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Starting Soon: Geophysical Classification for Munitions Response

- Geophysical Classification for Munitions Response (GCMR-2) at http://www.itrcweb.org/gcmr-2/
- Download PowerPoint file
  - Clu-in training page at http://www.clu-in.org/conf/itrc/gcmr/
  - Under “Download Training Materials”
- Using Adobe Connect
  - Full Screen button near top of page
  - Related Links (on right)
    - Select name of link
    - Click “Browse To”
  - Submit questions in the lower right
- Follow ITRC

No associated notes.

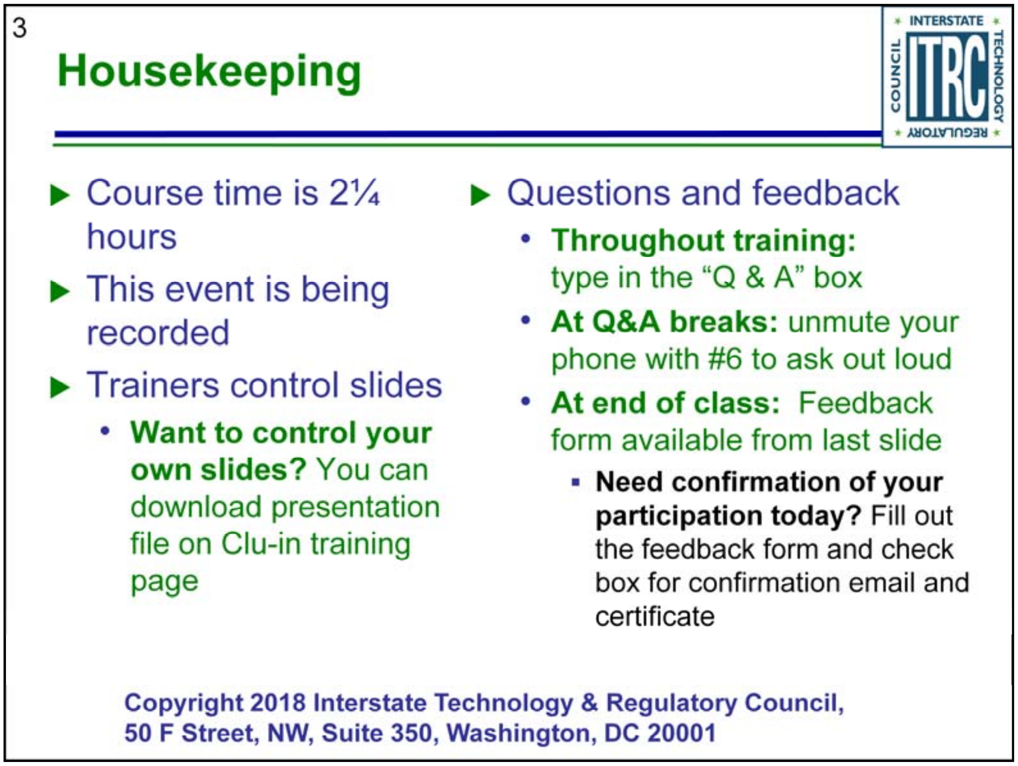
For decades, the U.S. Department of Defense (DOD) has produced and used military munitions for live-fire testing and training to prepare the U.S. military for combat operations. As a result, unexploded ordnance (UXO) and discarded military munitions may be present at over 5,200 former ranges and former munitions operating facilities throughout the United States. With the traditional technique to identify munitions for removal at these sites, DOD and its contractors have used various types of detection instruments to simply detect buried metal objects then excavation and examination of most of the detected items, to determine whether or not they are military munitions. Even highly trained UXO-qualified personnel typically excavate hundreds of metal items for each one munition recovered. Nearly half of these sites require a munitions response, at an estimated cost to complete of $14 billion and with a completion date of 2100. To improve the efficiency of munitions response, DODs Environmental Security Technology Certification Program and its research partners in academia and industry have developed a new approach: geophysical classification. Geophysical classification is the process of using advanced data to make principled decisions as to whether buried metal objects are potentially hazardous munitions (that is targets of interest) that should be excavated, or items such as metal clutter and debris (non-targets of interest) that can be left in the ground.

ITRCs Geophysical Classification for Munitions Response (GCMR-2, 2015) and training class explain the process of geophysical classification, describe its benefits and limitations, and discuss the information and data needed by regulators to monitor and evaluate the use of the technology. This document and training also emphasize using a systematic planning process to develop data acquisition and decision strategies at the outset of a munitions response effort, as well as quality considerations throughout the project. Stakeholder issues that are unique to munitions response are also discussed. After this training class, participants will:

- Understand the technology and terminology
- Be ready to engage in the planning process to address quality considerations throughout a project
- Find tools to transfer knowledge within organizations and to stakeholders
- Start to transition mindset to decisions that leave non-hazardous items in the ground

An audience who understand current munitions response tools and procedures (for example, geophysical surveys, sensors, data analysis) will benefit most from this document and training. For federal and state environmental regulators, scientists, and engineers, as well as contractors, munitions response managers, technical staff, geophysicists, and stakeholders, this document explains how geophysical classification can be used in munitions response. Stakeholders with an interest in a particular munitions response site (MRS) at which classification has been or may be proposed will also benefit from this document and training.

ITRC (Interstate Technology and Regulatory Council) www.itrcweb.org
Training Co-Sponsored by: US EPA Technology Innovation and Field Services Division (TIFSD) (www.clu-in.org)
ITRC Training Program: training@itrcweb.org; Phone: 402-201-2419

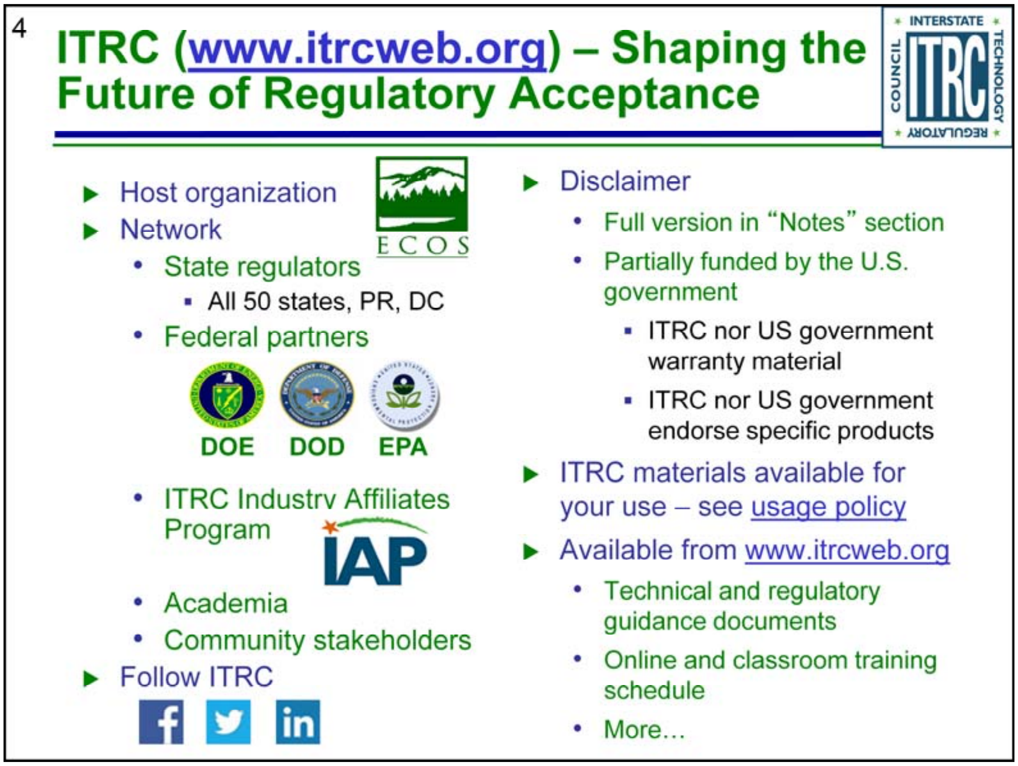


Although I'm sure that some of you are familiar with these rules from previous CLU-IN events, let's run through them quickly for our new participants.

We have started the seminar with all phone lines muted to prevent background noise. Please keep your phone lines muted during the seminar to minimize disruption and background noise. During the question and answer break, press #6 to unmute your lines to ask a question (note: *6 to mute again). Also, please do NOT put this call on hold as this may bring unwanted background music over the lines and interrupt the seminar.

Use the "Q&A" box to ask questions, make comments, or report technical problems any time. For questions and comments provided out loud, please hold until the designated Q&A breaks.

Everyone – please complete the feedback form before you leave the training website. Link to feedback form is available on last slide.



The Interstate Technology and Regulatory Council (ITRC) is a state-led coalition of regulators, industry experts, citizen stakeholders, academia and federal partners that work to achieve regulatory acceptance of environmental technologies and innovative approaches. ITRC consists of all 50 states (and Puerto Rico and the District of Columbia) that work to break down barriers and reduce compliance costs, making it easier to use new technologies and helping states maximize resources. ITRC brings together a diverse mix of environmental experts and stakeholders from both the public and private sectors to broaden and deepen technical knowledge and advance the regulatory acceptance of environmental technologies. Together, we're building the environmental community's ability to expedite quality decision making while protecting human health and the environment. With our network of organizations and individuals throughout the environmental community, ITRC is a unique catalyst for dialogue between regulators and the regulated community.

For a state to be a member of ITRC their environmental agency must designate a State Point of Contact. To find out who your State POC is check out the "contacts" section at www.itrcweb.org. Also, click on "membership" to learn how you can become a member of an ITRC Technical Team.

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Fred Vreeman is a retired regulator and teaches environmental science at University of Alaska – Fairbanks. Through April 2016, he managed Alaska's regulatory oversight of Federal cleanups from the Fairbanks office of the Department of Environmental Conservation. Since 2008, he has been involved in munitions response actions as Alaska, working with the Defense Department to clean up buried munitions at many sites from the World War II and Cold War eras. From 2009-2016, Fred served as Alaska's representative to the Interstate Technology and Regulatory Council (ITRC), and he is a current member of several technical teams developing guidance for new remediation technologies. He routinely presents at remediation technology conferences, training state or federal regulators and project managers in superfund (CERCLA) implementation, project plan (UFP-QAPP) development, chlorinated solvent remediation technologies, petroleum risk analysis, and high resolution site characterization. His public service career includes management positions with Alaska's Oil and Gas Division and with the Department of Natural Resources. His private career includes National Park Resort development, medical device development for the US Army, and various energy, water and wastewater projects as principal investigator, scientist, inventor and engineer. Fred earned bachelor's degrees in Natural Sciences and Sociology in 1981 from Dordt College in Iowa, a master's degree in Engineering Management in 1987 from the University of Alaska in Anchorage. He is now working as a riverboat captain for adventurous guests discovering Alaska's Yukon River, and during his spare time he's pursuing a Ph.D. in Environmental Engineering at University of Alaska, Fairbanks.

Dean Keiswetter is the Chief Scientist and Division Manager at Acorn Science & Innovation, Inc. (AcornSI) in Cary, North Carolina. He has worked for AcornSI since 2014. Dean is the program manager and technical project lead for the research and application of detection and classification technologies for unexploded ordnance (UXO). His group provides geophysical investigations designed to quantitatively classify hazardous UXO from non-hazardous clutter while simultaneously documenting the decisions via data products, quality control procedures, quality assurance plans, and standard operating procedures. Previously, Dean worked for Leidos for a year and for Science Applications International Corporation for 7 years. He is an active member of the ITRC Geophysical Classification for Munitions Response (GCMR) team and was the 2012 and 2014 ITRC Industry Recognition Award Winner from GCMR team. Dean earned a bachelor's degree in Geology/Earth Science from Fort Hays State University in Hays, Kansas in 1989, a master's degree in Geophysics from the University of Kansas in Lawrence, Kansas in 1991, a doctoral degree in Geophysics from the University of Kansas in Lawrence, Kansas in 1995, and an MBA from the University of North Carolina at Chapel Hill - Kenan-Flagler Business School in 2001.

Ed Walker is a Unit Chief in the Hazardous Waste Management Program and has worked on munitions response for the California Department of Toxic Substances Control in Sacramento since 2001. He has been a member of the ESTCP Classification advisory group and provided regulatory review of geophysical classification demonstrations on sights throughout the country since 2008. Ed has been the project manager for classification projects conducted at the Former Fort Ord and the Formerly Used Defense sites Camp San Luis Obispo and Camp Beale. He has been on the ITRC Geophysical Munitions Response team since 2012. Ed earned his bachelor's degree in mechanical engineering from California State University Sacramento in 2000 and is a California Licensed Civil Engineer.

William (Ed) Corl is the deputy director of the NAVSEA Laboratory Quality & Accreditation Office (LQAO) in Norfolk, Virginia and had worked for LQAO since 2006 and in the field of environmental chemistry since 1989. He oversees the Navy Shipyard materials and engineering laboratory accreditation program and also coordinates work on various areas of environmental data planning, sampling, and analysis. He previously worked for 12 years performing environmental analysis for the Naval Public Works Laboratory at the Norfolk Naval Base and then 6 years in the technical support division for NAVFAC Atlantic where he served as in-house expert on emerging contaminants, analytical chemistry and analysis, and risk assessments as part of the Environmental Restoration (ER) program. Ed earned a bachelor's degree in biochemistry in 1989, a master's degree in environmental chemistry in 1997, and a Ph.D. in environmental engineering in 2015 - all at Old Dominion University in Norfolk, VA. He is a certified environmental chemist by the National Registry of Certified Chemists (NRCC).

Herb Nelson has been the Program Manager for Munitions Response at SERDP and ESTCP since 2008. Prior to that he was a Research Chemist at the Naval Research Laboratory in Washington, DC. He has worked on problems associated with the detection and classification of unexploded ordnance since 1995; focusing most recently on classification using advanced electromagnetic induction sensors. He has been a member of the ITRC since 2008 on the Unexploded Ordnance team and Geophysical Classification for Munitions Response team. He earned a bachelor degree in Chemistry from Tulane University in New Orleans, LA in 1975 and a Ph. D. in Physical Chemistry from the University of California, Berkeley in 1980.

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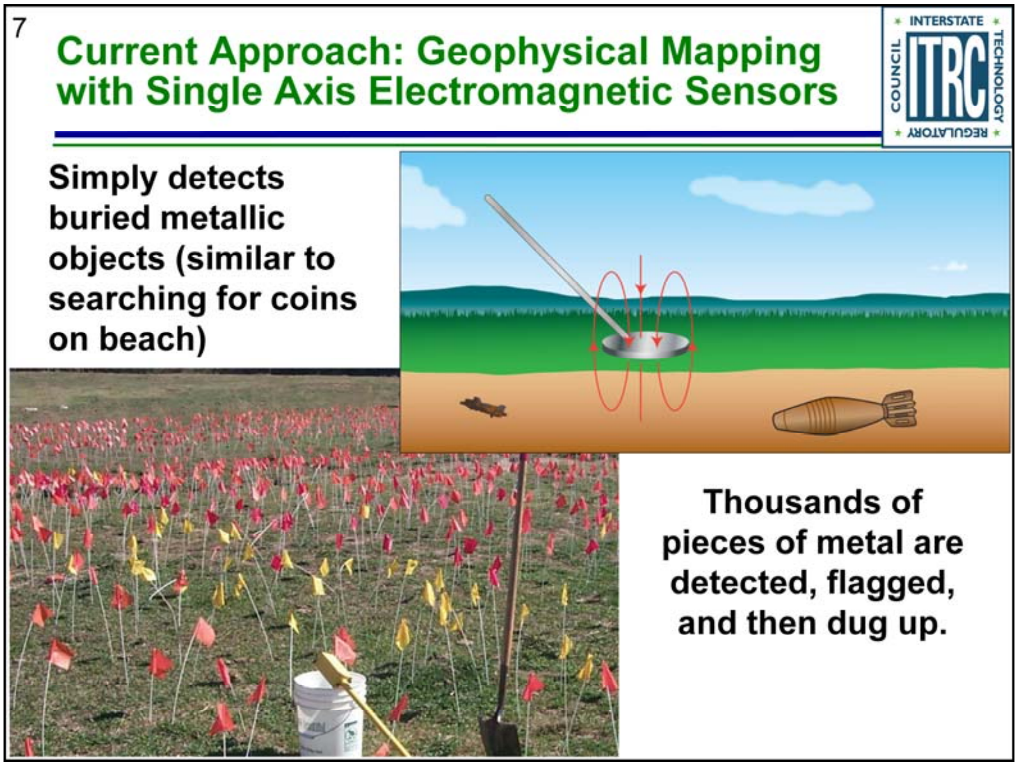
The Problem: Over 5,200 Sites in U.S. Half Require Munitions Response

- **Why:** To prepare U.S. military for combat operations, DOD used military munitions for testing and training
- Resulted in unexploded ordnance (UXO) and discarded military munitions (DMM) present at many sites requiring excavation

Video courtesy of Lockheed Martin Corporation - copyright 2015

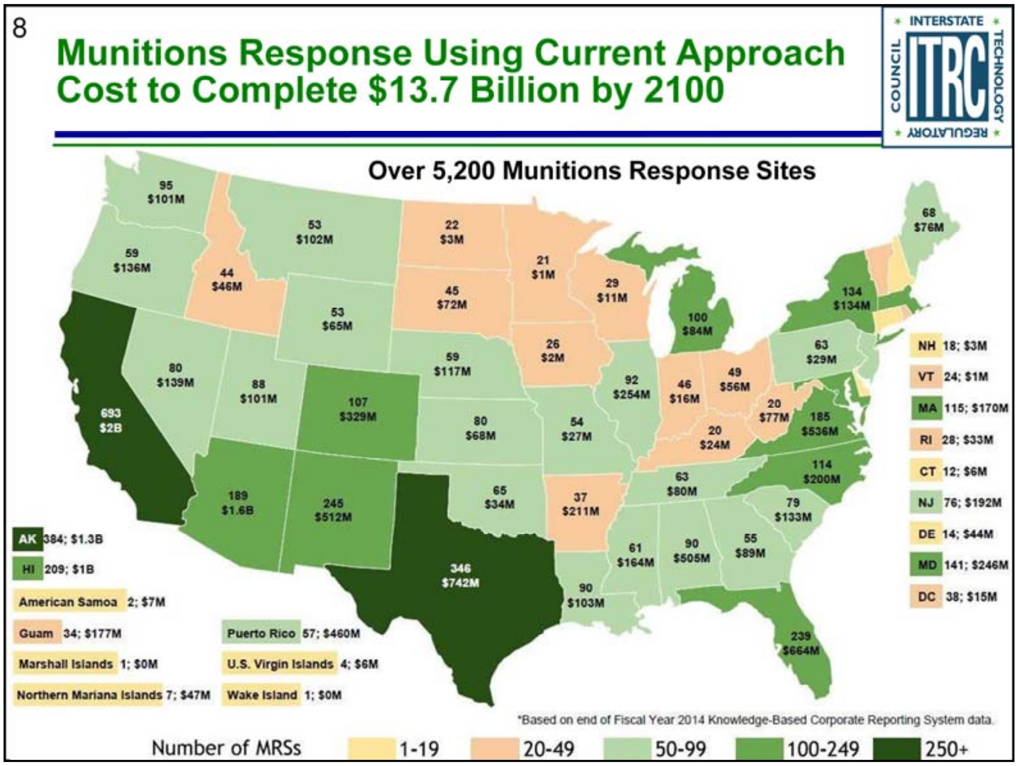
Example of munitions found at sites

Video of munitions and targets exploding on training range



- Current Technology: single axis sensors
- ITRC has been developing training and guidance on these for over 10 years

- Sea of Flags" - Thousands of pieces of metal are detected, flagged, and then dug up.



