NEARSHORE DEWATERING FOR COST-EFFECTIVE UNDERWATER MUNITIONS REMOVAL

MR22-B3-7345

Claudio Fassardi

Jacobs Government Services

Final Debrief

May 21, 2025

Project Team

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Bottom Line

- Use of cofferdams constructed with water-filled geotubes to dewater nearshore areas to perform removal of munitions faster, safer, and more economically with conventional land-based equipment and personnel.
- Unsuccessful 1st attempt at constructing the cofferdam in July 2023.
- In March 2024, successfully constructed a 5-tube, 600-foot long “U” shaped cofferdam in approximately 6 feet water depth.
- Water seeped through two connection collars and prevented complete dewatering.
- Cofferdam, acting as a breakwater, provided a wave- and current-free 0.74-acre area for:
  - wading instrument-aided survey, 52 metallic anomalies detected in 4 hours
  - wading intrusive investigation, removed 41 items (5 MDs) in 3 days

Performance Objectives

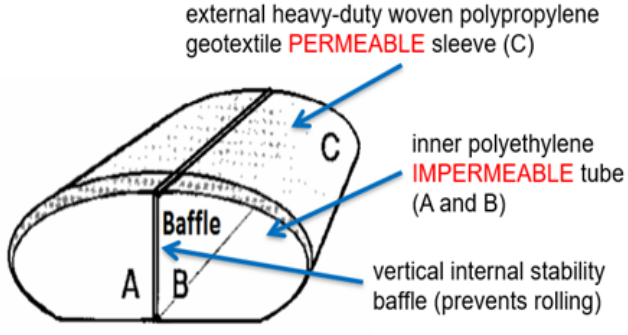
Objective	Data Requirements	Success Criteria
Assess cofferdam feasibility in a wave environment compatible with munitions removal work	Prototype-scale field demonstration flooding and surveys data, inspection results, waves and water level measurements.	Cofferdam remains structurally sound and maintains the dewatered area safe for estimated munitions removal durations using land-based equipment and personnel.
Develop cofferdam construction guidelines	Site characterization, cofferdam technology and materials, construction approach.	The cofferdams installed at the selected locations, in accordance with the guidelines, remain functional and safe for estimated munitions removal durations.
Develop cofferdam construction procedures	Cofferdam construction steps and lessons learned noted through field observations and time-lapse video.	Detailed and practical step-by-step construction procedures developed based on those used in the field.

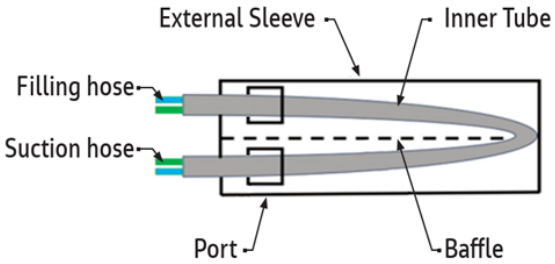
Site Description

Playa Bahia Salinas del Sur (Beach 2) at the former Vieques Naval Training Range (VNTR), Puerto Rico

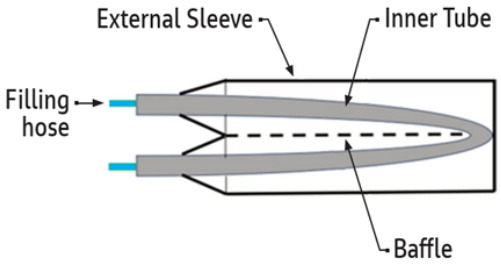
- Originally, two locations, to test cofferdam portability
- Deployed the cofferdam and Location 1 only
- Extensive knowledge of the nearshore environment.
- Existing infrastructure and personnel to support the Demonstration.
- Physical and meteorological and oceanographic conditions representative of US Navy impacted coastal sites around the world.

