

Introduction

Established during World War II, the Vieques Naval Installation was the premier training range of U.S. forces and NATO allies. For over half a century, more than 300,000 munitions were fired onto the land and into the surrounding waters to ensure the combat readiness of these militaries. Decommissioned between 2001 and 2003, the former installation was transferred to federal and local agencies, mostly for conservation as part of the Vieques National Wildlife Refuge with numerous areas identified for public recreational use.



Figure 1. The former Vieques Naval Installation is 23,000 acres, with another 12,000 acres of surrounding waters.

When the Commonwealth of Puerto Rico identified Vieques as its highest priority for cleanup, the 23,000-acre former installation and another 12,000 acres offshore were placed on the National Priorities List (NPL) in 2005 for cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Since that time, over 130,000 potentially explosive munitions have been eliminated, nearly 9 million munitions and munitions-related material have been removed from the former training ranges, and over 17 million pounds of this material has been recycled. The environmental restoration of Vieques remains the highest priority and the costliest project in the Navy's Munitions Response Program.

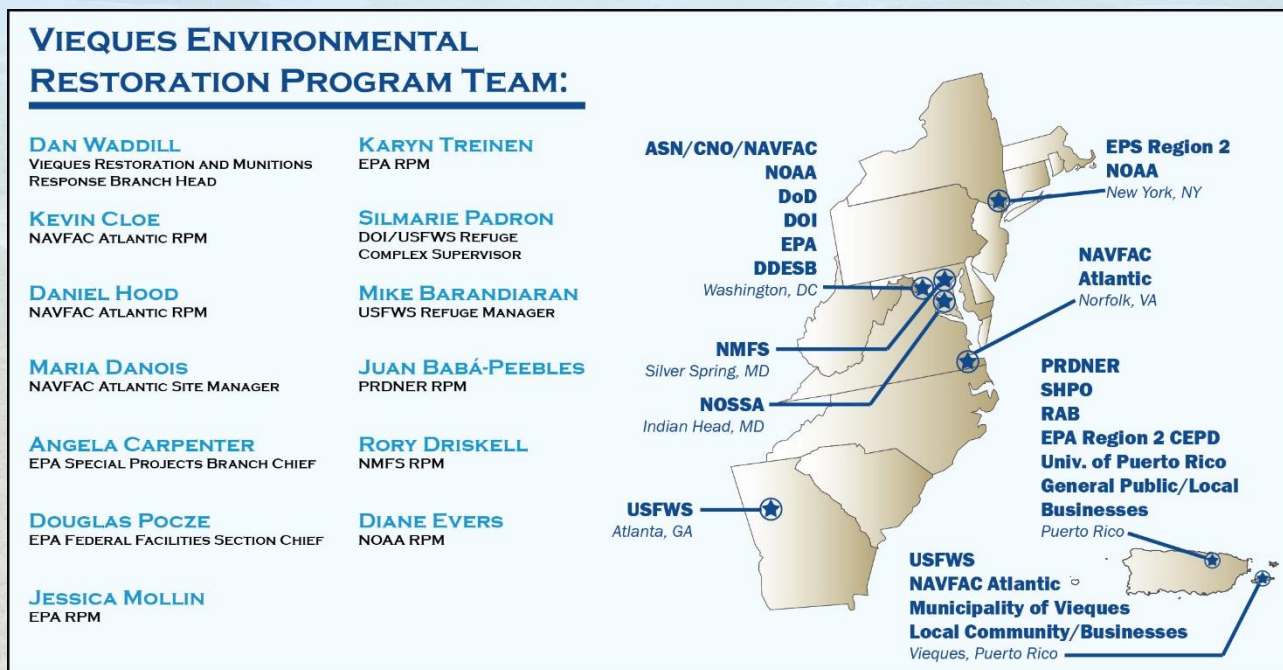


Figure 2. Due to unique regulatory, environmental, and natural and cultural resource conditions associated with Vieques, NAVFAC Atlantic teams with over a dozen Federal and Commonwealth agencies throughout the East Coast and Puerto Rico. To promote effective communications, the Vieques Environmental Restoration Program Team meets frequently among themselves and works closely with the many other stakeholders, including the local community, academia, and scientific organizations, to implement the cleanup program.