5200 sites all over America, and half of them will need some kind of geophysical investigation.

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In Need of a Better Way – Geophysical Classification Using Multi-Axis Sensors

Traditional Approach Single Axis Electromagnetic Sensor	New Approach Multi-Axis Electromagnetic Sensor
Simply detects buried metallic objects (similar to searching for coins on beach)	Identifies type of object present based on depth, size, density, wall thickness, shape
Requires that most detections are excavated	Limits excavations to objects identified as possible munitions or when data inconclusive (up to 80% digging reduction)
Less acreage covered	More acreage covered
Baseline technology for cost comparison	Estimated as 45% cost reduction from traditional approach
Extended area closures and evacuations	Reduces area closures and evacuations

Advantages of new technology

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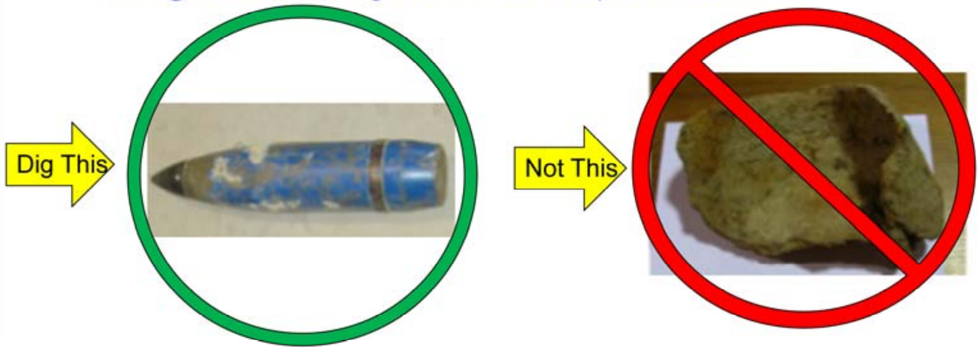
Geophysical Classification for Munitions Response (GCMR)

- Process of making principled decisions, using data collected by geophysical sensors, to ***differentiate between buried items that are potentially hazardous and those that can be safely left in the ground*** during munitions response actions



- "Classify" as possibly munitions or definitely not munitions
- Do not dig non-munitions items (Frag)

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GCMR – Accelerate Munitions Response Efforts

Focuses resources on investigation of metallic items identified as possible munitions or where the data are inconclusive

	Munition	Suspected Munition	Munition Fragment	Debris
Single Axis Sensor:	Dig	Dig	Dig	Dig
Multi-Axis Sensor: for Geophysical Classification	Dig	Dig	No Dig	No Dig

TOI = Dig List

Non-TOI = leave in place

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Technology Development through Department of Defense (DOD)

- Sensors and analysis originated in SERDP in decade of research and development
- Demonstrated in ESTCP Pilot Program at sites across the country

SERDP
DOD • EPA • DOE

ESTCP

Reference Materials at DOD Web Site

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Key Terminology

- Single-Axis Sensor: "Traditional" metal detector
- Multi-Axis Sensor: "New-Tech" used for classification
- Anomaly: Metallic item that causes a geophysical response
- Clutter: Non-hazardous metal "FRAGments"
- Targets of Interest (TOI): Maybe hazardous anomaly
- Classify: Determine whether "Frag" or "TOI"
- Validate: Prove your "classification" was "correct"
- QC & QA Seeds: Used to "validate" cleanup

Refer to Glossary

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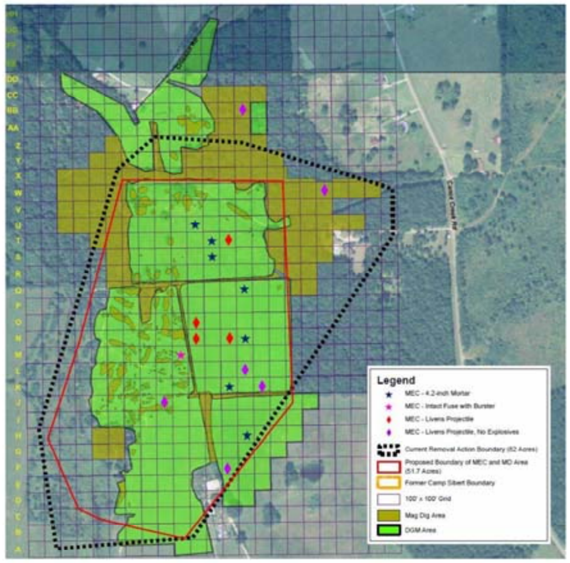
Example: Traditional “Single-Axis Sensors” at Camp Sibert in 2014

- **Single Axis Sensors**
- 5,295 excavations
- Symbols: 16 recovered UXO

Traditional approach:

- All items identified were excavated
- Over 99% of items excavated were non-hazardous items



GCMR-2, Appendix A

Camp Sibert – using single axis sensor

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Example: Geophysical Classification Demonstration at Camp Sibert in 2013

- **"Multi-Axis" Sensors used**
- 6,055 **anomalies** identified
- 970 excavated
  - All of "**QA seeds**" and three 4.2 in. mortars were correctly classified
  - 4% "**TOI**" plus 3% "**QC**" plus 2% discernable targets
  - 7% additional "**Clutter**" targets were excavated that were "**Classified**" non-hazardous to "**Validate**"
- 84% of the targets were non-hazardous items left in the ground

Figure A-9. MetalMapper in use at Camp Sibert Site 18

GCMR-2, Appendix A

Camp Sibert: using multi-axis sensor

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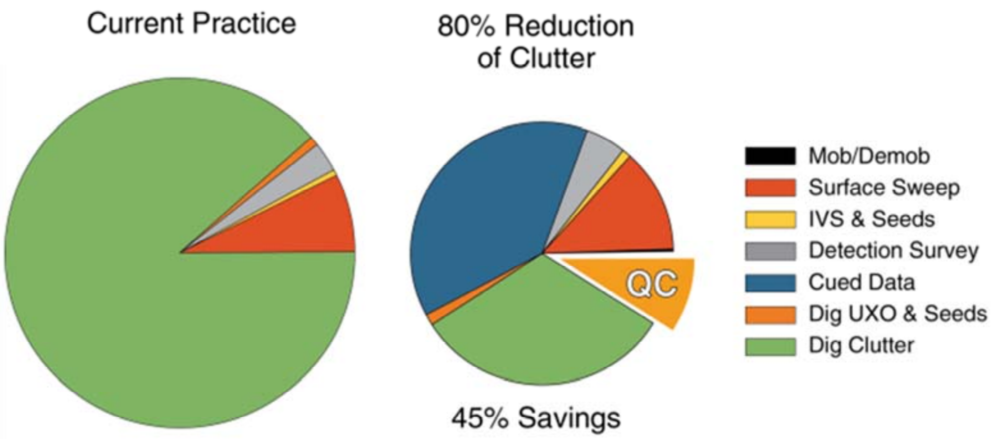
Technology Benefits – 45% Cost Savings

Cost Savings using Multi-Axis Sensors – at least 45%



GCMR-2, Figure 2-17

Cost savings

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You May Have Questions About Geophysical Classification

- How does the technology work?
- When to use and when not to use geophysical classification?
- What is the state regulators' role to ensure quality and confidently support decisions?
- Provide a case study where geophysical classification is used

Answers in ITRC's Geophysical Classification for Munitions Response (GCMR-2, 2015) and this associated training class

No associated notes.

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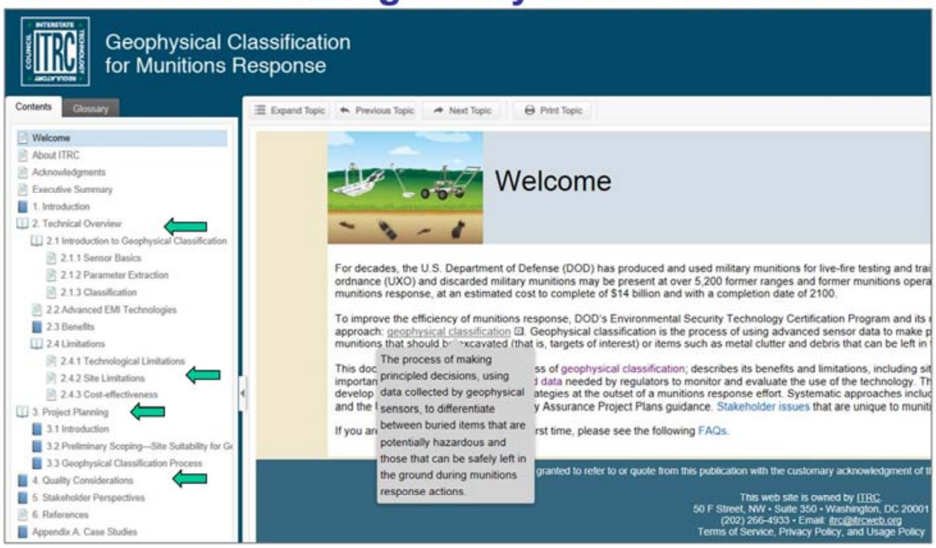
Geophysical Classification for Munitions Response (GCMR-2) August 2015

ITRC Technical & Regulatory Guidance Web-Based



Terminology – definitions pop up in web based document

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ITRC Geophysical Classification for Munitions Response Team

- Team evaluated technology
- Concluded geophysical classification is ready for use on production projects
- No regulatory barriers
- Team products include three Fact Sheets and Guidance Document
  - Fact Sheets
    - Introductory
    - Technical
    - Regulatory
  - Guidance Document

GCMR-1, GCMR-2

No associated notes.

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After Today's Training You Should be able to Use the ITRC GCMR Documents to…..

- Understand the technology to evaluate for use on your site
- Learn some Geophysical Classification and Munitions Response (GCMR) terminology
- Start to transition your mindset to decisions that leave non-hazardous items in the ground
- Find tools to transfer knowledge within your organization and to stakeholders

No associated notes.

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Presentation Overview

- Introduction
- **Technology and Background**
- Site Suitability
- Questions and Answers
- Quality Considerations
- Example Case Study
- Wrap Up

Introduced by prior speaker

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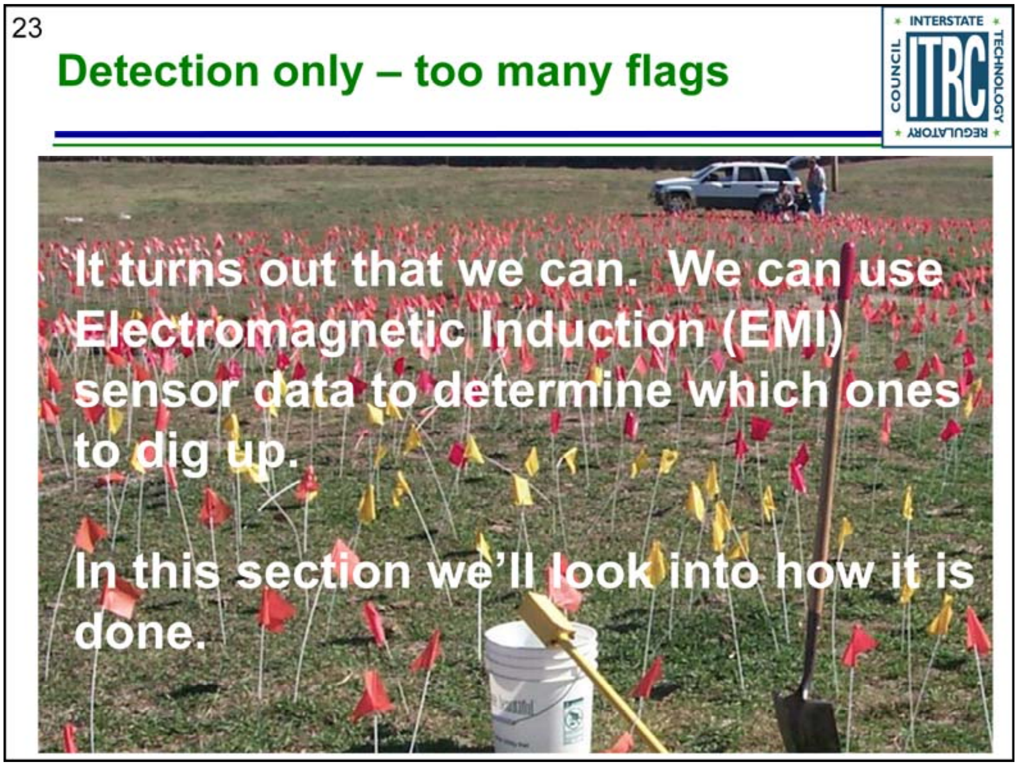
Detection only – too many flags

- Real site
- often lots of flags
- in past had to dig all, wouldn’t it be nice if we knew which ones were targets of interest and actually need to be dug up



- Real site
- often lots of flags
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Outline for this section…

1. How the sensors work and what they look like
2. How we utilize the acquired data
3. How the classification decision is made

Organization of talk

Sounds very technical and unfamiliar but will use analogy to help understand

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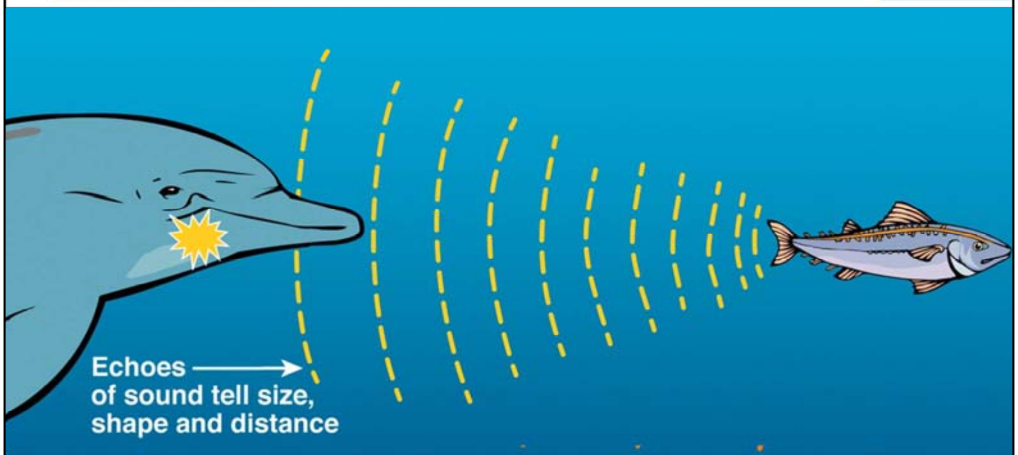
Echolocation: a Familiar Analogy



- Acoustic waves…locating objects by reflected sound. Used by dolphins and bats…

No associated notes.

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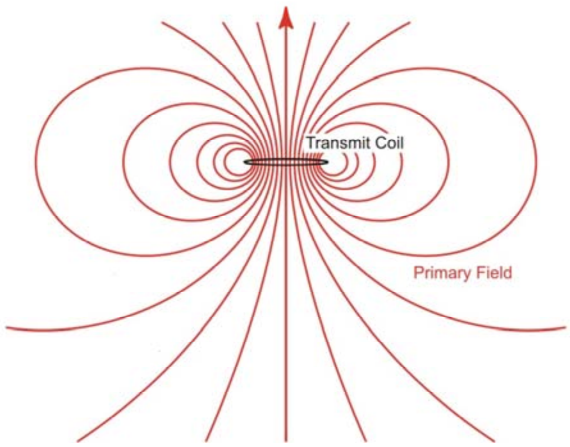
EMI: The Source

- Regulate electrical current in a wire to produce a time-varying magnetic field



Excitation Pulse

Set up a field

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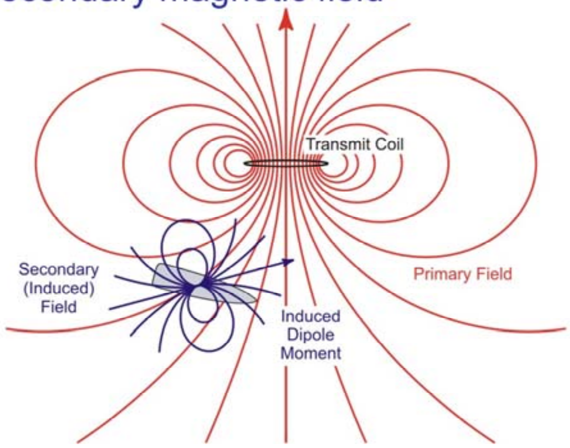
EMI: Interaction with Object

- Time-varying magnetic field induces electrical currents in nearby metallic objects, which in turn generates a secondary magnetic field



Induced Target Response

Interaction with target

Here’s diff between echo location and what EMI does

Electrical currents are induced in target and those create secondary electrical field (the ‘reflection’) and that is what we measure

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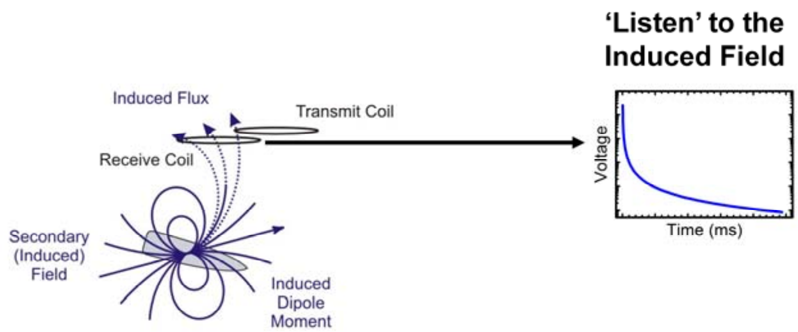
EMI: Received Signal

- Secondary magnetic field is measured by Receive Coils



Turn off inducing field and 'listen' to the induced field, which is how we get information about the target

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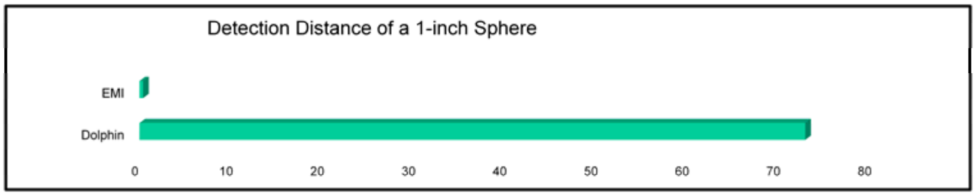
We've seen how the methods are similar, here is one major difference…

Distance: Using echolocation, Dolphins can detect a 2.54cm sphere at 73m!

Your chance to shine…
At what distance can EMI methods detect a 2.54cm metallic sphere?

Answer: 0.4m



EMI response is inversely proportional to the Distance^6 (sensor to object).

The sensors have to be very close to the object in order to detect and characterize buried objects!

