Visual Sample Plan Survey Design and Analysis

Former Kirtland Air Force Precision Bombing Range

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Prepared for ESTCP Wide Area Assessment Demonstration Project

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1. Introduction

This interim report documents the design of the ground survey of the Wide Area Assessment (WAA) Pilot Study performed at Former Kirtland Precision Bombing Range. The report also documents the processing and analysis of the survey data after they were collected. Both the sample design and the analysis were performed using Visual Sample Plan (VSP). [1]

1.1. Site Description

The WAA study area of Kirtland Precision Bombing Range contains at least three bull's-eye targets (N-2, N-3 and the "New" Demolition Targets), and is suspected to be the location of a Simulated Oil Refinery target. The bull's-eye targets have outer aiming circles that are 1000 feet (304.8 m) in diameter. The Simulated Oil Refinery target has been described as being 2000 (609.6 m) ft in the E-W direction by approximately 500 ft (152.4 m) in the N-S direction, with individual "cells" ranging in size from 20 x 250 ft to 50 x 250 ft. The location of the Simulated Oil Refinery target was indicated in the archival material as northwest of the Double Eagle Airport. Figure 1 shows the WAA study area boundaries, the expected locations of the three bull's-eye targets, and the boundaries of the area that may contain the Simulated Oil Refinery target. A complete description of the Kirtland WAA study area is provided in the Kirtland Conceptual Site Model (V0, July 2005).

1.2. The Demonstration Process

The purpose of this portion of the pilot study was to demonstrate the application of ground-based vehicle-towed geophysical sensor arrays using transect-based surveys to search for areas of concentrated munitions and explosives of concern (MEC) and associated materials.

The demonstration process followed these steps:

- **Initial Survey:** A series of assumptions regarding the possible sizes of areas of concentrated MEC were developed, based on the information from the conceptual site model. VSP was used to produce initial survey proposals, based on the assumptions. The initial survey designs were selected after presentation of the proposals to the Advisory Group.
- **"Fill-In" Survey:** Results from the implementation of the initial survey were analyzed, and "fill-in" surveys, consisting of 50 meter spaced transects oriented perpendicular to the initial survey transects, were designed. The purpose of these surveys was to gather more data from areas with high concentrations of anomalies.
- **Estimation of Boundaries:** The results from the initial and the fill-in surveys were used to estimate boundaries of areas that may contain concentrations of MEC and associated materials.

The remainder of this report describes these steps, and provides the results of analysis and conclusions drawn from the demonstration.

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[1] Versions 4.3 (for initial design and fill-in analysis) and 4.4b (for subsequent target-finding analysis), Pacific Northwest National Laboratory, http://dgo.pnl.gov/index.html.

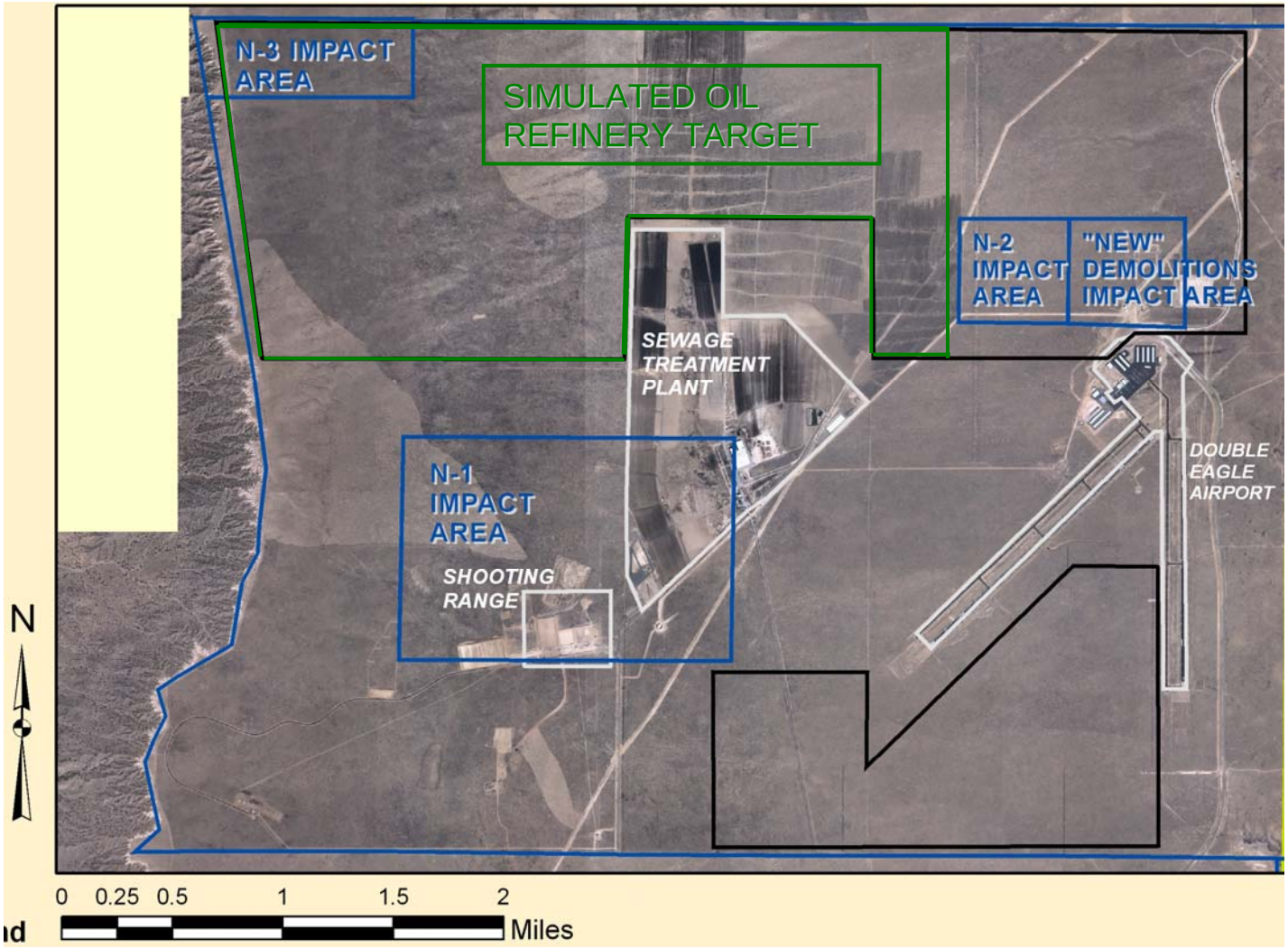

Figure 1: WAA Study Area at Former Kirtland Precision Bombing Range

2. Initial Survey

2.1. Assumptions

Four sets of assumptions were developed for the proposed VSP swath sampling designs. Two assumptions, one conservative and one non-conservative, were developed for searching for the bull's-eye targets:

- Conservative Bull's-eye Target Search: Search for a 500 ft (152.4 m) diameter circular target, based on the fact that practice bombs do not produce fragmentation and, therefore, practice target footprints may be smaller than the outer aiming circle.
- Non-conservative Bull's-eye Target Search: Search for a 1000 ft (304.8 m) diameter circular target, based on the observed size of the aiming circles.

Conservative and non-conservative assumptions were also developed for searching for the Simulated Oil Refinery target:

- Conservative Refinery Target Search: Search for a 50 ft (15.24 m) x 250 ft (76.2 m) cell of the simulated oil refinery target, assuming that each cell may have served as a target for the bombers, and that the 250 foot dimension is oriented in the east-west direction.
- Non-conservative Refinery Target Search: Search for the entire 500 ft (152.4 m) x 2000 ft (609.6 m) target, again assuming that the east-west orientation reported in the ASR is correct.

Sample designs were developed for three probabilities of traversing the target: 90%, 95%, and 99%. The Bull's-eye target searches were planned over the entire WAA study area; the Simulated Oil Refinery target search was limited to the area suspected to contain the Simulated Oil Refinery Target. The proposed swath sampling design parameters are presented in Table 1.

2.2. Design Selection

The selection of the initial survey design was primarily based on cost – the most conservative design that was still affordable was selected. This turned out to be the designs based on the conservative assumptions, at 99% probabilities of traversing the targets. The Bull's-eye target search transects were spaced at 155.1 meters on centers, oriented in an east-west direction. The Simulated Oil Refinery target searches were spaced at 79.5 meters on centers, in a north-south direction. Figures 2 and 3 show the survey designs for the Bull's-eye target and the Simulated Oil Refinery target searches. The start- and end-points of the design transects are documented in Appendix A.

Table 1: Summary of Initial Survey Design Options

	Total Swath Length (m)			Swath Spacing (m)			Area Under Swath					
							90%		95%		99%	
Approach	**90%**	**95%**	**99%**	**90%**	**95%**	**99%**	**sq. m (acre)**	**% Study Area**	**sq. m (acre)**	**% Study Area**	**sq. m (acre)**	**% Study Area**
Bull's-eye Conservative[1]	123,427	128,134	135,052	170.6	161.6	155.1	308,565 (76)	1.96%	319,975 (79)	2.03%	337,629 (83)	2.14%
Bull's-eye non-Conservative	61,713	640,067	67,526	341.2	323.2	310.2	154,283 (38)	0.98%	159,987 (40)	1.02%	168,815 (42)	1.07%
Oil Refinery Conservative[2]	124,696	132,118	136,455	87.4	82.8	79.5	311,740 (77)	2.87%	330,295 (82)	3.04%	341,137 (84)	3.14%
Oil Refinery non-Conservative[2]	14,545	17,393	17,944	680.1	644.3	618.3	36,363 (9)	0.33%	43,483 (11)	0.40%	44,859 (11)	0.41%

Notes:
1) Bull's-eye study area consisted of 15,742,890 m^2 (3890 acres).
2) Oil Refinery study area consisted of 10,874,917 m^2 (2687 acres)

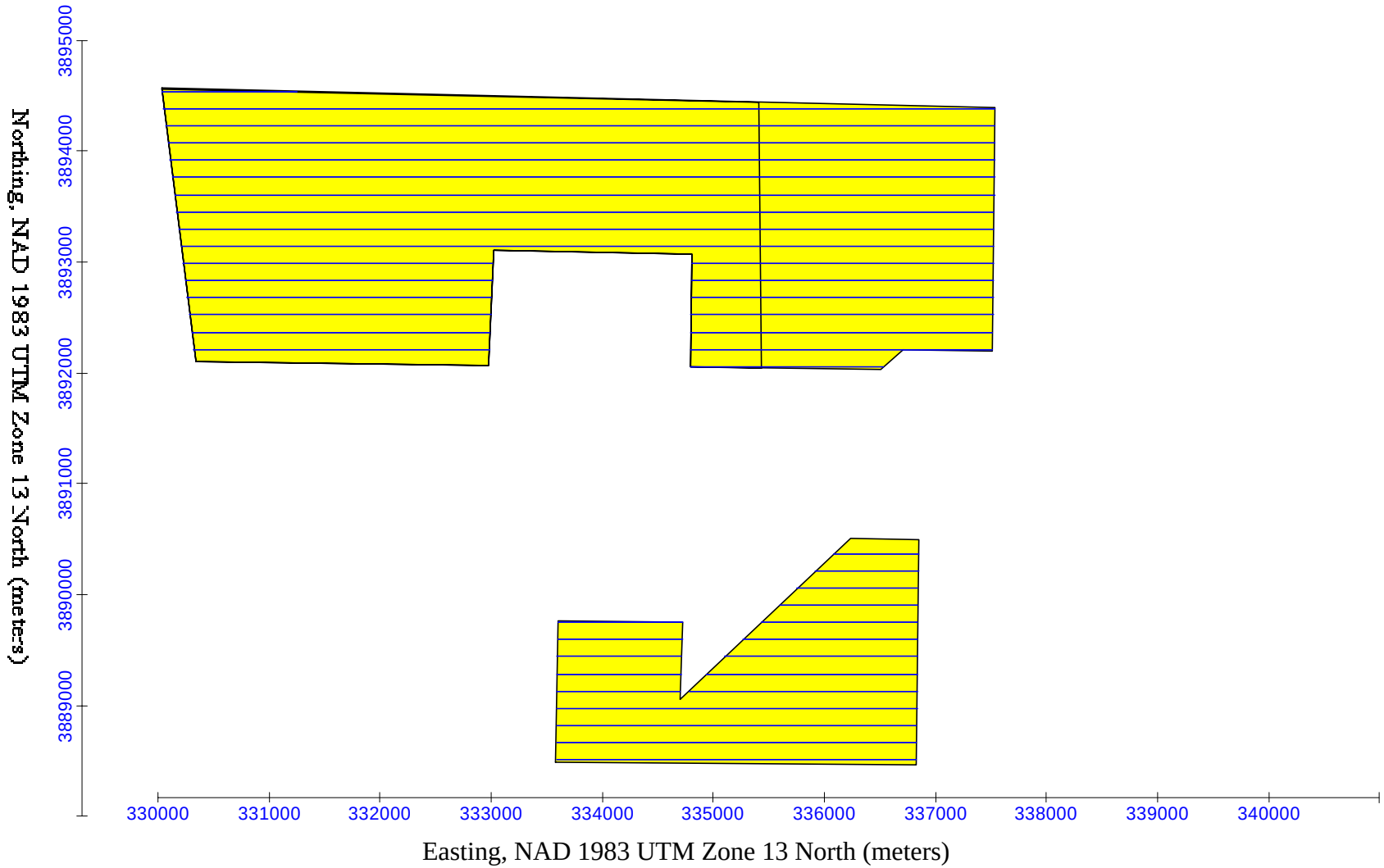

Figure 2: Bull's-eye Target Search Design

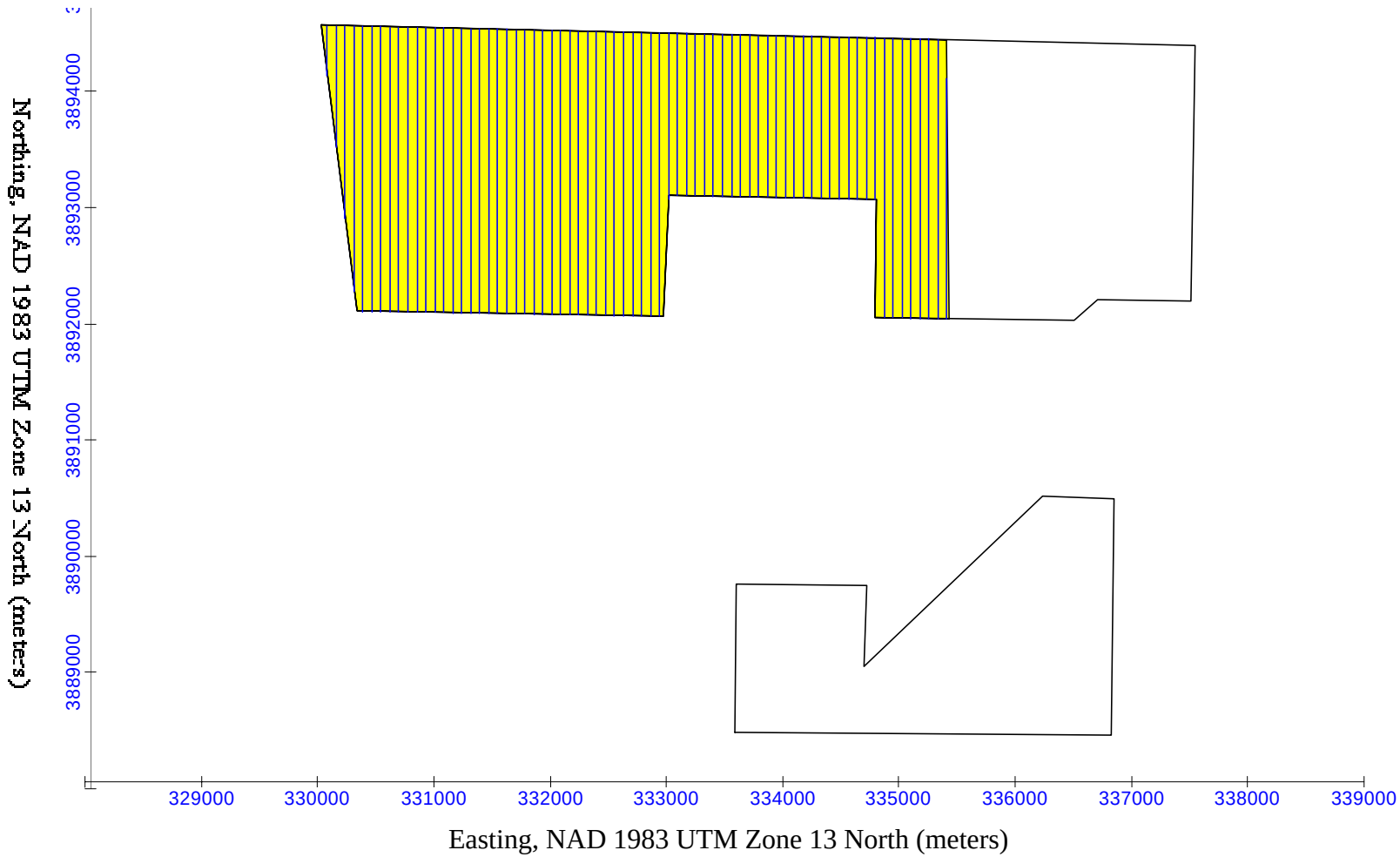

Figure 3: Simulated Oil Refinery Target Search Design

2.3. Implementation and Data Processing

Geo-Centers[2] performed the geophysical surveys using a simultaneous electromagnetic and magnetometer towed array system. The bulk of the work was performed between 9/21 and 10/20/2005. Additional work, especially in the western part of the site, was performed from 11/10 to 11/16/2005. The daily data submittals from Geo-Centers included the actual path of the survey, or "course over ground" (COG), and initial identifications of anomalies found during the surveys. These data were submitted in comma delimited ASCII files.

During the initial anomaly identification process, the Geo-Centers analyst placed each anomaly into one of three categories, based on characteristics of the EMI and magnetometer signals[3]:

- **Category 2** anomalies are high-confidence targets. These are strong, round, generally appear in both the EMI and the magnetometer data sets, and represent the analyst's estimation of the subset of targets that would yield compact metallic objects upon excavation.
- **Category 1** anomalies are medium-confidence targets. These have round signatures, usually appear in one but not both data sets, and are weaker and/or spatially smaller than the category 2 targets.
- **Category 0** anomalies are low-confidence targets. These, in the analyst's opinion, are probably sensor or geologic noise.

The analyses of the initial transect data, and the design of the fill-in surveys, are based only on the anomalies identified as Category 2 by the Geo-Centers analyst. The sensitivity of the analyses to the inclusion of Category 1 anomalies is described in Sections 4.3 and 4.4.

The COG and anomaly files for the transect-based surveys were collected in an Access database that allowed easy manipulation of the data. Queries were created to extract COG and anomaly data for different parts of the site and different times of the investigation. For example, a query was created that selects all Category 2 anomalies within the boundary of the Simulated Oil Refinery target search area. Another query selects only the east-west oriented transects within that same area.

The results of these queries were exported to Excel spreadsheets, where the column labels were deleted and the resulting data was saved as tab-delimited ASCII files for importation into VSP. The database tables and queries are documented in Appendix B. The database itself is included as a separate attachment to this report.

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[2] Geo-Centers has since been purchased by SAIC. This report only addresses the survey design and analysis using VSP; SAIC is responsible for an interim report covering the actual implementation of the ground survey.

[3] These descriptions are paraphrased from an email dated 9/27/05 from Rob Siegel, the Geo-Centers analyst, to Laura Wrench (Versar, Inc.) and Herb Nelson (NRL). The subject line of the email is: "GEO-CENTERS First Week Deliverables".

As the survey progressed, it became convenient to divide the Kirtland WAA study area into different sectors. The sectors are presented in Easting, NAD 1983 UTM Zone 13 North (meters)

Figure 4. The divisions were based, in part, on the past uses of the site, and in part on the logistics of the survey. There is a small arms range directly south of the Northwest Analysis Sector. Due to safety concerns, access to this portion of the study area was limited to two days a week (when the range was not operating). The effect of this logistical issue was to accelerate the completion of the surveys of the Northeast and the Oil Refinery Target (ORT) sectors, while the survey of the Northwest sector was not completed until the final site work in November of 2005.

2.4. Summary of Initial Transect Survey Results

Table 2 and Easting, NAD 1983 UTM Zone 13 North (meters)

Figure 5 through Figure 12 summarize the results for the initial transect surveys. Table 2 provides the acreage of each sector, and the number of Category 2, 1, and 0 anomalies identified during the initial transect surveys. The numbers in this table give a qualitative sense of how intensive the past uses may have been in each of the sectors.

