What's Up in the Munitions Response Program?

Steve Hammett
NAVFAC EXWC

Stacin Martin
NAVFAC LANT

All images courtesy U.S. Navy unless otherwise noted

RITS 2013

Presentation Overview

- ► Open Detonation Confirmatory Sampling Evaluation
- Update on Munitions Classification Technology
- Navy Detection Technologies for Underwater Munitions
- Munitions Response RI/FS Guidance
- Summary

Outline – Open Detonation Confirmatory Sampling Evaluation

- Why was the Open Detonation Confirmatory Sampling Evaluation performed?
- Background
  - What is an Open Detonation and why is it used?
  - What are Munitions Constituents (MCs)?
  - What are the recommended sampling methods for MCs?
- What facilities and sampling locations were used?
- How many samples were collected at each facility?
- What were the analytes and analyses?

3 Open Detonation Confirmatory Sampling Evaluation RITS 2013: What's Up in the Munitions Response Program?

- Each of these questions will be answered in the next slides.

Why was the Open Detonation Confirmatory Sampling Evaluation performed?

- To determine if MCs have been released to the environment in significant quantities

Key Point Confirmatory sampling is not sampling to support a risk assessment

- Regulators have requested confirmatory sampling
- However, Remedial Project Managers (RPMs) have been reporting no releases of MCs to the environment after an open detonation event

4 Open Detonation Confirmatory Sampling Evaluation RITS 2013: What's Up in the Munitions Response Program?

- The MRP Workgroup decided to do this evaluation of existing confirmation data because regulators are always requesting that confirmatory sampling be performed after a detonation event but the RPMs are indicating that the confirmation data indicate that it may not be needed.
- This presentation will provide the results of the data evaluation from four facilities that have collected open detonation confirmation samples.

Why was the Open Detonation Confirmatory Sampling Evaluation performed? (cont.)

- To evaluate if and where confirmatory sampling needs to be performed after an Open Detonation
- Will discuss
  - Sampling results from participating facilities
  - What to consider during Project Planning and execution

Open Detonation Preparation

What is an Open Detonation and Why is it Used?

- Open detonation is the open-air explosive destruction of MEC using an explosive donor charge to initiate the detonation to safely remove the explosive hazard
- Two types
  - Blow-in-Place (BIP) is the destruction of any MEC by detonating the item without moving it from the location where it was found

BIP Detonation Preparation

MEC = Munitions and explosives of concern

6 Open Detonation Confirmatory Sampling Evaluation RITS 2013: What's Up in the Munitions Response Program?

- Explosive safety is the primary issue at a MRS. Therefore, when MEC is found at a site, it is common to destroy it in place (when too dangerous to move the item) or consolidate it with other items and destroy it. The concern is whether the detonation fully destroys the MEC or residuals remain behind that could be considered a hazard.

- Note the MEC inside the red circle. Sometimes MEC can be hard to visually spot.

What is an Open Detonation and Why is it Used? (cont.)

– **Consolidated Detonation is the destruction of any MEC by detonating the items at a location other than where they were found to remove the explosive hazard, but……**

- Only for MEC that have been inspected and deemed acceptable or safe to move
- MEC are collected from the work area and consolidated at a designated area for detonation
- Items can be combined with item(s) that cannot safely be moved

Consolidated Detonation Preparation

Two Types of Detonation Orders

- High-order detonations
  - Little MC residue expected
- Low-order detonations
  - UNINTENTIONAL and UNDESIRABLE
  - Rarely occurs
  - Munitions filler is only partially detonated
  - MC may be scattered or still partially encased in the remaining portion of the munitions
- Only qualified UXO personnel can determine if detonation is low-order or incomplete

MC RESIDUE

Low-order mortar; Chocolate Mountains, CA

8 Open Detonation Confirmatory Sampling Evaluation RITS 2013: What's Up in the Munitions Response Program?

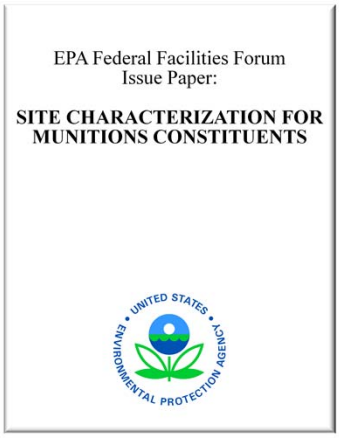
- High-order detonations are the norm and not the exception. Low-order and incomplete detonations are unintentional and undesirable; and they rarely occur.
- Video from Kaho'olawe Island, HI. Video clip courtesy of U.S. Navy.
- The photo points out MC residue (orange color stuff) on ground around mortar shell.
- Easy for qualified UXO personnel to tell the difference between a high-order and a low-order/incomplete detonation. However, this is not always noted in the field notes or reports.

What are Munitions Constituents?

- MCs are any materials originating from MEC or other military munitions, including explosive and non-explosive materials, emissions, degradation, or breakdown elements of such ordnance or munitions
  - MC as MEC – explosive material present in high enough concentrations to pose an explosive hazard
  - MC contamination may result from munitions shell breaching, leakage, corrosion, or low-order detonations

What is the Recommended Sampling Method for MCs at a Munitions Response Site (MRS)?

- 3 types of sampling methods used to determine if MCs have been released:
  - Discrete
  - Composite
  - Incremental (Recommended)
- Reference: EPA Federal Facilities Forum Issue Paper on Site Characterization for Munitions Constituents (2012)



10 Open Detonation Confirmatory Sampling Evaluation RITS 2013: What's Up in the Munitions Response Program?

A good reference that discusses the three sampling methods is the EPA Federal Facilities Forum Issue Paper on Site Characterization for Munitions Constituents (2012).

Discrete Sampling

- Provides point concentrations at specific coordinate locations
- Sampling results may not be reproducible and can yield significantly different results in adjacent sampling points
- Studies have shown that estimating a mean based on just a few discrete samples will result in a mean value that can be biased either low or high
- Concerns about using discrete samples to represent the average concentrations in soils

Composite Sampling

- Consists of multiple individual samples
- Results have confirmed the non-reproducible nature of discrete sampling
- Most controversial sampling
- Most regulators are not in favor of doing this type of sampling

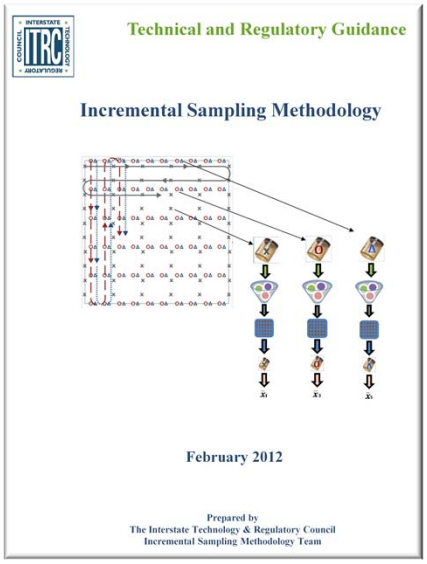
Some regulators are concerned that this approach dilutes the sample and therefore are not in favor of this type of sampling. However, other regulators are OK using it.

Incremental Sampling (Recommended)

- Conducted by defining a smaller sampling/decision unit based on the overall size of the MRS
- Samples can be collected using a systematic-random (recommended) pattern or a totally random pattern
  - Totally random pattern may over- or under-represent various areas of the sampling/decision unit
- Typically produces significantly more representative data
- Recommended characterization approach for MC at an MRS

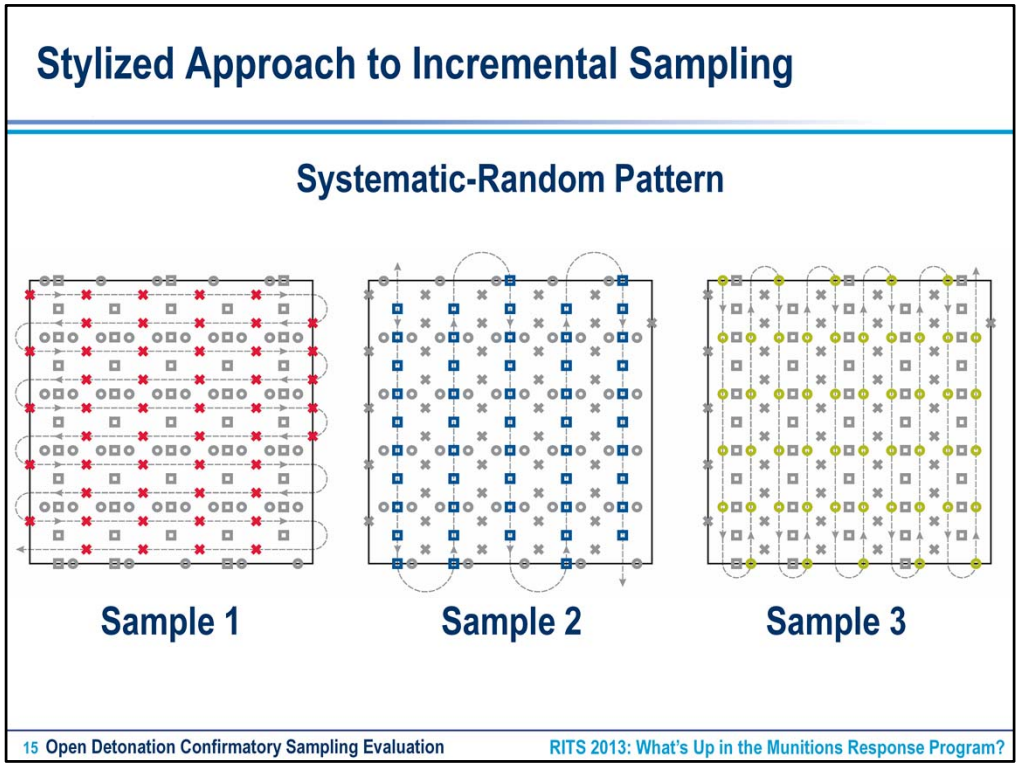
Incremental Sampling (cont.)