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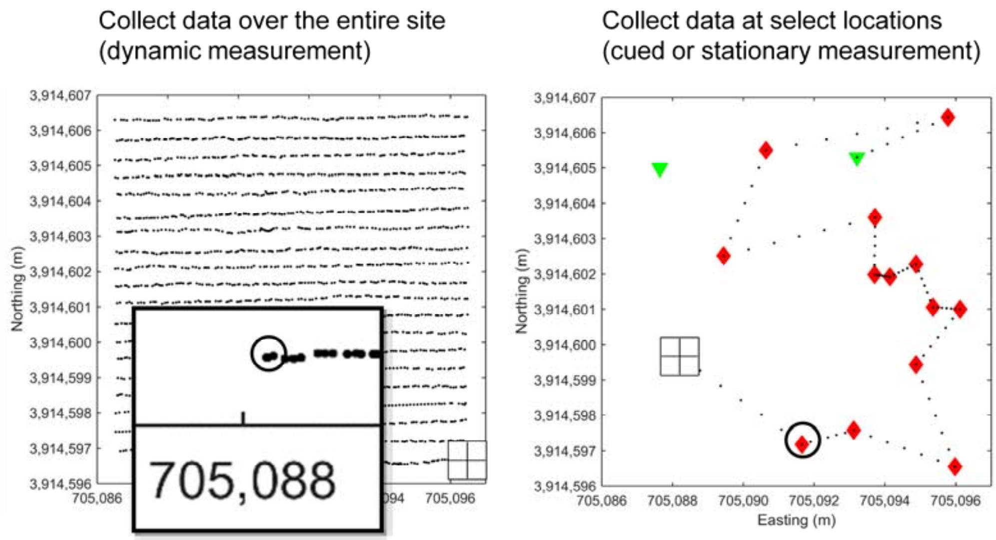
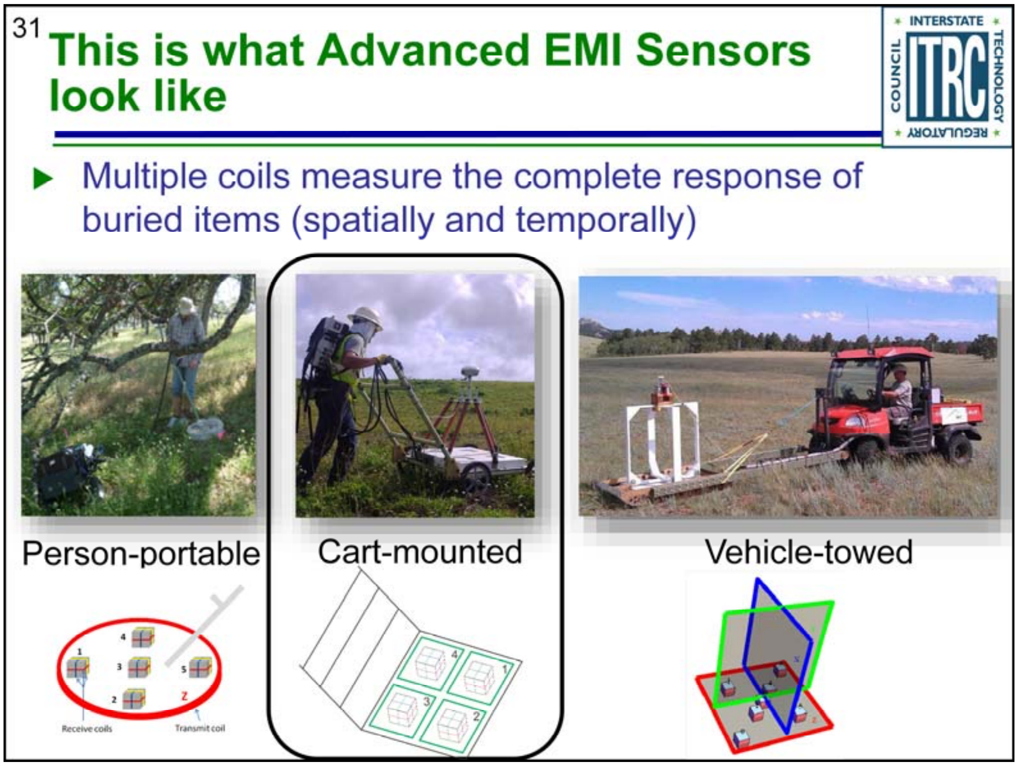
Two options for getting the sensors close to the buried objects…





These are prototypes. Standardization of sensors, manuals, procedures are being developed.

Various transmit and receiver setups, but all result in similar data sets as they all illuminate from multiple angles and receive at multiple locations

All fixed geometry - More and better data, better geolocated know where each data point is collected relative to the other data points

Deployment methods drove sensor design and different developers

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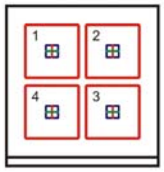
Advanced EMI Sensors: designed for UXO classification



Multiple transmitters and receivers are used to fully 'light up' or illuminate the object

Multi-axis receivers…for a given transmitter, additional information can be obtained by using multiple receivers orientated perpendicularly

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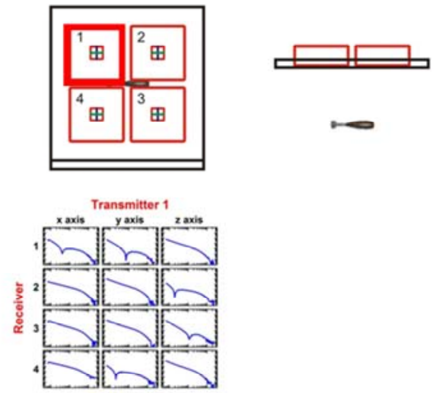
Measured data are affected by burial depth and object orientation



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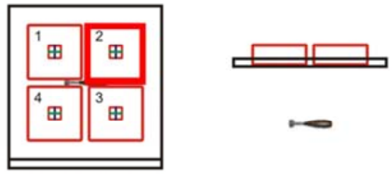
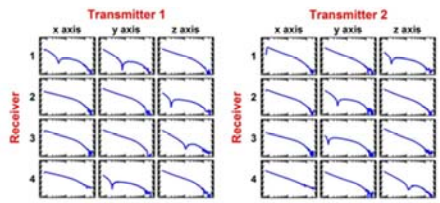
Measured data are affected by burial depth and object orientation





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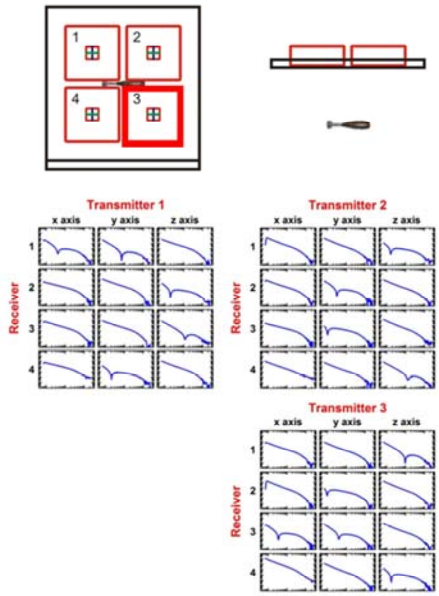
Measured data are affected by burial depth and object orientation



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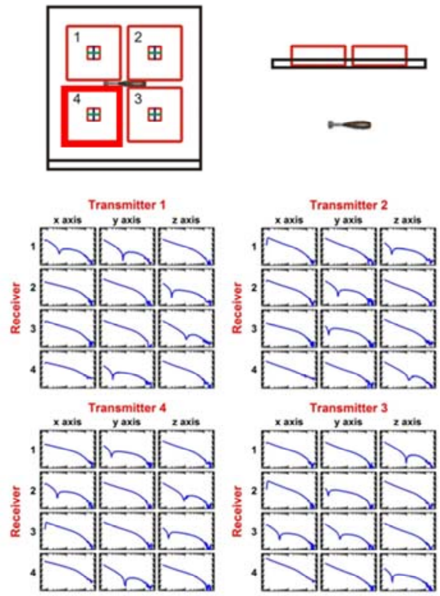
Measured data are affected by burial depth and object orientation



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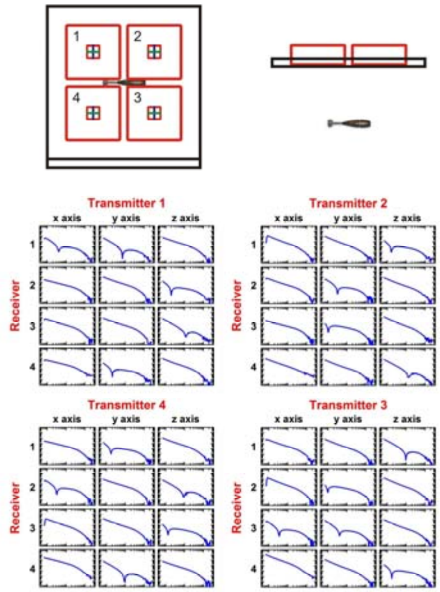
Measured data are affected by burial depth and object orientation



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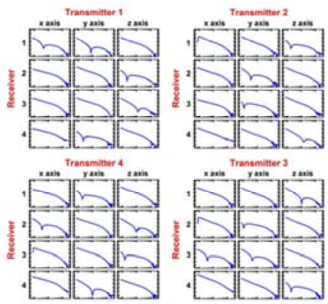
Process data to remove effects of burial depth and object orientation

Mathematical Model for the EMI Response

Pre-Process
- Remove sensor effects
- GPS coordinates



Sensor Data

location & orientation
(extrinsic properties)

+

polarizabilities
(intrinsic response; NOT affected by burial depth or orientation)

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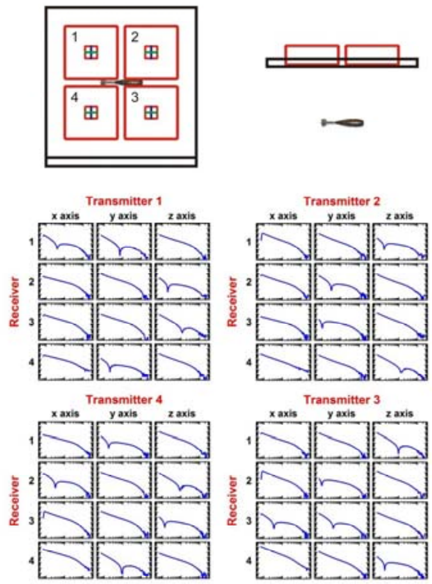
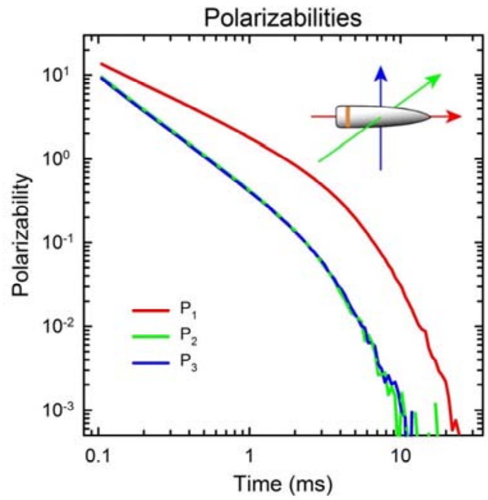
Polarizabilities do not change with burial depth or orientation





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Polarizabilities completely specify the target's EMI response characteristics

Object Property	Polarizability Property
Cylindrical Shape	Axial Symmetry
Wall Thickness	Decay Rate
Physical Size	Magnitude

Relate the item properties to pol properties

UXO, clutter columns show how they are different

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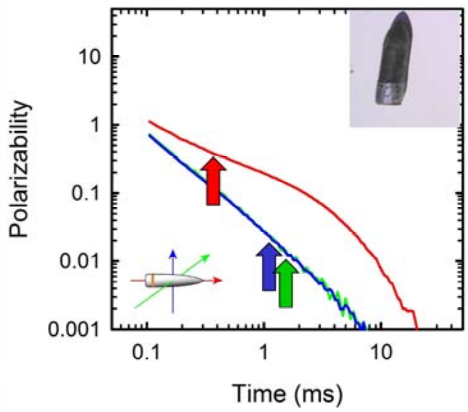
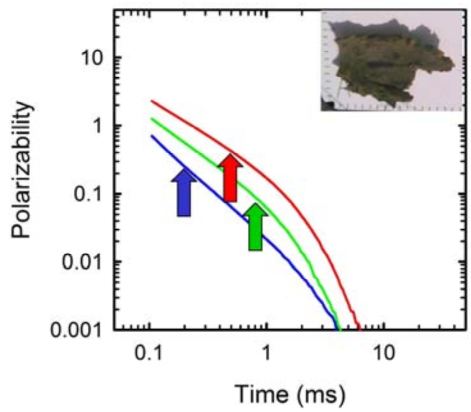
UXO are usually axial symmetric, clutter are not

Object Shape → Axial Symmetry

<u>UXO</u>
Cylindrical, axial symmetry



<u>Non-UXO</u>
Variable, often asymmetric

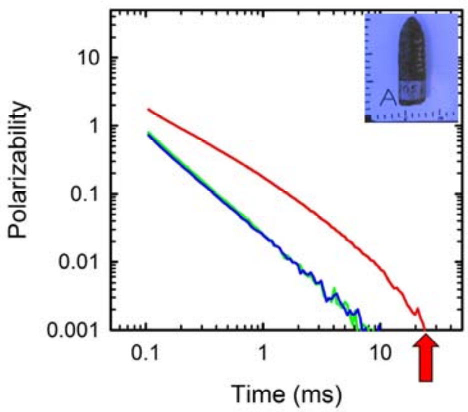


42

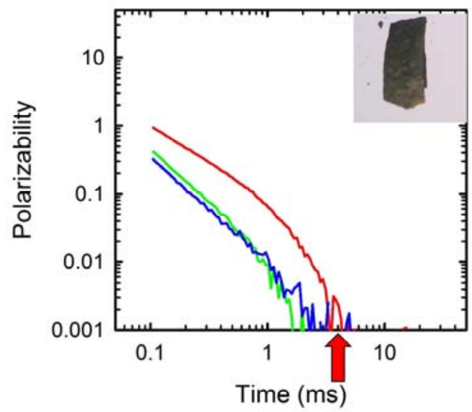
Thick-walled metal decays slower than thin-walled debris and clutter

Wall Thickness → Decay Rate

UXO
thick wall & slow decay



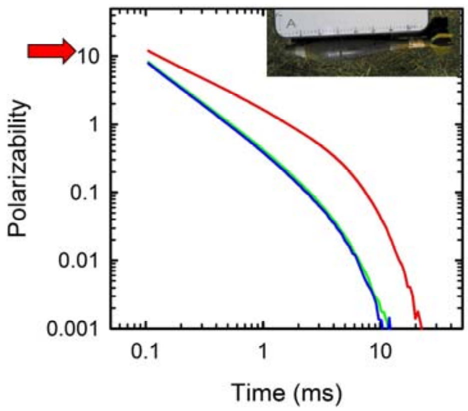
Non-UXO
thin wall & fast decay



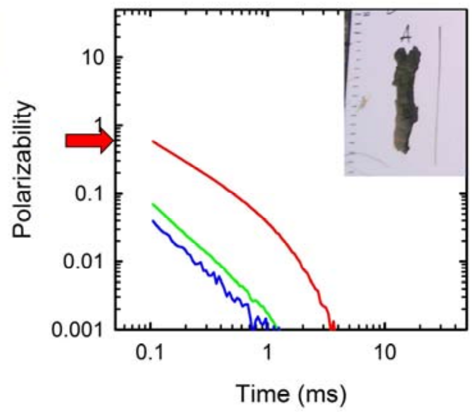
UXO vary in size (20mm to 155mm) but clutter is generally small

Size (volume) → Magnitude

UXO
Variable, often larger

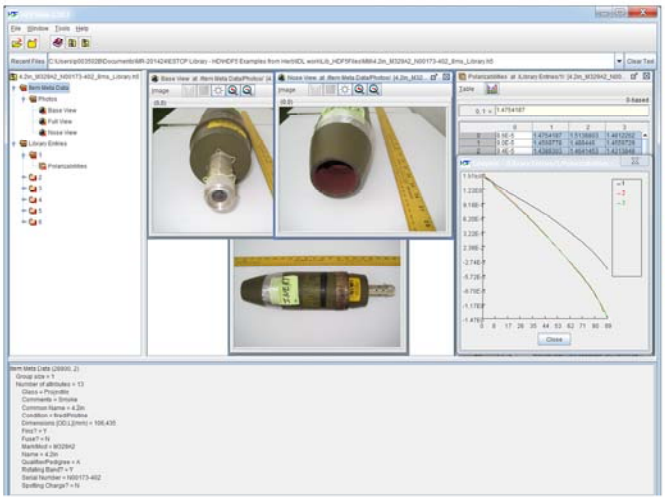


Non-UXO
Variable, majority are small



44

Target of Interest (TOI) Library



Collection of TOI signatures:

1. metadata,
2. sensor data, and
3. polarizations

ESTCP generated
DOD maintained

Polarizabilities are what we want to track

Try to measure and document all different types of items so we can compare against measurements

The government (through ESTCP) is developing this library and the DOD has signed up to maintain and make available to users in the future

Decision Process

Review:

- We know what is being measured
- We know how to process it
- We know what we are looking for
- Now what?

