A CASE STUDY OF REDSTONE ARSENAL MSFC-003-R-01: DEVELOPMENT & REFINEMENT OF THE CSM

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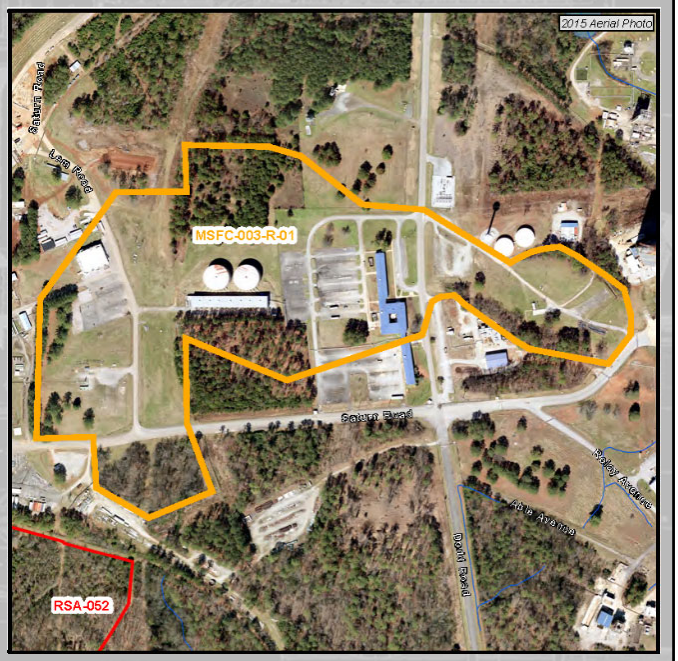
US Army Corps of Engineers



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AGENDA

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- Site location
- Background
  - Redstone Arsenal (RSA) history
  - Marshall Space Flight Center (MSFC) history
  - MSFC-003-R-01 history
- Site characterization activities for Interim Measures
  - Geophysical data collection with EM-61
  - Intrusive investigation
  - Sampling
- Site characterization results
- Selected Interim Measures Alternative
- Interim Measures Implementation
  - Advanced Geophysical Classification (AGC) data collection
  - Impact of AGC data on Conceptual Site Model (CSM)
- Summary and Conclusions

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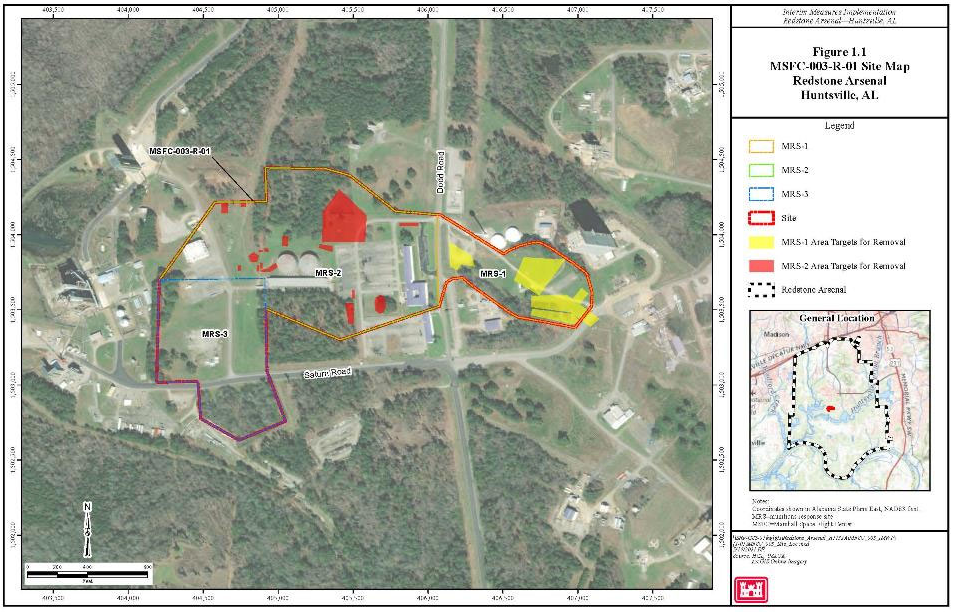
MSFC-003-R-01 SITE LOCATION



