PRELIMINARY CHARACTERIZATION AND AGC ANOMALY RESOLUTION

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6 September 2023

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AGENDA

Preliminary Characterization
– AGC vs. Non-AGC DGM sensors on preliminary characterization transects
– VSP Transect design for Practice Bombing Ranges
– VSP Geostatistical analysis and defining the critical density
Anomaly Resolution Requirements for No Contacts on AGC digs

PRELIMINARY CHARACTERIZATION – AGC VS. NON-AGC DGM SENSORS

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"KAREN BAKER" MEMO

5.(a) "AGC is the preferred method for geophysical da
collection in FUDS munitions response activities durin
the investigative phase (i.e., Remedial Investigation/Feasibility Study (RI/FS)) and clean up phases (i.e., Removal Action (RmA) and/or Remedial Action (RA)).This does not preclude use of other meth
for detection and subsequent cueing and classificatior
detected anomalies using AGC."

5.(b) "USACE Project Delivery Teams shall consider u
of advanced geophysical sensors as the standard for digital geophysical data collection in all phases of the Munitions Response process when it can be used effectively."

5.(i) "For site-specific cases where use of AGC is determined by the Project Delivery Team (PDT) to not feasible or practical within a given MRS, the specific reasons shall be clearly documented as part [sic] the documents that make up the administrative record for the

DEPARTMENT OF THE ARMY
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WASHINGTON, DC 20314-1000

REPLY TO ATTENTION OF

CEMP-CED (200-1a) APR 24 2017

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Advanced Geophysical Classification (AGC) Implementation at Formerly Used Defense Sites (FUDS) Military Munitions Response Program (MMRP) Projects

1. PURPOSE: This guidance memo and enclosures provide instructions on how to Implement AGC technology in all phases of the munitions response process.

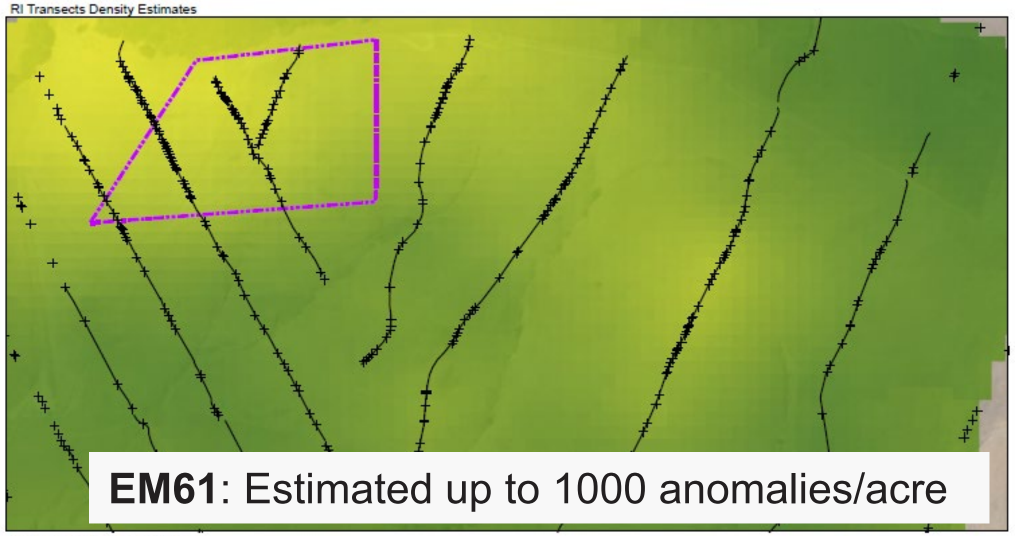
2. BACKGROUND: Munitions response activities involve detection and inspection of buried metallic objects (i.e., geophysical anomalies) that may be Munitions and Explosives of Concern (MEC). Traditional munitions response actions utilizing single loop sensors require a significant amount of digging to determine if they are MEC or other metallic debris. Often, less than 1% of the detected anomalies are actual MEC; thus, this method expends a huge amount of resources digging up items that turn out not to be hazardous. New geophysical sensors capable of detecting and classifying anomalies as MEC or other metallic debris are available for use in munitions response activities. This process, known as Advance Geophysical Classification (AGC), fits physics-based models to the observed sensor responses to determine physical characteristics such as geometry and wall thickness. The physical properties are compared to a library of known MEC items to classify them based on the closest match. The library forms the basis for determining if anomalies are potentially MEC or other metallic debris. Classification using advanced electromagnetic induction sensors has been shown to significantly reduce the cost of a munitions response.

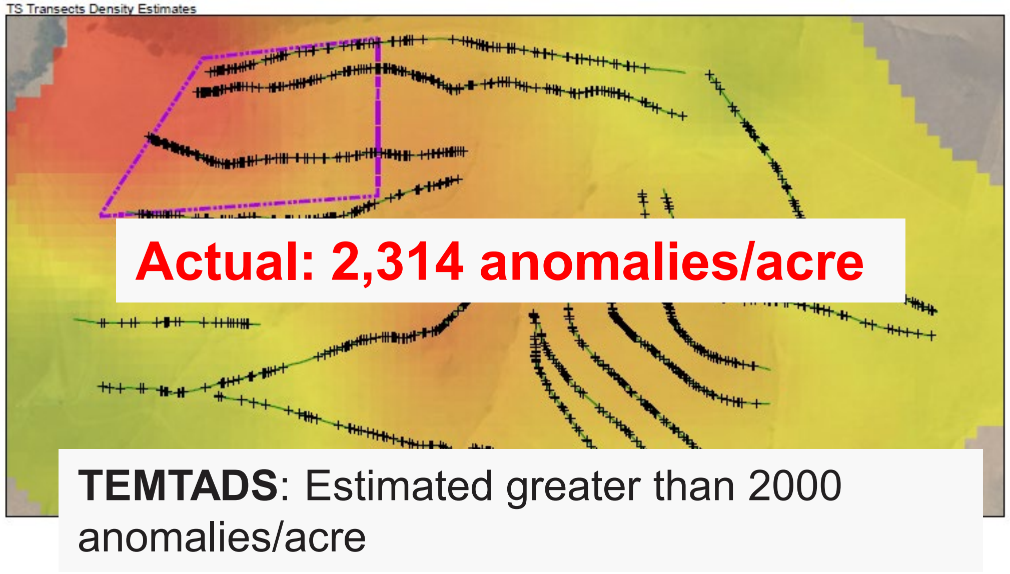
On April 11, 2016, the Office of the Assistant Secretary of Defense, Energy, Installations, and Environment (ASDEI&E) issued a policy memorandum Subject: Department of Defense Advanced Geophysical Classification Accreditation Program (DAGCAP). ASD (EI&E) established the DAGCAP to accredit organizations that use AGC at Munition Response Sites (MRSs). The DAGCAP provides a unified program for organizations performing AGC to demonstrate competency and document conformance to minimum quality systems requirements based on the International Organization for Standardization and the International

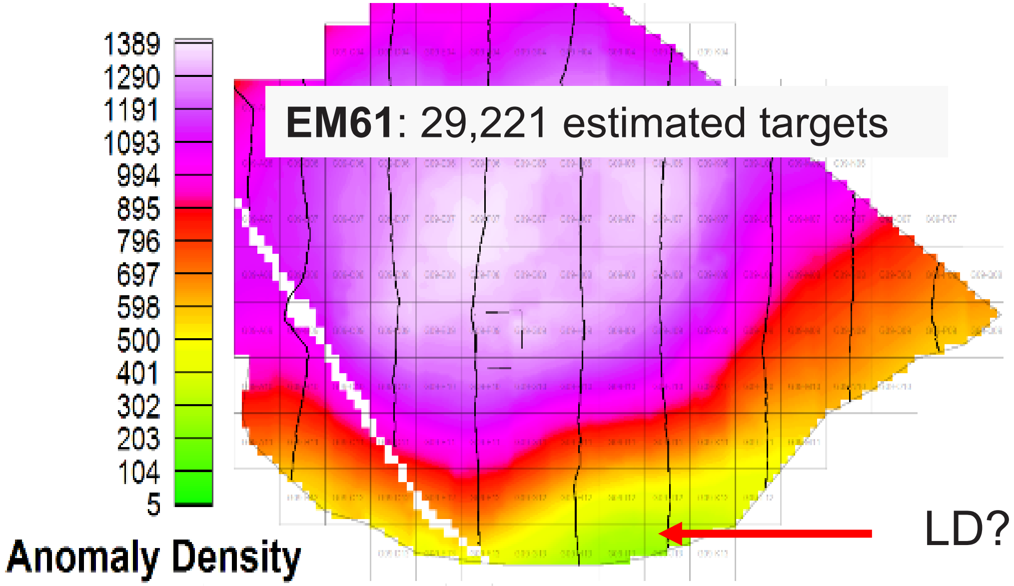
WHAT'S THE ISSUE?

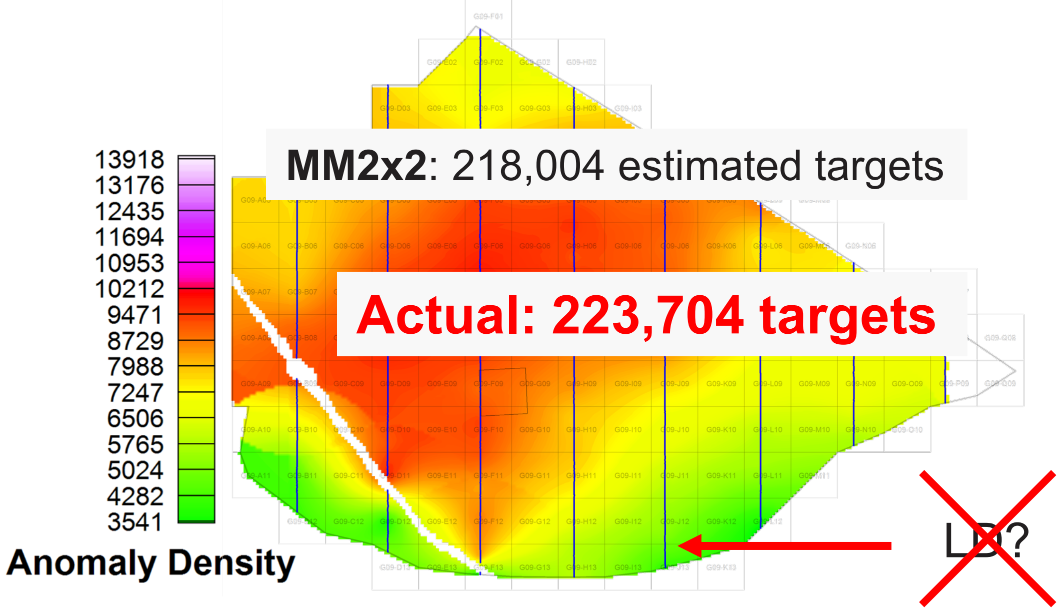
- ❖ Contractors are proposing non-AGC DGM (or pseudo-DGM) sensors for preliminary characterization in places they can obtain AGC transect data. **NOT compliant with FUDS policy.**
- ❖ There is no way to scale non-AGC DGM anomaly density to AGC anomaly density
  - – We know that AGC anomaly densities are 2-10x higher than EM61-MK2 anomaly densities
- ❖ It is not clear whether an HD area target is the same size for AGC vs. non-AGC DGM
- ❖ Post Preliminary characterization, plans to get AGC anomaly density widely vary
  - – a couple acres of grids
  - – some transects in identified HD areas
  - – AGC transects that follow preliminary characterization transects in HD areas

LIMITATIONS OF EM61 FOR ESTIMATING ANOMALY DENSITY









USING EM61 DATA FOR THE RI

Does this mean we can't use EM61 data for RIs anymore?

– No, it can still be used to find HD and LD areas, but…**FUDS program policy is to use AGC wherever practical**.

– AGC anomaly densities are reliable and are required in the RI even if EM61 data is used in preliminary characterization.

– AGC anomaly densities are more reliable in defining HD areas.

- If you collect non-AGC DGM data on preliminary characterization transects, part of your AGC anomaly density analysis should be to determine if AGC HD Area and HUA) boundaries are different

– EM61 anomaly densities are not reliable.

- Side note: analog and "MEC reconnaissance" transects should not be used for preliminary characterization decisions.

VSP TRANSECT DESIGN FOR PRACTICE BOMBING RANGES

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PRACTICE BOMBING RANGES VSP SAMPLE DESIGN

- VSP default for air dropped ≤ 100-lb HE bombs
  - 217.6-m target area radius
  - 36.76 acres
  - Inappropriate for non-fragmenting practice bombs
- HUAs for practice bombing ranges
  - HUAs 0-31 acres
  - HUAs not always found
  - Anomaly densities generally lower than bombing ranges with HE
- VSP Planning Considerations
  - Be conservative – you don't know what actual anomaly densities are and how large the HUA is
  - Recommend
    - Target area of 7.8 acres or ~100 meter target circle radius
    - Assume low anomaly densities
      - Background of ~5-10
      - Elevated anomaly density of ~30-70
- If no HD area found, place a grid in the middle of the target

Example Small Bombing Range Sizes

MRS Size (acres)	Range Type	HUA Area (acres)	RI DGM Anomaly Density Range (ApA)
43	Skip Bombing Target	20	0-30
26	Practice Bombing	13	0-580
175	Practice Bombing	0	0-69
101	Practice Bombing	0	0-143
222	Practice Bombing	31	400-1650
1008	Practice Bombing	17	150-400
595	Practice Bombing	7.8	100-200
1799.1	Practice Bombing	0	0-200
647	Practice Bombing	0	100-800

"I designed my transects to find a 36-acre bombing target. I'm not looking for things smaller than that."

