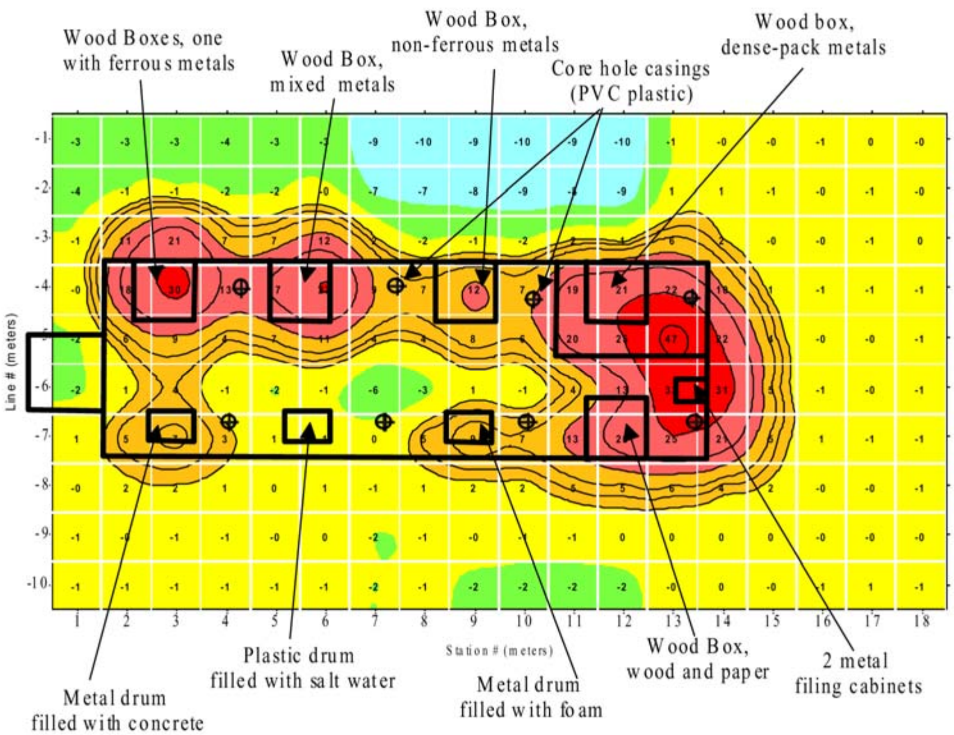
I.N.E.L.

Multi-Component NanoTEM Data

A new enhancement to the GDP-32 receiver permits it to gather NanoTEM data on three channels simultaneously. This multi-channel capability was used recently on a research project to acquire all three components of the magnetic field (Hx, Hy, and Hz) at each station on a grid over an environmental test pit in Idaho. The work was done at the Idaho National Engineering Laboratory (I.N.E.L.) as part of the Electromagnetic Integrated Demonstration (E.M.I.D.) project.



INTRODUCTION

The test surveys at the Idaho National Engineering Laboratory (INEL) as part of the U.S. Department of Energy's Electromagnetic Integrated Demonstration (EMID) gave us the chance to collect a large amount of data at a well-understood site. At the Calibration Cell, we acquired 3-component NanoTEM data over discrete objects such as 55 gallon drums and file cabinets, most buried at depths of approximately two meters. At the Cold Test Pit, on the other hand, the data are over a large simulated dump of objects such as barrels and metallic debris, covering an area larger than the transmitter loop. Thus we were able to get data over two common scenarios: a large dump area with a massive amount of metallic objects, and an area where individual discrete objects are buried.