Technology Description



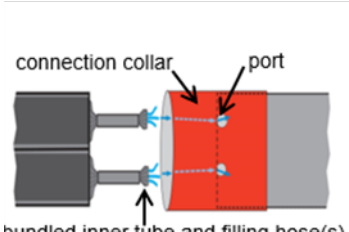


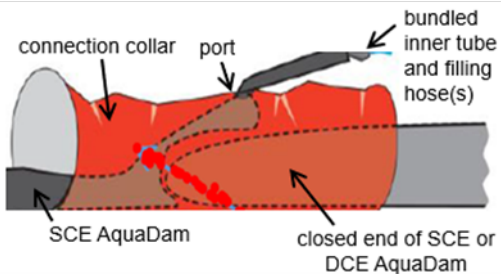
Doble Closed End (DCE) tube

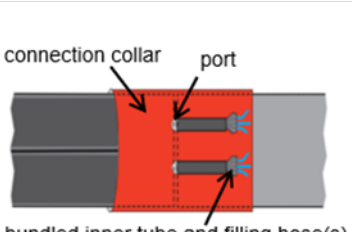


Single Closed End (SCE) tube

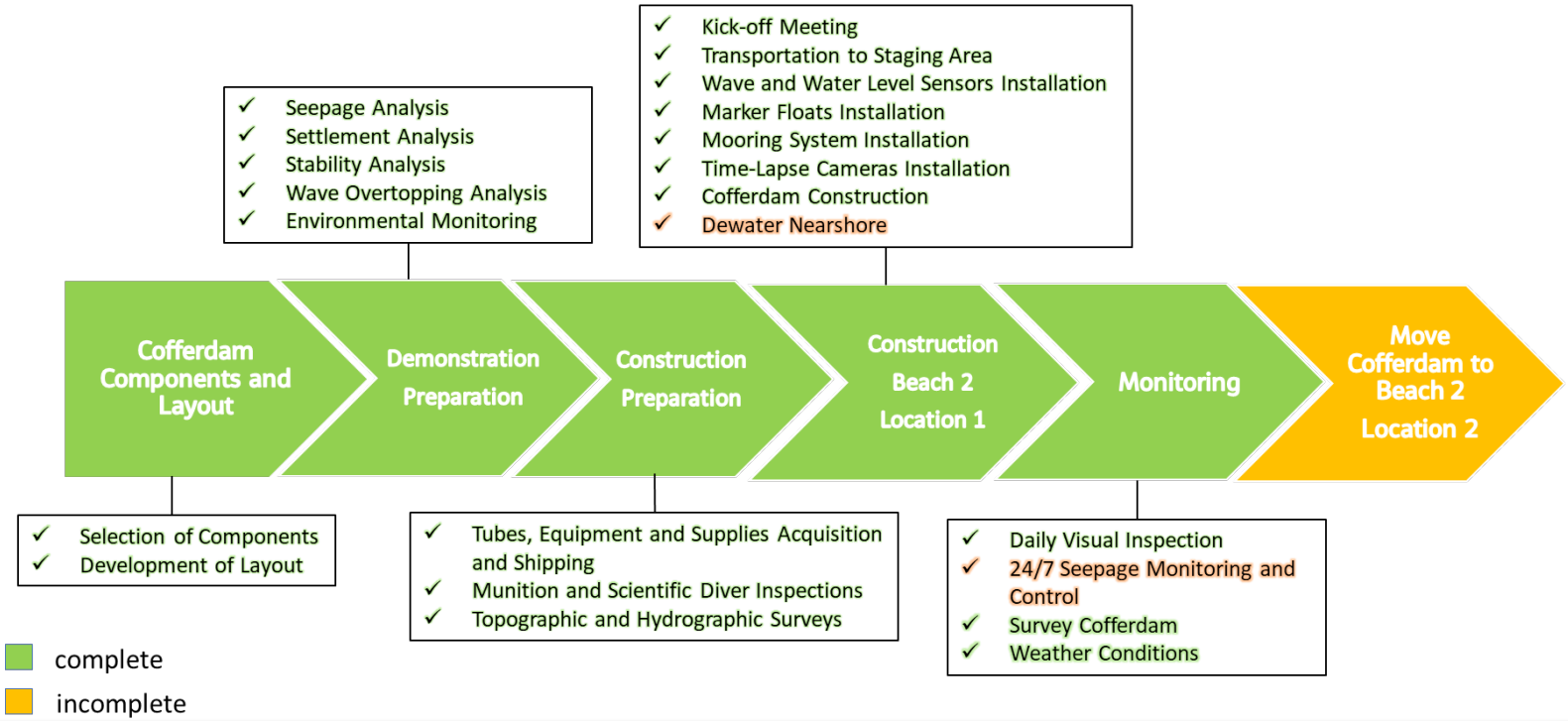
Source: AquaDam, Inc.