VSP GEOSTATISTICAL ANALYSIS AND DEFINING THE CRITICAL DENSITY

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WHY ARE WE REVIEWING THIS TOPIC

VSP geostatistical analyses not being done in accordance with training and guidance.

– “Honestly, I always found the critical density to be subjective.”
– “The VSP default inputs seemed reasonable, so I used them.”

We are not being conservative enough defining HD areas

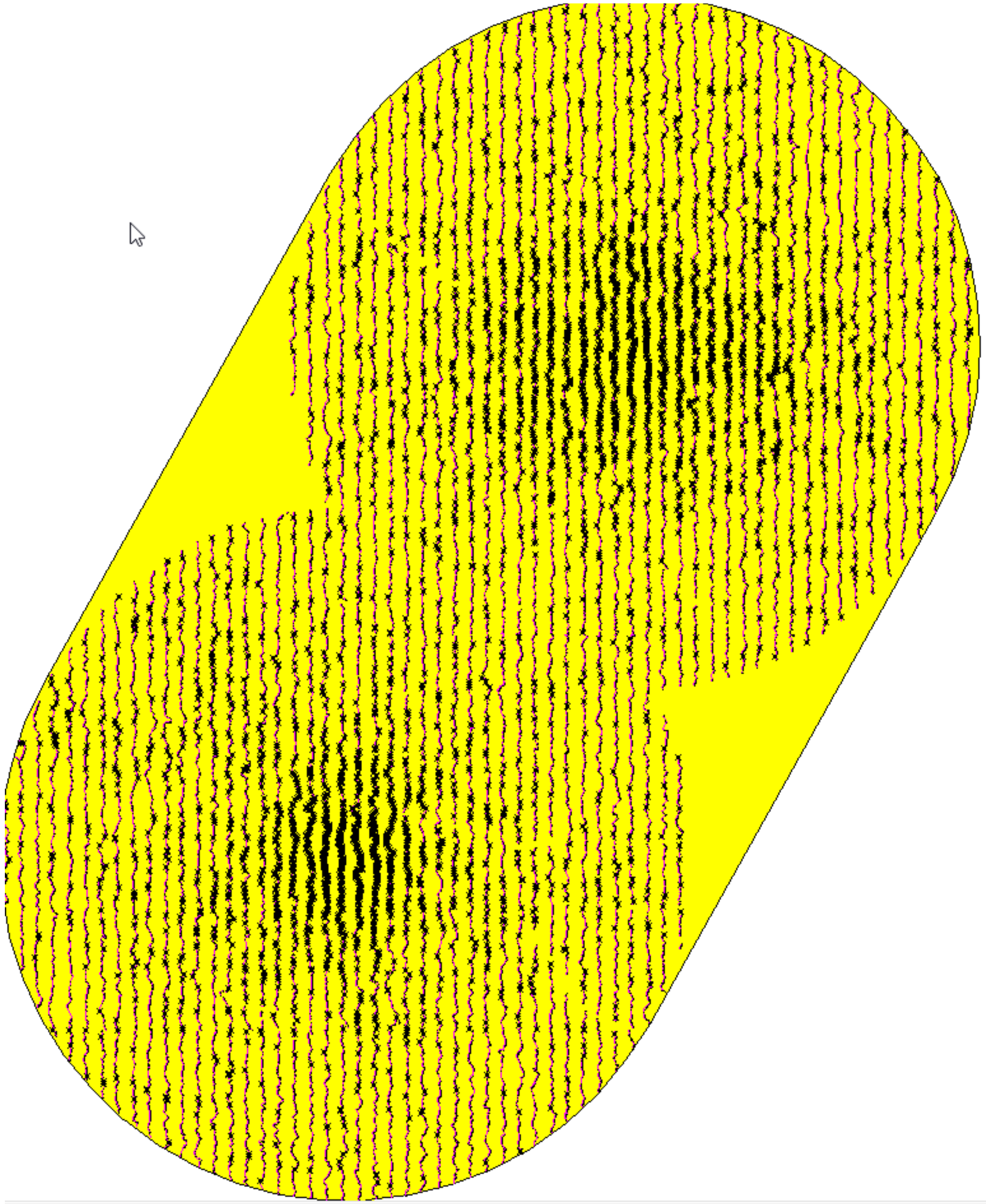
– Critical densities in the 100s to 1,000s anomalies/ Acre (ApA)

…BUT FIRST….A QUICK NOTE ON MR-QAPP DEFINITIONS

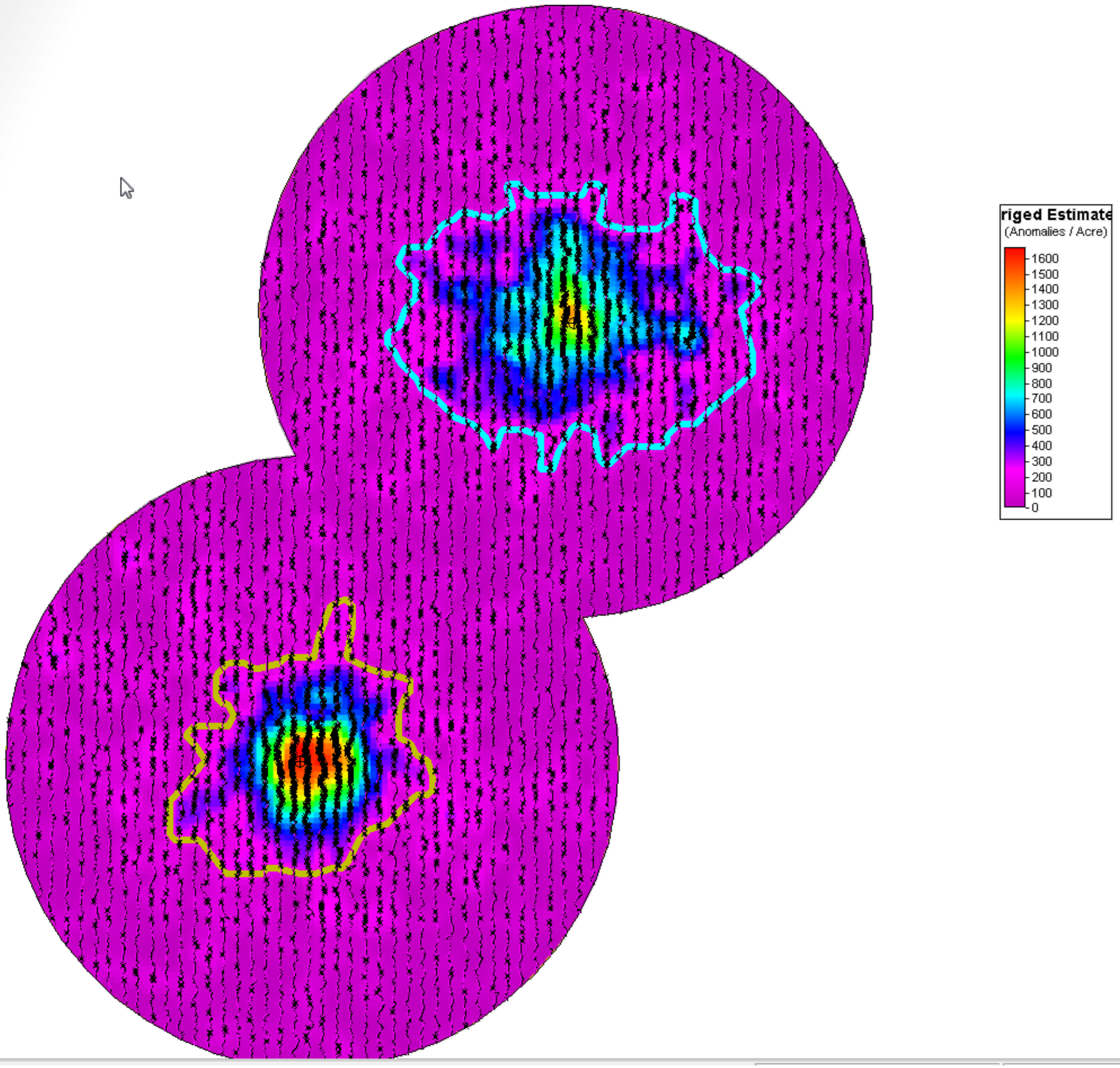
- **HUA: High use area:** HD area where munitions use has been confirmed. Unexploded ordnance (UXO) and/or discarded military munitions (DMM) are anticipated to be present in HUAs.
- **Critical (anomaly) density:** [A VSP input parameter] Defined in VSP as "the upper bound of acceptable anomaly density", i.e., the estimated, site-specific upper bound of anomaly density considered to be attributable to background (**non-munitions-related**) sources. It is the project-specific, user-defined value for anomaly density (inclusive of background) used to delineate high anomaly density (HD) areas from low anomaly density (LD) areas.
- **Background anomaly density:** **The anomaly density in an area where anomalies occur solely from geologic material or anthropogenic clutter not related to DoD range activities.** This information may not be known prior to Remedial Investigation activities. Background anomalies are assumed to be uniformly distributed throughout the site, or defined sub-areas of the site, as explained in the preliminary CSM. Initial estimates of background density are based on information contained in the CSM, including site history, geology, and the results of previous investigations. The actual background density can be measured using geophysical sensors in areas where no range activities have occurred.
- **Target (or HUA) boundary:** For the purpose of this document, the location, moving away from the target (or HUA) center, where the anomaly density drops to **background**. [Note: the background density is assumed to be uniform throughout the site or defined subsets of the site as explained in the preliminary CSM.]

EXAMPLE PROJECT

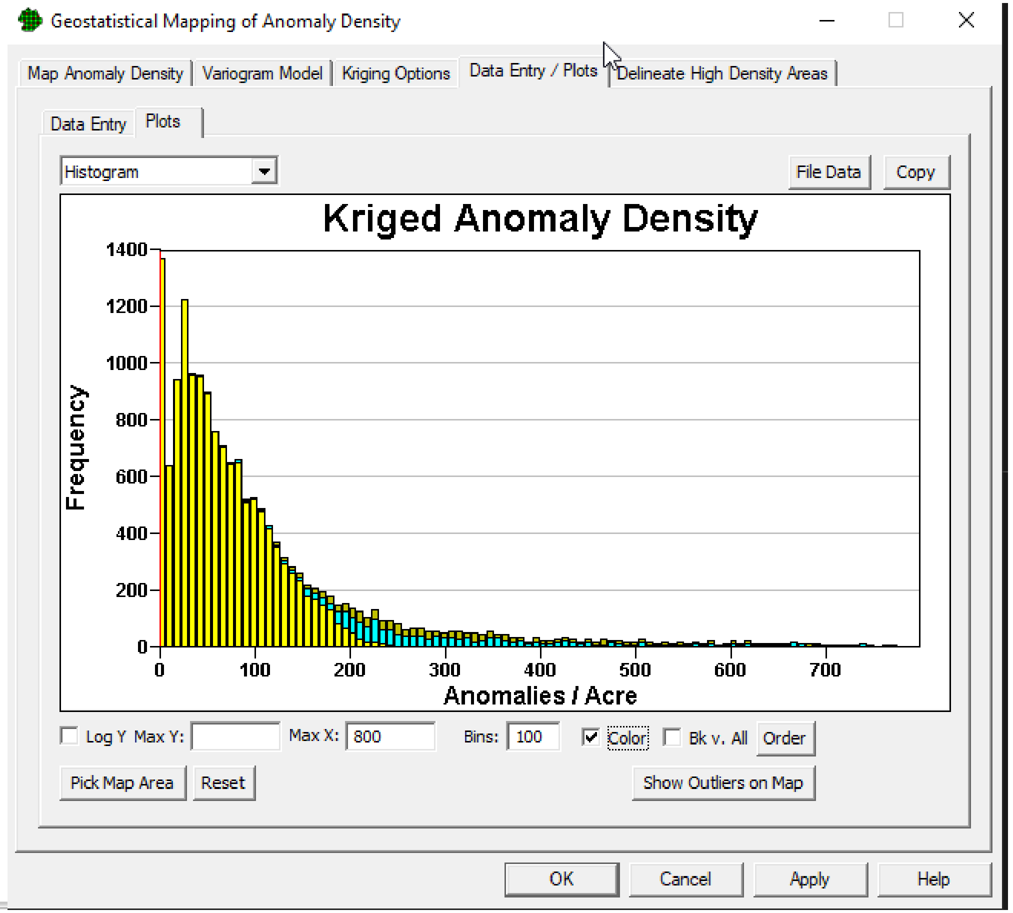
- Sent VSP to NAOC and USACE DCs
  - Intent – see how people are making decisions on an example dataset
  - See the range of potential issues in analysis
  - See the range of results
  - Use this information to inform training/guidance (this presentation)
- Directions
  - Use the attached data to generate a krigged anomaly density map and delineate the HD area(s) for this MRS
  - Assume this is a moderately used 100lb bombing target
  - Send us your VSP project with krigged densities and delineated HD area(s)
  - (optional) If you want, include your rationale for VSP inputs, selection of critical density, etc.
  - Assumption
    - 1 meter transect width
    - ~ 50-m transect spacing