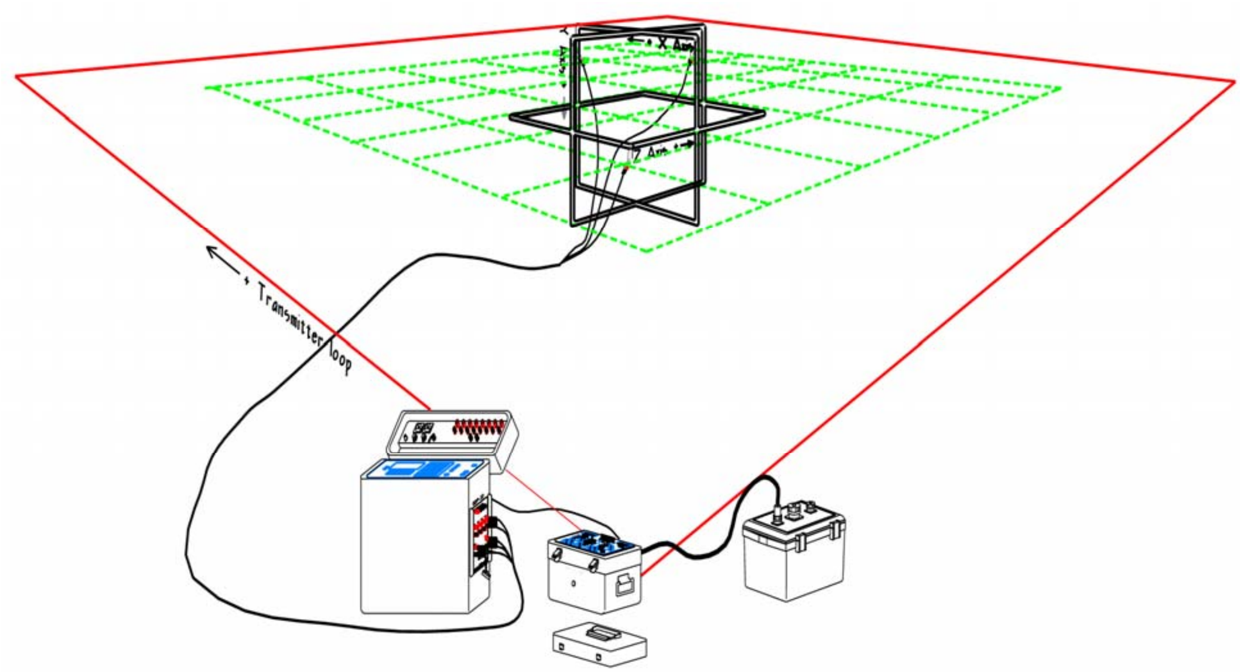


Figure 1: Basic setup of the NanoTEM system (GDP-32, NT-20, and NT Battery) using the three axis receiver loops. Usually a grid of six one meter by one meter stations is read within the each transmitting loop.

As a combination metal detector/TEM system, recent applications of NanoTEM include locating aluminum dross near salvage yards and detecting buried abandoned oil wells. In these cases, only the vertical magnetic field component (Hz) was recorded. Hz, measured at different locations within a large transmitter loop, is relatively uniform, except in the presence of small 3-D bodies. The eddy currents set up in metallic objects take substantially longer to decay than the earth response, so the NanoTEM system can be used as a deep-sounding metal detector by examining the data acquired after the background earth response has decayed into noise (usually in 10-40usec). Metallic objects stand out as positive, repeatable anomalies above random background noise.

Due to the very fast turn-off time of the NT-20 transmitter, data collection is possible at depths of 2 meters or less and in areas with electrical resistivities in excess of 20,000 ohm-meters. The GDP-16 and GDP-32 receivers record the decay curves from approximately 1.5 microseconds after transmitter turn-off to about 3 milliseconds after turn-off.

CALIBRATION CELL

The three axis data collected over the Calibration Cell offer a great example of the responses to several isolated objects of different composition. The relative strengths of anomalies change with decay time. Figure 2 shows two plan views of the data at different times after transmitter turn-off. Slice "A" shows the