BACKGROUND: REDSTONE ARSENAL (RSA)

- RSA is located in Madison County, Alabama, adjacent to Huntsville, Alabama, and consists of approximately 38,200 acres.
- RSA was formerly comprised of three separate military facilities originally established in 1941: the Redstone Ordnance Plant (ROP), the Huntsville Arsenal (HVA), and the Gulf Chemical Warfare Depot (GCWD). These three facilities worked together from 1942 to 1945 to produce conventional and chemical munitions for use during World War II.
- Munitions casings were filled at the HVA. The HVA was composed of three production plants, which produced a variety of CWM.
- Once munitions were filled with CWM at one of the three HVA facilities, they were then transported by rail to the ROP for final assembly.
- In 1949, the mission of RSA was changed to the research and development of rocketry and guided missile systems.
- In 1950, the three facilities (HVA, ROP, and GCWD) were combined into one facility under the name “Redstone Arsenal”.
- RSA is currently a RCRA Subpart X permitted facility under the authorization of the State of Alabama.

BACKGROUND: RSA AND MSFC

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- In 1960 the Marshall Space Flight Center (MSFC) was established in the center of RSA within the former HVA plants area as National Aeronautics and Space Administration (NASA) property.
- MSFC-003-R-01 encompasses approximately 51 acres and lies in a partially controlled and developed area in the approximate center of MSFC.
- MSFC-003-R-01 was a historical waste disposal area within HVA.
- Activities within the site currently include office support, test stand operation, and pump house support to the test stands.

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MSFC-003-R-01 BACKGROUND

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- The MSFC-003-R-01 environmental site boundary was officially and administratively established by the Army in 2007 to include four historical waste disposal areas:
- **MSFC-3** (~24 acres) is referred to as the “Boneyard,” and documentation indicates it was used in 1957 by various laboratories and construction contractors to dispose of scrap material that would normally be disposed of at the sanitary landfill or turned into salvage.
- **MSFC-3E** (~6 acres) is located east of MSFC-3. Records indicate that miscellaneous debris within the footprint of the water reservoirs created for the Saturn Test Stand in MSFC-3 was relocated to MSFC-3E.
- **MSFC-82 and MSFC-82S:** The southern two-thirds of MSFC-82 (~17 acres) and all of MSFC-82S (~4 acres) are located within the boundary of historical Area 11. The two areas were documented as accepting reject chemical munitions from the deactivation of HVA. These areas were noted as burning and destruction grounds contaminated with mustard agent, lewisite, arsenic, and white phosphorus. The boundary of historical Area 11 also includes nearby site RSA-052.

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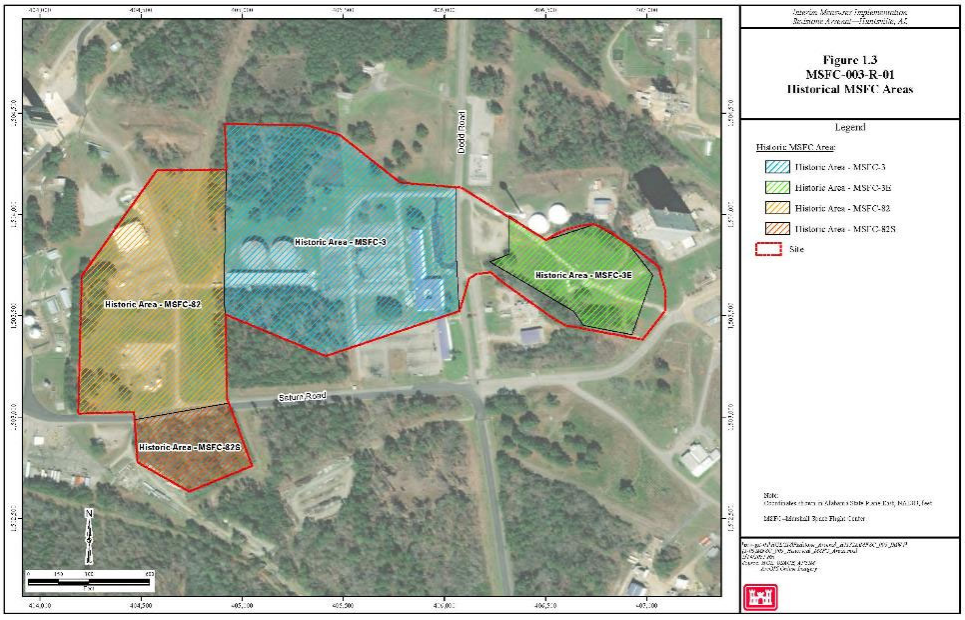
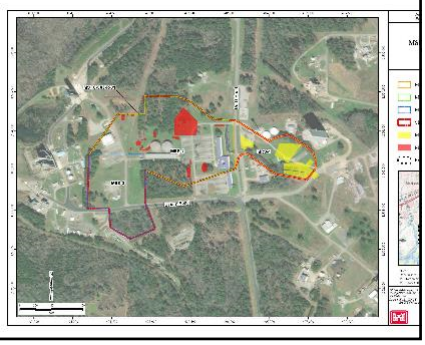
MSFC-003-R-01 WASTE DISPOSAL AREAS



