OhmMapper Survey at the Camp Parks RFTA Former Tank Farm (PRFTA13)

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1 SUMMARY

An OhmMapper survey was performed at the Survey at the Camp Parks RFTA Former Tank Farm (PRFTA13), a 5.5 acre site, to map the near subsurface resistivity and possible association with a 30-40 year old hydrocarbon plume and possibly locate any additional pipelines.

2 INTRODUCTION

A through description of the site history and possible subsurface contaminant can be found in USACHPPM report 38-EH-2938-02 (2002).

3 INSTRUMENT DESCRIPTION: THE OHMMAPPER, A CAPACITIVELY COUPLED RESISTIVITY SYSTEM

The OhmMapper is a capacitively couple resistivity system designed to measure subsurface resistivity in areas with high surface resistivity where measurement using traditional galvanically coupled (DC) resistivity systems is impractical. The OhmMapper consists of an ungrounded dipole transmitter and receiver. The operating principle is relatively simple: an alternating current with a particular frequency is induced in the earth by the alternating voltage applied to the transmitting dipole and the alternative voltage induced in the receiver's dipole is measured. This measured voltage will be proportional to the resistivity of the earth separating the two dipoles and the current delivered to the transmitter dipole. The transmitter and receiver are usually deployed in a dipole-dipole configuration where the transmitter and receiver are placed in line and separated by an integer number of dipole lengths. As with a DC resistivity system, an apparent resistivity is calculated by multiplying the appropriate geometric factor by the OhmMapper's received voltage and then normalizing this quantity by the transmitter current. Testing at several study areas has shown that the OhmMapper's response is identical (within 2%) to that of a dipole-dipole DC resistivity measurement. There are, however, two important restrictions that must be met in order for this favorable comparison to be realized: 1) the transmitter and receiver antennas must not be located in standing water and 2) the transmitter-receiver separation must not exceed one skin-depth. One skin-depth in meters is approximately 500*sqrt(rho/freq) and the operating frequency of the OhmMapper is 16 kHz. The result is that the maximum depth of investigation for the OhmMapper increases as the square root of the earth resistivity.

The OhmMapper is designed to be pulled along the ground as a streamer and thereby provide an almost continuous apparent resistivity profile. This design increases the resolving power and productivity of the system relative to DC instruments. The dipole cables, cable connectors, and instrument housings are made of tough, wear-resistant plastic. These external components will eventually wear out with extensive field use, but they are relatively inexpensive and can be quickly replaced in the field without tools. Our tests using the OhmMapper show a gain in crew production of a factor of 20 relative to conventional DC systems with no apparent degradation of data quality. Because the OhmMapper is designed for deployment and operation by a crew consisting of a single person, users can expect substantial productivity gains on OhmMapper resistivity surveys.

The OhmMapper is used with Geometrics' belt-mounted 858 magnetometer console. In operation the OhmMapper receiver is connected to one of the console's serial ports via a fiber optic isolator. Measurement data are stored as they are receiver at the serial port and are also graphically displayed in real time on the console's screen. The OhmMapper receiver delivers measurement data (receiver voltage/transmitter current) at a 2 Hz rate and at this rate the console has non-volatile storage space for about 24 hours of data acquisition. Geometrics' MAGMAP2K, a MS Windows program, is used to upload, edit, and process OhmMapper data and export it in several standard formats for presentation or for inversion using commercial DC resistivity interpretation tools.

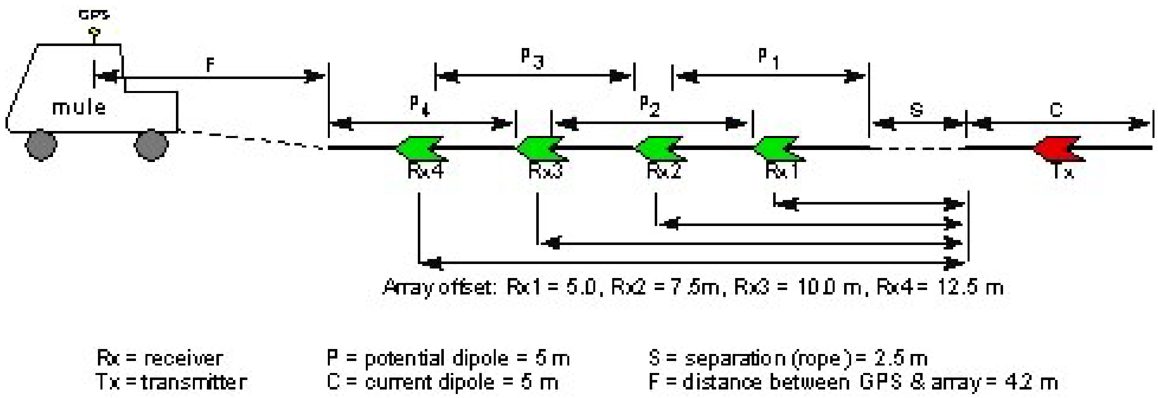

Figure 1. Schematic of the OhmMapper with 4 receivers and transmitter being pulled by the mule vehicle.

Figure 2. Photo of the OhmMapper during operation at Camp Parks. The mule is in the foreground pulling the OM array.