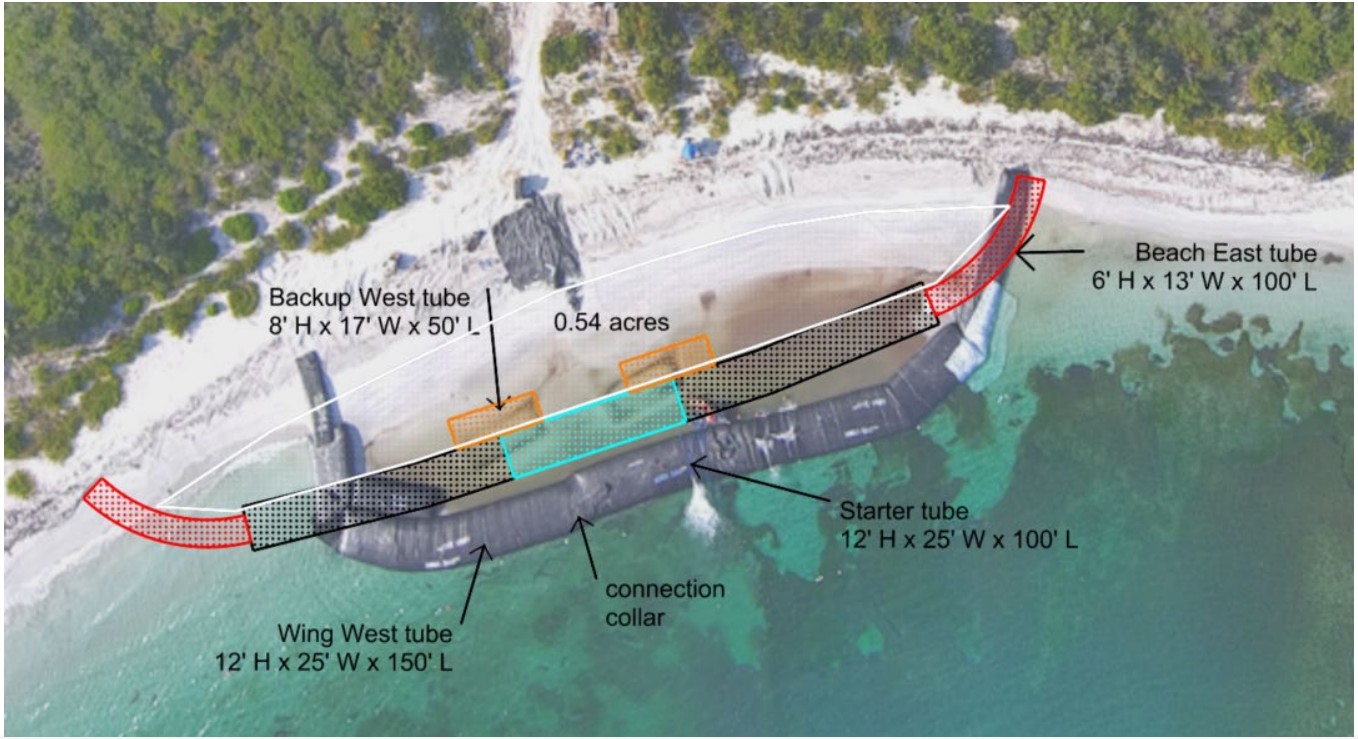
Demonstration Design



Cofferdam Layout

Planned Layout
- 2 backup tubes
- 0.54 acres
- 5’ water depth

Final Layout (March 2024)
- no backup tubes
- 0.74 acres
- 7’ water depth

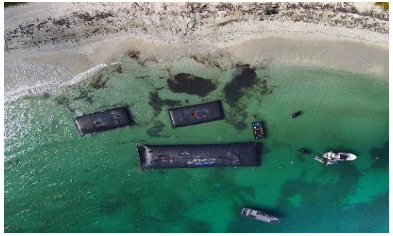


Demonstration Overview

3/5 - BACKUP 1 (east)

3/6 - BACKUP 2 (west) & 3 (east)

3/7 – BACKUPs, downtime (wind & waves)



3/8 - STARTER

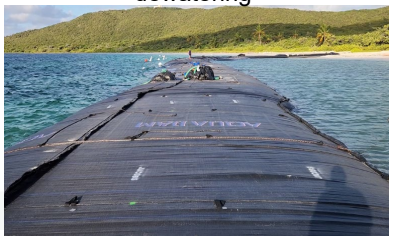
3/9 – STARTER & WINGS

3/10 – STARTER, WINGS & BEACH

3/11 – STARTER, WINGS & BEACH

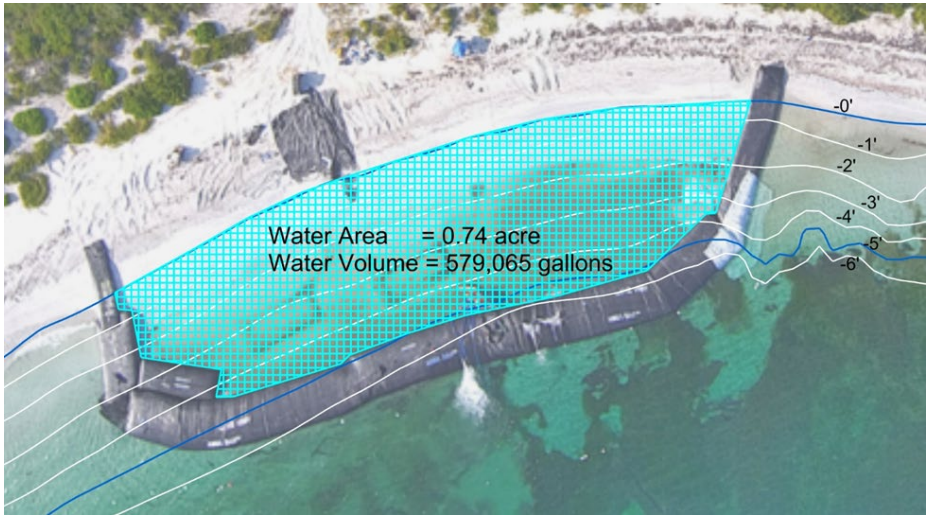
3/12 – wading instrument-aided survey, 1st dewatering

