused investigations."

Additional text has been added to Section 3.6 Survey Design for clarification: "Given that there is not prior knowledge of the background anomaly densities across the site, the VSP analysis provided above is appropriate as a starting point but is not conclusive with respect to EADA detection performance, nor is that necessary. The VSP analysis as presented uses fixed background anomaly density, EADA target density threshold, and minimum EADA dimension values to produce a suggested line spacing as a function of detection probability (Pd). A post hoc analysis (using VSP) of the survey results will be performed to determine what conclusions the data will support with respect to minimum dimension of detectable EADAs as a function of EADA density threshold. This will be done by using the 100-m line spacing, 100% Pd, and measured background anomaly levels as fixed values to determine the minimum EADA dimension as a function of EADA anomaly density threshold.

In addition to the areas of clustered munitions due to firing activities, the Vieques conceptual site model also includes three anchorage areas where DMM may have fallen off a ship (note, Mosquito Pier is not included in the WAA). While it is possible the line spacing derived from VSP for these areas may not be appropriate for finding DMM (unless the numbers and distribution of DMM are sufficient to result in an elevated anomaly density footprint greater than 250 m diameter), because there is not knowledge regarding

the expected anomaly densities in these areas and they total over 400 acres in size, the survey as planned will provide the background information required to design a statistically valid, focused investigation for these areas."

10. The UXO 16 Work Plan uses inconsistent terms to refer to the munitions related materials that are the subject of the assessment. It also is inconsistent in the use of some other related terminology. Examples of this include:

    a. Section 1, Introduction, refers to these items as munitions and explosives of concern (MEC) in the first sentence of the section. It then refers to these items as munitions and munitions constituents in the second sentence of that same section.

       Navy Response: The following text has been included in Section 1 for clarification: "Within this document, where the term "munitions" is used, it encompasses historically and/or currently used terms munitions and explosives of concern (MEC), material potentially presenting an explosive hazard (MPPEH), munitions debris (MD), unexploded ordnance (UXO), and discarded military munitions (DMM)."

    b. Section 1.2.5, Underwater UXO Mobility Modeling, uses the term unexploded ordnance (UXO) in the title and then discusses the migration of underwater munitions, some of which may not be UXO

       Navy Response: The heading of Section 1.2.5 has been changed to "Underwater Munitions Mobility Modeling" for consistency.

    c. Section 2.1, Release History, states that, "Munitions identified within the former NASD and former VNTR are generally classified as MEC, MPPEH, Munitions Debris (MD) or Range-Related Debris (RRD)." Note: RRD is NOT a munitions item per se and is defined in DoD 6055.09-V8 (Department of Defense Ammunition and Explosives Safety Standards, Volume 8, Glossary) as follows:

       I. "Range-related debris: Debris, other than munitions debris, collected from operational ranges or from former ranges (e.g., target debris, military munitions packaging and crating material)."

       Navy Response: The text in Section 2.1 has been modified to "Munitions and munitions-related items identified within the former NASD and former VNTR are generally classified as MEC, MPPEH, MD, or Range-Related Debris (RRD)."

    d. Section 2.3, Potential Munitions Transport Pathways discusses the mobility of "munitions."

       Navy Response: Please see the response to General Comment 10a.

    e. Section 2.4, Future Land Use and Potential Receptors, discusses individuals coming into potential contact with "MEC."

       Navy Response: The text in Section 2.4 has been modified to "Potential human receptors are recreational users (boaters, divers, snorkelers, and swimmers) and fishermen who may come into contact with munitions and MC."

    f. Attachment B, Bathymetry Side Scan Sonar Survey of UXO 16, discusses the activities in the areas that are "…potentially impacted by Munitions and Explosives of Concern (MEC)."

       Navy Response: The referenced sentence has been revised to "UXO 16 is approximately 11,500 acres in size and includes the underwater areas adjacent to the range and operational areas on East and West Vieques that are known to be or are potentially impacted by munitions."

    Review the terminology employed to define the munitions and/or munitions related materials that are the subject of the assessment and revise it as necessary to ensure that consistent and correct terminology is used to describe them.

Navy Response: The text has been revised as requested, in accordance with the response to General Comment 10a.

SPECIFIC COMMENTS

1. **Section 1.1.2, UXO 16, Page 1-2 and 1-3:** Please include the boundary of the inner range as a component area of UXO 16.

   Navy Response: Please see the response to General Comment 1.

   EPA Response: Please see response to the Navy response to General Comment 1.

   Navy Response to Evaluation: Please see the associated Navy response.

   EPA Response: See response to General Comment # 1.

   Navy Response: As noted previously, the current UXO 16 study area will remain as shown in the Work Plan at least until the activities discussed in the response General Comment #1 have taken place and further discussion with the regulatory agencies has been held. If a revision to the study area is warranted, it will be made at that time.

2. **Section 1.2.1, Side Scan Sonar Pilot Test and Underwater Magnetometer Survey, Page 1-4:** The last sentence of this section states, "MEC was confirmed in these areas," but it is unclear how the divers/snorkelers determined the objects associated with the anomalies were MEC, particularly if any of the items were partially buried or covered with coral or other aquatic life. Revise the text to explain how the divers/snorkelers determined that any specific anomaly was MEC.

   Navy Response: The text in Section 1.2.1 has been modified to state, "MEC was confirmed in these areas during the underwater visual inspection performed by the divers."

   EPA Response: The response partially addresses the comment. Specifically, the response does not state how anomalies were verified by divers/snorkelers in areas where coral was present or where anomalies were buried. It appears that the modified text implies that some anomalies could not be observed, but this should be stated explicitly. Revise the Draft Work Plan to state that buried anomalies and anomalies that were covered by coral could not be observed during the visual survey.

   Navy Response to Evaluation: The following text has been added to Section 1.2.1 for clarification: "Only items present on the surface of the seafloor were inspected by the divers. Buried anomalies and anomalies obscured by coral could not be observed during the survey."

3. **Section 1.2.3, Remotely Operated Vehicle Pilot Test, Page 1-4 and Section 3.1, Technology Description, Page 3-1:** The intent of the second sentence of Section 1.2.3 may be unclear to many readers. It states in part, "The pilot test demonstrated specifically that the ROV [remotely operated vehicle] was able to locate specific targets proud of the surface identified from pervious geophysical surveys." It appears that the intent is to indicate that the specific targets extended slightly above the surface, but this use of the word "proud" is uncommon. "Proud" is also used in the second paragraph of Section 3.1, which states, "Visual surveys are precluded due to the fact that their effectiveness is limited to targets that are at least partially proud (sic) of the sea floor." Replace the word "proud" with a more commonly used word or phrase that clarifies the meaning of these sentences in these sections and wherever this word is used in the UXO 16 Work Plan.

   Navy Response: The following text in Section 1.2.3 has been modified for clarification: "The pilot test demonstrated specifically that the ROV was able to locate specific targets located on the surface of the sea floor identified from previous geophysical surveys and identify those targets as munitions (USAE, 2009)."

The following text in Section 3.1 has also been modified for clarification: "Visual surveys are precluded due to the fact that their effectiveness is limited to targets that are not buried beneath the sea floor. Commercially available acoustic systems are also limited to investigation of targets that are located on the surface of the sea floor."

4. **Section 2.3, Potential Munitions Transport Pathways, Page 2-3:** A word or phrase appears to be missing from the second sentence in this section. The end of the sentence states "munitions would be expected to remain in place due to the relatively large changes in elevation and would trap munitions in place;" however, it is not clear what would trap the munitions in place. Revise the quoted phrase to clarify what would trap the munitions in place.

   Navy Response: The following text in Section 2.3 has been modified for clarification: "In areas with coral and a hard bottom, munitions would be expected to remain in place due to the relatively large changes in elevation and because munitions would be trapped in place by the coral reef."

5. **Table 3-4, Measurement Performance Criteria, Page 3-8 and 3-9:**

   a. The activity to assess measurement performance for "Representativeness, comparability" is "collection of 'background' data with sensors out of ground effect (at or near surface) in magnetically quiet region," but it is recommended that a transect line be repeated (in the same transect direction) once each day for purpose of comparison. Also, it is unclear how a magnetically quiet region will be determined and whether this area will have comparable water depth to the area being surveyed. Revise the UXO 16 Work Plan to clarify how the magnetically quiet region will be determined and whether this background area will have similar water depths to the areas being surveyed. Also, consider requiring repeating one transect line each day for purpose of comparability.

      Navy Response: The collection of data with the sensors out of ground effect is intended to be used to assess the system noise levels. Determination of a 'magnetically quiet region' is a simple qualitative assessment – if there are signals with a periodicity approaching that of the TOI, the region is not magnetically quiet. The farther away the array is from the bottom, the greater the chance that the collected data will be magnetically quiet (thus the "at or near the water surface" instruction). The water depth does not need to be comparable to the region being investigated – water depth does not affect the sensor signal levels.

      The daily IVS passes that will be performed at the site will be used to evaluate sensor repeatability on a daily basis. For this reason, it is not necessary to collect repeat transect data daily.

      The following text has been added to Section 3.8 for clarification, **Transect Layout:** The MQO for the transect layout is that the boundary is correct and the transect line spacing is correct. These are the theoretical transect lines that the survey crew will attempt to follow.

      DGM Survey Coverage: The MQO for survey coverage is established to ensure that the survey area has been appropriately investigated. Wind, currents and wave action will cause the vessel and array to deviate from the planned transects. The stated cross track tolerance of 410 ft (125 m) between survey lines for no more than 1640 ft (500 m) will provide sufficient coverage to ensure that the survey goals are met. Deviations required to avoid obstacles/sensitive habitats, or wildlife are anticipated and acceptable.

      The down-line sample spacing of 1 ft (0.3 m) is established to ensure that the sample density is sufficient to detect discrete ferrous objects that are potential TOI.

      DGM Survey Altitude: The MQO for DGM survey altitude is established to minimize the sensor offset from the sea floor while maintaining a safety buffer to avoid contact with the sea floor. A survey altitude between 3.3 ft and 6.6 ft above the sea floor is sufficient to meet the goals of the survey. Deviations required to avoid obstacles/sensitive habitats are anticipated and acceptable.

DGM Sensor measurements: This MQO is established to verify that valid total magnetic field data are being measured by the magnetometers. The physics governing the operation of cesium vapor magnetometers is such that these sensors do not require calibration (there is no 'gain' adjustment). Obtaining raw total magnetic field measurements in the 20,000 to 70,000 nT range that vary when the sensor is challenged with a ferrous object is sufficient to show that the sensor itself is operational. Note that this large 'background field' is removed during the levelling process to isolate the nT level responses used for detection of ferrous objects.

DGM Topside Positioning: The MQO for DGM topside positioning is that the accuracy of the GPS antenna above the surface of the water be less than 1 ft. A test location will be established by a professional land surveyor.

Target Positioning: The MQO for target positioning is established to ensure that the submerged targets are being detected with an accuracy of less than 5 feet. This check is accomplished with the use of the Instrument Verification Strip (IVS), a twice-daily survey over one or more objects at a fixed, known location.

DGM Sensor Response: The MQO for DGM sensor response is established to verify that the response values are consistent with the expected values for the item(s) located in the IVS. If the IVS uses a previously emplaced target where the expected response is unknown, the initial IVS survey will be used to establish the expected response. Prior to the initial IVS survey, the sensor responses will be verified with a static test using a known object (typically and industry standard object [ISO]).

DGM Sensor noise levels: The MQO for the DGM sensor noise levels are established in to enable monitoring of sensor noise levels. Typical noise levels in the marine environment are less than 0.1 nT (rms) but will vary depending upon the system configuration. Noise levels above 0.25 nT may indicate a problem with the sensors or a proximal noise source that will impact the sensitivity of the system.

Video image collection: The MQO for video image collection is that the video footage of the sea floor is clear enough to identify the environment and objects along the sea floor, and that it can be time stamped and matched to the GPS data. Environmental factors such as turbidity or dense vegetation may obstruct video clarity and are anticipated and acceptable.

Data Evaluation and Documentation: The MQO for data evaluation and documentation is established so that all data pass through the review process. A senior technical review will determine that data have been processed and presented appropriately.

Reporting: The MQO for reporting is the delivery of the final report. It will summarize all field and data processing activities and documentation, including analysis of the data and final results. Archived data will be maintained by the project team."

b. Are transect spacing described in this table site-specific or general? Are the assumptions described in Table 3-4 reasonable?

Navy Response: This transect spacing is consistent with similar WAA projects and is conservative (as discussed in Section 3.6), and the assumptions described in Table 3-4 regarding survey altitude and line spacing are also discussed in Section 3.6 and are reasonable to achieve the investigation objectives.

6. **Table 3-5, Definable Features of Work Auditing Procedure, Page 3-11:** The entry for Site Boundary and Transect Establishment includes "verifying area/boundary and transects," but specific criteria for determining whether the "area/boundary is correct and transects are appropriate" are not specified. Numerical criteria (e.g., 1 meter, 5 meters, etc.) should be specified. Revise Table 3-5 to include specific criteria for determining whether the area/boundary and transects have been established appropriately.

Navy Response: These are theoretical transects that are used for input for the navigation system and as such, quantitative accuracy criteria are not required (integer level precision is sufficient). The following text has been added to Section 3.8 for clarification: **"DGM Survey Coverage:** The MQO for survey coverage is

established to ensure that the survey area has been fully investigated. Wind, currents and wave action will cause the vessel and array to deviate from the planned transects. The stated cross-track tolerance of 410 ft (125 m) between survey lines for no more than 1640 ft (500 m) will provide sufficient coverage to ensure that the survey goals are met. Deviations required to avoid obstacles/sensitive habitats, or wildlife are anticipated and acceptable. The down-line sample spacing of 1 ft (0.3 m) is established to ensure that the sample density is sufficient to detect discrete ferrous objects that are potential TOI."

7. Results plotted in **Figures 3-1, Signal to Noise Ratio Curves for Magnetometers and EM61-MK2 Sensors**, and **Figure 3-5, Minimum Expected Total Magnetic Field Response**, are hypothetical based upon certain assumptions. Are those assumptions tenable for the UXO 16 underwater investigation?

   Navy Response: Figure 3-1 is intended only to depict the difference in performance between EMI sensors and magnetometers (thus the use of SNR to allow comparison). The following text has been added to Section 3.1 for clarification: "The noise assumptions for the data presented on this figure are consistent with terrestrial deployment (1 nT for the magnetometer and 0.5 mV for the EMI sensor). While it is anticipated that the SNR performance will improve slightly in the marine environment, this improvement will occur with both systems and the comparison between the systems remains valid." The data presented in Figure 3-5 are derived from test stand measurements and are reasonable for the study objectives.

8. **Attachment A, Bathymetry Data Review, Review Findings, Page A-2; Figure 1, Available Bathymetric Data Coverage, Vieques Puerto Rico; and Figure 2, Bathymetric Contours, Vieques Puerto Rico:** The text states that "the Site UXO16 boundary is shown in red on each of the four maps presented as Figure 1," but the UXO 16 boundary is shown in green on the four maps included on Figure 1. Similarly, the text also states that the UXO 16 boundary is shown in red on Figure 2, but the boundary is also depicted by a green line on this figure. Resolve these discrepancies.

   Navy Response: Attachment A, Figures 1, 2, and 3 have been modified to show the UXO 16 boundary in red.

9. **Attachment A, Bathymetry Data Review, Figure 3, UXO 16 Bathymetric Coverage and Resolution, Vieques Puerto Rico:** Although the legend appears to indicate that the UXO 16 boundary is a darker green than the area covered by the "NOAA 1/3 arc-second DEM – 6/22/2007," the same color was used on the figure. For clarity, depict the UXO 16 boundary in a different color.

   Navy Response: Attachment A, Figure 3 has been modified to show the UXO 16 boundary in red.

10. **Attachment B, Bathymetry Site Scan Sonar Survey of UXO 16, Summary of Results, Page B-3:** The text states that "targets identifying the 1 meter or greater vertical change on the seafloor for UXO 16 … are shown in Figure 5," but Attachment B does not include Figure 5. It appears these features may be shown on Figure 4, Potential Hazards Identified during the Side Scan Sonar Survey. Revise the text to cite Figure 4 or provide the missing Figure 5.

    Navy Response: The Attachment B text has been modified to refer to "Figure 4" instead of "Figure 5."

Clarification of Approach to WAA Survey at VNTR UXO 16 Technical Memo of Nov. 12, 2014

1. *"Although a 'bivariate' density distribution was used, a normal distribution was found to give essentially the same results (Pd = 1.00 vs .993 respectively)."*

   Comments

   Which bivariate distribution is referenced in the above sentence? What kind of normal distribution was used (univariate or bivariate) in the WAA at UXO16 to derive Pds mentioned in the above sentence? To the best of our knowledge, VSP uses a bivariate distribution to derive detection probabilities (PDs) for circular/elliptical areas of concern (AOCs). It will be nice to see VSP generated outputs (e.g., screen shots) showing the computed detection probabilities (and all assumptions used) mentioned in the above paragraph from the clarification memo.

Navy Response: VSP provides the option of selecting either 'normal' or 'bivariate.' The selection of 'normal' or 'bivariate' does not make a material difference in the results. As described in the revised Section 3.6, the parameters used were selected to be the most conservative with respect to the final derived line spacing (i.e., biased toward a tighter line spacing).

2. *"Upon completion of the survey, background density will be observed from the resulting data and, based upon this and line spacing used, the supporting statistical basis for conclusions drawn from the survey results will be provided. For example, for a given minimum size and shape (e.g., 250m diameter circle) these data will allow determination of what density above background can be claimed to have been detected with close to 100% probability. Conversely, for a given anomaly density elevation above the background, the minimum size of area that was detected can be determined with close to 100% probability."*

Comments

It is not clear which supporting statistical basis for conclusion is mentioned in the above paragraph. Given the natural causes and disturbances mentioned earlier, is it reasonable to assume that underwater anomaly distribution in AOCs will be circular of 250 meter diameter? Given so many uncertainties and unverifiable assumptions, the stated detection probability of close to 100% appears to be unreliable.