- ITRC's Technology and Regulatory Guidance Document on Incremental Sampling Methodology (ISM-1, Feb 2012)
- Specific guidance on incremental sampling is also described in the EPA SW8330B method guidance document

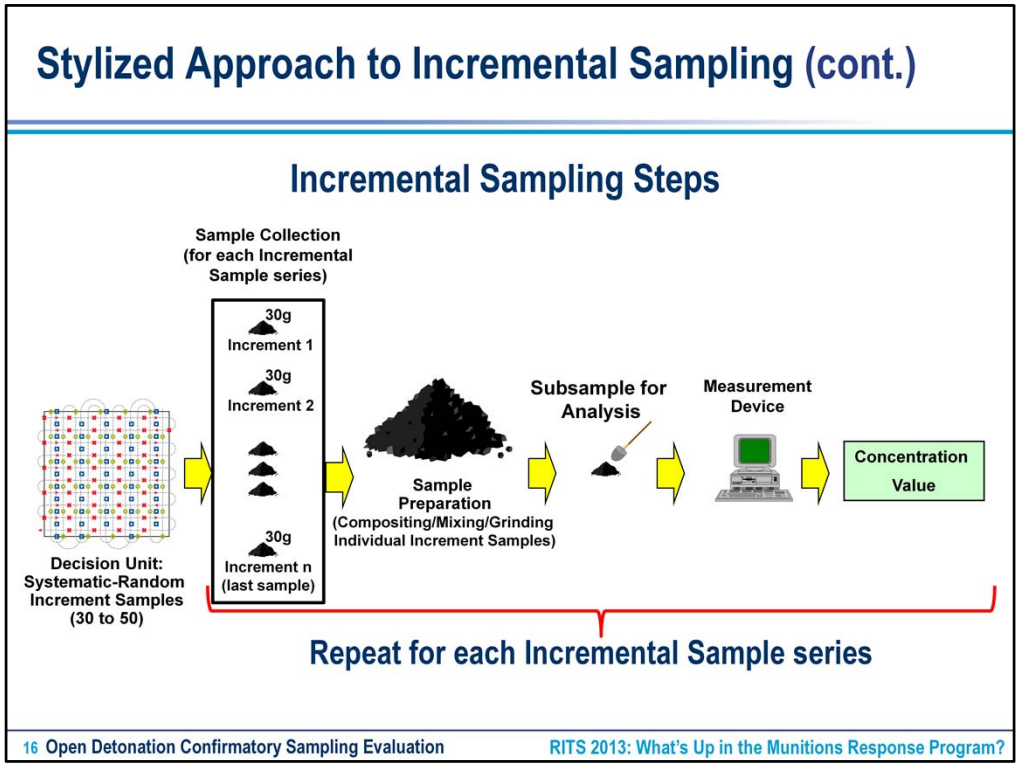


Sources for more info on Incremental Sampling Methodology:

- Incremental Sampling Methodology Technology Regulatory and Guidance Document (ISM-1, February 2012)
- ITRC Training Class - Soil Sampling and Decision Making Using Incremental Sampling Methodology (ISM)
- RITS Spring 2007 Topic – Characterization of Energetic Constituents on Ranges



This method involves breaking the site into decision units and then setting up a systematic random sampling grid across the Unit. Samples are collected from each sub area, combined and then a representative sample for the whole Unit is collected to send to the lab for analysis.



From Section 4.1.3 – Sampling Design and Rationale for Munitions Constituents of the new Munitions Response (MR) Remedial Investigation/Feasibility (RI/FS) Study Guidance

Sampling Methodology Comparison

Description	Incremental	Discrete	Composite
Analytical results are reproducible	Yes	No	No
Reduces data variability (compositional and distributional heterogeneity)	Yes	No	No
Provides results that better estimates the mean concentration of the sampled volume	Yes	No	No
Preferred characterization approach for MC at an MRS	Yes	Depends[1]	No
Sample collection and processing straightforward	No[2]	Yes	Yes
Low sample collection, processing, and analysis costs	No	Maybe[3]	Maybe

[1] Regulatory requirements may determine that discrete sampling be used

[2] Specialized sampling equipment is required and specific sample collection, preparation, and analysis protocols must be performed

[3] If multiple discrete samples are needed, then the cumulative cost may be more than the cost to perform incremental sampling

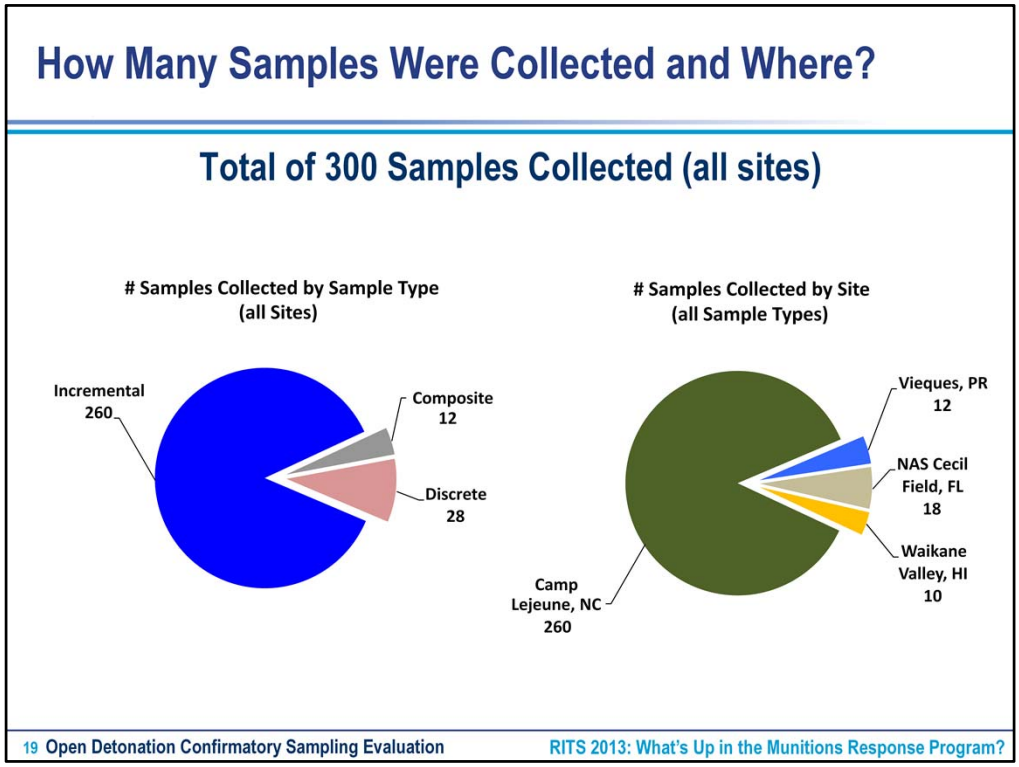
What Facilities and Sampling Locations were used?

- **Evaluated soil data from 4 facilities:**
  - **Camp Lejeune, NC**
  - **Vieques, PR**
  - **Waikane, HI**
  - **Cecil Field, FL**
- **Sample Location Categories**
  - **Inside of Crater (IC)**
  - **Outside of Crater (OC)**
  - **Other**
    - Decision Unit
    - Combined Inside and Outside of Crater

Bomb crater at Canadian Forces Base Gagetown
Photo courtesy of U.S. Army

18 Open Detonation Confirmatory Sampling Evaluation RITS 2013: What's Up in the Munitions Response Program?

- Photo shows "pink" water at a crater
- Because TNT is photo-chemically active, it turns a pink or red color in water as it decomposes. This process is called "photolysis". Other nitramine and nitroaromatic explosives such as HMX and RDX may also be present in pink water.
- Since the nitramine and nitroaromatic composition of pink water is highly variable and is dependent on process materials and operations, only field or laboratory analysis can determine the MC concentrations.
- Note: Pink water may also be caused by microscopic, unicellular organisms living in the water.