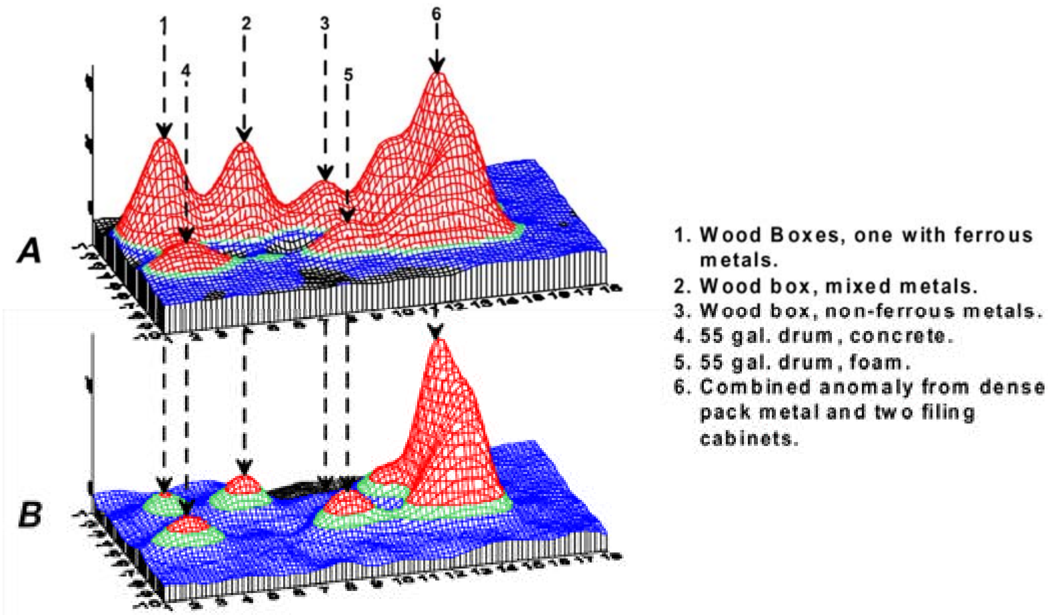


Figure 2: NanoTEM results over the Calibration Cell.

plan view for the time from 0.2563 to 0.8045 milliseconds (NanoTEM windows 21 through 26), and below it, Slice "B" shows the plan view for 0.8045 to 2. 539 milliseconds (windows 26 through 31). The vertical scale of the two plots has been adjusted so that the largest anomaly (object #6) is approximately the same size in each plot (even though the actual amplitude decreases from A to B with time, of course). Note that the 55 gallon metal drums are small anomalies relative to the metal in boxes in slice "A". At the later time, however, the drums are the same or larger in magnitude, suggesting that the eddy currents are decaying slower in the drums than in the boxed metal. While the anomaly associated with the drums remains about the same size relative to object #6 from time slice "A" to "B", the anomaly associated with object #3 (nonferrous metals) changes from being larger than the drums to being nonexistent. Object #3 and the drums are buried at the same depth of approximately 2 meters (from the surface to the top of the target).

At some window times, an extremely weak anomaly is seen between objects 4 and 5; a 30 gallon plastic drum containing saline water is located there, but it is debatable whether or not it causes a discernible anomaly. There is also some suggestion in the data that it may be possible to resolve object #6 into discrete anomalies by using the Hx and Hy data.