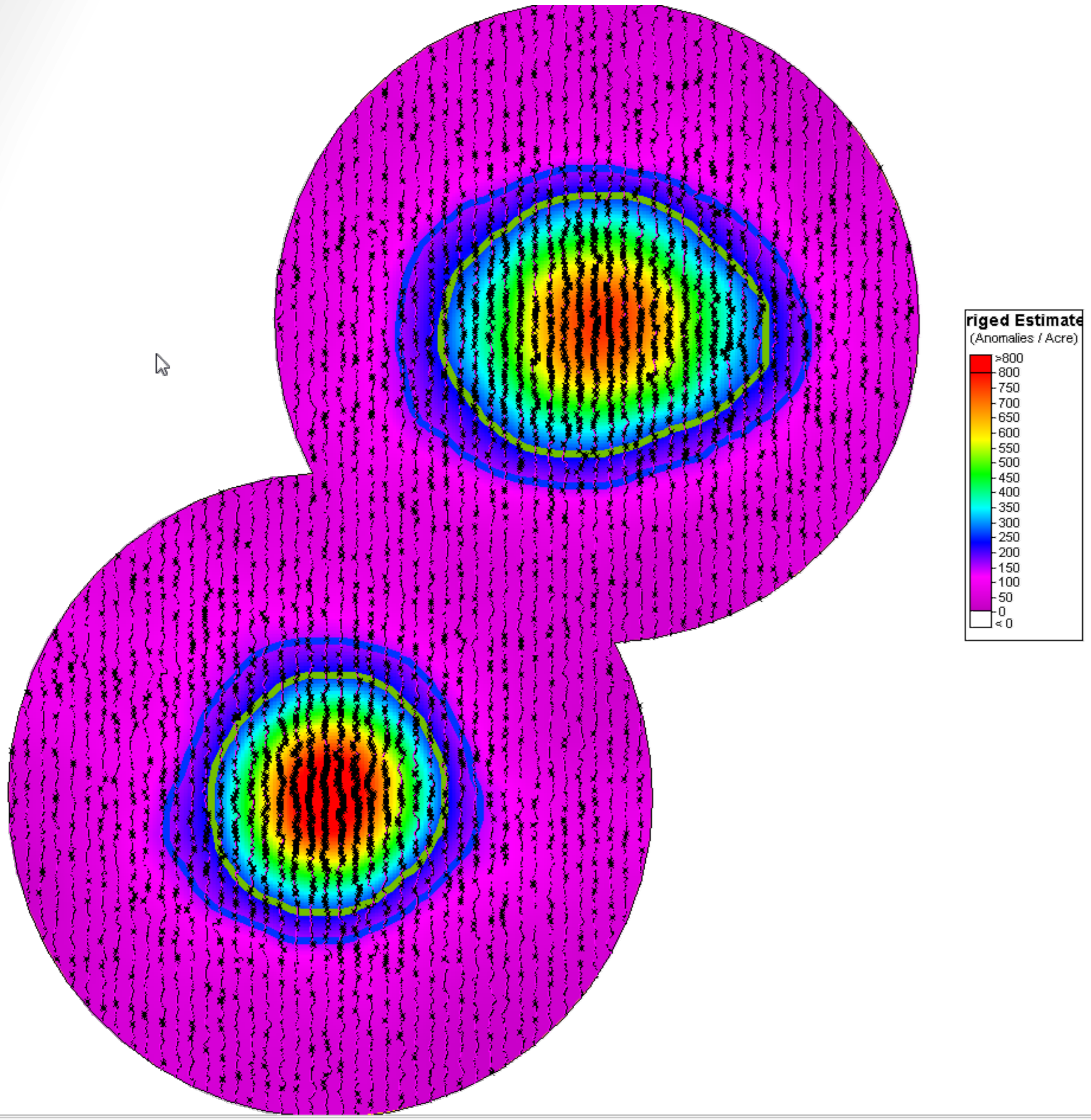
DEFINING HD AREA – ANALYST 1



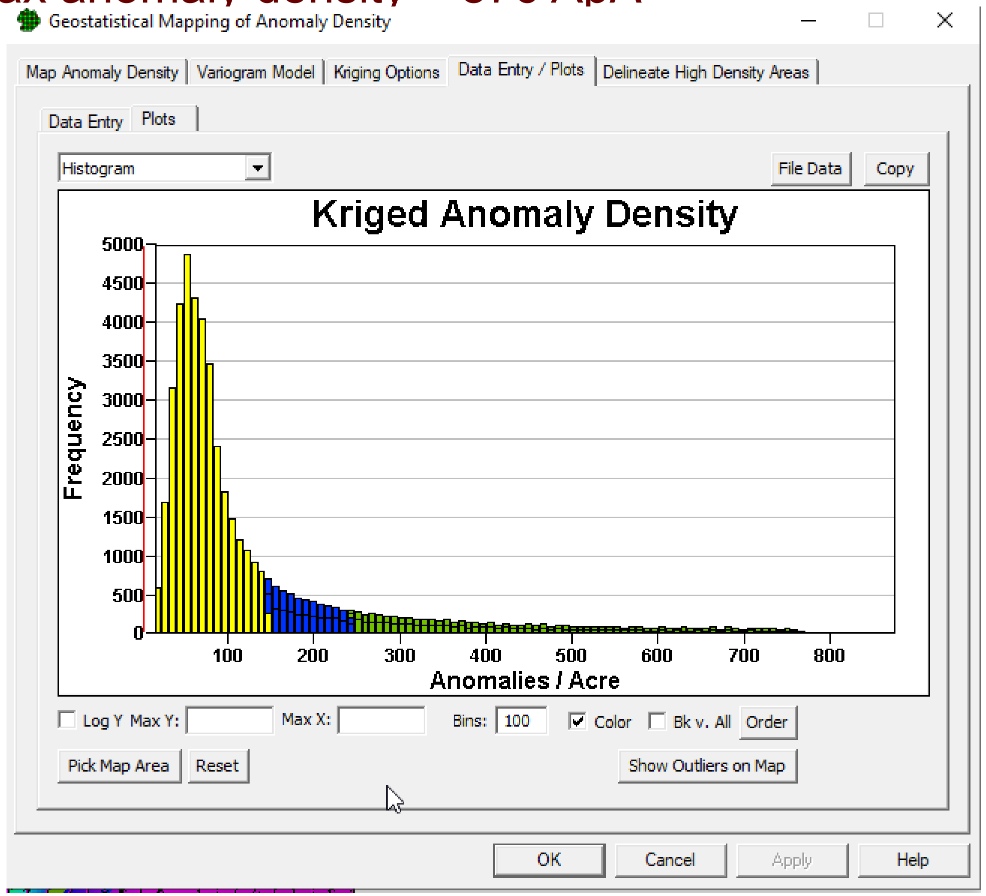
- ❖ Window Diameter – 90 meters
- ❖ Critical Density - 200 anomalies/acre
- ❖ Min Target Area - 30 acres
- ❖ Max anomaly density – 1,666 ApA



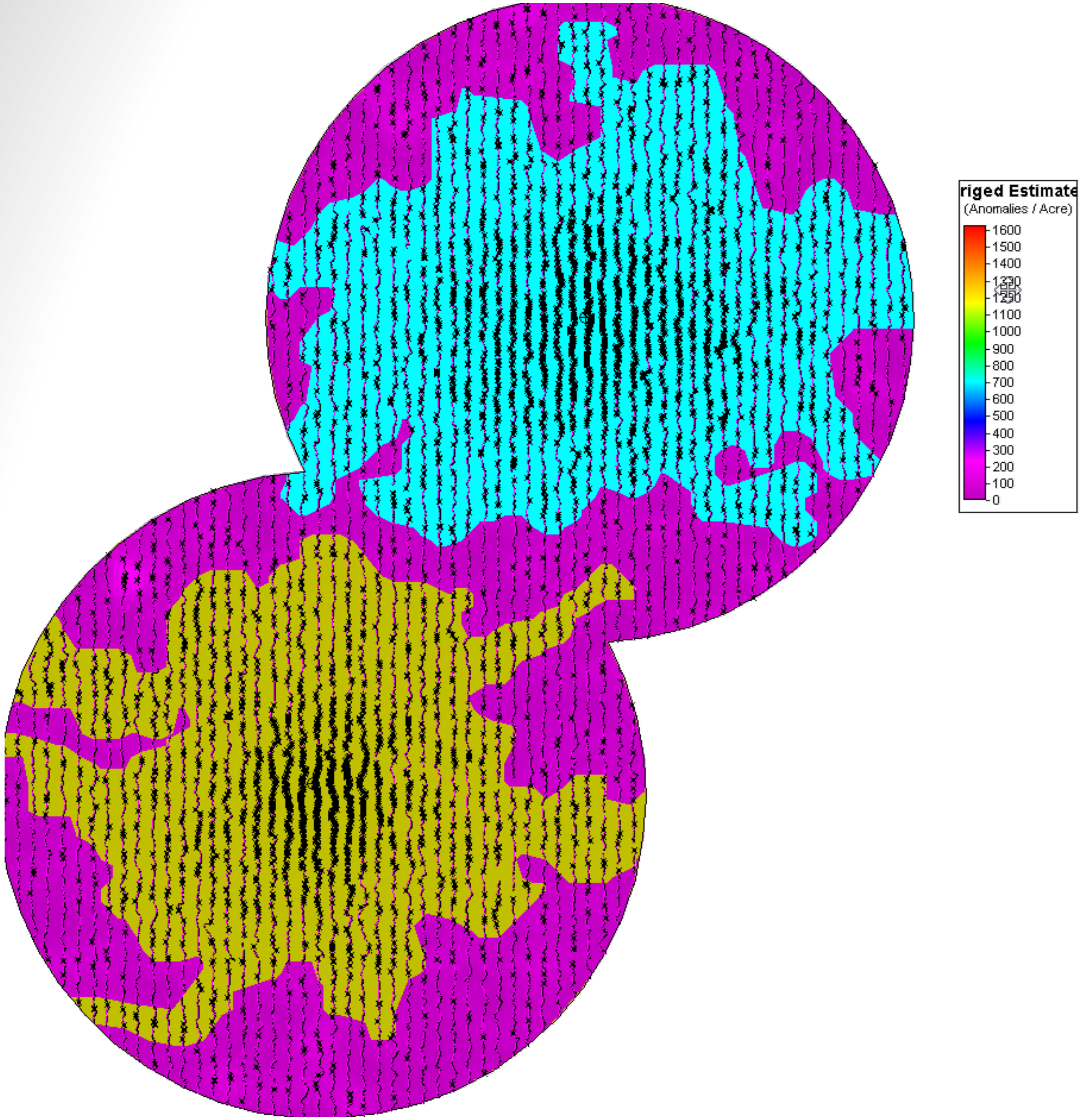
DEFINING HD AREA– ANALYST 2



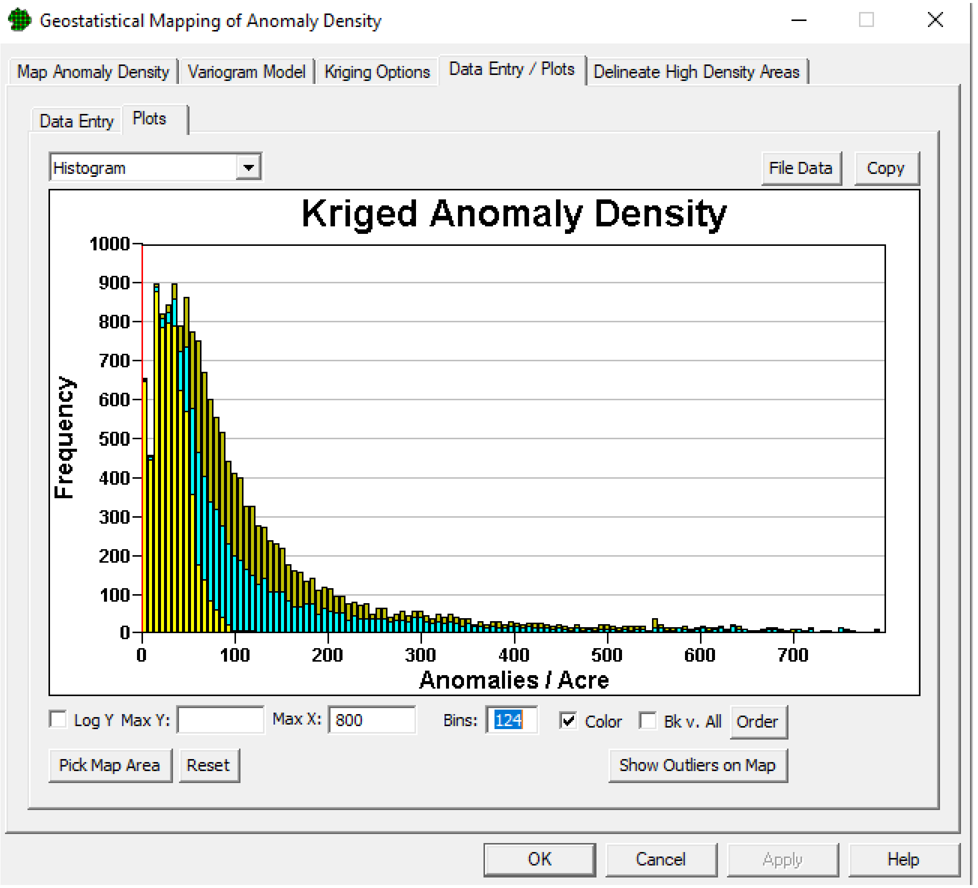
- Window diameter – 435 meters
- Blue - Critical Density -150 ApA; 10 acres min
- Green – Critical Density 250 ApA; 10 acres min
- Max anomaly density – 876 ApA