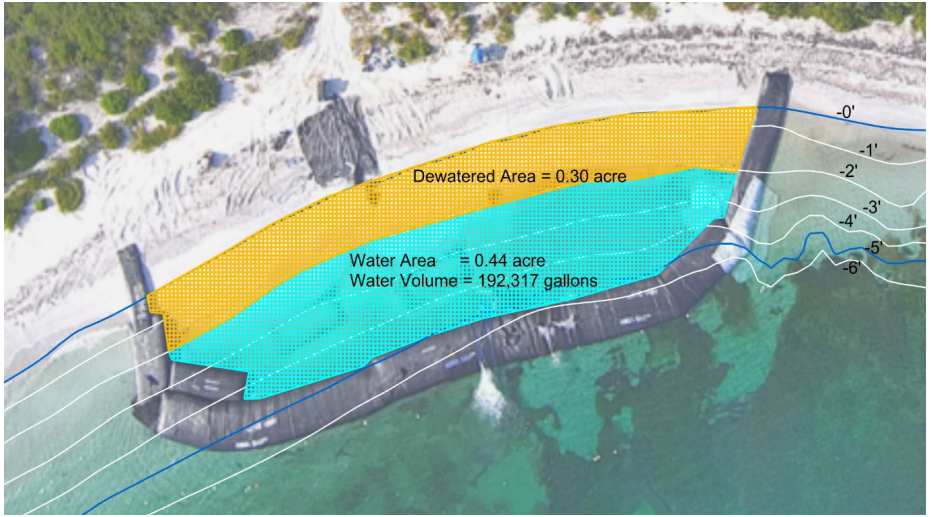
3/13 – 2nd dewatering



3/14 to 20 – wading intrusive investigation & monitoring

Results





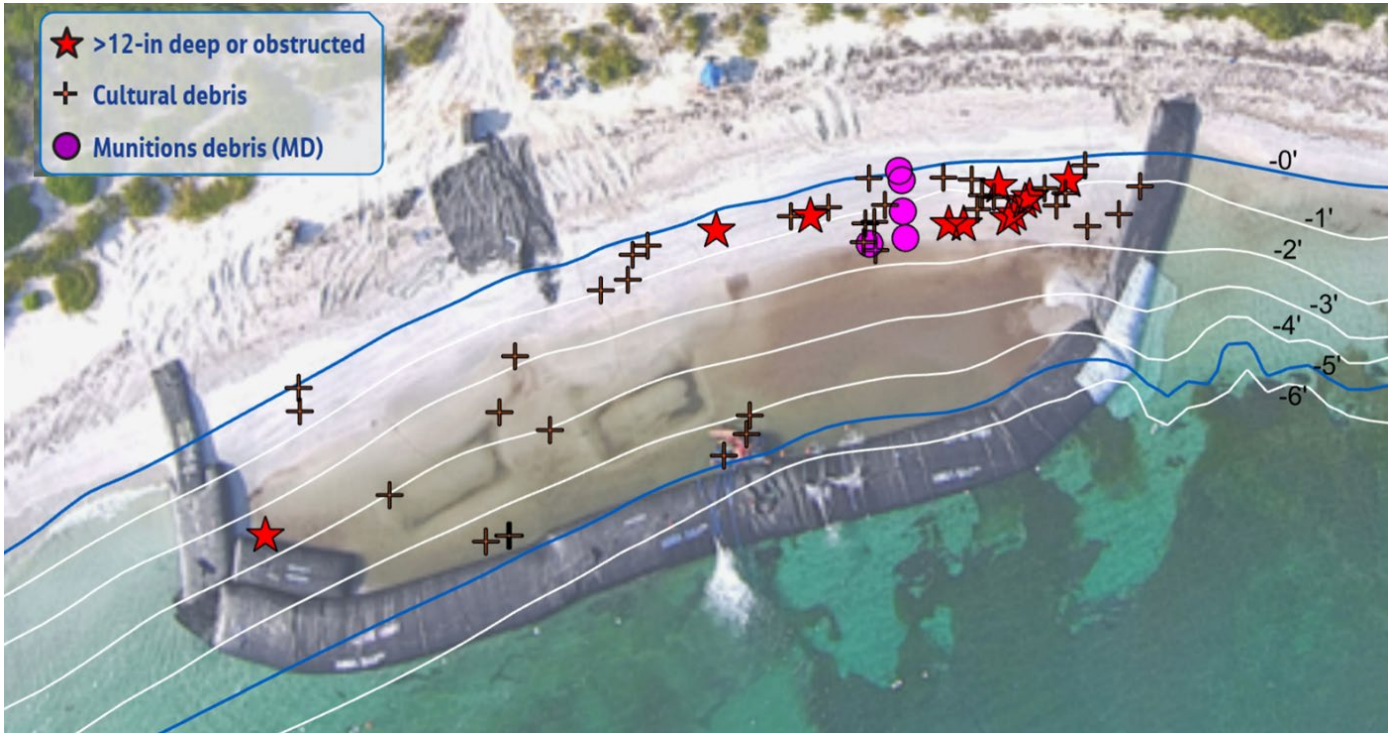
- Before dewatering: water area = 0.74 acre, volume = 579,065 gallons
- After dewatering: water area = 0.44 acre, volume = 192,317 gallons
- Water volume removed = 386,748 gallons (67%)

Results

Dewatered area

Results

- Wading instrument-aided survey, 52 metallic anomalies detected in 4 hours
- Wading intrusive investigation, removed 41 items (5 MDs) in 3 days



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Results

- **The Demonstration was not successful in dewatering the nearshore area. However, it did show that water-filled geotubes can be used as an effective breakwater to provide a wave- and current-free area for munitions removal.**
- Provided a wave- and current-free 0.74-acre area for:
  - wading instrument-aided survey, 52 metallic anomalies detected in 4 hours
  - wading intrusive investigation, removed 41 items (5 MDs) in 3 days
- **Developed construction guidelines and procedures**.
- Defined limiting wave conditions, ≈ 1-foot for tube deployment, ≈ 1-foot+ cofferdam stability
- Constructed the cofferdam in 7 days (1 day downtime).
- Partial dewatering, approximately 67% water volume removed.
- Monitored cofferdam for 7 days.
- No safety incidents.

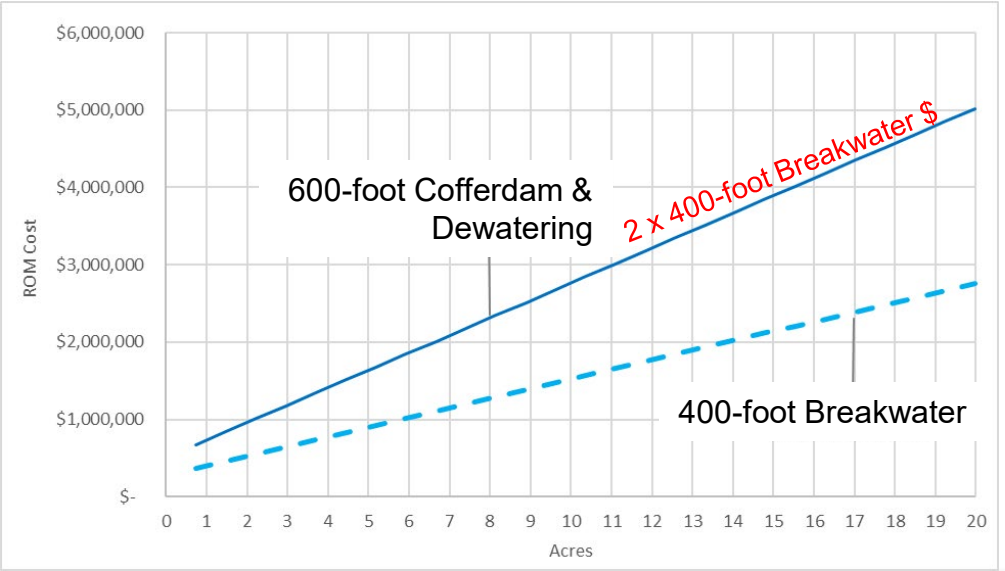
Cost Assessment

Cost model for nearshore dewatering with a temporary water-filled cofferdam (0.74-acre site)