We prioritize the sources from those that are most similar to UXO (our library) from those that are not…

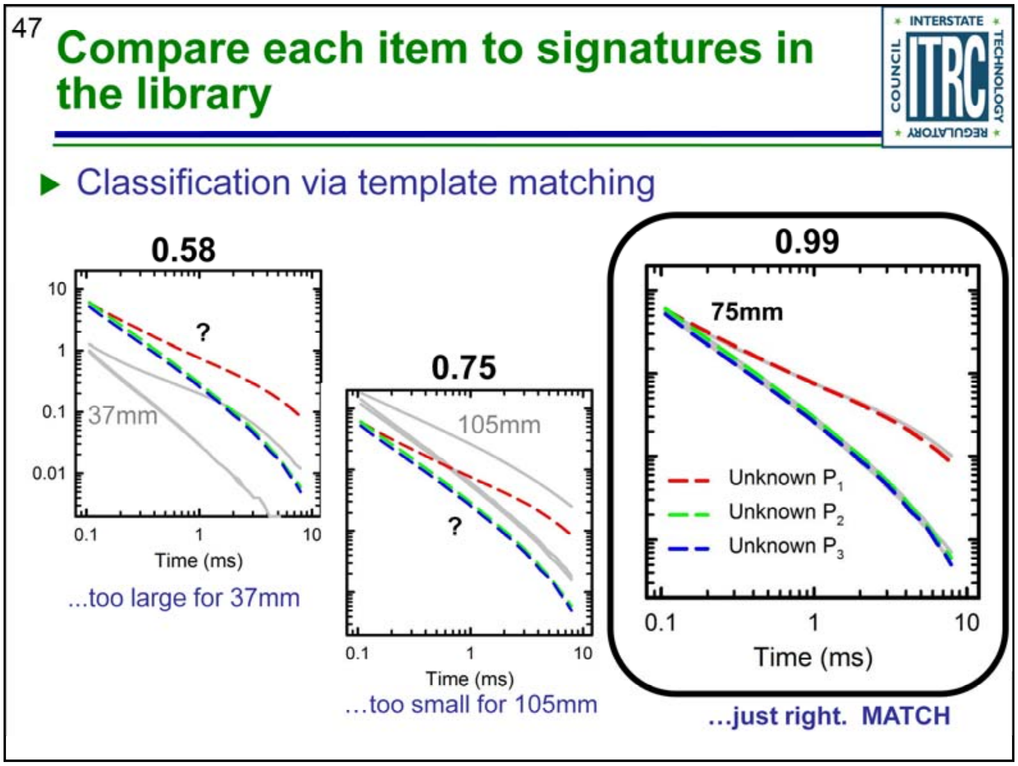
46

Decision Process

We prioritize the sources from those that are most similar to UXO (our library) from those that are not…

3 ways to get on the dig list:

★ 1. Look like an item in the library
★ 2. Be part of a cluster
3. Be big and deeply buried



Now we are moving to the classification decision stage

Colored polarizabilities are the measurement

Cycles through the library to look for a match (computer does rapidly through mathematics not visual)

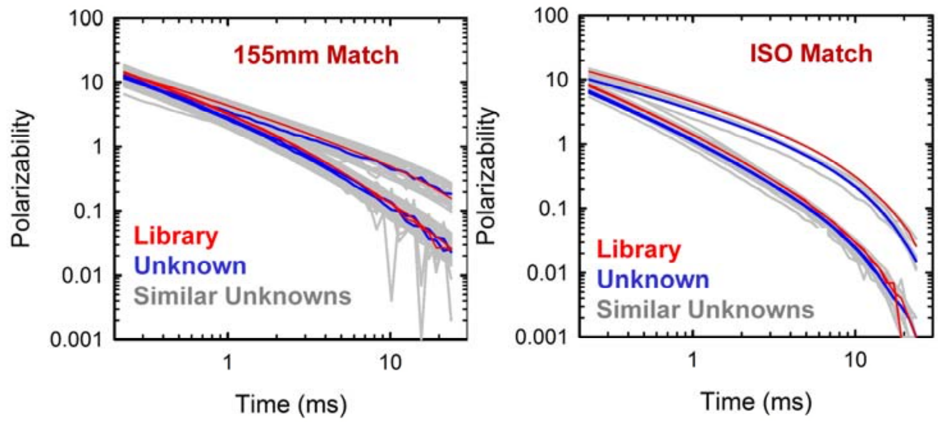
90-95% of decisions are made by matching the library

Other decisions are made through additional analyses…

48

Compare Each Signature to All Other Signatures on Site

- Look for clusters (groups of items with similar response)
- Most clusters correspond to things we know about, like these two examples



Look for 'signatures' that are similar to each other but may not be in the library

Pick representative items from the group and investigate them to see what they are

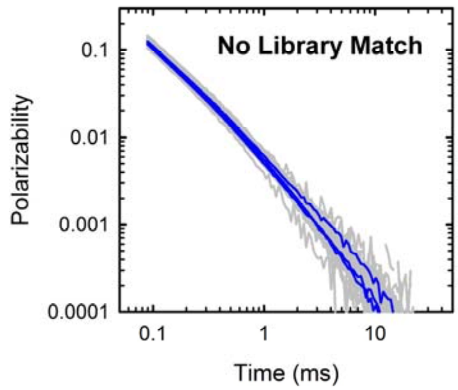
If they are an actual item of interest, the signature is added to the library and the remainder of the group are added to the dig list

If not of interest the items are kept off the dig list

49

Compare Each Signature to All Other Signatures on Site

- If there are clusters of items that do not match the library signatures, we excavate some of them and proceed accordingly…



T-Bar Fuze
Non-hazardous clutter, did not add to library

Look for 'signatures' that are similar to each other but may not be in the library

Pick representative items from the group and investigate them to see what they are

If they are an actual item of interest, the signature is added to the library and the remainder of the group are added to the dig list

If not of interest the items are kept off the dig list

Excavate, verify, and validate…

1. Dig up all items that were determined to be similar to the TOI items

2. Confirm recovered items match predictions

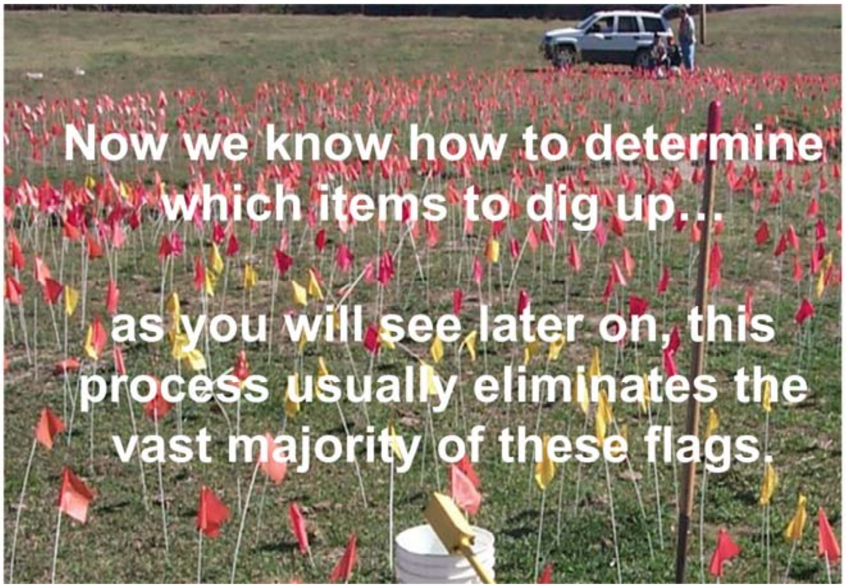
	Source ID	Metric Match	Type
Dig	GU-3	0.999	ISO
	GU-12	0.998	105mm
	GU-124	0.971	4.2in
	GU-383	0.962	105mm
	GU-465	0.955	Lg ISO
	GU-470	0.952	4.2in
	GU-534	0.923	75mm
	GU-621	0.908	75mm
	GU-663	0.896	Lg ISO
	GU-719	0.885	105mm
	GU-755	0.876	81mm
Do Not Dig	GU-799	0.749	
	GU-810	0.732	
	GU-845	0.645	
	GU-868	0.622	
	GU-884	0.618	
	GU-1007	0.512	
	GU-1111	0.451	
	GU-1112	0.421	

start digging

?

51

Classification makes sense…



Add Prioritized dig list

52

Presentation Overview

- Introduction
- Technology and Background
- **Site Suitability**
- Questions and Answers
- Quality Considerations
- Example Case Study
- Wrap Up

No associated notes.

53

Determining Site Suitability for Geophysical Classification (GCMR)

- Traditional signal-axis sensors and GCMR multi-axis sensors have very similar site requirements
- Site Characterization/Conceptual Site Model (CSM)
- Achievable Remedial Action Objective (RAO)
- Operational environment
- Geophysical Classification suitability for site team

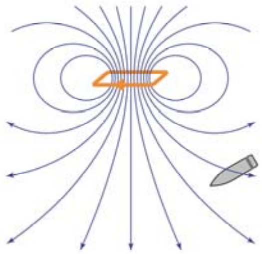
GCMR-2, Project Planning

No associated notes.

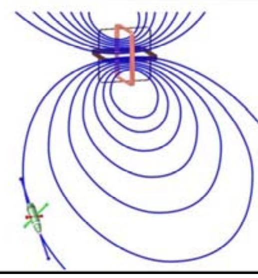
Is the GCMR Technology Appropriate for Your Site

- Single axis and multi axis sensor are fundamentally similar,
  - If single axis sensors were appropriate for your site than multi axis sensors will probably work as well and likely better

EM 61 single axis sensor



MetalMapper multi axis sensor

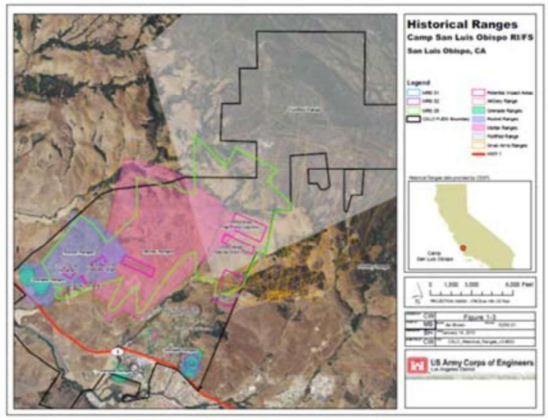


No associated notes.

55

Conceptual Site Model

- Success is directly related to the quality of the site characterization performed
- CSM
  - Land use
  - Historic ranges
  - Munitions response sites
  - Munition type and depth
  - Previous work
  - All decisions

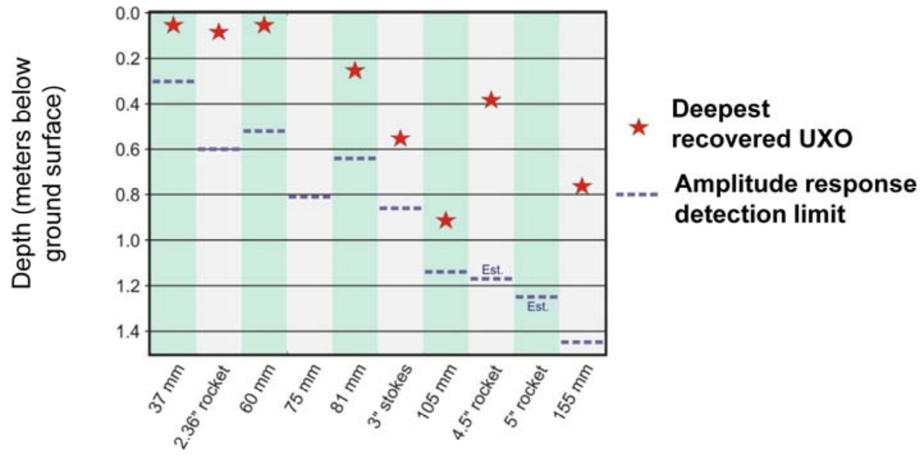


No associated notes.

56

Vertical Conceptual Site Model

- Contains information on expected munitions and depths (TOI)



No associated notes.

57

TOI - Remedial Action Objective

- Is GCMR appropriate for my site RAO?
- Have a clear expectation from stakeholders regarding TOI
  - a. Munitions that are known or expected to be on site
  - b. The site's operational history
  - c. Hazardous components that might exist following deployment, function, or malfunction during operations
- Multiple distinct pieces of metal of similar size to a TOI, can lead to classification performance decline

T-Bar Fuze

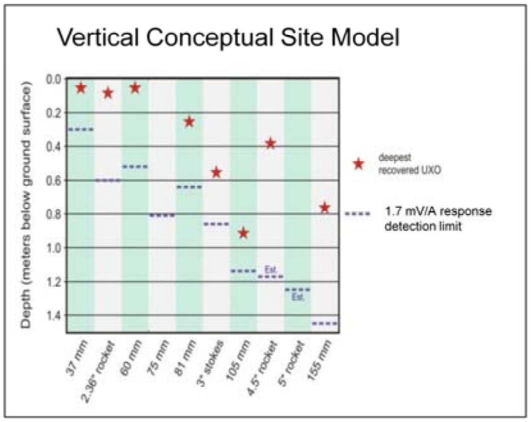
Munitions Sub Components

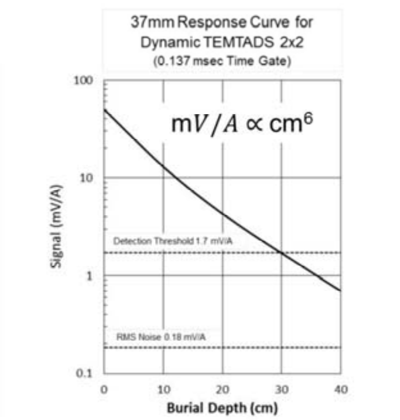
No associated notes.

58

Remedial Action Objective Depth

- EMI sensors do not consistently detect deeply buried, smaller munitions
- Confirm that TOI are detectable relative to the RAO





No associated notes.

59

Operational Environment Constraints

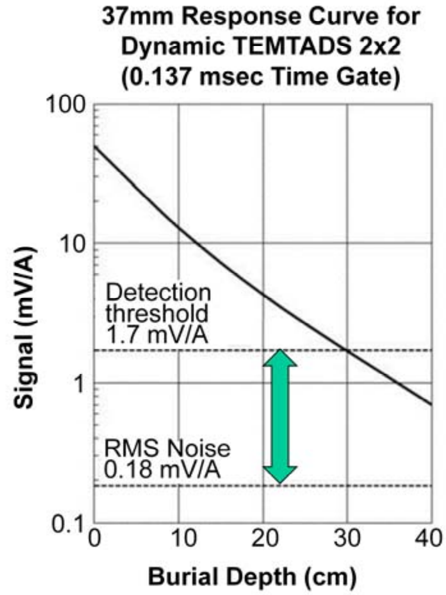
- Site conditions impact ability to use all geophysical equipment including multi axis sensors
- Multi axis sensors are not currently used on airborne or underwater platforms
- Key considerations include
  - Site background (geophysical noise)
  - Anomaly density (anomalies per acre)
  - Vegetation
  - Terrain slope
  - Structures/utilities

No associated notes.

60

Geophysical Noise

- Geologic conditions can generate geophysical noise (for instance, areas with primarily mafic or ultramafic rocks such as basalt)
- Geophysical noise evaluation
  - Requires measurement of site noise
  - Amplitude response must be above background noise



No associated notes.

Anomaly Density

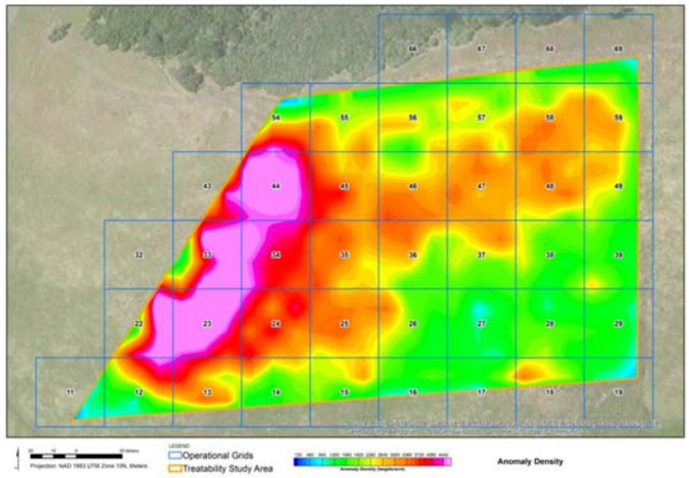
- Classification is difficult in high density anomaly areas
  - Sensor has to be able to identify individual anomalies
  - Similar to removal actions using single axis sensors, high density areas may require a different approach
- Utilize site records and detection survey data to identify high density areas

No associated notes.

62

High Density Areas

- Site specific transect based density estimate
- Portions of site estimated to have more then 4400 anomalies per acre (high density)

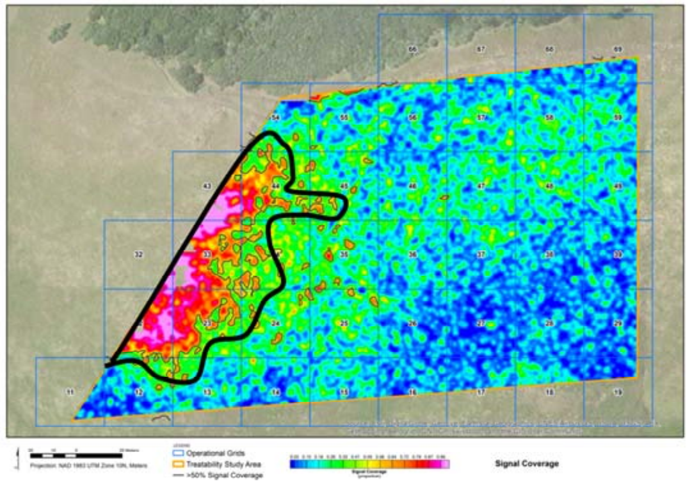


No associated notes.

63

Advanced Sensor Detection Survey

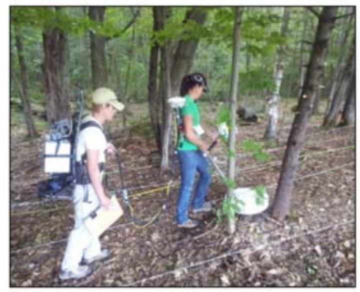
- Detection survey typically used by project team to identify areas too dense for classification
- Portions of site may require a different approach, i.e. mag and flag or sifting



No associated notes.

Vegetation

- Local vegetation
  - Sensors must operate near the ground
  - Sensors utilizing RTK GPS general need a clear view of sky
  - Sensor must fit between obstacles



No associated notes.

65

Is Vegetation Removal Acceptable?

Brush Cutting

Brush Burning

No associated notes.

Terrain

- Terrain may dictate the use of specific sensor platform or technique
  - Towed
  - Cart mounted
  - Person portable

Less then 20 %

Up to 30 %

30 % and beyond

No associated notes.

67

Structures and Utilities

- Presence of structures and utilities
  - Can directly interfere with data collection
  - Mask the sensor response of potential munition

Wire fencing

Buildings and utilities

No associated notes.

68

Is GCMR Suitability for the Site Team

- Resources

Training

- ITRC Geophysical Classification for Munitions Response Guidance Document
- ITRC Internet-based training

Demonstrations

- Over 20 successful demonstrations conducted by ESTCP

Quality Assurance

- Uniform Federal Policy Quality Assurance Project Plan


Uniform Federal Policy for Quality Assurance Project Plans Template

No associated notes.

69

Questions and Answers

Follow ITRC

- Introduction
- Technology and Background
- Site Suitability
- **Questions and Answers**
- Quality Considerations
- Example Case Study
- Wrap Up

No associated notes.