BACKGROUND: MSFC-003-R-01 MRSs

- **MRS-1:** Includes two historical waste disposal landfills in MSFC-3E. Fieldwork confirmed Munitions and Explosives of Concern (MEC) in disposal areas. No evidence of CWM was identified. The CWM probability is “Occasional.”
- **MRS-2:** Includes historical waste disposal area MSFC-3 and the northern third of historical waste disposal area MSFC-82. Fieldwork confirmed numerous single point anomalies (SPAs) that contain MEC (some of which has the potential to be CWM), potential chemical container debris, and areas of burn pit/waste disposal pits. Approximately 11,000 SPAs remain in this area. The CWM probability for a majority of MRS is “Occasional,” with a small portion of the MRS having a CWM probability of “Seldom.”
- **MRS-3:** Includes the southern two-thirds of historical waste disposal area MSFC-82 and historical waste disposal area MSFC-82S. These two areas were historically associated with operations related to Area 11 and RSA-052. The CWM probability is mix of “Occasional,” and “Seldom.”



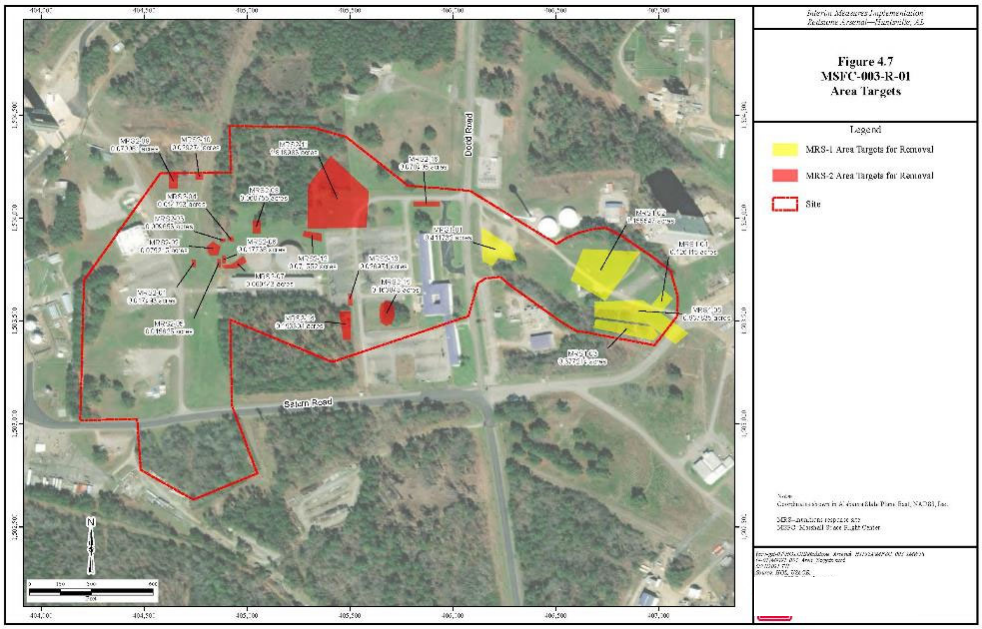
MSFC-003-R-01 AND RSA's RCRA PERMIT

- MSFC-003-R-01 is listed in RSA's RCRA Permit as a SWMU that requires:
  - Interim measures (IMs) and/or source removal, followed by a:
  - A RCRA Facility Investigation (RFI)
- For the IM, the permit specifies an "IM Work Plan to include removal of disposed chemical munitions, toxic materials, chemical wastes, and burn pits" is required.