DEFINING HD AREA – ANALYST 3



- ❖ Window Diameter – 105.6 meters
- ❖ Critical Density - 60 ApA
- ❖ Min Target Area size - 50 acre
- ❖ Max Anomaly density – 1,624 ApA



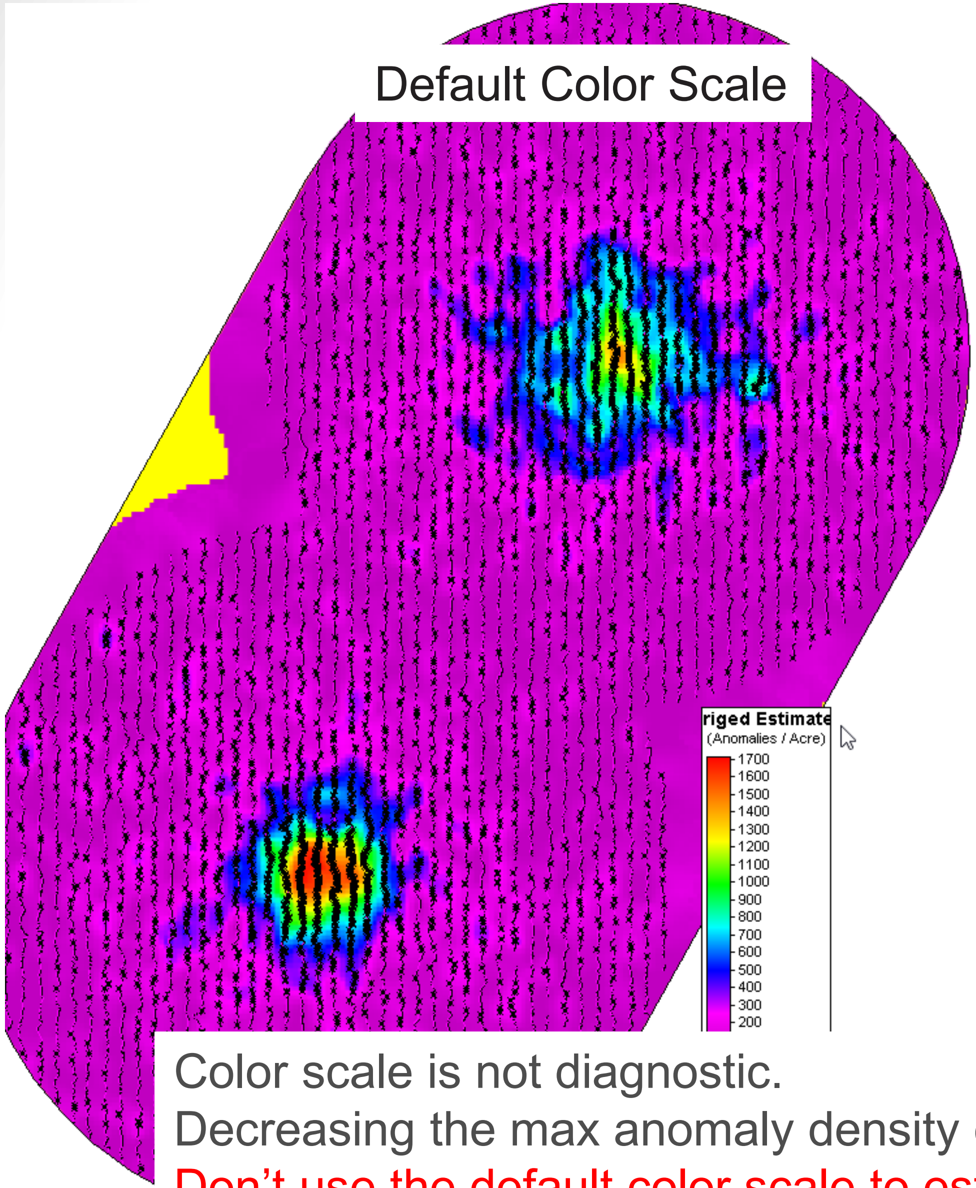
ANALYST SUMMARY

<table>
<tr><th>Analyst</th><th>Window Diameter (m)</th><th>Critical Density (ApA)</th><th>Min Target Area (acres)</th><th>Total HD Area (acres)</th><th>Max Anomaly Density (ApA)</th></tr>
<tr><td>Analyst 1</td><td>90</td><td>200</td><td>30</td><td>152.87</td><td>1,666</td></tr>
<tr><td rowspan="2">Analyst 2</td><td rowspan="2">435</td><td>150</td><td>10</td><td>342.95</td><td rowspan="2">876</td></tr>
<tr><td>250</td><td>10</td><td>213.73</td></tr>
<tr><td>Analyst 3</td><td>105.6</td><td>60</td><td>50</td><td>780.41</td><td>1,624</td></tr>
</table>

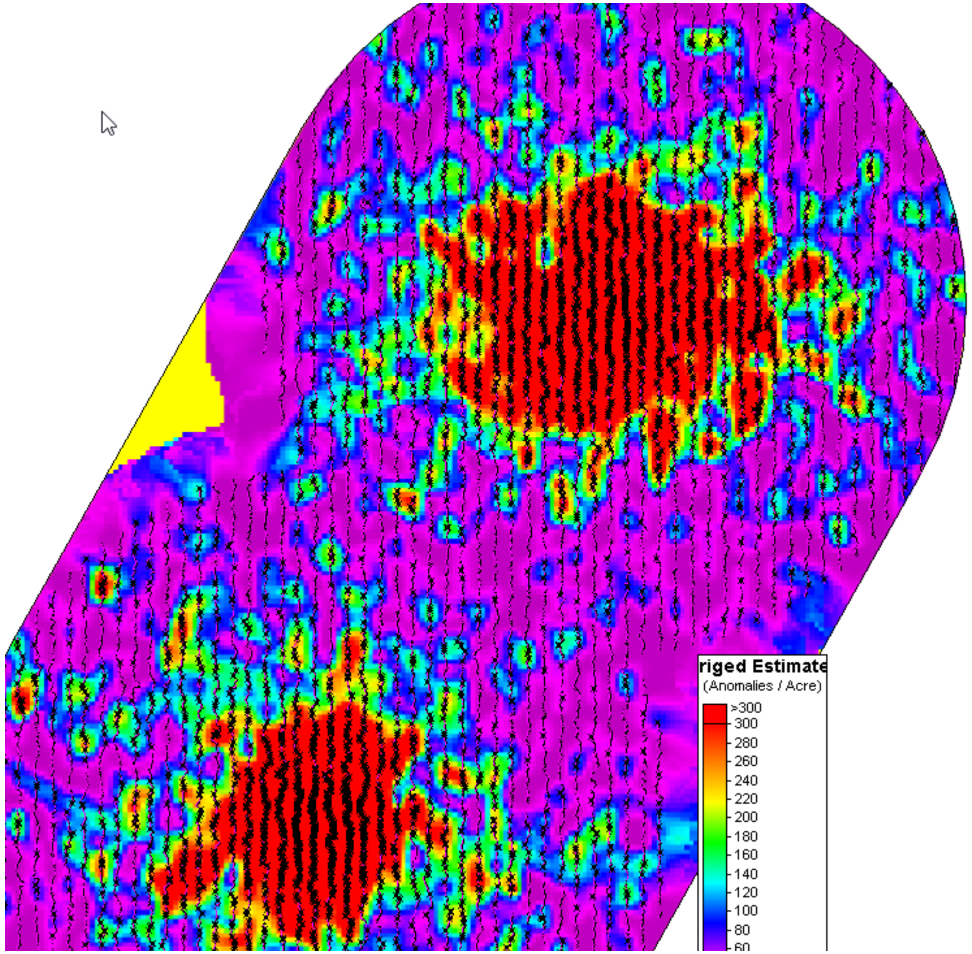
So, which is right?

VSP COLOR SCALES

Default Color Scale



Modified Maximum Anomaly Density Color Scale



Color scale is not diagnostic.

Decreasing the max anomaly density can provide greater understanding of the anomaly density distribution.

Don't use the default color scale to establish critical density.

VSP AND EM 200-1-15

Two methods to identify HD areas
– Flag areas above a specific anomaly density
– Identifying HD areas via kriging methods

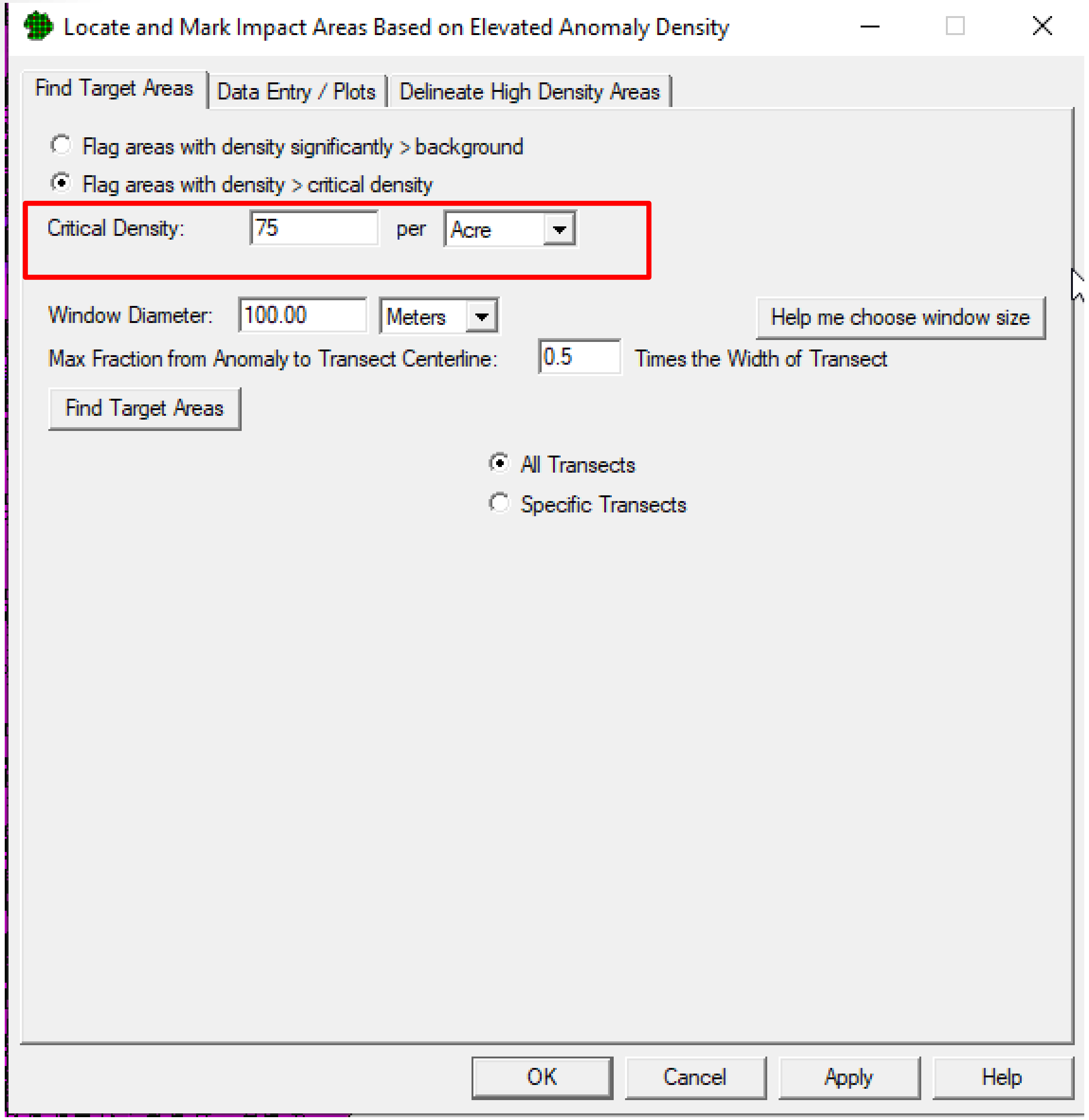
EM 200-1-15

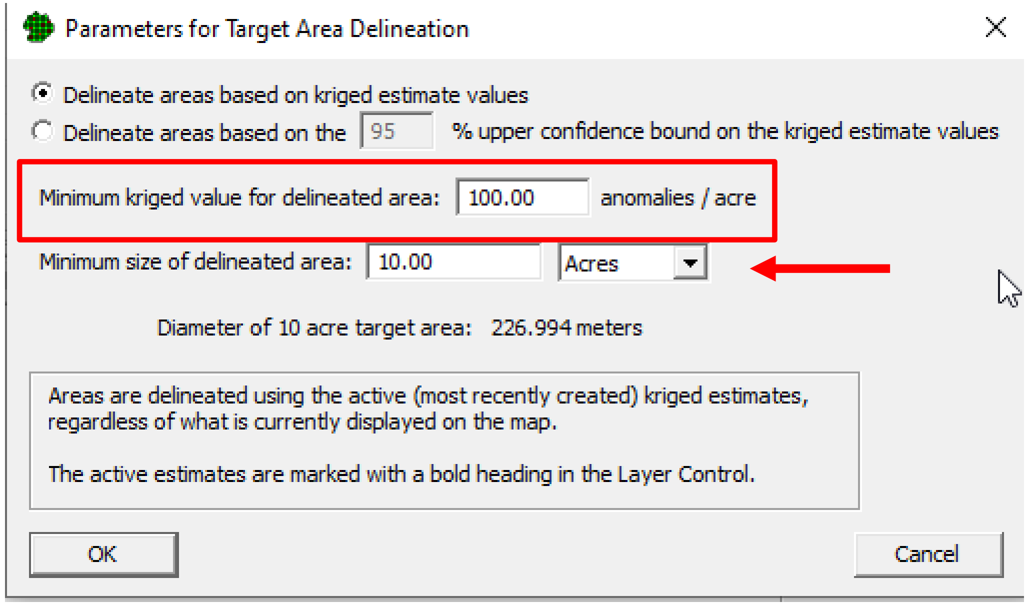
- The **window diameter and critical anomaly density** parameters greatly affect the number of areas that are flagged. **The analysis should evaluate multiple window diameters and critical anomaly densities** to show the effects these parameters have on the number and locations of flagged segments.
- Window sizes that are too small will tend to identify small, localized areas of elevated background, while large window sizes can mask the presence of small, but real HD areas.