3.1 Specifications:

3.1.1 Streamer:

Instrument description: constant-current, capacitively coupled, resistivity meter
Transmitter frequency: approximately 16000 Hz
Measurement cycle rate: 2 Hz
Power line rejection: greater than 100 db
Standard dipole cables: 2.5, 5, and 10 meters in length terminated with hermaphroditic connectors so that cables can be interconnected to provide dipole lengths of 5, 10 15, 20, 25, and 30 m.
Operating range: 2% linear from 3 to 100000 Ohm-m while transmitter-receiver separation less than one skin-depth
Operating temperature: -35 to 50 degrees C

Water tight depth: 0.9m
Power: 2, 6 V rechargeable gel cell.
Transmitter w/ battery, receiver w/ battery, depressor weight: 2 kg, 2 kg, 3 kg
Dipole cable weight: .3 kg/m

3.1.2 Data logger:

Description: belt/harness-mounted console which incorporates a keypad and 320x200 pixel daylight visible graphic LCD display and runs software controlling all system setup functions, data acquisition parameters, data monitors, and data displays.
Data storage: 2 Mbytes non-volatile RAM
Audio output: Metronome, signal amplitude, disconnect.
Internal clock: .01 sec precision, .1 sec resolution; drift less than 1 sec/day
Operating temperature: -25 to 50 degrees C
Water tight to .9 m depth
Shock: 1m drop on hard surface without damage
Battery: 28 V rechargeable gel cell, 1.6 kg pack/harness

The estimated shipping weight of the complete system including its shipping case is 24 kg.

4 SURVEY DESCRIPTION: CAMP PARKS RFTA FORMER TANK FARM

Located on the Camp Parks Reserve Force Training Area (RFTA) in Dublin, California, the OhmMapper (OM) survey was performed over a 5.5 acre site that used to be an old tank farm (PRFTA13) as shown in

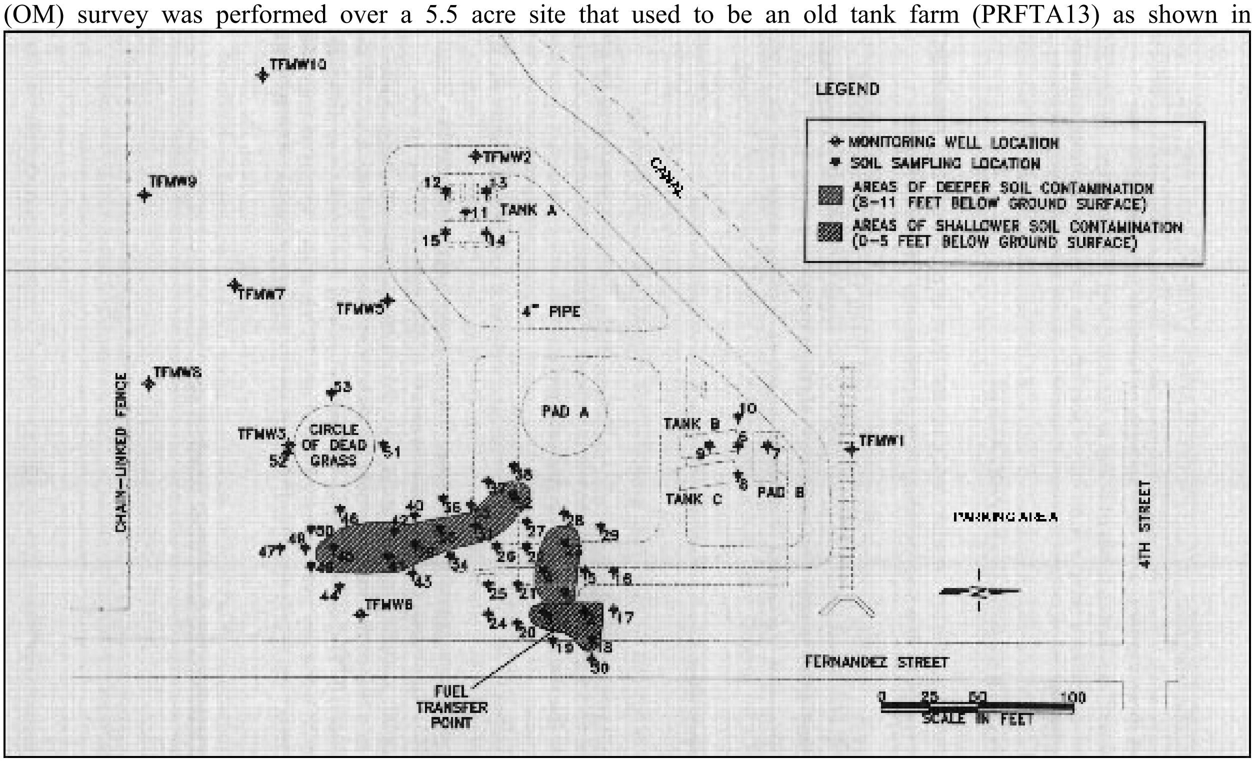

Figure 3. OM data were acquired using 4 receivers with a transmitter receiver separation of 5.0, 7.5, 10.0 and 12.5 m. Nominal depth of investigation is roughly 40% of the transmitter-receiver separation. The sensor array was pulled with a small vehicle, called a Mule, shown in Figure 2. Survey data were located with a Trimble Global Positioning System (GPS) system The GPS data stream was fed into the OM data logger so received data for each transmitted signal was assigned a location coordinate. The GPS was attached to the Mule, and hence there is an offset between data located with the GPS coordinates and the actual plotting point of receiver, which is accounted for in the processing program. The Mule and GPS system were furnished by Engineering & Environmental, Inc.

.Data were acquired on 2.5 m line spacing on both a north-south and east-west grid. The two directions were employed for two reasons: dense data coverage, and differential coupling between the OM and structures in the earth. The GPS maps are shown in Figure 4. Spatial data density along a profile line is roughly a point/2 m.

The multiple receiver OM is a new system and as previously agreed upon, there may be some debugging required and in fact two surveys were conducted to attain high quality data. Phase one was performed on 3-4 Oct 02 and problems with the sampling frequency and baud rate that created unacceptable noise in the system. After testing at Geometrics the problem was ascertained and corrected, and a second survey was performed on 28-29 Jan 03. Data quality was of significant quality in the 2nd survey.