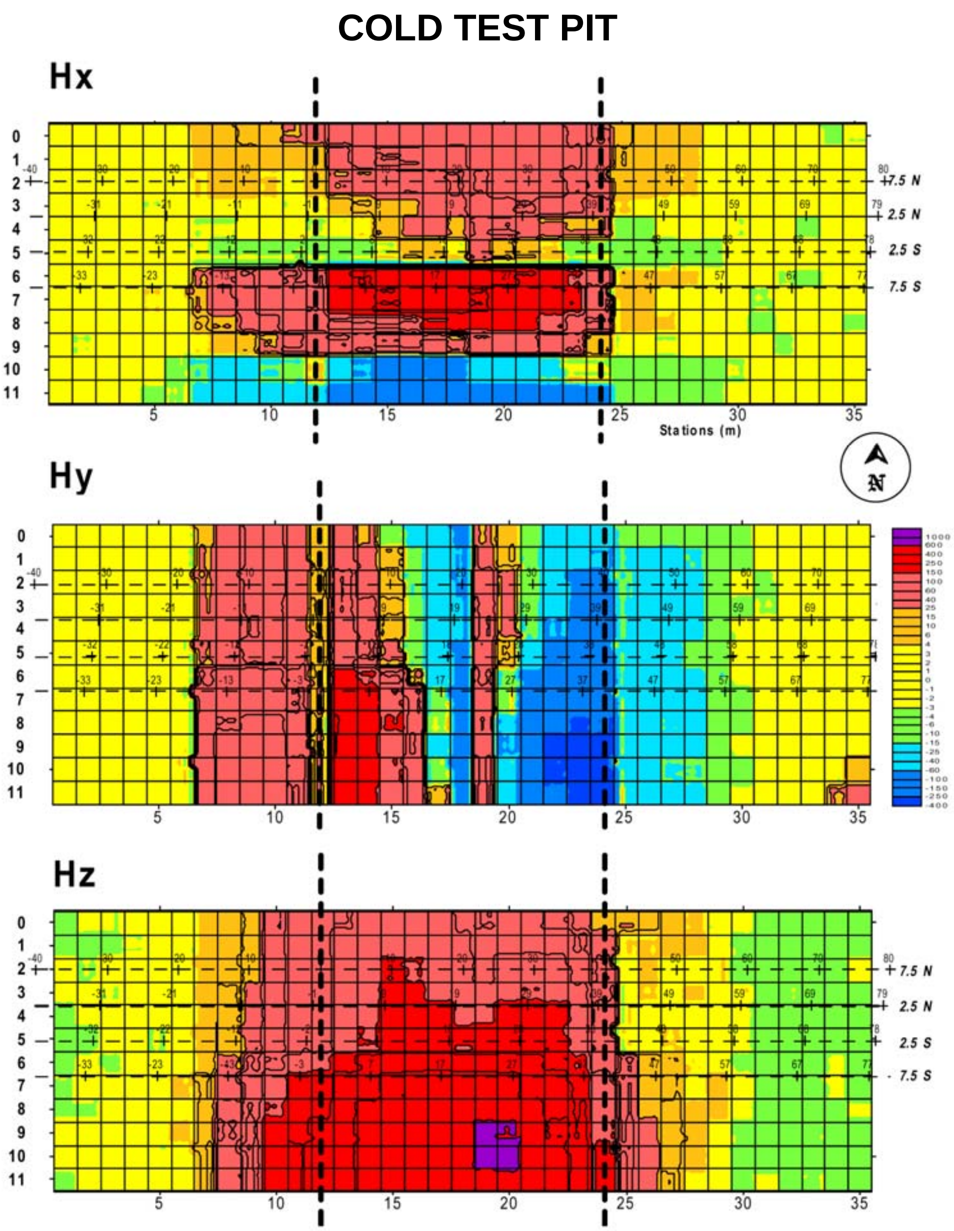


Figure 3: Three component Cold Test Pit results at window 12.

Three axis NanoTEM data were also collected over the Cold Test Pit, a simulated dump containing large amounts of metallic debris. Transmitter loops of 10 meters by 10 meters were used along with a six by six grid of one meter square receiver loops. The dashed lines mark the lateral extent of the simulated dump.

The Hx and Hy are affected by the massive amount of metallic material beyond the edges of the dump. The anomalous in the Hx readings can be seen several meters to the east and west of the known boundaries. The same can not be stated for the Hy readings because the data did not enclose the northern and southern boundaries of the Cold Test Pit. By using the Hx and Hy components, data acquisition can be minimized by recording fewer stations until the data shows a dramatic increase in the absolute magnitude. Then a more tightly spaced grid would be necessary to define the outline of the anomaly.

Figure 4 shows a comparison of the decay curves for each component at one station over the dump (red) and one station away from the dump (blue). Note the longer decay times in all components for the station affected by the metallic material within the dump.