The refuge and surrounding waters host a variety of natural resources, including sensitive habitats such as mangroves, subtropical dry forests, lagoons, and reefs, and endangered species such as corals, sea turtles, manatees, and brown pelicans. As the cleanup progresses, areas are opened to the general public for recreation and for access to culturally significant sites.

Background

The potential presence of unexploded ordnance (UXO) and associated contaminants across approximately 35,000 acres of land and seafloor presents unique and complex challenges to environmental restoration of the former Vieques Naval Installation. These challenges are heightened by abundant ecologically and culturally sensitive resources, the island’s remote location, and the often-disparate objectives of numerous stakeholders, including the local community, educational and scientific organizations, and various advocacy groups. To meet these challenges, the Vieques Environmental Restoration Program Team comprises representatives from Naval Facilities Engineering Systems Command (NAVFAC) Atlantic, the Environmental Protection Agency (EPA), Puerto Rico Department of Natural and Environmental Resources (PRDNER), National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Department of Interior (DOI), and United States Fish and Wildlife Service (USFWS).

Team Purpose and Goals

The 2007 Federal Facilities Agreement (FFA) establishes the framework under CERCLA for the stakeholder agencies on the Vieques team to collaboratively implement the Environmental Restoration Program to achieve the following objectives:

- Develop safe, innovative, and cost-effective techniques to reduce risk
- Engage the local community to promote safety and public involvement in the cleanup process
- Apply sustainable approaches to preserve sensitive habitat and endangered species
- Partner with federal, commonwealth, and local authorities to return land to beneficial reuse as quickly as possible
- Support the DoD research community in developing and transferring new approaches to others

Summary of Accomplishments

Partnerships with Government, Academic, and Community Stakeholders to Enhance Safety, Protect the Environment, and Reduce Costs

Integrating Underwater Munitions Cleanup with U.S. Military Operational Readiness

There are approximately 12,000 offshore acres adjacent to the former Vieques Naval Installation where munitions lie on the seafloor as a result of a half century of short falls, overshoots, and seaward targeting. With 30 miles of coastline around the former training ranges, the nearshore area attracts beachgoers, swimmers, boaters, and anglers despite the presence of underwater munitions. As part of a multipronged approach to address this potential explosive safety situation, the Navy

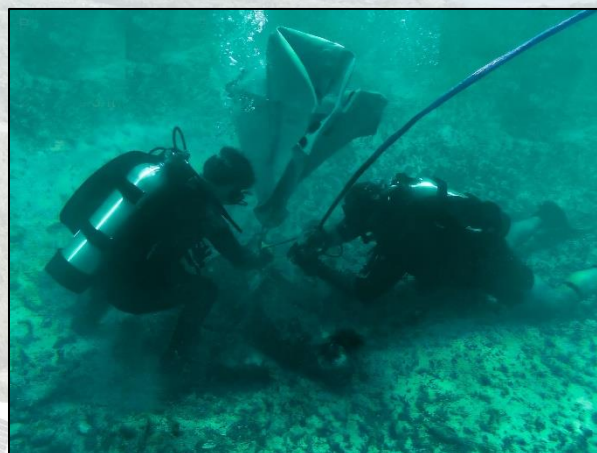


Figure 3. Active-duty EOD dive team removing a bomb from the seafloor in an innovative partnership with NAVFAC that is accelerating cleanup offshore of the former Vieques training ranges and enhancing U.S. Navy operational readiness.

initiated an expedited search and removal of munitions under CERCLA using contractor divers. In 2023, a pioneering integration of active-duty Navy underwater explosive ordnance disposal (EOD) Units into the Vieques offshore munitions cleanup was implemented. Approved by U.S. Fleet Forces Command, the Navy Expeditionary Combat Command provided three Navy EOD dive teams (two from the east coast and one from the west coast) to supplement the contractor divers in performing nearshore underwater munitions cleanup. This novel integration of active EOD into munitions cleanup was mutually beneficial. The Vieques munitions cleanup program realized nearly \$200,000 in savings and a doubling of productivity and the EOD dive teams enhanced their skills with ordnance locating and live munitions handling, which ultimately heightens the U.S. Navy’s operational readiness. The demonstrated success of the 2023 integration has led to a plan to continue this partnership into future years with additional EOD Units and expanded underwater areas.