Table 2: Number of Anomalies Identified After Initial Survey

Analysis Sector	Sector Area (acres)	Number of Identified Anomalies			
		Category 2	Category 1	Category 0	Total
Northeast	1159	369	387	271	1027
Northwest	1530	568	560	186	1314
ORT	1204	584	361	394	1339
South	1153	85	97	76	258

There are two figures for each sector. The first figures (Figures 5, 7, 9, and 11) show the COG and the category 2 anomalies for the sectors. The second figures (6, 8, 10 and 12) show only the anomalies. It is easier to recognize developing anomaly patterns with the COG lines removed from the views. Areas with concentrations of anomalies have been circled on the figures for the Northeast, Northwest and ORT sectors.

Figure 4: Kirtland WAA Study Area Analysis Sectors

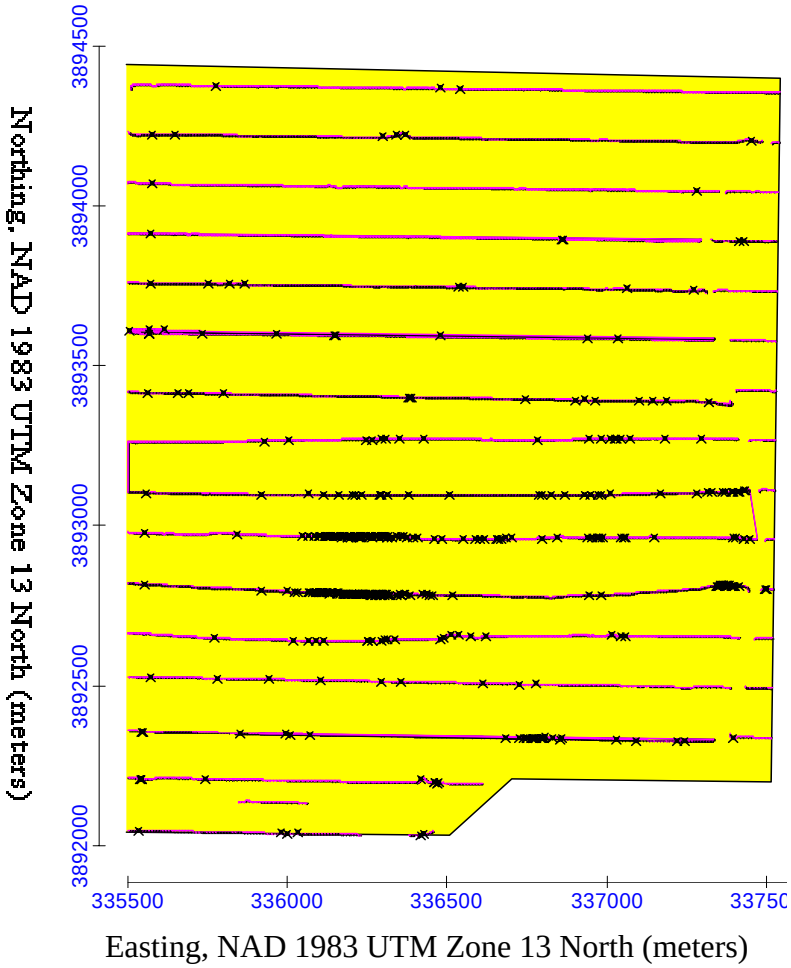


Figure 5: Northeast Sector Initial Survey Results

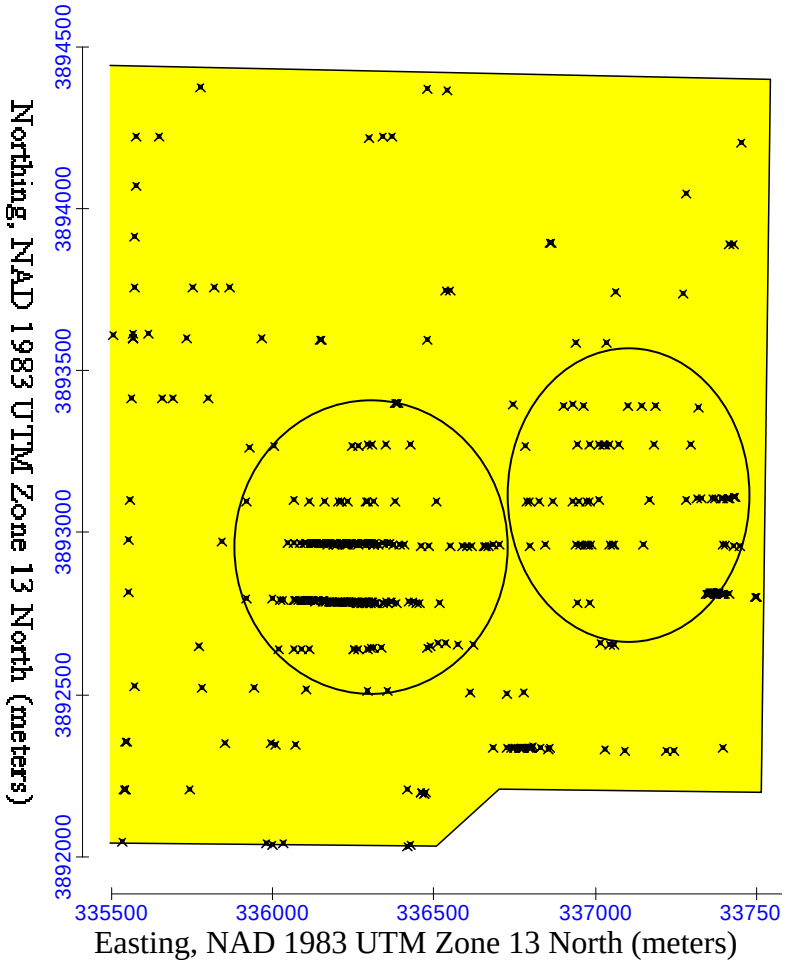


Figure 6: Northeast Sector without COG Lines

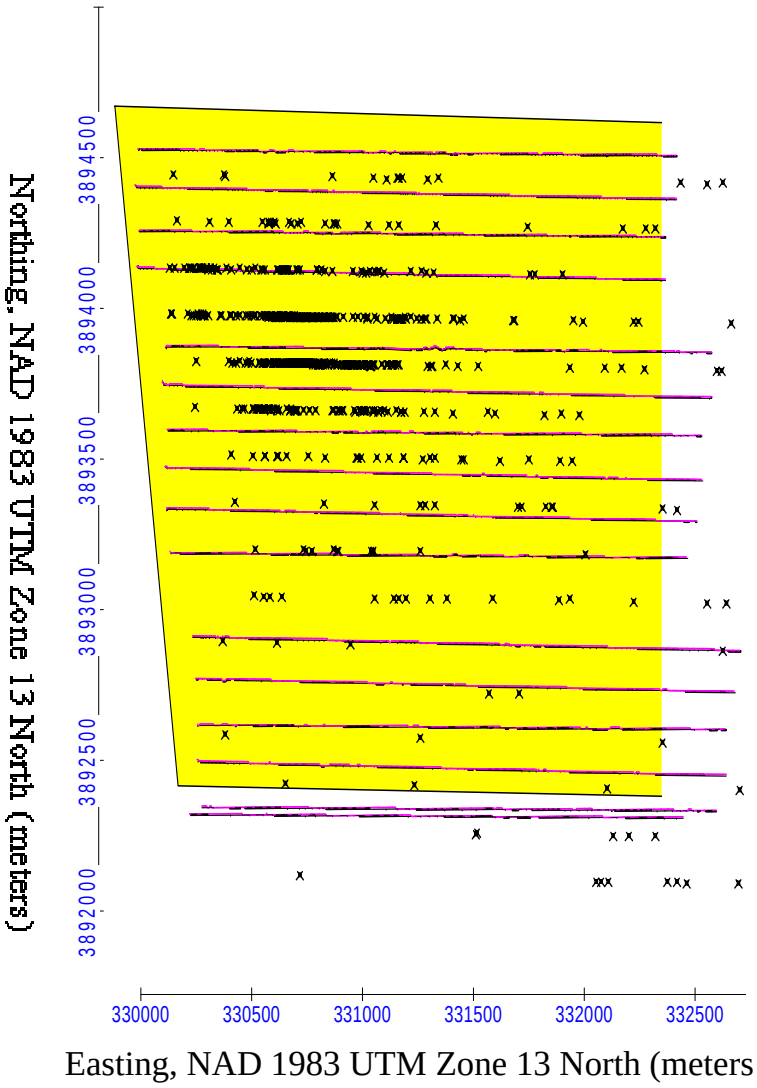


Figure 7: Northwest Sector Initial Survey Results

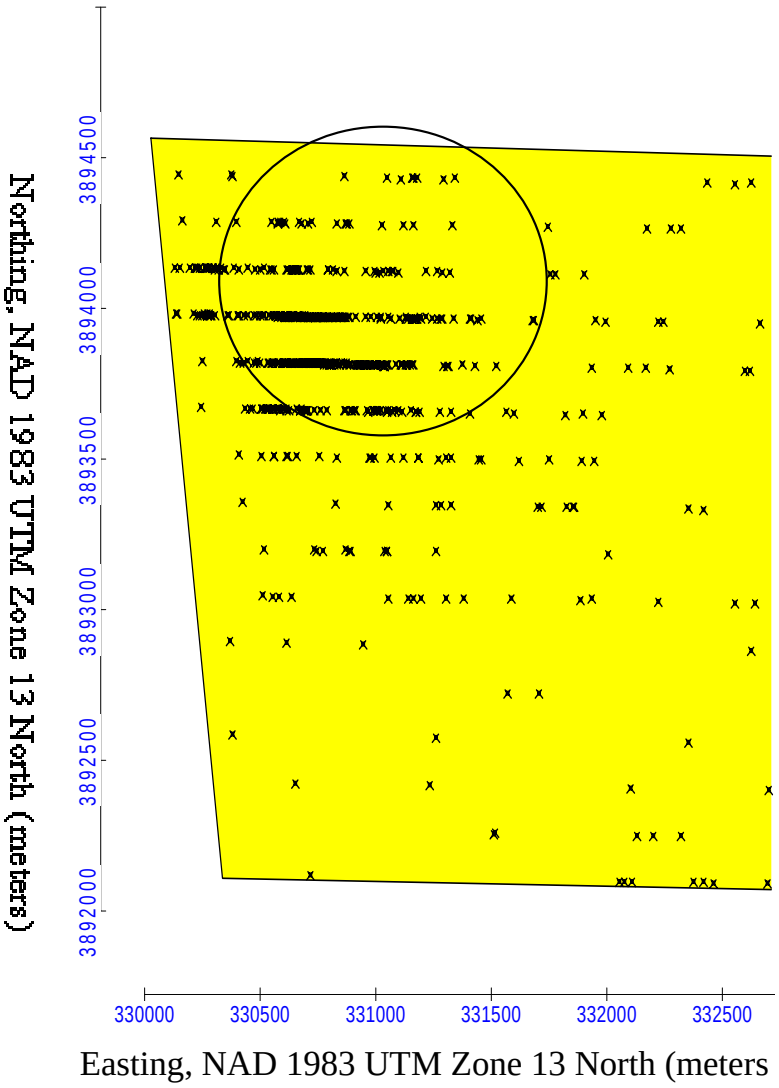


Figure 8: Northwest Sector without COG Lines

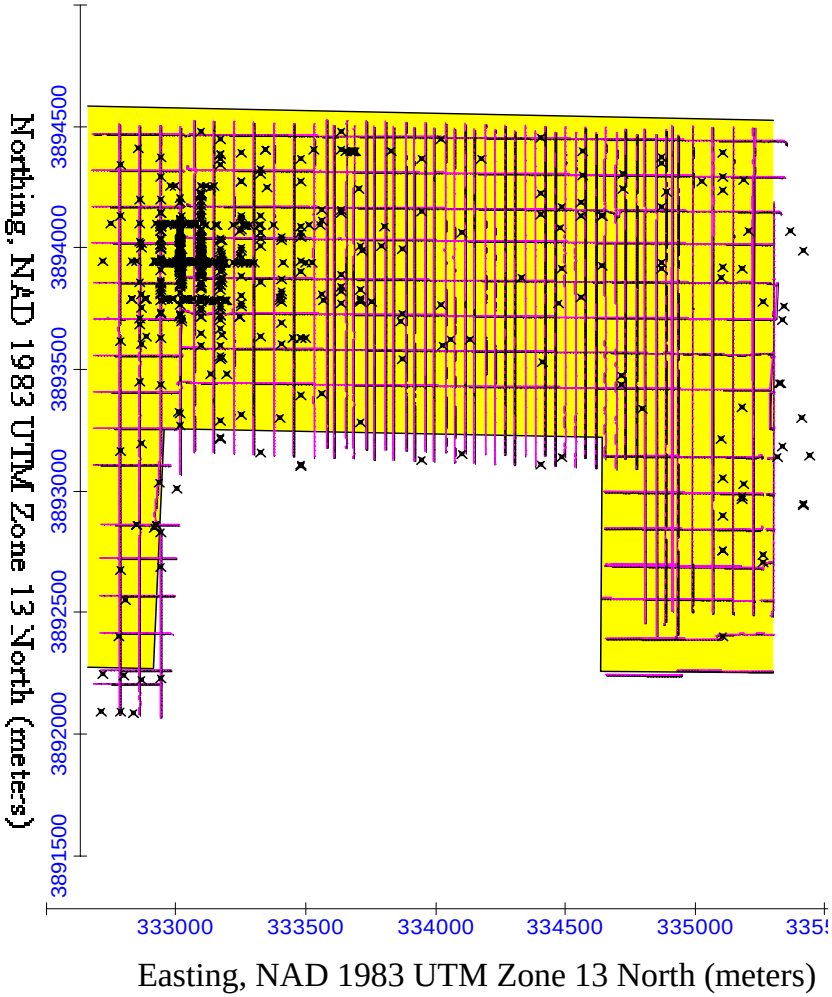


Figure 9: ORT Sector Initial Survey Results

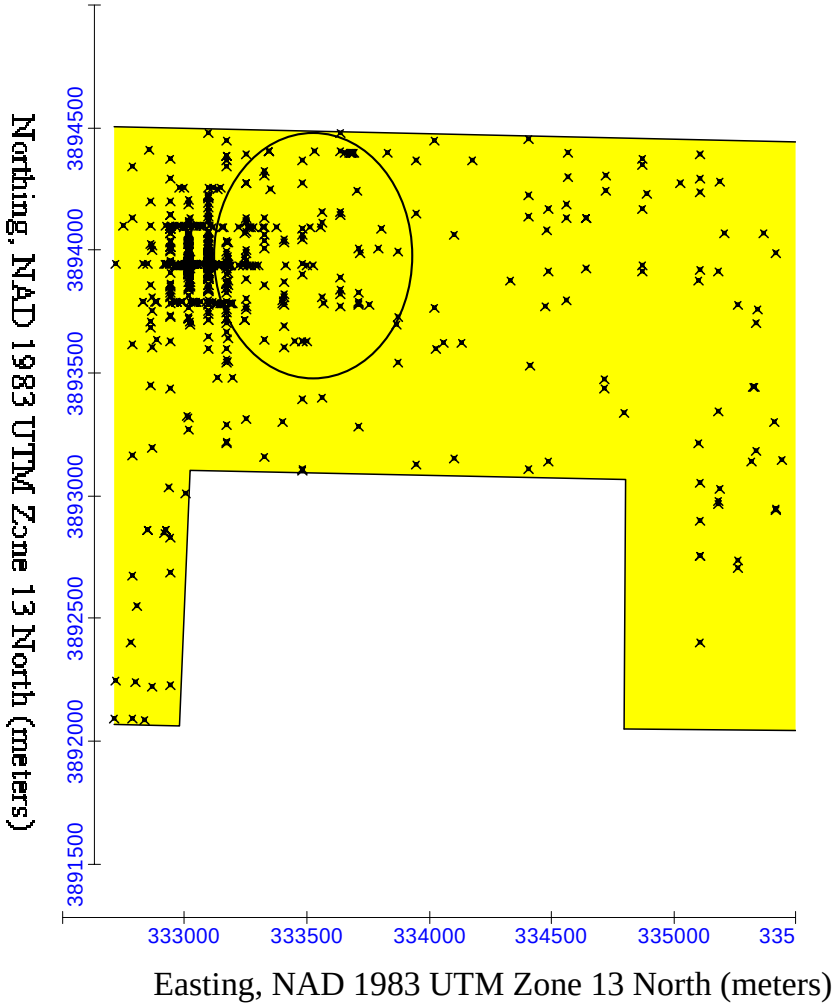


Figure 10: ORT Sector without COG Lines

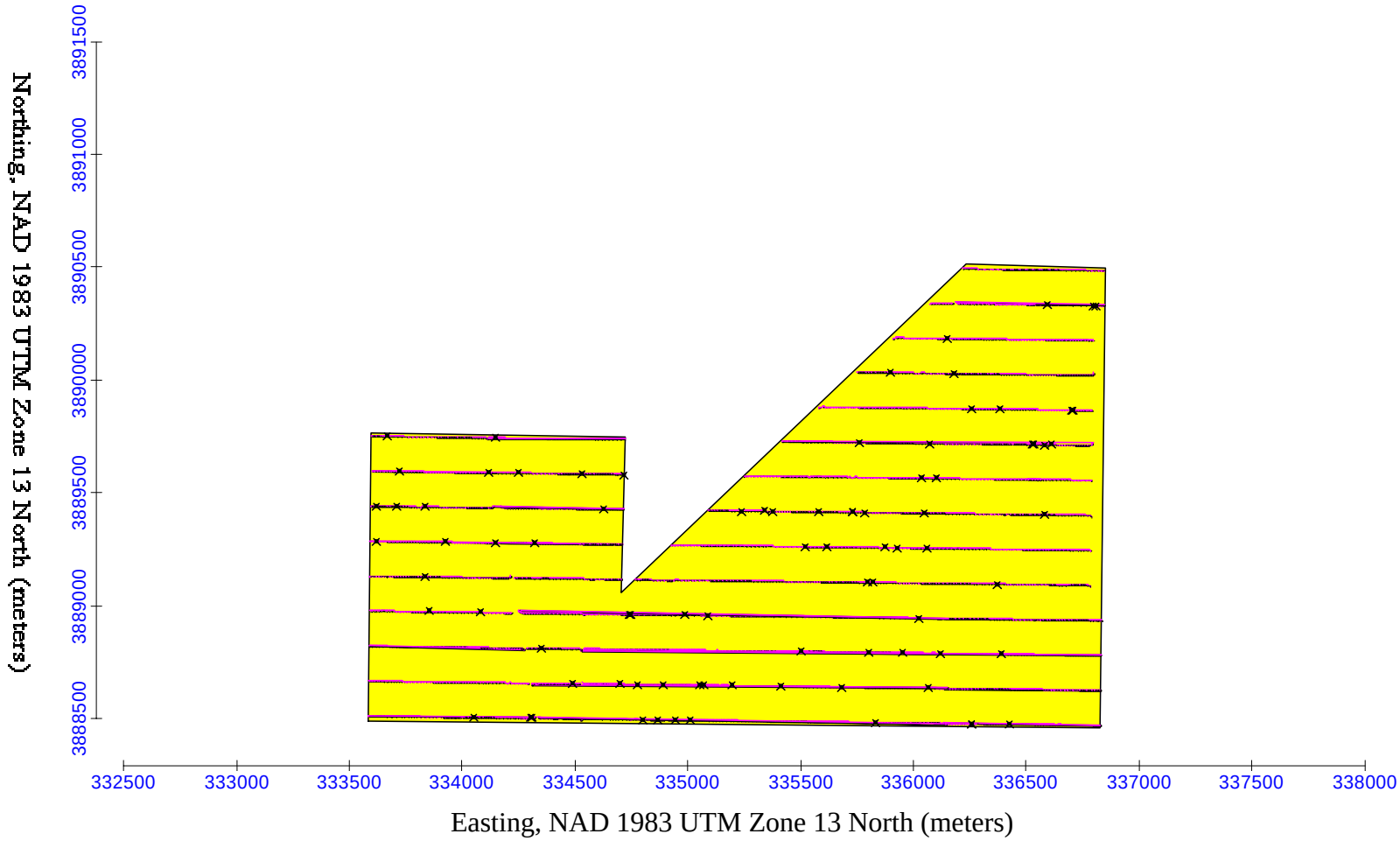


Figure 11: South Sector Initial Survey Results

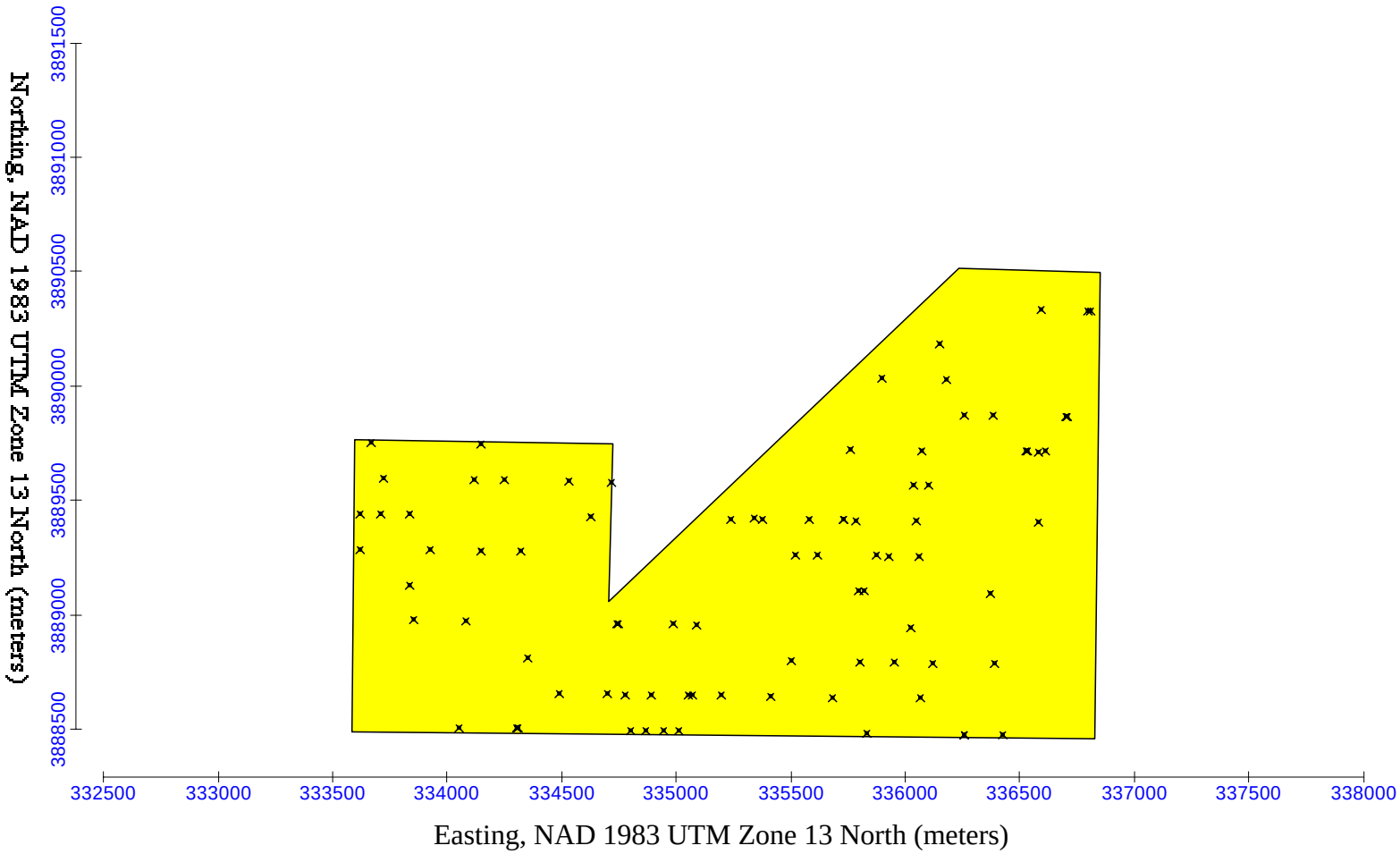


Figure 12: South Sector without COG Lines

3. Initial Transect Data Analysis and Fill-in Survey Design

The objective of the analysis of the initial transect data was to identify areas where the anomaly pattern indicated that there may be a concentration of MEC items. This analysis served as the basis for the design of the fill-in surveys. The purpose of the fill-in surveys was to obtain data in order to delineate the boundaries of suspected targets. The category two anomalies were analyzed during the initial transect data analysis. Fifty meter spacing was selected for the fill-in surveys.

The conservative search design for the oil refinery target (north-south oriented swaths with 80 m spacing), combined with the Bull's-eye target search transects, provided adequate coverage to delineate target areas in the oil refinery search area. Therefore, no analysis of initial transect data was performed for this part of the site.

The process within VSP used to perform the analysis was:

- Use the VSP "Find Target Areas" module to calculate the anomaly density within a user-specified window. This calculation is made in steps along the entire length of each transect. The transect width used was 2.5 meters. The resulting densities are plotted in a histogram. For the initial analysis, a window diameter equal to approximately one half of the transect spacing was selected. The rationale for window size selection is discussed below.
- Select a "critical density" based on the histogram. VSP then flagged the areas on each transect with densities above the critical density. The selection of critical densities for this analysis was based on the histograms plotted in VSP. The rationale for the selection of the critical densities is discussed below.
- Use VSP to design the fill-in surveys. New sample areas were created around areas flagged by VSP, and coordinates for the 50-meter spaced transects were generated.

Window Size Selection: A 75 meter window size was used in the analysis of the initial transect data. This is approximately half the transect spacing of 155 meters. The purpose of the survey was to find concentrations of anomalies of the size of the target being searched, and the size of that area determined the transect spacing. The 75 meter window was selected in order to increase the chances that density calculations would be made within the target area, in the event a target area was traversed by any of the transects.