– EM 200-1-5 (cont.)

- Critical densities selected too close to the upper range of natural background variation will result in excessive elevated background areas being flagged. Selecting a critical density that is too high risks not identifying an HD area that could be associated with an infrequently used target area or a target area that was operational for only a short period of time.
- The VSP analyst must identify the parameters that best fit observations in data and document the analysis supporting the selection of the final Kriging parameters.
- **It is standard practice to run through the routine multiple times using different parameters to convey to the PDT the different conclusions that might be drawn from the data.**

CRITICAL DENSITY





Critical density is whatever number you use to differentiate between HD and LD areas

Note: we also need to specify the minimum size of the HD area. Include these in your QAPPs.

EVALUATING WINDOW DIAMETER

- ❖ Locate and Mark impact areas based on elevated anomaly density
  - – Critical Density
  - – Window Diameter
- ❖ Critical density and window diameter greatly affect the number of areas flagged
  - – Analysis needs to evaluate multiple window diameters and critical anomaly densities
- ❖ Evaluating window diameters
  - – Start with slightly less than transect spacing
  - – Select intervals for window steps and anomaly density
  - – Run multiple times to refine input parameters

Window Size Sensitivity

Min Window Diameter: 50 (meters) Window Step: 50 (meters) Steps: 4

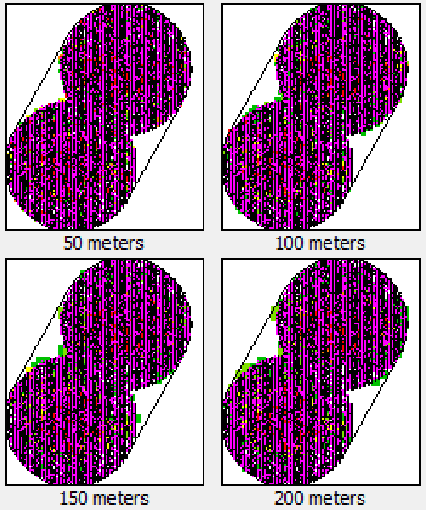
Min Density: 50 (anomalies/acre) Density Step: 25 (anomalies/acre) Steps: 5

Total site density: 151.832 anomalies / acre

Evaluate Flag areas with density > critical density

Window Size	Critical Density (anomalies/acre)				
(meters)	50	75	100	125	150
50	39.0% / 329	31.9% / 264	25.5% / 191	22.3% / 188	18.8% / 148
100	60.9% / 5	45.0% / 1	35.3% / 0	27.5% / 0	22.9% / 0
150	63.0% / 2	46.1% / 0	35.0% / 0	28.0% / 0	22.2% / 0
200	66.5% / 1	45.8% / 1	34.3% / 0	26.8% / 0	22.2% / 0

Percent of the site above threshold / Number of isolated flags

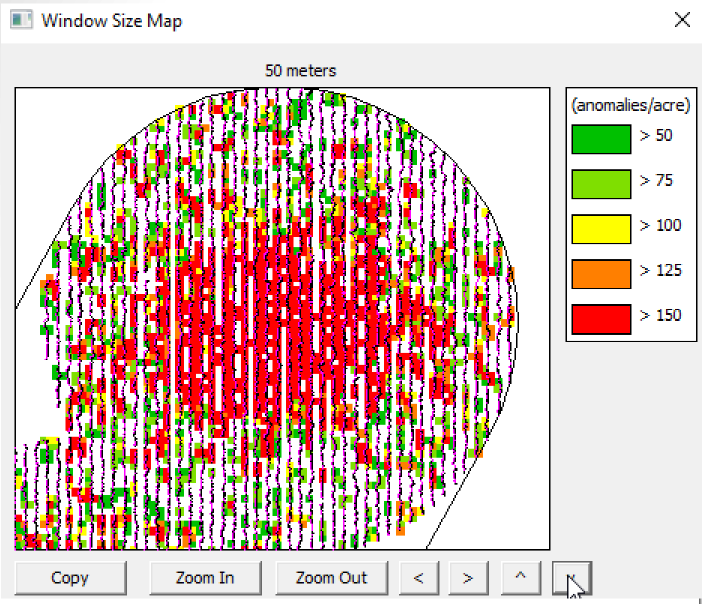


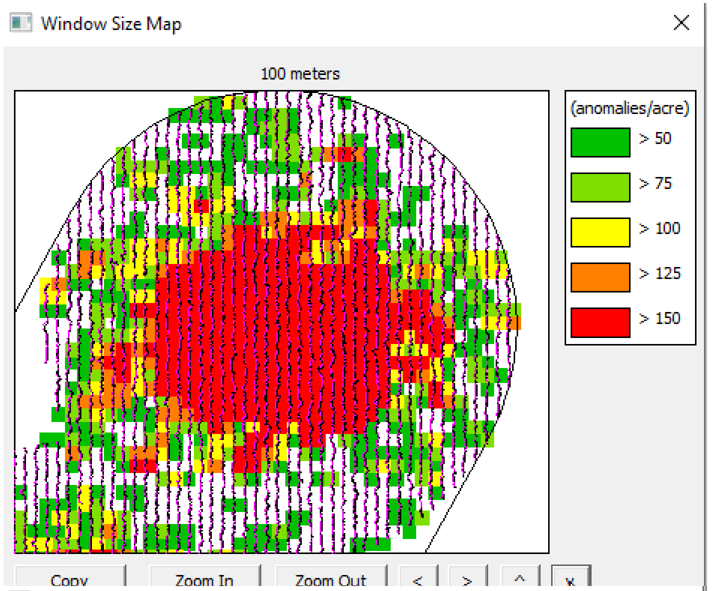
(anomalies/acre)
- > 50
- > 75
- > 100
- > 125
- > 150

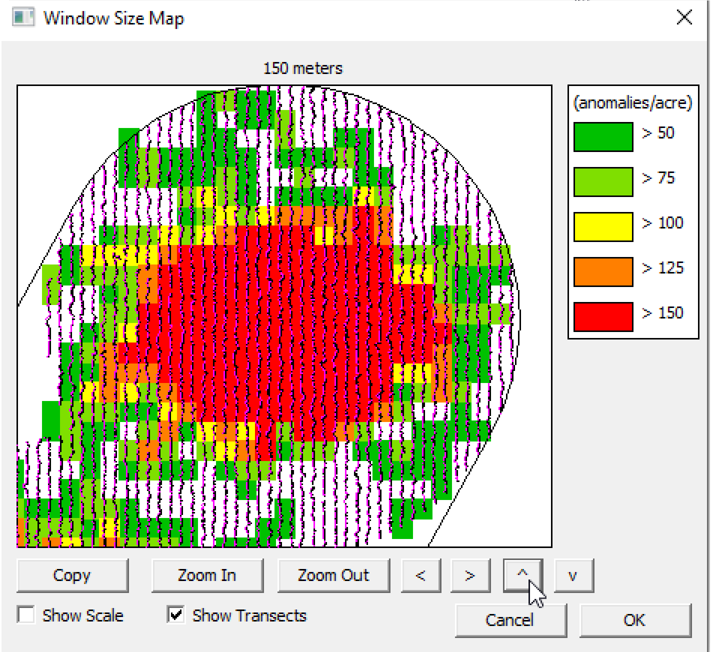
Click on a map above to select and see details. Copy Maps