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Presentation Overview

- Introduction
- Technology and Background
- Site Suitability
- Questions and Answers
- **Quality Considerations**
- Example Case Study
- Wrap Up

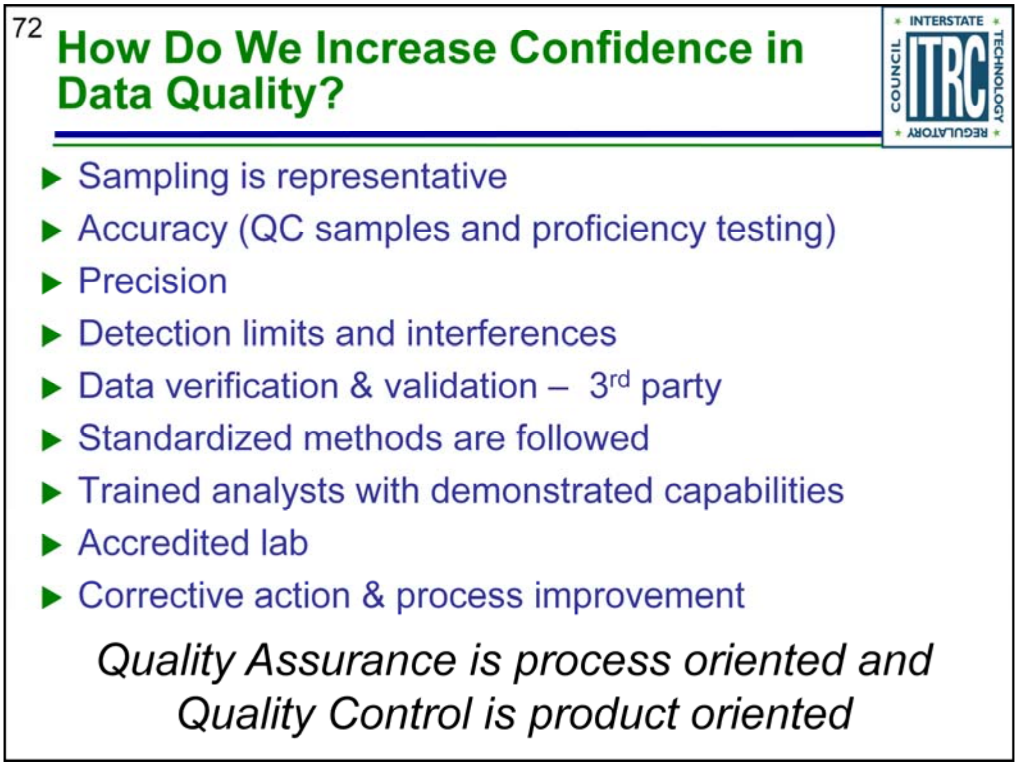
No associated notes.

71

Why Do We Care About Quality?

- Before the geophysical classification technology was developed, we dug all of the items above
- With the geophysical classification technology, we are only digging the munitions on the left and leaving the clutter on the right behind
- **We need to make sure that the work performed to identify and remove the munitions is of high quality because we don't want to leave an explosive hazard behind!**

No associated notes.



No associated notes.

73

Section 4: Quality Considerations

Section 4.1 Quality Systems Manual

Section 4.2 Personnel qualifications

Section 4.3 Quality considerations contained in the GCMR-QAPP (including the processes and procedures that occur during planning, collection, and processing of data, and the ultimate data usability requirements)

Section 4.4 DOD Advanced Geophysical Classification Accreditation Program (DAGCAP)

Section 4.5 Government oversight

No associated notes.

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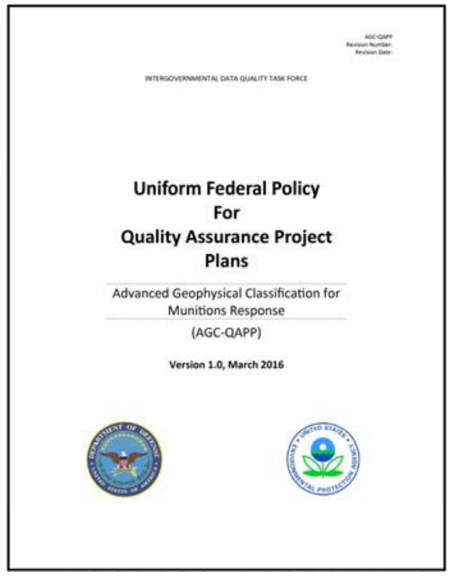
GCMR QAPP Template

- Developed by Intergovernmental Data Quality Task Force (IDQTF)
- Contains Worksheets and Standard Operating Procedures for Geophysical Classification
- Additional testing at the former Lowry AFB, CO
- Version 1.0 (March 2016) is available from IDQTF AGC Website



AGC-QAPP
Revision Number:
Revision Date:

INTERGOVERNMENTAL DATA QUALITY TASK FORCE

Uniform Federal Policy
For
Quality Assurance Project Plans

Advanced Geophysical Classification for Munitions Response

(AGC-QAPP)

Version 1.0, March 2016

No associated notes.

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4.3 Quality Considerations: Planning

- **4.3.1 Systematic Planning**
- ↓ 4.3.2 Site Preparation
- ↓ 4.3.2 Detection Survey
- ↓ 4.3.3 Cued Survey
- ↓ 4.3.4 Intrusive Investigation

GCMR QAPP

Worksheet 9-Planning

Worksheet10-CSM

Worksheet11-DQO's

No associated notes.

4.3 Quality Considerations: Planning

Systematic Planning: Data Quality Objectives (DQO)/Technical Planning (TPP)

- Conceptual Site Model (CSM) – DQO Step 1
  - Type of activities and land use
  - Historical data and munition used
  - Site conditions and objectives
- Data Quality Objectives – DQO Steps 2-7
  - Outputs produce sampling design and data quality needs of the project
- GCMR 2, Chapter 3 - specifics on planning

No associated notes.

77

Quality Considerations – QA/QC

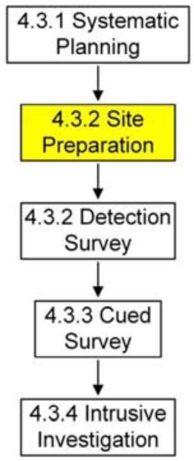
- Project-specific Measurement Performance Criteria (**MPC's**): Minimum performance specifications that the geophysical survey design, including instruments and procedures, must meet to ensure collected data will satisfy the DQOs. (precision, accuracy, representativeness, completeness, comparability and sensitivity)
- Measurement Quality Objectives (**MQO's**):Procedures for performing testing, inspections and quality control for all field data collection activities. Designed to control data collection process in the field such that ultimate project performance criteria will meet project needs (objectives).

GCMR QAPP
Worksheet 12: Measurement Performance Criteria
Worksheet 22: Equipment Testing, Inspection, and Quality Control

No associated notes.

78

Quality Control



Field Measurement Quality Objectives (MQO's) – Site Preparation

- On-going Instrument Verification Strip (IVS) Positioning (**Precision**)
- Derived position of IVS targets (**Accuracy**)
- In-line spacing coverage (**Representativeness**)
- Polarizability match of IVS items (**Comparability**)
- All seeds detected (**Completeness**)
- Decay amplitudes lower than project threshold (**Sensitivity**)

GCMR-QAPP Worksheet 22-1: Equipment Testing, Inspection, and Quality Control

No associated notes.

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Measurement Quality Objectives (MQO's)

QAPP Worksheet #22: Equipment Testing, Inspection, and Quality Control

(UFP-QAPP Manual Section 3.1.2.4)

(EPA Guidance QA/G-5, Section 2.2.6)

This worksheet documents procedures for performing testing, inspections and quality control for all field data collection activities. References to the applicable definable feature of work (DFW) and standard operating procedures must be included. Where appropriate the failure response will prescribe a corrective action (CA). Otherwise a root cause analysis (RCA) will be conducted to determine the appropriate CA. Examples are provided in blue text. Minimum recommended specifications are provided in black text. The project-specific QAPP must explain and justify any changes to black text. An appendix may be used for this purpose.

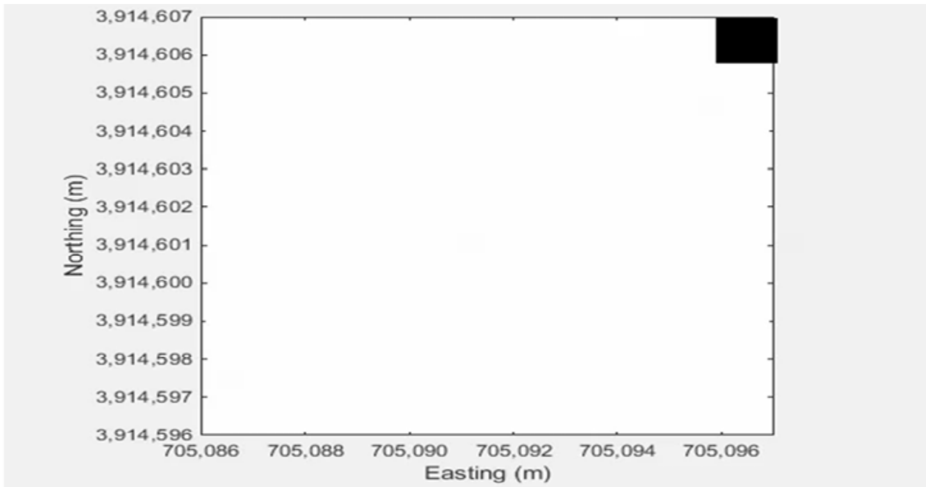
Table 22-1: Dynamic Survey (instrument: ______________________________)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified by	Acceptance Criteria	Failure Response
Verify correct assembly		Once following assembly	Field Team Leader/ instrument assembly checklist/Project Geophysicist	As specified in SOP-X, Assembly checklist	CA: Make necessary adjustments, and re-verify
Initial Instrument Function Test (Instrument response amplitudes)		Once following assembly	Field Geophysicist / Initial IVS Memorandum/ Project Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all monostatic Tx/Rx combinations	CA: Make necessary adjustments, and re-verify
Initial dynamic positioning accuracy (IVS)		Once prior to start of dynamic data acquisition	Project Geophysicist/ IVS Memorandum/QC Geophysicist	Derived positions of IVS target(s) are within 25 cm of the ground truth locations	CA: Make necessary adjustments, and re-verify
Initial dynamic detection response amplitudes		Once prior to start of dynamic data	Project Geophysicist/ IVS Memorandum/	Response amplitudes within 25% of	CA: Make necessary adjustments, and re-verify

No associated notes.

80

MQO Example: In-line and Cross-Track Spacing Ensure Overlap and Coverage of Site

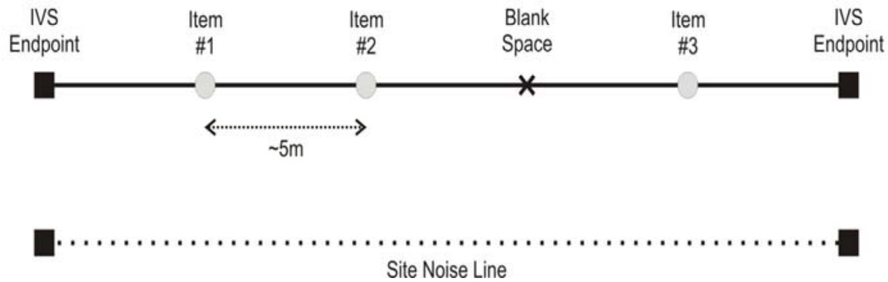


MQO's for Representativeness and Completeness

No associated notes.

Instrument Verification Strip (IVS)

- One or more buried inert munitions or industry standard objects (ISOs) spaced approximately 5 meters apart
- Utilized at the beginning and end of each day to verify correct operation of the detection and classification system



No associated notes.

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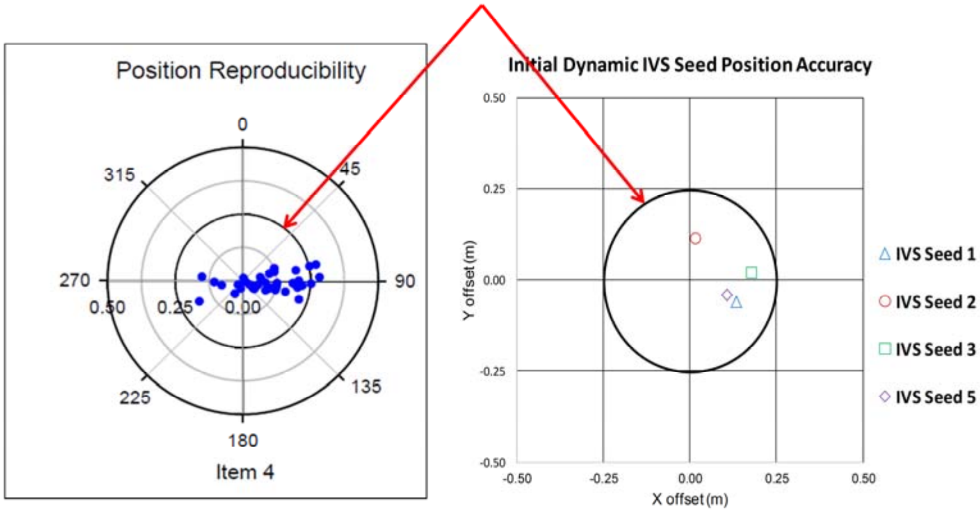
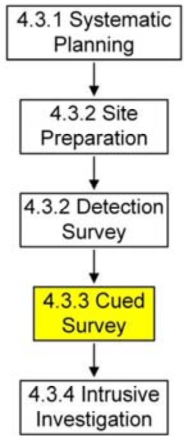
Instrument Verification Strip (IVS)

Acceptance Criteria



No associated notes.

Quality Control



Field Measurement Quality Objectives (MQO's) – Cued

- GPS Benchmark Positioning (**Precision**)
- IVS Library Match metric ≥ 0.9 (**Accuracy**)
- background threshold (**Representativeness**)
- polarizability match of IVS items (**Comparability**)
- All seeds detected (**Completeness**)
- Peak transmit current (**Sensitivity**)

GCMR-QAPP Worksheet 22-2: Equipment Testing, Inspection, and Quality Control

No associated notes.

84 *Production Area Seed Detection and Classification Requirements*

QC Seed (Contractor control checks)

- Emplaced by contractor QC personnel
- Failure to detect or properly classify a QC seed target allows the production team to perform corrective action
- Provide a means of identifying root causes so that corrective action (CA) can be undertaken while in the field

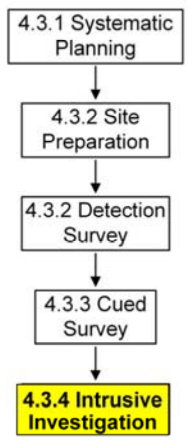
Validation Seeds (Government proficiency checks)

- Emplaced by Government or 3rd Party QA personnel
- Failure indicates a significant concern
- Also monitored as a part of accreditation

No associated notes.

85

Quality Control



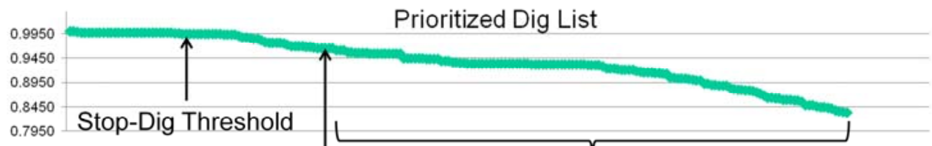
Field Measurement Quality Objectives – Verification/Validation

- 100% conclusive TOI match ground truth prediction (**Accuracy**)
- 100% conclusive TOI match size prediction (**Accuracy**)
- 100% non-TOI match prediction (**Completeness**)
- Verify threshold (**Completeness**)

GCMR-QAPP Worksheet 22-3: Equipment Testing, Inspection, and Quality Control

No associated notes.

86 **How Do We Verify and Validate the Process? Conservative approach in protecting against false negatives**



Threshold verification: Dig an additional 200 items beyond the last TOI

- If necessary, reset threshold and start intrusive investigation again

Validation digs: randomly select an additional 200 non-TOI for qualitative confirmation. Validation of the entire process!

The number 200 is a consensus number reached by the members of the IDQTF Advanced Classification Subgroup. The threshold verification digs are a process control check on the ranked list and are designed to lend further confidence in the implementation of the technology and ensure that the list was created correctly.

No associated notes.

87

Management, Reporting, and Review

- 4.3.5 Data Management and Reporting
  - Specifications for all data management tasks and deliverables
- 4.3.6 Data Review
  - Project Records – necessary documents for all data review phases
  - Data verification – completeness
  - Data validation – conformance to specifications
  - Data Usability Evaluation by the project team – qualitative and quantitative evaluation of data against all MPCs and DQOs to determine if data support the objectives

GCMR QAPP

- Worksheet 29: Data Management, Project Documents, and Records
- Worksheet 34: Data Verification, Validation, and Usability Inputs
- Worksheet 35: Data Verification and Validation Procedures
- Worksheet 36: Geophysical Classification Process Validation
- Worksheet 37: Data Usability Assessment (DUA)

No associated notes.

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4.4 UXO Contractor Accreditation

DoD policy requires that contractors performing advanced geophysical classification work be accredited

- ✓ Analyst have documented qualifications, training, and demonstration of capabilities
- ✓ Provides formal recognition to competent testing organizations
- ✓ Provides a means to identify testing organizations that meet minimum program requirements
- ✓ Successful classification of validation seeds which act as the equivalent of blind proficiency test samples
- ✓ Organization must perform internal audits and document corrective actions including process improvement
- ✓ Enhances confidence in results by clients, regulators, and the public

No associated notes.

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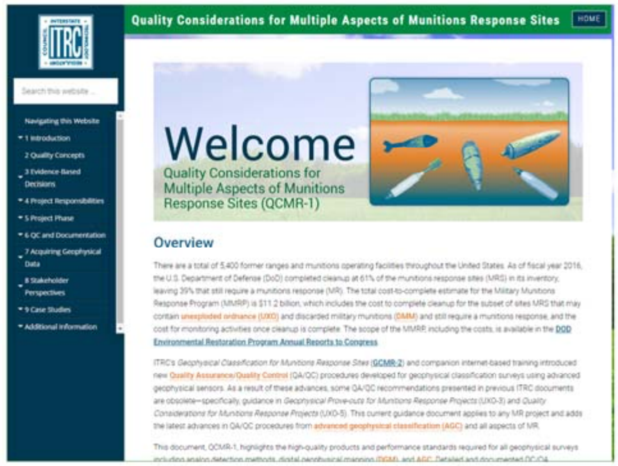
Increasing Confidence in Data Quality

- Coverage (sampling is representative)
- QA & QC seeds (accuracy & precision)
- Temporal and spatial monitoring (interferences)
- Signal to noise for IVS & seeds (detection limits)
- QAPP (standardized methods are followed)
- Additional digs (data verification & validation)
- Data review & data usability assessment (DUA) (WS 34-37)
- Accreditation (DAGCAP)
  - Trained analysts with demonstrated capabilities
  - Corrective action & process improvement
  - Quality system

No associated notes.

New Document on MR Quality

- Just released by ITRC
- Discusses a wide range of quality considerations for a Munitions Response project
- Online training coming soon



[ITRC Quality Considerations for Multiple Aspects of Munitions Response Sites (QCMR-1, 2018)]

No associated notes.

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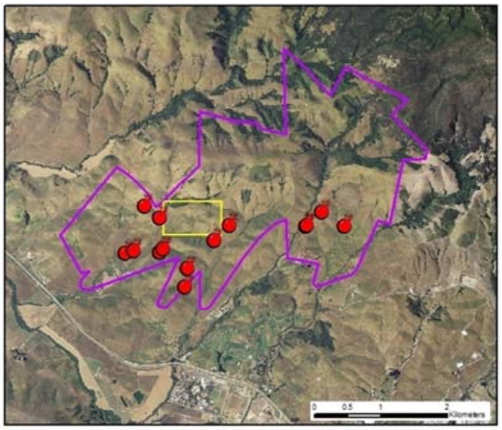
Presentation Overview

- Introduction
- Technology and Background
- Site Suitability
- Questions and Answers
- Quality Considerations
- **Example Case Study**
- Wrap Up

No associated notes.

Example Site



- University owned
  - No access restrictions
  - Cattle grazing
  - Geotechnical classes
  - Camping
- Multiple, overlapping range fans
- MRS ~ 2,500 acres
- 100 acres in Year 1

No associated notes.