Navy Response: See response to General Comment 7b.

Final Responses to PREQB and PRDNER Comments on the Draft Wide Area Assessment, UXO-16, Atlantic Fleet Weapons Training Area – Vieques, Former Naval Ammunition Support Detachment, Vieques, Puerto Rico

Puerto Rico Environmental Quality Board Comments

GENERAL COMMENTS

1. Please provide descriptions of and information for all protected threatened and endangered species and the SOPs related to ensuring protection of these species. If that information will be forthcoming in subsequent documents please describe such documents and anticipated schedules of the upcoming detailed work plans.

   Navy Response: Attachment D (Standard Operating Procedures for Protection of Federally-Listed Species and Habitat) has been added to the Work Plan to detail procedures for the protection of endangered species during the UXO 16 WAA.

2. Throughout the document please consider revising all unit dimensions for consistency to reflect either feet or meters. Please provide all conversions where necessary.

   Navy Response: The document has been revised for consistency to use feet as the primary unit of measurement. Conversions to meters are provided where necessary.

3. Please clarify the apparent discrepancies in the text as to what the geophysical survey is designed to detect:

   - Section 1.1.2 on Page 1-3 describes maximum primary fragment distances for a MK 83 bomb indicating that the project is concerned with the dispersion of fragments and is going to use them as an indicator for the presence of MEC.

     Navy Response: This section is intended to provide background information about the site and how the UXO 16 boundary was developed. The primary fragment distances should not be interpreted as an indicator of planned detection performance. Detection performance is discussed in later sections of the Work Plan.

   - Figures 3-1 and 3-5 indicate that MEC the size of small ISOs (approximately the size of a 20-mm projectile) will not be detected at the planned sensor deployment height indicating that small MC fragments will not be detected.

     Navy Response: Small ISOs are similar in size to 37mm projectiles. As shown on Figure 3-1 and Figure 3-5, items of this size will not be reliably detected during the WAA (although some items of this size may be detected). The intent of the WAA is to not to identify small munitions fragments, but instead to identify elevated anomaly density areas, as stated in the second paragraph of Section 1.

   - Section 3.5.2 says dipole analysis will be used to rule out very small objects as potential MEC. This indicates that very small objects, such as fragments, are expected to be detectable.

     Navy Response: The text in Section 3.5.2 has been modified for clarity to state: “For this reason, the dipole size estimate can only be used as a coarse classifier to characterize anomaly sources as small, medium, or large. Due to the range in size of targets of interest (TOI) (up to MK83 1,000 lb bombs) the size estimates will not be used to exclude anomalies from the anomaly density analysis, but the dipole analysis results may prove instructive to help characterize the populations of the identified EADAs. For each identified EADA, the relative proportion of small, medium, and large anomaly sources, as well as the average estimated burial depth of these sources will be used to plan any potential follow on investigations.”

- Section 3.7.3 says the geophysicists will use the criteria presented to screen out insignificant anomalies and select only significant anomalies for further analysis. This indicates the ability to detect very small objects such as ordnance fragments that aren't significant while flying the sensor 1-meter to 2-meters above the ocean floor.

  Navy Response: The text in Section 3.7.3 stated "The geophysicists will use the following criteria for selecting significant anomalies…" This text was not meant to imply that very small objects (ordnance fragments) were considered insignificant anomalies nor would be screened out. The text has been modified to remove the word "significant" to reduce the potential for misinterpretation of this text.

- Please resolve this comment by describing the smallest MEC that is planned to be detected on the ocean floor when the sensor is deployed at the maximum acceptable height (2-meters).

  Navy Response: The following text has been added to Section 3.6 for clarification: "The sensor altitudes will be nominally between 3.3 ft (1 m) and 6.6 ft (2 m). At 1 m altitude, targets as small as 37mm projectiles on the sediment surface should be reliably detected. However at 2 m altitude, objects less than the size of 60mm mortars on the sediment surface will not be reliably detected. Because the WAA is intended to identify EADAs, the reliable detection of small ordnance classes is not critical to the success of the survey."

  PREQB Evaluation of Responses: The intent of this comment may have been misunderstood and is restated as follows: EQB understands that the WAA is intended to identify areas of elevated anomaly density. This identification of EADAs depends on the ability to detect individual anomalies so that they can be included in the overall assessment of anomaly density to identify the EADAs. This ability to detect anomalies will constantly vary with the changes in elevation of the sensor from the seabed and the undulating nature of the seabed. Therefore, the ability to identify EADAs will constantly vary throughout UXO 16. For example, in some areas the sensor is likely to be near enough to the seabed to detect bomb and projectile fragments the size of 37-mm projectiles or smaller. In other areas, where the sensor height is elevated, these anomalies will not be detected and will not be counted toward identification of EADAs. Normalizing the overall WAA survey to achieve a consistent assessment and identification of EADAs is not described in the work plan but it is an important factor for demonstrating that consistent and adequate WAA survey was performed. This sensor elevation factor isn't an issue for terrestrial surveys because the sensor can be maintained at a consistent height above the ground. But it is potentially critically important for underwater surveys and needs to be adequately addressed in the work plan.

  Navy Response to Evaluation: The Navy understands that detection performance will vary with altitude. However, the altitude variations will occur over much smaller spatial scales than >250 m diameter Elevated Anomaly Density Areas (EADAs) being targeted. Therefore, these relatively small-scale variations will not affect the ability to identify the EADAs, as observed during numerous helicopter-borne terrestrial surveys with similar altitude changes. For these past efforts, a review of survey altitude vs density was performed to ensure that there were no artificial density 'lows' or 'highs' caused by altitude variations.

  The following text has been added to Section 3.6: "Although detection performance will vary with altitude, the altitude variations will occur over much smaller spatial scales than the >250 m diameter EADAs being targeted. Therefore, these relatively small-scale variations will not affect the ability to identify EADAs (this has been the case for many helicopter-borne terrestrial surveys that have similar altitude challenges). A review of survey altitude versus density will be performed to ensure that there are no artificial density 'lows' or 'highs' caused by altitude variations. Once this evaluation is complete, dipole size estimates will be used to exclude targets that may be undetectable at higher altitudes. The survey altitude data and its effect on detection performance will be evaluated during the data analysis."

4. Please clarify how the geophysical data will be analyzed and used. For example:

- Section 3.5 says that a dipole fit analysis will be performed on individual anomalies to extract information about the likely source of the anomaly and density distribution. Please clarify if this dipole analysis is going to be used to eliminate some anomalies from consideration in the VSP analysis of EADAs.

  Navy Response: It is unlikely the dipole analysis would result in rejection of anomalies based on the size range. Please also see the response to General Comment 3 (third bullet).

- Section 3.5.2 also discusses dipole fit analysis and says it can be used as a coarse classifier to rule out very small and very large dipoles as MEC. Please clarify if this analysis will be used to eliminate anomalies from the VSP analysis of EADAs.

  Navy Response: Please see the response to the previous comment.

- Section 3.5.2 says that only targets in the "correct size range to be potential MEC will be examined to identify EADAs. Please clarify what the correct size range is and how this determination will be made with a high degree of accuracy.

  Navy Response: Please see the response to General Comment 4 (first bullet).

- Section 3.6 says WAA surveys look for EADAs that indicate concentrations of targets of interest. Please clarify if there are there some ferrous anomalies that are not of interest and will not be considered in the VSP analysis.

  Navy Response: All ferrous responses will be used in the target density calculations. The WAA is designed to find EADAs that are "possible concentrations of targets of interest." The composition of the EADAs will be determined through follow-on investigations. The following text has been added to Section 3.5.2 for clarification: "The spatial distribution of all of the detected anomalies will be examined to identify EADAs and thus potential OUs requiring detailed investigations. This process will involve deriving density distribution maps (i.e., maps of anomalies/acre) and using Visual Sample Plan (VSP) to identify EADAs within the survey region. The appropriate VSP parameters used for this investigation will be based in part on the character of the anomaly density data. Background anomaly density will be derived from the survey data and, based upon this and the line spacing used, the supporting statistical basis for conclusions drawn from the survey results will be provided. For example, for a given minimum size and shape (e.g., 250m diameter circle) these data will allow determination of what density above background can be claimed to have been detected with close to 100% probability. Conversely, for a given anomaly density elevation above the background, the minimum size of area that was detected can be determined with close to 100% probability."

- Please describe how the data will be analyzed and used to identify EADAs. If some anomaly data is going to be filtered out and not used please describe that process.

  Navy Response: All detected anomalies will be used in the target density calculations. VSP will be used to derive density maps and identify EADAs. The following text has been added to Section 3.5.2 for clarification: "For this reason, the dipole size estimate can only be used as a coarse classifier to characterize anomaly sources as small, medium, or large. Due to the range in size of targets of interest (TOI) (up to MK83 1,000 lb bombs) the size estimates will not be used to exclude anomalies from the anomaly density analysis, but the dipole analysis results may prove instructive to help characterize the populations of the identified EADAs. For each identified EADA, the relative proportion of small, medium, and large anomaly sources, as well as the average estimated burial depth of these sources will be used to plan any potential follow on investigations."

5. Figure 2-1 shows that the boundary of UXO 16 includes the danger zones downrange from small arms ranges in the northeast portion of the VNTR. Please clarify whether these areas will be investigated as it is not possible for the geophysics to detect small arms projectiles because the magnetometer is being used and magnetometers can't detect non-ferrous small arms projectiles and the small arms are too small to be

detected by the sensor deployed as described in this work plan. Also, small arms projectiles have no explosive hazard. Please consider performing this WAA geophysical survey in the down-range (water) portions of the safety fans for the northeastern ranges where explosive ordnance was used, such as the 3.5-in. rocket ranges while eliminating the large, small arms downrange hazard areas where implementing the WAA work plan will not produce actionable data.

Navy Response: Figure 2-1 mistakenly showed impacts from Range 1 and Range 2 to UXO 16. Range 1 and Range 2 were small arms ranges. Figure 2-1 has been modified to show potential impacts from Range 3 (Rifle Grenade Range) and Range 4 (Rocket Range).

6. An IVS is mentioned in Table 3-4 to assess navigation accuracy and perform sensor function checks. Please add a requirement and procedures for an IVS to document that the survey equipment is functioning within specifications.

Navy Response: Table 3-4 has been modified to include IVS requirements and procedures.

7. As this is the first underwater WAA being performed on the Vieques project, procedures for this new work need to be developed as has been done for the more familiar terrestrial work elements. It is understandable that the specific contractors may not have been selected yet and their SOPs may not be available. If this is the case, please insert a place-holder appendix for the SOPs to occupy when they are developed and insert text in the work plan saying that the SOPs will be distributed for agency review and added to the final plan prior to performing the work. Please note that SOPs are referenced in the QC plan on Table 3-5 as being required.

   Navy Response: Table 3-4 presents the measurement performance criteria for transect layout, conducting the DGM survey, and data evaluation that must be met to meet the project goals. Additional detail has also been included throughout Section 3 to detail the requirements for each task. Any subcontractor selected will be able to meet these requirements. Because equipment-specific procedures are unique to each potential subcontractor, SOPs will be appended to the Work Plan once the subcontractor has been selected.

   PREQB Evaluation of Response: Please verify that the contractor SOPs will be provided for agency review when they are developed. Based on this understanding the response resolves this comment.

   Navy Response to Evaluation: As noted previously, any subcontractor procured will be able to meet the data quality objectives. Once the subcontractor is procured, subcontractor-specific SOP(s) prepared will be provided to the regulatory agencies for informational purposes.

PAGE-SPECIFIC COMMENTS

1. Acronyms and Abbreviations: Please add

   - m Meters
   - nT unit

   Navy Response: The Acronyms and Abbreviations section has been modified to include these acronyms.

2. Section 1.1.2: This section describes Explosives Safety Arcs and Artillery Safety Fans but doesn't describe the expected distribution of ordnance from ships firing into the VNTR. Please clarify if any of the naval gunfire support targets on land are known and whether this information can be used to identify areas of over- and under-shoots. Figure 2-1 contains an icon showing NGFS targets. Please clarify if the icons indicate specifically the locations of known targets or if these icons just conceptually illustrate firing from ship to shore. Note that if the icons are for illustration purposes only, please modify the figure as it appears to show specific targets on land and in the water.

Navy Response: The locations of the naval gunfire support targets on land are known, and this information was used in the development of the UXO 16 site boundary. The following text has been added to Section1.1.2 for clarification: "Figures 2-1 and 2-2 present the conceptual site model (CSM). The historical site operations and the NGFS targets shown conceptually illustrate site operations and impacted areas. The NGFS are placed in locations consistent with the current understanding of the CSM. Following the WAA, the CSM will be re-evaluated to confirm that the WAA findings are appropriately reflected."

3. Page 1-4, Section 1.2.1 Side Scan Sonar Pilot Test and Underwater Magnetometer Survey, Paragraph 1:

   a. This section states, "During November 2006, a joint pilot test between National Oceanic and Atmospheric Administration (NOAA) Office of Response and Restoration (OR&R) the Office of Coast Survey, the Navy, and the University of New Hampshire's Joint Hydrographic Center was conducted using high resolution side scan and multibeam sonar…" Please clarify or specify the project date as "2006 or 2009" since the project referenced below does not appear on Figure 1-4. If correct as "2006," please update Figure 1-4.

      Navy Response: The work referenced in this comment was performed in 2006, and the data from this event was reported in the "(NOAA, 2007)" document referenced at the end of the paragraph. This work is shown on Figure 1-4, labeled "NOAA, 2007." To help clarify, the following text has been added to the first paragraph of Section 1.2: "Where there is an associated report, the report author and date are cited in Figure 1-4; where no associated report was produced, the date(s) of the investigation are cited in the figure."

   b. Paragraph 2:

      i. SSS acronym missing in above Paragraph 1 for the first occurrence of side scan (sonar)

         Navy Response: The text has been modified to define SSS in Section 1.2.1.

      ii. Please confirm that 603 magnetic anomalies were all identified "within 195 acres of Bahia Salinas del Sur," during the 2007 survey. If so please clarify, if known, the number of magnetic anomalies identified at Bahia Icacos.

         Navy Response: It was confirmed 603 anomalies were identified within Bahiá Salinas del Sur during the magnetometer pilot test. The magnetometer pilot test did not include any work within Bahiá Icacos.

   c. Paragraph 3:

      i. As stated "…Based on the results of the SSS pilot test and the underwater magnetometer survey, divers/snorkelers conducted an underwater visual survey of 42 anomalies identified at Bahia Salina Del Sur and Bahia Icacos…" Please consider rephrasing to specify the number of magnetic anomalies by location. For example "of the total 603 items identified, 42 were further investigated by visual survey, [number] at Bahia Salina Del Sur and [number] at Bahia Icacos.

         Navy Response: The text in Section 1.2.1 has been modified for clarification to state: "Based on the results of the side-scan sonar (SSS) pilot test and the underwater magnetometer survey, divers/snorkelers conducted an underwater visual survey of 42 anomalies identified at Bahia Salina Del Sur to determine if the sources of the anomalies were munitions or only had the general appearance (shape and size) of potential munitions. Additionally, a metal detection survey was conducted within a small portion of Bahia Icacos to evaluate the potential for munitions north of the LIA (Geomarine, 2007)."

      ii. Please clarify to which study "the SSS pilot test" refers, as side-scan sonar is discussed in the first study discussed in paragraph 1, but the pilot test is referred to in the second paragraph for a different study.

Navy Response: The text in Section 1.2.1 has been modified for clarification to state: "Based on the results of the side-scan sonar (SSS) pilot test and the MTA magnetometer pilot test, divers/snorkelers conducted…"

4. Page 1-4. Section 1.2.2 Aerial Magnetometer Survey, Paragraph 1:

   a. Please consider adding language to identify the year in which the study was done. For example "In 2009, an aerial magnetometer survey (AMS) was conducted to assess…"

      Navy Response: The text in Section 1.2.2 has been modified to include the date of the AMS and now states: "In November and December 2008, an aerial magnetometer survey (AMS) was conducted to assess potential munitions locations over the entire VNTR terrestrial portion, extending into the near shore areas (Figure 1-4)."

   b. Reference to Figure 1-5: The AMS identified 12 EADAs that lie wholly or partially in the water (Figure 1-5). All locations highlighted in purple add up to 12, but it is unclear if the total number of anomalies are represented by the numbers in the figure or if they are for some other purpose. Please consider discussing and identifying the numbers associated by offering further explanation in the text and in the figure legend to provide meaning for the numbers on the figure.

      Navy Response: Figure 1-5 has been modified to include the following note: "A total of 46 EADAs were identified during the aerial magnetometer survey. The 12 EADAs located wholly or partially in UXO 16 are included on this figure. The number associated with each EADA corresponds with the EADA number assigned based the aerial magnetometer survey results."

   c. Please also add more information on the site which is labelled as "20" and covers mostly terrestrial land mass, including information as to why this area would have been covered in the "offshore survey."

      Navy Response: As stated in Section 1.2.2, the AMS was performed over the entire VNTR terrestrial portion and extended into the near shore areas. A large portion of the LIA and associated offshore areas were identified as an EADA during the AMS as indicated on Figure 1-5.

5. Page 1-4, Section 1.2.3 Remotely Operated Vehicle Pilot Test, Paragraph 1: This section states, "…In January 2009, the Navy conducted a pilot test of a VideoRay Miniature Remotely Operated Vehicle (ROV) within the underwater areas at Bahia Salinas. …" The project referenced does not appear on Figure 1-4. Please consider adding this pilot ROV project to the Figure 1-4.

   Navy Response: Figure 1-4 has been modified to identify the 2009 ROV pilot test location, which is now labeled as "Remotely Operated Vehicle Pilot Test (USAE, 2009)."