Cost Element	Labor (hours)	Expenses
Components and Layout	80	$0
Planning	140	$9,556
Construction Preparation	400	$308,729
Construction	1,200	$66,696
Removal	480	$23,620
Total	**2,300**	**$408,601**

ROM cost/acre for munition removal

- 600-foot Cofferdam & Dewatering
- 400-foot Breakwater



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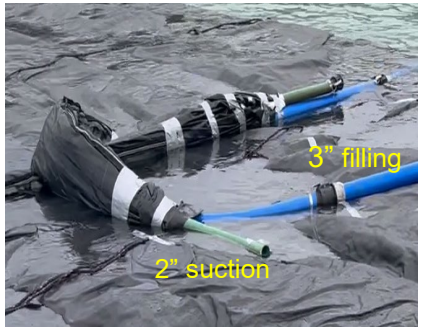
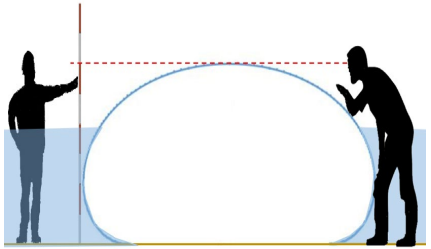
Issues

Inner tubes (membrane) material too thin ➔ cofferdam motions in waves, internal friction may develop tiny leaking holes

Connection collars ➔ Design and connection method, leaks and flooding



Standard filling hoses too small ➔ Slow filling, tube motions in waves and inaccurate location



Difficult checking tube height ➔ Under or over tube inflation, lack of stability in waves, high static/dynamic stresses

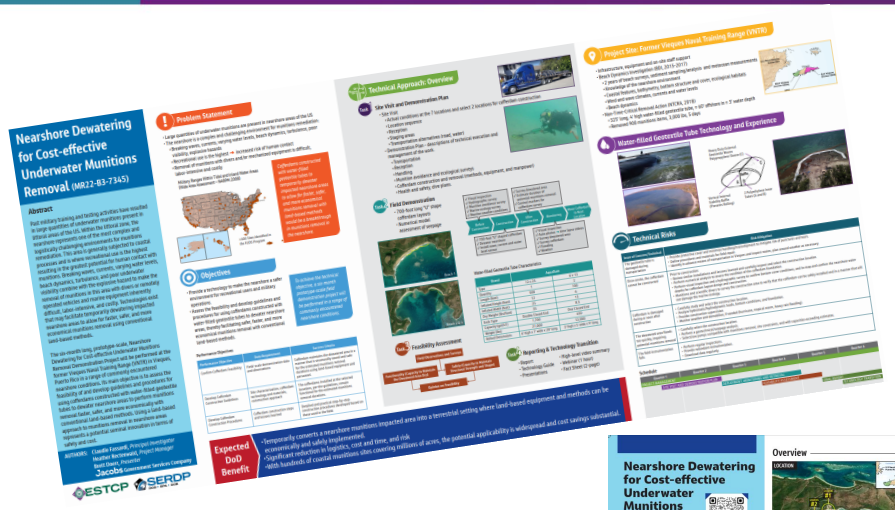
Insufficient, weak straps ➔ Difficult to hold the tubes in place during filling/deployment

No means to fully empty double closed end tubes ➔ Tube not reusable

Lessons Learned

- Seepages at the connection collars may prevent the complete dewatering of an area enclosed by a cofferdam. This may be prevented by joining tubes of roughly equal size or using a cofferdam composed of a single tube.
- The standard inner tube material may be too thin such that small leaking holes develop requiring intermittent tube filling to compensate for leaks. A thicker inner tube material may overcome this issue.
- The relatively few and small-diameter standard tube filling hoses hinder fast filling of the tubes. This may require retrofitting the tubes with additional, stiffer and larger diameter hoses to allow for much higher flow rates which would result in the tubes “grounding” on the seafloor faster, facilitating the handling of the tubes in the water during deployment by reducing the time of exposure to the effects of waves.
- The nearshore characteristics (e.g., beach slope, shoreline shape, beach ends, etc.) and wave conditions may be conducive to wave-induced undertow currents. If strong enough, these currents can drift the tubes seaward during deployment, which would require beachside moorings, in addition to offshore moorings, to keep the tubes in position. Strong perimetral straps would be needed to moor the tubes and overcome this phenomenon.
- The stability of the geotube structure is highly dependent on the tubes fill level (weight) which is difficult to determine in the presence of nearshore waves and uneven seafloor. Use of a sensor or surveys would help overcome this issue.
- It may be difficult to empty the double closed end tubes. Specialty ports and hoses to empty these tubes may overcome this issue.

Technology Transfer



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Symposium 2023

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Symposium 2024

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Technology Transfer

CRITICAL FINDINGS

Nearshore Dewatering for Cost-effective Underwater Munitions Removal

MR22-B3-7345 | May 2025

TECHNOLOGY DESCRIPTION

- An inflatable, water-filled cofferdam intended to temporarily dewater a nearshore area containing munitions, thereby creating conditions conducive for their removal using land-based methods.
- Relative to a traditional cofferdam, the water-filled cofferdam utilizes geotubes that provide for straightforward construction, removal and portability.
- Useful for soft bottom nearshore areas effected by a range of wave, current and water-level conditions.