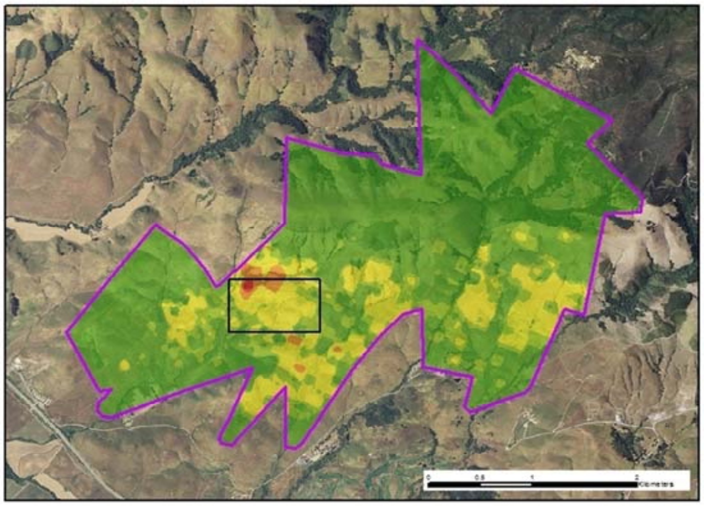
93

Site History

- Initially established in 1928
- Expanded during WWII
- Transferred to private owners after Korean War
- Previous investigations
  - Preliminary Assessment (1986 and 1993)
  - Time Critical Removal Action (1992)
  - Archives Search Report (1994)
  - Site Inspection (2007)
  - Time Critical Removal Action (2010)
  - Remedial Investigation (2011)

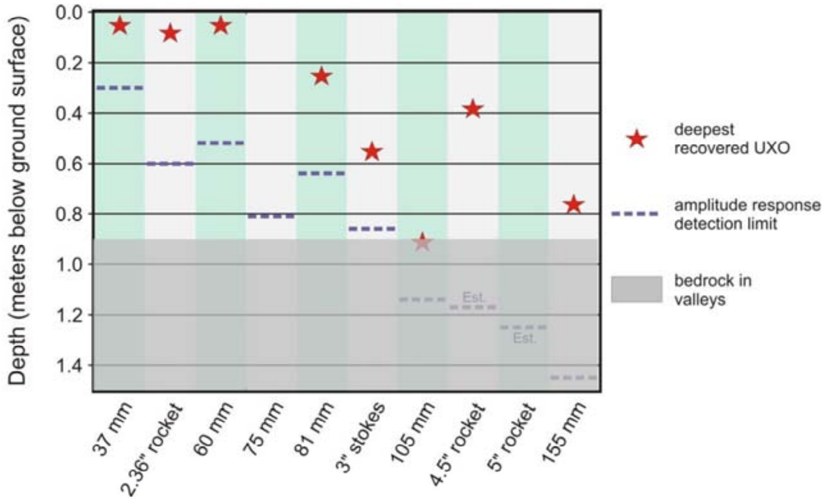
No associated notes.

CSM – Spatial Distribution of MEC



No associated notes.

CSM – Vertical Distribution of MEC



No associated notes.

Remedial Objective

- Detect and dispose of MEC that can be detected using a detection threshold required to detect a 37mm projectile at 12 inches below the ground surface, and to do so as efficiently as possible
  - Remove any MEC detected irrespective of depth
  - As efficiently as possible = most economical method to accomplish remedial objectives

No associated notes.

97

Projected Costs for Year 1 (2015)

Item	Units	Cost	
Mob/Demob	1	$25,000	range: $15,000 to $30,000
Surface Sweep	acre	$1,500	range: $500 to $5,000
IVS	each	$6,000	One day of three-person crew
Seed Emplacement	per day	$5,250	assumes 25 seeds emplaced per day, crew size of 3
EM61 Data Collection and Analysis	acre	$1,000	range: $1,000 with array to $5,000 with single sensor
Dynamic TEMTADS Collection and Analysis	acre	$6,000	range: $3,300 to $5,500
Cued TEMTADS Collection and Analysis	per anomaly	$40	
Intrusive Investigation	per dig	$120	range: $75 to $200

	Traditional Approach – No Classification		Classification	
Mob/Demob	= unit costs	$25,000	same as traditional	$25,000
Surface Sweep	= 100 acres * per acre	$150,000	same as traditional	$150,000
IVS	= unit cost	$6,000	same as traditional	$6,000
Seed Emplacement	= 25 QC + 25 QA	$10,500	= 200 QC + 200 validation	$84,000
EM61 survey and analysis	= 100 acres * DGM costs	$100,000	n/a	
Dynamic TEMTADS	n/a		= 100 acres * TEMTADS costs	$600,000
Cued TEMTADS	n/a		= 50% reduction from advanced analysis	$1,000,000
Seeds Dug	= seeds * cost per dig	$6,000	= seeds * cost per dig	$48,000
Native UXO Dug	= # UXO * cost per dig	$60,000	same as traditional	$60,000
Clutter Dug	= # clutter * cost per dig	$5,940,000	= 80% clutter rejection	$1,188,000
Fixed Costs		$400,000		$400,000
Total		**$6,697,500**		**$3,561,000**

No associated notes.

Sensor Selection

- Unobstructed sky view
- Steep terrain
- TEMTADS 2x2 with RTK GPS

No associated notes.

99

Initial TPP Meeting

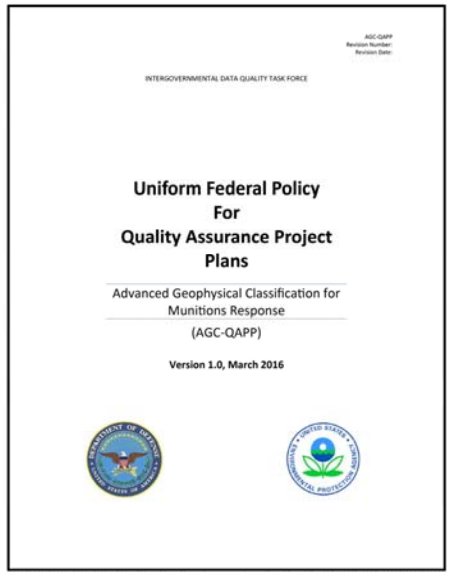
- Agree on:
  - Remedial Objective
  - Survey lane spacing
  - Anomaly selection methodology
    - Informed Source Selection (ISS)
  - Schedule
  - …..

No associated notes.

100

GCMR-QAPP

- Based on template
- As discussed in previous section of this presentation



AGC-QAPP
Revision Number:
Revision Date:

INTERGOVERNMENTAL DATA QUALITY TASK FORCE

Uniform Federal Policy
For
Quality Assurance Project Plans

Advanced Geophysical Classification for Munitions Response

(AGC-QAPP)

Version 1.0, March 2016

No associated notes.

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Project Workflow

TPP → QAPP	DFWs	Example Tasks	Products
Site Prep	1,2	Surface Clearance QC & QA Seed Emplacement IVS Construction	Surface Clearance Tech Memo QC Seed Emplacement Memo Validation Seed Memo (Govt Only)
Detection Survey	3,4,5	Dynamic Survey Anomaly Selection	IVS Tech Memo Weekly QC Submittal Anomaly Selection Memo
Cued Survey	6,7	Background Data Collection Anomaly Data Collection	IVS Tech Memo Weekly QC Submittal
Classify Anomalies	9,10	"Training" Digs Construct Ranked Anomaly List	Classification Tech Memo Ranked Anomaly List
Intrusive Investigation	11	Dig Items Compare Recoveries to Predictions	Intrusive Investigation Report Photos Final Draft Validation Plan
Verification and Validation	12	Verify Thresholds Validate Process	Final Report

No associated notes.

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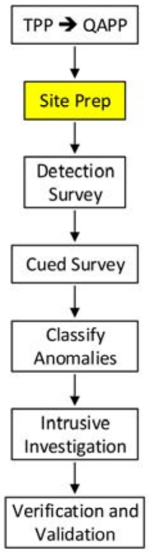
Surface Clearance Memo



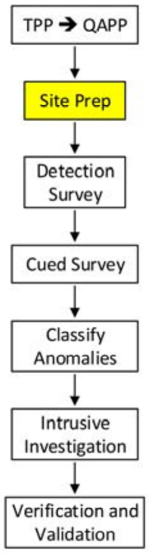
- Was everything found consistent with the CSM?
- Is there anything the analysts need to know?
- Opportunity for cost savings

CSM	Evidence from Surface Sweep?
37-mm projectile	Y
2.36-in rocket	Y
60-mm mortar	Y
75-mm projectile	Y
81-mm mortar	N
3-in stokes mortar	Y
unexpected munition	N

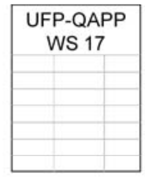
No associated notes.

103

Contractor's QC Seeds



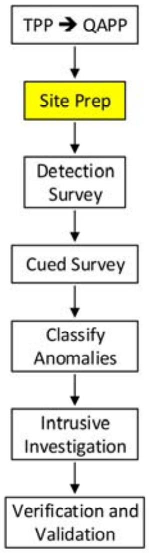
- Inert 37-mm projectiles and small ISO80s
- 200 QC seeds, approximately 50% of each
- Seeds placed at six depths up to the maximum PWS detection depth (5, 10, 15, 20, 25, & 30 cm)



No associated notes.

104

Government Validation Seeds

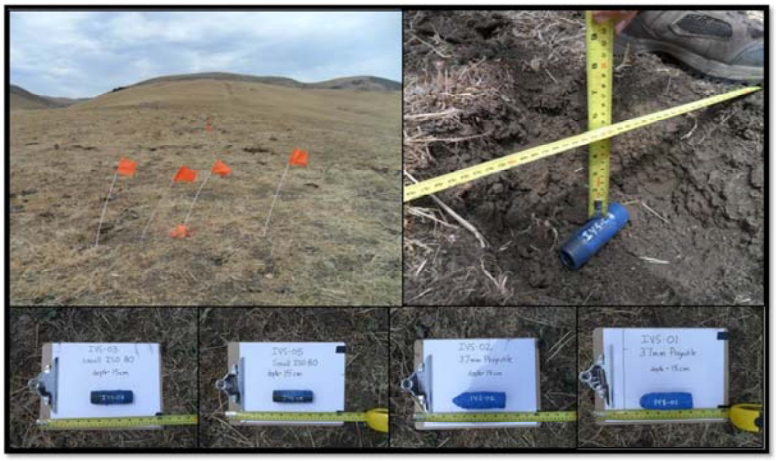


- ~200 seeds
- Small ISO80, 37-mm projectiles, mortars
- Full depth range of interest
  - 30 cm for small ISO and 37mm
  - 45 cm for 60-mm mortar
  - 65 cm for 81-mm mortar

No associated notes.

IVS Construction

TPP → QAPP
↓
Site Prep
↓
Detection Survey
↓
Cued Survey
↓
Classify Anomalies
↓
Intrusive Investigation
↓
Verification and Validation



No associated notes.

IVS Tech Memo

TPP → QAPP

Site Prep

Detection Survey

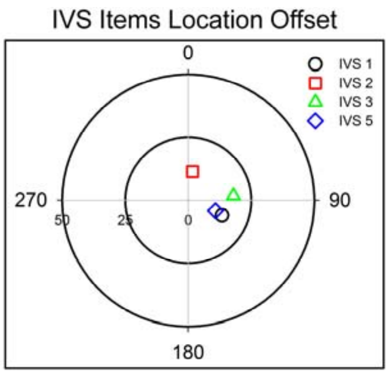
Cued Survey

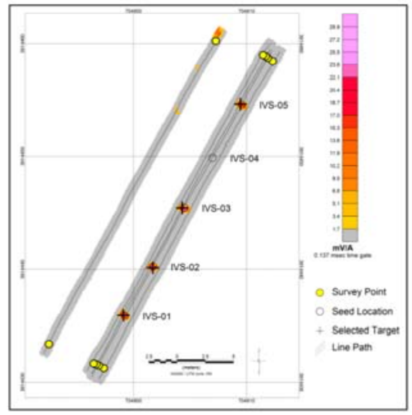
Classify Anomalies

Intrusive Investigation

Verification and Validation

Is the Sensor Functioning Properly and Ready to Collect Data?





No associated notes.

107

IVS Tech Memo

TPP → QAPP

Site Prep

Detection Survey

Cued Survey

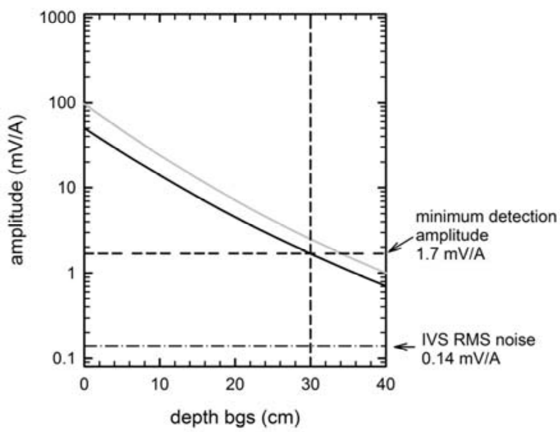
Classify Anomalies

Intrusive Investigation

Verification and Validation

Are the Remedial Objectives Achievable?

TEMTADS 2x2 Sensor Response Curves for
2 Variants of 37-mm Projectile

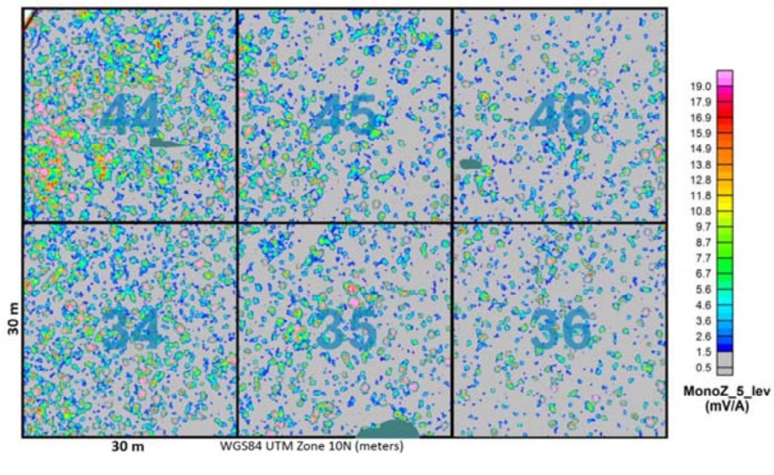


No associated notes.

108

Detection Survey

- TPP → QAPP
- Site Prep
- **Detection Survey**
- Cued Survey
- Classify Anomalies
- Intrusive Investigation
- Verification and Validation



Monostatic Z Component Response Amplitude

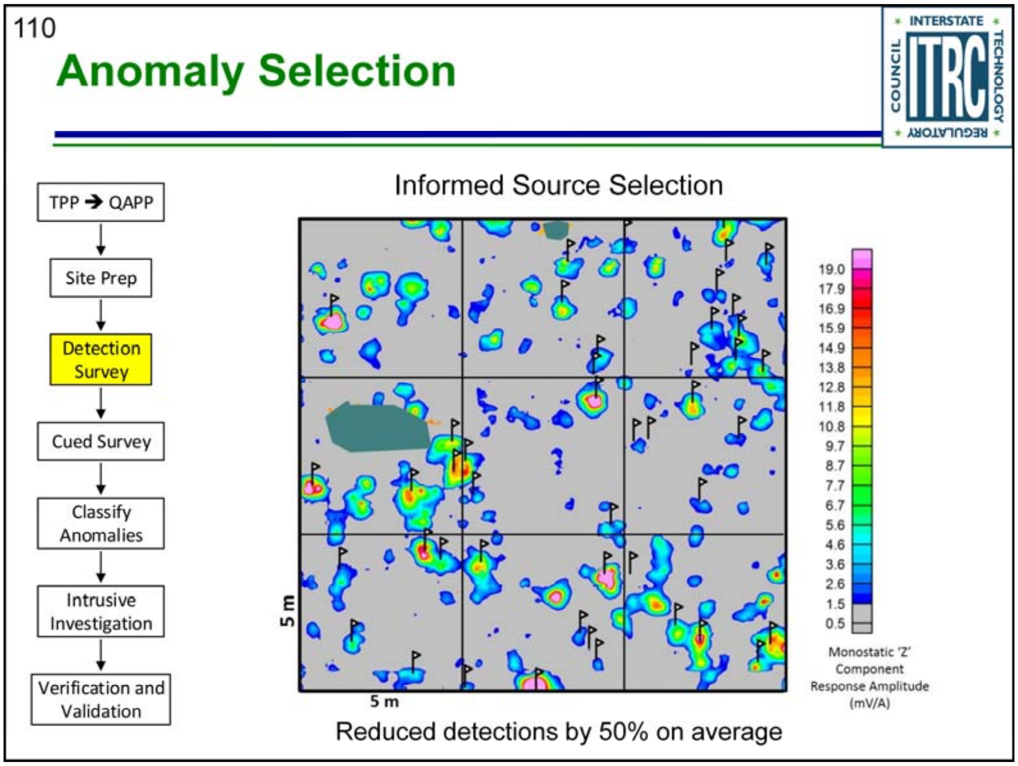
No associated notes.

109

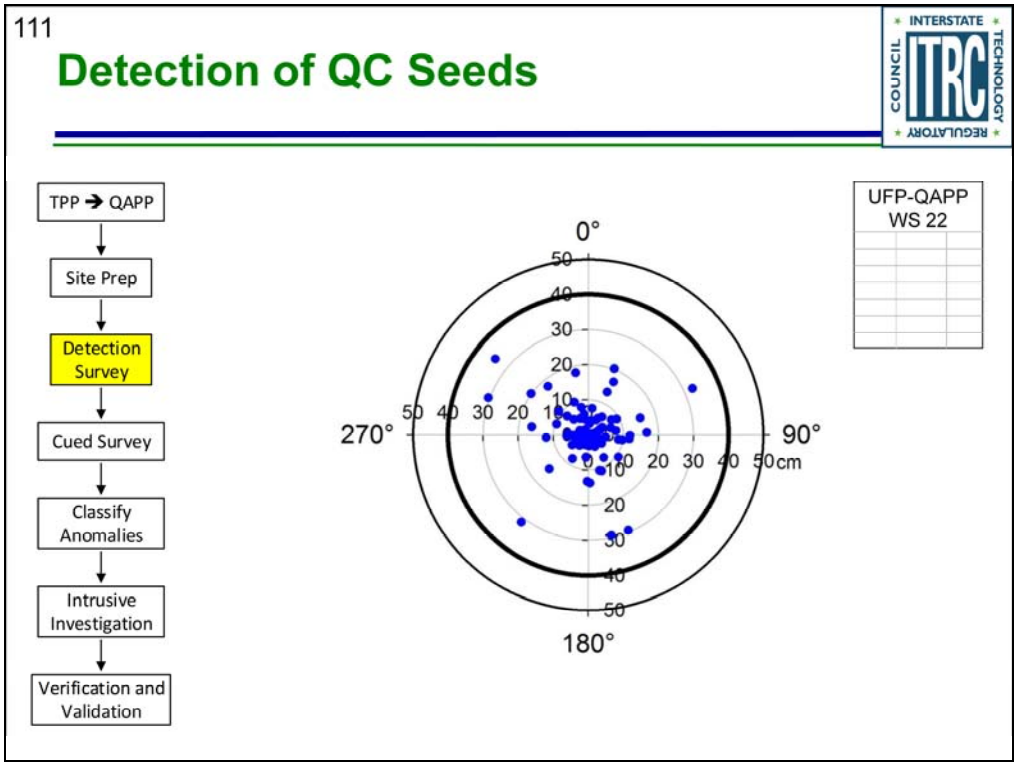
Anomaly Selection Methodology

- Amplitude Threshold
  - Small, near-surface frag results in amplitude equal to deeper targets of interest – lots of unnecessary "detections"
- Informed Source Selection
  - Use all channels of data collected from all receivers in analysis. Only flag anomalies that result from items big enough to be the smallest TOI (37-mm projectile in this case).