The version of VSP (Version 4.3) used to design the fill-in surveys allowed the user to specify either a rectangular or circular window in the Find Target Areas module. The analysis documented here was completed using the rectangular window. A subsequent release of VSP has removed the rectangular window option from the module, and the specific results presented here are not replicable with the new version of the software.

Critical Density Selection: During this initial analysis, the selection of critical densities was based solely upon the visual inspection of the VSP-produced histograms. Very loose criteria were applied: the selected critical densities were greater than the apparent background density (as judged from the histogram), but less than the majority of the "outlier" densities. Figure 16 best illustrates these concepts. A more repeatable approach to selecting critical densities is described in Section 4.3.

3.1. Northeast Sector

The critical density selected from the histogram was 0.1 anomalies/m^2 (405 anomalies/acre). This resulted in VSP selecting 34 areas above the critical density, which are illustrated in Figure 13 (for the northern portion of the target area) and Figure 14 (for the southern portion). A 605 acre sample area was created, and the 50 meter spaced transect fill-in survey design was generated, which resulted in 28.4 acres of additional sampling. The survey design is illustrated in Figure 15. The design coordinates are provided in Appendix A.

3.2. Northwest Sector

A critical density of 0.125 anomalies/m^2 (506 anomalies/acre) was selected from the density histogram (see Figure 16).

VSP identified 88 areas above the critical density in the northwest sector, and these are depicted in Figure 17. Fill-in sample areas totaling 249 acres were identified to encompass the VSP-identified areas (see Figure 17). The design resulted in 10.9 acres of additional geophysical transects. The design coordinates are in Appendix A.

3.3. South Sector

The maximum density in this area was approximately 0.016 anomalies/m^2 (65 anomalies/acre); the average over the entire area was 0.00823 anomalies/m^2 (3 anomalies/acre). These densities are significantly below the critical densities selected for the northern part of the site, and no fill-in surveys were recommended for this sector. The sector is illustrated in Figure 18.

3.4. Fill-in Survey Results

The completed fill-in surveys for the Northeast sector are presented in Figure 19(with the COG lines) and Figure 20 (without the COG lines). Figure 21 (with COG lines) and Figure 22 (without COG lines) present the results for the Northwest sector.

The fill-in survey for the Northeast sector successfully captured the boundaries of the target areas. The fill-in surveys for the Northwest sector bounded two major target areas, and provided enough information to remove the south-most survey area (circled on Figure 21) from consideration.

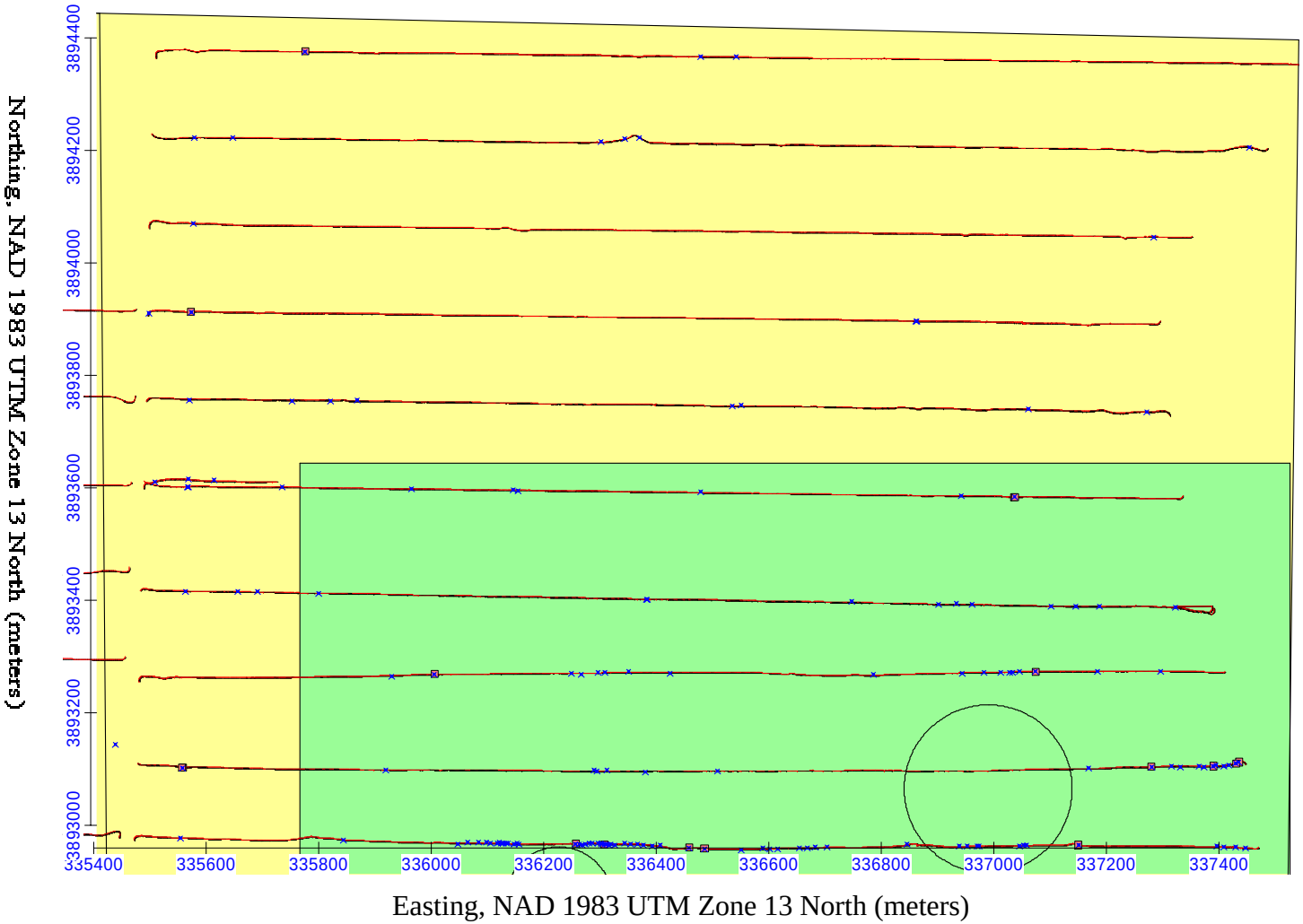


Figure 13: Close-up of Northern Part of Northeast Sector, Potential Targets Flagged by VSP

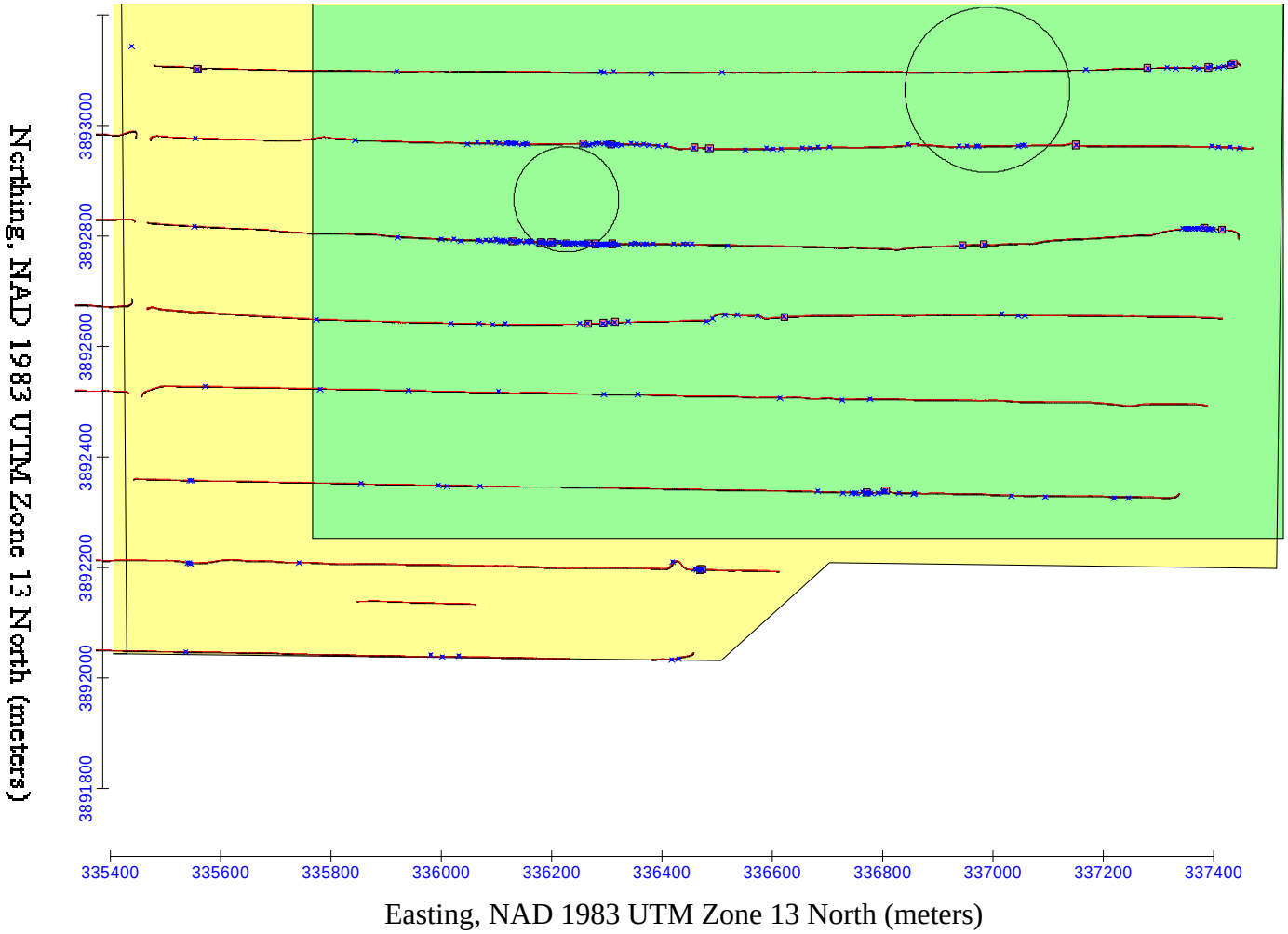


Figure 14: Close-up of Southern Part of Northeast Sector, Potential Targets Flagged by VSP

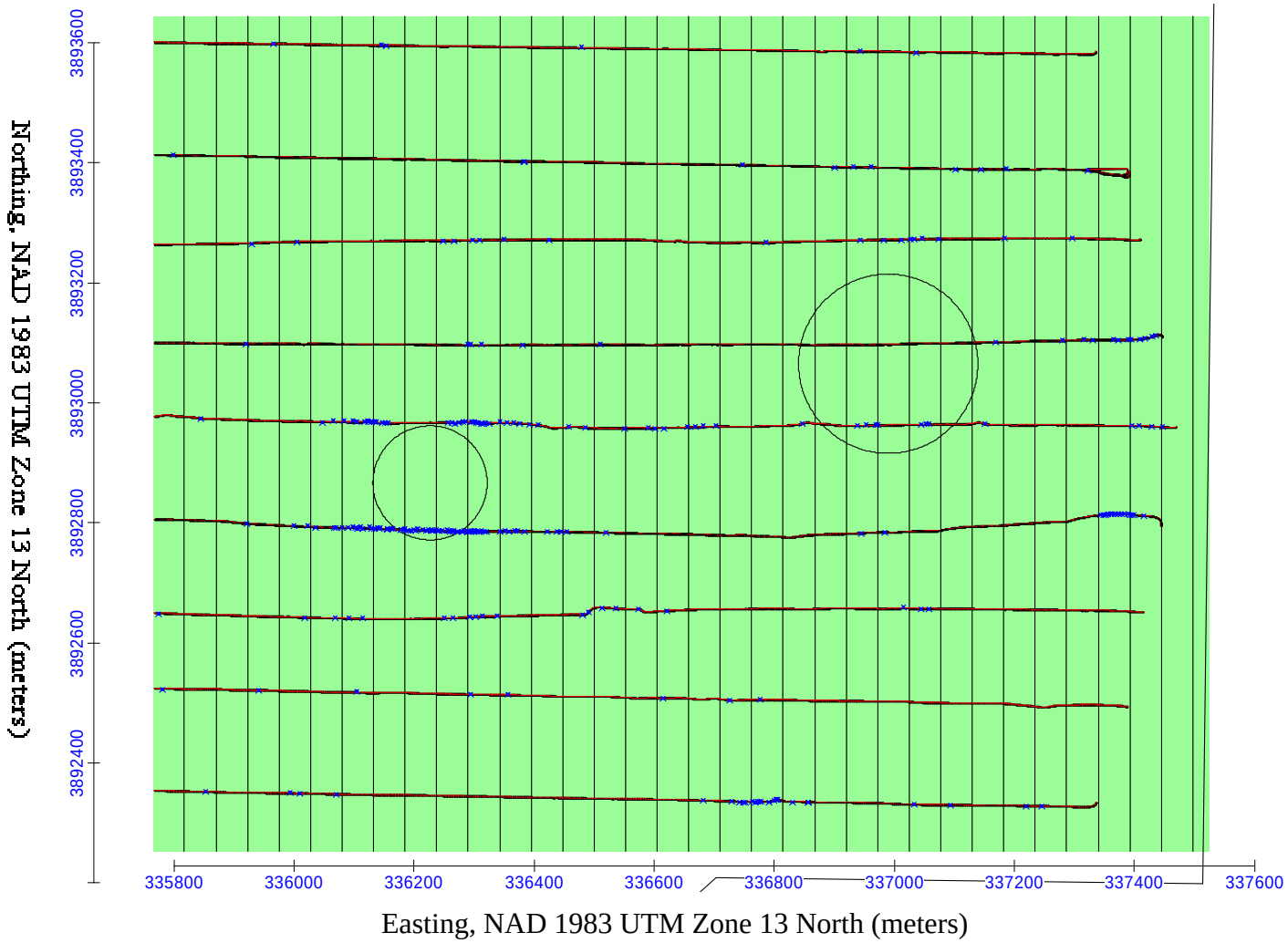


Figure 15: Northeast Sector Fill-in Survey Design

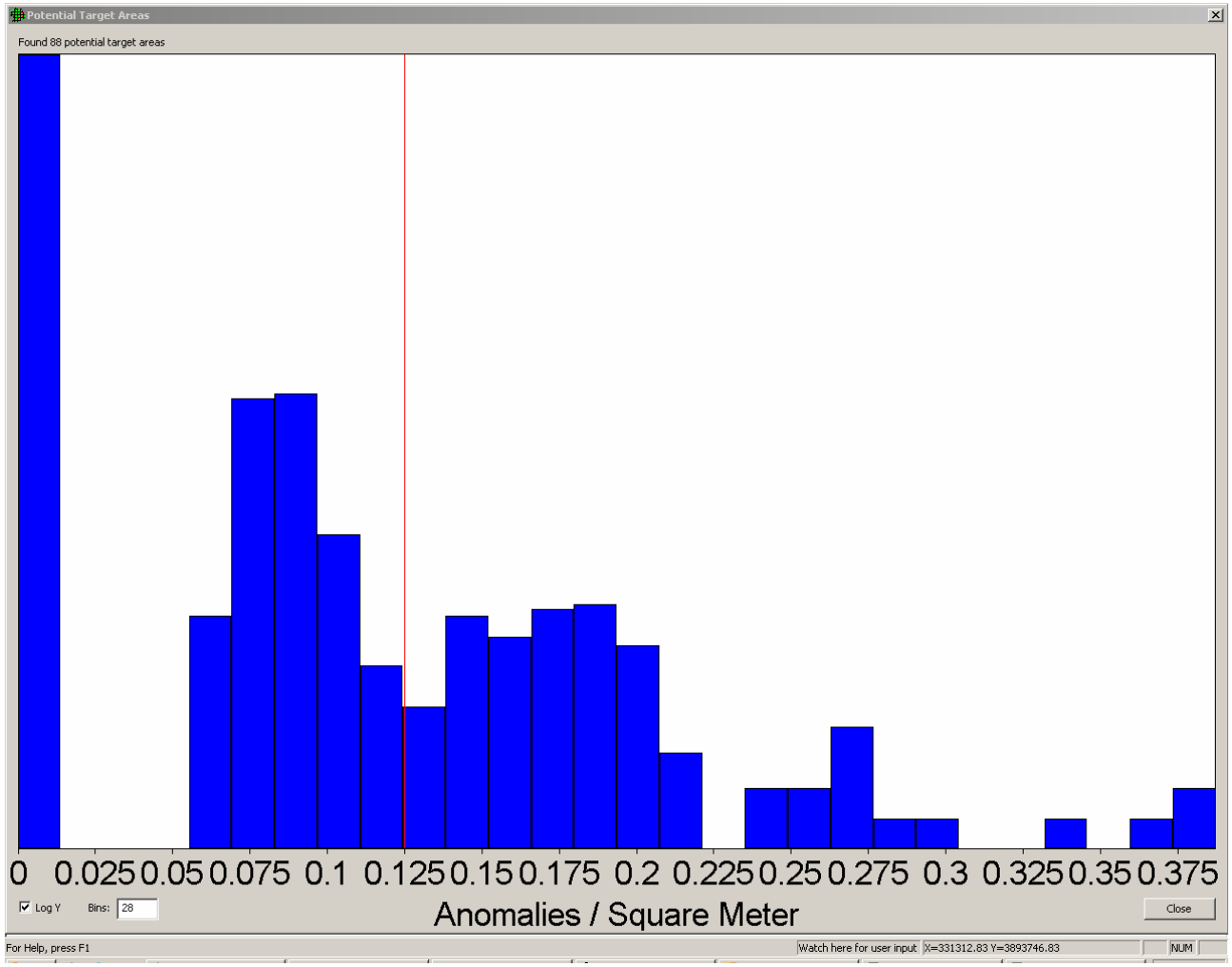


Figure 16: Histogram for Critical Density of 0.125 anomalies/m^2, Northwest Sector