Cofferdam constructed in Bahía Salina del Sur, at the former Vieques Naval Training Range (VNTR) in Vieques, Puerto Rico

DEMONSTRATION OVERVIEW

- The objectives of the Demonstration were:
  - ✓ Assess the feasibility and develop guidelines and procedures for using temporary, portable cofferdams constructed with water-filled geotubes to dewater nearshore areas to perform munitions removal faster, safer, and more economically with conventional land-based methods.
  - ✓ Provide a technology to make the nearshore a safer environment for recreational users and military operations.
- A 600-foot-long cofferdam was constructed in March 2024 at Bahía Salina del Sur, at the former Vieques Naval Training Range (VNTR) in Vieques, Puerto Rico.
- The cofferdam used standard, "off-the-shelf" geotubes (i.e., not designed and constructed specifically for the Demonstration).
- The cofferdam consisted of five individual tubes joined to each other with connection collars and deployed in a U-shape fashion to enclose and dewater an approximately 0.74-acre nearshore area.
- Cofferdam construction took 6 days, plus 2 days of repairs due to seepages beneath connection collars and leaks from the water-filled geotubes.
- On the last day of dewatering, when the nearshore area had been dewatered by approximately 67 percent, seawater seepage beneath the cofferdam in two locations occurred preventing the full dewatering.
- Although dewatering ended and the enclosed area allowed to refill, monitoring of cofferdam integrity, stability, and ability to maintain the calm-water conditions followed for 7 days.
- Taking advantage of the wave and current-free conditions within enclosed area, munition divers surveyed the full 0.74-acre area, located 52 sub-bottom anomalies, performed intrusive investigation, and removed 41 items, including munitions-related items in 4 days.
- After monitoring, the cofferdam was removed in 3 days.

CRITICAL FINDINGS

- As demonstrated, the cofferdam configuration did not allow for dewatering the enclosed area because the connection collars joining the tubes led to seepage that could not be overcome.
- The Demonstration did show that temporary, portable structures such as water-filled geotubes can be effective breakwaters to provide a wave- and current-free area, thereby allowing for cost-effective munitions removal in areas where this has been practically impossible to date.
- Although the Demonstration utilized water-filled geotubes, alternative mobile structures, such as portable, submersible barges, may be appropriate to consider for future applications.
- Even if dewatering is deemed preferable for a particular situation, the ability of a cofferdam constructed with water-filled geotubes to achieve and maintain a dewatered state would need to be demonstrated before full-scale application is considered. Alternatively, a smaller cofferdam composed of a single tube may overcome the functional challenges associated with the connection collars.
- The cost of using water-filled geotubes as a breakwater is estimated to be approximately half that of using them as a cofferdam for dewatering (assuming dewatering can be demonstrated).
- The Demonstration identified a wave height limit ≈ 1 foot for the construction phase of this cofferdam configuration.
- Once constructed, the cofferdam was stable in 1 to 1.5-foot waves, with periodic filling to compensate for leaks.

ADVANTAGES OVER ALTERNATIVES

- Used as a breakwater, the temporary, portable structure:
  - ✓ Represents a significant innovation in terms of safety and cost, as it overcomes the conditions that has made effective munitions removal within the surf zone with divers and/or equipment practically impossible.
  - ✓ Creates a wave and current-free area.
  - ✓ Greatly improves the ability to locate, identify, and remove items thanks to better visibility and positioning.
  - ✓ Significantly enhances the safety of working conditions.

About ESTCP

ESTCP is the U.S DoD's environmental and resilience demonstration program, harnessing the latest science and technology to improve the DoD's environmental performance, reduce costs, and sustain mission capabilities.

Points of Contact

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Learn more by visiting the project page here:

www.serdp-estcp.mil

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Technical Guide

Nearshore Dewatering for Cost-effective Underwater Munitions Removal

MR22-B3-7345

April 2025

Version 1

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Jacobs Government Services Co.

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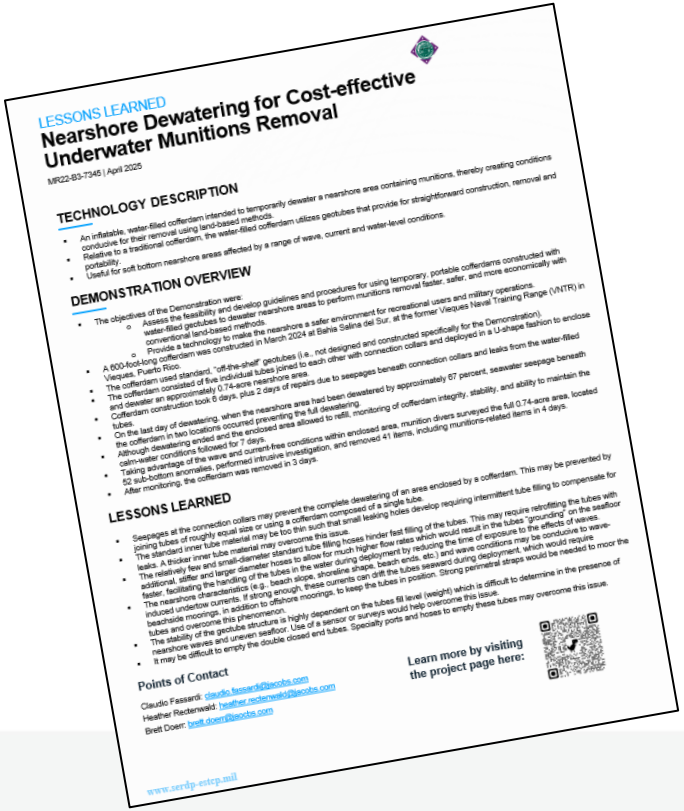
Technology Transfer



LESSONS LEARNED

Nearshore Dewatering for Cost-effective Underwater Munitions Removal

MR22-B3-7345 | April 2025

TECHNOLOGY DESCRIPTION

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- Relative to a traditional cofferdam, the water-filled cofferdam utilizes geotubes that provide for straightforward construction, removal and portability.
- Useful for soft bottom nearshore areas affected by a range of wave, current and water-level conditions.