- To facilitate execution of the IM, it was broken into two phases:
  - Phase I: site characterization
  - Phase II: implementation of IM
- Phase I investigation for MRS-1 and MRS-2 was completed in 2016.
- Phase I investigation for MRS-3 (historically associated with operations related to other areas) is anticipated to be awarded in FY22.

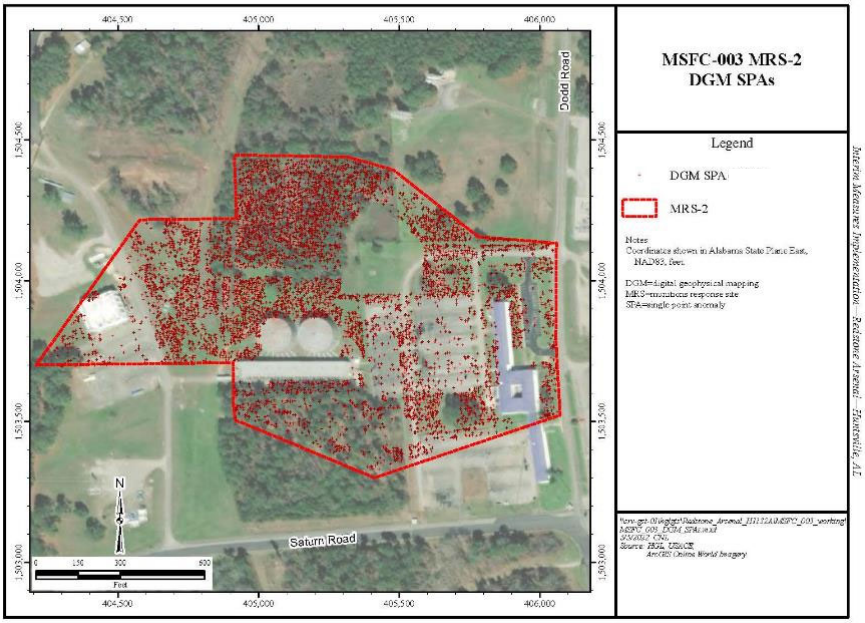
PHASE I SITE CHARACTERIZATION ACTIVITIES

- Geophysics: EM61-MK2 and EM31 SH (2013-2014), and TEMTADS surveys (2015-2016, 7 grids only)
  - 11,700 single point anomalies (SPAs) identified
  - 27 area targets identified
- Intrusive investigation (2016)
  - Using advanced classification, 310 SPA locations selected for intrusive investigation
  - 36 test pits excavated
- Groundwater and soil environmental sampling (2016)
  - Soil samples collected below each SPA where MEC was identified and where evidence of munitions-related items, disposal pits, or burn areas was present
  - Soil samples collected from test pits that showed evidence of Permit-specified features
  - 8 soil borings installed to further characterize area targets (2 surface and 37 subsurface samples collected)
  - 11 groundwater samples collected
  - Analyses included CA headspace screening, CA (mustard and lewisite), TCL VOCs, TCL SVOCs with low-level PAHs plus TICs, TAL metals, explosives plus, perchlorate, thiodiglycol, and thianes.