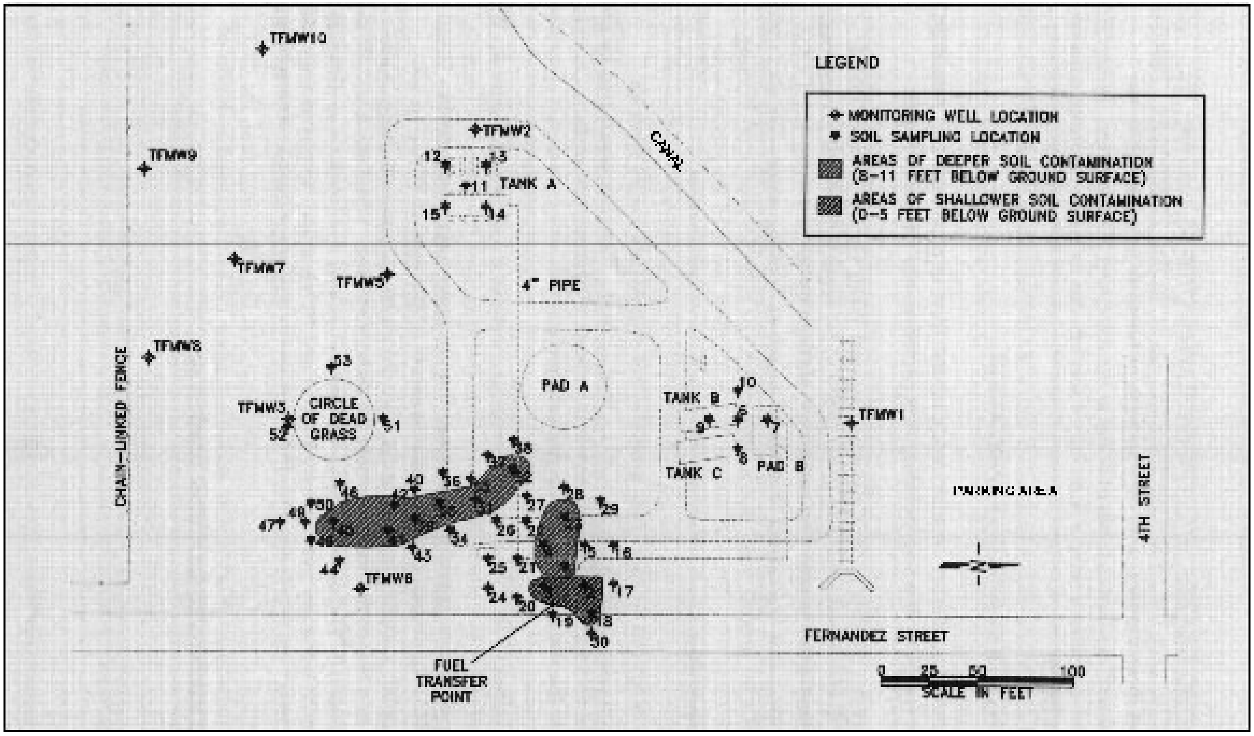

Figure 3. Former tank farm showing the soil sampling locations prior to Oct 2002 and mapped plume (from USACHPPM site inspection report no. 38-EH-2938-02).

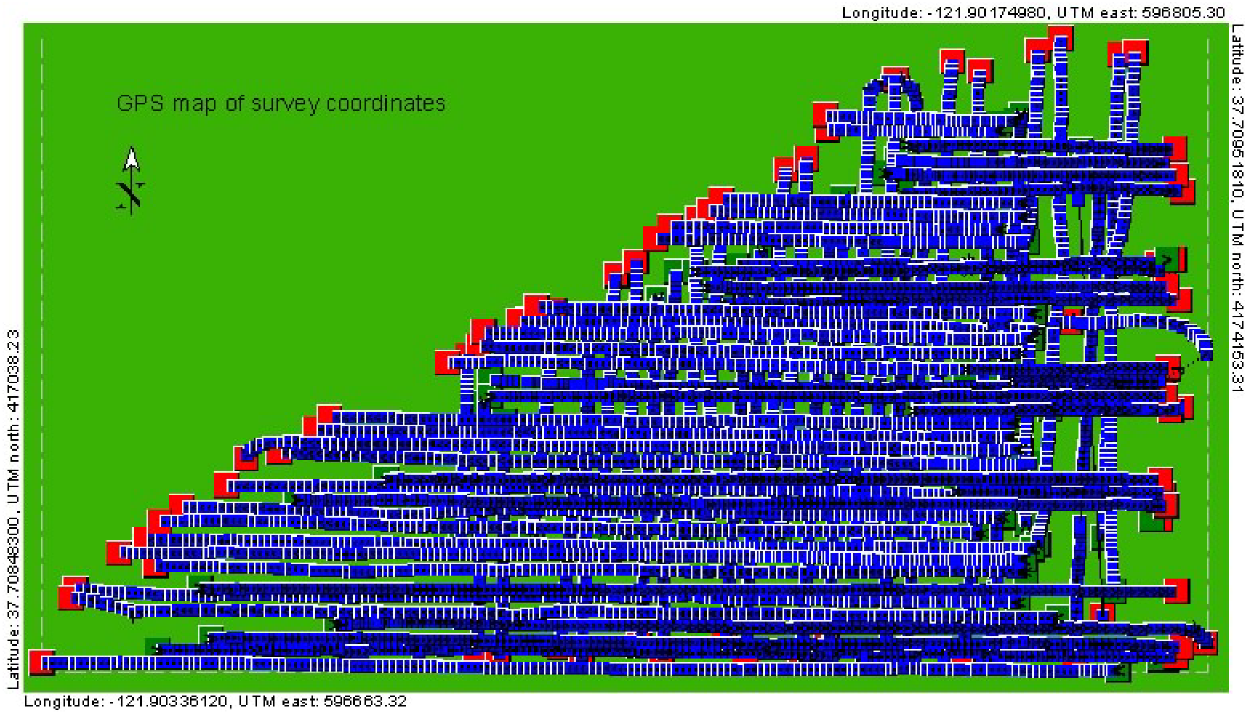

Figure 4. The GPS map of the survey for the both the north-south and east-west traverse directions. Arrows in the blue lines indicate the profile direction. Coordinates, in latitude & longitude and UTM, noted in the upper right and lower left corners refer to the intersection of the white dashed lines.