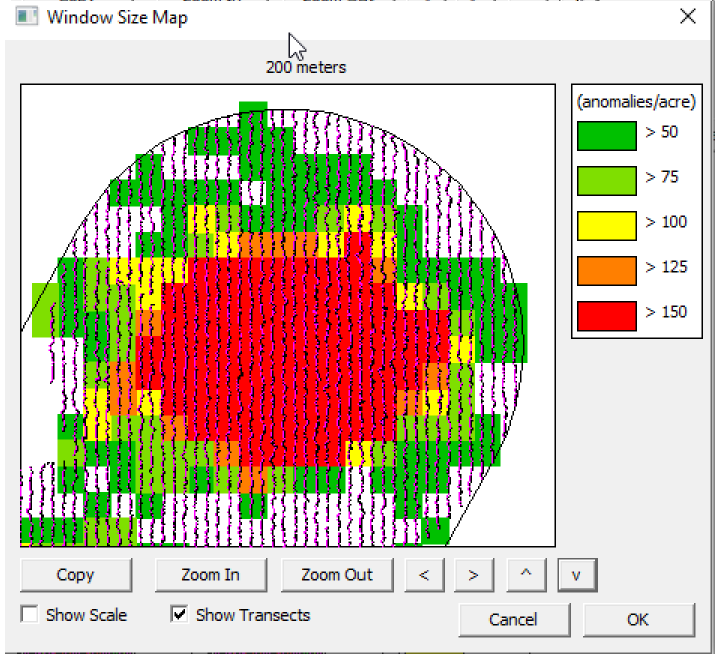
OK Selected window diameter: 200 Cancel

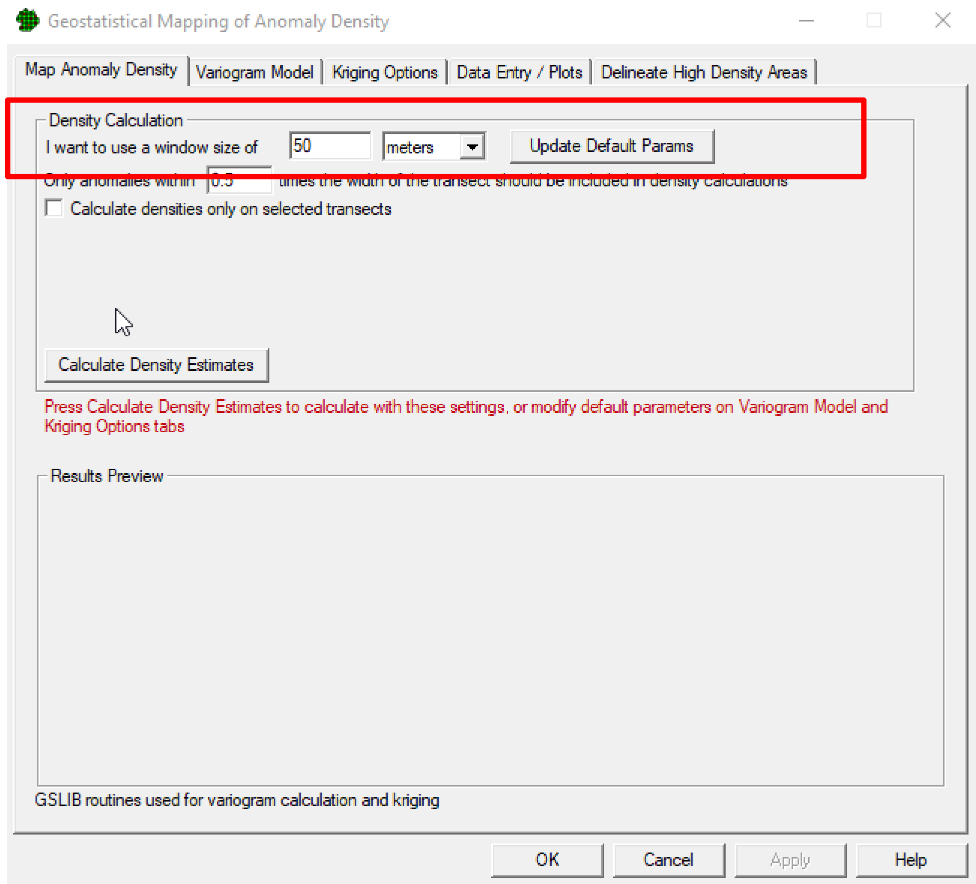
EVALUATING WINDOW DIAMETER





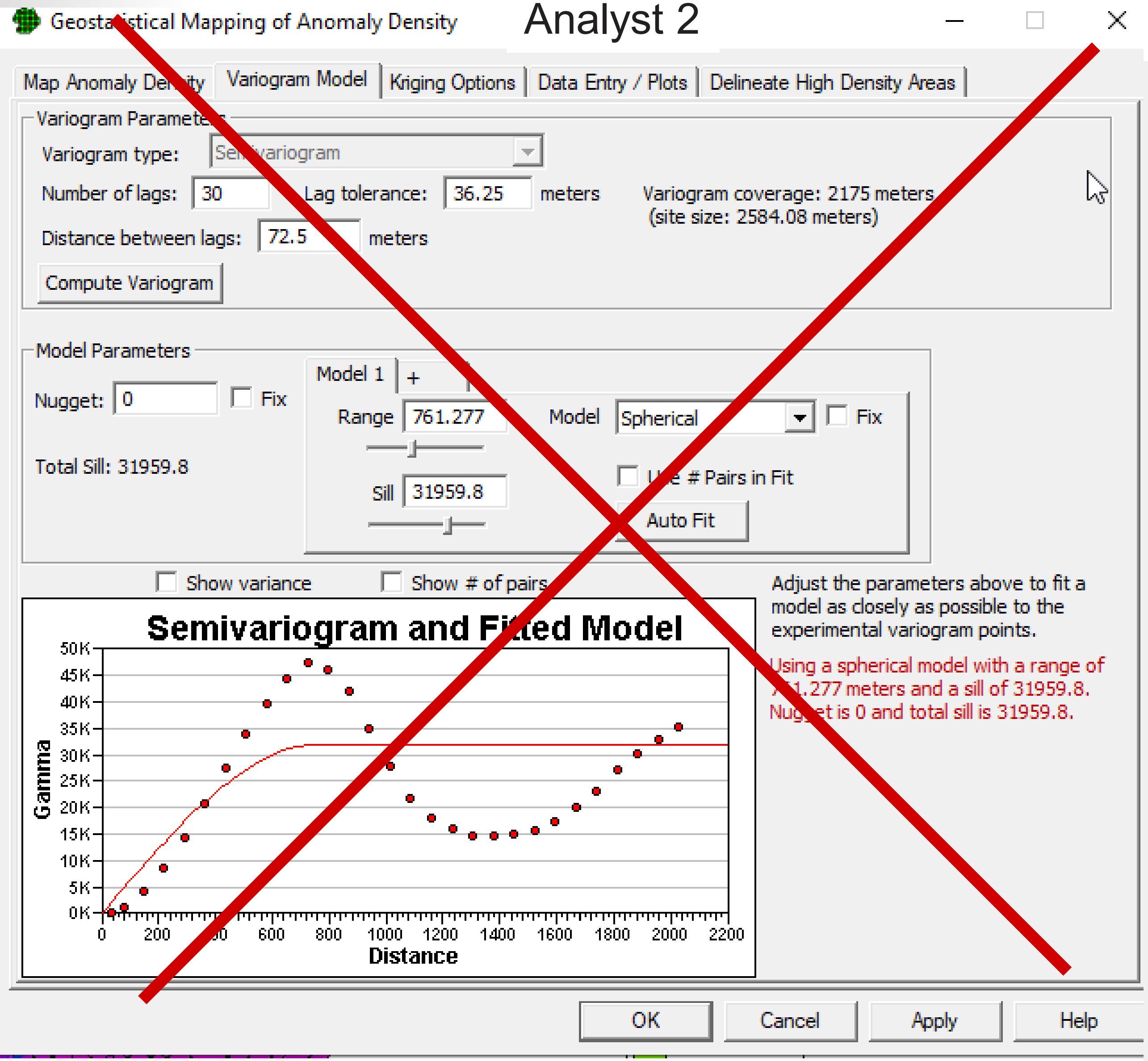




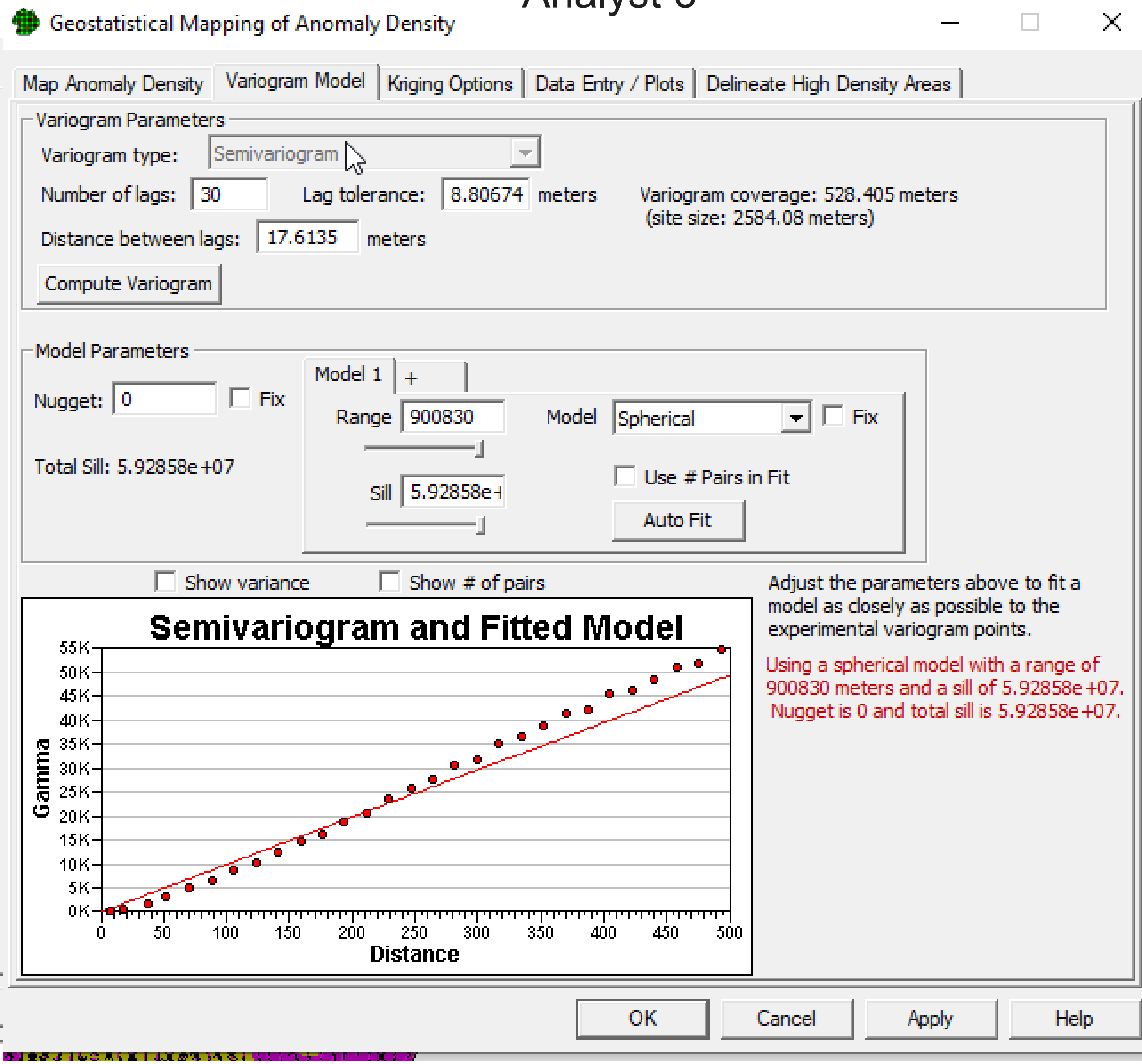


FITTING VARIOGRAM

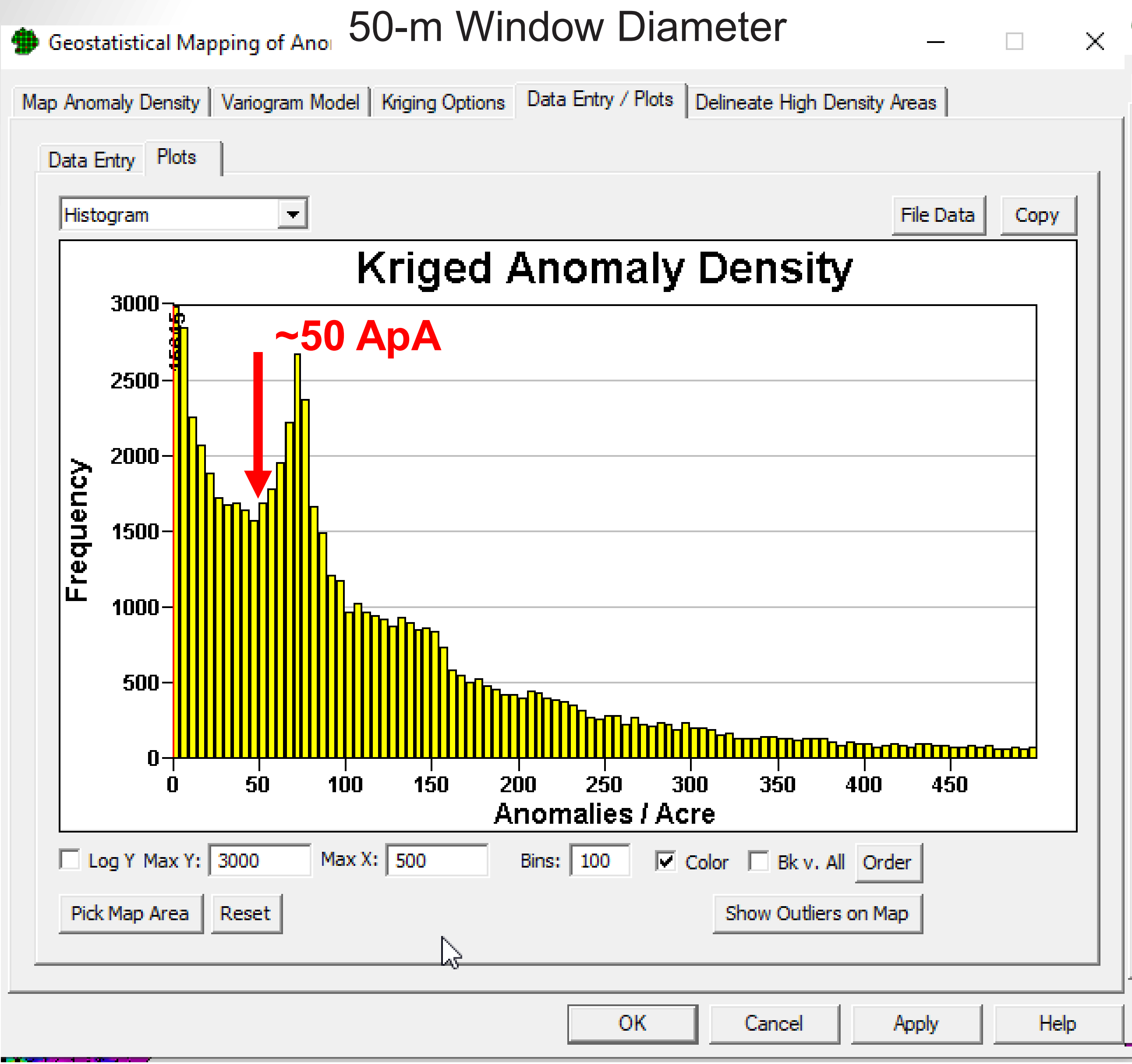