This summarizes the data set that was evaluated:

- Camp Lejeune – all incremental
- Vieques – all composite
- Cecil Field – all discrete
- Waikane – all discrete

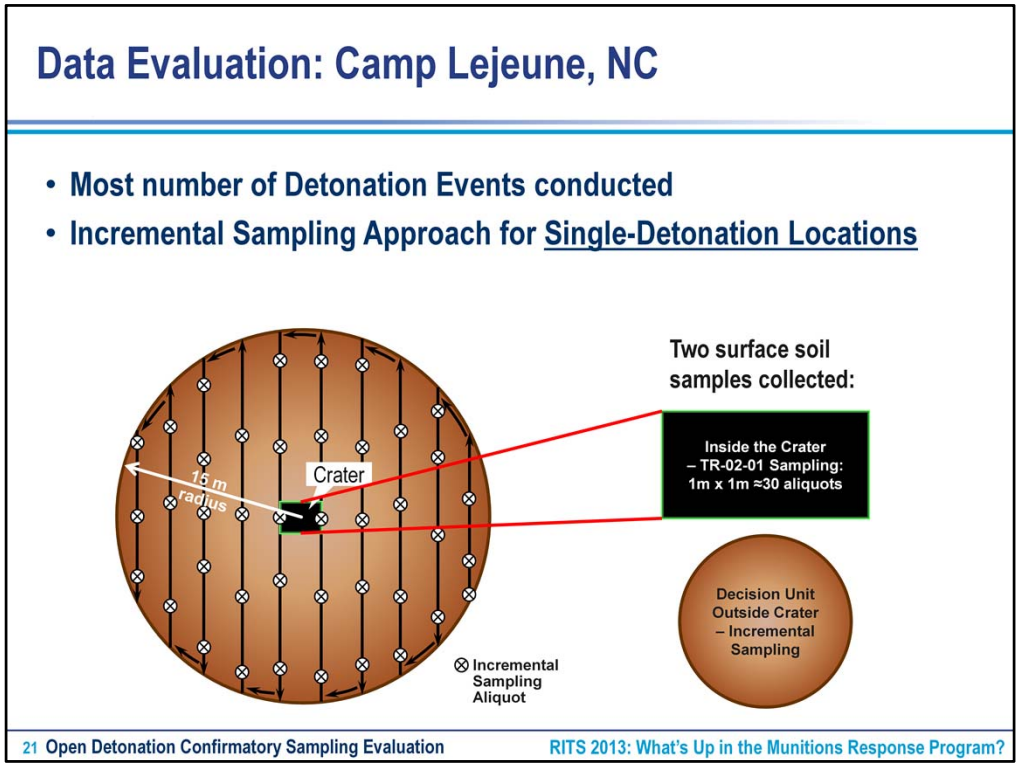
What Were the Analytes and Analyses?

Analyte Name	Analytical Group	Analytical Method					
		6850	6850M	8330	8330A	8330B	8332
1,3,5-Trinotrobenzene	EXPLOSIVES			X	X	X	
1,3-Dinotrobenzene	EXPLOSIVES			X	X	X	
2,4,6-Trinitrotoluene	EXPLOSIVES			X	X	X	
2,4-Dinitrotoluene	SVOA			X	X	X	
2,6-Dinitrotoluene	SVOA			X	X	X	
2-Amino-4,6-Dinitrotoluene	EXPLOSIVES			X	X	X	
2-Nitrotoluene	EXPLOSIVES			X	X	X	
3-Nitrotoluene	EXPLOSIVES			X	X	X	
4-Amino-2,6-Dinitrotoluene	EXPLOSIVES			X	X	X	
4-Nitrotoluene	EXPLOSIVES			X	X	X	
HMX	EXPLOSIVES			X	X	X	
Nitrobenzene	SVOA			X	X	X	
Nitroglycerin	EXPLOSIVES			X	X	X	X
Perchlorate	EXPLOSIVES	X	X				
PETN	EXPLOSIVES			X	X	X	X
RDX	EXPLOSIVES			X	X	X	
Tetryl	EXPLOSIVES			X	X	X	

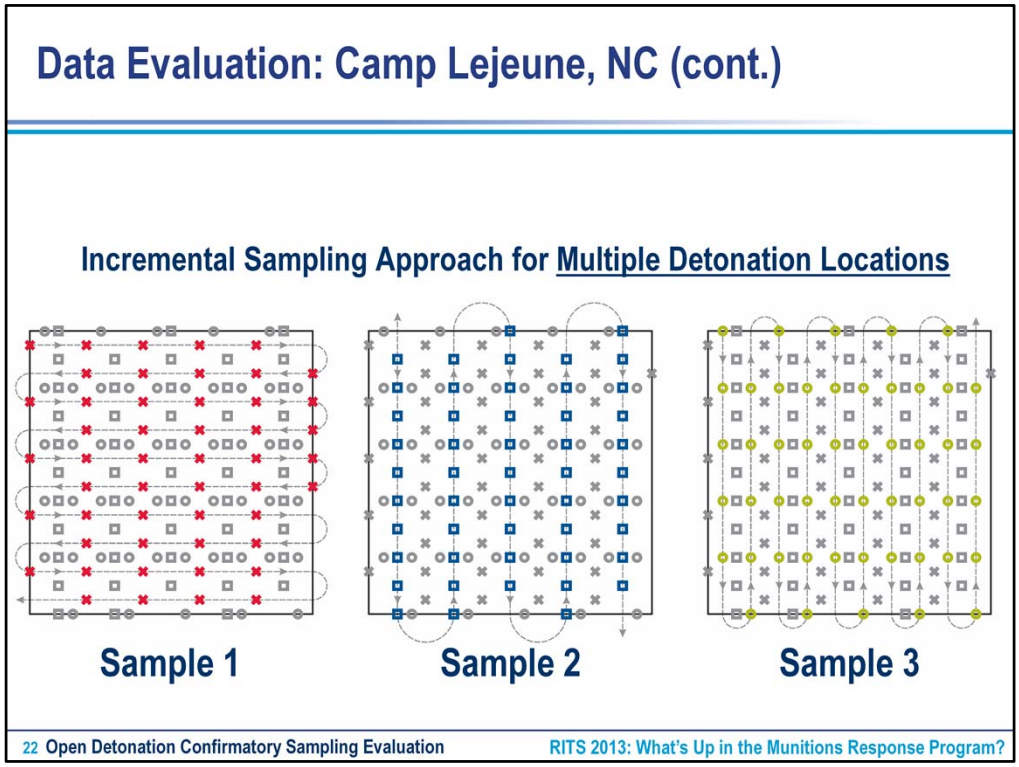
4,887 analytical results from 300 samples collected (all sites)

20 Open Detonation Confirmatory Sampling Evaluation RITS 2013: What's Up in the Munitions Response Program?

- This represents the list of analytes that were covered by the samples. Note that not all samples were analyzed for each of these analytes.
- 8330B is a method of analysis that includes an appendix on incremental sample collection.
- See Section 4.9 – Analytical Methods in the new Munitions Response (MR) Remedial Investigation/Feasibility (RI/FS) Study Guidance.
- Table 4-9 for Common Analytical Methods for MC in the new Munitions Response (MR) Remedial Investigation/Feasibility (RI/FS) Study Guidance for more detailed information.

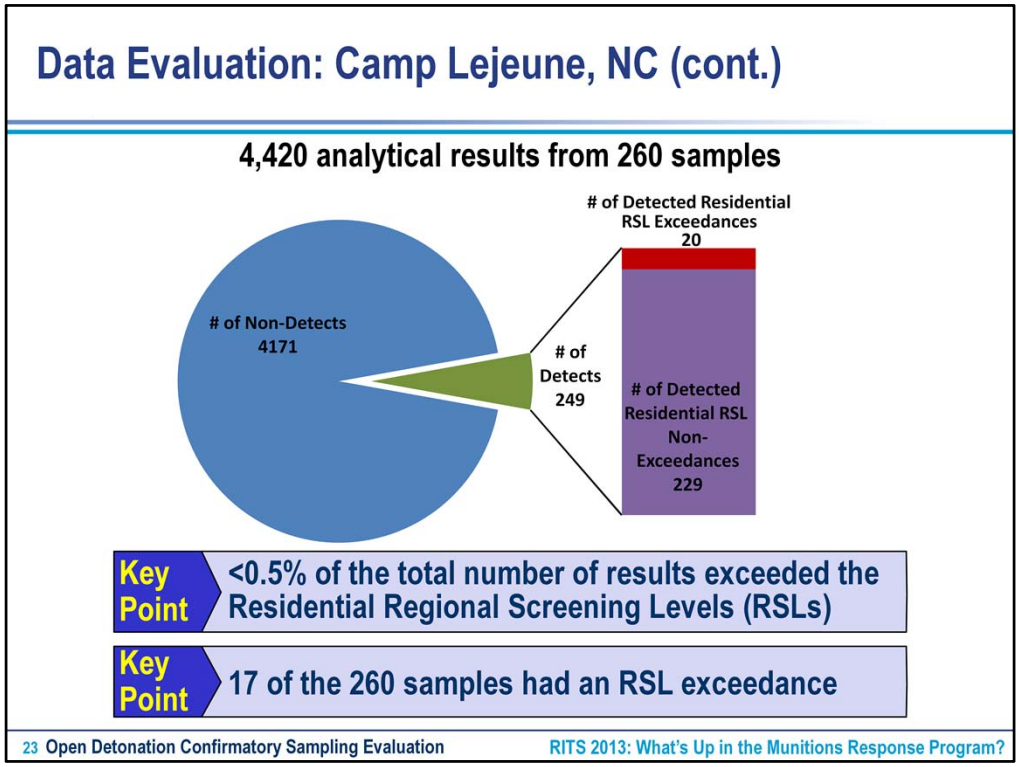


- All increment points are combined into one sample.