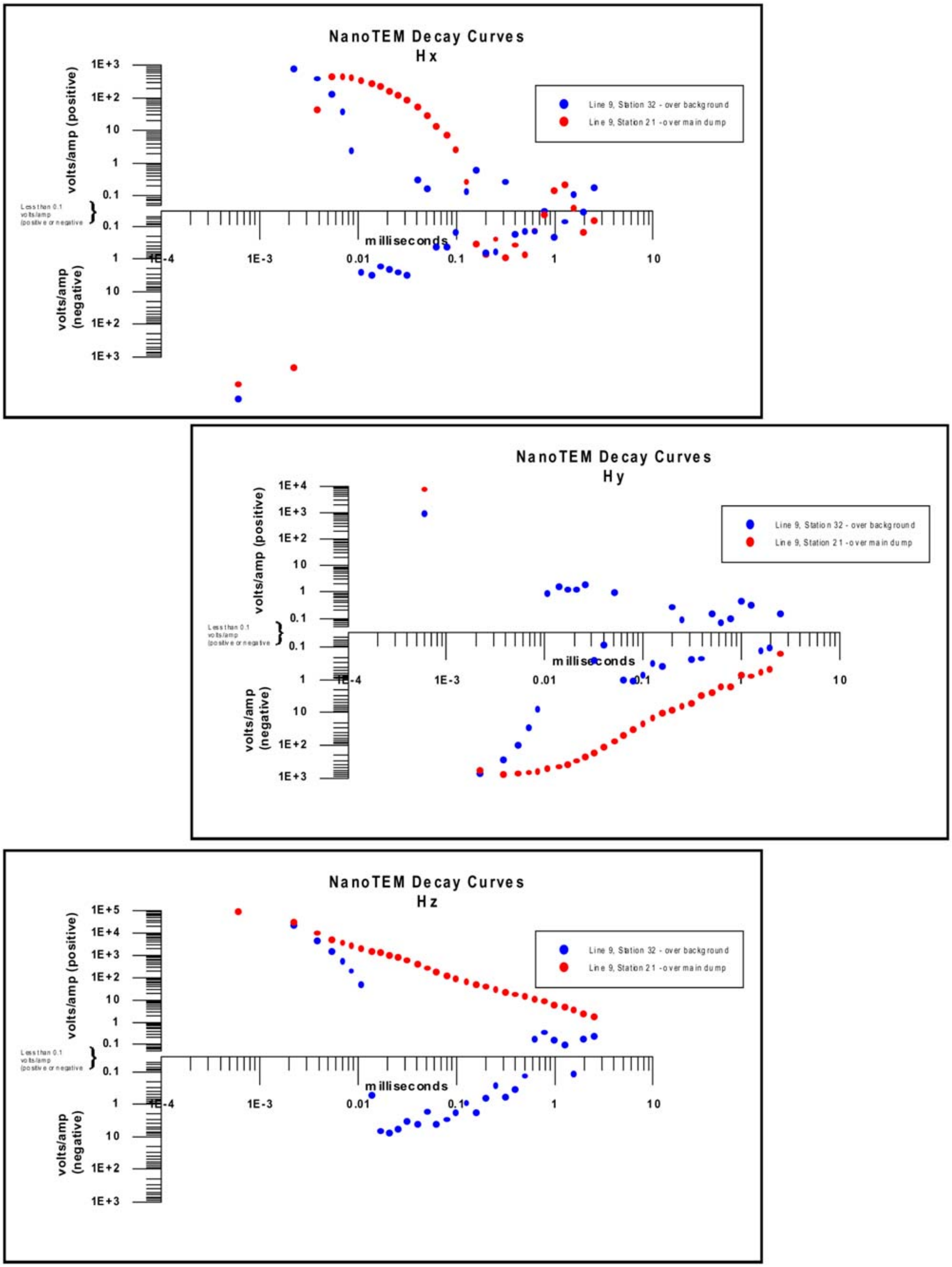


Figure 4: Decay curves for each component showing the difference between data gathered over and away from the dump.

COMPARISON

Collecting Data over the Calibration Cell as well as the Cold Test Pit offered an opportunity to compare readings over areas without anomalies, large anomalies, isolated anomalies, and weak anomalies in the Hx, Hy, and Hz components. Figure 5 shows a comparison of magnitude values for window 12 over a variety of objects.

Background data acquired near the Cold Test Pit display magnitude values for window 12 ranging from -7 to 2 microVolts/amp. Over the massive anomaly, values range from approximately –300 to 650. By comparison, all stations over the massive anomaly show an increase in the absolute value. The third column in Figure 5 displays the data over one anomaly. Stations in this area range from 250 to –250 near the anomaly to background values, away from the object. The difference between the massive anomaly and the isolated anomaly can be seen in the magnitude and in the lateral extent of elevated values. The fourth row presents data collected over a weak isolated anomaly. Only stations very near the object will show an increase in magnitude (40 to –20) while the other stations display background like responses.