5 DATA REDUCTION AND PROCESSING

Data are reduced and processed using the DataMap software (Geometrics, 2001) and the two-dimensional inversion software of Loke (1996). After transferring binary data from the data logger to the PC, it is converted to ASCII format for plotting and editing. Filtering techniques were employed to delete outliers and smooth the data with a 3 pt running average.

6 SURVEY RESULTS

6.1 Apparent Resistivity Maps

Data are presented as apparent resistivity plan view maps for the 4 transmitter-receiver separations and the EW, NS and both transverse directions, in Figure 5 thru Figure 10 . The same color scale is used in all maps with 2.5 ohm-m being the conductive end of the scale in red and 25 ohm-m the resistive in blue. The subsurface is quite conductive resulting in a shallow depth of investigation, and becomes more conductive with increasing depth. Recent studies have shown that hydrocarbon contamination greater than 30-40 years is conductive (get reference - Estella), contrary to intuition that a hydrocarbon are a resistive, therefore nearly invisible material in the subsurface. Correlation with the soil sampling data is necessary to determine whether a geophysical signature of the hydrocarbon plume is present.

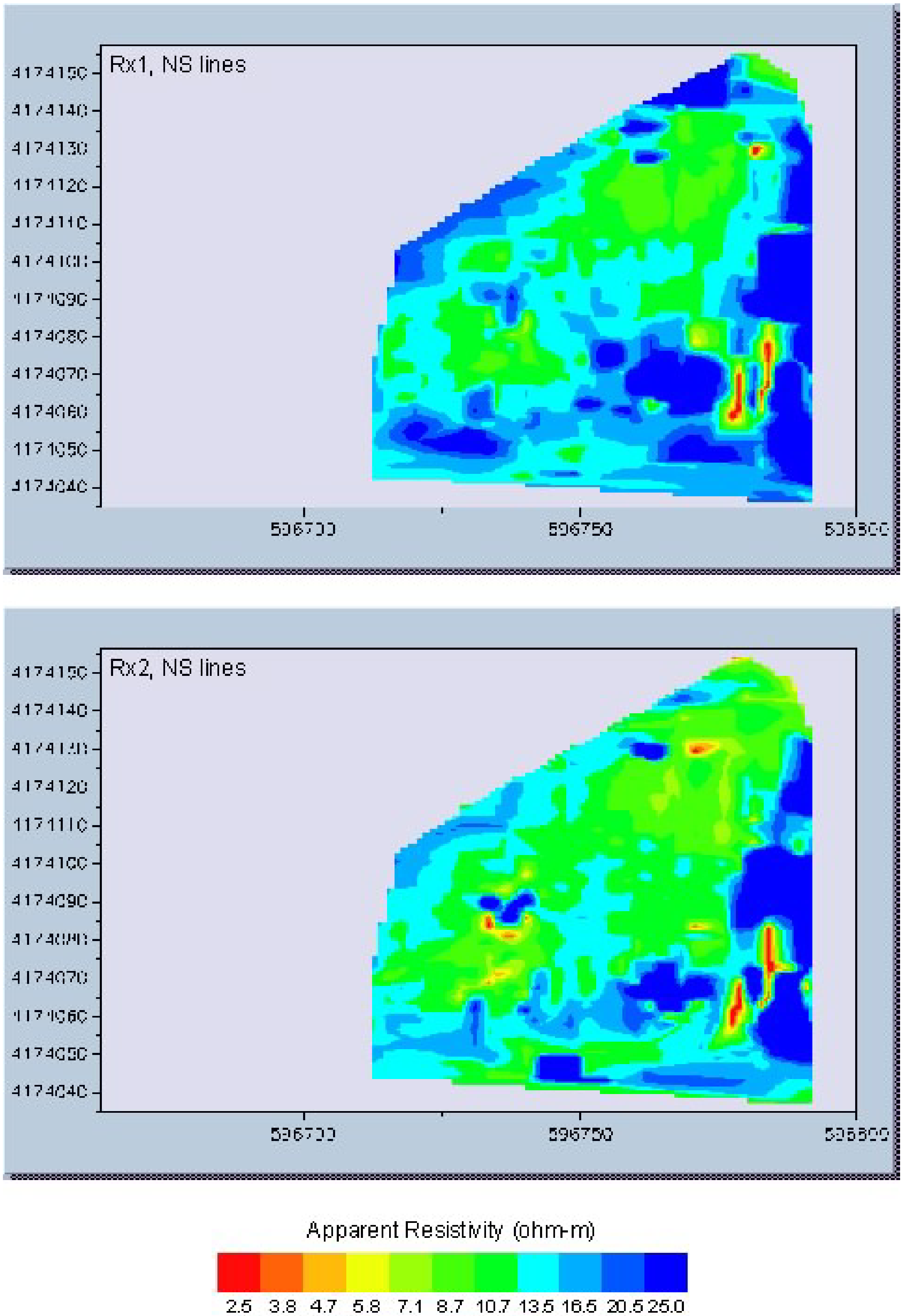

Figure 5. Apparent resistivity plan view maps for the NS line direction for the 2 shallower array configurations.