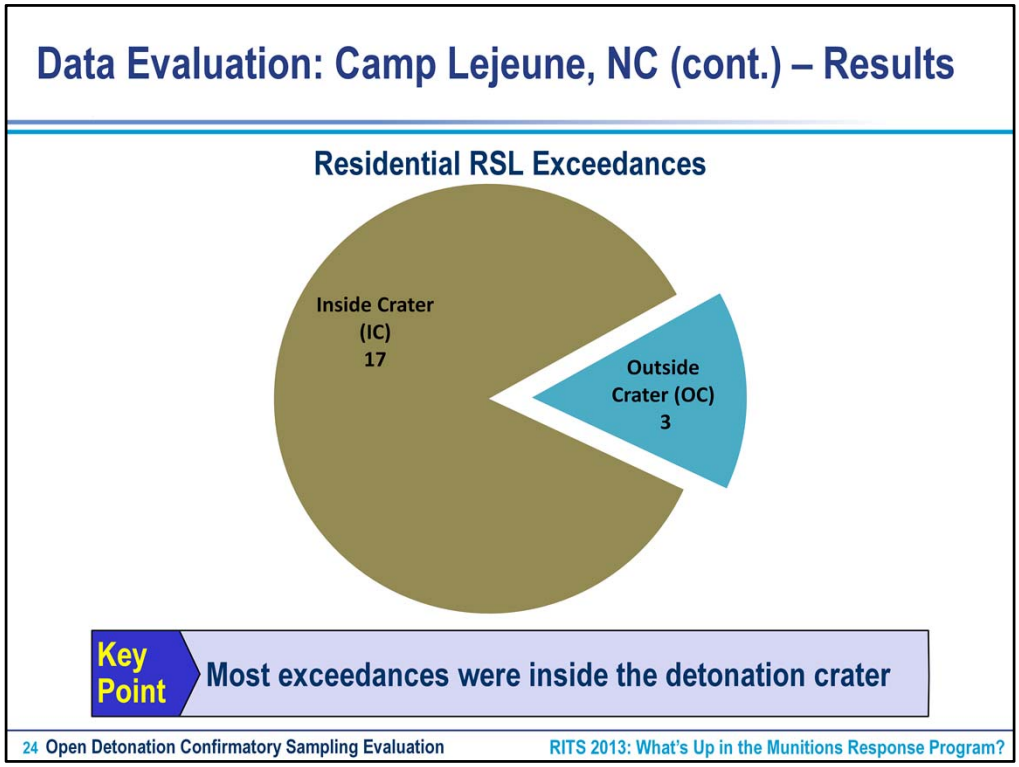


- For multiple detonation locations they used a square pattern vice a circle for single detonation locations.

- Camp Lejeune used the Systematic Random sampling approach for their incremental sampling at multiple detonation locations.



- Just having a detection does not mean you have an environmental concern.
- A sample can have many analytes and therefore have many results (1 sample, 20 analytes, 20 individual analytical results).



- This shows the number of samples collected inside and outside the crater at Camp Lejeune.

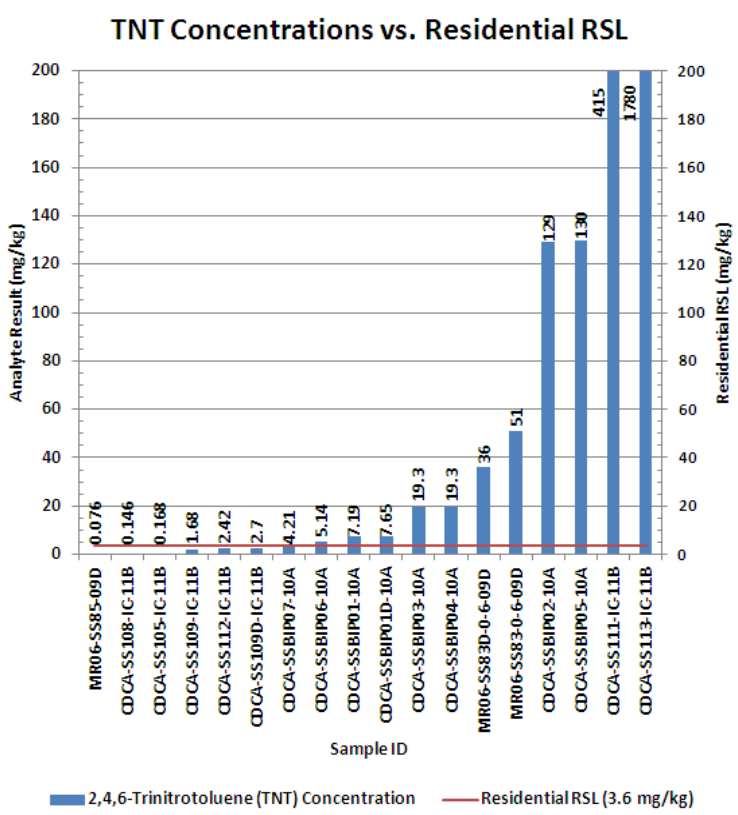
Data Evaluation: Camp Lejeune, NC (cont.) – Results

Residential Regional Screening Level (RSL) Exceedances

Sample Position	Analyte	# Residential RSL Exceedances	Max Detect (mg/kg)	Residential RSL (mg/kg)
Inside Crater (IC)	2,4,6-Trinitrotoluene (TNT)	10	1,780	3.6
	2,4-Dinitrotoluene	2	7.04	1.6
	2-Nitrotoluene	1	4.96	2.9
	Nitroglycerin	3	1.77	0.61
	RDX	1	98	5.6
Outside Crater (OC)	Nitroglycerin	3	2.22	0.61

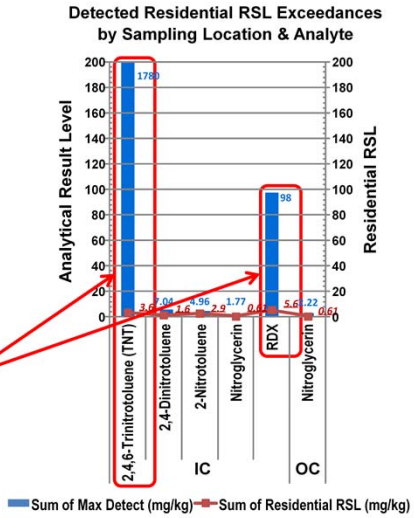
Key Point Most # of exceedances were for TNT (common explosive material) and were from inside the crater

- TNT, RDX, and HMX are common explosive fillers in munitions.



Data Evaluation: Camp Lejeune (cont.) – Summary

- Only facility where incremental sampling was performed
- Only facility that had results exceeding Residential RSLs
- The RSL exceedances may be indicative of an incomplete detonation.
- Max results for TNT & RDX were significantly higher than their respective Residential RSLs

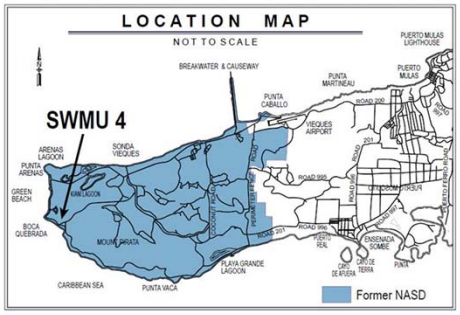


26 Open Detonation Confirmatory Sampling Evaluation RITS 2013: What's Up in the Munitions Response Program?

- When you look at the number of exceedances (for TNT) you have several that are just barely over the RSL and then you have several that are significantly higher than the RSL.
- The 1780 result can't be explained but is not consistent with other results.

Data Evaluation: Vieques, PR

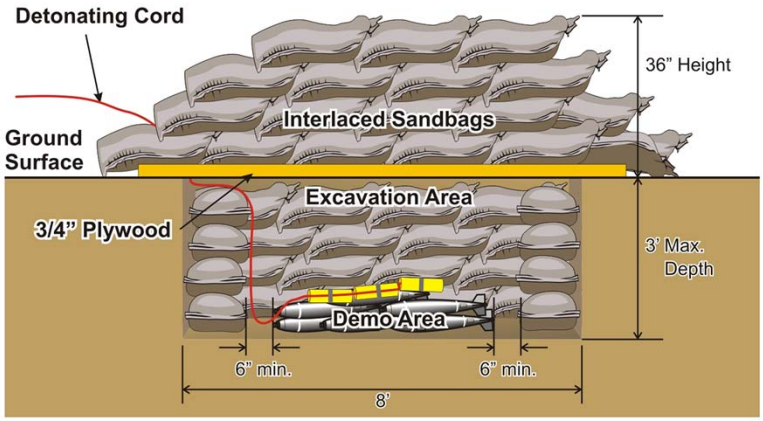
- 12 composite grab samples collected after 2 Consolidated Detonation events
  - Project team decision to collect composite grab samples
- Engineering controls (excavated pit and sand bags) were used to tamp detonations with added benefit to contain MC residue