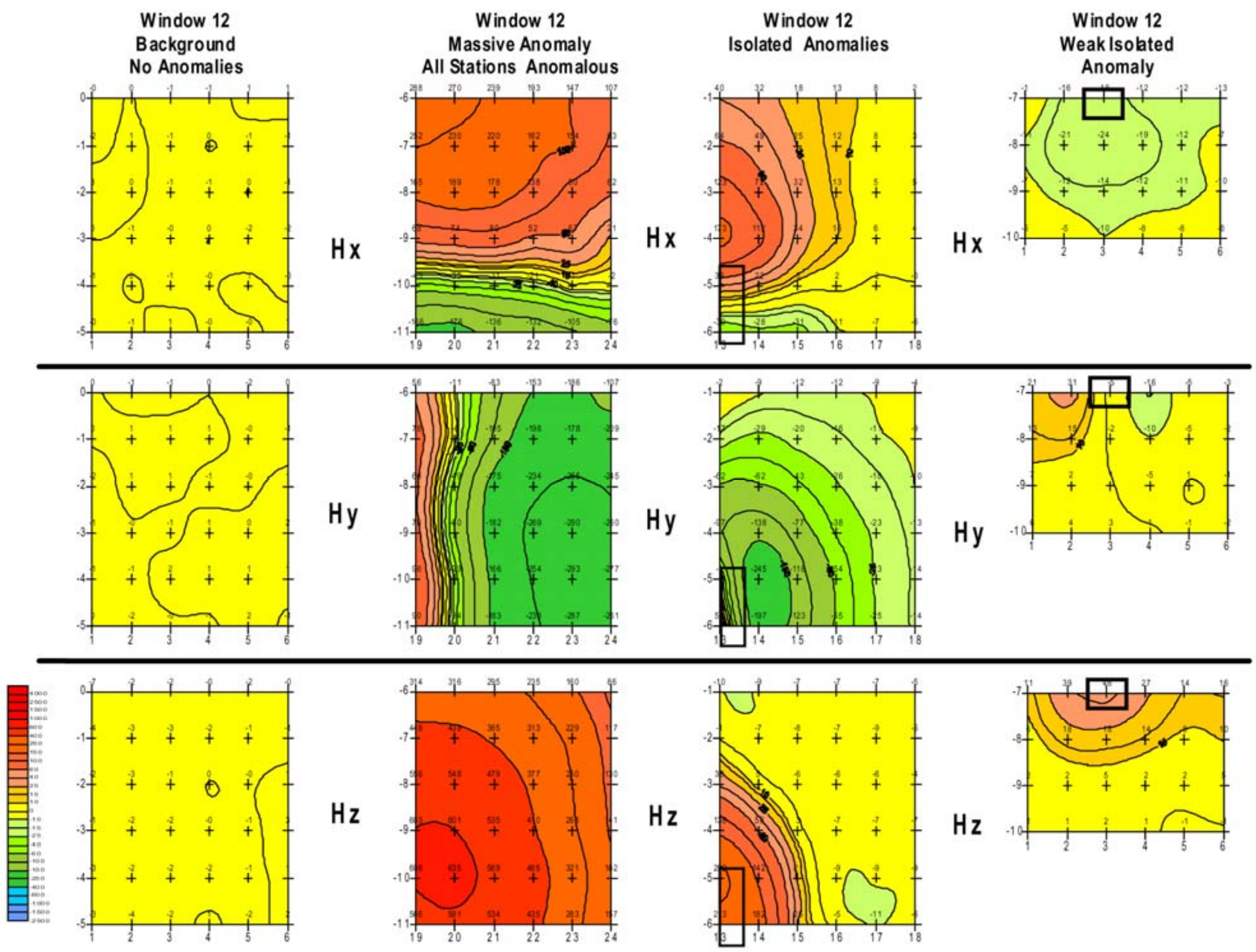


Figure 5: Comparison of NanoTEM data over different objects.