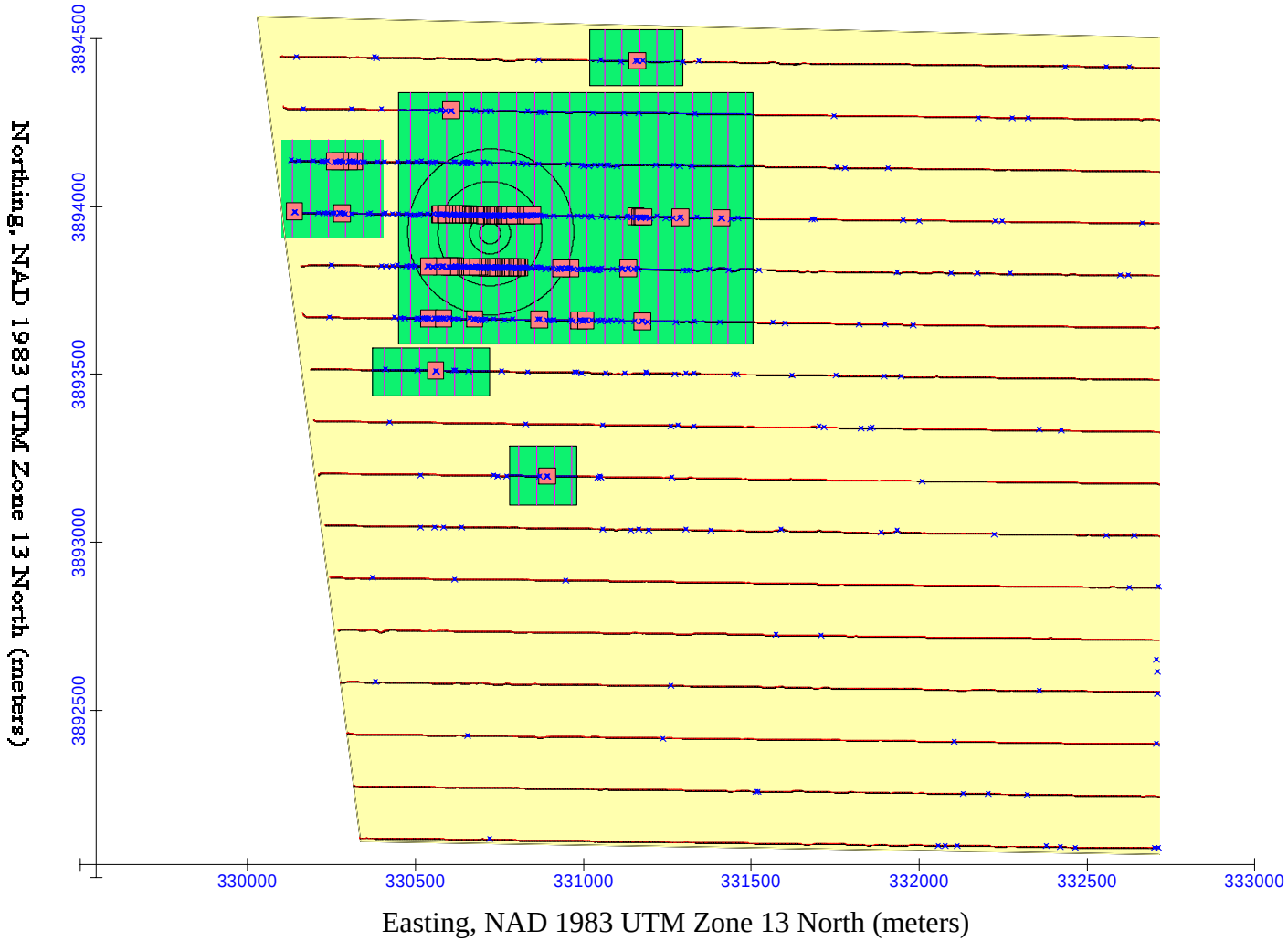


Figure 17: Fill-in Survey Design for the Northwest Sector

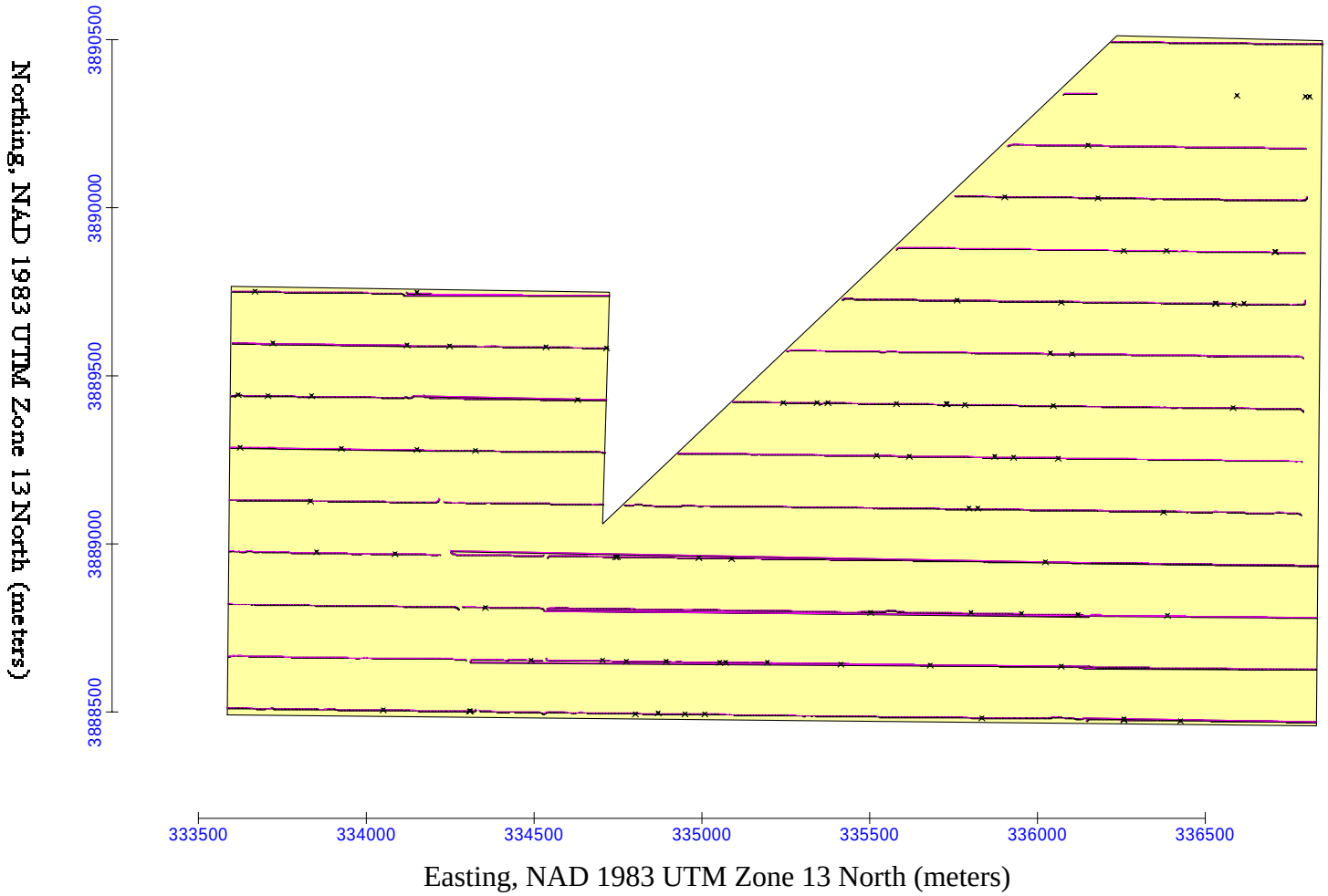


Figure 18: Category 2 Anomalies in Southern Sector of Bull's Eye Target Search Area

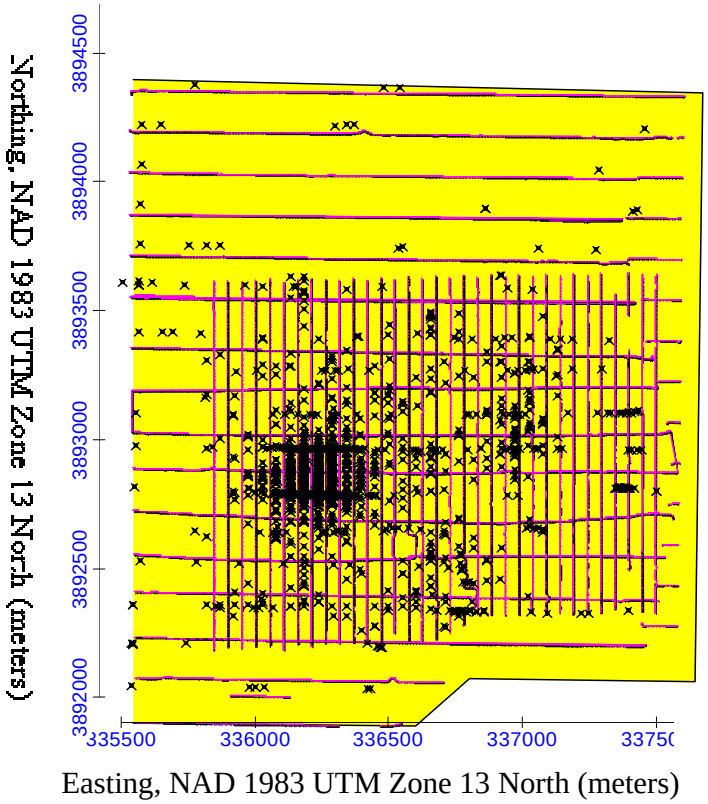


Figure 19: Northeast Sector Fill-in Survey Results

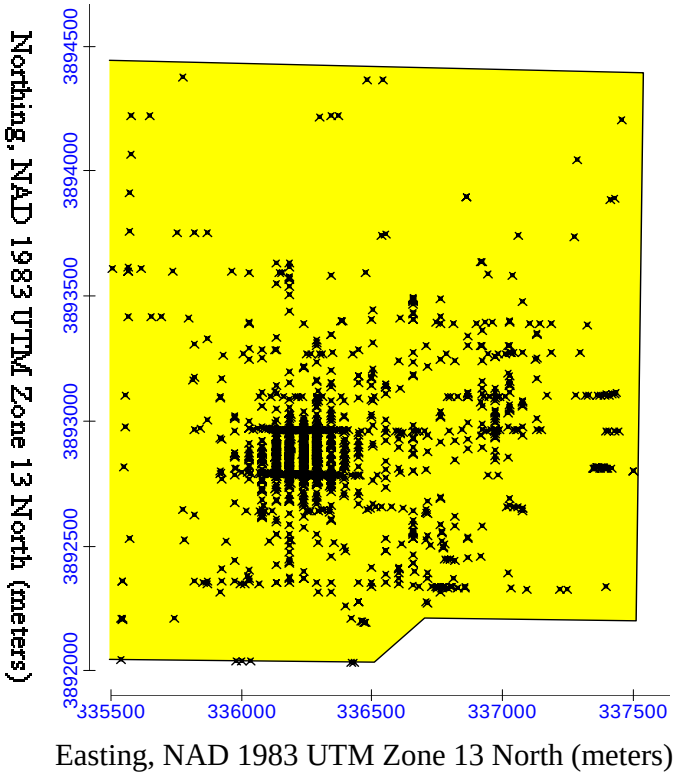


Figure 20: Northeast Sector Fill-in Survey without COG Lines

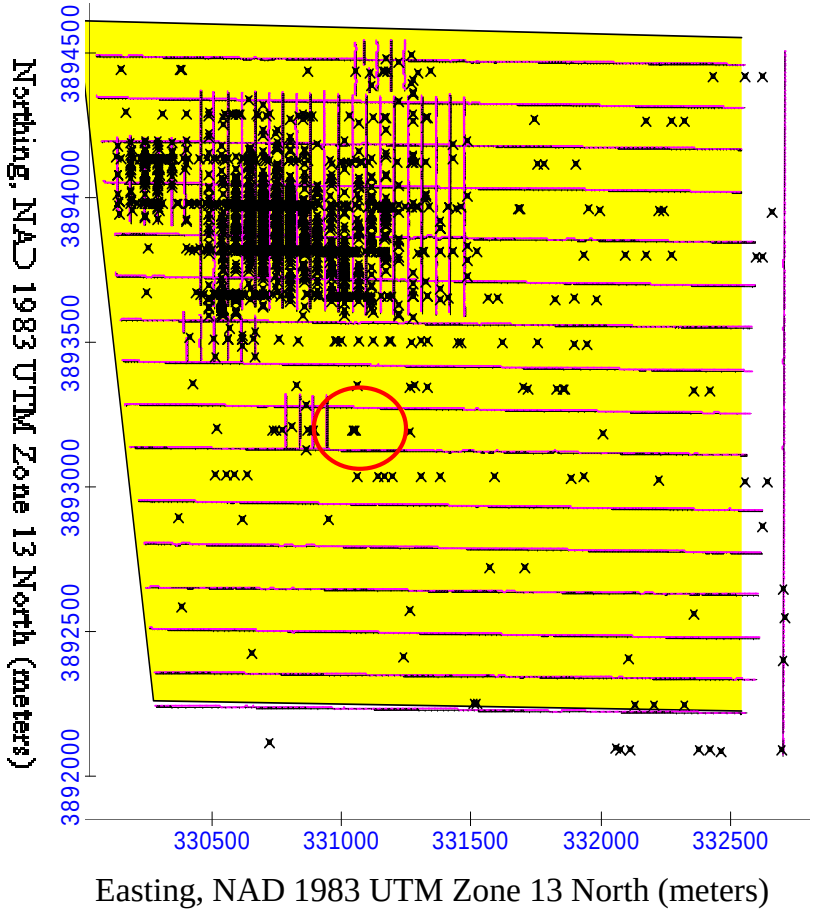


Figure 21: Northwest Sector Fill-in Survey Results

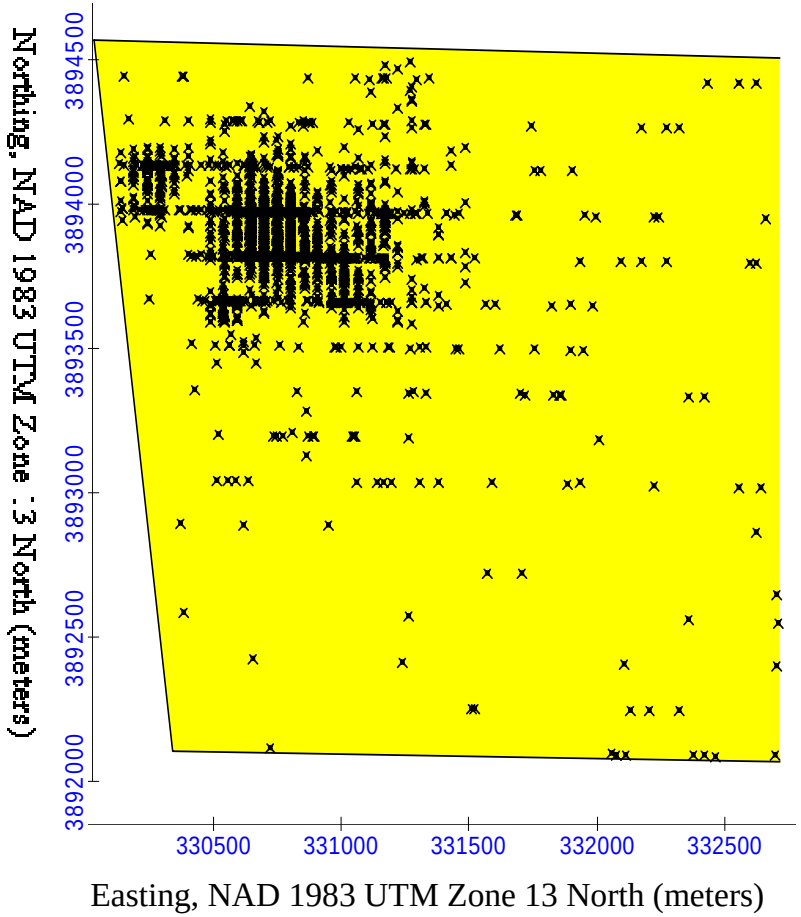


Figure 22: Northwest Survey Fill-in Survey without COG Lines

4. Preliminary Boundary Estimations

The Northeast, Northwest, and ORT sectors all contain apparent target areas. The boundaries of the targets were estimated after the areas outside the vicinities of the apparent target areas were removed from the analysis. The areas used in the boundary estimations are shown in Figure 23. The target boundaries were estimated first through visual examination and then by using the VSP Find Target Areas module.

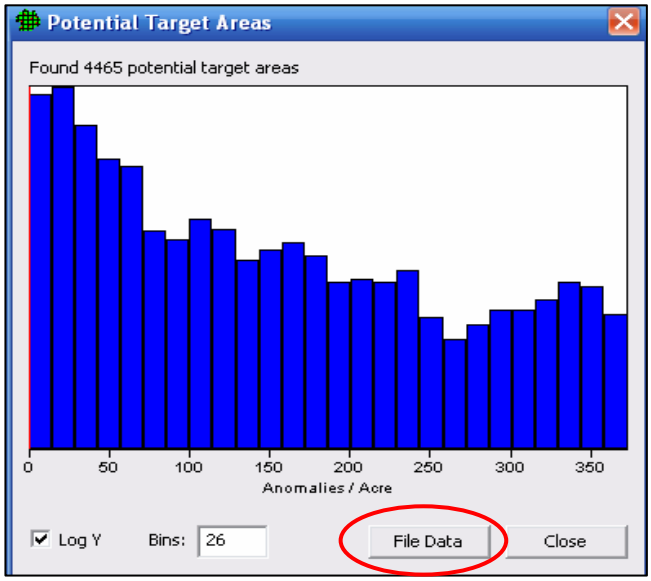
4.1. Visual Examination

Target boundaries were estimated by visually examining the anomaly patterns within and around each target area. Those estimated boundaries are shown in Figure 24 (Northeast sector), Figure 28 (Northwest sector), and Figure 32 (ORT sector). As can be seen in the figures, each of the apparent target areas was crossed by multiple east-west and north-south transects, providing ample information to estimate the boundaries of the target areas. This fact, combined with the use of only the most "UXO-like" (i.e., category 2) anomalies, make the apparent target areas very easy to distinguish.