PHASE I RESULTS: AREA TARGETS



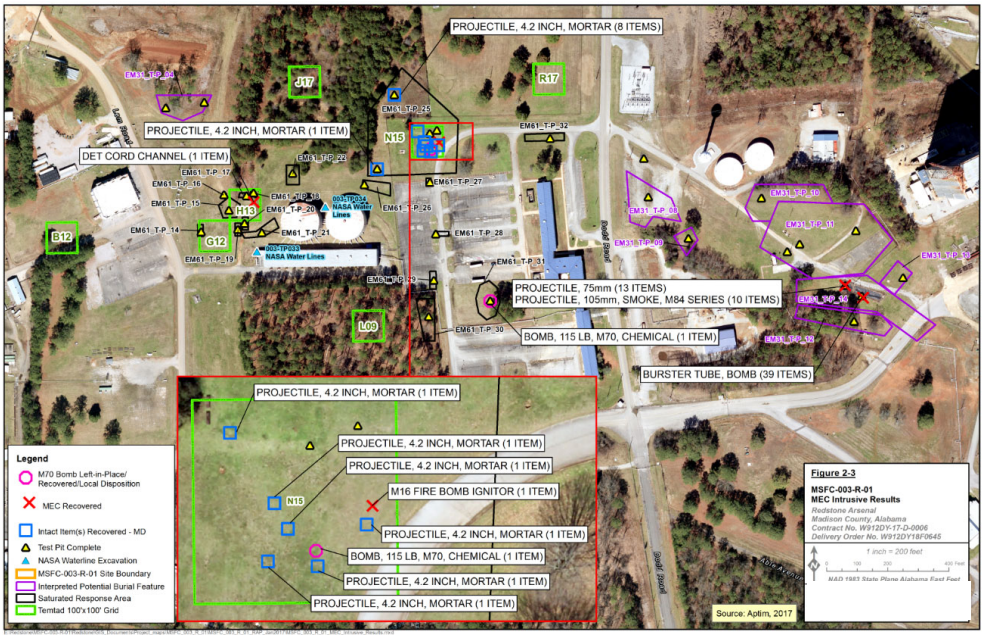
PHASE I RESULTS: SPAs IN MRS-2



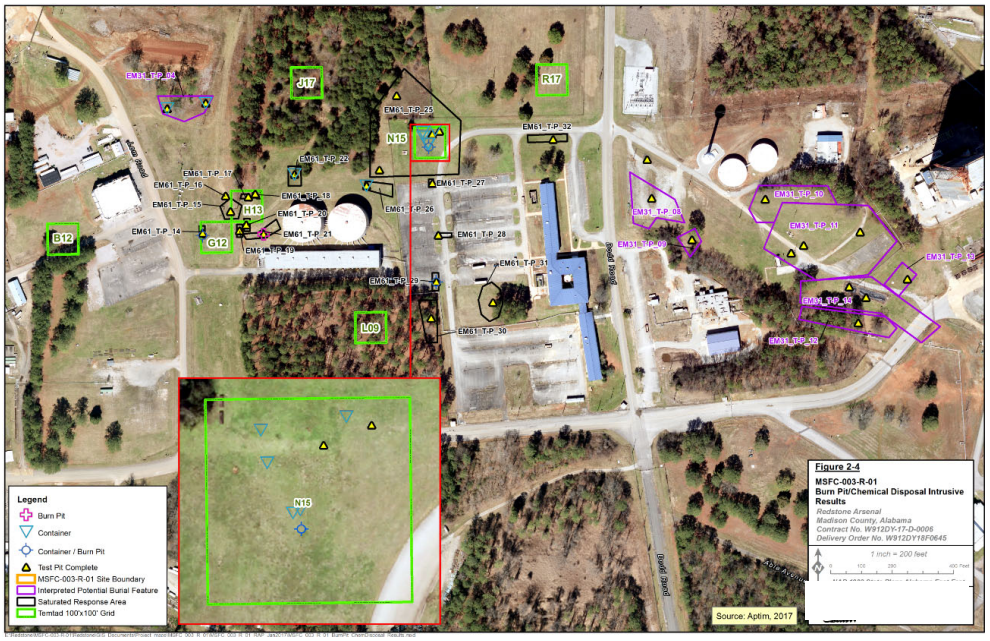
IM CHARACTERIZATION RESULTS

- PCWM (potential CWM), later determined to be MD
  - M70 Chemical bombs (2 each)
  - 4.2-inch Mortar projectiles (10 each)
- MEC
  - Burster Tube, bomb, (Tetryl) (33 each)
  - Burster Tube, bomb, (Tetryl RP) (6 each)
  - 75mm M89 Projectile (10 each)
  - 105mm, smoke, M84 Projectile (15 each)
  - Detonating Cord Channel from M50 Dispenser (1 each)
  - M16 Fire Bomb Igniter, Fuze and Burster Components (1 each)
- MD
  - Burster Tube, bomb (394 each)
  - 4.2-inch Mortar projectiles (21 each)
  - M69 Incendiary Bomb (2 each)
  - Bomb Burster Tube (1 each)
  - 4.2-inch Mortar projectile, Burster Tube (1 each)
  - M50 Incendiary Bomb pieces (20 each)
  - Box Fins from 100-pound M47 Bomb (1 each)
  - Rifle Grenade parts (1 each)
- Burn Pits/Chemical Drum Debris (permit-specified features)
  - Evidence of both encountered in several locations in MSFC-3 (MRS-2)

INTRUSIVE RESULTS- MEC



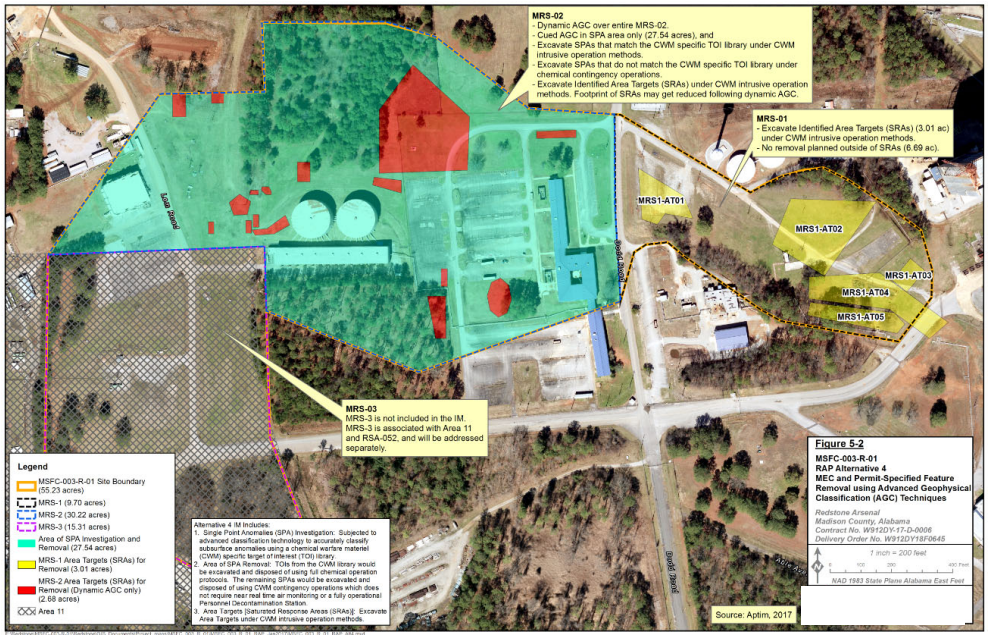
INTRUSIVE RESULTS- PERMIT FEATURES



SUMMARY OF IM CHARACTERIZATION

- Based on the IM site characterization results, IMs are required at MSFC-003-R-01 to address the unacceptable near-term hazard and/or risk to human health and the environment posed by MEC and PCWM.
- The following IM objectives were identified in the RAP:
  - Minimize current and future direct exposure to MEC.
  - Minimize current and future direct or indirect exposure to CA or CACM.
- Selected IM: Remove MEC and Permit Specified Disposal Features Using Advanced Geophysical Classification
  - Removal of all MEC and other Permit-specified features in MRS-1 and MRS-2
  - MRS-3 not included in selected IM
  - Perform full coverage Advanced Geophysical Classification (AGC) in MRS-2.
    - Target of Interest (TOI) is the 4.2” mortar, only munition likely to be chemically configured at MSFC-003-R-01.
    - AGC will be used to classify all anomalies as TOIs or non-TOIs and possibly allow for reduction in size of saturated response areas (area targets) in MRS-2.
    - Only TOIs and area targets will be investigated under full CWM protocols. This approach will result in excavating fewer anomalies under full CWM protocols.