Strengthening Community Involvement in the Cleanup Process and UXO Safety Awareness

An essential element of the Vieques Environmental Restoration Program is an effective community involvement program that proactively engages residents in the cleanup process and fosters munitions awareness and safety. Emerging from the restrictions established during the COVID pandemic, the Environmental Restoration Program Team renewed direct interaction with various sectors of the Vieques community to bolster involvement in the cleanup process and reinforce explosive safety awareness. In 2023, representatives from the Navy, EPA, PRDNER, and USFWS hosted a tour of areas within the former Vieques Naval Installation where public access is planned once cleanup is completed, including several beaches. Approximately 50 Vieques Restoration Advisory Board and other community members participated in the tour during which there was interactive discussion regarding the cleanup progress and specific plans for the areas.

While munitions cleanup remains the cornerstone of the Navy’s restoration program, community outreach is an essential element in protecting the Vieques community from explosive hazards in the former Navy training areas. In addition to using mechanisms such as social media and publications to reach the broad spectrum of island residents, providing face-to-face explosive awareness education significantly enhances the safety messaging effectiveness for those at higher risk of encountering UXO. In 2023, the Navy visited five elementary and junior high schools and provided awareness instruction to approximately 500 students about the dangers associated with UXO and what to do in the unlikely event they are encountered. In addition, the Navy conducted munitions awareness training for the island’s first responders who may receive reports of potential UXO or be first on the scene where UXO may be present. Providing emergency personnel with this training gives them essential knowledge to help keep the community safe from explosive hazards.



Figure 4. Educating school children in-person to recognize and avoid munitions is part of a community outreach program focusing on those most likely to encounter UXO.

Navy Support for Independent Community Evaluation of Environmental Conditions in the Former Vieques Training Areas

Under a grant issued by EPA, a consortium of Vieques community members and researchers from the University of Massachusetts, Boston University, and the University of Puerto Rico proposed sediment sample collection from nine lagoons in Vieques, including four located in the former Navy training areas. In support of the project, entitled “Community-driven Assessment of Environmental Health Risks in Vieques, Puerto Rico,” the Navy hosted a video teleconference with the primary researchers to develop the field protocol for sample collection within the former Navy training areas.



Figure 5. With oversight of an independent, community-led consortium, Navy staff collecting lagoon sediment samples to support the consortium’s assessment of environmental conditions in the former Navy training areas.

Because these areas are restricted due to the potential presence of explosive hazards, the consensus approach consisted of the Navy collecting samples under direct visual oversight of the researchers from safe locations. The Navy also videoed all sampling activities, which were provided to the University of Massachusetts field team leader for confirmation and record-keeping purposes. In addition to providing samples to the researchers, the Navy collected sediment samples from three of the four lagoons for offsite analysis of explosives and metals, the two constituent types most commonly used to assess munitions-related contamination. No explosive compounds were detected in any of the samples and metals concentrations were consistent with naturally occurring conditions.

Accelerated Environmental Cleanup and Green Remediation

Coupling Site Prioritization and Sustainable Remediation Accelerates Public Access to a Hidden Gem

Located at the far western end of Vieques is a remote beach characterized by soft, golden sand; calm, clear waters; vibrant coral reefs; abundant fish; and a coastal forest. These features make the area highly sought after by the public for land-based recreational activities such as sunbathing, picnicking, hiking, biking, and birdwatching, as well as wading, swimming, snorkeling, fishing, and lobstering just offshore. Recognizing the inter-relationship of these planned uses and the area’s significant ecological value, the Environmental Restoration Program Team developed a coordinated plan to implement environmentally responsible remedial actions at both the terrestrial and offshore portions of this 650-acre former open burn/open detonation site. Green remediation at both the land and water portions of the site focuses physical munitions removal on only those areas where human contact with the land and seafloor is anticipated to be highest (e.g., beach, trails, nearshore). This area represents approximately 20 percent of the 650-acre site. For the remaining 80 percent, controls such as educational signage will be used to provide visitors with munitions awareness guidance and encourage them to remain in areas planned for recreational use. In this way, potential explosive hazards are mitigated in planned-use areas and controlled in other areas such that potential deleterious effects on the site-wide terrestrial and marine ecology are avoided. In 2022, the remedial action within the land portion of the site was implemented, and in 2023, the Record of Decision for the offshore portion of the site was issued. Public access is anticipated to begin in 2024 following implementation of the offshore remedial action. Compared to a munitions clearance