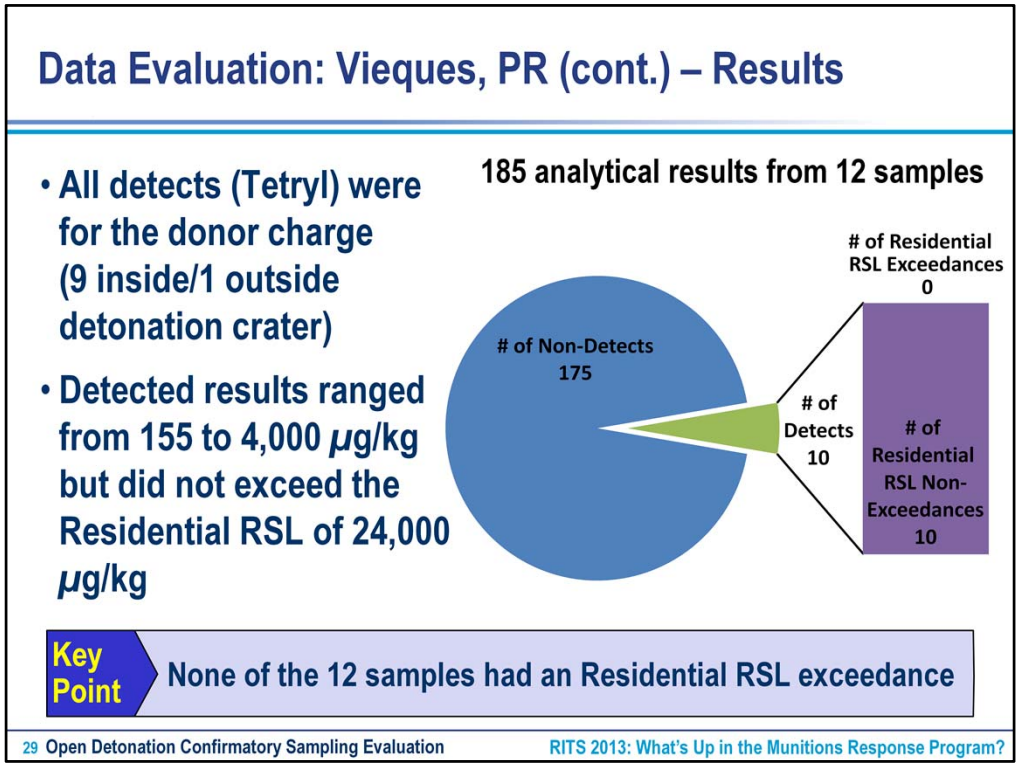


Vieques Island Live Impact Area

Data Evaluation: Vieques, PR (cont.)

Conceptualized Schematic of Engineering Controls (06/2010 Vieques Detonation Event)

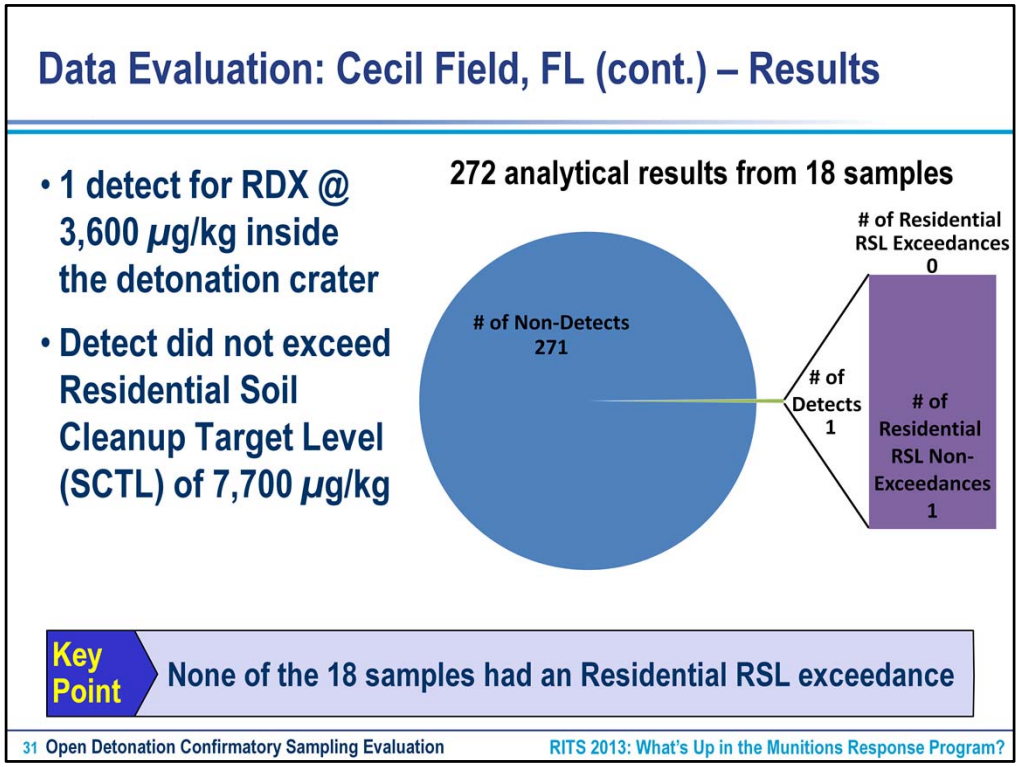




- All detects were for Tetryl:
  - 9 inside detonation crater
    - 4 of the 9 were from spoils pile (182 to 1610 µg/kg)
    - 1 of the 9 was a field duplicate (182 µg/kg for FD vice 221 µg/kg for sample)
  - 1 outside detonation crater
    - 155 µg/kg
- On east end of Vieques there have been hundreds of detonation events performed under Interim Removal Actions but no confirmatory sampling performed after each detonation event. The Vieques RI will address performing soil sampling for MC residue.

Data Evaluation: Cecil Field, FL

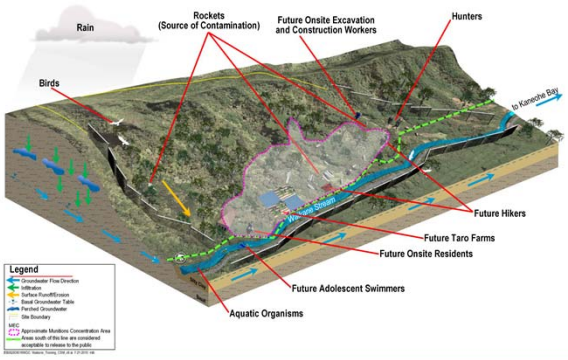
- 18 discrete grab samples collected after 18 detonation events
  - State emergency treatment permits for detonation events required discrete sampling to be performed
- Detonation events were consolidated detonations
- Samples were collected after visibly-impacted soil was first removed post-detonation



- This result may be from the "nugget" effect (1 chunk can ruin your whole day).
- Did exceed Leachability based on Groundwater (LGW) Criteria SCTL of 2 µg/kg (0.002 mg/kg).

Data Evaluation: Waikane, HI

- 10 discrete grab samples collected after 10 Consolidated Detonation events (1 sample per event)
  - Project team decision to collect discrete samples
- Consolidated Detonation events occurred during RI
- No detects for explosives from post-detonation confirmatory sampling
- Influenced the decision for no further sampling required during Remedial Action phase



32 Open Detonation Confirmatory Sampling Evaluation RITS 2013: What's Up in the Munitions Response Program?

- Samples were collected from inside the crater.
- It is unknown if engineering controls were used.

Summary

- <0.5% of the total # of results exceeded the Residential RSLs
- 5.6% of the total # of samples had results that exceeded the Residential RSLs
- 85% of the Residential RSLs exceedances were from samples collected inside the detonation crater

33 Open Detonation Confirmatory Sampling Evaluation RITS 2013: What's Up in the Munitions Response Program?

- The percentage of samples (5.6%) that had results exceeding the Residential RSLs is comparable to the average ammunition dud rate of 3% (from "Study of Ammunition Dud and Low Order Detonation Rates", DAC, July 2000 noted in Basic MRSM Course).
- 5.6%=17/300
- One site had detects for Tetryl which is from the donor charge.
- Analytical results show that we are not degrading the environment.
- Consider how much explosive material is contained in munitions and after numerous detonation events the overwhelming majority of analytical results are non-detects and of those that are detects, very few exceed RSLs.

Take-Away Messages

- **Project Planning Stage**
  - **Do you really need to do *confirmatory sampling* at all?**
    - Confirmatory sampling is not risk assessment sampling
  - **Discuss with stakeholders the need for sampling and when. One size does not fit all.**
  - **If sampling is required, perform Incremental Sampling**
    - Typically produces significantly more representative data and is often the preferred characterization approach for MC at an MRS

34 Open Detonation Confirmatory Sampling Evaluation RITS 2013: What's Up in the Munitions Response Program?

- The Army Corps of Engineers (ACOE) performed a similar evaluation and has basically come to the same general conclusions regarding determining the need for Post-BIP sampling and to perform Incremental Sampling when sampling is to be done.

Take-Away Messages (cont.)