6. Page 1-4, Section 1.2.4 Navy Explosive Ordnance Disposal (EOD) Diver Surveys, Paragraph 1:

   a. Please consider adding project years to this paragraph so that the project information is more readily cross referenced with Figure 1-4:

      "The Navy conducted several visual surveys using Navy explosive ordnance disposal (EOD) divers/snorkelers to identify locations of underwater munitions. As part on the Preliminary Range Assessment (CH2M HILL, 2003), a transect inspection was conducted in the shallow waters adjacent to Blue Beach during 2003 and 2011 and Red Beach during 2003 (Figure 1-4) [emphasis added]."

      Navy Response: The text in Section 1.2.4 has been modified for clarification to state: "The Navy conducted several visual surveys using Navy explosive ordnance disposal (EOD) divers/snorkelers to identify locations of underwater munitions. As part of the Preliminary Range Assessment (CH2M HILL, 2003), a transect inspection was conducted in the shallow waters adjacent to Blue Beach and Red Beach in 2003 (Figure 1-4). No munitions were identified in these areas. In 2010, Navy EOD divers/snorkelers conducted visual underwater surveys at Puerto Diablo, within Bahia de la Chiva, and at UXO 15. Navy EOD divers identified MEC at Puerto Diablo. Additionally nine potential MEC/MPPEH were identified

within Bahia de la Chiva just west and south of the island, five MEC items were identified as 5-inch rockets and four other as unidentified items. No MEC were identified near UXO-15."

b. This section states, "…In 2010, Navy EOD divers identified MEC at Puerto Diablo…" Please consider adding the project identified to Figure 1-4, since it is stated that divers did identify MEC at this location.

Navy Response: Figure 1-4 has been modified to identify the 2010 EOD survey, which is now labeled as "2010 Navy EOD Diver Survey."

7. Page 1-5, Section 1.2.5: Please indicate when the model was developed. Also, a minor editorial note - please confirm the reference MR-201003 with the reference listed in the reference section (MR-20103).

Navy Response: The text in Section 1.2.5 has been modified for clarification (including to respond to a comment from NOAA) to state: "The modeling results, issued in 2012, predicted that over a 30-year period, UXO surrogates may remain stationary (in deeper, offshore areas) or migrate (in more in-shore areas) from the reef platform a maximum of only about 10 ft (3 m) into adjacent sand channels and, in some cases, become buried in sand. Field measurements using UXO surrogates confirmed the modeling results (surrogates remained stationary in deeper, offshore areas and migrated a maximum of about 13 ft [4 m] in the in-shore areas). These high density areas, as well as where the model predicted and field measurements confirmed munitions would migrate are within the planned WAA study area." Additionally, the reference has been corrected in the Reference section to"MR-201003."

8. Page 1-5. Section 1.2.6, Bathymetry Data Review, Paragraph: Please revise reference from Appendix A to Attachment A. This comment also applies to Section 1.2.7 in reference to Attachment B (rather than Appendix B).

Navy Response: The text has been modified for consistency to refer to all Attachments as Appendices.

9. Page 1-5, Section 1.2.7: Please clarify the horizontal length scale associated with the 1 m change in the seafloor used as a criterion for underwater obstructions (i.e., a 1 m rise across how many meters in the vertical).

Navy Response: The 1 meter rise is independent of any horizontal distances; it is relative to the area immediately adjacent.

PREQB Evaluation of Response: Please revise the text to add the information provided in the response.

Navy Response to Evaluation: This text has been added to Section 1.2.7 as requested.

10. Page 1-5. Section 1.3.1: Please define CSM, as this is the first time this acronym is used in the text.

Navy Response: Section 1.3.1 has been modified to define "CSM."

11. Page 1-6, Section 1.3.2: Please consider rephrasing text to replace "underwater ecology" with "benthic habitats and species" and "ecological regimes" with "benthic habitats"

Navy Response: Section 1.3.2 has been modified as requested.

12. Figure 1-2:

a. Please consider revising figure labelling to distinguish Cayo La Chiva as UXO 18 in a color other than pink in order to distinguish it from UXO 16 areas not covered under the WAA.

Navy Response: The pink color used in the vicinity of Cayo La Chiva is being used appropriately, as this area will not be included in the UXO 16 WAA since the area has already been surveyed and is the focus of an upcoming NTCRA.

b. Please add label for SWMU 4.

Navy Response: Figure 1-2 has been modified to identify the "Former OB/OD Area" as the "Former OB/OD Area SWMU 4."

c. Please consider changing the line weight and color within the Former VNTR to more readily distinguish between EMA/SIA/LIA/ECA.

Navy Response: Figure 1-2 has been modified to make the boundary lines for the EMA/SIA/LIA/ECA more distinguishable.

13. Figure 1-4

a. Please label all locations for referenced projects and associated previous surveys, including but not limited to:

- Bahia Icacos
- Puerto Diablo
- Bahia Salinas

Navy Response: Figure 1-4 has been modified to include the investigations and location labels for sites discussed in Section 1.2, including those in the list above.

b. Please clarify whether surveys have taken place at the OB/OD site and/or the three Anchorage Areas.

Navy Response: The 2012/2013 side-scan sonar survey was performed within the OB/OD site boundary and at the three anchorage areas. The results of the survey in those areas are presented in Figure 1-6.

14. Figure 1-5: Please consider adding a description for the numeric values (4, 6, 7, 9, 10, 11, 13, 18, 20, 22, 23, and 24) to the legend.

Navy Response: Please see the response to Page-specific Comment 4b.

15. Page 2-1, Section 2.2.1, Wind: Prevailing winds are discussed in this paragraph, associated with conventional trade wind patterns. However, winds associated with episodic storm activity (e.g. tropical storms, hurricanes, or other disturbances) are likely more significant to the migration of MEC. Please include some discussion of peak (i.e., storm) winds, including frequency, intensity, recurrence interval, etc. Although information on waves associated with hurricanes is presented in Section 2.2.7, there is no discussion in either section on wind speeds, the potential for coastal setup, the generation of rip currents or undertow, or the combined effect of storm surge, all of which may have significant impacts on the mobility and migration of MEC. Please address.

Navy Response: The following text has been added to Section 2.2.1 to discuss episodic storm activity: "Coastal processes associated with winds due to episodic storms (e.g., tropical storms and hurricanes) may affect the migration of munitions. Vieques is on the path of Atlantic tropical storms and hurricanes, and it has been affected by both in recent history. From June to November, the high sea surface temperatures and favorable atmospheric conditions in the Atlantic Ocean allow the development of tropical lows into tropical depressions, tropical storms, and hurricanes. These storms track from east to west, and southeast to northwest. In recent history, Hurricanes David and Frederic in 1979, and Hurricane Hugo in 1989, were violent hurricanes that severely impacted Vieques coastline and marine habitats. According to Lizano (1991), Hurricane David passed approximately 90 nautical miles to the south of Vieques in an east to west direction with winds in the order of 90 mph. Rodriguez (1994) reports that Hugo, with winds greater than 150 mph, was the most intense hurricane to impact Puerto Rico since 1956.

Figure X [***ACTUAL FIGURE NUMBER WILL BE INSERTED ONCE FINAL FIGURE ORDER HAS BEEN DETERMINED***] shows the tracks of 18 tropical storms and hurricanes (both referred to as storms herein) for the period from 1900 to 2012, and passing within a 25 nm radius of Vieques. For the 113 years of record, the frequency is approximately an average of 1 storm every 6 years, with nearly 50% occurring in the month of September and 25% in August."

16. Page 2-2, Section 2.2.2, Bathymetry: Please provide horizontal length scales to quantify terms such as "slopes gently" or "drops abruptly." The depth contours in Figure 2-3 are not at high enough resolution to show this effectively.

Navy Response: The following Section 2.2.2 text has been modified for clarification: "The sea floor in this area slopes gently (e.g., 1:100) from the shore to a depth of approximately 50 ft, with a broad 80-ft deep shelf that extends to the north and west. The south side of Vieques is characterized by numerous small inlets and lagoons, and a shore-parallel coral reef at a depth of 50 to 65 ft approximately 1 to 2 miles offshore. South of the reef, there is a steep slope (e.g., 1:10) where the seafloor drops abruptly to depths over 3,000 ft."

17. Page 2-2, Section 2.2.4, Currents:

    a. Please provide information about the temporal/seasonal variability of the prevailing currents, as well as the influence of wave activity on the longshore current near the shoreline.

       Navy Response: There are no known data available regarding the temporal/seasonal variability of the prevailing currents around Vieques. However, as stated in Section 2.2.4, previous studies (GMI, 2005) noted prevailing currents along the north and south shores of Vieques are weak and driven mainly by wind. The prevailing current flows from east to west at approximately 0.10 meter/second (0.20 knot) along the north and south coastlines.

       The following text has been added to Section 2.2.4 for clarification: "This is consistent with rule-of-thumb estimates of 2 to 3% of the wind speed which would result in wind-induced currents in the order of 0.20 to 0.45 knots for the typical 10 to 15-knot easterly winds.

       The Vieques north and south shores are relatively broken and consist of a series of rocky headlands separating pocket beaches and bays. This particular coastal morphology is not conducive to the establishment of spatially and temporally constant wave-induced longshore currents. Instead, longshore currents are a function of the specific bathymetry and wave conditions within bays and along pocket beaches."

    b. The complex bathymetry of the shoreline, particularly along the southern edge of the island, may result in local spatial variability of the prevailing currents, which may be of particular importance to the potential migration of MEC. Please address.

       Navy Response: Waves have been identified as the principal mechanism of MEC transport, not the prevailing wind- or tidal-induced currents. See the responses to Page-specific Comments 17a and 18a for additional detail.

18. Section 2.2.6, Waves:

    a. On page 2-3 (Section 2.3) waves are identified as the most predominant mechanism for MEC migration. Please provide further detail in 2.2.6 regarding wave refraction, and wave breaking (which will be primarily responsible for migration).

       Navy Response: The many and different coastal features existing around Vieques will modify incoming wave height and direction in various degrees. Section 2.2.6 has been modified to include a description of refraction and wave breaking at Puerto Ferro on the south shore of Vieques as an example of how shoreline features such as those encountered at Puerto Ferro can affect waves.

       PREQB Evaluation of Response: Please ensure that the text has been modified as indicated in the response.

       Navy Response to Evaluation: The associated text of Section 2.2.6 was modified to state: "The many and different coastal features existing around Vieques will modify incoming wave height and direction in various degrees. The Vieques shoreline is extensive and, at the conceptual level of this assessment, it is not possible to assess how particular areas might affect wave refraction and breaking. Nevertheless, a description for a Puerto Ferro on the south shore of Vieques is provided as representative of other locations along this shore.

Puerto Ferro is essentially a natural, generally shallow (6 to 10 ft [2 to 3 m]) MSL deep bay, featuring a low shoreline consisting of mangroves. It is connected to the sea through an approximately 2,800 ft (850 m) long, 820 ft (250 m) wide natural channel, oriented in a northwest-southeast direction. The channel is sided by rocky shores with few sandy pockets on each side which slope up to 65 ft to 98 ft (20 m and 30 m) high headlands to the east and west, respectively. Just offshore Puerto Ferro, the bottom is approximately 26 ft (8 m) MSL deep, and gently slopes up to a 10 ft (3 m) MSL deep shoal midway in the channel, to then drop into a 13 to 16 ft (4 to 5 m) MSL deep depression in the center the bay. The bottom of the channel consists of sand covered by patches of seagrass, while the bay is predominantly covered by unconsolidated mud also covered by patches of seagrass. PI-9 East is an area within Puerto Ferro where MEC has been found, likely as a consequence of wave transport. PI-9 East is located at the northwest edge of the channel where the bottom conditions and shoreline features of the bay transition. Figure 1 shows the Puerto Ferro bathymetry, bottom constituents, shoreline characteristics and PI-9 East."

PREQB Evaluation of Response: The response adequately describes the bathymetry in the Puerto Ferro region as an example, but needs to include specific information about how these features might refract and/or break waves. Please add additional text, as appropriate, to tie the bathymetry to wave activity (and ultimately to MEC/MC migration).

Navy Response to Evaluation Comment: The following has been appended to the beginning of the text in the above response: "As waves approach the coast they are transformed due to the proximity of the bottom, refracting and gradually aligning their fronts with the depth contours, and shoaling and breaking in shallow water."

PREQB Evaluation of Response: Please note that the intent of the comment was to close the gap between bathymetry and wave breaking/MEC migration by indicating where wave breaking is most likely to occur. Therefore, please clarify whether it is currently known as to where wave breaking is most likely to occur (i.e., based on on-site observations or a first order assessment of the bathymetry). This information would enhance understanding of regions of potential MEC mobility, and inform targeted transect placement, in the WAA or future phases of the work.

Navy Response: Wave breaking is a function of wave height and water depth, and it is generally accepted that waves will break when the wave height to water depth ratio is approximately 0.78. While the bathymetry at the locations of interest is known, wave conditions are variable and therefore locations of wave breaking are also variable. The Beach Dynamics Investigation, currently being performed, will be evaluating these areas (via transects) at various beaches and will produce wave measurements which, in combination with wave modeling, will assist in the definition of areas of potential MEC mobility. This information will be added to the WAA Work Plan.

New PREQB Comment for Clarification

PREQB requests to confirm that the UXO 16 WAA project is not intended to be an all-encompassing evaluation of MEC in the waters near Vieques. EQB confirms that our understanding is that the intention of the UXO 16 WAA project is, as stated in the introduction to the work plan: "The WAA is not intended as a full-scale study of the nature and extent of MEC or MC contamination; rather, the findings of the WAA will be used to aid in the decision-making process for future investigations and munitions response actions, as applicable, for UXO 16."

The purpose of this reaffirmation of the goal of the UXO 16 WAA project is to clearly establish agreement that the UXO 16 WAA is not intended to be an all-encompassing analysis of MEC in the Vieques waters. Our understanding is that the Navy intends to use the WAA data to identify areas within the current established UXO 16 boundary where MEC contamination is obvious and where hazard reduction may be easiest to achieve, similar to performing a site walk on land. The WAA will provide quick and efficient data that may be helpful for planning the path forward for UXO 16. However, the WAA data is not intended to eliminate areas from further

investigation. It is understood that it may be used for that purpose if the data in some areas are determined to be of sufficient quality to support such decisions. Also, it is possible that new areas of MEC contamination, outside of the original WAA project boundary, will be discovered in the future through accidental discovery or additional historical research. In this case these areas will still be subject to investigation under CERCLA if this MEC is determined to have originated from the operation of the Vieques Naval Training Range. PREQB requests that the Navy acknowledge its agreement with the above statement of understanding to ensure that all parties have a full understanding of the purpose of the WAA project. PREQB further requests that the UXO 16 WAA Work Plan document the historical records search conducted to date, the basis for the current boundary, and a discussion of data gaps and additional records search needed to complete the conceptual site model associated with historical Naval activities within the waters surrounding Vieques.

Navy Response: Yes, the goal is as stated above. The goal is to identify areas of high densities of magnetic anomalies, which are potentially representative of high densities of munitions and/or targets (including vessels). This information can then be used to focus further investigation within the current UXO 16 study area, potentially eliminate some areas from further study, and potentially expand investigation outside the current study area. Information regarding the basis of the existing study area is provided in Section 1.1.2 of the Work Plan. As stated in other responses (e.g., see response to EPA General Comment #1), an additional records search will be conducted.

b. Figure 2-8 shows general refraction patterns, but these may be modified significantly at the smaller scales associated with the local inlets and cayos, particularly along the southern edge of the island. At a minimum, please show more detailed bathymetric plans with some discussion of how the bathymetry in particular areas might affect wave refraction and breaking, even if no measurements or site-specific modeling has been performed.

   Navy Response: Please see the response to the previous comment.

c. While the advantages of magnetometer surveys are made clear, there may be some advantages to acoustic sensors used in combination with the magnetometer arrays, to aid in interpretation. Given the presence of the vessels already collecting the magnetometer data, the addition of extra sensors may not add substantially to the cost of the effort. Please discuss whether acoustic sensors were considered as part of the WAA.

   Navy Response: High resolution acoustic technologies were considered, but there are no commercially available systems that deploy both technologies simultaneously and that are also suitable for WAA. High resolution acoustic technologies are more suitable for the focused investigations of EADAs and will be considered during their planning.

d. Paragraph 3: For clarity, please consider revising text as follows:

   During these winter months, storms and cold fronts are farther north and produce stronger than usual 25 to 30-knot winds from the northeast which can contribute to the development of 10 to 11 ft waves with 12 to 16-second periods that often reach Vieques.

   Navy Response: The following text has been included in Section 2.2.6: “During these winter months, storms and cold fronts farther north produce stronger than usual 25 to 30-knot winds from the northeast which can contribute to the generation of 10 to 11 ft waves with 12 to 16-second waves that often reach Vieques.”

19. Page 2-3, Section 2.3: This section states, “…Areas covered by unconsolidated sediment with gentle slopes would be conducive for munitions mobility if hydrodynamic (depth, waves, and currents) and munitions characteristics (shape, size, weight, condition, and relative orientation) are suitable. Munitions in unconsolidated sediment areas is [sic] expected to migrate in the direction of the waves; tidal and general circulation currents are less predominant transport mechanisms around Vieques.” As this is the first

reference to unconsolidated sediments in the document, please add a discussion of this feature and where unconsolidated sediments are located within UXO-16.

Navy Response: The following additional text has been added to Section 2.3 regarding unconsolidated sediments: "Along the north shore, there is a narrow area of unconsolidated sediment. This area is bounded by coral and hard bottom to the north and south, along the 20 and 10 m depth contours, respectively. Munitions in this narrow area, if not buried, are expected to migrate in the predominant wave direction and accumulate along the 10 m depth contour. In this narrow area of unconsolidated sediment, typical 1 to 2 m, 5 to 10-second waves would generate bottom flow velocities in the order of 0.75 knots, while 3 to 3.5 m, 12 to 16-second storm waves in the winter would generate velocities in the order of 1 knot. These wave conditions depending on shape, size, weight, condition and relative orientation of munitions could induce transport. Between the shore and the 10 m depth contour, there are a few pockets of unconsolidated sediment where munitions are expected to migrate similarly (e.g., toward the shore and in the predominant wave direction). Provided that waves do not break over the reefs, bottom wave-induced velocities in this area would increase due to shallower water and could reach 1 to 3 knots.