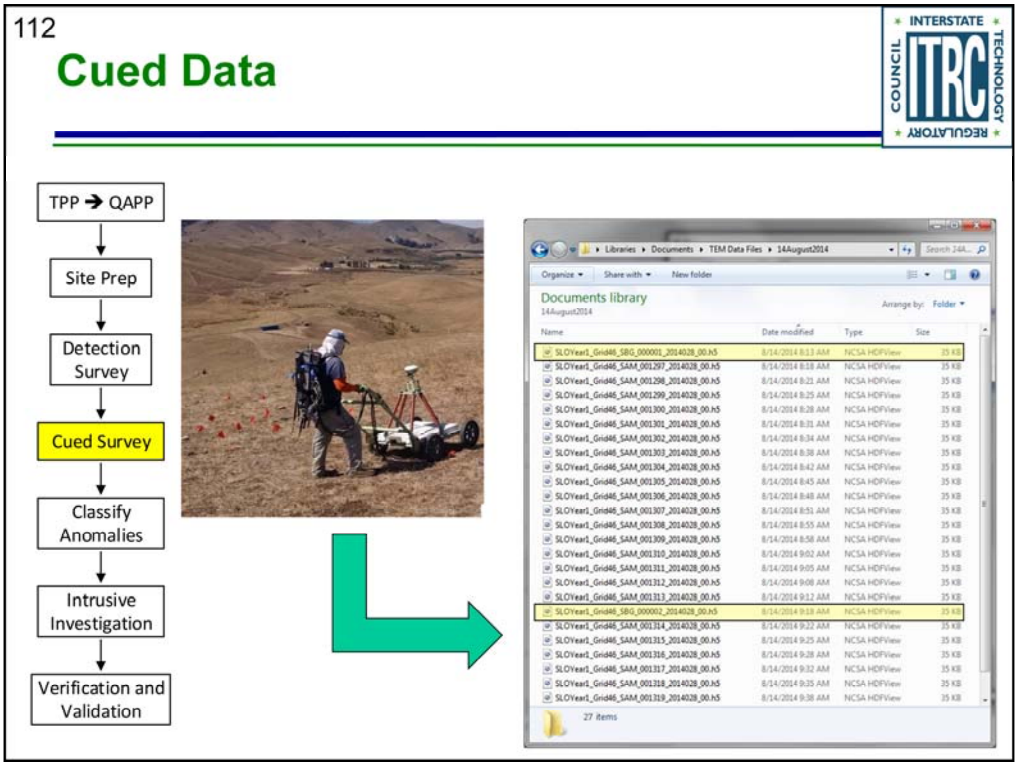
No associated notes.



The data shown are from the SW quadrant of grid 46.



No associated notes.

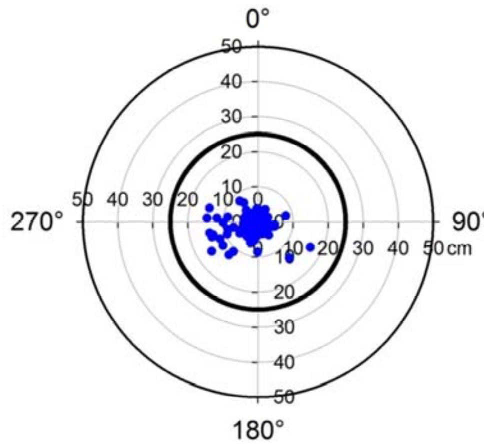


No associated notes.

113

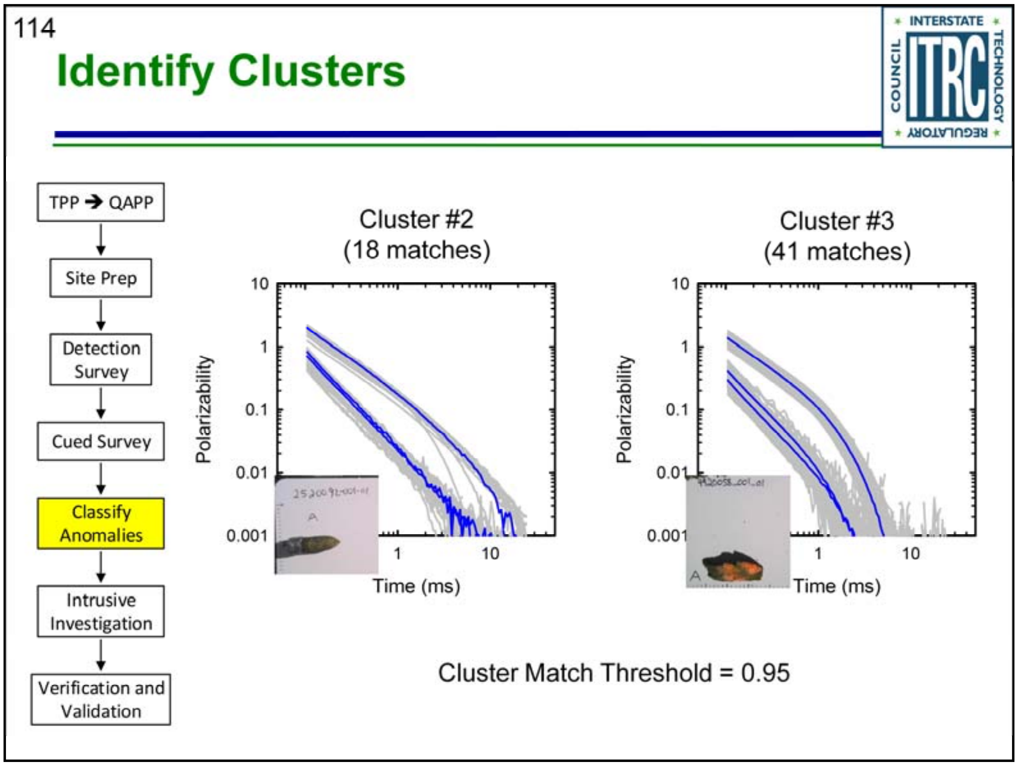
Government Evaluation of Validation Seed Locations after Inversions

- TPP → QAPP
- Site Prep
- Detection Survey
- **Cued Survey**
- Classify Anomalies
- Intrusive Investigation
- Verification and Validation



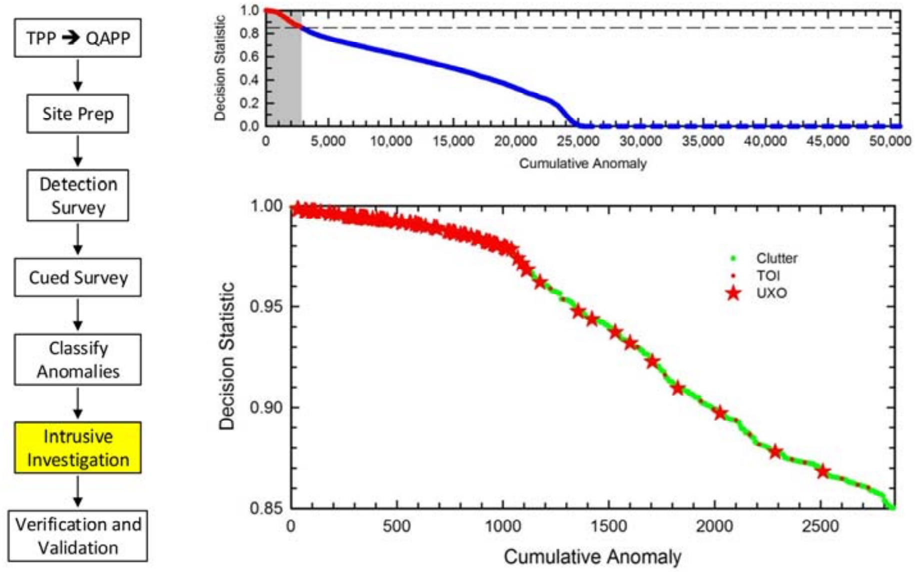
UFP-QAPP
WS 22

No associated notes.



No associated notes.

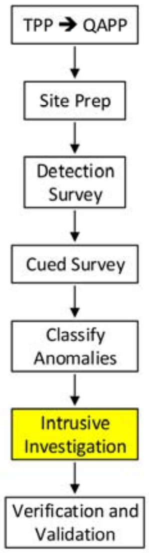
Intrusive Investigation



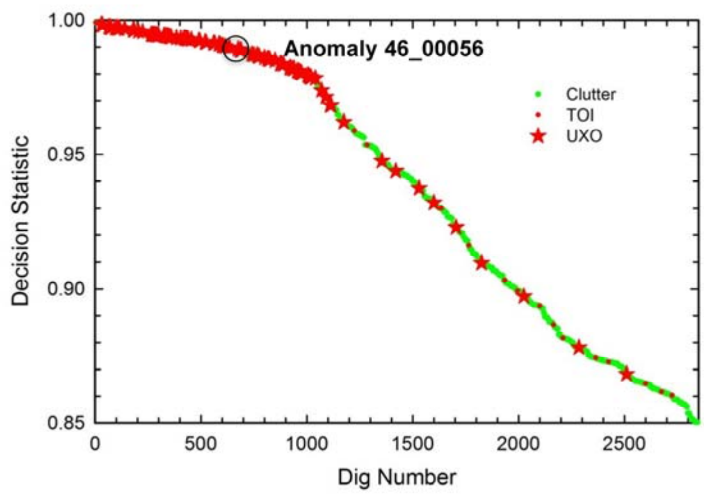
No associated notes.

116

Intrusive Investigation Report



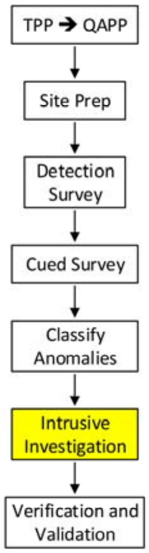
Were all recovered items consistent with analyst's predictions?

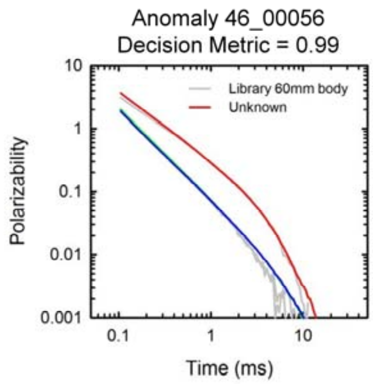


No associated notes.

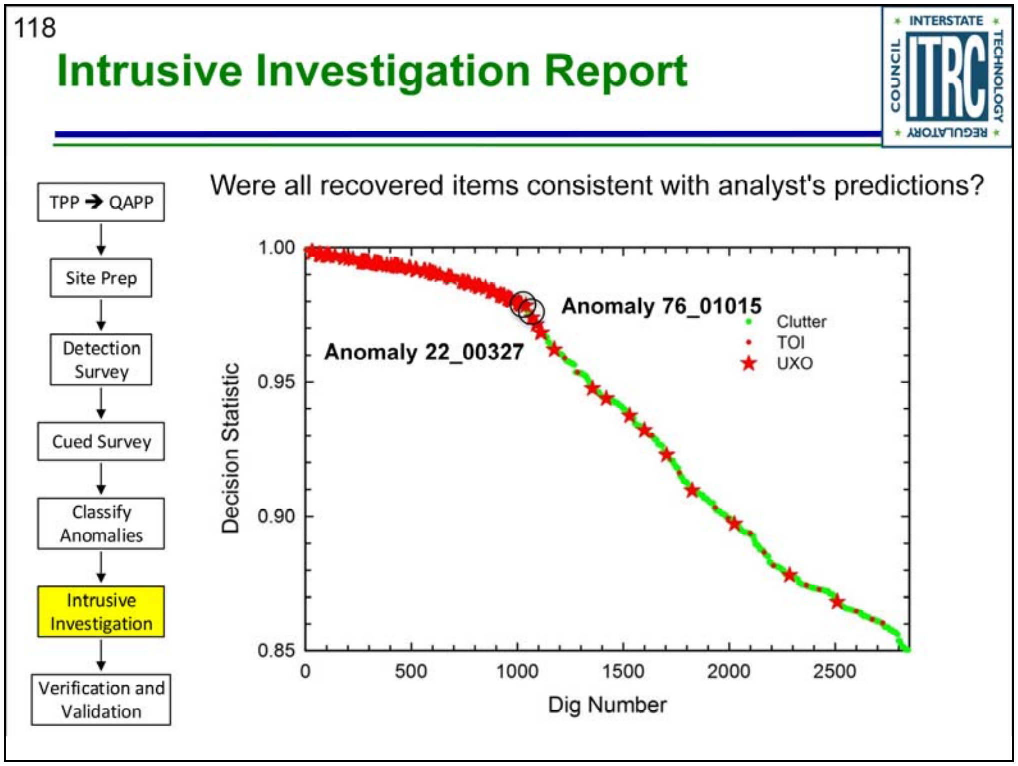
117

Intrusive Investigation Report



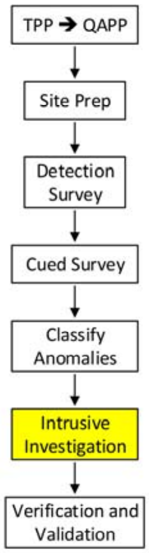


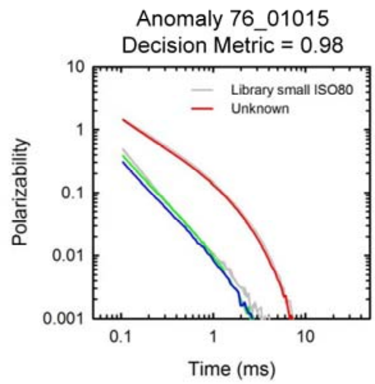
No associated notes.

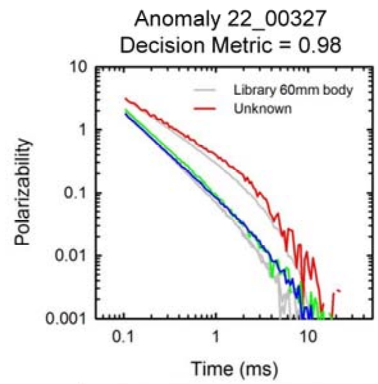


No associated notes.

Intrusive Investigation Report



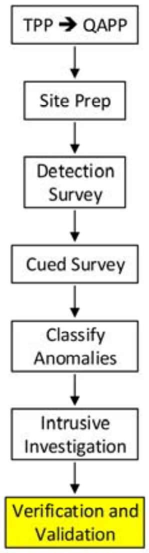




No associated notes.

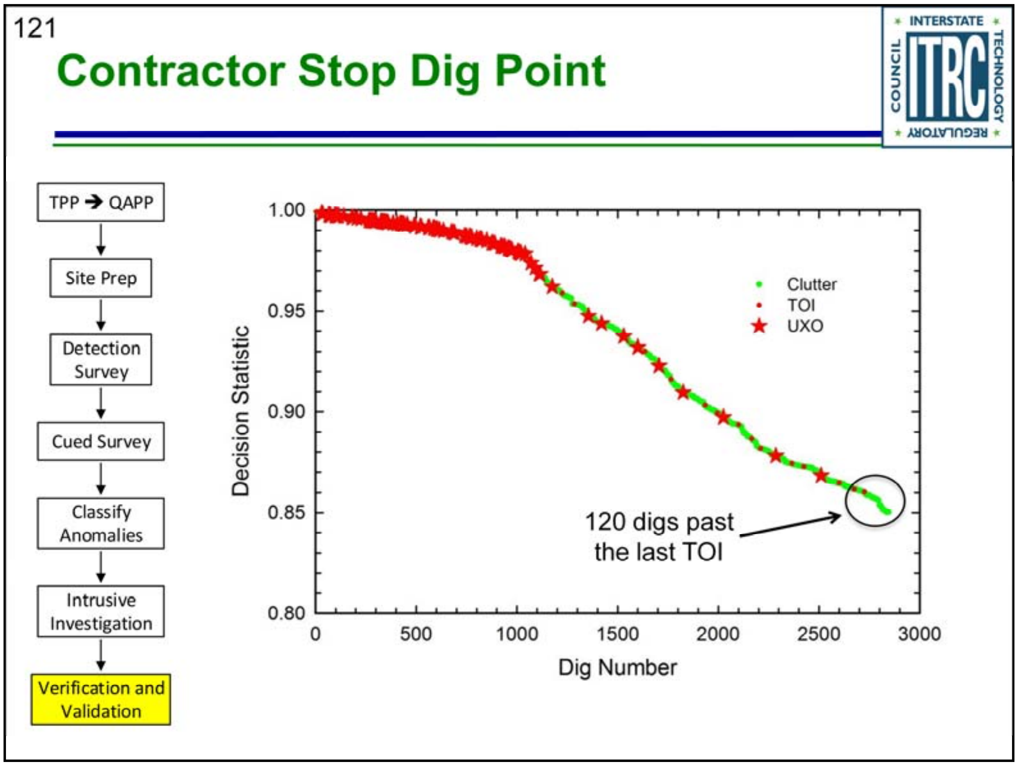
120

Verification and Validation

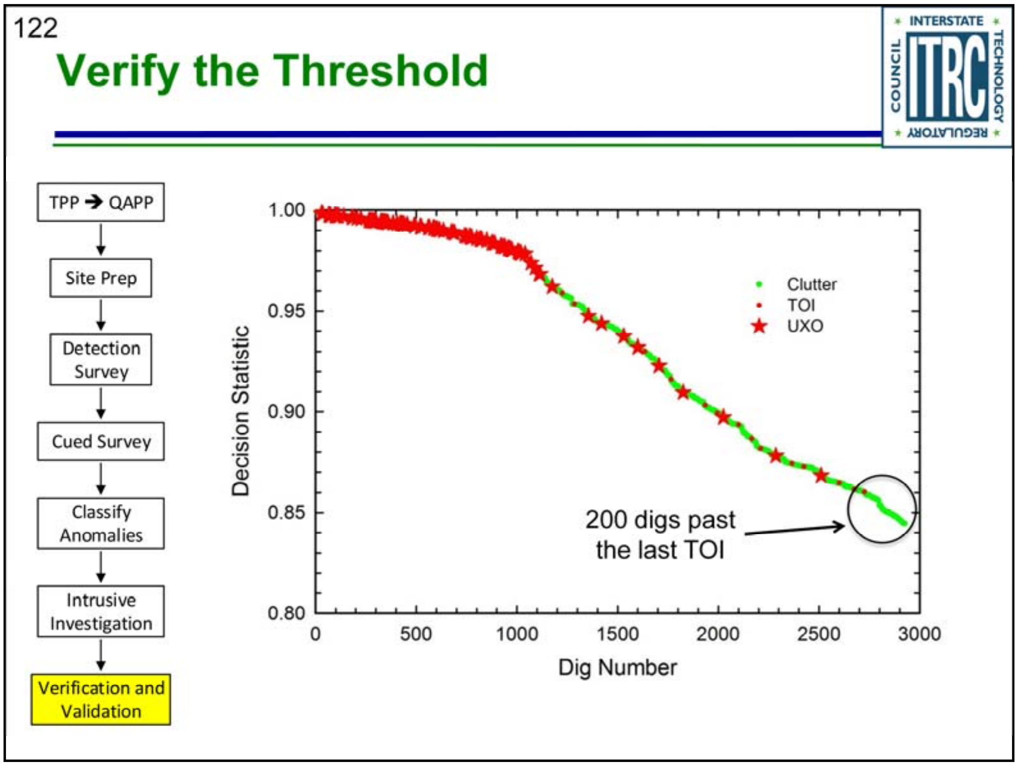


- Verify the stop-dig threshold
  - Dig past the last TOI

No associated notes.