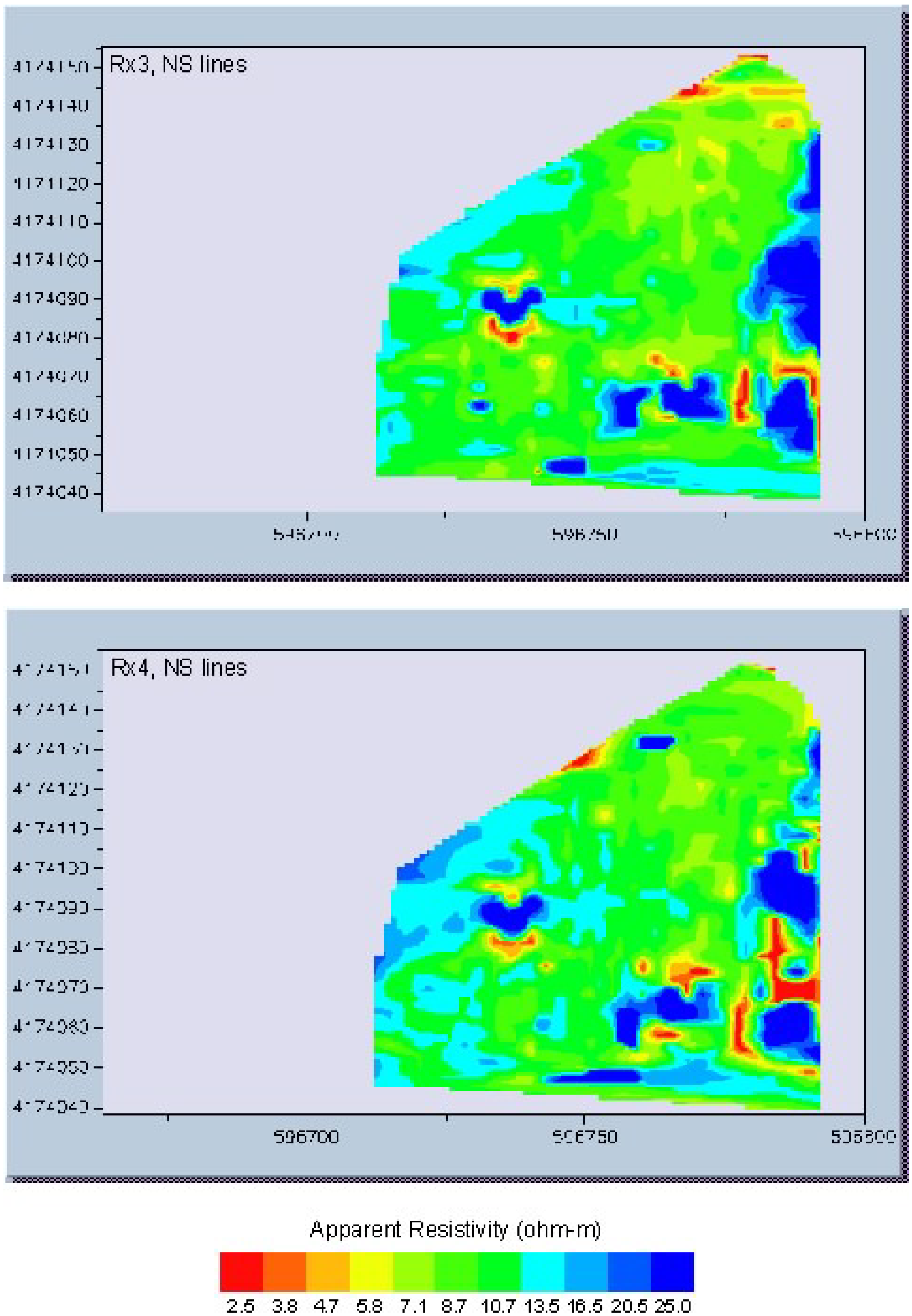

*Figure **6**. Apparent resistivity plan view maps for the NS line direction for the 2 deeper array configurations.*

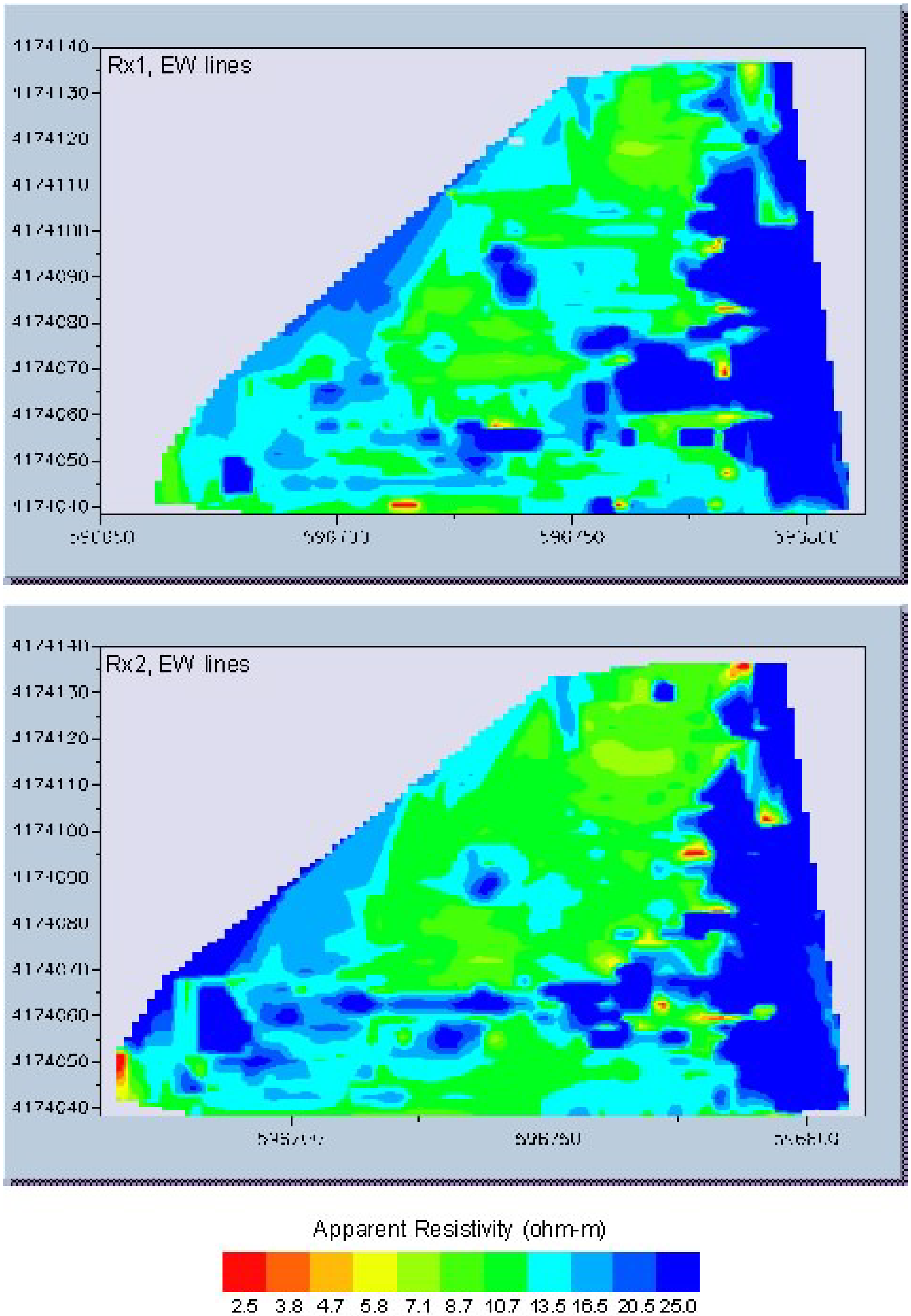
Rx1, EW lines
Rx2, EW lines
Apparent Resistivity (ohm-m)
2.5 3.8 4.7 5.8 7.1 8.7 10.7 13.5 16.5 20.5 25.0