4.2. VSP Target Areas Module

The following process was used with the VSP Find Target Areas module to flag the areas of high anomaly density[4]:

- A window diameter of 250 meters was selected. The two smallest potential target areas that were visually identified were approximately 300 meters along their smallest dimensions (see Figure 24 and Figure 28 for these measurements). Selecting a window of 250 meters (smaller than the 300 meters) ensures that at least one full density calculation was made within the smallest visually identified potential target areas.
- For each sector, the Find Target Areas module was run with a 1 anomaly per acre *critical density*[5]. The resulting density calculations were exported to a text file using the "File Data" button on the histogram screen (see the screen capture picture on this page). The resulting text files were imported to Excel spreadsheets (see Section 4.3 for further explanation).



[4] Visual Sample Plan Version 4.4b was used for this analysis.

[5] It was later determined that any value of critical density would have produced an identical text file. The VSP module calculates the density within each instance of the window, and that density does not change unless the window diameter is changed.

- A background density for each of the areas was estimated by taking the average of the individual density calculations.
- The Find Target Areas module was run again with the 250 meter diameter window, this time with a *background density* equal to the average calculated in the previous step, and the confidence that the window density is above background set to the default of 95%.

The flagged areas resulting from this process are illustrated in Figure 25 (Northeast sector), Figure 29 (Northwest sector), and Figure 33 (ORT sector). The background densities used for each area are listed in Table 3.

Because the apparent target areas were already distinct, the density flagging by VSP does not really provide significantly different results than those obtained by visual examination. The exception is the center area in the Northwest sector identified visually, but not flagged by VSP.

4.3. Critical Densities

An approach similar to the boundary delineation approach described above was used to calculate critical densities for the initial survey results for the Northeast and Northwest sectors. The approach is summarized as follows:

- The window diameter of 75 meters was maintained from the original analysis. The rationale for the window size remains the same: Use of a 75 meter window increased the chances that if a target area had been traversed, density calculations would be made within the target area.
- For each sector, the Find Target Areas module was run with a 1 anomaly per acre critical density. The resulting density calculations were exported to a text file using the "File Data" button on the histogram screen. The resulting text files were imported to Excel spreadsheets.
- The individual densities were sorted in descending order, and the averages of the *non-zero* densities were taken. These were used as an estimate of the critical density for use in the Find Target Areas module. This is contrasted with using all of the densities (zero and non-zero) to calculate the background densities used in the boundary delineation.
- The areas for a fill-in survey were flagged using the Find Target Areas module with the 75 meter diameter window and the critical density equal to the average calculated in the previous step.

For the Northeast sector, the critical density was estimated to be 55 anomalies per acre; the critical density for the Northwest sector was estimated to be 69 anomalies per acre. The results of the VSP density flagging are in Figure 36 and Figure 37.

4.4. Analysis with Category 1 Anomalies Added

A sensitivity analysis of the effect of including Category 1 anomalies in the boundary delineation analyses was undertaken to examine the effect a noisier set of data on the results of the analyses. The estimation of the background density for the combined category 1 and 2 anomalies followed the same steps as those outlined in Section 4.2 for the category 2 only anomalies. The estimated background anomaly densities for the category 1 and 2 anomalies are presented in Table 3.

Table 3: Background Density Estimates

Analysis Sector	Estimated Background Anomaly Density (per acre)	
	Category 2 Anomalies	Category 1 and 2 Anomalies
Northeast	35	59
Northwest	92	120
Oil Refinery Target	40	52

The target areas with the category 1 and 2 anomalies are shown in Figure 26, Figure 30, and Figure 34 for the Northeast, Northwest, and ORT sectors, respectively. The flagged areas identified by VSP are presented in Figure 27, Figure 31, and Figure 35.

The inclusion of the category 1 anomalies did not substantially change the boundary delineations for the Northwest and the ORT sectors. In the Northeast sector, the region between the two targets was flagged. The Northeast sector with the category 1 and 2 anomalies also best demonstrates the usefulness of the VSP Find Target Areas module, as the boundaries of the target areas are much harder to discern visually (see Figure 26).

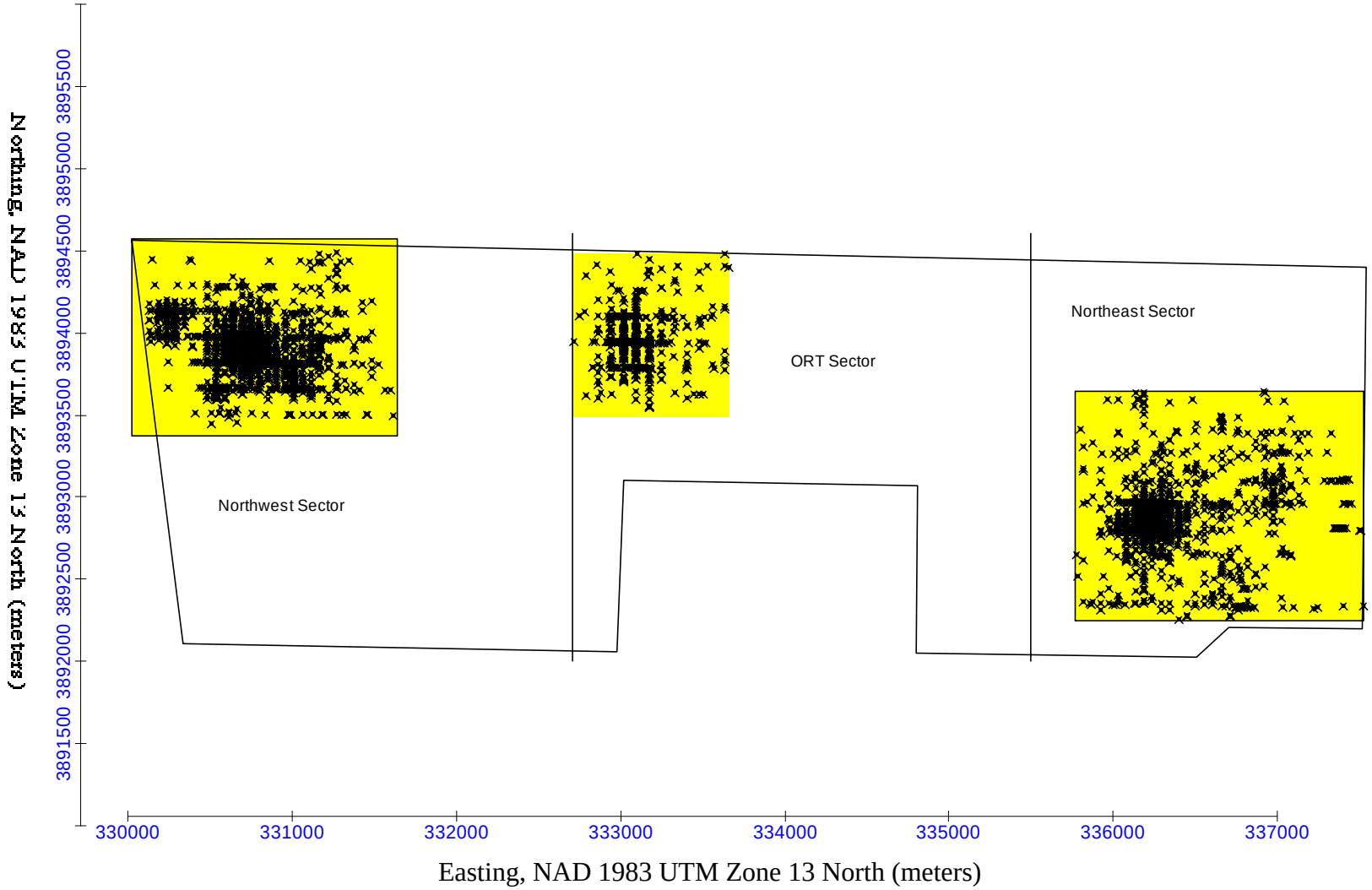


Figure 23: Areas Used for Boundary Estimation

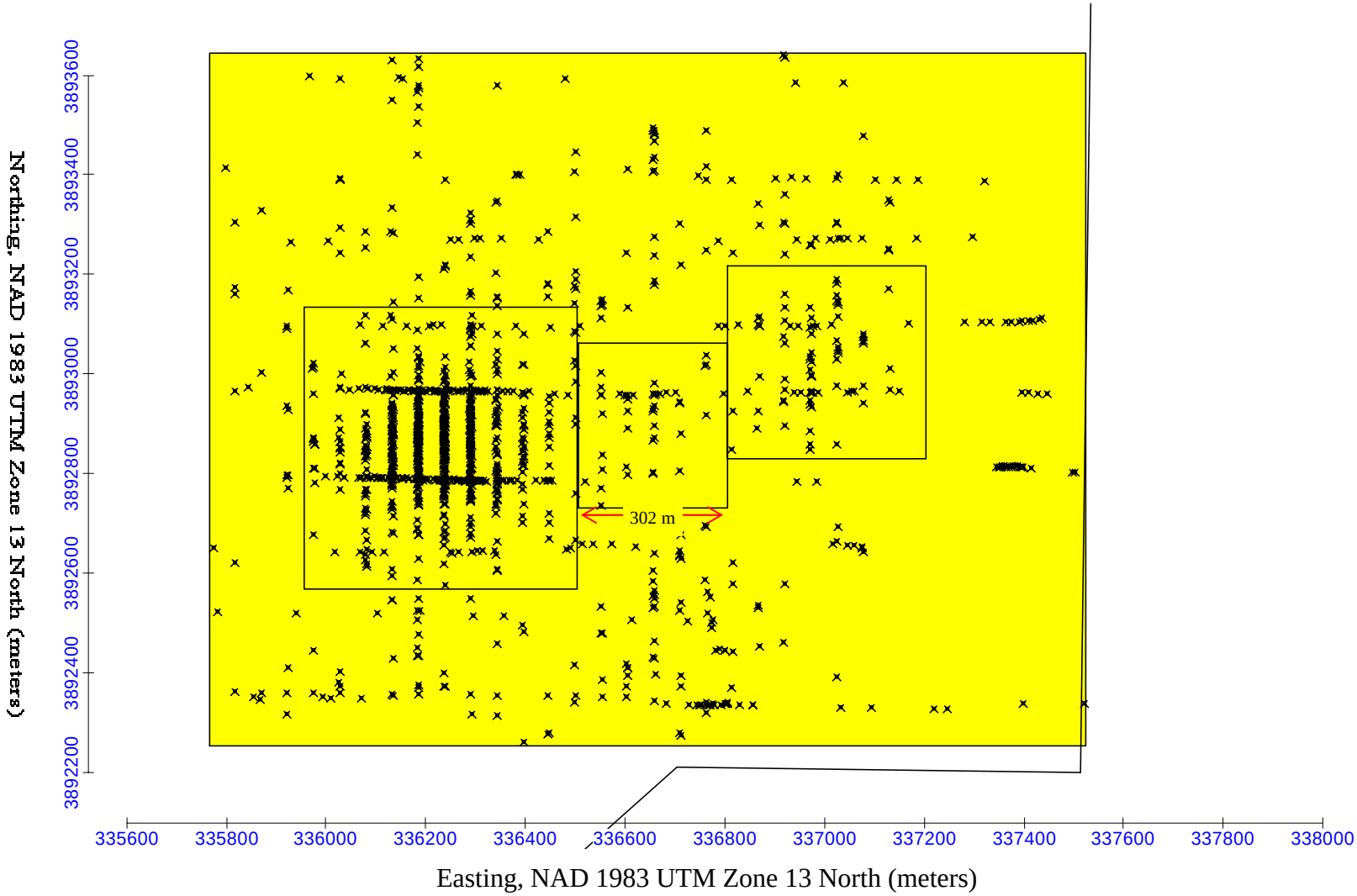


Figure 24: Visually Estimated Target Boundaries, Northeast Sector

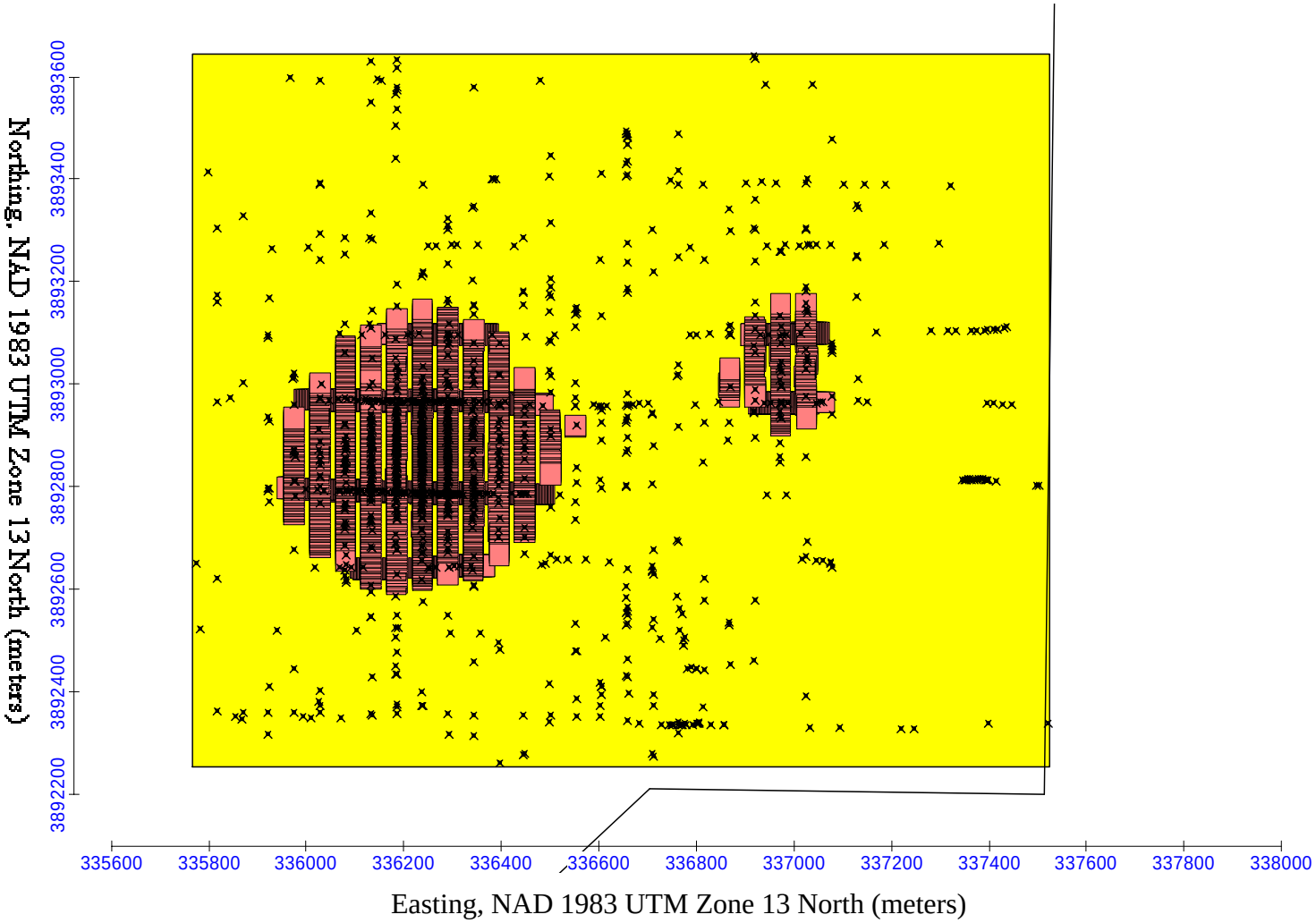


Figure 25: Northeast Sector with Category 2 Anomalies, Flagged Areas with Density Greater Than 35 Anomalies/Acre Background

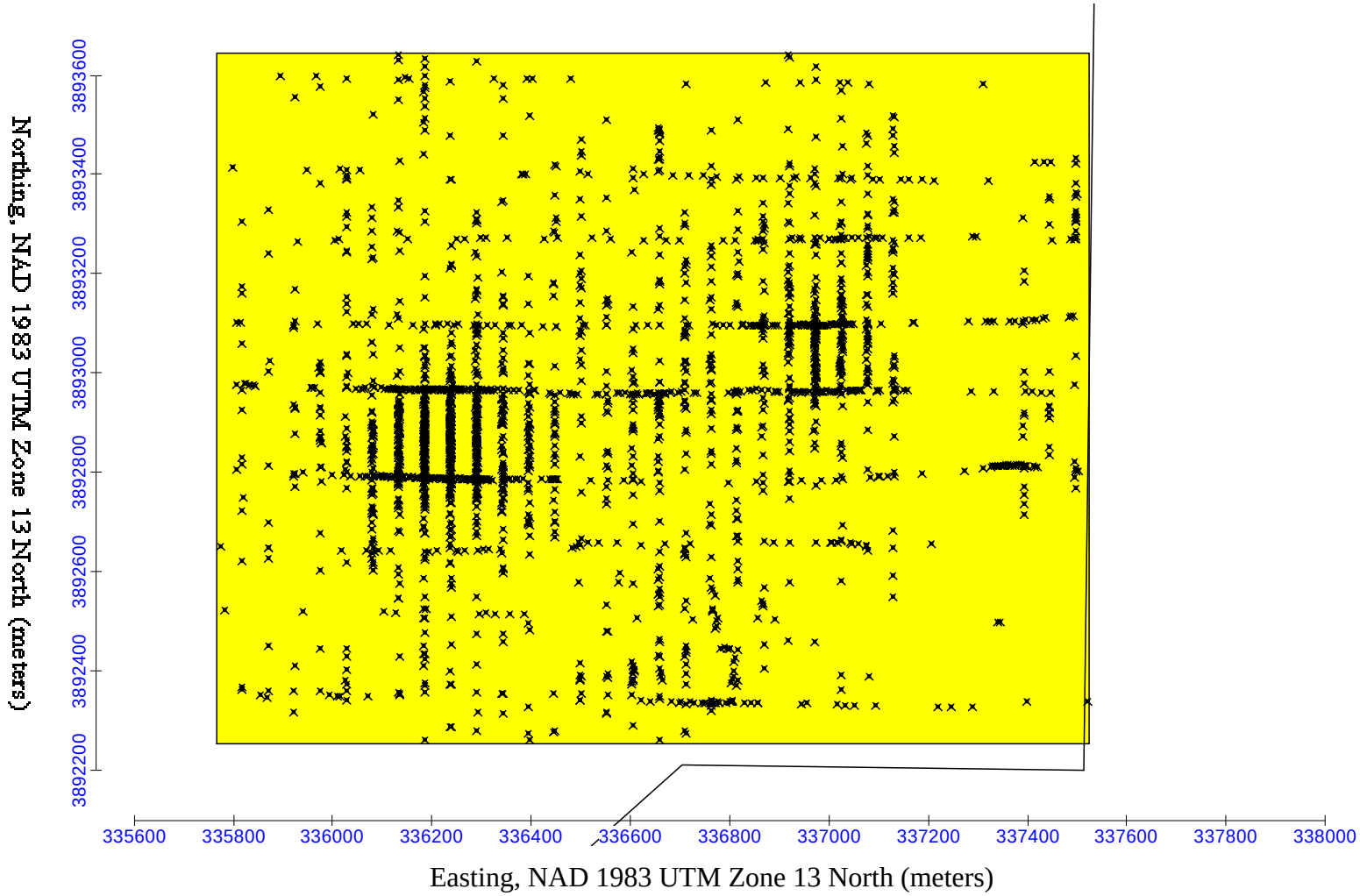


Figure 26: Category 1 and 2 Anomalies in the Northeast Sector Target Area Vicinity