DEMONSTRATION OVERVIEW

- The objectives of the Demonstration were:
  - Assess the feasibility and develop guidelines and procedures for using temporary, portable cofferdams constructed with water-filled geotubes to dewater nearshore areas to perform munitions removal faster, safer, and more economically with conventional land-based methods.
  - Provide a technology to make the nearshore a safer environment for recreational users and military operations.
- A 600-foot-long cofferdam was constructed in March 2024 at Bahía Salina del Sur, at the former Vieques Naval Training Range (VNTR) in Vieques, Puerto Rico.
- The cofferdam used standard, "off-the-shelf" geotubes (i.e., not designed and constructed specifically for the Demonstration).
- The cofferdam consisted of five individual tubes joined to each other with connection collars and deployed in a U-shape fashion to enclose and dewater an approximately 0.74-acre nearshore area.
- Cofferdam construction took 6 days, plus 2 days of repairs due to seepages beneath connection collars and leaks from the water-filled tubes.
- On the last day of dewatering, when the nearshore area had been dewatered by approximately 87 percent, seawater seepage beneath the cofferdam in two locations occurred preventing the full dewatering.
- Although dewatering ended and the enclosed area allowed to refill, monitoring of cofferdam integrity, stability, and ability to maintain the calm-water conditions followed for 7 days.
- Taking advantage of the wave and current-free conditions within enclosed area, munition divers surveyed the full 0.74-acre area, located 52 sub-bottom anomalies, performed intrusive investigation, and removed 41 items, including munitions-related items in 4 days.
- After monitoring, the cofferdam was removed in 3 days.

LESSONS LEARNED

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ESTCP Jacobs NAVFAC Naval Facilities Engineering Command

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Acknowledgements

- Kevin Cloe / NAVFAC Atlantic - provided logistical support and related assistance for cofferdam storage, preparation, staging, construction and removal.

Thank you

Backup Slides

MR22-B3-7345: Nearshore Dewatering for Cost-effective Underwater Munitions Removal

Performers: *Jacobs Government Services Company.*

Technology Focus: *Use of cofferdams constructed with water-filled geotubes to dewater nearshore areas to perform munitions removal faster, safer, and more economically with conventional land-based methods.*

Demonstration Site: *Playa Bahia Salinas de Sur, former Vieques Training Range (VNTR), Puerto Rico.*

Demonstration Objectives: *Assess feasibility, develop construction guidelines and procedures. Cofferdam remains structurally sound and maintains the dewatered area safe for the duration of munitions removal with land-based equipment and personnel.*

Project Progress and Results: *Completed. Using 5 water-filled tubes, successfully constructed a 600-foot long "U" shaped cofferdam in approximately 7-foot water depth in March 2024. Water seeped through two connection collars and prevented complete dewatering. The cofferdam, acting as breakwater, provided wave- and current-free 0.74-acre area. A wading instrument-aided survey detected 52 metallic anomalies in 4 hours, and a wading intrusive investigation removed 41 items (5 MDs) in 3 days.*

Technology Transfer: *Posters presented at SERDP-ESTCP Symposium 2022, '23 and '25. Final Report, Technical Guide, Critical Findings, Lessons Learned and Video submitted.*

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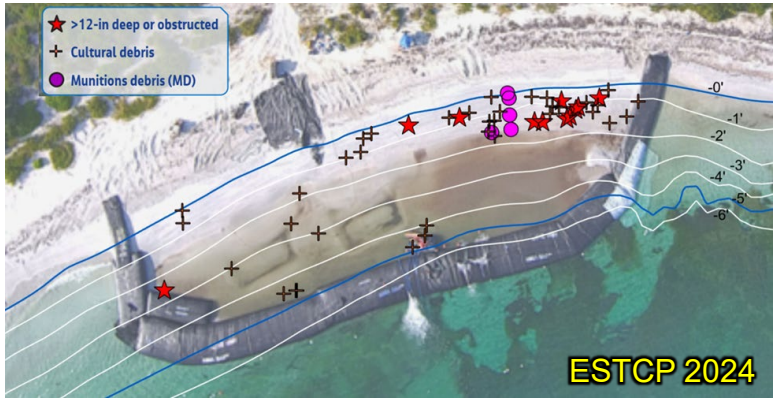
Plain Language Summary

- Past military training and testing activities have resulted in large quantities of underwater munitions present in littoral areas.
- Within the littoral zone, the nearshore represents one of the most complex and logistically challenging environments for munitions removal.
- Removal of munitions in the nearshore with divers or remotely operated vehicles and marine equipment is inherently difficult, labor-intensive, unsafe and costly.
- Depending on site conditions, cofferdams constructed with water-filled geotubes to temporarily dewater impacted nearshore areas are a feasible alternative for faster, safer, and more economical removal of munitions with land-based methods.
- The Demonstration aimed at developing a technology to make the nearshore a safer environment for remediation work, recreational users and military operations.
- The use of structures such as the water-filled geotubes used in the Demonstration to provide wave- and current-free areas is a significant innovation in terms of safety and cost, as these structures overcome the conditions that make munitions removal in the nearshore with divers and/or equipment practically impossible. The nearshore is where recreational use is the highest resulting in the greatest potential for human contact with munitions. It is also where underwater removal may not be feasible or implementing diver or marine equipment-based underwater removal technologies and methods would be difficult, labor-intensive, and costly. For the hundreds of munition-impacted coastal sites covering millions of acres (SERDP-ESTCP, 2010), a land-based approach to munitions removal in the nearshore through cofferdam construction represents not only significant cost savings but also an accelerated rate of munitions removal.