Figure 7. Apparent resistivity plan view maps for the EW line direction for the 2 shallower array configurations.

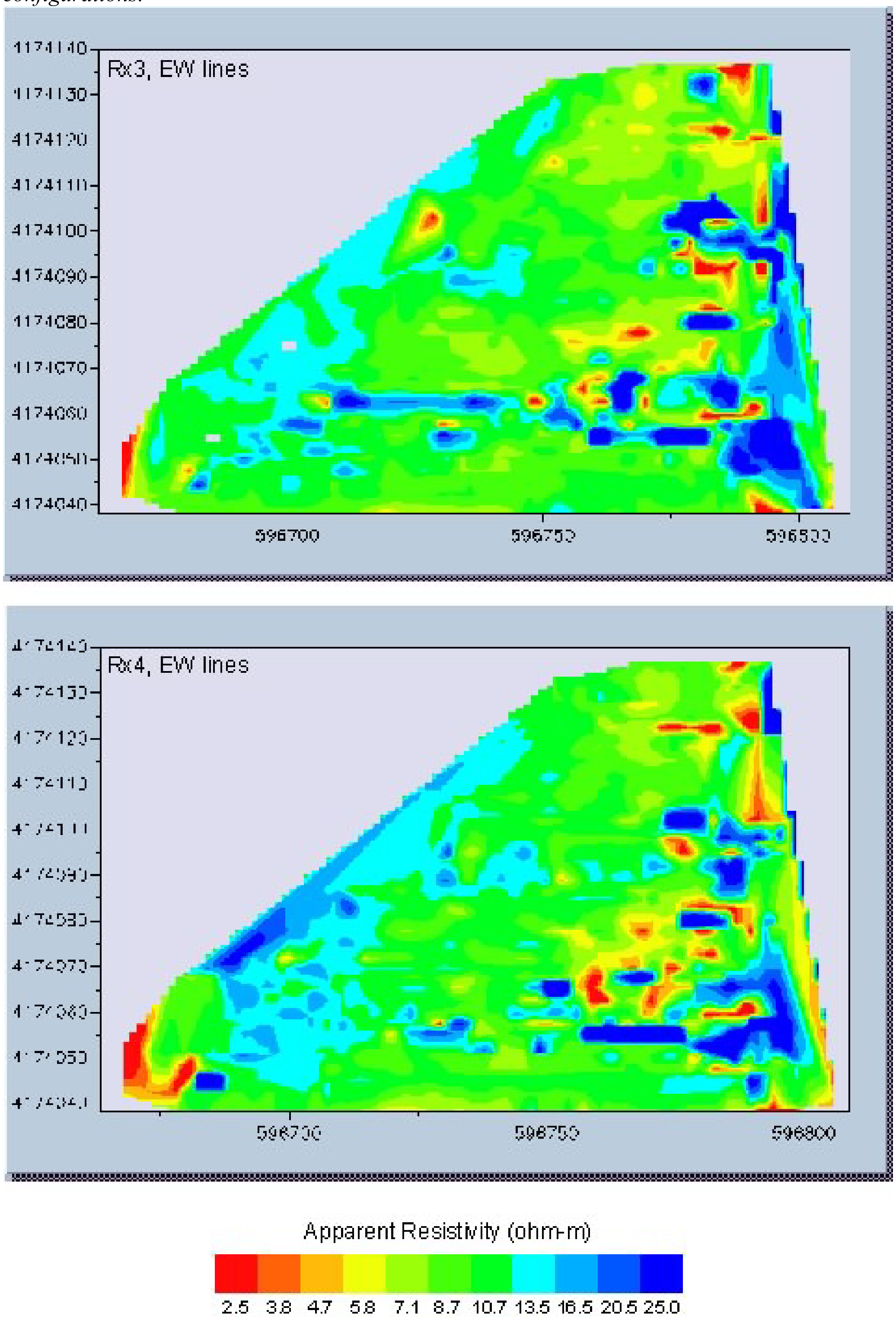

Figure 8. Apparent resistivity plan view maps for the EW line direction for the 2 deeper array configurations.