On the south shore the predominant bottom condition in the area of potential munitions presence is unconsolidated sediment. In principle, a similar behavior to what was described for munitions on the north shore on unconsolidated sediment should be expected. It is important to note, however, that the south shore features a broken coastline with pocket beaches bounded by headlands and fronted by islands, reefs and shoals that offer wave protection. These features significantly transform the deep water waves as they travel to the shore, decreasing the potential of waves to transport munitions. Therefore, low mobility of munitions could be expected in this area in typical conditions."

20. Page 2-4, Section 2.4 Future Land Use and Potential Receptors, Paragraph 3: Please consider discussing seabirds as a taxonomic group dependent on the coastal and oceanic environment for important life history requirements, such as foraging, rather than including seabirds in the list of aquatic organisms.

    Navy Response: The following text in Section 2.4 has been modified for clarification: "The diversity of aquatic organisms in these coastal habitats is high and includes approximately 50 species of corals, large numbers of benthic and epibenthic invertebrates (e.g., polychaetes, mollusks, crustaceans), over 30 seagrass and macroalgae species, over 200 species of fish, 28 species of aquatic mammals (mostly cretaceans), and 4 species of sea turtles. At least 16 species of seabirds are dependent on the coastal and oceanic environment for important life history requirements, such as foraging."

21. Figure 2-1:

    - Please clarify if all of the ranges in the northeast (Ranges 1 – 5) are small arms ranges as show on this map. It is believed that some of them were used for training with explosive ordnance such as 3.5-in. rockets.

      Navy Response: The following text has been added to Section 1.1.1 for clarification: "The ranges located in the northern portion of the EMA were used for the following activities: Small arms ranges (Range 1 and 2), Rifle Grenade Range (Range 3), Rocket Range (Range 4), and Grenade Range (Range 5)."

    - The legend refers to these ranges as "Small Arms Artillery Ranges." Please revise as this category or range doesn't exist.

      Navy Response: Figure 2-1 has been modified to refer to these areas as "Range." As noted above, the specific range details have been added to Section 1.1.1 of the text.

22. Figures 2-1, 2-5, 2-7: Please consider a change in scale to encompass the entirety of the northernmost safety fan within EMA-UXO 16.

Navy Response: Figures 2-1, 2-5, and 2-7 have been modified to shown the northern extent of the UXO 16 boundary as requested.

23. Figures 2-2, 2-4, 2-6: Please consider a change in scale, or add an inset, to encompass the northernmost Anchorage Area. If this location has been eliminated from the study area please provide further explanation to clarify this, rather than leaving the reader to wonder.

    Navy Response: Figures 2-1, 2-5, and 2-7 have been modified to show the northernmost Anchorage Area.

24. Figures 2-9 and 2-10:

    a. Please fully label the Y axis for both figures with units of measure m= meters, s= seconds.

       In addition in text areas where these two figures are discussed please describe units for both the X & Y axis.

       Navy Response: Figure 2-9 and 2-10 have been modified to fully label the Y axes. Section 2.2.6 has also been modified to reference the units on the Y axes.

    b. Please consider showing converted data in feet as that is the unit of measurement discussed in the text on Page 2-3, Section 2.2.6 Waves

       Navy Response: Figures 2-9 and 2-10 were generated using the CariCOOS website, which is incapable of producing the graphs in English units.

    c. Please add date of access to the

       Navy Response: Figure 2-9 and 2-10 have been modified to indicate that CariCOOS was accessed in March 2013.

25. Figure 2-10: Please edit title to read *"Typical Dominant Wave Periods Offshore East of Vieques*

Navy Response: Figure 2-10 has been renamed "Typical Dominant Wave Periods Offshore East of Vieques."

26. Page 3-1, Section 3.1, Technology Description:

    a. This section identifies that arrays will be towed from surface vessels. Has any consideration been given to autonomous underwater vehicle (AUV) surveys, which may have significant advantages in terms of positional accuracy, ability to operate under adverse weather conditions, ability to carry a variety of sensor payloads, etc.

       Navy Response: Autonomous underwater vehicle (AUV) surveys were considered; however, no commercial systems were identified that have the same capabilities as a towed array. AUV systems have a limited swath width and each varying sensor payload would require a separate deployment.

    b. Paragraph 3: Please provide the basis and the reference for the statement, "…expected depth of investigation is as deep as approximately 80 ft…"

       Navy Response: The referenced sentence has been revised to read: "Because the water depth of the investigation is as deep as approximately 80 ft (bathymetry data [Section 2.2.2] showed the maximum water depth within UXO 16 is 80 feet) . . . ."

27. Page 3-1, Section 3.2:

    a. Please define what is meant by "broad swath" in terms of distance from or radius about the array.

       Navy Response: The text in Section 3.2 has been modified to state: "An array of 4 to 8 magnetometers will be deployed in a towed platform so that a broad swath (up to 6m [19 ft] depending upon the system geometry) can be surveyed for each single transect."

    b. Please clarify what criteria will be used to determine whether 4 or 8 magnetometers will be used.

       Navy Response: The number of sensors and deployment geometry will be determined and dictated by the commercially available system configurations of the selected contractor.

    c. Please clarify what will the final area of coverage will be expressed in square feet or square meters.

Navy Response: The following sentence has been included in Section 3.6 for clarification: "Assuming the final array geometry provides a 13 ft to 20 ft (4 m to 6 m) swath width (the final array configuration will depend upon the subcontractor selected), the 328 ft (100 m) line spacing will result in 4% to 6% coverage of the survey area."

d. Please clarify what percentage of the track line corridor will ultimately be covered/surveyed by the effective horizontal range of the sensors.

Navy Response: See response to Page-specific Comment 27c.

28. Page 3-2, Section 3.3, Positioning/Navigation:

a. Please provide additional information regarding depth limitations of the positioning/navigation systems, including, at what depth the USBL system will be necessary.

Navy Response: The depth limitation for the non-USBL positioning is system dependent and will not be finalized until the contractor is identified. In general, USBL would be used for depths greater than 10 to 15 m. The following text has been added to Section 3.3 for clarification: "It is anticipated that the USBL system would be used at depths greater than approximately 32 to 50 ft (10 to 15 m), although this determination is dependent upon the subcontractor-specific equipment and will be made after the selection of the subcontractor."

PREQB Evaluation of Response: The response is accepted; however, please see our evaluation of response to the following comment.

b. Please identify how altitude of the towed array will be adjusted dynamically during the tow operations. Please clarify if these controls are computer-driven with constant adjustments to maintain a uniform altitude, or are they manually adjusted, and at what frequency.

Navy Response: The altitude control approach is system dependent and will not be finalized until the subcontractor is identified. Automatic and manual control have both proven to be effective at maintaining the correct stand-off distance within the specified tolerances. The following text has been added to Section 3.3 for clarification: "Both manual and autopilot controlled approaches require continuous control to maintain optimal survey altitude."

PREQB Evaluation of Response: As discussed during the March 2015 ERP meeting, various subcontractor systems may have different means of achieving the required metrics, and no stipulations would be placed on the methods themselves. This is acceptable, but please reference in this section of the text the appropriate table that describes the required specifications and tolerances, and include the 1-m tolerance on flight altitude discussed during the meeting.

Navy Response to Evaluation: The following text has been added to the discussion of survey altitude in Section 3.3: "Regardless of the vertical navigation methodology, survey altitude will be maintained in accordance with the MQO presented Table 3-4 (Section 3.8)."

c. Please provide anticipated vessel speeds during survey operations, and how this will affect resolution.

Navy Response: The following text has been added to Section 3.3: "Survey speeds will be nominally between 2 and 4 knots (kts) – the equivalent of 3 to 6.5 feet per second (1 to 2 meters per second [m/s]). At a 10 Hz sample rate this corresponds to samples every 0.3 to 0.6 feet (0.1 to 0.2 m). The final combination of sample rate and survey speed will require that sample intervals do not exceed 1 ft (0.3 m).

d. Please describe the anticipated depth ranges for "shallow water" and "deeper water."

Navy Response: The text in Section 3.3 has been modified to state: "Positioning of the data gets more challenging in deeper water (>15 m [49 ft]) because this method relies on precise measurement of the tow cable angle, depth and catenary."

29. Page 3-2, Section 3.4, Ancillary Sensors: Please clarify if any other data besides video surveys, such as side scan sonar, will be collected simultaneously with the magnetometer array data, to aid in the interpretation of collected data.

    Navy Response: No additional data other than the video survey will be collected during the WAA as other technologies are not compatible with simultaneous deployment of the magnetometer array and are not critical to the goals of the WAA. Side scan sonar data already exist for the study area.

    PREQB Evaluation of Response: As discussed during the March 2015 ERP meeting, existing side-scan sonar data is of insufficient resolution to aid in the interpretation of magnetometer data. Please indicate in the text that no other data, aside from video surveys, will be available to aid interpretation.

    Navy Response to Evaluation: Section 3.4 provides a description of the ancillary sensors that will be used during the investigation. If the ancillary equipment to be used is listed, it is unclear why additional clarification is necessary.

30. Page 3-2, Section 3.5, Data Processing: Please define the resolution of the "regularly sampled grid," and how the data collected will be able to populate that grid (i.e., how many independent grid cell values within a single swath, and how many empty grid cells between swaths).

    Navy Response: The following text has been added to Section 3.5.1 for clarification: "The resolution of the regularly sampled grid will be 0.5m – measurements falling within a grid cell will be averaged to provide a value for that grid cell. Grid cells with no measurements will be assigned null values. The final distribution of grid cells populated with values will depend upon the final system geometry and sample rate."

    PREQB Evaluation of Response: The specific gridding software that will be utilized and the expectations/limitations that will be imposed on interpolations used to populate grid cells with no data points were discussed during the March 2015 ERP meeting. Please incorporate this information (i.e., the software package information and the interpolation expectations) into the text.

    Navy Response to Evaluation: The following text has been added to include additional information about the software package: "These results are interpolated to a regularly sampled grid covering the survey area using Geosoft's standard gridding software. The interpolations are limited to the effective horizontal range of the sensors (nominally 1 to 2 m, depending the size of source objects). The resolution of the regularly sampled grid will be 0.5m – measurements falling within a grid cell will be averaged to provide a value for that grid cell. Grid cells with no measurements will be assigned null values. The final distribution of grid cells populated with values will depend upon the final system geometry and sample rate."

31. Section 3.5.2 says that targets in the correct size range will be "examined." Please clarify how this examination will be performed. As this is a WAA project that is designed to determine areas with elevated anomaly counts it isn't expected that examination of underwater objects will be performed. Please describe how and when the examination of objects determined to be the correct size will be accomplished.

    Navy Response: The term 'examined' is intended to indicate that the spatial distribution (i.e. anomaly density distribution) will be examined. The following text in Section 3.5.2 has been modified for clarification: "The spatial distribution of the anomalies will be examined to identify EADAs and thus potential OUs requiring detailed investigations. This process will involve deriving density distribution maps (i.e., maps of anomalies/acre) and using Visual Sample Plan (VSP) to identify EADAs within the survey region. The appropriate VSP parameters used for this investigation will be based in part on the character of the anomaly density data. Background anomaly density will be derived from the survey data and, based upon this and the line spacing used, the supporting statistical basis for conclusions drawn from the survey results will be provided. For example, for a given minimum size and shape (e.g., 250m diameter circle) these data will allow determination of what density above background can be claimed to have been detected with close to 100% probability. Conversely, for a given anomaly density elevation above the background, the minimum size of area that was detected can be determined with close to 100% probability."

32. Page 3-3, Section 3.6, Survey Design:

    a. Please define the resolution of the helicopter magnetometer surveys and clarify how this compares to the size of the identified EADAs.

       Navy Response: Resolution of the geophysical survey data (both marine and airborne) is sufficiently small to be a non-factor in the identification of EADAs. The 'resolution' of the helicopter magnetometer surveys was 0.5m - less than 1% of the size of the EADAs. The resolution of the marine surveys will be the same order of magnitude as the airborne data. The following text has been added to Section 3.5.1 for clarification: "The resolution of the regularly sampled grid will be 0.5m – measurements falling within a grid cell will be averaged to provide a value for that grid cell. Grid cells with no measurements will be assigned null values. The final distribution of grid cells populated with values will depend upon the final system geometry and sample rate."

       Additionally the Section 3. Text has been modified as follows for clarification: "The resolution of the geophysical survey data (both marine and airborne) is sufficiently small to be a non-factor in the identification of EADAs. The 'resolution' of the helicopter magnetometer surveys was 0.5m - less than 1% of the size of the EADAs. The resolution of the marine surveys will be the same order of magnitude as the airborne data."

    b. Paragraph 2:

       i. Please clarify how it was determined that 25 targets/acre is the acceptable threshold for EADA detection. Please clarify if it is assumed that areas with less than 25 targets/acre is not of concern.

          Navy Response: The following text has been added to Section 3.6 for clarification: "Without prior knowledge of the target densities, these initial estimates were used to create a conservative line spacing. It is important to note that these estimates are not actionable thresholds and will not be used as a basis for identification of elevated anomaly density areas – they are only used as starting estimates for the sole purpose of deriving a conservative line spacing."

       ii. Please provide additional details regarding the VSP calculations and the confirmation of the selected 100-m line spacing, including the assumptions used for the calculations and other pertinent details.

          Navy Response: The assumed background anomaly density (5 anomalies/acre) and elevated target density (25 anomalies/acre above background) were selected to be conservative (i.e., biased towards a tighter line spacing). Although a 'bivariate' density distribution was used, a normal distribution was found to give essentially the same results (Pd = 1.00 vs .993 respectively). Without prior knowledge of the target densities, these initial estimates were used to create a conservative line spacing. It is important to note that these estimates are not actionable thresholds and will not be used as a basis for identification of elevated anomaly density areas – they are only used as starting estimates for the sole purpose of deriving a conservative line spacing.

          The following text in Section 3.6 has been modified for clarification, "Without prior knowledge of the target densities, these initial estimates were used to create a conservative line spacing. It is important to note that these estimates are not actionable thresholds and will not be used as a basis for identification of elevated anomaly density areas – they are only used as starting estimates for the sole purpose of deriving a conservative line spacing. Also, although a 'bivariate' density distribution was used, a normal distribution was found to give essentially the same results (Pd = 1.00 vs .993 respectively). The actual shape of an EADA is not predictable due to the myriad of factors affecting the final resting positions of TOI. However, the actual shape of an EADA does not need to be circular for the statistics obtained with a circular assumption to be valid. The circle is just used to estimate the smallest dimension of an EADA. By using a 250 m circle as the input, the implication is that 250 m is the minimum size in any direction that will be detected with a probability of close to 100% (i.e. any area that has a minimum dimension of 250 m or greater will be detected)."

c. Paragraph 3:

i. Please revise the sentence to reference Attachment A rather than Appendix A.

Navy Response: Attachments A and B have been changed to Appendices A and B throughout the document. For this reason, the Section 3 reference to Appendix A has been retained.

ii. Please provide an example of the "nominal line spacing" changes that might occur when avoidance of identified items is required. For example, to avoid a patch of coral please clarify if the whole transect would be repositioned or would it just incorporate a segment that goes around the coral patch. Please also clarify if adjustments would be designed to generally result in tighter transect or transect segment spacing.

Navy Response: Changing whole transects is not necessary – segments of transects will be modified to avoid obstacles. Gaps in coverage due to obstacles may be unavoidable but attempts to minimize these gaps will be made. The changes will result in tighter spacing between some transects and wider spacing between others (i.e., if an obstacle is avoided, the path of the transect will be closer to the adjacent transect on one side of the obstacle and further on the opposite side). If significant gaps in coverage (defined as gaps between lines greater than 410 ft [125 m] for distances of 1640 ft [500 m]) occur, a summary of them and their potential effect on the survey results will be discussed in the WAA Report. The following text has been added to Section 3.6 for clarification: "Gaps in coverage due to obstacle/sensitive habitat avoidance may be unavoidable. Additionally, real-world conditions such as currents, wind, and wave action will likely result in some deviation of the array from its intended transect. Significant gaps in coverage (defined as gaps between lines greater than 410 ft [125 m] for distances of 1640 ft [500 m]) will be re-collected if possible (e.g., unless they were incurred for obstacle/sensitive habitat/wild life avoidance). Due to the conservative line spacing, gaps up to this size will not affect the usability of the survey data to detect EADAs. Gaps greater than this size that are unavoidable will be identified and their effect on the survey results will be discussed in the WAA Report."

- Paragraph 4:

iii. This section says the sensor altitude will vary "between 3.3 ft (1 m) and 6.6 ft (3 m)." Note that 6.6-ft. is 2 meters; therefore, please clarify if the maximum sensor height will be 2 meters or 3 meters.

Navy Response: The text in Section 3.6, has been modified to state: "The sensor altitudes will be nominally between 3.3 ft (1 m) and 6.6 ft (2 m)."

iv. Please provide additional information regarding altitude, and whether the tows will be performed at 1 m vs. 3 m (or 2 m). Please clarify if the exact altitude be determined in real-time by the array operators or if targeted depths will be determined a priori.