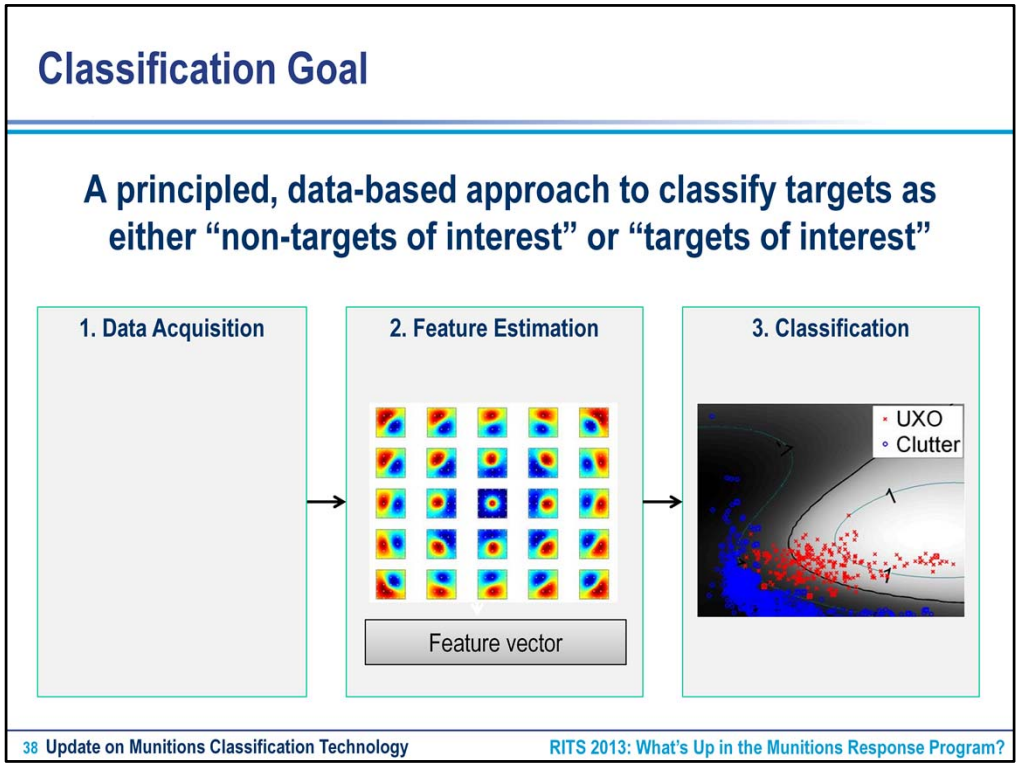
- **Project Planning Stage (cont.)**
  - **For High-Order Detonations**
    - If required to sample, perform initial sampling inside detonation crater only, and
    - If initial results are consistently below RSLs, consider reduced frequency of sampling or discontinue sampling after demonstrating that the contractor routinely performs high-order detonations
  - **For Incomplete Detonation**
    - Perform routine post-detonation clearance maintenance, and then
    - Perform sampling both inside and outside detonation crater

Take-Away Messages (cont.)

- **Detonation Event Planning, Setup, and Execution**
  - **Use only the required amount of donor charge for the amount of munitions to be detonated**
  - **Use engineering controls when and where applicable**
  - **Record on reports whether a detonation event is either a high-order or an incomplete detonation**
  - **Do not excavate soils unless visibly-impacted**
  - **Do not over-excavate visibly-impacted soils after detonation**
    - Can lead to unnecessarily increasing the amount and cost of soils to be disposed

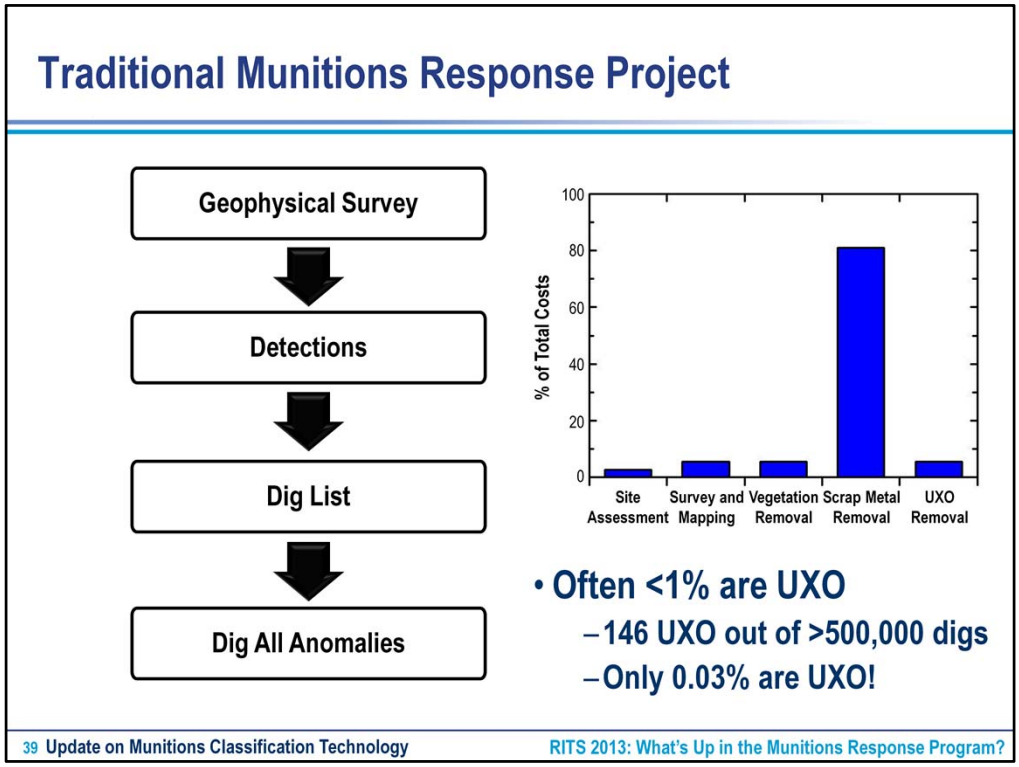
Presentation Overview

- Open Detonation Confirmatory Sampling Evaluation
- ► Update on Munitions Classification Technology
- Navy Detection Technologies for Underwater Munitions
- Munitions Response RI/FS Guidance
- Summary



- The standard approach to classification is:
  1. collect geophysical data over the target;
  2. use those data to derive parameters of the buried target (sometimes called features); and
  3. use those parameters to classify the buried target as UXO or not.

- Classification benefits:
  - Reduce the time EZs, evacuations, road closures, etc. are in place
  - Possible cost avoidance of up to 75%, thus clearing more acres for the same amount of money
  - Reduced excavation will mean less ecological damage
  - Offers a better understood and documented product
    - Rigorous and reviewable
    - Tied to TOI and not every piece of metal



- Traditional approach identifies all metal items that are then dug up to determine if munitions. Typically, most items are NOT munitions. Digging up non-munitions related items is expensive and time consuming.

- The new munitions classification technology allows you to better identify the item in the field without digging it up.

Update on Munitions Classification Technology

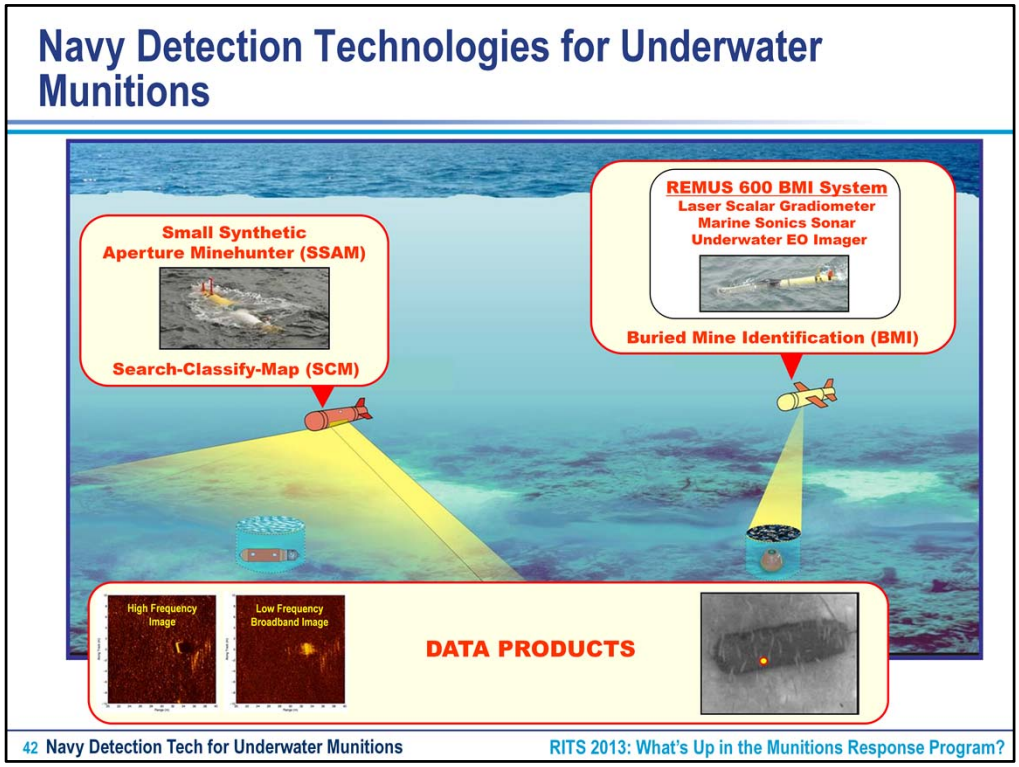
- New MR RI/FS Guidance discusses the technology and considerations for use
  - Depends on site-specific factors
- Advanced MRP Course gives more detail on what it is
- Currently only performed for terrestrial sites
- Interstate Technology and Regulatory Council (ITRC) Geophysical Classification for Munitions Response Team
  - Classification Case Study at Former Camp Beale, CA
  - Draft Technical Fact Sheet on Geophysical Classification for Munitions Response
- ESTCP's Guidance for Implementing Advanced Classification on Munitions Response Sites (being updated)