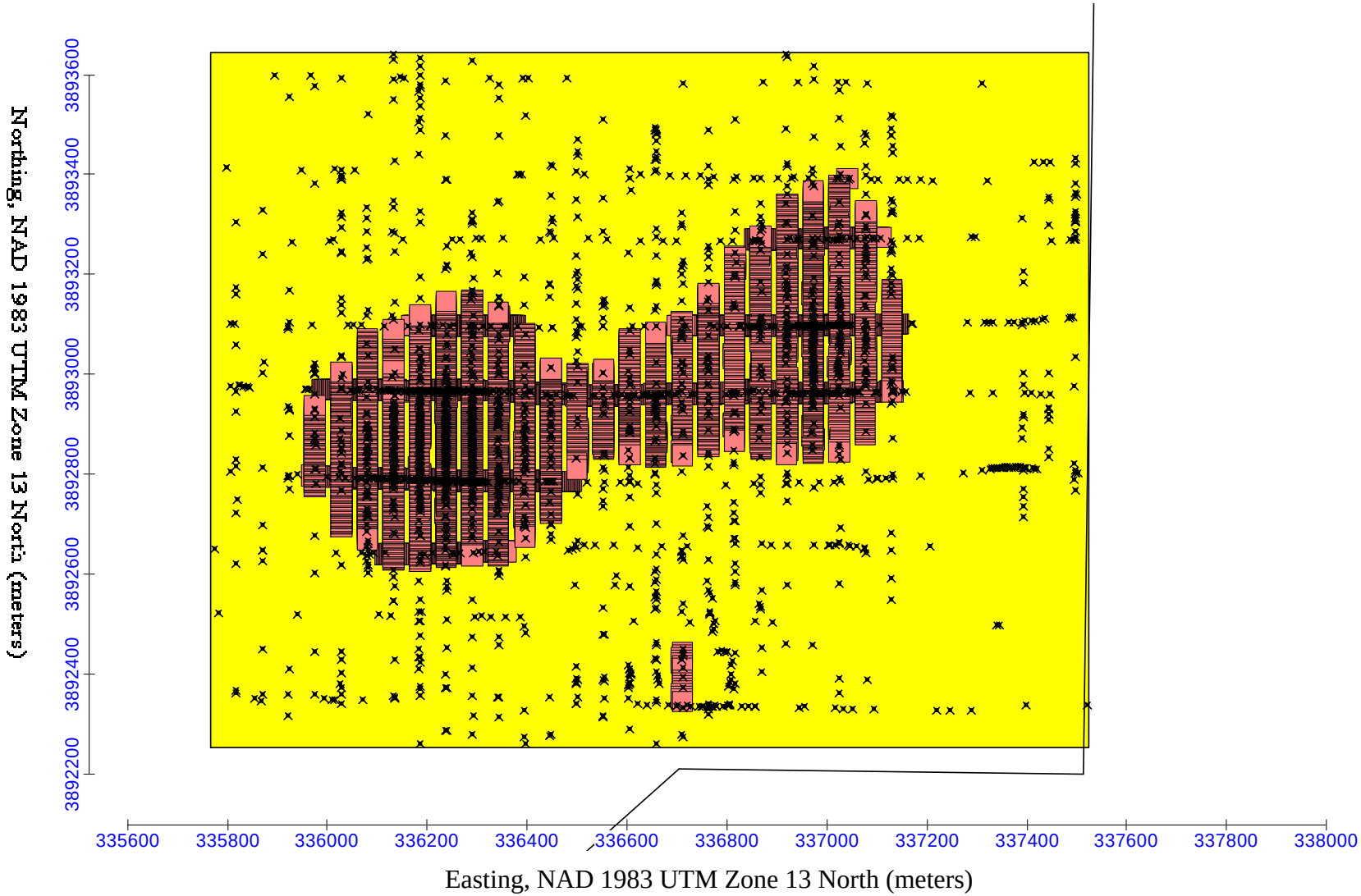


Figure 27: Northeast Sector with Category 1 and 2 Anomalies, Flagged Areas with Densities Greater Than 59 Anomalies/Acre Background Density

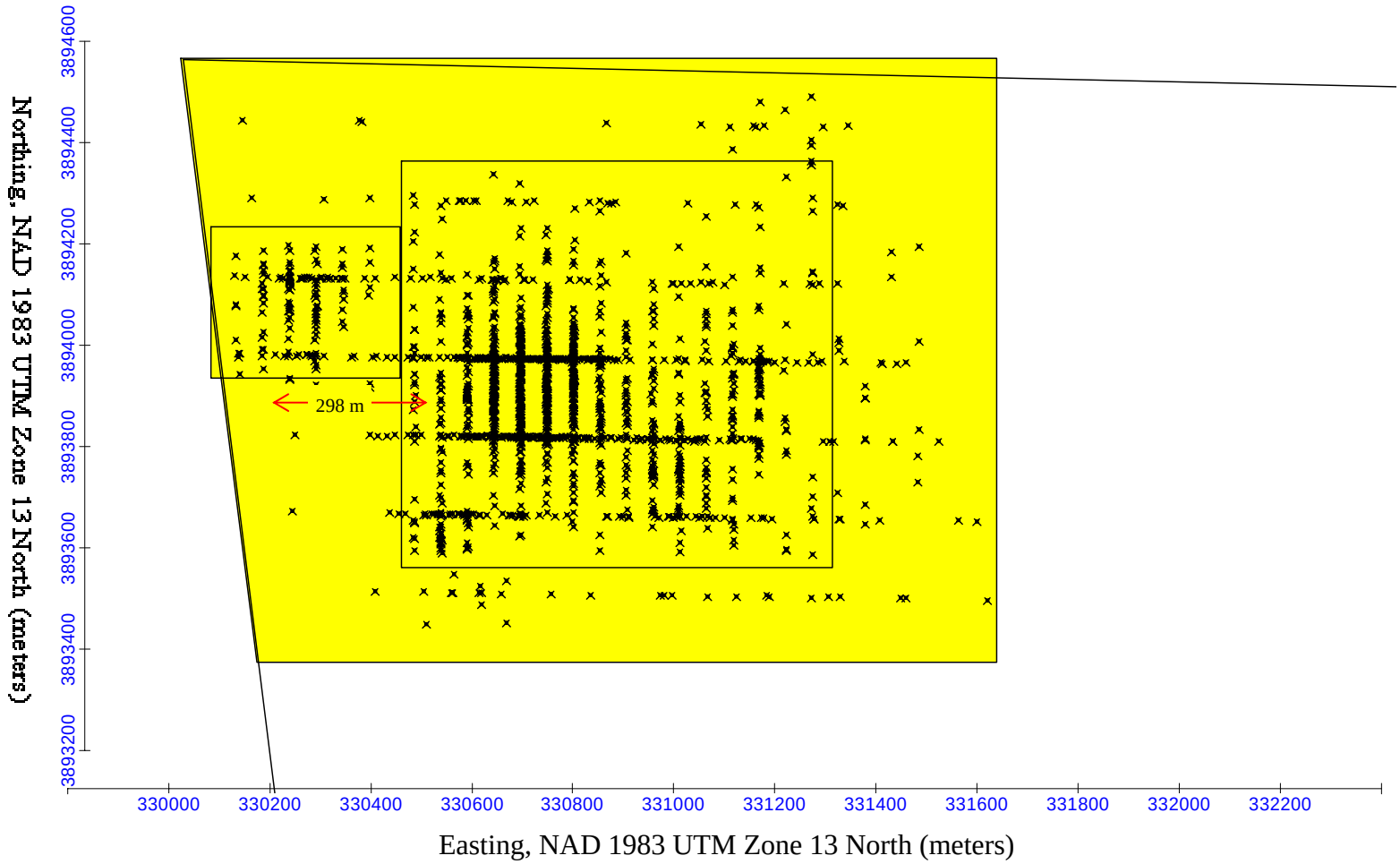


Figure 28: Visually Estimated Target Boundaries, Northwest Sector with Category 2 Anomalies

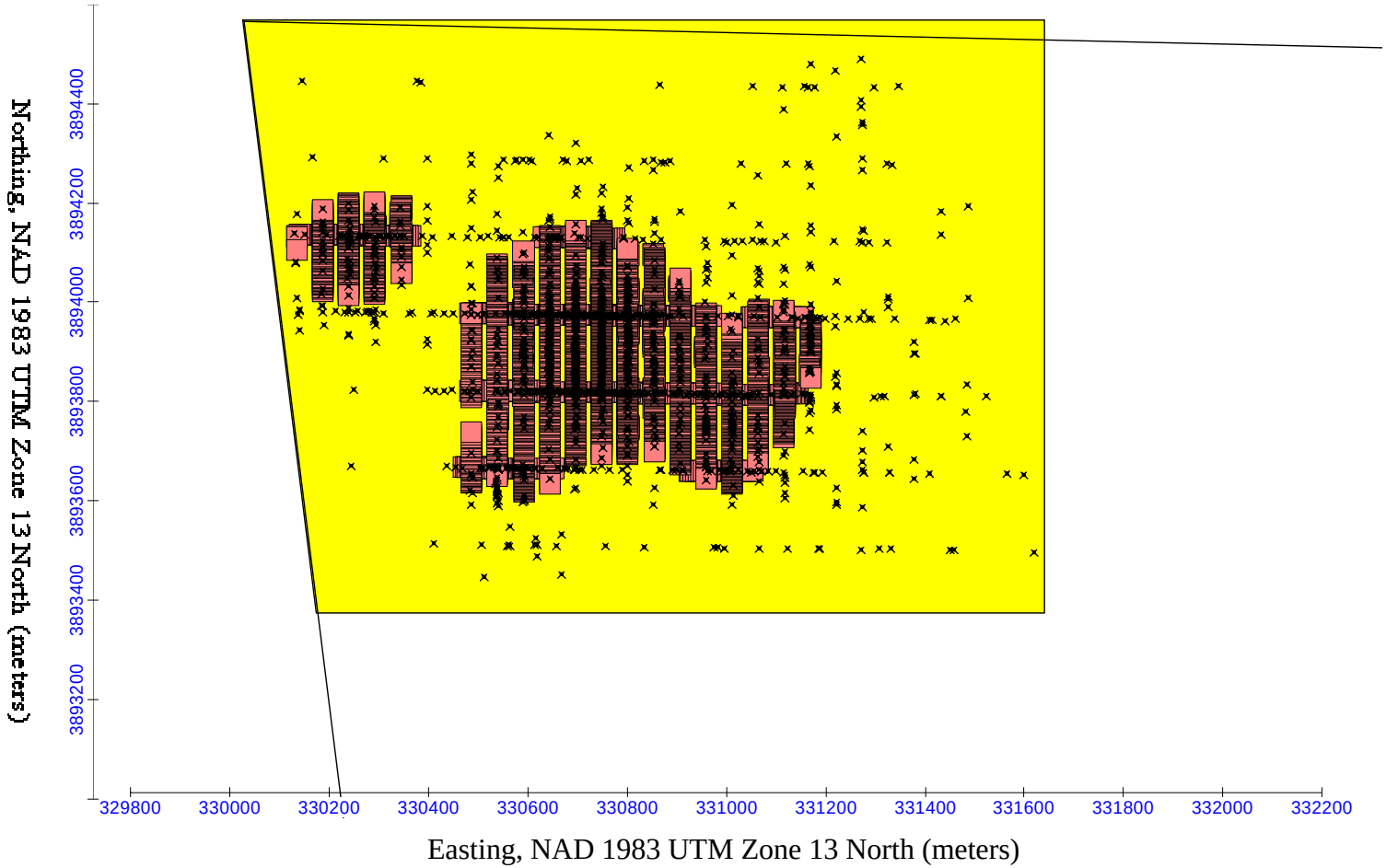


Figure 29: Northwest Sector with Category 2 Anomalies, Flagged Areas with Density Greater Than 92 Anomalies/Acre Background Density

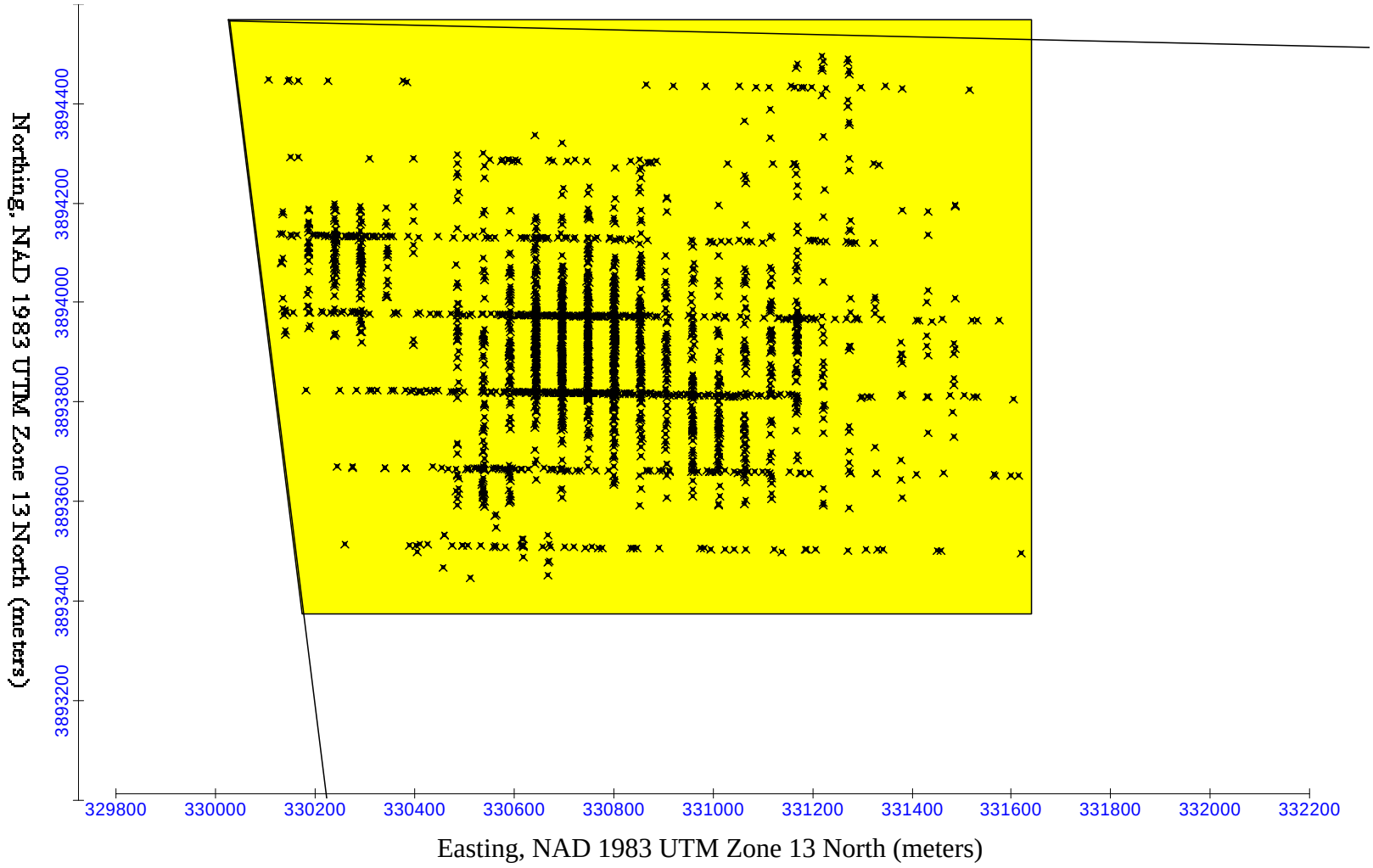


Figure 30: Category 1 and 2 Anomalies in the Vicinity of the Northwest Target Area

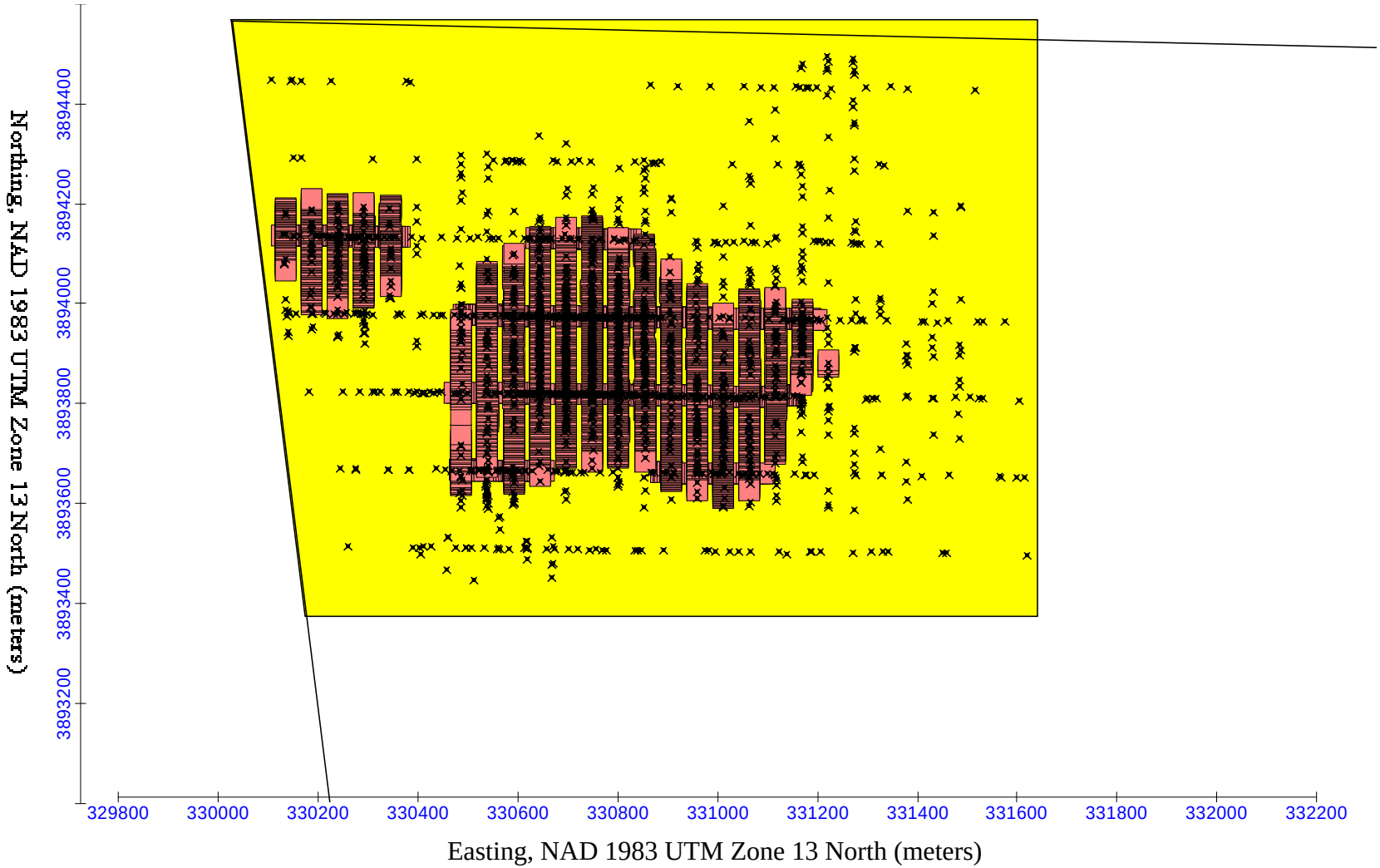


Figure 31: Northwest Sector with Category 1 and 2 Anomalies, Flagged Areas with Densities Greater Than 120 Anomalies/Acre Background