OTHER TESTS

We were also able to take this opportunity to run other tests of the system, and make use of the flexibility of the NanoTEM system to acquire data in other loop configurations. For example, one of the tests was intended as a quick check for coupling on the receiver coil cables, and another tested the effects of a person standing near the receiver coils during data acquisition. In the "Walkout Test" we changed the loop configuration from a 10 meter square transmitter loop to a five meter square transmitter loop. Measurements were made starting from the center of the transmitter loop, moving at one meter intervals until the receiver loop was outside the transmitter loop, and continued across the edge of the dump into background. Figure 6 shows the results of the Hz component plotted in standard profile form, for windows 7 through 15 (7 microseconds to 64 microseconds). This part of the decay curve exhibits only background noise off the dump, but is clearly and repeatably anomalous over the conductive dump material. As a result, the edge of the dump is delineated extremely well in this configuration.

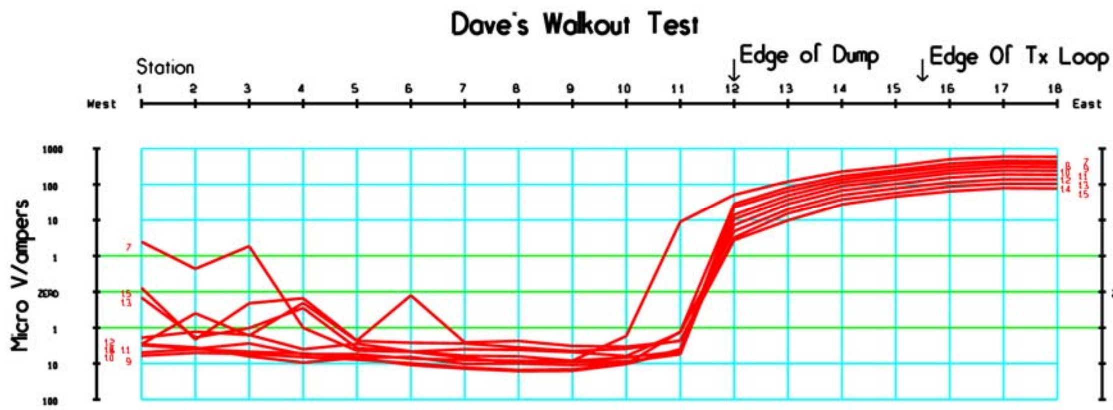


Figure 6: Results from Dave's Walkout Test, windows 7-12, extending from within the dump to several meters away from the edge.

Another test was called the "Bart/NoBart" test. The idea behind the test was to determine what the effects are, primarily on the Hx and Hy components, of a person standing near the receiver coils during data acquisition. For these measurements, Bart Black stood one meter due west of the receiver coils during the measurements, and then the measurements were repeated with Bart well outside the transmitter loop. Surprisingly, Bart had no effect on the data. We had planned to also make measurements with him at increasing distances from the coils, but since no effect was seen at one meter, the test was discontinued. Since conductive objects buried one meter below the receiver coils are easily detected, the fact that we could not detect a person one meter to the side of the coils was unexpected. At the VETEM meeting at Lawrence Berkeley Laboratories, these tests were discussed briefly; the most likely explanation offered was that the test was done over the conductive dump, and any effects resulting from Bart were swamped by the dump effects. Other possible explanations considered the fact that the background material for Bart was air, while objects below the receiver are in a substantially more conductive host.

Zonge International
(1-800) 523-9913 (USA and Canada only)
3322 East Fort Lowell Road
Tucson, Arizona 85716
Tel: (520) 327-5501 Fax: (520) 325-1588 Email zonge@zonge.com

37029 Denise Lake Drive
Soldotna, Alaska 99669
Tel: (907) 262-5072 Fax: (907) 262-5072 Email zonge@alaska.net

Zonge International
924 Greg Street
Sparks, Nevada 89431
Tel: (775) 355-7707 Fax: (775) 355-9144 Email ZongeNV@zonge.com

Zonge International
7711 West 6th Avenue, Suite G
Lakewood, Colorado 80214
Tel: (720) 962-4444 Fax: (720) 962-0417 Email ZongeCO@zonge.com

Zonge International
4700 West 77th Street, Suite 200,
Minneapolis, Minnesota 55435
Tel: (952) 832-2616 Fax: (552) 832-2601 Email ZongeMN@zonge.com