40 Update on Munitions Classification Technology RITS 2013: What's Up in the Munitions Response Program?

- See Geophysical Classification for Munitions Response Team Fact Sheet (October 2012) for stakeholders.
- RITS 2012 Topic on "Implementing Classification on Munitions Response Projects"

Presentation Overview

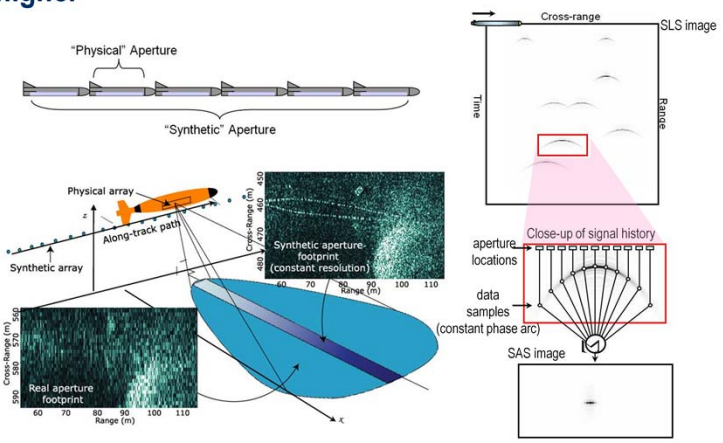
- Open Detonation Confirmatory Sampling Evaluation
- Update on Munitions Classification Technology
- ► Navy Detection Technologies for Underwater Munitions
  - Synthetic Aperture Sonar (SAS)
  - Laser Scalar Gradiometer (LSG)
- Munitions Response RI/FS Guidance
- Summary



- These technologies have better detection capabilities than the ones used by UXO contractors.
- These technologies are not commercially available and are only available via Navy EOD units.
- Comparison table for underwater technologies will be in the new MR RI/FS Guidance document.

Synthetic Aperture Sonar (SAS) – What is it?

- **SAS combines a number of acoustic pings to form a sonar image with much higher resolution than conventional sonars, typically 10 times higher**



43 Navy Detection Tech for Underwater Munitions RITS 2013: What's Up in the Munitions Response Program?

- More signals = more data = more computer processing intensive

SAS – Why/When to Use It

- Multi-ping SAS processing produces range-independent, high-resolution seafloor images across complete swath
  - Swath width is typically 200 meters
- Lower frequency SAS has demonstrated detection of buried objects
- More effective in deeper depths
- Not effective in the surf zone (0-10 ft deep)

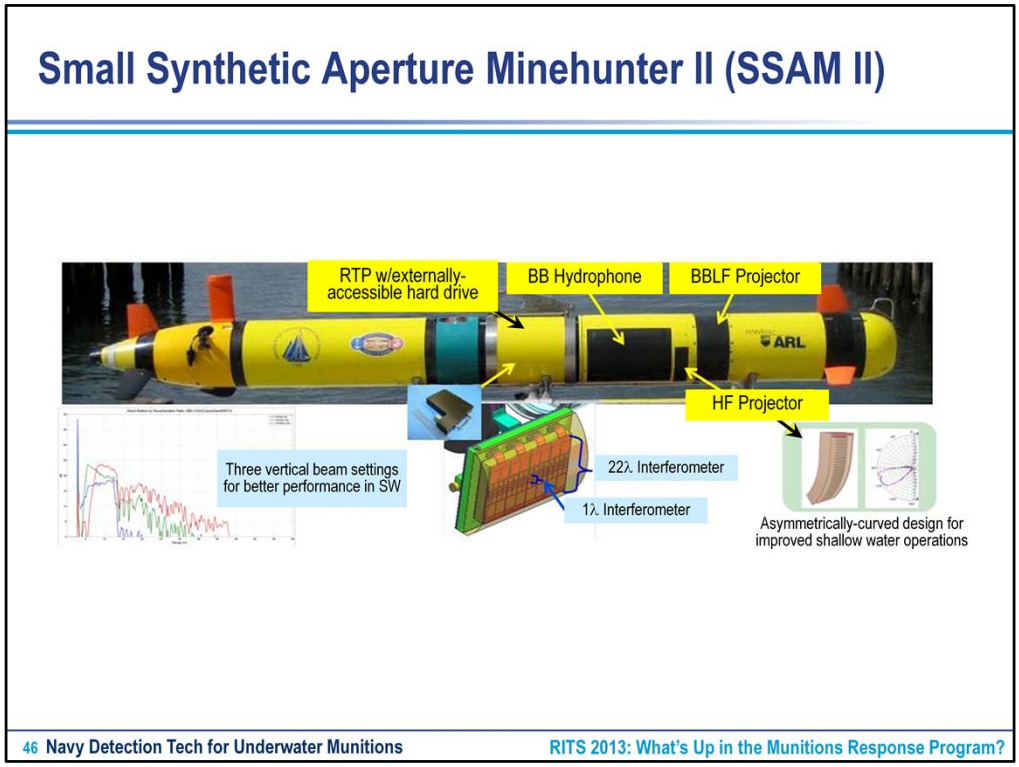
- Swath width allows more coverage of an area.
- System functionality is dependant on the sea conditions (needs to be calm seas) more than depth restrictions.
- Covers more area than what is done on a terrestrial transect.

SAS – Availability

- Owned by the U.S. Navy and operated by the Naval Surface Warfare Center (NSWC) Panama City Division (PCD)
  - Costs are significantly lower than UXO contractor with ability to generate higher resolution data
  - Contact NAVFAC Washington or EXWC for help in scheduling
- Integrated into the Small Synthetic Aperture Minehunter II (SSAM II) onboard sensor package
  - Location map of targets with GPS coordinates (GPS data file also)
  - Images of targets
  - Raw digital sonar data will not be released due to distribution classification

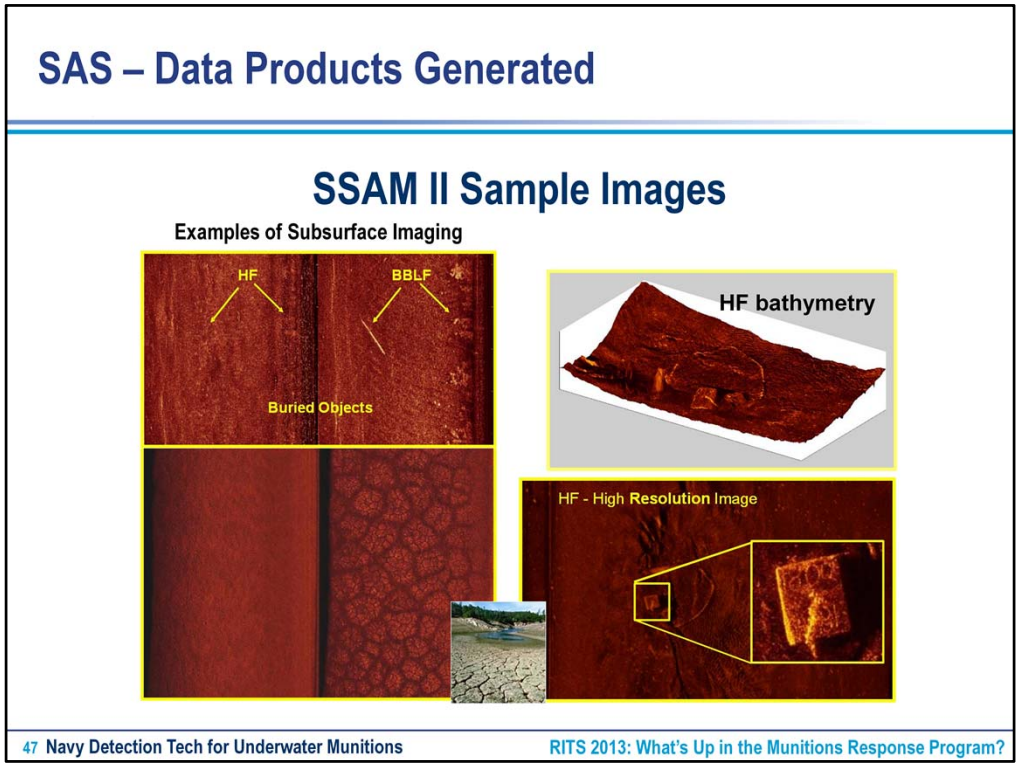
45 Navy Detection Tech for Underwater Munitions RITS 2013: What's Up in the Munitions Response Program?

- Contact Brian Wallace at NAVFAC Washington or Bryan Harre at NAVFAC EXWC.
- Brian Wallace can assist in developing a cost estimate.
- System can be deployed on a vessel (>35 ft in length), a pier, or a boat ramp launch. Unit can be containerized.