Navy Response: Maintaining an exact altitude is not possible. However, the altitude will be maintained as close to 1m as possible. Altitudes between 1 m and 2 m (due to seafloor topography) are acceptable for data analysis. The following text has been added to Section 3.6 for clarification: "The altitude will be maintained as close to 1 m as possible (maintaining an exact altitude is not possible). At 3.3 ft (1 m) altitude, targets as small as 37mm projectiles on the sediment surface should be reliably detected. However, at 6.6 ft (2 m) altitude, objects less than the size of 60mm mortars on the sediment surface will not be reliably detected. Because the WAA is intended to identify EADAs, the reliable detection of small ordnance classes is not critical to the success of the survey."

v. For clarity, please replace "as" with "at," as indicated below (note – although a minor editorial note, without the change the sentence is confusing): "With an assumed detection threshold of 0.5 nT, small targets lying on the surface of the seafloor can be detected at survey altitudes up to 1.5m and medium targets on the seafloor will be detected at altitudes approaching 3m…"

Navy Response: The text has been modified as requested.

d. The survey design shown in Figure 3-6 is at a small scale so it is not possible to see the details of surveys within the coves and bays, many of which are presumably identified as off limits to the magnetometer survey due to shallow depths and the lack of side scan sonar data, and along the shoreline in general. A series of larger scale maps would be useful in delineating the sampling plan.

Navy Response: Figure 3-6 (which has been renumbered as Figure 3-5) shows only a conceptual design of the planned survey transects. The exact selection method and final transect locations are dependent up on the subcontractor, who has not yet been selected.

PREQB Evaluation of Response: Please clarify if the subcontractor will provide specific sampling plans for review prior to initiating work.

Navy Response to Evaluation: Please see the response to Comment 2 above.

Because the transects will be established in the field, the final transect design will be provided in the WAA Report. As noted previously, the transect design will meet the specifications established in the Work Plan. In addition, all regulatory agencies will have the opportunity to provide comment on how the WAA was conducted and whether it met the stated objectives. Establishing all transects in advance and providing the design for review in advance of the WAA would cause significant delays. As with the recent UXO 16 Expanded Site Inspection, transects were not provided for review. Instead, the objectives and specifications of areal coverage were provided, reviewed, and concurred upon in the Work Plan. Actual transect locations were established in the field during the ESI to ensure the mutually agreed upon objectives and specifications were met.

e. Please identify if there are any plans to investigate the areas designated as regions where side scan sonar could not be performed.

Navy Response: Underwater DGM is precluded in these areas for the same reasons that side scan sonar could not be performed. Whether these areas warrant further investigation will be determined following the WAA and potentially follow-on investigations.

33. Page 3-4 to 3-5, Section 3.7.2, Data Collection:

a. Paragraph 1: A swath width of 8 to 10 feet is indicated. Please clarify:

i. if this is instrument-dependent (no manufacturer/model number for the magnetometer array has been identified in the document),

Navy Response: The swath width will be dependent upon the geometry and configuration of the systems that are commercially available at the time of the survey, which will be determined once the contractor is identified. The following text has been added to Section 3.1 for clarification: "Details regarding final array geometry and positioning methodology that are specific to the commercial provider will be determined once a subcontractor is identified. The information will then be provided to the agencies."

ii. if this width varies with altitude of the array above the seabed, and

Navy Response: The following text has been added to Section 3.2 for clarification: "This swath width is dependent upon the width of the array and does not vary with altitude."

b. Please reference Table 3-4 in the discussion of "straight and evenly spaced transects" and/or discuss metrics for determining what is considered "approximately straight."

Navy Response: The text in Section 3.7.3 has been modified to state: "Efforts will be made to maintain approximately straight, evenly spaced transects (consistent with the MQOs presented in Table 3-4) to the extent that the ocean conditions permit. It is important to note that the study objectives can be met

even if transects are not straight and evenly spaced. The final spacing and orientation of the transects will be presented in the WAA report and any potential impact on the study objectives will be discussed."

c. Please explain the nature and frequency (daily, weekly, monthly, etc.) of the performance functionality QC testing. Please clarify if data collection will be performed along a test transect, seeded with known targets. Please also provide additional detail on reporting and recording of test events.

Navy Response: The following text in Section 3.7.3 has been added for clarification: "Performance functionality QC testing will be conducted for all geophysical equipment on a daily basis to ensure detection capabilities. The QC tests will include repeatability tests, standard response tests, background noise level evaluation, and positioning evaluation. Because a subcontractor and system has not yet been procured, QC testing and reporting procedures will be provided in a SOP to be added to the Work Plan prior to finalization."

34. The DFW and tasks in Table 3-1 need to include a requirement for an IVS. This important function test is needed to establish the detection capability of the magnetometer array. Section 3.7.2 has some words on "performance functionality QC testing" but there is no explanation for what this is or requirements for performing this testing in the work plan. Please add a requirement for an IVS and performance functionality testing to the work plan.

Navy Response: Table 3-1 has been modified to include an IVS; however, its purpose is to demonstrate performance functionality as opposed to establishing the detection capability of the magnetometer array. The performance functionality is determined by the type of sensor and physics and is well documented (i.e., all magnetometer systems using the same type of sensors will have identical detection capabilities at the same distance from similarly oriented ferrous items).

35. Please address the following comments pertaining to the QC program:

a. Section 3.7.2 on "data collection" states, "Initial PDF maps of raw DGM results will be evaluated frequently to allow for a determination of whether data collected from the transects should be adjusted." Please update Chapter 4 on QC to include the requirement to do this evaluation, how this evaluation will be performed, what standard will be used to determine if the data should be adjusted, how this data adjustment will occur and what it will consist of.

Navy Response: This referenced text has been deleted as the 'evaluation' of data needed is associated with the measurement performance criteria presented in Table 3-4.

b. Similarly, this same section makes statements on performing functionality QC testing on all geophysical equipment to ensure detection capabilities, and Chapter 4 on QC needs to be updated to include this requirement and procedures.

Navy Response: The quality control tests and how they will be performed are specific to the system to be used. The text in Section 3.7.3 has been modified to state: "The QC tests will include repeatability tests, standard response tests, background noise level evaluation, and positioning evaluation. Because a subcontractor and system has not yet been procured, the procedures will be provided in a Standard Operating Procedure (SOP) to be added to the Work Plan prior to finalization." Regardless of the procedures employed, all of the Measurement Performance Criteria (MPCs) identified in Table 3-4 are required to be met.

c. Also, this section requires QC review of field logbooks to verify equipment functionality tests are being conducted at least once a day and other investigation details are being recorded and this requirement needs to be reflected in the QC plan.

Navy Response: Table 3-5 has been modified to include this requirement.

d. Section 3.7.3 requires the DGM subcontractor to provide each day's data for QC inspection and there needs to be a corresponding requirement in Chapter 4 to do this inspection and a description of how it will be performed.

Navy Response: Table 3-5 has been modified to include this requirement.

36. Page 3-5, Section 3.7.3, Data evaluation:

a. Please explain how "sensor offsets, latency, and drift" will be determined.

Navy Response: 'Drift' is not applicable to Cs vapor magnetometers (they provide accurate measurements with no requirement for calibration or drift correction). Reference to drift has been removed from the document and the following text has been added to Section 3.7.4 for clarification: "The sensor offsets are a fixed value dependent on the system geometry. 'Latency' is a term that refers to the difference between the time of applicability of the geophysical data and that of the positioning data. This time adjustment is relatively small (0.1 to 0.2 seconds) and is determined by comparing the initial IVS data collected on reciprocal headings. The latency correction will be equal to half of the measured offset (in time) between the anomaly peaks over the IVS target(s).

b. A list of four criteria is provided in Section 3.7.3 that will be used to evaluate the significance of the anomalies that are detected. This indicates the ability to "classify" anomalies as significant or insignificant based on underwater magnetometer geophysical data collected from 1-meter to 2-meters above the ocean floor. Please provide supporting research or evidence that this is technically possible. Also, please explain why this WAA project can reliably locate areas with elevated anomaly density while at the same time excluding some anomalies as not significant.

Navy Response: The text has been modified to remove the word 'significant.' The criteria will be used to identify any geophysical anomalies that could potentially represent metallic objects.

37. Table 3-4:

a. Measurement Performance Criteria:

- Please specify measurement performance criteria (MPC) for the very important equipment verification at an IVS. Please add these specifications and a requirement for an IVS to the MPC.

Navy Response: The MPCs for the IVS overlap with those for the transect surveys; the Definable Feature of Work column in Table 3-4 has been modified to indicate which MPCs are applicable to the Initial IVS Survey, Daily IVS, and Transect Data Collection activities.

- Related to the above bullet, the MPC for DGM measurement is for the magnetometers to be operational and providing data values between 20,000 nT and 70,000 nT. This appears to be the only operational check on the magnetometers. As previously stated, an IVS that is implemented at the start of the project and periodically throughout the project needs to be added to the plan. Also, please explain the implication of the 20,000 nT to 70,000 nT specification. Please clarify what size objects will be detected on the ocean floor at 20,000 nT with the sensor at the maximum allowable altitude of 6.6 feet.

Navy Response: Table 3-4 has been modified to include IVS MPCs.

Regarding the intensity of the Earth's magnetic field, this intensity, measured in nT, varies depending on location and time (as it changes annually). 20,000nT is not a 'threshold' of detection but rather the approximate minimum value experienced anywhere on the planet. The raw total magnetic field measurements are within the range of 20,000 nT to 70,000 nT. Following the geophysical survey, the raw data are 'leveled' to remove the background using a de-median filter. This results in a final data channel that sits at zero (plus/minus noise) unless an anomaly is detected. Figure 3-5 shows the anomalous response amplitudes for a set of ordnance types. The following text has been modified in Section 3.5.1 for clarification: "The raw total magnetic field data (measurements between 20,000 and 70,000 nT) are transcribed into the database and are time aligned and merged with the positioning data.

System geometry, vessel and platform attitude, and ancillary sensor measurements (angle encoders and/or USBL data) are used to translate the GPS antenna coordinates to each geophysical sensor measurement. A set of site-specific filters are used to isolate the target responses by removing unwanted 'background' signal (geology, diurnal variations and sensor heading effects) resulting in a 'leveled' data set where the data are essentially at 'zero' unless there is an anomalous response due to a proximal ferrous object. These results are interpolated to a regularly sampled grid covering the survey area."

- The MPC for DGM survey coverage is that spacing between survey lines will not exceed 120 meters for a length greater than 500 meters along the parallel lines. Please clarify how this specification was selected and why is it adequate.

  Navy Response: This value is a qualitative approximation of a length of transect that, because of real-world conditions (e.g. currents, wind, wave action), might cause the boat to deviate from the intended path and return to that path. The conservative approach to line spacing was taken so that this amount of deviation will not affect the overall WAA results. The following information has been added to Section 3.6 for clarification: "Gaps in coverage due to obstacle/sensitive habitat avoidance may be unavoidable. Additionally, real-world conditions such as currents, wind, and wave action will likely result in some deviation of the array from its intended transect. Significant gaps in coverage (defined as gaps between lines greater than 410 ft [125 m] for distances of 1640 ft [500 m]) will be re-collected if possible (e.g., unless they were incurred for obstacle/sensitive habitat/wild life avoidance). Due to the conservative line spacing, gaps up to this size will not affect the usability of the survey data to detect EADAs. Gaps greater than this size that are unavoidable will be identified and their effect on the survey results will be discussed in the WAA Report."

- The along-track specification is that measurement spacing will not exceed 1 foot, but the next sentence says the maximum along-track gap is 5 meters. Please reconcile these two apparently conflicting specifications.

  Navy Response: As stated in Table 3-4, the MPC is that 95% of the along-track measurement spacing for each transect will not exceed 1.0 ft (0.3 m) and the maximum allowable along track gap will be 5.0 m. This allows for 5% of the measurements to be between 0.3 m and 5.0 m.

- There is an MPC for video imaging but there is very little mention on this in the text. Please add to the work plan how the video will be deployed and what it is expected to accomplish.

  Navy Response: The deployment approach will be dependent on the subcontractor selected and the specific system they employ. The following text has been added to Section 3.4 for clarification: "The imagery will be georeferenced and/or time stamped to facilitate mapping of identified features. Because a subcontractor and system has not yet been procured, the procedures will be provided in a Standard Operating Procedure (SOP) to be added to the Work Plan prior to finalization."

- There is an MPC for reporting. Please provide additional details on what information the report will contain. For example, the report needs to include the criteria for reporting an area as an EADA.

  Navy Response: Section 3.7.4 contains a description of the report, and a Reporting DFOW has been added to Table 3-5, including an audit procedure. There are no pre-defined criteria for reporting an area as an EADA as the densities are unknown and cannot be predicted; they will be determined via observation of the data collected. This determination will be presented to the Vieques Environmental Restoration Program Technical Subcommittee for review and discussion.

- This same MPC for reporting describes "recollects." Please clarify what is meant by "recollects."

  Navy Response: Table 3-4 has been modified to define the Reporting Failure Response as "Portions of the report not accepted by senior technical review will be rewritten."

b. Under completeness (coverage), please explain the second entry "95% of the along-track measurement spacing for each transect will not exceed 1.0 feet . . ." Is this referring to the distance between tracks, which was identified in the first entry as being within 10 m?

Navy Response: The 1-ft spacing refers to the along-track distance between measurements on the same transect. The previous entry in this table is referring to the crosstrack distances (distance between transects). Table 3-4 has been modified for clarification.

c. Under representativeness (altitude), the two entries are contradictory, describing an upper limit of 6 ft in the first entry and 6.6 ft in the second entry. Please clarify.

Navy Response: The text in Table 3-4 has been modified with the correct value of 6.6 ft.

d. Under accuracy (topside positioning), please clarify where the control stations for GPS validation are located, and how the positions are independently measured. Please clarify how frequently these checks will be conducted.

Navy Response: The control stations will be placed in a convenient location where they can be easily reached by the field team. The specific locations will be selected at mobilization, and the test will be performed as part of each IVS survey. Table 3-4 has been modified to include this information and to indicate that the positions will be established by a professional land surveyor.

e. Under accuracy (target positioning), reference is made to an Instrument Verification Strip (IVS), but no further description of this is provided. Please clarify how the IVS will be constructed. Also, please clarify how often instruments will be checked against it.

Navy Response: Additional text related to an IVS has been added to Section 3.7.2 and referenced throughout the document.

PREQB Evaluation of Response: Please provide the proposed text for agency review.

Navy Response to Evaluation: The following text has been included in Section 3.7.3: "After site setup activities and prior to commencement of data collection activities, initial testing of the system to validate proper function will be performed. These tests will verify that all of the system components are operating properly and will include function tests of each magnetometer, static position accuracy tests for the GPS and a test run over a modified instrument verification strip (IVS) to ensure that the system as a whole is functioning properly.

Establishment of an IVS in the marine environment poses many challenges. The costs of emplacing targets, mobility of emplaced targets and time required to get to and from the IVS are all challenges that are not typically encountered on land based projects. For the purposes of the WAA, a modified approach to the initial and daily IVS surveys will be performed. Where practical, existing submerged targets (with independently known positions) may be used as a single target IVS. One or more targets may be emplaced in convenient locations to act as a single or multi target IVSs."

38. Section 3.8:

a. It is stated for every QC phase that an inspection for that phase will be performed before beginning the DFOW (for preparatory and initial inspections) or at regular intervals during performance of the DFOW (for follow-up inspections). If this requirement is going to be implemented then each DFOW needs to have at least three corresponding inspections (at least one for each QC phase) listed on Table 3-5. Please revise Table 3-5 to comply with the stated requirement to have three-phased inspections on all DFOW.

Navy Response: Table 3-5 has been modified to include this information.

b. The description of preparatory phase inspections says that all equipment will be tested to ensure functionality. Please include detailed information on how this will be done. Please add this information including an IVS to ensure functionality of the survey equipment.

Navy Response: Please see response to Page-specific Comment 35b. Additional text related to an IVS has been added to Section 3.7.3 and referenced throughout the document.

c. The description of preparatory phase inspections also says that personnel will receive training in accordance with the requirements of this work plan but the work plan doesn't appear to include information on training requirements. Please add these requirements to the work plan.

Navy Response: The text "training in accordance with the requirements of this work plan" has been removed as, just like any other task performed on Vieques, only staff qualified to perform the tasks are utilized. The sentence has been modified to state: "The FTL and project geophysicist will verify that required plans and procedures have been approved and are available to the field staff; field equipment is appropriate, available, functional, and properly calibrated for its intended/stated use; staff responsibilities have been assigned and communicated; staff have reviewed the Work Plan and associated SOPs; arrangements for support services have been made; and prerequisite site work has been completed."

d. The sections on initial and follow-on inspections discuss performing corrective actions for unsatisfactory and nonconforming conditions but there are no procedures for this. Typically a QC plan provides a process for addressing these issues and may provide forms for reporting the condition and the resolution. Please add this information to the work plan.

Navy Response: Section 3.2 has been included to discuss Preventative and Corrective Actions. Additionally QC Forms have been added as a work plan appendix.

39. Table 3-5, work auditing procedures for each DFOW:

a. Four DFOWs are listed on Table 3-1. Two of them are not covered and are missing from Table 3-5. Please clarify.

Navy Response: The DFOW nomenclature has been modified throughout the document for consistency between the tables and text.

b. QC requirements for the critical IVS need to be added to this table.

Navy Response: The Equipment Testing task within Table 3-5 has been modified to more appropriately state: "Verify initial and daily IVS surveys are performed and applicable MPCs are being met."

c. For "GIS Setup" please add direction or specification in the work plan for how to implement the requirement to determine that the "GIS system has been set up and is ready for site data."

Navy Response: The audit procedure in Table 3-5 has been modified to state: "GIS system has been set up and is ready for site data, including: GIS technician has prepared a GIS project with all available GIS information; System is ready for import of new data."

d. For many of the DFOWs, the required "action" is to "not proceed with field activities until criterion is passed." However, there does not appear to be specific criteria presented in either this table or the document as a whole. Please address by developing specific documentable requirements and then describing how the QC managers will evaluate and document achieving the requirements in the QC plan.

Navy Response: Details have been added to Table 3-5 where applicable. Some of the criterion are qualitative in nature, whereby the determination is made by the QC Manager. In all instances, this information will be summarized and provided in the draft report to the regulatory agencies for review.

e. For "Document Management and Control" please revise the work plan to provide information on how to determine that "appropriate measures are in place to manage and control project documents."