Analyst 2

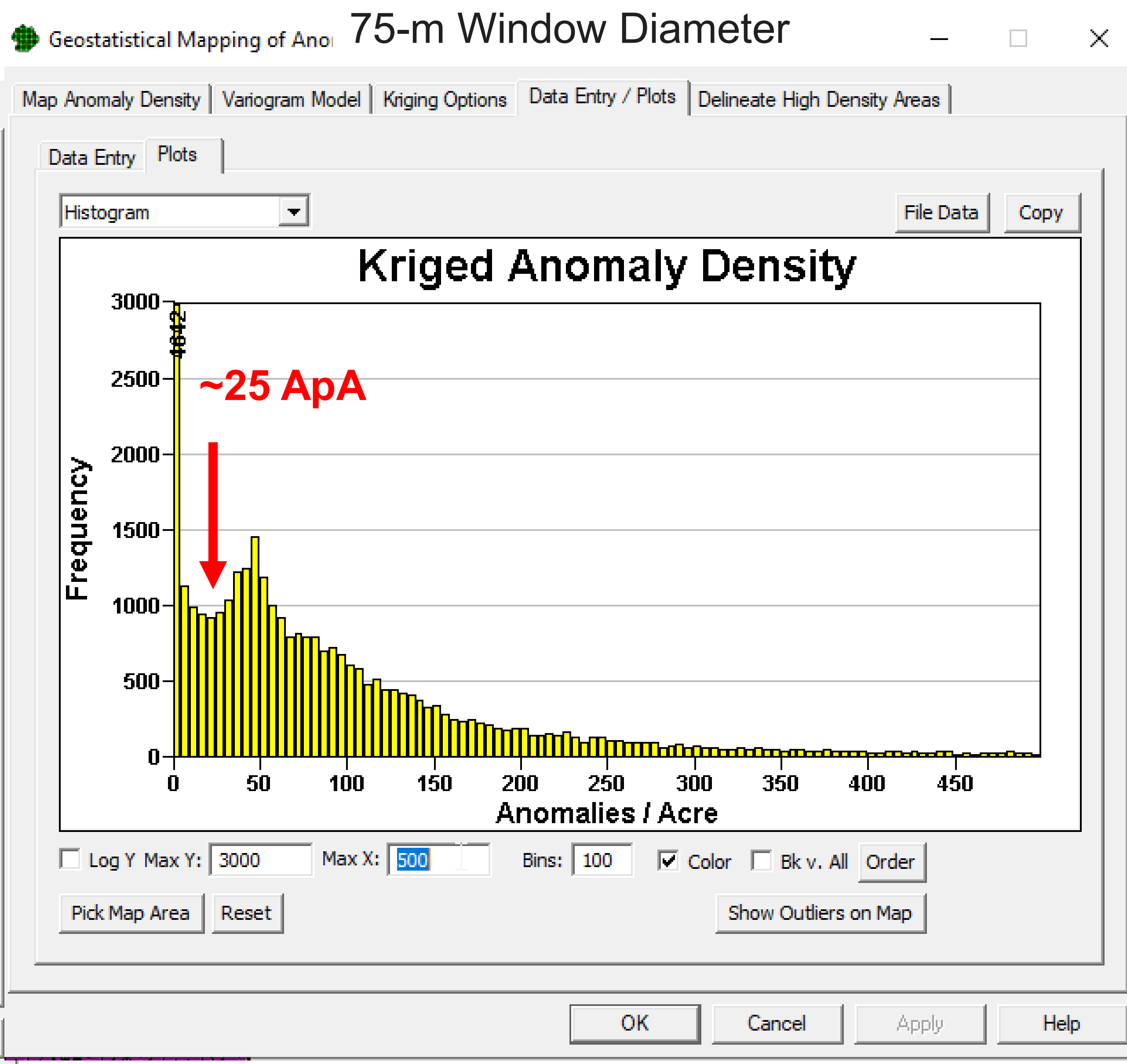


Analyst 3



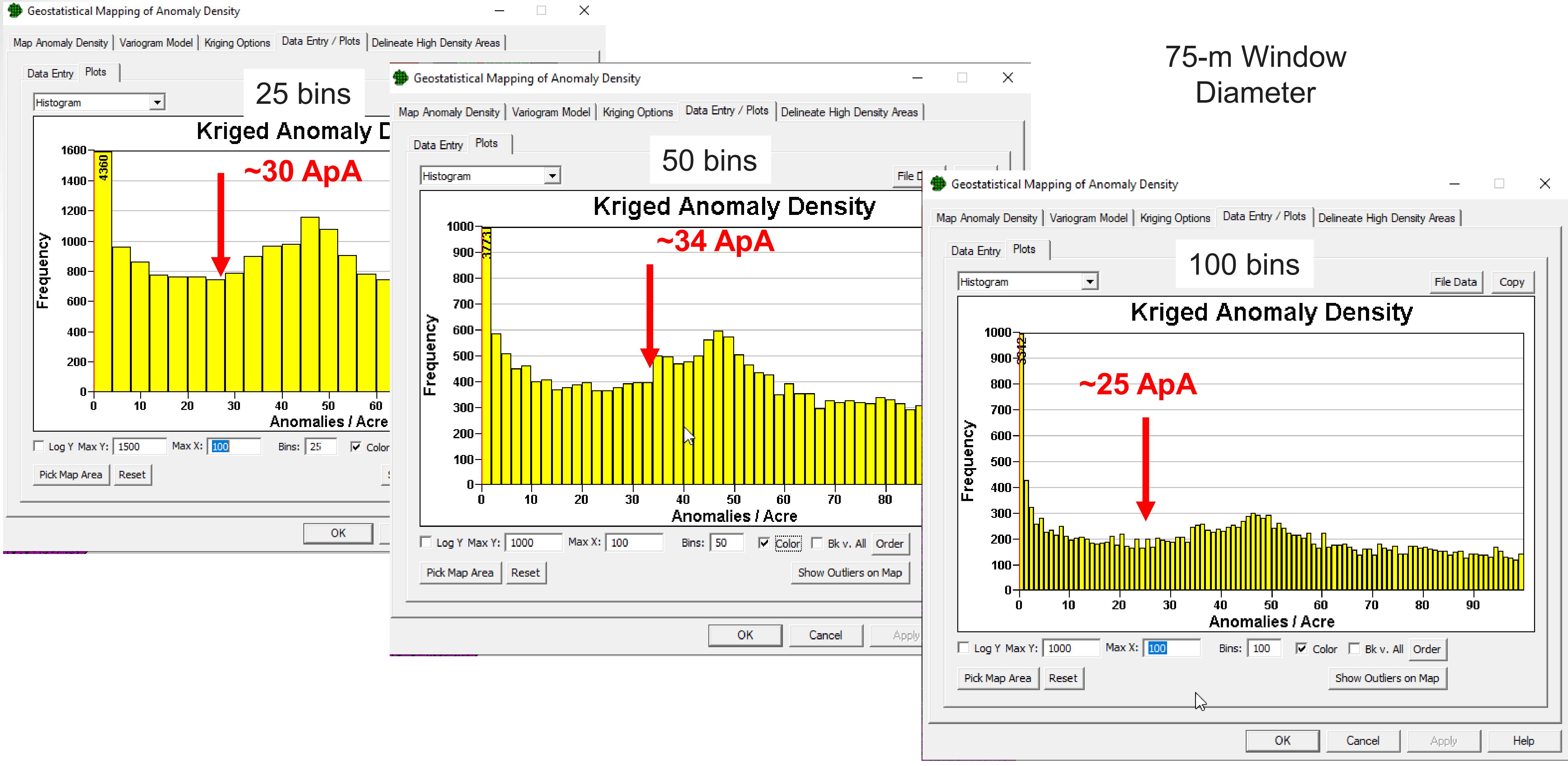
ANOMALY DENSITY HISTOGRAM ANALYSIS – WHERE'S CRITICAL DENSITY?





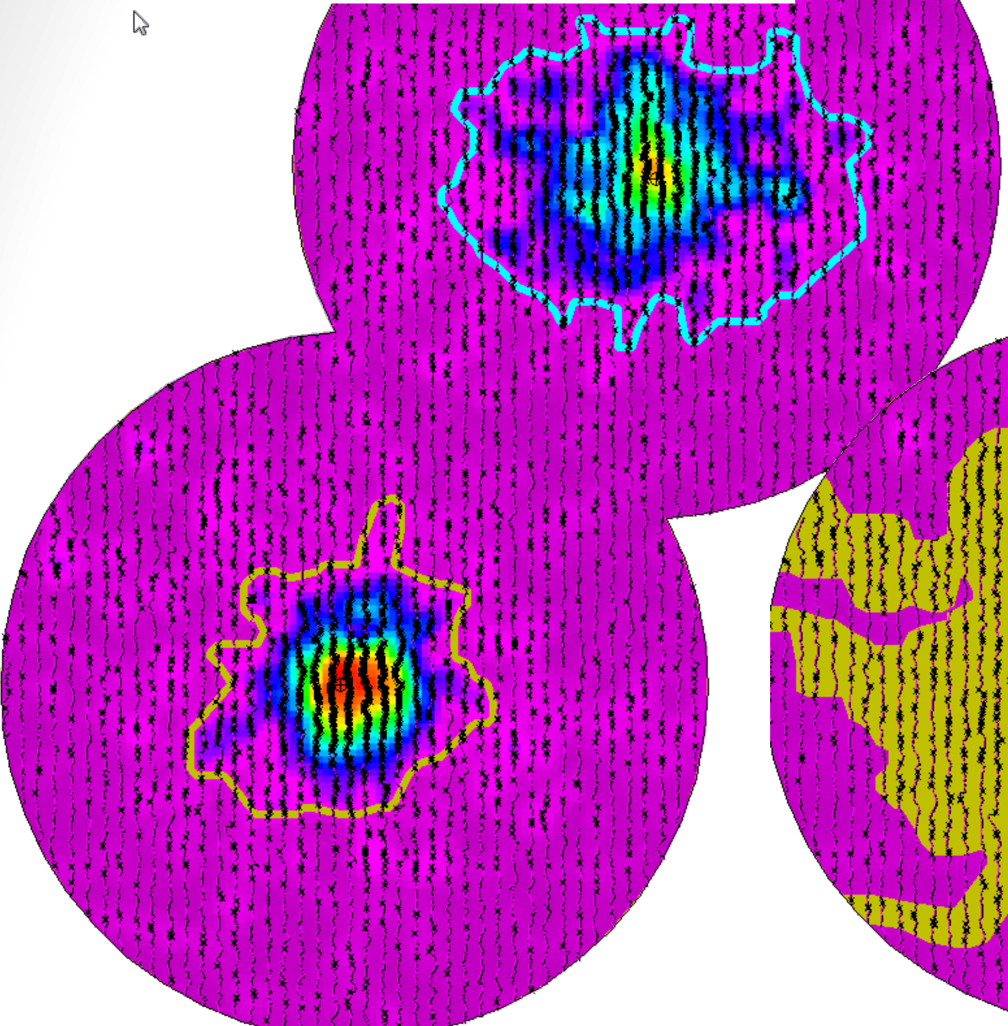
ZOOM IN AND RE-BIN TO REFINE CRITICAL DENSITY