SSAM II System:

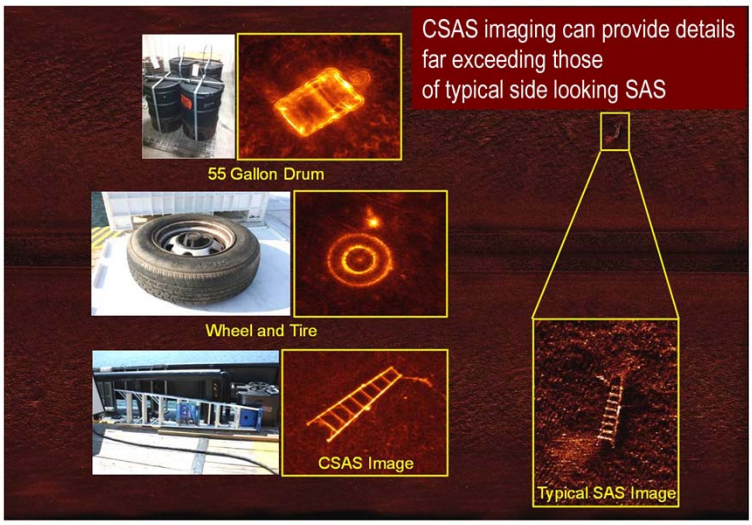
- Length = 14 ft
- Diameter = 12.75”
- Weight Dry = 675 lbs
- Mission Speed = 3 kts (vehicle rated up to 5 kts)
- Endurance = 10 Hours at 3 knots
- Max Depth = 600 ft

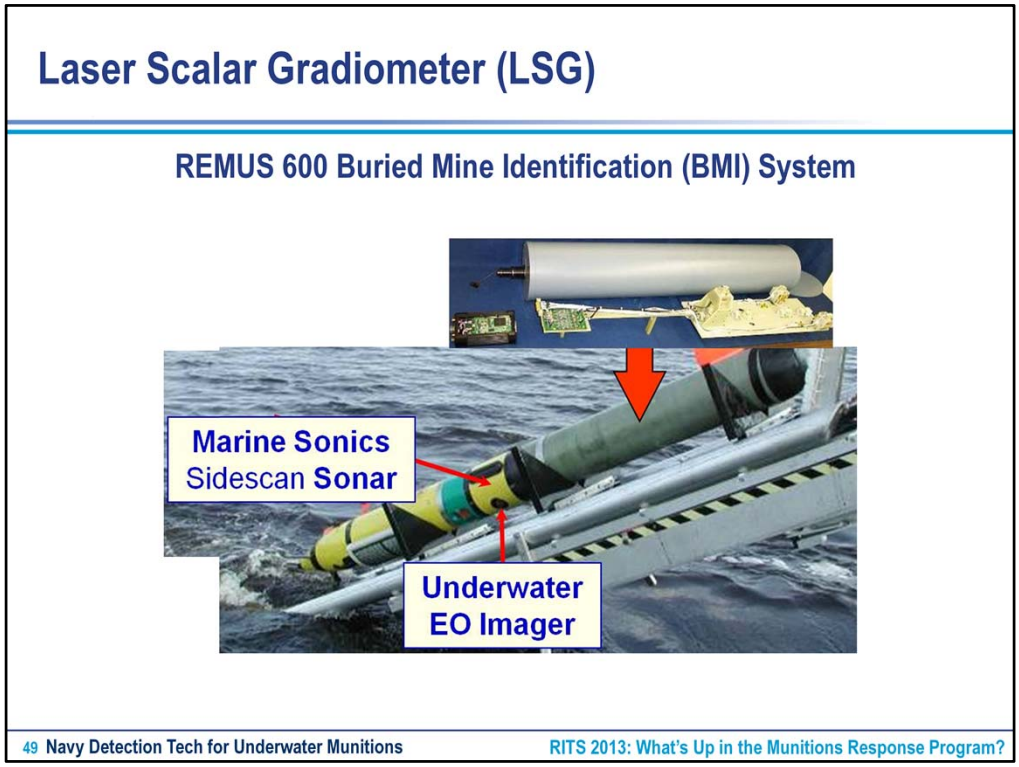


- HF – High Frequency
- BBLF – Broad Band Low Frequency

SAS – Data Products Generated (cont.)

SSAMII Closed Aperture SAS (CSAS) Imaging





- System can be deployed upon a vessel of opportunity (>35 ft in length), a pier, or a boat ramp launch. Unit can be containerized.
- REMUS 600 BMI System
  - Length = 168”
  - Diameter = 12.75”
  - Weight Dry = 660 lbs
  - Mission Speed = 3 kts (vehicle rated up to 5 kts)
  - Endurance = 12 Hours at 3 knots
  - Max Depth = 90 m with LSG in composite payload (vehicle rated to 600 meters)

LSG – What is it?

- Ultra-sensitive magnetic sensor
- Uses scalar, instead of vector sensing elements
- More modern sensor than the Real-Time Gradiometer (RTG)
- Intrinsically more sensitive than RTG
- Developed to detect, classify, and localize (DCL) buried underwater mines

LSG – Why/When to Use It

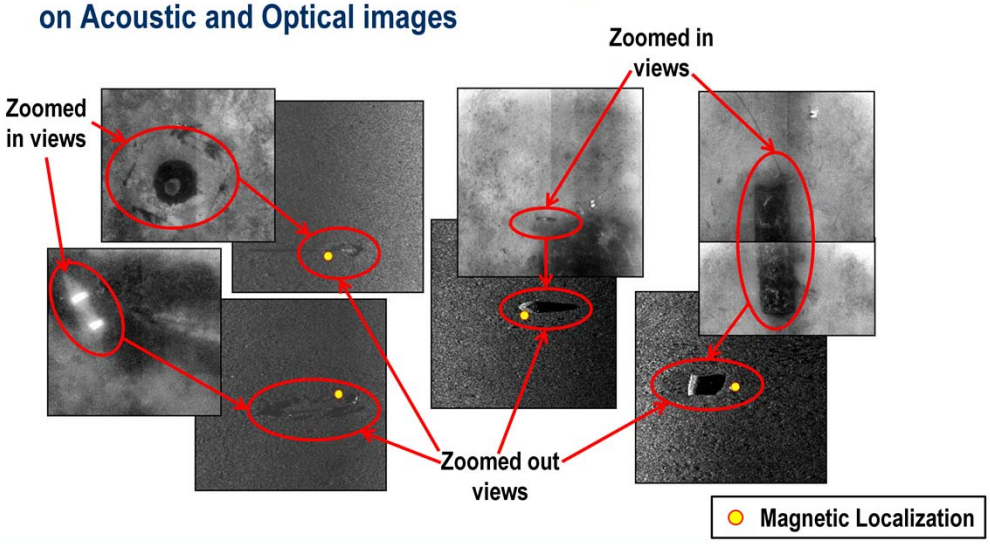
- Detects magnetic metals (ferrous)
- Used in challenging water environments characterized by high clutter, target burial, and low visibility (*i.e.,* ports)
- Used in conjunction with other sensors (sonar and electro-optic)
- Capability to detect proud and deeply buried targets (both conventional and low-observable)
- Owned by the U.S. Navy and operated by NSWC PCD

51 Navy Detection Tech for Underwater Munitions RITS 2013: What's Up in the Munitions Response Program?

- Same POCs as for SAS

LSG – Data Products Generated

- LSG Autonomous Localizations are co-registered with and overlaid on Acoustic and Optical images



Presentation Overview

- Open Detonation Confirmatory Sampling Evaluation
- Update on Munitions Classification Technology
- Navy Detection Technologies for Underwater Munitions
- ► Munitions Response RI/FS Guidance
- Summary

Munitions Response RI/FS Guidance

- Provides Navy guidance on conducting an RI/FS at a MRS
- Significant differences between an RI for a MRS and an RI for a traditional Installation Restoration (IR) site
- Provides information on unique challenges and requirements posed on cleaning up a MRS
- Available for distribution by end of 4th Quarter FY13

Presentation Overview

- Open Detonation Confirmatory Sampling Evaluation
- Update on Munitions Classification Technology
- Navy Detection Technologies for Underwater Munitions
- Munitions Response RI/FS Guidance
- ► Summary

Key Take-Home Points

- **Open Detonation Confirmatory Sampling Evaluation**
  - **Discuss with stakeholders during initial project planning the need for sampling for high-order/incomplete detonations and where to sample**
  - **If sampling, perform Incremental Sampling**
    - <0.5% of all of the results exceeded the Residential RSLs
    - Out of all of the samples collected only a few (<5.6%) had results that exceeded the Residential RSLs
  - **Document the type of detonation in reports**

Key Take-Home Points (cont.)

- Munitions Classification Technology Update
  - New MR RI/FS Guidance discusses considerations for use
  - Currently only performed for terrestrial sites
- Navy Underwater Technologies (SAS & LSG)
  - Multi-ping SAS processing produces range-independent, high-resolution seafloor images
  - LSG is an ultra-sensitive magnetic sensor used in challenging VSW environments characterized by high clutter, target burial, and low visibility (*i.e.,* ports)
  - Raw digital sonar data will not be released due to distribution classification

References

- EPA Federal Facilities Forum Issue Paper on Site Characterization for Munitions Constituents (2012)
- EPA SW8330B method guidance document
- ITRC's Incremental Sampling Methodology Technology Regulatory and Guidance Document (ISM-1, February 2012)
- Interstate Technology and Regulatory Council (ITRC) Geophysical Classification for Munitions Response Team
  - Introduction to Geophysical Classification for Munitions Response Team Fact Sheet
  - Classification Case Study at Former Camp Beale, CA
  - Draft Technical Fact Sheet on Geophysical Classification for Munitions Response

References (cont.)

- ESTCP's Classification on Munitions Response Sites
- ESTCP's Guidance for Implementing Advanced Classification on Munitions Response Sites: A Guide to Informed Decision Making For Project Managers, Regulators, and Contractors