SELECTED IM RAP ALTERNATIVE

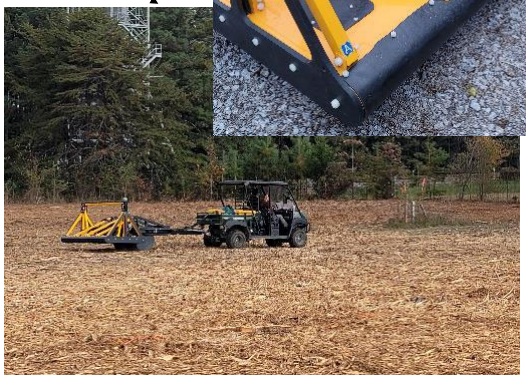


IM IMPLEMENTATION: AGC COLLECTION

– Full coverage AGC conducted at MSFC-003-R-01 in late 2021
- 25.6 acres covered using UltraTEM Classifier (29 days of surveying)
- 1.7 acres covered using UltraTEM Screener in areas Classifier could not reach (8 days)
- 2.9 acres of obstruction (buildings, tanks, etc.)

Screener

Classifier



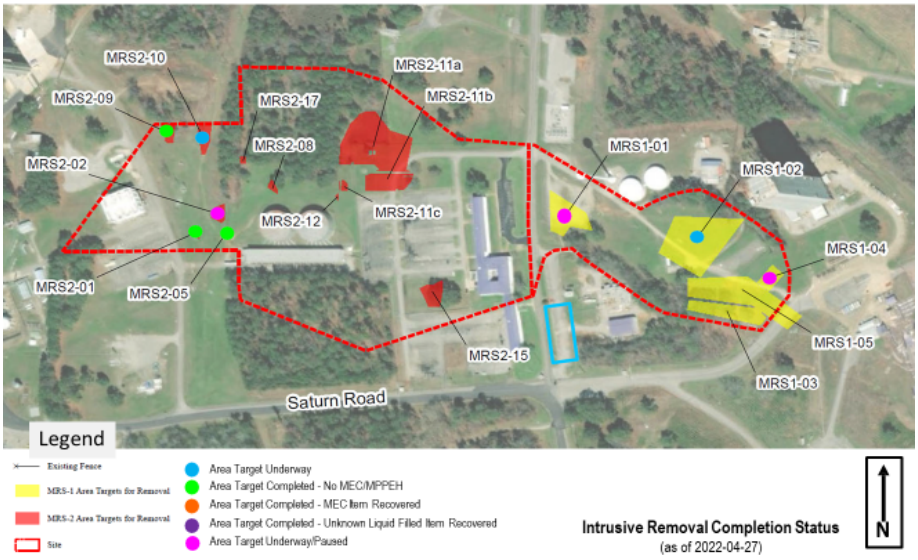
CSM REFINEMENT USING AGC: AREA TARGETS

SRA	Pre AGC Acres	Post AGC Acres
MRS2-01	0.016	0.023
MRS2-02	0.085	0.066
MRS2-05	0.036	0.013
MRS2-08	0.039	0.030
MRS2-09	0.078	0.067
MRS2-10	0.035	0.123
MRS2-11	1.800	1.404
MRS2-12	0.071	0.005
MRS2-15	0.168	0.152
MRS2-17	0.000	0.014
Total	**2.328**	**1.897**

18.5% reduction in SRA area

Figure 6. UltraTEM Classifier data in MSFC-003-R-01 showing saturated response areas (blue lines) and infrastructure polygons (magenta lines). Acreages for numbered SRAs are given in Table 3.