Navy Response: Table 3-5 has been modified to include additional details.

f. The "Audit Procedure" and "Pass/Fail Criteria" for "Subcontractor Procurement" references "qualifications, training, and licenses" and requires that they are up-to-date and acceptable. Please specify the minimum standard for qualifications, training and licenses in the work plan. Please add this information to allow the requirements of Table 3-5 to be implemented.

Navy Response: Table 3-5 has been modified to include additional details where applicable.

g. Similarly, the "Audit Procedure" for "Equipment Testing" is to "Verify equipment testing has been performed and equipment is functional." Please specify the minimum requirements for determining that the equipment is functioning adequately. This needs to be added to the work plan to allow the requirements of Table 3-5 to be implemented.

Navy Response: The Equipment Testing task has been modified to more appropriately state: ". . . and daily IVS surveys are performed and MPCs are being met."

Please note that the above list provides examples of concerns associated with Table 3-5, and additional information and detail is needed to provide sufficient direction to the QC managers.

Navy Response: Table 3-5 has been modified to include additional details.

40. Figure 3-1:

a. This figure provides an estimate for detection capabilities based on "signal to noise ratio curves." However, it appears that this measurement standard isn't used to describe the detection capabilities of the sensor as the work plan describes signal intensity and requires a specific signal intensity of between 20,000 nT and 70,000 nT as a description of adequate data elsewhere in the plan. Please explain how this figure showing "signal to noise ration [sic] curves" is used to determine the detection capability of the sensor.

This figure appears to show that small ISO can be detected at approximately 3.5 feet. Please clarify if that is the proposed detection capability for the sensor or whether this depth changes as the background noise changes. Also, if approximately 3.5 feet is the detection threshold for a small ISO then please state in the work plan that the detection capability for MEC the size of small ISOs is likely to be minimal at best considering the requirement to collect data at no more than 2 meters above the ocean floor.

Please also provide a table showing the expected detection capability of the sensor when it is flown at the specified maximum acceptable height of 2 meters above the ocean floor.

Navy Response: Figure 3-1 is intended to provide a comparison of detection capabilities of EM vs total magnetic field technologies – they cannot be compared using their native units. Figure 3-5 presents the detection capabilities in nT (total magnetic field units) of the down-selected technology.

The raw total magnetic field measurements are within the range of 20,000 nT to 70,000 nT. – values outside of this range indicate a fault of some kind. The raw data are 'leveled' to remove the background using a de-median filter. This results in a final data channel that sits at zero (plus/minus noise) unless there is an anomaly. Figure 3-5 shows the anomalous response amplitudes for a set of ordnance types.

The total magnetic field response will vary depending upon the orientation of the object relative to the Earth's magnetic field. Figure 3-5 shows the 'minimum response' indicating that the object would be reliably detected when the offset distance is less than 1.5 m. This only means that not all 37 mm would be detected at distances above 1.5 m (37 mm projectiles that are aligned with the Earth's field are detectable a distances above 1.5m). Because the WAA is being performed to find EADAs, the fact that not all 37 mm targets will be detected is not critical.

The following text explaining the orientation effect has been added to Section 3.6 for clarification: "Depending upon the aspect ratio of the object, its orientation with respect to the Earth's magnetic field will have a large effect on the magnitude of the total magnetic field response. Where a sphere will

produce a response that does not vary with orientation of the Earth's field, an object like a 37mm projectile will produce a maximum response (oriented parallel the Earth's field) that is more than double its minimum response (oriented normal to the Earth's field)."

PREQB Evaluation of Response: The response addresses this specific comment. However, the statement in this response that "… the fact that not all 37 mm targets will be detected in not critical" is an example of the issue discussed in General Comment 3 above that needs to be addressed because as the sensor rises, or as the seabed undulates or both, the detection capability of the sensor will greatly vary and the number of anomalies detected will vary. This will affect to some degree the ability to identify EADAs and this needs to be accounted for and normalized if a consistent WAA survey is going to be achieved. Please address.

Navy Response to Evaluation: See response to Comment 1 (original General Comment 3) above.

b. Minor typo: "Ration" in the figure title and footnote of Figure 3-1 should be "ratio."

Navy Response: Figure 3-1 has been modified as requested.

41. Figure 3-5:

- Please clarify if the detection threshold shown in Figure 3-5 relates to the signal-to-noise ratio curves shown in Figure 3-1. Please clarify if the detection threshold shown on Figure 3-5 changes if the signal-to-noise ratio changes.

  Navy Response: Figure 3-1 is presented to show the relative detection performance of EMI vs Total Magnetic Field (thus the conversion to SNR for comparison). The detection threshold shown on Figure 3-5 assumes a noise level of 0.1 nT. The detection threshold will move up or down, depending upon the system/site noise characteristics. The following has been added to the last paragraph of Section 3.6 for clarification: "This detection threshold assumes system and site specific noise levels of 0.1 nanotesla (nT) (a reasonable assumption given the sensor noise levels are below 0.001 nT)."

- Figure 3-5 shows that a 37-mm projectile is not detectable on the ocean floor unless the sensor is at an altitude of less than 1.5 meters. This means that this MEC is highly unlikely to be detected. Please clarify how this affects the results of the WAA project.

  Navy Response: The total magnetic field response will vary depending upon the orientation of the object relative to the Earth's magnetic field. Figure 3-5 shows the 'minimum response' indicating that the object would be reliably detected when the offset distance is less than 1.5 m. This does not imply that the object would be 'highly unlikely' to be detected at distances greater than 1.5 m; it means that not all 37 mm would be detected. Because the WAA is being performed to find EADAs, the fact that not all 37 mm targets will be detected is not critical.

  The following text has been added to the last paragraph of Section 3.6 for clarification: "Depending upon the aspect ratio of the object, its orientation with respect to the Earth's magnetic field will have a large effect on the magnitude of the total magnetic field response. Where a sphere will produce a response that does not vary with orientation of the Earth's field, an object like a 37mm projectile will produce a maximum response (oriented parallel the Earth's field) that is more than double its minimum response (oriented normal to the Earth's field)."

  PREQB Evaluation of Response: The response to the comment in the second bullet restates the quote from Comment 40. This issue of the constantly varying detection capability of the underwater WAA survey has not been adequately addressed.

  Navy Response to Evaluation: See response to Comment 1 (original General Comment 3) above.

- Please clarify how the response amplitudes shown in Figure 3-5 relate to the operational requirements for determining whether or not the data is adequate as shown in the MPC in Table 3-4. The MPC requires response amplitudes to be between 20,000 nT and 70,000 nT while the amplitude scale on

Figure 3-5 goes from 0.1 nT to 100 nT. Please explain the widely different expected response amplitude ranges provided for the magnetometer data.

Navy Response: The raw total magnetic field measurements are within the range of 20,000 nT to 70,000 nT. – values outside of this range indicate a fault of some kind. Figure 3-5 shows the anomalous response amplitudes for a set of ordnance types.

The raw data are 'leveled' to remove the background using a de-median filter. This results in a final data channel that sits at zero (plus/minus noise) unless an anomaly is detected. The following text has been added to Section 3.5.1 for clarification: "A set of site-specific filters are used to isolate the target responses by removing unwanted 'background' signal (geology, diurnal variations and sensor heading effects) resulting in a 'leveled' data set where the data are essentially at 'zero' unless there is an anomalous response due to a proximal ferrous object."

- Please clarify what the smallest MEC is that is likely to be reliably detected under this work plan at the maximum allowable sensor height of 2 meters.

  Navy Response: See responses to Page-specific Comments 40 and 41 above.

42. Figure 3-6: Please note that Cayo La Chiva is not included in this WAA WP, as it is unclear in this figure (i.e., use of double dashed lines).

    Navy Response: Figure 3-6 has been modified to remove the double-dashed line around Cayo La Chiva and replace it with a single-dashed line.

43. Section 4 on "reporting" consists of one three-sentence paragraph. Please provide more information on what information will be contained in the report.

    Navy Response: The discussion of the reporting effort has been moved to Section 3.7.4 and the text has been modified to state: "A UXO 16 WAA report will be developed following the completion of the field activities and submitted to the Vieques Environmental Restoration Program Technical Subcommittee for review. This report will include the following information:

    - An update to the CSM (as applicable)
    - Documentation of the technical investigation approach
    - Data collection/processing/analysis methods
    - Data quality evaluation
    - Results of the data analysis
    - Identify OUs and EADAs
    - Recommendations for future investigations and/or actions within UXO 16
    - Archives of the raw data and final processed data."

44. The map on Figure 3 of Appendix B shows colors that aren't described on the legend. It is understood that Appendix B is an already existing document and it may not be possible to modify it. If it can't be modified to explain the purpose of all of the colors used on this map, please include a statement in the work plan text describing what the different colors mean.

    Navy Response: The colors shown on Figure 3 of Appendix B are used to identify the different area of UXO 16, for example Northeast Area 3. The identifier for each colored area is included on the figure within each colored area.

Department of Natural and Environmental Resources Comments

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3	iv		Magnetc	3-5: fix spelling of "Magnetc"	The spelling error has been fixed.
4	v		CSM	CSM: fix spelling of "mode"	The spelling error has been fixed.
8	1-3	1.1.2	Other Offshore Areas subsection	Local dive shop operators and scuba fishers should be interviewed regarding their knowledge of other areas of concern, as a check on the completeness of the survey area proposed. Attn: Carlos Ventura (Fishing Association President), Mr. Zenon (Another Fishing Association President), and Blackbeard Sports (dive shop). If this was done earlier, it should be updated. **PRDNER Technical Evaluation of Response to Comment**: It is DNER's understanding and observations from early 2015 that UXO/MEC may occur outside the current UXO 16 boundary. Further, the Agency understands that, pursuant to CERCLA, the "boundary" itself is based on the presence of contaminants of concern, rather than a static geographic boundary. This is especially important in underwater areas where transport of contaminants/contaminated materials is common. Based on the March 2015 CTC meeting in New York, it is understood that the Navy will redefine the "boundary" of the WAA based on likelihood of encountering UXO/MEC/MPPEH/RRD/etc. PRDNER looks	The UXO 16 site boundary was designated in the National Priorities List (NPL) listing (Federal Register, Vol. 69, No. 156, August 13, 2004) via reference to a letter from the Commonwealth of Puerto Rico (May 26, 2004) summarizing consensus on the "Agreed Area" by representatives of, among others, the Navy, EPA, and Commonwealth of Puerto Rico. As such, this will be the boundary for the WAA. It should be noted that the WAA is an initial reconnaissance to guide future investigations at UXO 16. The need for characterization beyond the UXO 16 boundary will be based on the findings of the WAA and, potentially, subsequent investigations. This information has been added to Section 1.1.2. **Navy Response to Evaluation Comment:** There is no known information that indicates there were targets outside the current UXO 16 boundary. As stated in the original response, the WAA included in this Work Plan will be conducted within the current UXO 16 boundary. However, it is recognized that adjustments to the boundary may be warranted based on the findings of the WAA or

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				forward to Navy's submission of a revised WAA boundary for UXO 16 based on a conceptual site plan/WAA study design which contemplates actual or potential UXO/MEC/MPPEH/RRD/etc. which lie outside the current UXO 16 boundary delineation. **DNER Technical Evaluation of Navy Response (June 5, 2015):** In the interest of timely progress on the UXO 16 WAA, DNER agrees with proceeding with the proposed field survey work, as scheduled. DNER recognizes that the WAA is not the RI for UXO 16, and that a more thorough investigation of UXO/MEC/MPPEH/RD/etc. shall occur during the UXO 16 RI, as warranted. However, the following additional/concurrent actions should be added to the WAA Work Plan: 1. Concurrent archival records survey of all known records that may address the presence/absence of UXO/MEC/MPPEH/RD/etc. in Vieques coastal waters that lie both inside and outside of the WAA study area. The results of this archival records search should be included in the WAA findings report along with the results of the WAA field survey. These archival findings also may result in revisions to the Preliminary	other information identified that suggests the need to investigate beyond that boundary. Upon completion of the WAA within the existing UXO 16 boundary, a report will be produced that provides the findings and recommendations for additional investigation, potentially including areas outside of the existing UXO 16 boundary.

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				Assessment/Site Inspection report (PA/SI) report as well. **Navy Response:** To the extent practical, additional archival records will be evaluated and included with the WAA findings. This information has been added to the WAA Work Plan. 2. As a component of the archival records survey, DNER, again, requests Navy to interview local dive shop operators and scuba fishers and others regarding their knowledge of underwater areas of concern to identify submerged areas of concern both inside and outside the current UXO 16 boundary within Vieques coastal waters. Recommended local contacts include (but are not limited to): Carlos Ventura (Fishing Association President), Mr. Zenon (Another Fishing Association President), and Blackbeard Sports (dive shop). The results of these interviews should be added to the WAA findings report and, possibly, result in revisions to the PA/SI report for UXO 16 as well.	

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				Navy Response: The historical information survey will be focused on archival records. Additional, credible information identified and provided by other agencies will be considered. 3. The WAA Work Plan should add a section to the document which – in detail – provides the theoretical basis for the current UXO 16 boundaries (i.e., above and beyond the statement that this is what was negotiated between Navy and the regulators) – in other words, what was the actual reason for siting/positioning these boundaries as they (currently) are. **Navy Response:** The basis for the shape/area of UXO 16 is provided in Section 1.1.2 of the WAA Work Plan.	
8	1-3	1.1.2	Cayo La Chiva (UXO 18) is a 12-acre island located south of the EMA (**Figure 1-2**). No historical training activities are documented for UXO 18; however, fired 5-inch rockets were identified both on and offshore of Cayo La Chiva	Operation Portrex was a training operation in early 1950 that involved Cayo La Chiva (i.e., a machine gun nest) – see accompanying documentation. This should be referenced in the Cayo La Chiva discussion in Section 1.1.2.	The following text has been added to Section 1.1.2 for clarification: "A simulated machine gun nest was located on Cayo La Chiva during Operation Portrex conducted in 1950 (Sibert 1993)."

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13	N/A	Figure 1-2	N/A	Besides the former OB/OD area off of SWMU 4 and Mosquito Pier, has there been any preliminary reconnaissance to determine whether or not the offshore area of the NASD has MEC/MPPEH/MD/RRD on the seafloor (especially, near the eastern boundary of the NASD)? If so, what were the results of those surveys? If not, then why not? In other words, what is the basis for excluding the western portion of offshore Vieques from UXO 16? Prevailing east to west winds, waves and (to a lesser extent) currents may have transported munitions westward. Accordingly, stopping surveys at the western VNTR border may be premature, requiring underwater survey data to support the delineation of the western border of UXO 16 on (especially) the north side of the island, and, possibly, the south side of Vieques, too.	No additional reconnaissance activities have been performed offshore of the NASD area. Please see the response to DNER's first comment on Work Plan PDF Page # 8.
20	2-3	2.3	Munitions in unconsolidated sediment areas is expected to migrate in the direction of the waves; tidal and general circulation currents are less predominant transport mechanisms around Vieques.	Change to: "Munitions in unconsolidated sediment areas **are**…"	The text in Section 2.3 has been modified as requested.
21	2-4	2.4	Multiple species of corals, aquatic mammals, sea turtles, and seabirds in the vicinity of Vieques are currently protected under the	"…aquatic mammals, sea turtles, **fish**, and …" **PRDNER Technical Evaluation of Response to Comment**: It is known that several T&E fish species occur in nearshore waters of Vieques	Fish have been excluded from this statement because there are no threatened or endangered fish species within the project area.

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			Endangered Species Act (ESA) and analogous territorial Acts.	(i.e., within UXO 16), including: Nassau Grouper should be added to this of ESA species. Further, DNER Regulation 6766 includes Epinephelus striatus (Nassau Grouper) as Endangered. Ojeda (2007) lists two potential Spawning Aggregation Sites (SPAGs) for eastern Vieques for Nassau Grouper. Spawning aggregation sites are where the adult spawners may come from 10 miles or more distance to congregate for spawning purposes for a few days each year. Thus, when not spawning, these endangered fish may be found almost anywhere in the vicinity of Vieques. SPAG activity for Nassau grouper seems to peak around January, but has been documented during several other months of the year. It appears to be least common from April to July. Also, Sphyrna lewini, the scalloped hammerhead shark, was recently listed by NOAA Fisheries, and its range includes PR and Vieques. While not threatened or endangered per se, a note in the UXO WAA WP about seahorses would be good as well. **DNER Technical Evaluation of Navy Response (June 5, 2015):** DNER concurs with Navy response.	**Navy Response to Evaluation Comment:** In Section 2.4, the last sentence has been updated to include fish, as follows: "Multiple species of corals, aquatic mammals, sea turtles, fish, and seabirds in the vicinity of Vieques are currently protected (or proposed) under the Endangered Species Act (ESA) and analogous territorial Acts." Section 2.4 describes the conceptual site model and is intended only to generally describe the groups of protected species; therefore, it is not necessary to list specific species of fish in this section. However, it is recognized that NOAA has listed the scalloped hammerhead shark (central and southwest Atlantic distinct population segment) as threatened, and has proposed the Nassau grouper as a threatened species. In addition, DNER has identified seahorses (*Hippocampus* spp.) as vulnerable.
22		Figure 2-1		Question: Is there an inventory of shell craters along the shores of the SIA and LIA? Why is there no illustration of activity by submarines? Did submarines fire practice (or live) torpedoes? If so, where?	No inventory of shell craters along the shores of the LIA/SIA has been performed. There is no site documentation indicating that submarines fired upon the LIA/SIA, which is why submarines are not included on Figure 2-1.