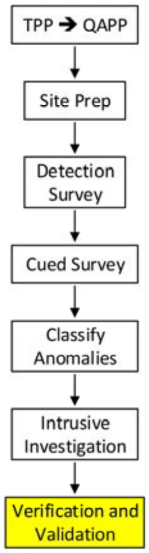
No associated notes.



No associated notes.

123

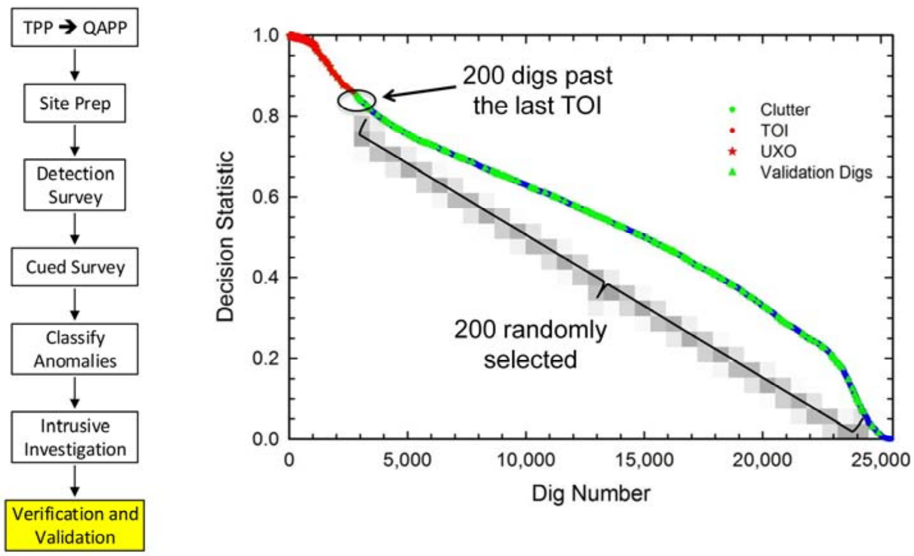
Verification and Validation



- Verify the stop-dig threshold
  - Dig past the last TOI
- Validate the whole process
  - Targeted investigation of items classified as likely clutter

No associated notes.

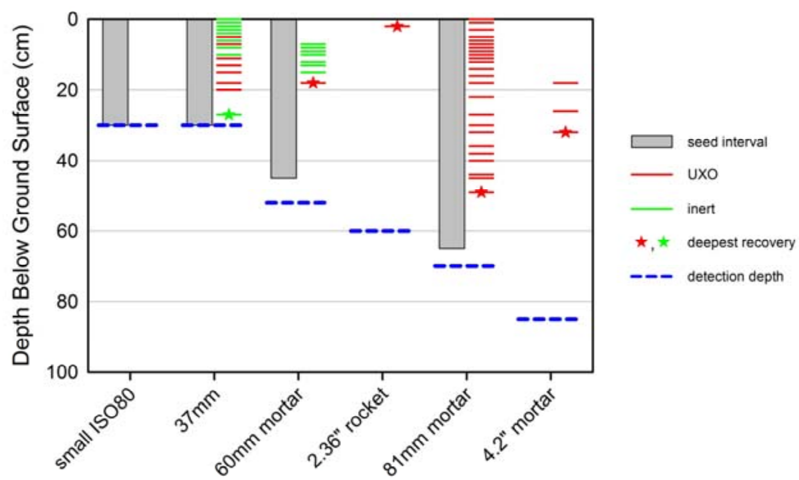
Validate the Process



No associated notes.

125

After Action Vertical CSM



No associated notes.

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Everybody Is Happy Now!

No associated notes.

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Presentation Overview

- Introduction
- Technology and Background
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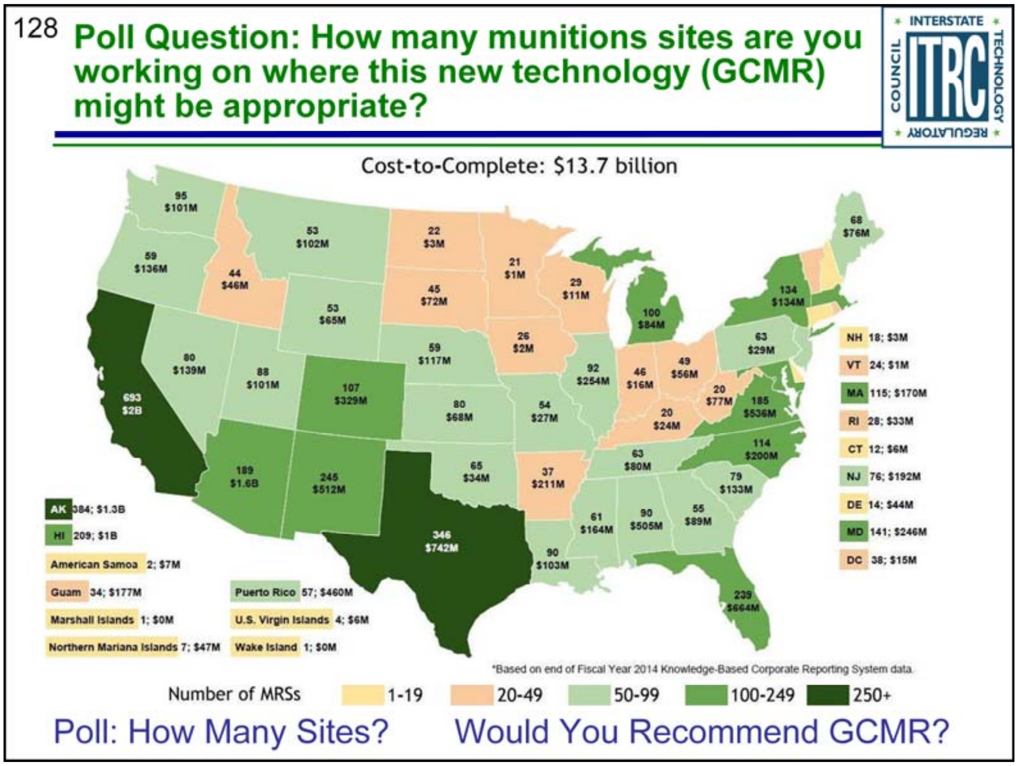
- Questions and Answers
- Quality Considerations
- Example Case Study
- **Wrap Up**

No associated notes.



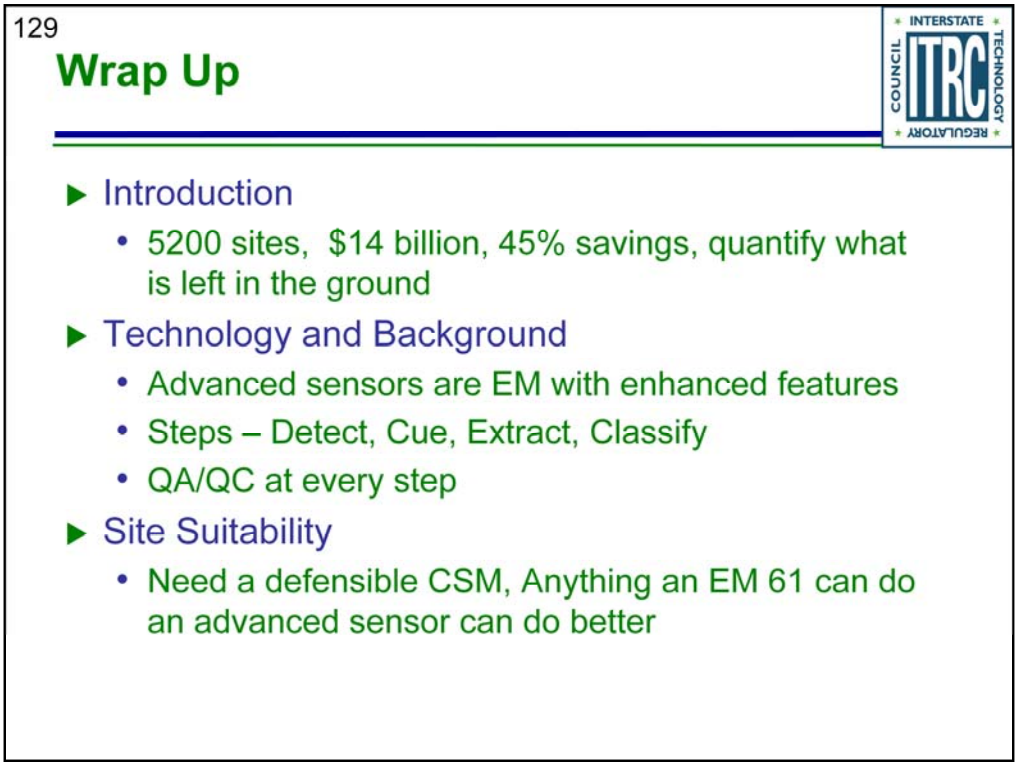
Poll Questions:

How many sites do you know of where GCMR might be used?

- 0
- 1-19
- 20-50
- More than 50

Would you Recommend it at your sites?

- Yes
- No
- I need more Information



Now let's wrap things up so you can start using what you learned:

- 5200 sites across the country, half will need geophysical investigation, and it will take until next century to clean up.
- With multi-axis sensor technology we can pick out just the things that are hazardous and dig them up
- Technology works
- Deployment requires a rigorous approach with quality checks and controls at every step
- Target quality standard is 100% of QA seeds detected
- Need to know your site and what you're likely to find there
- Any site suitable for a single axis sensor you could use one of these new multi-axis sensors.

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Wrap Up (continued)

- Quality Considerations
  - UFP QAPP Integration – enhanced QC/QA, accreditation
- Example Case Study
  - The technology has been demonstrated to be effective at nearly 20 real sites, is ready and in use on projects today
- Documents and Resources are available
  - ITRC, SERDP/ESTCP
  - https://www.serdp-estcp.org/Tools-and-Training/Munitions-Response/Classification-in-Munitions-Response
  - http://www.itrcweb.org/Team/Public?teamID=9

- Uniform Federal Quality Assurance Project Plan was developed for this technology.
- DOD Accreditation program required for companies who deploy the new sensors
- Case study based on real world demonstrations.
- Links provided to other resources

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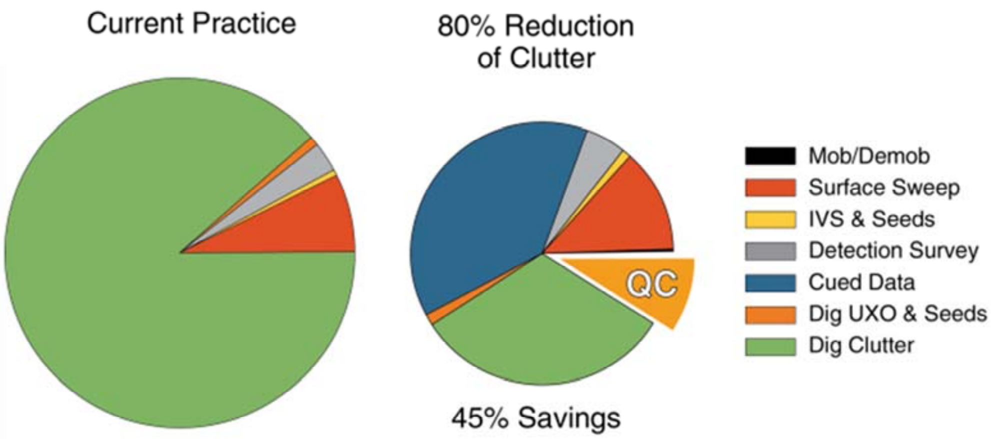
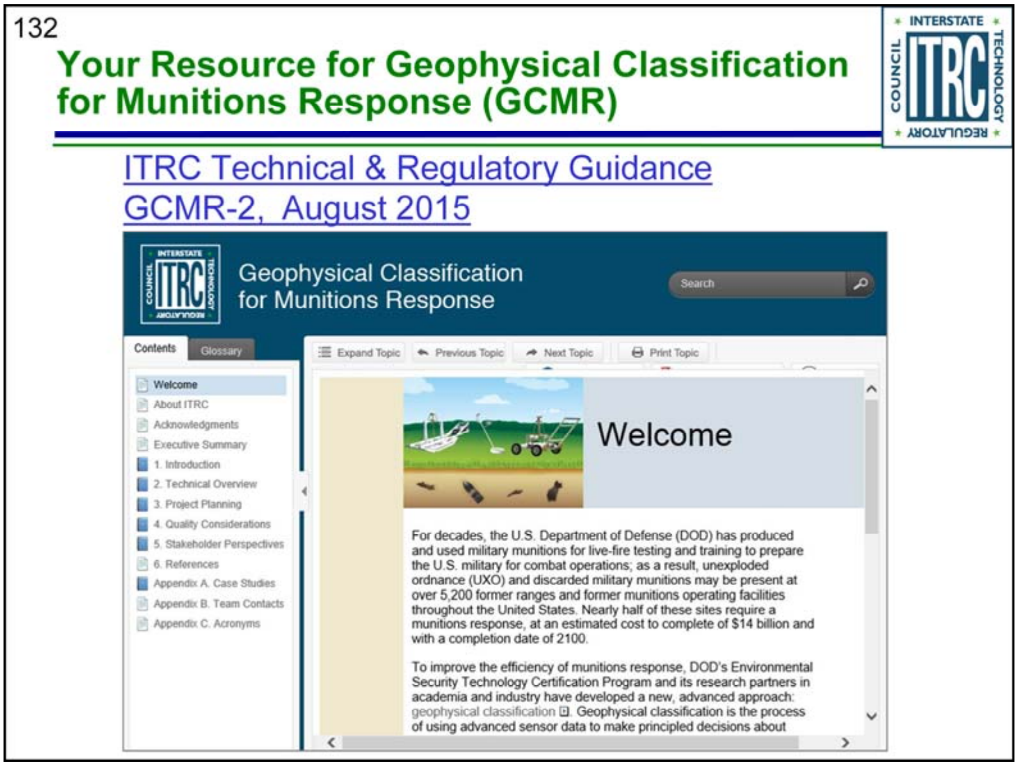
Technology Benefits – 45% Cost Savings

Cost Savings using Multi-Axis Sensors – at least 45%



GCMR-2, Figure 2-17

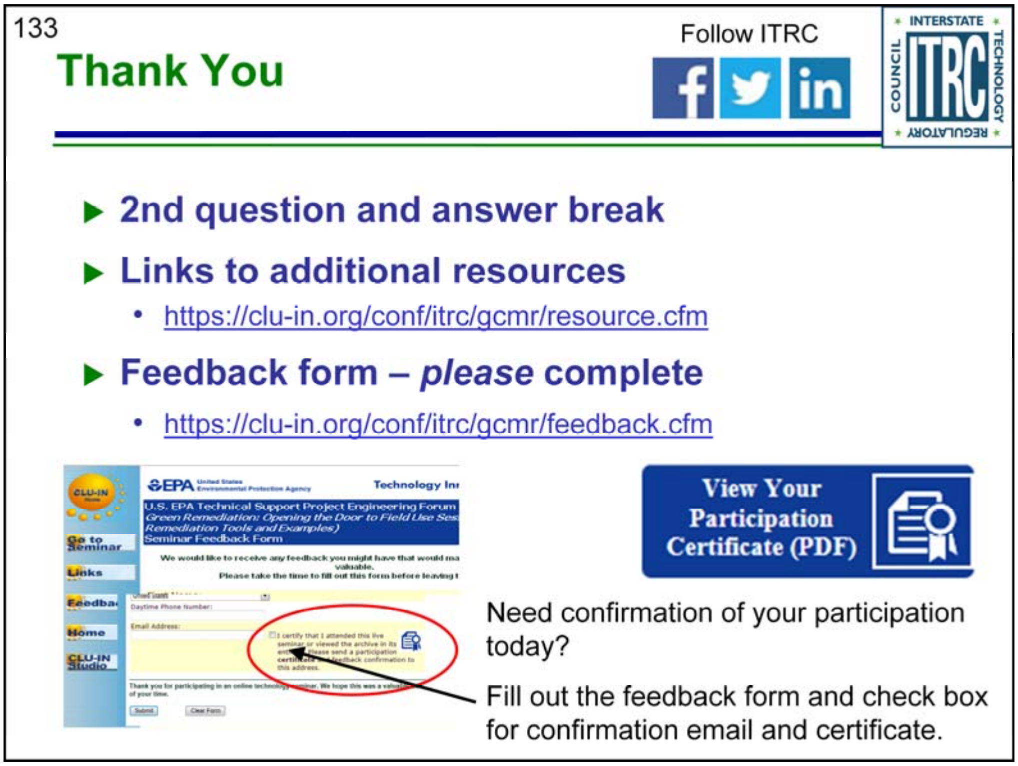
Cost savings



Summary of what you learned:

- Multi-axis sensor can distinguish bomb from scrap metal.
- How to evaluate advanced sensor technology for use on your site
- GCMR terminology and acronyms – and where to find glossary
- How multi-axis sensors are deployed
- Tools to share information within your organization and to stakeholders
- How to use the web based guidance document and UFP-QAPP
- Links to learn more about the technology

Please evaluate whether GCMR might be appropriate for your sites.



Links to additional resources:
https://clu-in.org/conf/itrc/gcmr/resource.cfm

Your feedback is important – please fill out the form at:
https://clu-in.org/conf/itrc/gcmr/feedback.cfm

The benefits that ITRC offers to state regulators and technology developers, vendors, and consultants include:

✓Helping regulators build their knowledge base and raise their confidence about new environmental technologies

✓Helping regulators save time and money when evaluating environmental technologies

✓Guiding technology developers in the collection of performance data to satisfy the requirements of multiple states

✓Helping technology vendors avoid the time and expense of conducting duplicative and costly demonstrations

✓Providing a reliable network among members of the environmental community to focus on innovative environmental technologies

How you can get involved with ITRC:

✓Join an ITRC Team – with just 10% of your time you can have a positive impact on the regulatory process and acceptance of innovative technologies and approaches

✓Sponsor ITRC's technical team and other activities

✓Use ITRC products and attend training courses

✓Submit proposals for new technical teams and projects