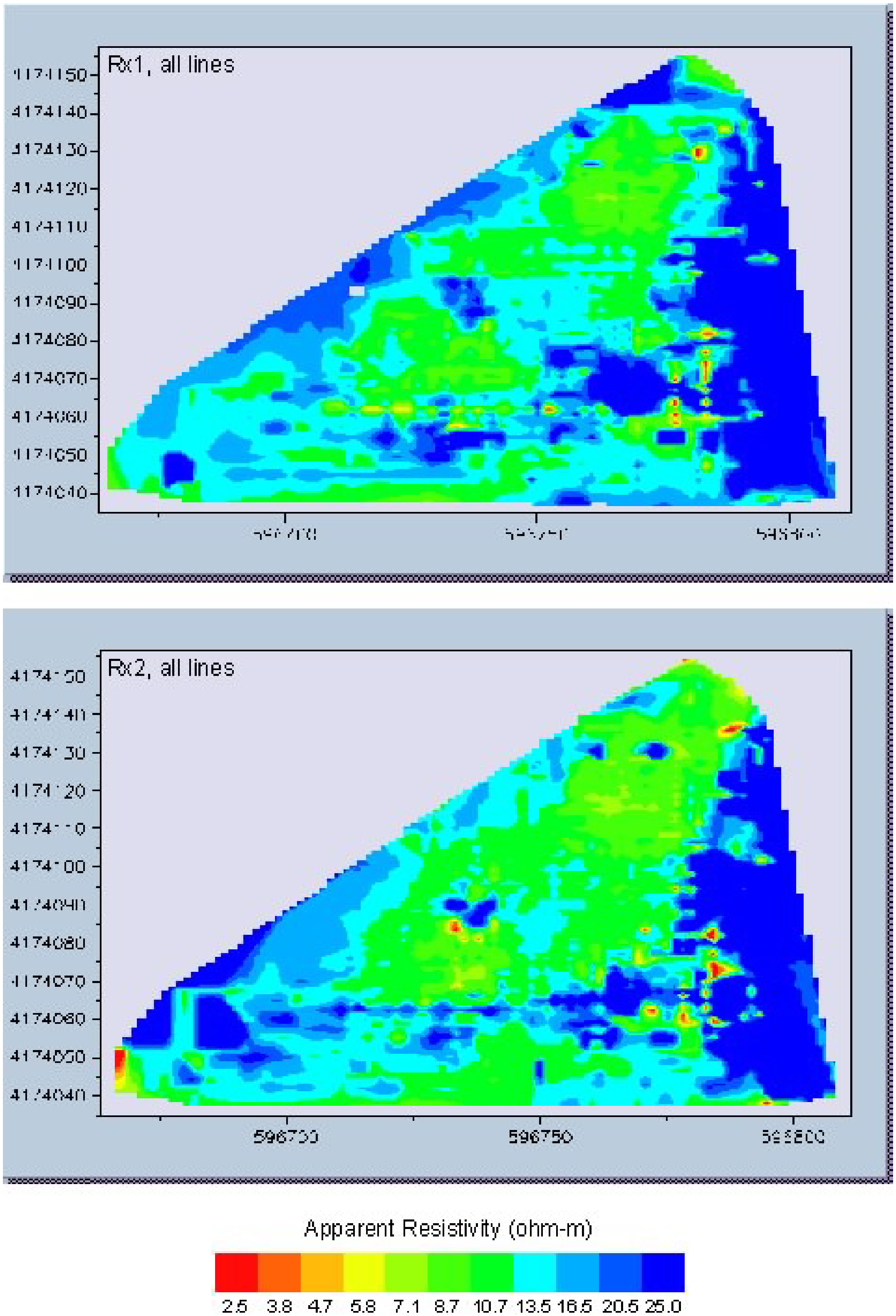

Figure 9. Apparent resistivity plan view maps for the all line direction for the 2 shallower array configurations.