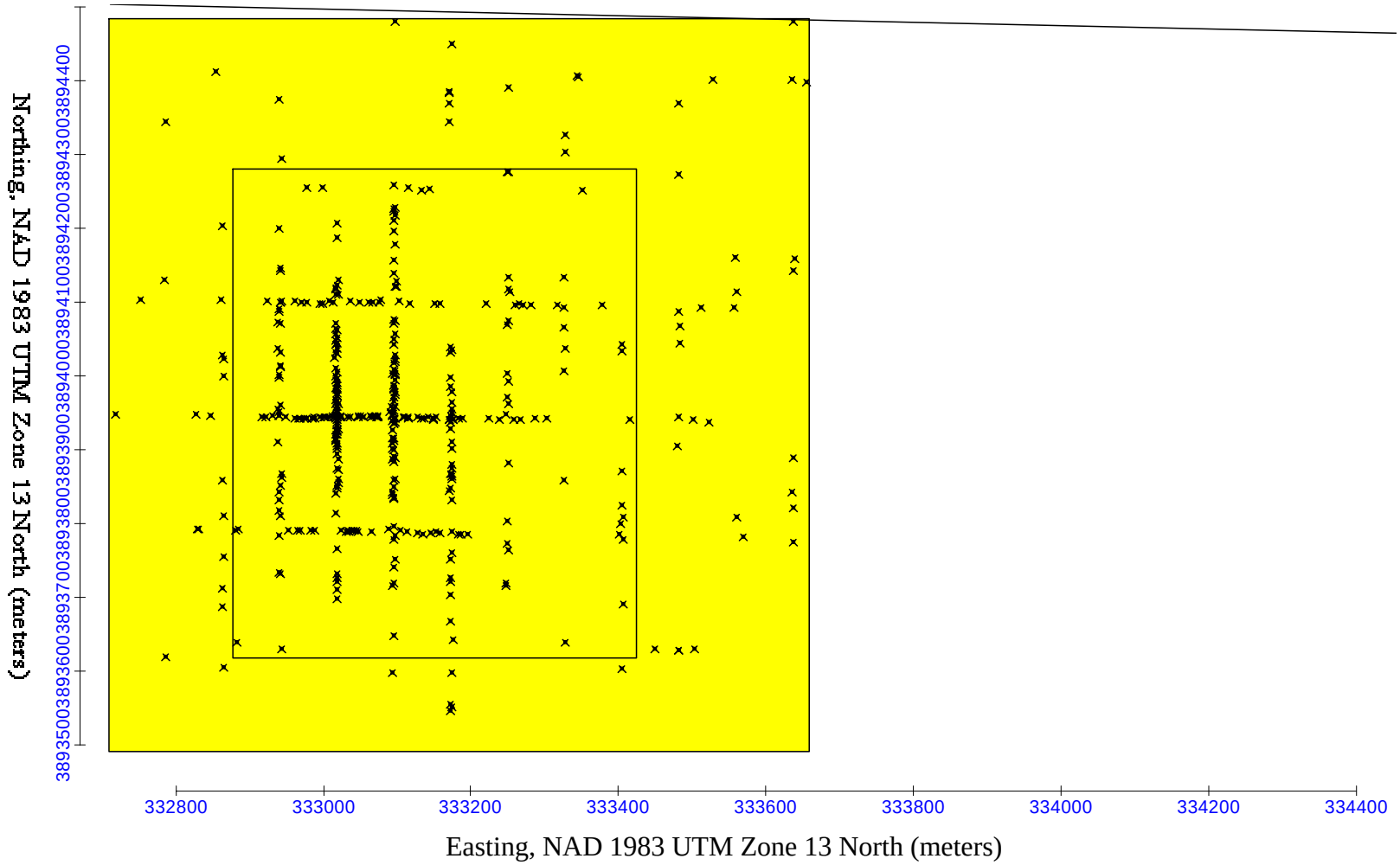


Figure 32: Visually Estimated Target Boundaries, ORT Sector

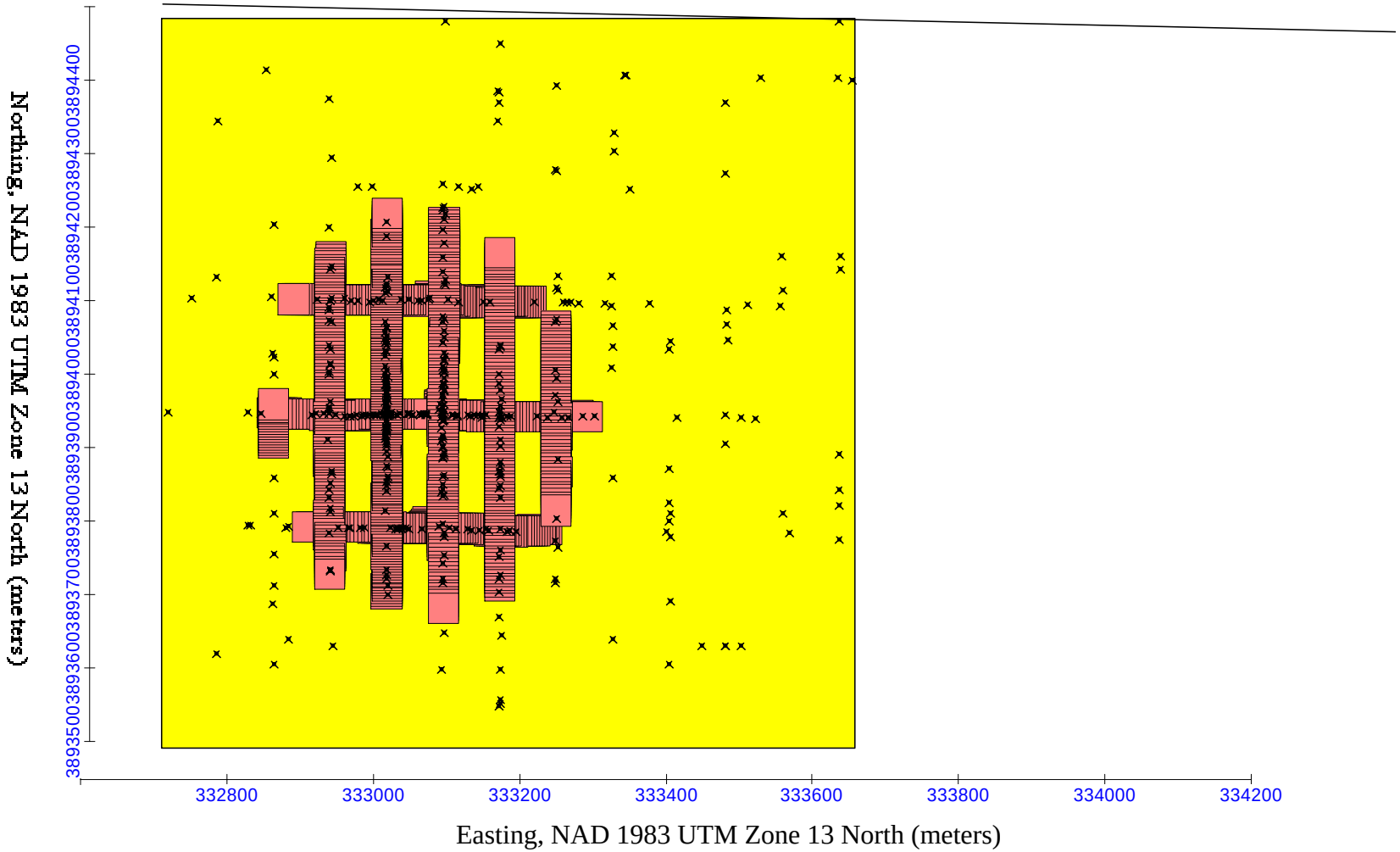


Figure 33: ORT Sector with Category 2 Anomalies, Flagged Areas with Density Greater Than 40 Anomalies/Acre Background

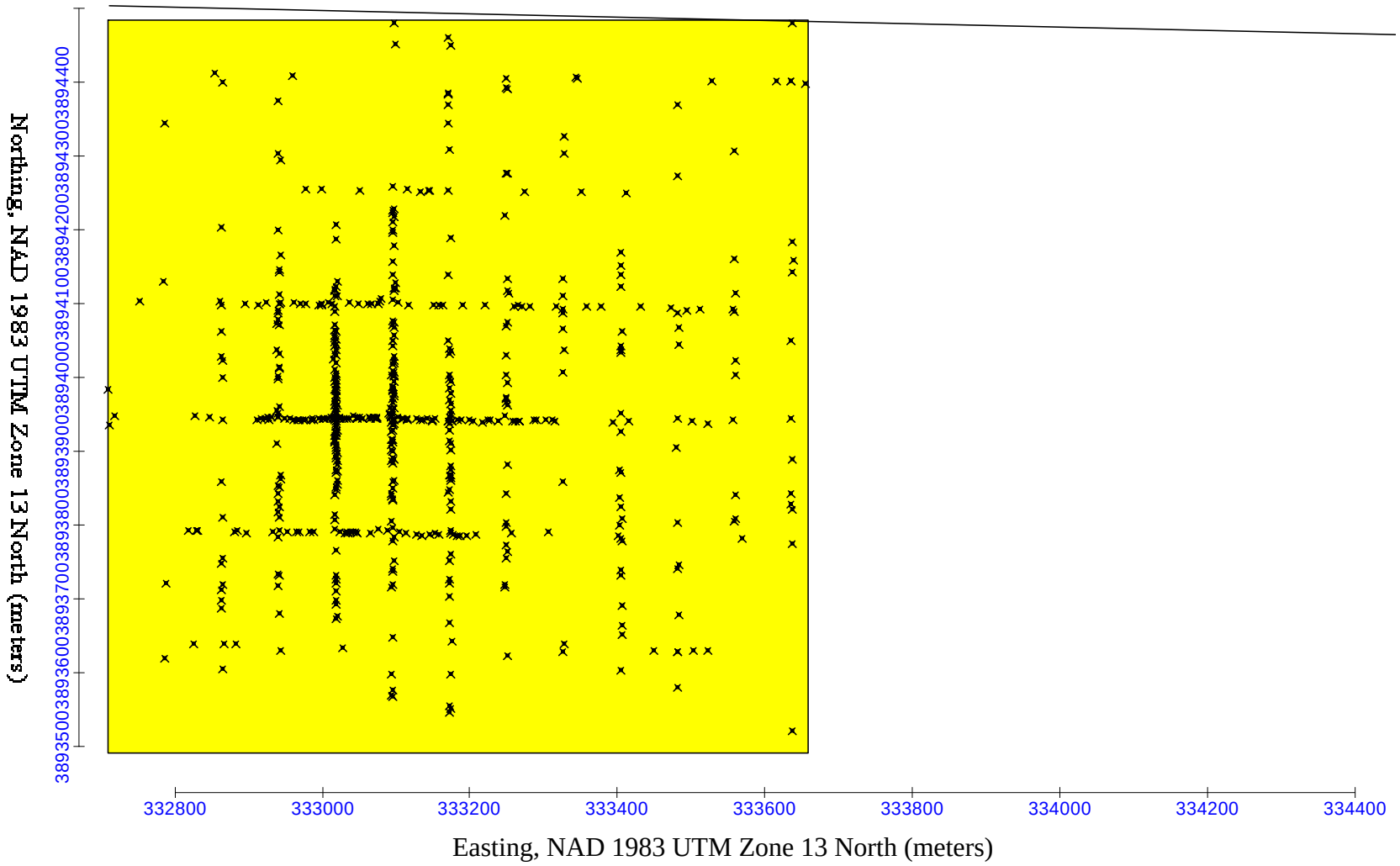


Figure 34: Category 1 and 2 Anomalies in the Vicinity of the ORT Target Area

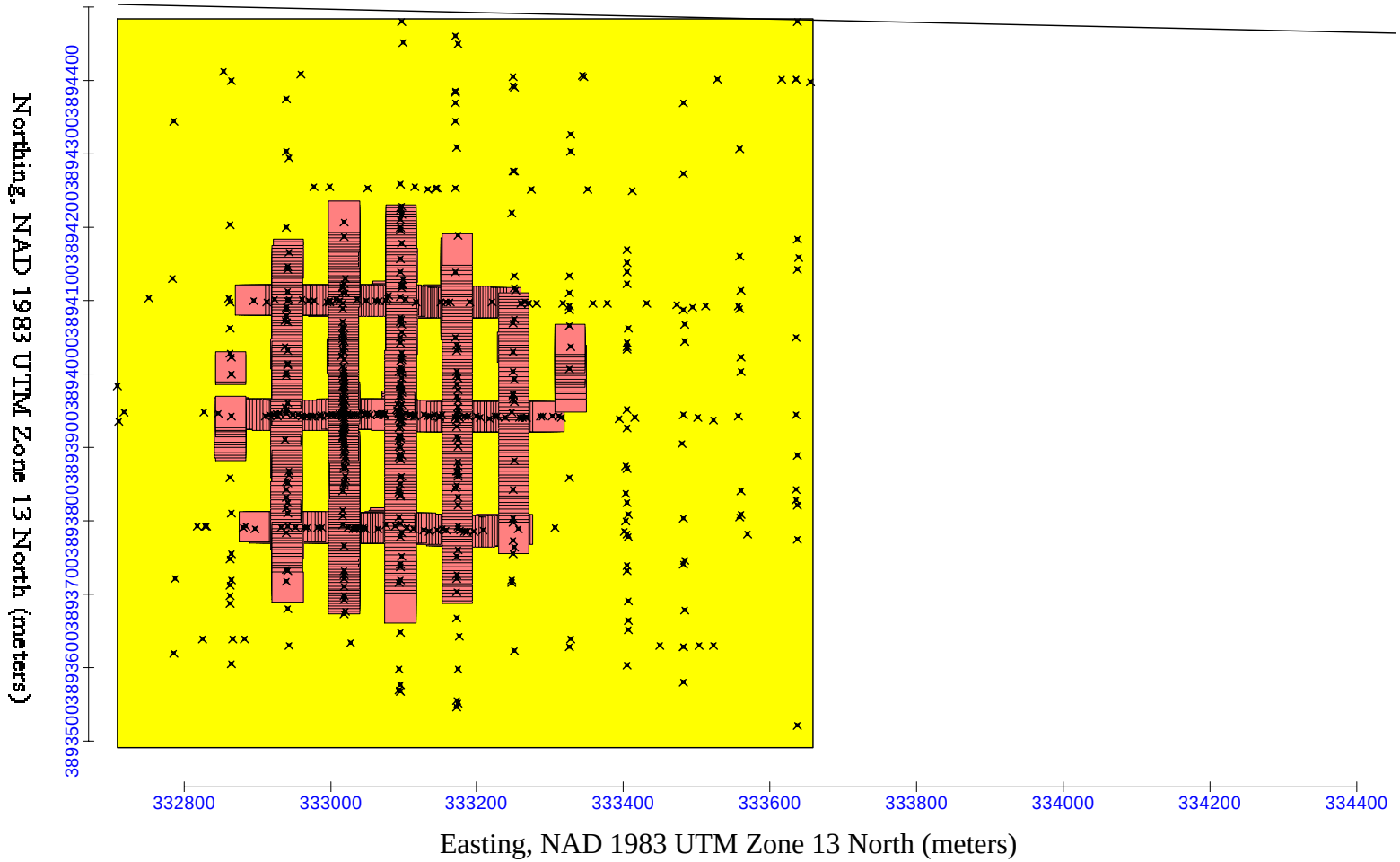


Figure 35: ORT Sector with Category 1 and 2 Anomalies, Flagged Areas with Density Greater Than 52 Anomalies/Acre Background

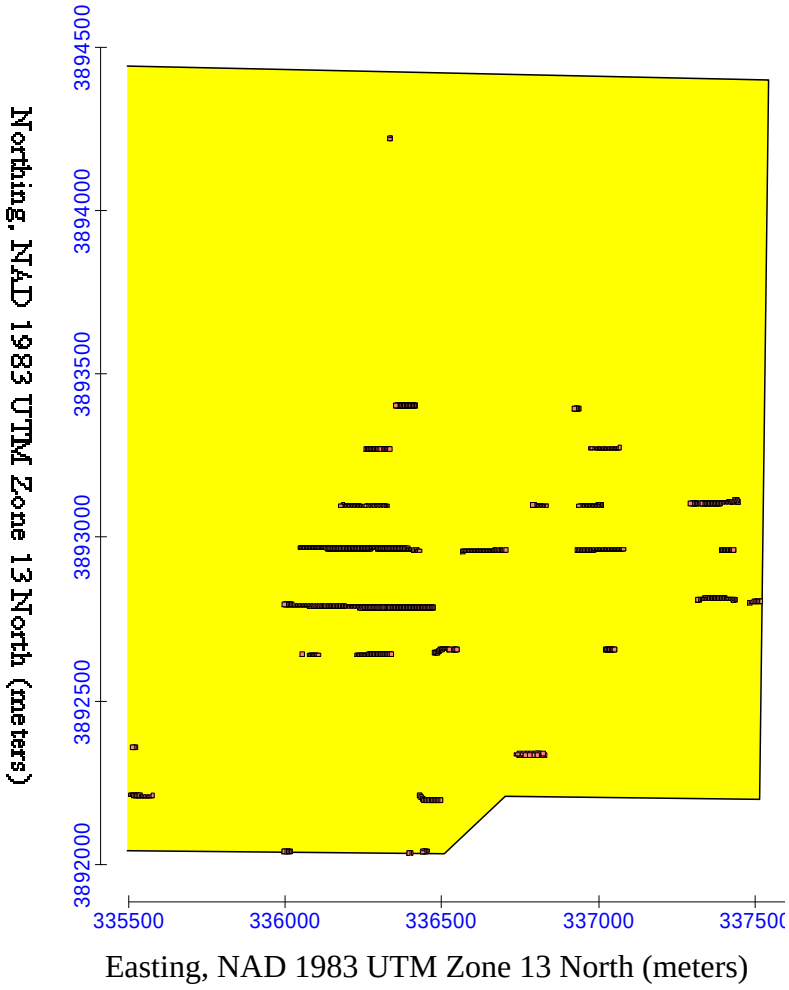


Figure 36: Northeast Sector, Initial Survey Results with 55 Anomalies/Acre Critical Density

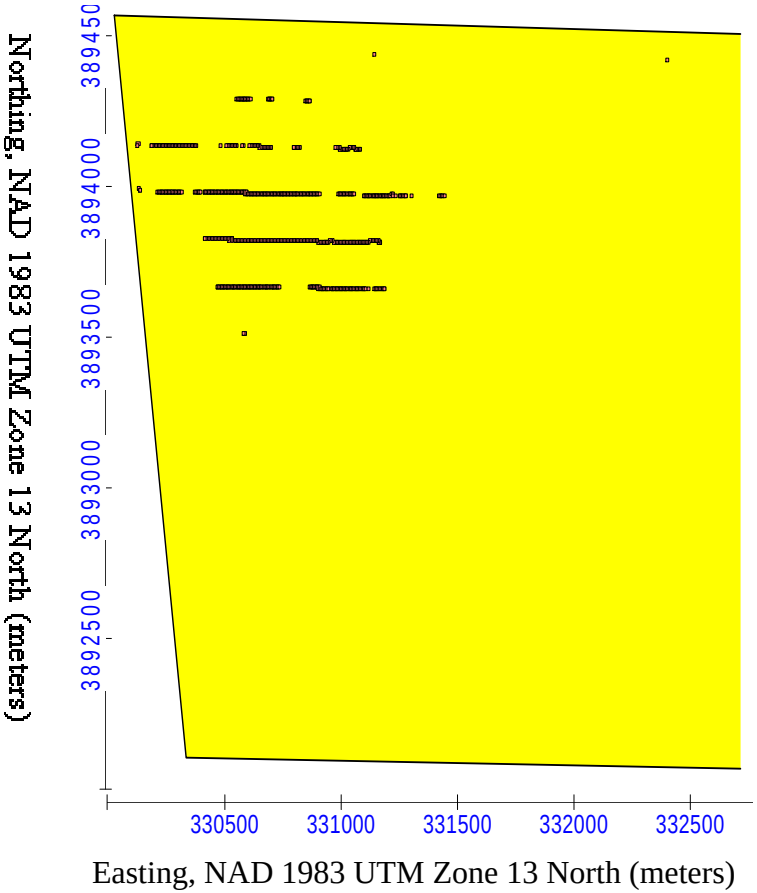


Figure 37: Northeast Sector, Initial Survey Results with 69 Anomalies/Acre Critical Density

5. Summary and Recommendations

The results of the VSP-designed ground surveys of the Kirtland WAA study area provided sufficient information to identify the locations of all the targets suspected to be present at the site.

The site was over-sampled (in other words, the assumptions about the sizes of the targets to be searched for were very conservative) and therefore there was very little uncertainty about the general location of the target areas after the initial survey. Use of only the most "UXO-like" anomalies, as categorized by Geo-Centers, in the analyses for the fill-in surveys and the boundary delineation, coupled with the over-sampling, rendered the capabilities of the VSP Find Target Areas module somewhat redundant. Inclusion of the category 1 anomalies increased the "noise" in the boundary delineation analysis, especially in the Northeast sector, and increased the usefulness of the Find Target Areas module. However, the over-sampling should increase the certainty that there are no targets of concern within the South sector of the site.