involving land surface/subsurface and seafloor bottom/sub-bottom removal across 100 percent of the site, the remedies are anticipated to save over \$75,000,000, preserve high-value ecological resources, and accelerate beneficial use by several years.

Reducing Risk to Human Health and the Environment

Innovative Underwater Munitions Characterization Approach Reduces Risk and Expedites Public Beach Use

Within the former Navy training areas, there are 29 current and planned public-use beaches under USFWS’ land use plan. Continued or future public use of these beaches relies upon characterizing, making remedy decisions, and implementing remedial actions for the offshore areas adjacent to the beaches, all of which have the potential to contain underwater munitions. Recognizing the significance of public beaches to the Vieques residents and local economy, the Environmental Restoration Program Team developed a novel approach to address these nearshore areas and ultimately expedite the availability of these beaches for USFWS’ public beach plans. Focusing on the area where beachgoer contact with the seafloor is highest through such activities as wading, swimming, snorkeling, surfing, and fishing, the Team defined the zone between the shoreline and a water depth of about 15 feet for characterization of both munitions and munitions constituents. Teams of divers, employing an advanced underwater navigation, tracking, and imaging system commonly used by the military, ensured nearly uniform coverage throughout the nearshore area. This approach, the first of its kind for an underwater munitions site, resulted in a higher percent coverage than is common for terrestrial munitions sites and facilitated characterization of the 600-acre nearshore area in a matter of months. By prioritizing the nearshore area for characterization and, ultimately, remedial action, risk reduction and public beach access can be accelerated by years compared to an approach that addresses the offshore munitions area as whole.



Figure 6. Teams of divers utilizing underwater navigation equipment search for munitions on and beneath the seafloor adjacent to planned public beaches as part of a novel characterization approach.

A Novel Approach to Estimate Underwater Munitions Burial Depths Using Geophysical Technology

Whether underwater munitions are likely to remain exposed on the seafloor or bury beneath the depth of potential human contact is critical to understand because it can have significant impact on cleanup decisions. This understanding is based, in part, on the seabed stratigraphy. Traditionally, sub-bottom sediment type and thickness are determined through physical observation using methodologies such as coring. This technique is costly and logistically challenging in the marine environment, and not safe to perform where munitions may be present. The Vieques Environmental Restoration Team designed an innovative approach to employ a common geophysical technology, referred to as a sub-bottom profiler, to safely evaluate the

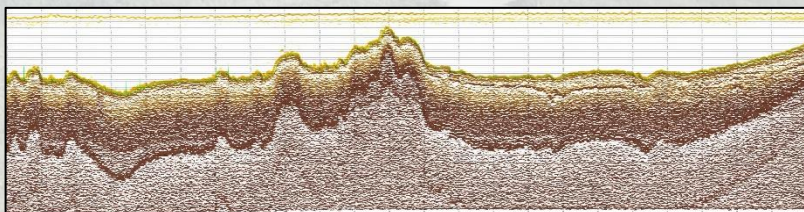


Figure 7. Sub-bottom profiler cross-sections such as this provide valuable information about where munitions may bury beneath the seabed.

stratigraphy of the sub-bottom across the 12,000-acre offshore munitions response area. The sub-bottom profiler uses acoustical imaging to identify seabed sedimentary and lithologic sequences, thereby distinguishing areas and thicknesses of soft sediments conducive for munitions burial and areas of hardbottom (corals/rock) that would inhibit burial. Compared to a traditional approach, the 2022 Vieques sub-bottom profile survey was completed months faster, required no bottom contact, was logistically simple, and at a cost of about \$100,000, was at least an order of magnitude less costly. Further, the resulting information facilitates focusing cleanup in areas where human contact with bottom and sub-bottom munitions is a concern versus areas where such contact is not likely, thereby avoiding unnecessary impact to the marine ecology. In 2023, the Navy and EPA attended the Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP) where this novel use of a sub-bottom profiler, results of the Vieques survey, and the utility of the data to estimate potential munitions burial and help make munitions cleanup decisions were presented and discussed.