MSFC-003-R-01 Interim Measures Phase II
Proposed Area Targets for Removal



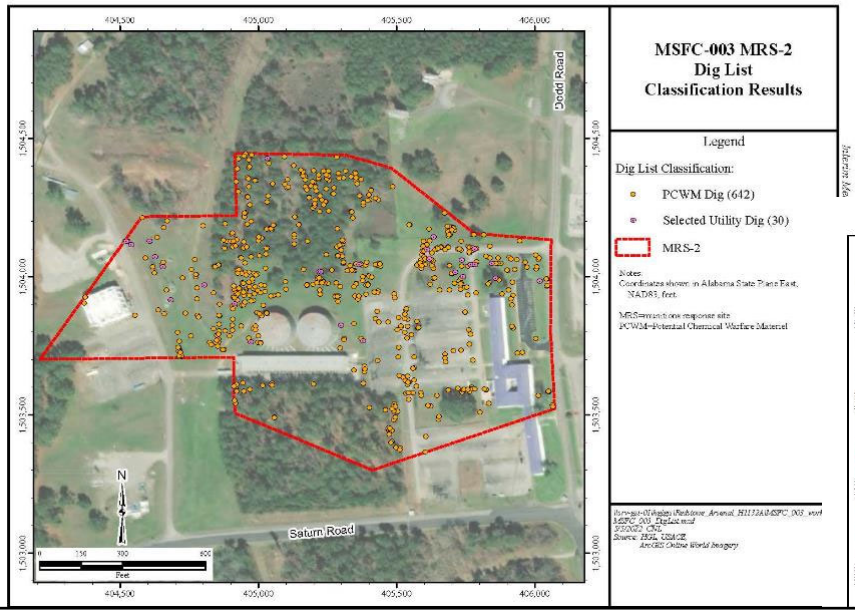
IM IMPLEMENTATION: AREA TARGET EXCAVATION

CSM REFINEMENT USING AGC: SPAs

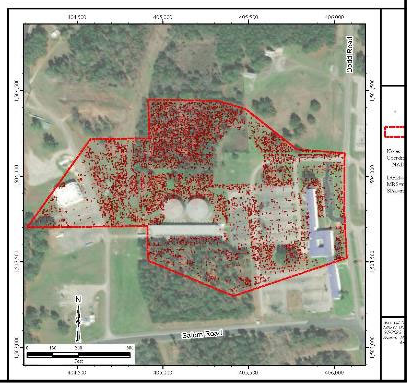
- Original quantity of anomalies from EM-61 data: 11,700
- Anomalies from AGC data: 17,083
  - AGC sensor receiver coils are smaller than EM61 coils, resulting in a signal response from a smaller footprint than a EM61 coil.
  - One large EM61 anomaly can resolve into multiple anomalies using AGC sensors, hence the increased quantity of anomalies.
- A total of 672 of the AGC anomalies were classified as TOIs, meaning they have a high likelihood to be 4.2” mortars, the munition TOI for MSFC-003-R-01.
- This subset of TOIs were intrusively investigated under full CWM protocols.
- The remaining anomalies will be investigated under CWM contingency protocols.
- Use of AGC resulted in a 96% reduction in number of anomalies requiring investigation under full CWM protocols, representing a huge cost savings to the Government.

MSFC-003-R-01 TOIs

After AGC



Before AGC



SUMMARY AND CONCLUSIONS

- MSFC-003-R-01 is an area that was used in the 1950s for waste disposal, including munitions, construction debris, etc.
- Findings from the Phase I intrusive investigation
  - Evidence of conventional munitions, PCWM, and burn pits/chemical drum debris.
  - EM61 data collection assessed MRS-2 as having almost 12,000 individual anomalies and over 2 acres of saturated response areas
- Anomalies were refined using AGC data collection
  - Acreage of saturated response areas in MRS-2 reduced almost 20%
  - Quantity of individual anomalies increased to around 17,000, however AGC allowed reduction of anomalies required to be investigated under CWM protocols to under 700
- A Phase II Interim Measure is currently underway.
  - All TOIs have been intrusively investigated under full CWM protocols
  - Area targets are being investigated/excavated currently
  - Remaining anomalies from AGC will be intrusively investigated using CWM contingency protocols
- CSM refinement using AGC resulted in a significant time and cost savings to the Government.