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25		Figure 2-4		What about checking a corridor between the NW anchorage area and mosquito pier given the high use of this area by ships?	Please see the response to DNER's first comment on Work Plan PDF Page # 8.
27		Figure 2-6		Questions: 1. Are there any UW photos of the anchor zones? 2. The anchor area by Mosquito Pier is labeled on nautical chart as "Explosive anchorage area" "wire dragged to 38." However, it appears as seagrass in Fig. 2-6. Please explain what "wire dragged" means. Did this technique remove seagrass? If so, what area was impacted?	There are no underwater photos of the anchorage areas. The following text has been added to Section 1.1.2 for clarification: "The NOAA nautical chart indicates that wire dragging had been performed in some of the anchorage areas. Wire dragging refers to the practice of hanging a wire at a specific depth between two vessels. The wire is then dragged between two points to identify submerged rocks or other obstructions. Wire dragging would be performed to ensure that ships could safely navigate in those areas and avoid obstructions. This historical practice will not affect the planned WAA activities." Seagrass would not be affected by wire dragging at 38 feet.
33	3-2	3.5.2	Additionally, the peaks of the positive and negative responses are spatially offset from the position of the source object	Please explain what this means in the present context. This seems to imply implicit error in locating the source object.	The following has been added to Section 3.5.2 following the text that describes the peaks of positive and negative responses: "In other words, the analytic signal will be used to locate the anomalies instead of utilizing the positive and negative responses due to the spatial offset. By utilizing analytic signal, the location of each object will be accurately identified."
34	3-3			Clarify if EADA or RRD would include sunken Navy vessels (e.g., U.S.S. Killen), anchors, lines, chains, cargo nets, targets, barrels or other items that could be identified as potential	All ferrous responses (including sunken vessels, anchors, chains, etc.) will be used in the target density calculations. The WAA is designed to find EADAs that are "possible concentrations

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				sources of contaminants or environmental damage.	of targets of interest." The composition of the EADAs will be determined through follow-on investigations. The following text has been added to Section 3.5.2 for clarification: "The spatial distribution of all of the detected anomalies will be examined to identify EADAs and thus potential areas requiring detailed investigations."
34	3-3	3.6	Visual Sample Plan (VSP) was used to confirm that 100 m line spacing would detect all 250 m diameter (125m radius) areas with an elevated anomaly density of 25 targets/acre above a background of 5 targets per acre	State why a 250 m diameter was assumed for VSP calculation purposes. Also, state how and why 25 targets/acre was chosen as a standard for detection?	The following text has been added to Section 3.6 for clarification: "Without prior knowledge of the target densities, these initial estimates were used to create a conservative line spacing. It is important to note that these estimates are not actionable thresholds and will not be used as a basis for identification of elevated anomaly density areas – they are only used as starting estimates for the sole purpose of deriving a conservative line spacing. Also, although a 'bivariate' density distribution was used, a normal distribution was found to give essentially the same results (Pd = 1.00 vs .993 respectively). The actual shape of an EADA is not predictable due to the myriad of factors affecting the final resting positions of TOI. However, the actual shape of an EADA does not need to be circular for the statistics obtained with a circular assumption to be valid. The circle is just used to estimate the smallest dimension of an EADA. By using a 250 m circle as the input, the implication is that 250 m is the minimum size in any direction that will be detected with a probability of close to 100% (i.e. any area that has a minimum

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					dimension of 250 m or greater will be detected)."
34	3-3	3.6	Due to the suspected presence of MEC as well as sensitive benthic habitats, the DGM system will not intentionally make contact with the sea floor	Very good.	
35	3-4	3.7.2	The survey is not anticipated to be conducted in water depths shallower than 4-6 ft.	We believe there is a high likelihood of MEC/MPPEH/MD/RRD in these shallow areas. Accordingly, how will nearshore, subtidal (<4-6 ft) surveys be conducted?	The following text has been added to Section 3.7.3 for clarification, "As with the side-scan sonar survey, the nearshore areas will not be accessible due to the WAA equipment configuration. Investigation of nearshore areas will be evaluated for future investigations."
37	3-6	3.7.3	Once QC inspection of all geophysical data has been performed, the data will be evaluated to determine the potential presence of EADAs that my represent areas…	Change "my" to "may"	The text has been modified as requested.
N/A	N/A	N/A	N/A	It appears that follow-up intrusive investigations of identified EADAs will not occur as part of the WAA. Is this correct? If so, state in the Work Plan that no invasive investigations are planned during this phase of work, and the schedule for such investigations are planned in the future, if known.	As described in Sections 1.3.1 and 1.3.2, the WAA includes only the DGM effort, the results of which will be used to identify EADAs and provide recommendations for additional investigations. The dates of additional investigation activities following the WAA are not yet known.
N/A	N/A	N/A	N/A	Has an underwater archaeological survey been performed within UXO-16? How will WAA and subsequent intrusive investigations	No underwater archaeological survey has been performed within UXO 16. Contact with the seafloor and obstructions will be avoided during the WAA using the side-scan sonar

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				contemplate archaeological investigation findings?	survey results. If contact with the bottom is anticipated in future investigation, the State Historic Preservation Office (SHPO) will be contacted to determine any necessary activities associated with the planned studies.
N/A	N/A	N/A	N/A	Since MEC/MPPEH/MD/RRD moves with storms to low areas and channels, how are blow holes and bomb craters in seagrasses surveyed? Similarly, how are any other areas where there is ≥1 m change in vertical height surveyed? This may be a real issue with coral reefs with substantive topography (rugosity)	As noted above and described in Sections 1.3.1 and 1.3.2, the WAA includes only the DGM effort, the results of which will be used to identify EADAs and provide recommendations for additional investigations. Investigation of areas such as those included in the comment would be considered at that time.
N/A	N/A	N/A	N/A	The anchor area off the west coast and the one by Arrecife Mosquito were also apparently "wire dragged." What was the purpose and effect of this?	Please see the response to the DNER comment on Work Plan PDF Page # 27.
N/A	N/A	N/A	N/A	Were all concrete practice mines recovered after exercises? If not, will they be identified as RRD or EADA? Where were they dropped? Please add to Fig. 2-1.	It is unlikely that all concrete practice mines were recovered at the site. The location of any remaining practice mines is not known. Because the practice mines include ferrous material, the mines may be detected during the WAA.
39-40	3-8 to 3-9	Table 3-4	N/A	The DFOW "DGM Data Evaluation and Documentation" listed in Table 3-5 (page 3-11) also should be added to Table 3-4 (Measurements of Performance Criteria) in order to describe for this DFOW: Measurement Performance Criterion, Activity to Assess Measurement Performance and Failure Response.	Measurements of Performance Criteria have been added to Table 3-4 as requested.

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N/A	N/A	N/A	N/A	Are pre-placed "spikes" (i.e., pre-placed metal objects to test the accuracy of the magnetometers in the field) – both on and in the seafloor - planned to be deployed to determine performance of magnetometers? If not, how will the ability of a magnetometer to pick up anomalies be adequately assessed? This QA/QC practice of using pre-placed spikes is commonly used by the USACE for underwater MEC operations off Culebra.	Blind seeding (preplaced spikes) is unreliable (and therefore unwarranted) for marine transect surveys. Unlike 100% coverage detection surveys, the logistics of emplacing seeds where they will be reliably surveyed when only 4% to 6% of the survey region would require considerable rework and would not materially affect the survey results. The QC metrics in place are sufficient to ensure the survey goals are met.
62	B-3	Attach B		"Summary of Results" – SSS mapped several known wrecks and sunken boats. DNER is interested in the locations. **PRDNER Technical Evaluation of Response to Comment:** It is understandable that avoiding those benthic areas within UXO 16 where the vertical change is >1 meter may help to protect coral reef areas during surveys. However, would large objects (e.g., sunken ships) also yield a >1 meter change during SSS surveys, potentially resulting in future WAA surveys avoiding areas with large objects such as sunken ships? In other words, how were the SSS data interpreted such that large anthropogenic objects will be included in the WAA and sensitive natural resources avoided during the WAA?	The SSS survey was performed to evaluate locations with a 1-meter or more vertical change on the seafloor, so that those locations could be avoided during the WAA. The SSS survey data were not evaluated in such detail to identify sunken ships. **Navy Response to Evaluation Comment:** The following text was added to Section 1.2.7 for clarification: "The limitations to the investigation with respect to survey altitude (or other avoidance measures) imposed by obstructions such as sunken ships are the same as those posed by coral reefs. In addition the magnetic signature of the ships will essentially mask any smaller targets in close proximity to the ships. However, the relatively small gaps in coverage imposed by the spatial extent of these ships will not adversely affect the survey results, and the regions in close proximity to

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				DNER Technical Evaluation of Navy Response (June 5, 2015): DNER concurs with Navy response.	these ships will be considered for follow on, focused investigations as warranted."

The waters surrounding Vieques Island harbor suitable habitat for the federally listed Antillean manatee *(Trichechus manatus manatus)* and sea turtles (Hawskbill-*Eretmochelys imbricate,* Green- *Chelonia mydas,* Leatherback- *Dermochelys coriacea*). Please contact NOAA Fisheries Caribbean Field Office regarding possible effects on sea turtles in the waters and fisheries habitat.

The proposed action requires the use of a powerboat vessel while towing a vessel/platform with the DGM equipment. The information submitted in the Work Plan does not include any specific measures to avoid potential impacts to these species. In addition, the size and speed of the towing vessel and the vessel/platform were not described nor does it mention how many vessels would be associated with the proposed action. We recommend that the Navy include and follow in the Work Plan avoidance and minimization measures to prevent any potential collision with manatees and sea turtles.

For example, the Navy should consider the use of certified observers in order to detect manatees that may be in the path of the vessel and the towed array. This is particularly important in shallow waters with sea grass beds that harbor suitable feeding and resting habitat for both manatees and sea turtles. In addition, we recommend that all manatee and sea turtle sightings should be GPS recorded and provided as part of a final project report.

Navy Response: National Marine Fisheries Services has been contacted to ensure appropriate protocol for protection of listed species is implemented. Based on this, Appendix D (Standard Operating Procedures for Protection of Federally-Listed Species and Habitat) has been added to the Work Plan to detail procedures for the protection of endangered species during the UXO 16 WAA.

USFWS Evaluation Comment to General Comment #1: The Navy states that they have included the Standard Operating Procedure (SOP) for the Protection of Federally-Listed Species and Habitat as Appendix D. Please make sure that this SOP incorporates the recommendations made concerning the Antillean manatee in the FWS comments. The SOP should be provided to FWS for review.

Navy Response to Evaluation: The SOP entitled "Standard Operating Procedures for Protection of Federally Listed Species and Sensitive Habitat, UXO 16 Wide Area Assessment," includes avoidance measures for preventing collisions with manatees, and proper documentation of all manatee sightings. This SOP is attached for review.

Comments on Specific Sections

Acronyms and Abbreviations, page v: Please add ISO, PDF, QA, and FTP to the list.

Navy Response: The text has been modified to include these acronyms in the Acronyms and Abbreviations list.

Section 1, Introduction, page 1-1: Although it is noted in Section 1.3.1 and again in Section 3.6, it is suggested that this introductory text specifically describe the data analysis and step-down process that will be used to delineate operable units and design the more site-specific and focused investigations that will follow the Wide Area Assessment.

Navy Response: Section 1 has been modified to include the following, "The objectives of the WAA are to characterize sea floor conditions including obstructions, bathymetry, ecological regimes, and endangered species; identify and evaluate the anomaly density and lateral extent of EADAs within UXO 16; and provide recommendations for additional investigations and possible munitions response actions at UXO 16."

Section 1.2, Previous Investigations, page 1-4 and Figure 1-4: Please revise the document and/or the labels on Figure 1-4 to more clearly reflect the studies cited in the text. It is suggested that the labels on Figure 1-4 be changed to match the literature citations in the text.

Navy Response: Figure 1-4 and Section 1.2 have been modified to be more consistent with one another.

Section 1.2.5, Underwater UXO Mobility Modeling, page 1-5: The text indicated that the mobility of munitions items in Bahia Salinas and Bahia Salina del Sur were modeled using the UXO Mobility Model for Reef-Type Range Environments. The results indicate that, over a 30-year period, most of the munitions items would have migrated from the reef platform to adjacent sand channels and have become completely buried. If this is the case, the document should discuss the effect of this on the ability to detect elevated anomaly density areas and how these results will be used to interpret data and make decisions regarding future investigations.

Navy Response: Detection is a function of distance between the sensor and the targets of interest. Buried targets can be detected as long as they are within the distances discussed. The following text has been added to Section 3.6 for clarification: "The proposed technology will detect targets buried in the sediment as well as on the seafloor."

Section 1.2.7, Bathymetry Side Scan Sonar Survey, page 1-5: Please specify the horizontal distance over which the 1-meter vertical change in seafloor elevation was noted.

Navy Response: As described in Section 1.2.7, a 1-meter vertical change in the sea floor elevation was observed at 1,622 locations throughout the investigation area, which were identified as potential obstructions. The dimensions (horizontal distance) of each potential obstruction are different. For this reason, dimensions of each potential obstruction are not included in the Work Plan. The side scan sonar data will be used when selecting the transect locations for the field effort.

Section 2, Conceptual Site Model, page 2-1: While the Wide Area Assessment is primarily aimed at the detection of elevated anomaly density areas and secondarily at characterizing the benthic habitat, the conceptual site model should include mention of munitions constituents.

Navy Response: The following text has been added to Section 2.1, "MC may be/may have been released into the marine environment due to historical site activities. However, studies indicate that any impact from MC is localized to the area immediately at and adjacent to munitions (USACE, 2013)."

Section 2.2, Physical Characteristics, page 2-1 through 2-3: This section describes the physical environment of UXO-16 and potential UXO transport mechanisms. Section 1.1.2 describes the designation of UXO-16 by the Navy, EPA, PREQB, and DOI as an "Agreed Area" that was determined on the basis of anchorage areas, activities at Mosquito Pier, OB/OD actions and firing range explosive safety arcs and artillery fans. The document should indicate here and/or in Section 3.6 how/if the Wide Area Assessment will account for the potential migration of munition items outside of the current UXO-16 boundary. This is particularly important since munition debris has been located outside of the boundary.

Navy Response: The UXO 16 site boundary was designated in the National Priorities List (NPL) listing (Federal Register, Vol. 69, No. 156, August 13, 2004) via reference to a letter from the Commonwealth of Puerto Rico (May 26, 2004) summarizing consensus on the "Agreed Area" by representatives of, among others, the Navy, EPA, and Commonwealth of Puerto Rico. As such, this will be the boundary for the WAA. It should be noted that the WAA is an initial reconnaissance to guide future investigations at UXO 16. The need for characterization beyond the UXO 16 boundary will be based on the findings of the WAA and, potentially, subsequent investigations. This information has been added to Section 1.1.2.

Section 2.2.2, Bathymetry, page 2-2 and Figure 2-3: Please label the Escollo de Arenas as a sand and gravel shoal on Figure 2-3.

Navy Response: Figure 2-3 has been modified to identify Escolle de Arenas as a sand and gravel shoal.

Section 2.2.4, Currents, page 2-3: The location of the Vieques Passage should be identified on the appropriate figures (suggest Figure 1-1).

Navy Response: Figure 1-1 has been modified to identify the Vieques Passage.

Figure 2-4 and 2-5: These figures have what appear to be depth contours in the off shore areas. Please label them appropriately.

Navy Response: Figures 2-4 and 2-5 have been modified to remove the lines that were not essential to showing the coral cover extent. The lines were associated with the non-coral cover features and those features are still shown in Figures 2-6 and 2-7.

Section 3.1, Technology Description, page 3-1: The first paragraph includes a list of potential technologies available for this investigation and digital geophysical mapping was selected as the most appropriate. However the other technologies are likely to be selected and used for future site-specific investigations and this should be mentioned in the second paragraph of this section.

The term total field magnetrometry should be described.

Navy Response: The following text has been added to Section 3.1: "Visual surveys and/or acoustic techniques may be considered for future OU-specific investigations at UXO 16." Additionally, a description of total field magnetrometry is included in the following modified text: "Because the required water depth of investigation is as deep as approximately 80 ft, use of total field magnetometry (i.e., DGM using total magnetic field sensors to map the localized distortions, or 'anomalies,' in the earth's magnetic field caused by discrete ferrous objects) is selected to minimize the impact of the sensor altitude."

Section 3.5, Ancillary Sensors, page 3-2: Please indicate that the video imagery will be georeferenced and keyed to the positioning/navigation system.

Navy Response: The following text has been added to Section 3.4: "The imagery will be georeferenced and/or time stamped to facilitate mapping of identified features."

Section 3.5, Data Processing and Analysis, page 3-2: It would be useful to specifically mention that the targets identified through data processing and analyses are areas that will likely require additional investigation.

Navy Response: The following text has been added to Section 3.5.2: "The spatial distribution of the anomalies will be examined to identify EADAs and thus potential OUs requiring detailed investigations." Additionally a more detailed description of the data evaluation process has been added to this section.

Table 3-4, Measurement Performance Criteria, pages 3-8 and 3-9: In a number of instances, the presumptive corrective action is the rejection of data affected by the failure and/or the repair/replacement of equipment, whereas in other instances, the presumptive corrective action is the recollection of data affected by the failure. It is unclear why the recollection of affected data is not part of the presumptive corrective action in all instances where performance criteria are not met.

Navy Response: Text within Table 3-4 has been modified to explicitly state that data affected by failure will be recollected.

Table 3-5, Definable Features of Work Auditing Procedure, page 3-11: The "Action if Failure Occurs" cell for the subcontractor procurement task appears to be described in two cells. Please edit the table to include the two actions in one cell.

The text in the "Pass/Fail Criteria" cell for the geophysical survey (towed array) task appears to be missing text. Please edit accordingly.

The "Action if Failure Occurs" cell for the demobilization from the site task indicates that the site will be restored to preconstruction condition. It is assumed that this includes restoration of the aquatic habitat should damage occur.

Navy Response: The subcontractor procurement task within Table 3-5 has been reformatted to address this comment. Additionally, the geophysical survey text within Table 3-5 has been modified to state: "DGM activities are being performed in accordance with this WP and associated SOPs." Appendix D (Standard Operating Procedures for Protection of Federally-Listed Species and Habitat) has been added to the Work Plan to detail procedures for the protection of endangered species during the UXO 16 WAA.

Figure 3-2, Positioning Sensor Schemes: It would be useful if the horizontal cable distance between the survey vessel and the towed array is specified on the figure.