Groundbreaking Technologies and Innovative Strategies

Innovative Artificial Reef Provides Potential Coral Restoration Mechanism

In late 2021, two pilot-scale artificial reefs were deployed in an offshore munitions cleanup area in a cooperative effort among the Vieques Environmental Restoration Program, the Naval Information Warfare Center Pacific (NIWC), and researchers from Harvard and San Diego State University. These artificial reefs, referred to as “arks,” were designed to study the effectiveness of coral restoration using innovative structures that are both mobile and buoyant, features that actual coral reefs do not possess. The mobile arks can be geographically located and positioned within the water column to create conditions conducive for coral proliferation. In this way, it may be possible not only to restore corals in areas where they are in decline, but to create reefs where they currently do not exist. Because threatened and endangered corals may be impacted by Navy cleanup activities, these artificial reefs could offer a mechanism for meeting legal mitigation requirements. Following deployment, the arks were populated with coral fragments provided by NOAA and PRDNER and their growth and survival rates were monitored throughout 2022 and 2023. The data collected during that time demonstrated a higher coral survival rate and a lower percent coverage of biomass that inhibits coral proliferation on the arks than in the control area. Based on the results of this study, the Navy will be assisting



Figure 8. Engineer divers provided by the Navy installing coral “arks” supporting NIWC, Harvard, and San Diego State coral mitigation study.



Figure 9. Scientific divers provided by the Navy attaching growth plates containing coral fragments to each of two “arks.”

NIWC with relocating the arks to an area outside of the offshore munitions cleanup area for continued evaluation.

Use of a Closed Detonation Chamber to Destroy Munitions in Vieques

In accordance with requirements set forth in the FY20 National Defense Authorization Act (NDAA), the Navy acquired a closed detonation chamber to destroy UXO recovered during munitions cleanup of the former Navy training ranges. The Navy began chamber operation in 2022 after obtaining the required safety approvals from the Naval Ordnance Safety and Security Activity (NOSSA) and Department of Defense Explosives Safety Board (DDESB). Throughout this process, the Vieques Environmental Restoration Team kept the local community informed of the chamber’s planned use. Operation of the chamber is a complex, labor intensive, and time-consuming process due to the strict safety protocols, set up of each detonation event, post-detonation structural inspections, and waste management. In addition, use of the chamber is influenced by other logistical, safety, and design constraints that affect the type of munitions that can be placed in it. Nevertheless, in its first year of operation, 20-millimeter projectiles (144 total) recovered during range cleanup operations were destroyed in the chamber.



Figure 10. Closed detonation chamber being prepared for destruction of 20-millimeter projectiles recovered during cleanup of the former Vieques Navy training ranges.

Water Jet Cutting System Accelerates Processing of Inert Munitions in Vieques

In addition to acquiring the closed detonation chamber, the Navy purchased a water jet cutting system to assist in the cleanup of munitions from the former Vieques Navy training ranges. Although many of the munitions recovered during the cleanup are inspected and certified as having no explosive content, they must be processed in such a way that they no longer resemble munitions



Figure 11. Water jet cutting system dismantling an inert practice bomb recovered during the munitions cleanup in Vieques. Processing inert munitions in this manner is a cost-effective way to enable the metal casings to be recycled for beneficial reuse.

before they can be disposed of or recycled. Cost-effectively processing these inert munitions had been a challenge historically, especially for large munitions such as 2,000-pound bombs. Acquiring the water jet system provided a novel alternative to more traditional approaches such as deforming or crushing because it uses a narrow stream of high-pressure water (up to 60,000 pounds per square inch) mixed with abrasive sand to cut through hard materials such as metal, glass, and stone. In its first year of operation that began in 2022, the water jet system cut into manageable pieces nearly 1,500 inert munitions, enabling the pieces to be shipped offsite for recycling and beneficial reuse. Water and abrasive material used in the cutting was collected and managed in accordance with environmental regulations.