Impact to DoD Mission

- To demonstrate removal of munitions within a dewatered area with land-based equipment and personnel, a 600-foot long “U” shaped cofferdam built with water-filled geotubes was constructed at the Playa Bahia Salinas del Sur at the former VNTR in Vieques, Puerto Rico, in March 2024.
- Water seeped through two connection collars and prevented complete dewatering.
- However, the wave- and current-free 0.74-acre area behind the cofferdam allowed for a wading instrument-aided survey to detect 52 metallic anomalies in 4 hours, and a wading intrusive investigation to remove 41 items (5 MDs) in 3 days.
- The results of the Demonstration furthered cofferdam technology for munition removal in the nearshore, first used by Jacobs and USA Environmental, Inc. (USAE). In 2018, a Non-Time-Critical Removal Action (NTCRA) was performed to reduce the explosive hazard associated with nearshore munitions in a small, protected cove at former VNTR. The cofferdam was 325-feet long and 4-feet high and was installed approximately 60 feet offshore in approximately 3-foot water depth. Within five days, removed 900 munition items were removed weighing a total of 3,000 pounds.



Publications

- None

Literature Cited

- SERDP-ESTCP. 2010. Munitions in the Underwater Environment: State of the Science and Knowledge Gaps. White Paper, June.

Acronym List

DCE	Double Closed End
DoD	Department of Defense
ESTCP	Environmental Security Technology Certification Program
Jacobs	Jacobs Government Services Company
MD	Munition Debris
NAVFAC	Naval Facilities Engineering Systems Command
NTCRA	Non-Time-Critical Removal Action
SCE	Single Closed End
SERDP	Strategic Environmental Research and Development Program
USAE	USA Environmental, Inc.
VNTR	Vieques Naval Training Range

Additional Photos

3/10 – filling WING tube (east)

3/11 - fish clearing

Additional Photos

3/12 – 1st dewatering

Additional Photos

3/12 – 1st dewatering

Additional Photos

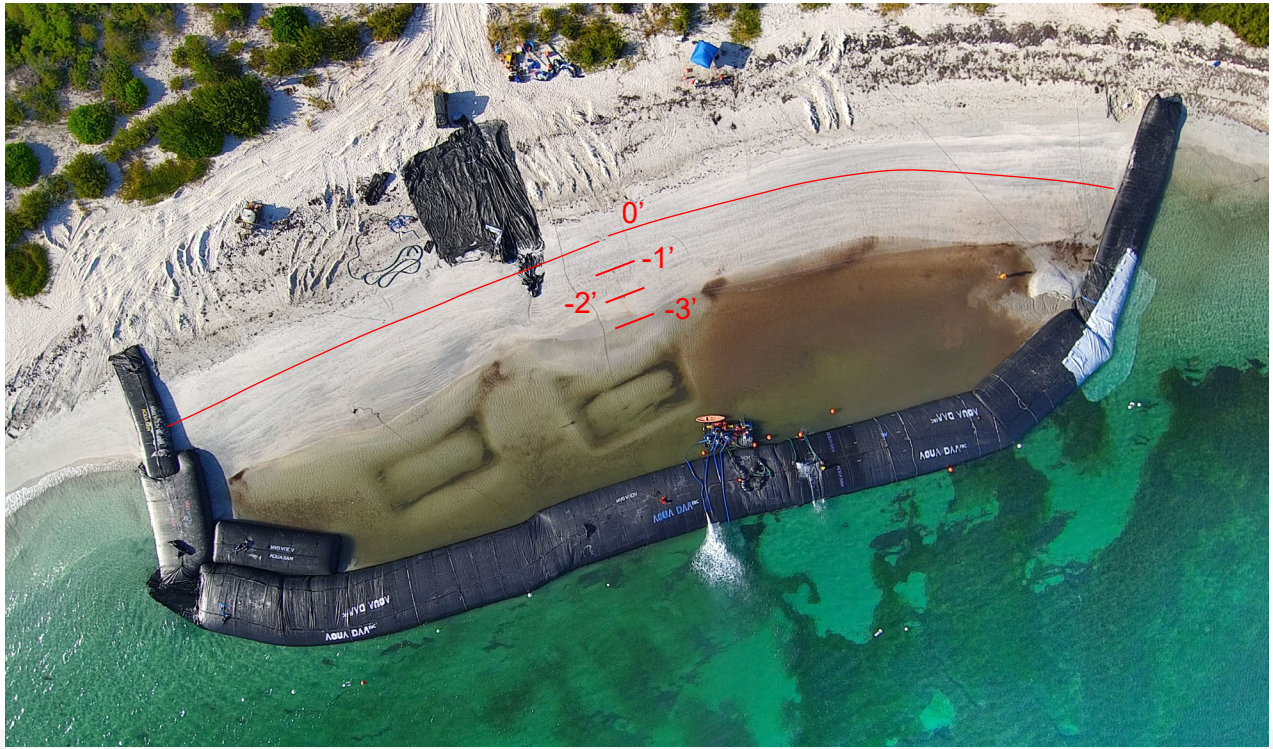
3/13 – 1st dewatering

Additional Photos

3/13 – 2nd dewatering

11:20, 4 x 4” pumps dewatering
13:00, added 3 x 3” pumps

Additional Photos



3/13 – 2nd dewatering

11:20, 4 x 4” pumps dewatering
13:00, added 3 x 3” pumps

ESTCP

Additional Photos

WING - BEACH (east) tube leak

STARTER- WING (west) tube leak

3/13 – 2nd dewatering