It is not clear what the diagram in the lower right portion of Figure 3-2 depicting. It is suggested that this be described in the text.

Navy Response: The horizontal cable distance is not a fixed value – it varies with depth for both geometry positioning and USBL positioning. The cable length is not critical for the USBL positioned system. For the geometry positioning, a cable length example of 15m is shown using a combination of tow angle sensors, depth sensors and vessel/platform attitude sensors.

The following text has been added to Section 3.3 for clarification: "The top figure depicts a system positioned using USBL and the bottom figures show a side view (left) and plan view (right) of the geometry involved using combinations of tow angle sensors, depth sensors and vessel/platform attitude sensors."

Appendix A, Figures 1 through 3: The boundary of UXO-16 is depicted in green on Figures 1 through 3 whereas the text indicated the boundary is shown in red. Please correct.

Navy Response: Appendix A, Figures 1 through 3, have been modified to shown the UXO 16 boundary in red.

Appendix B, Figure 5: Figure 5 is really Figure 4. Please revise the figure and the corresponding text.

Navy Response: The Appendix B text has been modified to refer to "Figure 4" instead of "Figure 5."

Final Responses to NOAA Fisheries Comments on the Draft UXO 16 Wide Area Assessment Work Plan to assess the potential presence of munitions and explosives of concern offshore of the Former Naval Ammunition Support Detachment and the former Vieques Naval Training Range in Vieques, Puerto Rico.

After reviewing the document, I have the following comments and edits to address my concerns related to Endangered Species Act (ESA) resources:

1. Please clarify where the benthic habitat data that is in Figures 2-4 to 2-7 came from. The information in these figures does not appear to correspond to the results of other surveys, including the in-water area of SWMU 4 which has several colonized hard bottom and reef areas, some of which are dominated by recently listed corals. The benthic information in these figures also does not appear to correspond to what was mapped as part of the 2013 side scan sonar surveys, although these surveys appear to have been limited to specific areas around Vieques.

   Navy Response: The sources of the data presented in Figures 2-4 through 2-7 have been added as notes in the figures.

2. Specify the water depths where surveys will be performed. Page 3-4 states that it is not anticipated that work will be conducted in water depths shallower than 4-6 feet, but this is not the same as specifying depths where equipment will operate versus where it won't and why.

   Navy Response: The following sentence has been added to the end of the first paragraph in Section 3.6: "The water depths where the survey will occur range from several feet to approximately 80 feet, the deepest depth within the UXO 16 boundary. Due to practical limitations of equipment access and the need to maintain the array off the seafloor to avoid contacting potential munitions, ESA-listed coral species, and other obstructions, it may not be possible to survey all areas. Additional detail is provided in the remainder of this subsection."

3. States that a video system will be used to collect imagery to provide information regarding potential targets. Suggest ensuring that imagery be collected to enable an identification of the coral species in the area around and on the target using high quality video and still photos. This will facilitate the assessment of options for further investigation and removal and potential impacts to ESA-listed species.

   Navy Response: This survey is being conducted by towing an array through the water along predetermined transects and as such is not conducive to the collection of high resolution still photos. Identification of coral species in the area around any particular target of interest, as suggested in the comment, will be more suited to the focused, follow-up investigations that will be planned upon evaluation of the data collected during the WAA.

4. It appears that the side scan sonar surveys were concentrated on areas with significant changes in relief. It also appears that the side scan sonar surveys did not map several near shore hard bottom areas within the area to be investigated. This means the areas containing corals, included ESA-listed corals, may not be included in project maps.

   Navy Response: SSS was conducted within the vast majority of the planned WAA survey area. However, for the few areas where it was not possible to collect SSS data, DGM surveys will not be conducted. To clarify, the third paragraph of Section 3.6 has been modified as follows:

   "Due to the suspected presence of munitions as well as sensitive benthic habitats, the DGM system will not intentionally make contact with the sea floor. In 2013, a SSS survey was performed to identify obstacles and

sensitive corals that the DGM survey must avoid (Figure 1-6 and Appendix A). The nominal line spacing of 330 ft (100 m) will be modified as required to avoid items identified from this survey. Figure 3-6 presents the conceptual survey design and transect spacing for the UXO 16 WAA.

The subcontractor will utilize the previously collected SSS data to identify obstacles and sensitive habitats when establishing transects and programming, as applicable, into the vessel navigation system prior to commencing the survey. Any area without SSS coverage will not be surveyed by the DGM system. Additionally, procedures for protection of federally-listed species and habitat are detailed in Appendix D."

5. Figure 3-6 shows some transects over coral areas. Because the sensor altitudes will be between 3.3 and 6.6 feet, this could result in impacts to corals. Please clarify methodology including decisions regarding depths at which equipment will operate and areas where it will be operated.

   Navy Response: Please see the response to Comment 4. As discussed in Section 3.6, the target sensor altitudes and transect spacing will be adjusted to avoid potential obstacles, including ESA-listed corals.

6. Suggest that more detailed maps for smaller segments of the work area be developed and that these be included in the vessel navigation system prior to commencing any surveys to minimize possibility for accidental groundings or collisions with coral areas.

   Navy Response: Please see the response to Comment 4.

7. Suggest that avoidance and minimization measures to protect ESA resources, including swimming sea turtles and ESA-listed corals and elkhorn and staghorn critical habitat be developed as standard operating procedures (SOPs) to be included in the work plan and followed by those who will implement the plan in the field. SOPs have already been developed for other work done around Vieques and we also have examples from our coordination with the U.S. Army Corps of Engineers for their work within the Formerly Used Defense Site around Culebra Island and many of the surrounding islands and cays.

   Navy Response: Please see Appendix D that contains the SOP for protection of the species cited in the comment.

Final Responses to National Oceanic and Atmospheric Administration (NOAA) Comments on the Wide Area Assessment Work Plan

Background

The Draft UXO 16 Wide Area Assessment (WAA) Work Plan provides details on the activities proposed by the Navy to identify elevated anomaly density areas (EADAs) that may represent areas impacted by munitions using underwater digital geophysical mapping (DGM), and to determine the relative density distribution across and between each EADA. The WAA is not intended as a full-scale study of the nature and extent of munitions and explosives of concern (MEC) or munitions constituent (MC) contamination; rather, the findings of the WAA will be used to aid in the decision making process for future investigations and munitions response actions, as applicable, for UXO 16. UXO 16 comprises the waters surrounding the former NASD and VNTR. As noted in the work plan, the underwater area adjacent to Cayo La Chiva, adjacent to the former OB/OD Area, and the underwater area adjacent to Mosquito Pier are part of separate investigations and are not included in the WAA.

As a supplement to the WAA Work Plan, a Technical Memorandum on Clarification of the Approach to WAA Survey at VNTR UXO 16 was also provided for review.

Comments

1. Page 1-1: Though it is noted in the Introduction that the results of the WAA will be used to guide future efforts, the work plan does not provide any details on how the data will be used. Some thought should be given to this in advance of conducting the surveys to avoid collecting data that will not be useful for future efforts planned.

   Navy Response: The following sentence has been added at the end of the second paragraph of Section 1: "By identifying where EADAs occur, and factoring this information into the conceptual site model, areas for detailed evaluation can be identified and prioritized." In addition, Section 3.5.2 has been modified to clarify how the anomaly detections are made as well as describe how the EADAs will be identified as follows: "The spatial distribution of all of the detected anomalies will be examined to identify EADAs and thus potential OUs requiring detailed investigations. This process will involve deriving density distribution maps (i.e., maps of anomalies/acre) and using Visual Sample Plan (VSP) to identify EADAs within the survey region. The appropriate VSP parameters used for this investigation will be based in part on the character of the anomaly density data. Background anomaly density will be derived from the survey data and, based upon this and the line spacing used, the supporting statistical basis for conclusions drawn from the survey results will be provided. For example, for a given minimum size and shape (e.g., 250m diameter circle) these data will allow determination of what density above background can be claimed to have been detected with close to 100% probability. Conversely, for a given anomaly density elevation above the background, the minimum size of area that was detected can be determined with close to 100% probability."

2. Page 1-3, Paragraph 5: The work plan notes the safety fans provide an estimate of the lateral extent of the potential MEC impact area extending from the ranges and artillery gun positions. On Page 1-5, Section 1.2.5, Underwater UXO Mobility Modeling, the work plan describes work completed to predict where munitions might have moved over a 30-year period. It is unclear whether the results of this modeling effort were incorporated into the selection of areas to be surveyed during the WAA.

   Navy Response: The modeling indicated the UXO surrogates may have migrated only a short distance (3 meters or less), into adjacent sand channels, which are within the planned study area. Field measurements using UXO surrogates confirmed the modeling results (surrogates migrated 4 meters or less). To clarify, the last sentence of Section 1.2.5 has been modified as follows: "The modeling results, issued in 2012, predicted

that over a 30-year period, UXO surrogates may remain stationary (in deeper, offshore areas) or migrate (in more in-shore areas) from the reef platform a maximum of only about 10 ft (3 m) into adjacent sand channels and, in some cases, become buried in sand. Field measurements using UXO surrogates confirmed the modeling results (surrogates remained stationary in deeper, offshore areas and migrated a maximum of about 13 ft [4 m] in the in-shore areas). These high density areas, as well as where the model predicted and field measurements confirmed munitions would migrate are within the planned WAA study area."

3. Page 1-4, Section 1.2.1, Side Scan Sonar Pilot Test and Underwater Magnetometer Survey: NOAA conducted a total of three UXO demonstration projects during November 2006 and June 2007. The work plan describes only the side scan and multibeam sonar work from 2006. I have attached a summary of the NOAA efforts to this memo for clarification.

   Navy Response: The information provided has been used to revise Section 1.2.1.

4. Figures 2-1 and 2-2: Nice graphics.

5. Page 2-2, Section 2.2.5, Benthic Habitats: The source of the data presented on the maps on Figures 2-4 through 2-7 should be identified.

   Navy Response: The sources of the data presented in Figures 2-4 through 2-7 have been added as notes in the figures.

6. Page 3-2, Section 3.2, Total Magnetic Field Sensors, Paragraph 2: The width of the swath surveyed for each single transect using the magnetometer array should be provided.

   Navy Response: The swath width will be dependent upon the geometry and configuration of the systems that are commercially available at the time of the survey, which will be determined once the contractor is identified. The following text has been added to Section 3.1 for clarification: "Details regarding final array geometry and positioning methodology that are specific to the commercial provider will be determined once a subcontractor is identified. The information will then be provided to the agencies."

7. Page 3-3, Section 3.6, Survey Design, Paragraph 2: The work plan notes that in 2009 a helicopter borne magnetometer array survey conducted identified a number of EADAs in the shallow, near shore areas of UXO 16 and that the smallest of these EADAs was approximately 250 m x 250 m. It is further noted that Visual Sample Plan (VSP) was used to confirm that 100 m line spacing would detect all 250 m diameter areas with an elevated anomaly density of 25 targets/acre above a background of 5 targets per acre. This was discussed at length during the October 2014 Vieques Technical Subcommittee Meeting and further detailed in the in the Clarification of Approach to WAA Survey at VNTR UXO 16 Technical Memorandum dated November 12, 2014. During the meeting, it was requested that additional details be provided regarding the input parameter assumptions for VSP and survey result usage. The memo clarifies that the VSP inputs for the assumed background anomaly density (5 anomalies/acre) and elevated target density (25 anomalies/acre) were selected to be conservative and that using the assumption of a bivariate vs a normal distribution resulted in essentially the same results. The memo does note that without prior knowledge of the target densities, the initial estimates were used to create conservative line spacing and further notes that they are only used as starting estimates for the sole purpose of deriving conservative line spacing. Still lacking are details on how the post-survey data will be analyzed to allow for conclusions to be drawn at the level of confidence predicted. The use of VSP for underwater surveys for munitions has been limited and certainly not used for an area as large as being proposed here. The challenge for its application to the underwater areas surrounding Vieques is that one can assume that even without prior knowledge on what the target densities are that they are not the same for all the underwater areas. It would have been useful to have conducted this more on a pilot scale level, perhaps for one of the bays north of the LIA initially, just to see how all the assumptions look post-survey data processing and even better would be a comparison of what the survey results from running transects along the 100 m line spacing vs. surveying 100% of the area look like. Logistically, it is acknowledged that this would likely be difficult to accomplish due to the costs of mobilizing the equipment and field crew for such an effort. That being said, it is recommended that the

Vieques Technical Subcommittee continue to work closely with the Navy on the details and sequencing of this survey effort as more of the specifics of the WAA are developed to allow for data to be collected and processed in a manner that will be the most valuable for this and future efforts.

Navy Response: The following text has been added to Section 3.6 for clarification: "Without prior knowledge of the target densities, these initial estimates were used to create a conservative line spacing. It is important to note that these estimates are not actionable thresholds and will not be used as a basis for identification of elevated anomaly density areas – they are only used as starting estimates for the sole purpose of deriving a conservative line spacing. Also, although a 'bivariate' density distribution was used, a normal distribution was found to give essentially the same results (Pd = 1.00 vs .993 respectively). The actual shape of an EADA is not predictable due to the myriad of factors affecting the final resting positions of TOI. However, the actual shape of an EADA does not need to be circular for the statistics obtained with a circular assumption to be valid. The circle is just used to estimate the smallest dimension of an EADA. By using a 250 m circle as the input, the implication is that 250 m is the minimum size in any direction that will be detected with a probability of close to 100% (i.e. any area that has a minimum dimension of 250 m or greater will be detected)."

8. Page 3-3, Section 3.6, Survey Design, Paragraph 4: The work plan should provide size/examples of what is considered to be a small or medium target.

   Navy Response: The fourth paragraph of Section 3.6 has been modified to add examples of small and medium targets as follows: "With an assumed detection threshold of 0.5 nT, small targets (37mm projectiles) lying on the surface of the seafloor can be detected at survey altitudes up to 1.5m and medium targets (75mm projectiles) on the seafloor will be detected at altitudes approaching 3m."

9. Page 3-5, Section 3.7.2, Data Collection, Paragraph 2: The work plan notes initial PDF maps of raw DGM results will be evaluated frequently to allow for a determination of whether data collected from the transects should be adjusted. The criteria that this decision will be based on should be provided.

   Navy response: This referenced text has been deleted as the 'evaluation' of data needed is associated with the measurement performance criteria presented in Table 3-4.

If you have any questions regarding these comments or need further assistance, please feel free to contact me at (240)338-3411 or at diane.wehner@noaa.gov.

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Vieques Underwater Unexploded Ordnance Demonstration Projects

November 2006

Background

The Vieques Underwater Unexploded Ordnance (UXO) Demonstration Project took place in November 2006, off the south eastern shore of Vieques Island, P.R. The land adjacent to the project area, Bahiá Salina del Sur, was used for many years as a military training ground. A variety of training exercises occurred throughout the region and many types of munitions were used and are known to have landed in the bay. The small bay area is approximately 3/4 of a mile square and water depths range from the shoreline to approximately 45 feet.

The goal of the project was to evaluate the use of an interdisciplinary approach to locate and identify UXO and related debris. The tool suite included sidescan- and multibeam sonar; a magnetometer, underwater photography and videography and SCUBA divers.

Methodology

Four individual surveys were carried out to identify locations of possible UXO. These surveys were: 1) a high resolution bathymetric survey using a multibeam sonar system; 2) a high resolution side scan sonar survey; 3) a magnetometer survey and finally; 4) a ground truth survey performed by an ROV with video camera and divers with still cameras.

Results

Many targets were selected from the bathymetry, sidescan sonar and magnetometer data sets. Of these targets 20 were investigated by remotely operated vehicle (ROV) video and 42 were investigated by divers equipped with a metal detector and camera. All targets were photographed from different view directions and positions, bottom type and associated habitats were documented.

Conclusions

The chosen approach is appropriate for rapid evaluation of UXO exposed on the seafloor. Many of the targets identified in the sonar records correlate well to those located in the underwater photography. Many of the UXO found were characterized by the presence of a grazing halo. The cause of the halo is likely the habitat created by the UXO's structure.

The bathymetry gridded at 5cm proved to be the most conclusive of the various data sets. In particular targets surrounded by a grazing halo were easily positively identified. The sidescan data set enabled the detection of more and smaller UXO, but also a larger number of misidentified targets.

The underwater photography provided many positive correlations to the selected targets. However, the analysis of underwater photography would greatly benefit from more diver-verified targets using higher accuracy underwater positioning.

In an exposed body of water such as Bahiá Salina del Sur, an Autonomous Underwater Vehicle (AUV) would be a preferable vehicle to an ROV due to the AUV's greater independence of sea-state.

June 2007

Background

The November 2006 Vieques Underwater UXO Demo Project proved that imaging UXO and related debris with sonar is an appropriate approach to rapidly assess UXO exposed on the seafloor adjacent to Vieques Island. The lessons learned from the first demo project led NOAA to the decision to use an Autonomous Underwater Vehicle (AUV) to cover a larger area of water in a shorter amount of time with few field personnel.

The June 2007 AUV project area was located north of Bahiá Icacos and Bahiá Salinas, and covered an area of approximately three square nautical miles. Water depths ranged from six feet to approximately 50 feet.

Methodology

NOAA used a REMUS 100 AUV to conduct a high resolution sidescan survey on the northern shores of the Live Impact Area. Hydrographers selected targets from the sidescan imagery and performed a ground truth survey using an ROV equipped with a video camera. The ROV video collection was performed from a locally hired dive boat and captain.

Results

Many targets were selected from the sidescan sonar data set. 25 of these targets were investigated by ROV video. All ground truth targets were imaged by the ROV from different view directions and positions, bottom type and associated habitats were documented.

Conclusions

The NOAA AUV team selected contacts that were identified in the sidescan sonar records that were not always clearly distinguishable as ordnance, coral, or rock. The team's built a catalog of images that can positively correlate side scan sonar imagery with the ROV video imagery. All positions, video, UXO type and approximate physical condition are in a NOAA maintained geographic information system.