75-m Window Diameter

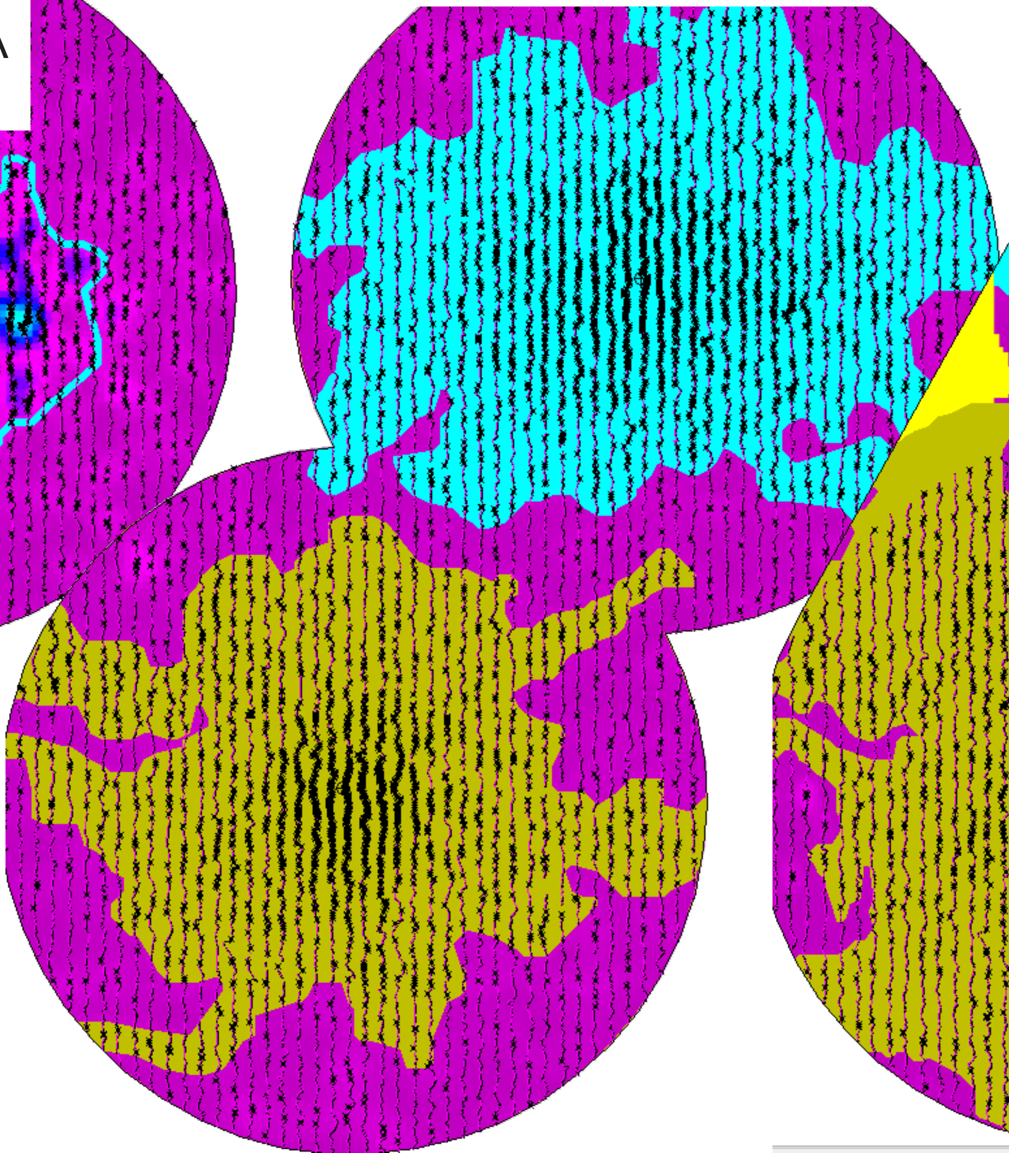


DEFINED HD AREAS

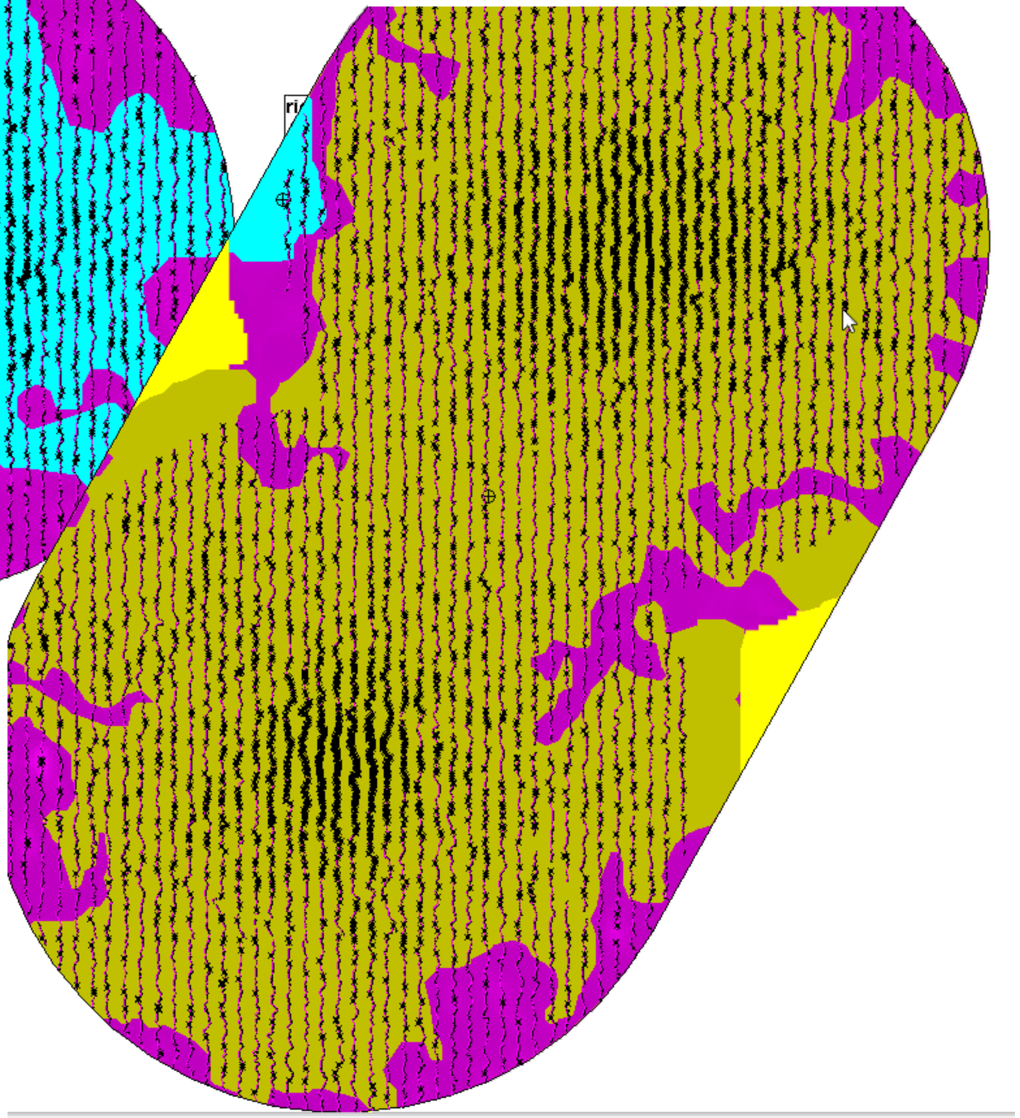
Analyst 1
Window Diameter – 90m
Critical Density = 200 ApA
HD Area = 152.87 acres



Analyst 3
Window Diameter – 105.6 m
Critical Density = 60 ApA
HD Area = 780.4 acres



EM CX Conservative Option
Window Diameter – 75-m
Critical Density = 34 ApA
HD Area = 1,124 acres



SO, WHICH IS RIGHT?

That is a PDT decision (not JUST a geophysicist decision)

Some factors to consider

- VSP inputs/outputs
- Evaluate errors and potential variability for each decision
- What are the issues with being too conservative?
  - Increased cost in detailed characterization (structure PWS to account for this)
    - Over and above work options
    - Firm fixed price unit price optional tasks for additional grids in detailed characterization phase
  - Potentially need to go outside MRS to delineate HD areas
  - Increased remedial action acreage/cost
- What are the issues with being too liberal
  - Increased risk to receptors (calling an area with significant UXO a LUA)

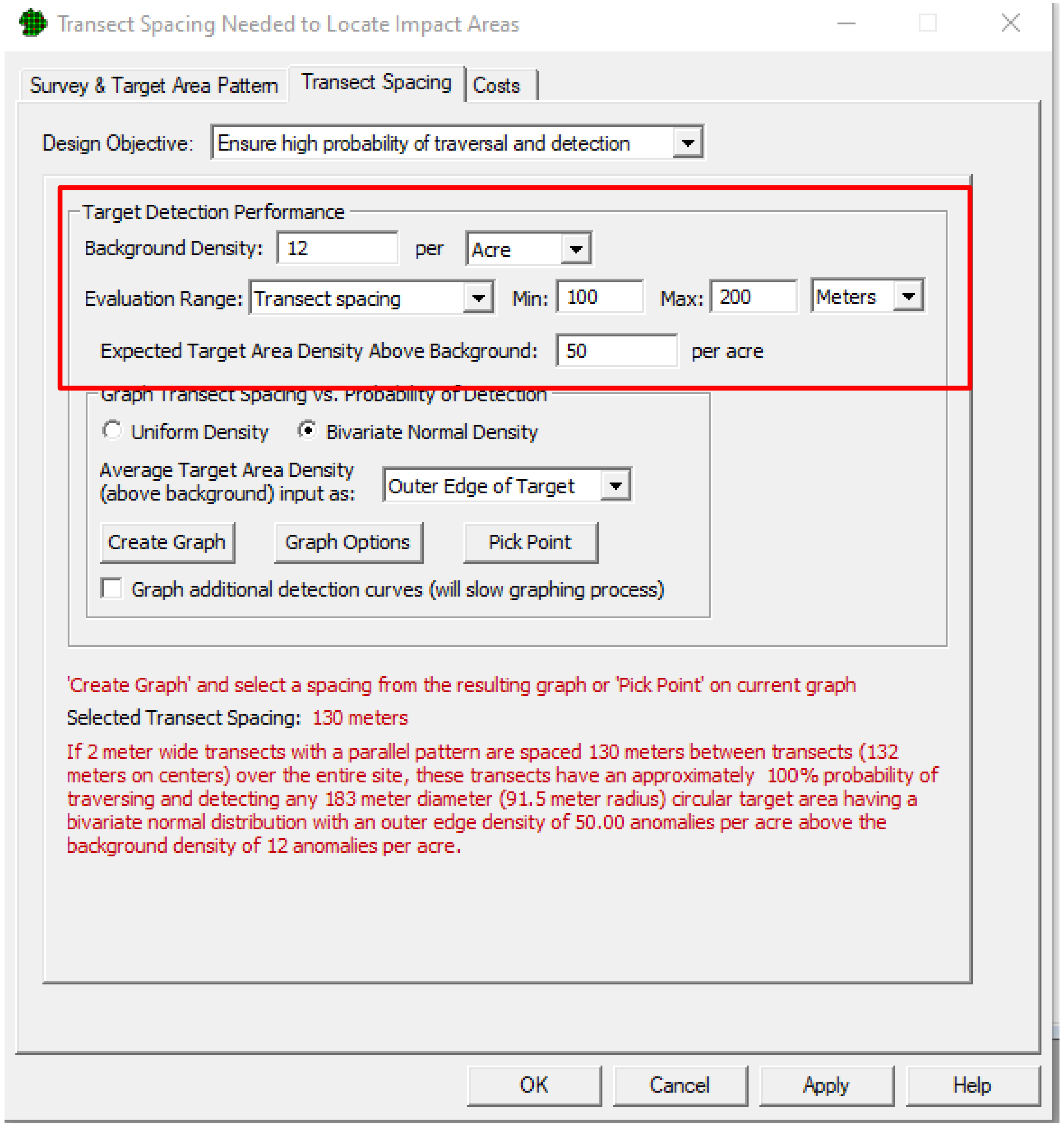
DETERMINING BACKGROUND

DEFINING BACKGROUND DENSITY

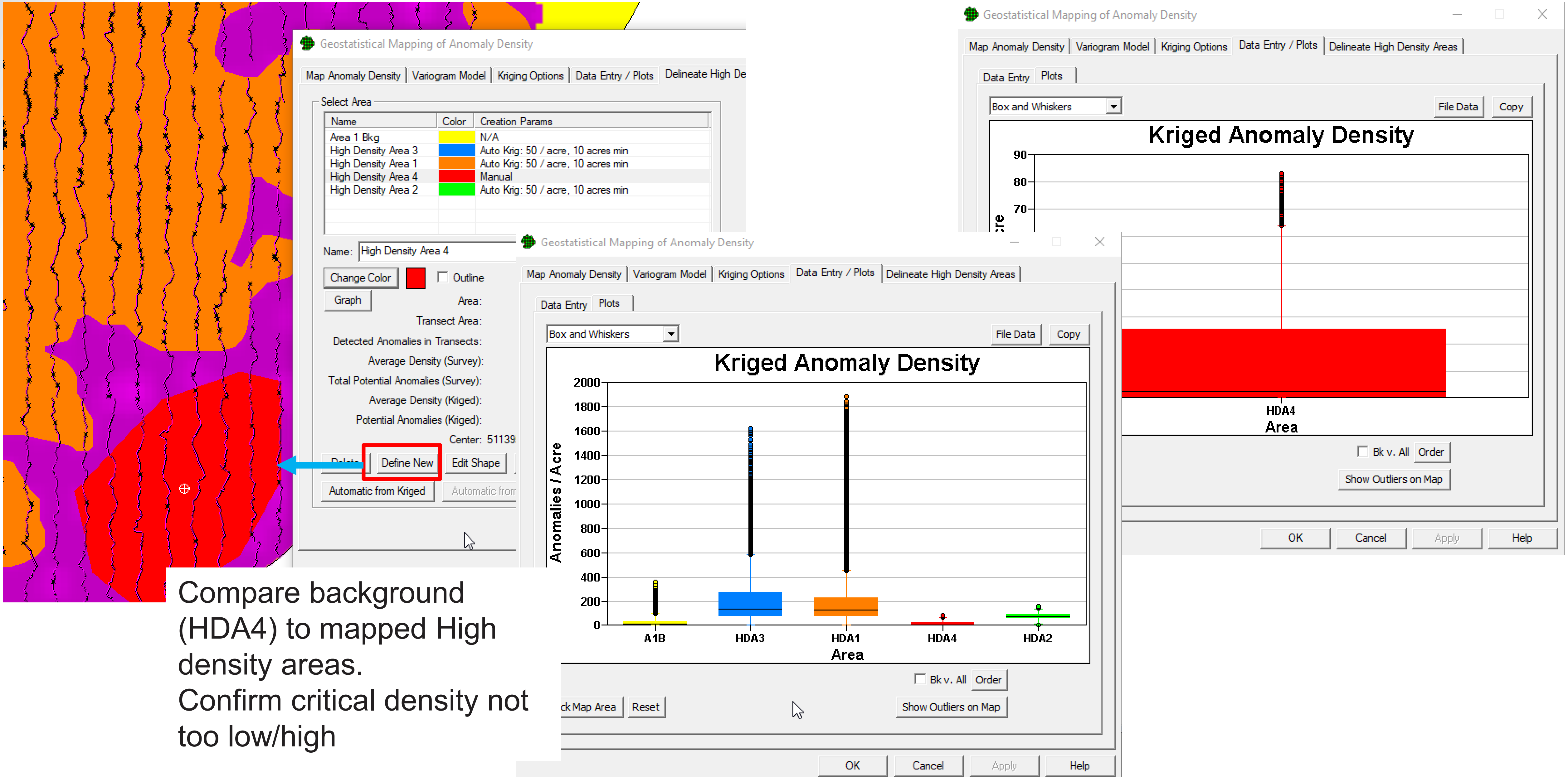
MR-QAPP Module 1 WS 17 DFW 6: Perform VSP analyses, conduct Preliminary Data Usability Assessment (DUA), and delineate HD/LD areas: Describe the procedures to be used to identify HD areas. Document and **discuss any changes to planning assumptions based on field work (e.g., different background density observed…**

In planning stage, we assumed some background anomaly density and some elevated target area density above background

– **Were our assumptions valid?**



DEFINING BACKGROUND DENSITY



Compare background (HDA4) to mapped High density areas.

Confirm critical density not too low/high

SOME SOLUTIONS

Planning
- For complex sites, include FUP tasks for additional grids during detailed characterization
  - Allows flexibility for unknowns

Preliminary Characterization
- QA Geo should perform their own VSP analysis
- Prelim. Characterization Tech Memo should
  - Document inputs, VSP analysis, and the rationale for selecting inputs
  - Assess the potential errors associated with each input
  - Evaluate whether VSP planning assumptions were correct (e.g., background density)
  - Evaluate background density areas and relate them to critical density
- Ensure contractors
  - Perform window diameter analysis
  - Re-bin histograms to determine the correct critical density
- If critical density is >100 ApA, the PDT should discuss with the CX

ANOMALY RESOLUTION REQUIREMENTS FOR NO CONTACTS ON AGC DIGS

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MQO – CONFIRM DERIVED FEATURES MATCH GROUND TRUTH

Measurement Quality Objective	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Confirm derived features match ground truth (2 or 2)	Evaluated for all recovered items including seeds	Project Geophysicist/ Dig List and Intrusive Database/ Project or QC Geophysicist	Cued data analysis shows 100% of seeds & recovered items have polarizability parameters that are consistent with their actual size, shape/symmetry, and wall thickness	RCA/CA

Contractor argued that the MQO only applies to "Recovered" items.

Does a no contact or no find fail this MQO?

Short Answer: Yes

MQO EVALUATION

1) Category 0 (Inconclusive) anomalies are excluded from analysis under this MQO since we don’t have reliable classification results.
   a. Therefore, a No Find at a Category 0 anomaly does not fail this MQO
   b. However, a metallic source was detected, so there should be a piece of metal in the ground or some other explanation for the detected response (e.g., geologic noise). If this doesn’t initiate a non-conformance, there should be some additional investigation (e.g., anomaly resolution) to confirm there is no metal that is potentially MEC and that investigation needs to be documented.
2) Any no find at a Category 1 (Likely TOI) , Category 2 (Can’t decide – if you still use this terminology) or Category 3 (likely non-TOI) target requires a Non-conformance and RCA.
   a. Logic being…if you recover nothing, then the actual dig results do not match the predicted size, shape/symmetry, and wall thickness.

QUESTIONS?

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