Appendix A
Survey Design Transect Coordinates

A-1. Coordinates for North Section Bull's-eye Search
NM State Plane, Feet

X1	Y1	X2	Y2
1457256	1513246	1465935	1513246
1471899	1513246	1477539	1513246
1457186	1513755	1465949	1513755
1471896	1513755	1478092	1513755
1457116	1514263	1465962	1514263
1471894	1514263	1480808	1514263
1457046	1514772	1465976	1514772
1471891	1514772	1480808	1514772
1456976	1515281	1465990	1515281
1471888	1515281	1480808	1515281
1456906	1515789	1466004	1515789
1471886	1515789	1480808	1515789
1456836	1516298	1466018	1516298
1471883	1516298	1480808	1516298
1456766	1516807	1480808	1516807
1456695	1517315	1480808	1517315
1456625	1517824	1480808	1517824
1456555	1518333	1480808	1518333
1456485	1518842	1480808	1518842
1456415	1519350	1480808	1519350
1456345	1519859	1480808	1519859
1456275	1520368	1480808	1520368
1456205	1520876	1480808	1520876

A-2. Coordinates for South Section Bull's-eye Search
NM State Plane, Feet

X1	Y1	X2	Y2
1468067	1501549	1478715	1501549
1468067	1502058	1478713	1502058
1468066	1502567	1478712	1502567
1468065	1503075	1478710	1503075
1468065	1503584	1471723	1503584
1471921	1503584	1478708	1503584
1468064	1504093	1471730	1504093
1472444	1504093	1478707	1504093
1468063	1504601	1471736	1504601
1472966	1504601	1478705	1504601
1468063	1505110	1471743	1505110
1473489	1505110	1478704	1505110
1468062	1505619	1471750	1505619
1474011	1505619	1478702	1505619
1474534	1506127	1478700	1506127
1475056	1506636	1478699	1506636
1475578	1507145	1478697	1507145
1476101	1507654	1478695	1507654
1476623	1508162	1478694	1508162

A-3: Coordinates for Simulated Oil Refinery Target Search UTM, meters

X1	Y1	X2	Y2
330081.9	3894137	330081.9	3894563
330159.2	3893519	330159.2	3894562
330236.4	3892901	330236.4	3894560
330313.7	3892283	330313.7	3894558
330391	3892106	330391	3894556
330468.3	3892105	330468.3	3894555
330545.5	3892104	330545.5	3894553
330622.8	3892103	330622.8	3894551
330700.1	3892101	330700.1	3894549
330777.3	3892100	330777.3	3894548
330854.6	3892099	330854.6	3894546
330931.9	3892097	330931.9	3894544
331009.2	3892096	331009.2	3894543
331086.4	3892095	331086.4	3894541
331163.7	3892094	331163.7	3894539
331241	3892092	331241	3894537
331318.3	3892091	331318.3	3894536
331395.5	3892090	331395.5	3894534
331472.8	3892089	331472.8	3894532
331550.1	3892087	331550.1	3894530
331627.3	3892086	331627.3	3894529
331704.6	3892085	331704.6	3894527
331781.9	3892084	331781.9	3894525
331859.2	3892082	331859.2	3894523
331936.4	3892081	331936.4	3894522
332013.7	3892080	332013.7	3894520
332091	3892079	332091	3894518
332168.3	3892077	332168.3	3894517
332245.5	3892076	332245.5	3894515
332322.8	3892075	332322.8	3894513
332400.1	3892073	332400.1	3894511
332477.3	3892072	332477.3	3894510
332554.6	3892071	332554.6	3894508
332631.9	3892070	332631.9	3894506
332709.2	3892068	332709.2	3894504
332786.4	3892067	332786.4	3894503
332863.7	3892066	332863.7	3894501
332941	3892065	332941	3894499
333018.3	3893066	333018.3	3894497
333095.5	3893104	333095.5	3894496
333172.8	3893103	333172.8	3894494
333250.1	3893101	333250.1	3894492
333327.3	3893100	333327.3	3894491
333404.6	3893098	333404.6	3894489

A-3: Coordinates for Simulated Oil Refinery Target Search (cont.)

X1	Y1	X2	Y2
333481.9	3893096	333481.9	3894487
333559.2	3893095	333559.2	3894485
333636.4	3893093	333636.4	3894484
333713.7	3893091	333713.7	3894482
333791	3893090	333791	3894480
333868.3	3893088	333868.3	3894478
333945.5	3893086	333945.5	3894477
334022.8	3893085	334022.8	3894475
334100.1	3893083	334100.1	3894473
334177.3	3893081	334177.3	3894471
334254.6	3893080	334254.6	3894470
334331.9	3893078	334331.9	3894468
334409.2	3893077	334409.2	3894466
334486.4	3893075	334486.4	3894465
334563.7	3893073	334563.7	3894463
334641	3893072	334641	3894461
334718.3	3893070	334718.3	3894459
334795.5	3893068	334795.5	3894458
334872.8	3892050	334872.8	3894456
334950.1	3892049	334950.1	3894454
335027.3	3892048	335027.3	3894452
335104.6	3892047	335104.6	3894451
335181.9	3892047	335181.9	3894449
335259.2	3892046	335259.2	3894447
335336.4	3892045	335336.4	3894445
335413.7	3892044	335413.7	3894110

A-4: Northeast Sector Fill-in Survey Design
UTM, meters

X1	Y1	X2	Y2	Width	Length
335817.6	3892252	335817.6	3893644	2.5	1391.638
335870.1	3892252	335870.1	3893644	2.5	1391.638
335922.6	3892252	335922.6	3893644	2.5	1391.638
335975.1	3892252	335975.1	3893644	2.5	1391.638
336027.6	3892252	336027.6	3893644	2.5	1391.638
336080.1	3892252	336080.1	3893644	2.5	1391.638
336132.6	3892252	336132.6	3893644	2.5	1391.638
336185.1	3892252	336185.1	3893644	2.5	1391.638
336237.6	3892252	336237.6	3893644	2.5	1391.638
336290.1	3892252	336290.1	3893644	2.5	1391.638
336342.6	3892252	336342.6	3893644	2.5	1391.638
336395.1	3892252	336395.1	3893644	2.5	1391.638
336447.6	3892252	336447.6	3893644	2.5	1391.638
336500.1	3892252	336500.1	3893644	2.5	1391.638
336552.6	3892252	336552.6	3893644	2.5	1391.638
336605.1	3892252	336605.1	3893644	2.5	1391.638
336657.6	3892252	336657.6	3893644	2.5	1391.638
336710.1	3892252	336710.1	3893644	2.5	1391.638
336762.6	3892252	336762.6	3893644	2.5	1391.638
336815.1	3892252	336815.1	3893644	2.5	1391.638
336867.6	3892252	336867.6	3893644	2.5	1391.638
336920.1	3892252	336920.1	3893644	2.5	1391.638
336972.6	3892252	336972.6	3893644	2.5	1391.638
337025.1	3892252	337025.1	3893644	2.5	1391.638
337077.6	3892252	337077.6	3893644	2.5	1391.638
337130.1	3892252	337130.1	3893644	2.5	1391.638
337182.6	3892252	337182.6	3893644	2.5	1391.638
337235.1	3892252	337235.1	3893644	2.5	1391.638
337287.6	3892252	337287.6	3893644	2.5	1391.638
337340.1	3892252	337340.1	3893644	2.5	1391.638
337392.6	3892252	337392.6	3893644	2.5	1391.638
337445.1	3892252	337445.1	3893644	2.5	1391.638
337497.6	3892252	337497.6	3893644	2.5	1391.638

A-4: Northwest Sector Fill-in Survey Design
UTM, meters

Area: NW Area 1			
X1	**Y1**	**X2**	**Y2**
331062.6	3894358	331062.6	3894526
331115.1	3894358	331115.1	3894526
331167.6	3894358	331167.6	3894526
331220.1	3894358	331220.1	3894526
331272.6	3894358	331272.6	3894526
Area: NW Area 4			
X1	**Y1**	**X2**	**Y2**
330406.3	3893435	330406.3	3893577
330458.8	3893435	330458.8	3893577
330511.3	3893435	330511.3	3893577
330563.8	3893435	330563.8	3893577
330616.3	3893435	330616.3	3893577
330668.8	3893435	330668.8	3893577
Area: NW Area 3			
X1	**Y1**	**X2**	**Y2**
330808.8	3893111	330808.8	3893286
330861.3	3893111	330861.3	3893286
330913.8	3893111	330913.8	3893286
330966.3	3893111	330966.3	3893286

A-4: Northwest Sector Fill-in Survey Design (cont.)

Area: NW Area 2			
X1	**Y1**	**X2**	**Y2**
330486.4	3893591	330486.4	3894338
330538.9	3893591	330538.9	3894338
330591.4	3893591	330591.4	3894338
330643.9	3893591	330643.9	3894338
330696.4	3893591	330696.4	3894338
330748.9	3893591	330748.9	3894338
330801.4	3893591	330801.4	3894338
330853.9	3893591	330853.9	3894338
330906.4	3893591	330906.4	3894338
330958.9	3893591	330958.9	3894338
331011.4	3893591	331011.4	3894338
331063.9	3893591	331063.9	3894338
331116.4	3893591	331116.4	3894338
331168.9	3893591	331168.9	3894338
331221.4	3893591	331221.4	3894338
331273.9	3893591	331273.9	3894338
331326.4	3893591	331326.4	3894338
331378.9	3893591	331378.9	3894338
331431.4	3893591	331431.4	3894338
331483.9	3893591	331483.9	3894338
Area: NW Area 5			
X1	**Y1**	**X2**	**Y2**
330134.3	3893910	330134.3	3894199
330186.8	3893910	330186.8	3894199
330239.3	3893910	330239.3	3894199
330291.8	3893910	330291.8	3894199
330344.3	3893910	330344.3	3894199
330396.8	3893910	330396.8	3894199

Appendix B
Kirtland Transect Data Database Documentation

The Kirtland Transect Data database contains three data tables. They are described in the tables below:

Table B-1: Anomaly Data

Name	Type	Size	Description
Anomaly Number	Long Integer	4	Unique ID number assigned to the anomaly
X	Double	8	Easting, UTM meters
Y	Double	8	Northing, UTM meters
Confidence	Long Integer	4	0=low, 1=med, 2=high
Date	Date/Time	8	Date anomaly was acquired

Table B-2: COG Index

Name	Type	Size	Description
Transect ID	Long Integer	4	Unique ID number assigned to the transect
StartX	Double	8	Initial easting coordinate, UTM meters
StartY	Double	8	Initial northing coordinate, UTM meters
EndX	Double	8	Last easting coordinate, UTM meters
EndY	Double	8	Last northing coordinate, UTM meters
Orientation	Text	2	EW=East-West, NS=North-South
Date Collected	Date/Time	8	Data transect was surveyed

Table B-3: Transects

Name	Type	Size	Description
Point Number	Long Integer	4	Unique point number assigned to the COG point
Transect ID	Long Integer	4	ID number assigned to entire transect (non-unique in this table)
X	Double	8	Easting, UTM meters
Y	Double	8	Northing, UTM meters

The database also contains 19 queries set up to extract anomaly and course over ground (COG) data from the database. The query results were exported to Excel, where column headers and extraneous data (e.g., point numbers for transects) were deleted. The resulting data was saved as tab-delimited ASCII files which were imported into VSP. The queries are described in the remaining pages of this appendix.

Query: Northeast Anomalies Cat 1 and 2

Extracts category 1 and 2 anomalies located within the Northeast sector.

SQL

```
SELECT [Anomaly Data].X, [Anomaly Data].Y, [Anomaly Data].Confidence
FROM [Anomaly Data]
WHERE ((([Anomaly Data].X)>=335500 And ([Anomaly Data].X)<=3377550) AND (([Anomaly
Data].Y)>=3892000 And ([Anomaly Data].Y)<=3894600) AND (([Anomaly Data].Confidence)>=1));
```

Columns

X
Y
Confidence

Query: Northeast Anomalies Cat 1 and 2 EW

Extracts category 1 and 2 anomalies that were acquired on the east-west transects in the Northeast sector.

SQL

```
SELECT [Anomaly Data].X, [Anomaly Data].Y, [Anomaly Data].Date
FROM [Anomaly Data]
WHERE ((([Anomaly Data].X)>=335500 And ([Anomaly Data].X)<=3377550) AND (([Anomaly
Data].Y)>=3892000 And ([Anomaly Data].Y)<=3894600) AND (([Anomaly Data].Date)<=#9/26/2005#)
AND (([Anomaly Data].Confidence)>=1));
```

Columns

X
Y
Date

Query: Northeast Anomalies Cat 2

Extracts category 2 anomalies located within the Northeast sector.

SQL

```
SELECT [Anomaly Data].X, [Anomaly Data].Y, [Anomaly Data].Confidence
FROM [Anomaly Data]
WHERE ((([Anomaly Data].X)>=335500 And ([Anomaly Data].X)<=3377550) AND (([Anomaly
Data].Y)>=3892000 And ([Anomaly Data].Y)<=3894600) AND (([Anomaly Data].Confidence)=2));
```

Columns

X
Y
Confidence

Query: Northeast Anomalies Cat 2 EW

Extracts category 2 anomalies that were acquired on the east-west transects in the Northeast sector.

SQL

SELECT [Anomaly Data].[Anomaly Number], [Anomaly Data].X, [Anomaly Data].Y, [Anomaly Data].Date

FROM [Anomaly Data]
WHERE ((([Anomaly Data].X)>=335500 And ([Anomaly Data].X)<=3377550) AND (([Anomaly Data].Y)>=3892000 And ([Anomaly Data].Y)<=3894600) AND (([Anomaly Data].Date)<=#9/26/2005#)

Columns

X
Y
Date

Query: Northeast Transect List

Lists transect information for all transects in the Northeast sector.

SQL

SELECT [COG Index].[Transect ID], [COG Index].[Date Collected], [COG Index].Orientation, [COG Index].StartX, [COG Index].EndX, [COG Index].StartY, [COG Index].EndY
FROM [COG Index]
WHERE ((([COG Index].StartX)<=337550 And ([COG Index].StartX)>=335500) AND (([COG Index].StartY)<=3894600 And ([COG Index].StartY)>=3892000)) OR ((([COG Index].EndX)<=337550 And ([COG Index].EndX)>=335500) AND (([COG Index].EndY)<=3894600 And ([COG

Columns

Transect ID
Date Collected
Orientation
StartX
EndX
StartY
EndY

Query: Northeast Transects

Extracts all transect points for transects located within the Northeast sector.

SQL

SELECT Transects.[Transect ID], Transects.X, Transects.Y, Transects.[Point Number]
FROM Transects
WHERE (((Transects.X)>=335500 And (Transects.X)<=337550) AND ((Transects.Y)>=3892000 And (Transects.Y)<=3894600));

Columns

Transect ID
X
Y

Point Number

Query: Northwest Anomalies Cat 1 and 2

Extracts category 1 and 2 anomalies located within the Northwest sector.

SQL

```
SELECT [Anomaly Data].X, [Anomaly Data].Y
FROM [Anomaly Data]
WHERE ((([Anomaly Data].X)>=330000 And ([Anomaly Data].X)<=332710) AND (([Anomaly
Data].Y)>=3892000 And ([Anomaly Data].Y)<=3894600) AND (([Anomaly Data].Confidence)>=1));
```

Columns

X
Y

Query: Northwest Anomalies Cat 1 and 2 EW

Extracts category 1 and 2 anomalies located on the east-west transects within the Northwest sector.

SQL

```
SELECT [Anomaly Data].X, [Anomaly Data].Y, [Anomaly Data].Date
FROM [Anomaly Data]
WHERE ((([Anomaly Data].X)>=330000 And ([Anomaly Data].X)<=332710) AND (([Anomaly
Data].Y)>=3892000 And ([Anomaly Data].Y)<=3894600) AND (([Anomaly Data].Date)>=#9/27/2005#
And ([Anomaly Data].Date)<=#10/10/2005#) AND (([Anomaly Data].Confidence)>=1)) OR ((([Anomaly
Data].X)>=330000 And ([Anomaly Data].X)<=332710) AND (([Anomaly Data].Y)>=3892000 And
([Anomaly Data].Y)<=3894600) AND (([Anomaly Data].Date)=#10/15/2005#) AND (([Anomaly
Data].Confidence)>=1));
```

Columns

X
Y
Date

Query: Northwest Anomalies Cat 2

Extracts category 2 anomalies located within the Northwest sector.

SQL

```
SELECT [Anomaly Data].X, [Anomaly Data].Y
FROM [Anomaly Data]
WHERE ((([Anomaly Data].X)>=330000 And ([Anomaly Data].X)<=332710) AND (([Anomaly
Data].Y)>=3892000 And ([Anomaly Data].Y)<=3894600) AND (([Anomaly Data].Confidence)=2));
```

Columns

X
Y

Query: Northwest Anomalies Cat 2 EW

Extracts category 2 anomalies acquired on east-west transects located within the Northwest sector.

SQL

SELECT [Anomaly Data].X, [Anomaly Data].Y, [Anomaly Data].Date
FROM [Anomaly Data]
WHERE ((([Anomaly Data].X)>=330000 And ([Anomaly Data].X)<=332710) AND (([Anomaly Data].Y)>=3892000 And ([Anomaly Data].Y)<=3894600) AND (([Anomaly Data].Date)>=#9/27/2005# And ([Anomaly Data].Date)<=#10/10/2005#) AND (([Anomaly Data].Confidence)=2)) OR ((([Anomaly Data].X)>=330000 And ([Anomaly Data].X)<=332710) AND (([Anomaly Data].Y)>=3892000 And ([Anomaly Data].Y)<=3894600) AND (([Anomaly Data].Date)=#10/15/2005#) AND (([Anomaly

Columns

X
Y
Date

Query: Northwest Transect List

Lists transect information for all transects in the Northeast sector.

SQL

SELECT [COG Index].[Transect ID], [COG Index].[Date Collected], [COG Index].Orientation, [COG Index].StartX, [COG Index].EndX, [COG Index].StartY, [COG Index].EndY
FROM [COG Index]
WHERE ((([COG Index].StartX)<=332710 And ([COG Index].StartX)>=330000) AND (([COG Index].StartY)<=3894600 And ([COG Index].StartY)>=3892000)) OR ((([COG Index].EndX)<=332710 And ([COG Index].EndX)>=330000) AND (([COG Index].EndY)<=3894600 And ([COG

Columns

Transect ID
Date Collected
Orientation
StartX
EndX
StartY
EndY

Query: Northwest Transects

Extracts all transect points for transects located within the Northeast sector.

SQL

SELECT Transects.[Transect ID], Transects.X, Transects.Y, Transects.[Point Number]
FROM Transects
WHERE (((Transects.X)>=330000 And (Transects.X)<=332710) AND ((Transects.Y)>=3892000 And (Transects.Y)<=3894600));

Columns

Transect ID
X

Y
Point Number

Query: ORT Anomalies Cat 1 and 2

Extracts category 1 and 2 anomalies located within the Oil Refinery Target sector.

SQL

```
SELECT [Anomaly Data].X, [Anomaly Data].Y
FROM [Anomaly Data]
WHERE ((([Anomaly Data].X)<=335500 And ([Anomaly Data].X)>=332710) AND (([Anomaly
Data].Y)>=3892000 And ([Anomaly Data].Y)<=3894600) AND (([Anomaly Data].Confidence)>=1));
```

Columns

X
Y

Query: ORT Anomalies Cat 2

Extracts category 2 anomalies located within the Oil Refinery Target sector.

SQL

```
SELECT [Anomaly Data].X, [Anomaly Data].Y
FROM [Anomaly Data]
WHERE ((([Anomaly Data].X)<=335500 And ([Anomaly Data].X)>=332710) AND (([Anomaly
Data].Y)>=3892000 And ([Anomaly Data].Y)<=3894600) AND (([Anomaly Data].Confidence)=2));
```

Columns

X
Y

Query: ORT Transects

Extracts all transect points for transects located within the Oil Refinery Target sector.

SQL

```
SELECT Transects.[Transect ID], Transects.X, Transects.Y, Transects.[Point Number]
FROM Transects
WHERE (((Transects.X)<=335500 And (Transects.X)>=332710) AND ((Transects.Y)>=3892000 And
(Transects.Y)<=3894600));
```

Columns

Transect ID
X
Y
Point Number

Query: ORT Transects List

Lists transect information for all transects in the Oil Refinery Target sector.

SQL

```
SELECT [COG Index].[Transect ID], [COG Index].[Date Collected], [COG Index].Orientation, [COG
Index].StartX, [COG Index].EndX, [COG Index].StartY, [COG Index].EndY
FROM [COG Index]
WHERE ((([COG Index].StartX)<=335500 And ([COG Index].StartX)>=332710) AND (([COG
Index].StartY)<=3894600 And ([COG Index].StartY)>=3892000)) OR ((([COG Index].EndX)<=335500
And ([COG Index].EndX)>=332710) AND (([COG Index].EndY)<=3894600 And ([COG
```

Columns

Transect ID
Date Collected
Orientation
StartX
EndX
StartY
EndY

Query: South Anomalies Category 2

Extracts category 2 anomalies located in the South sector.

SQL

```
SELECT [Anomaly Data].X, [Anomaly Data].Y
FROM [Anomaly Data]
WHERE ((([Anomaly Data].Y)<3892000) AND (([Anomaly Data].Confidence)=2));
```

Columns

X
Y

Query: South Transects

Extracts all transect points for transects located within the Oil Refinery Target sector.

SQL

```
SELECT Transects.[Transect ID], Transects.X, Transects.Y, Transects.[Point Number]
FROM Transects
WHERE (((Transects.Y)<3892000));
```

Columns

Transect ID
X
Y
Point Number

Query: South Transects List

Lists transect information for all transects in the Oil Refinery Target sector.

SQL

```
SELECT [COG Index].[Transect ID], [COG Index].[Date Collected], [COG Index].Orientation, [COG
Index].StartX, [COG Index].EndX, [COG Index].StartY, [COG Index].EndY
FROM [COG Index]
WHERE ((([COG Index].StartY)<=3892000) AND (([COG Index].EndY)<=3892000));
```

Columns

Transect ID
Date Collected
Orientation
StartX
EndX
StartY
EndY