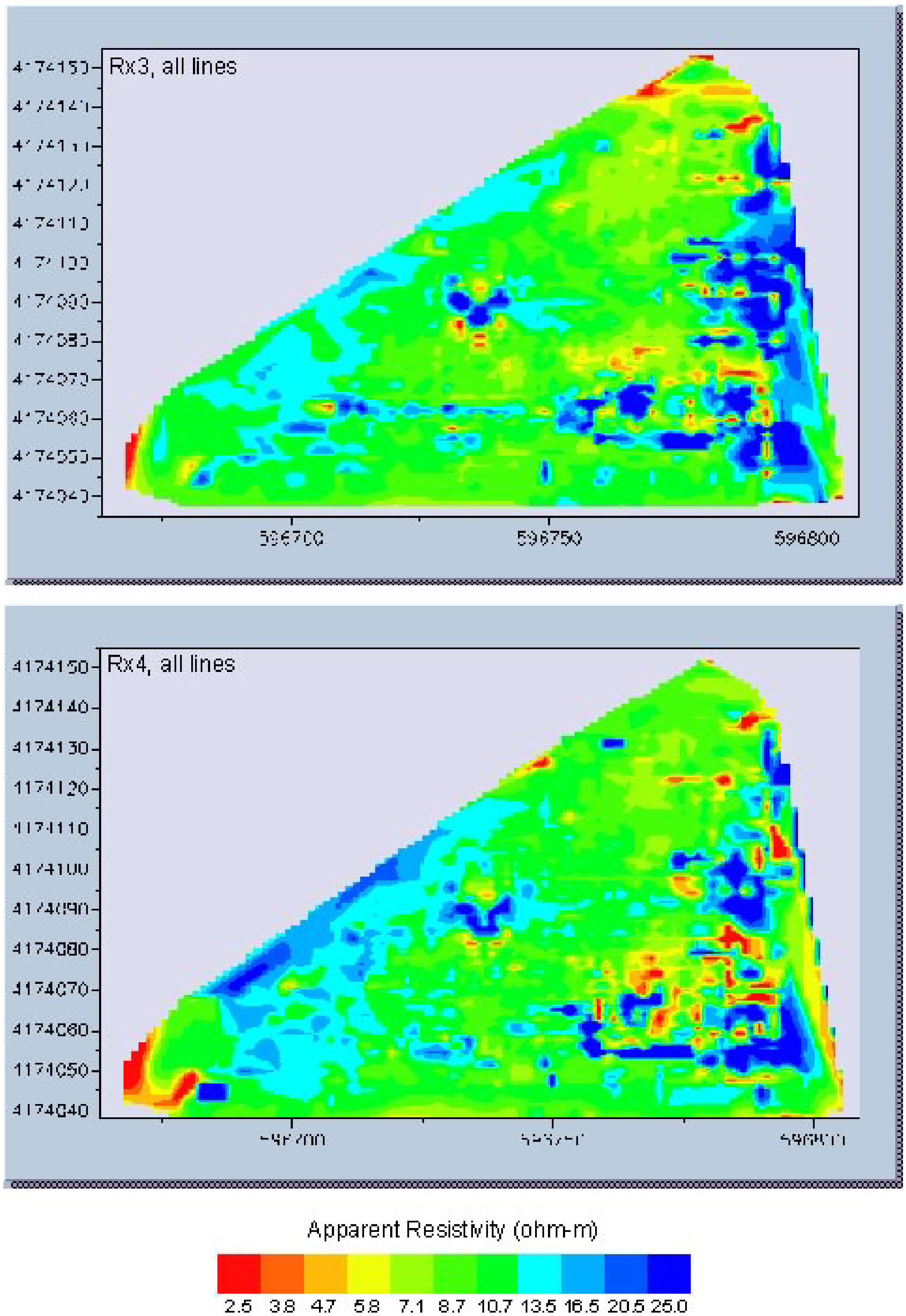

Figure 10. Apparent resistivity plan view maps for the all line direction for the 2 deeper array configurations.

6.2 Depth Sections

Data are plotted for the for array separation in a pseudo-section. Pseudo referring to the depth scale being a function of the separation, which correlates to depth. The data are processed with a two-dimensional (2d) inversion (Loke and Barker, 1996; Loke, 1999) to convert to true depth section. Data were processed for two lines shown below in Figure 11 and Figure 12. Note the color scale is different from that of the apparent resistivity maps above. Depth of exploration is about 4.5 m. Again we can see the subsurface is quite conductive. In Line 65, Figure 11, there are two very distinct resistive objects in the near surface, which possible correspond to sewer pipes. This needs to be further analyzed. The most striking feature in Line 8 is the contrast in properties in each portion of the line. More 2D section need to be produced to capture nature of these structures.

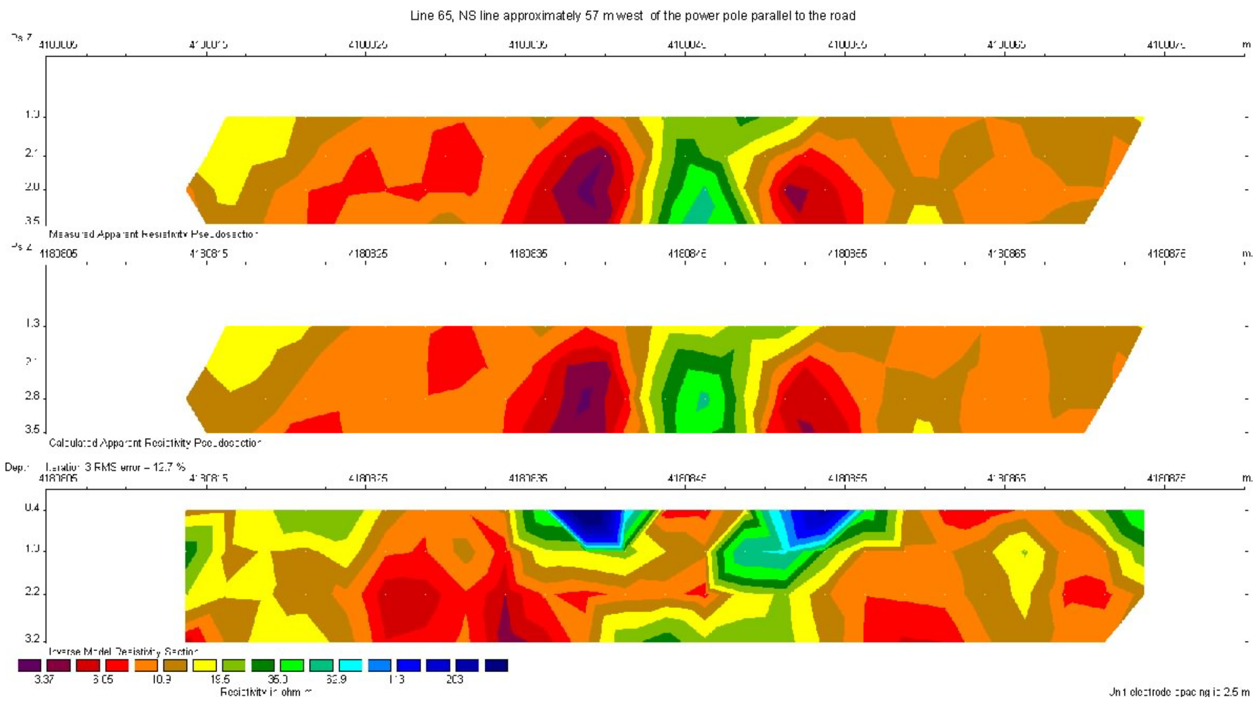

Figure 11. From top to bottom, pseudo-section of the field data, the model data, and the corresponding 2D inverse model along Line 65, which is a NS line roughly 57 m west of power poles.

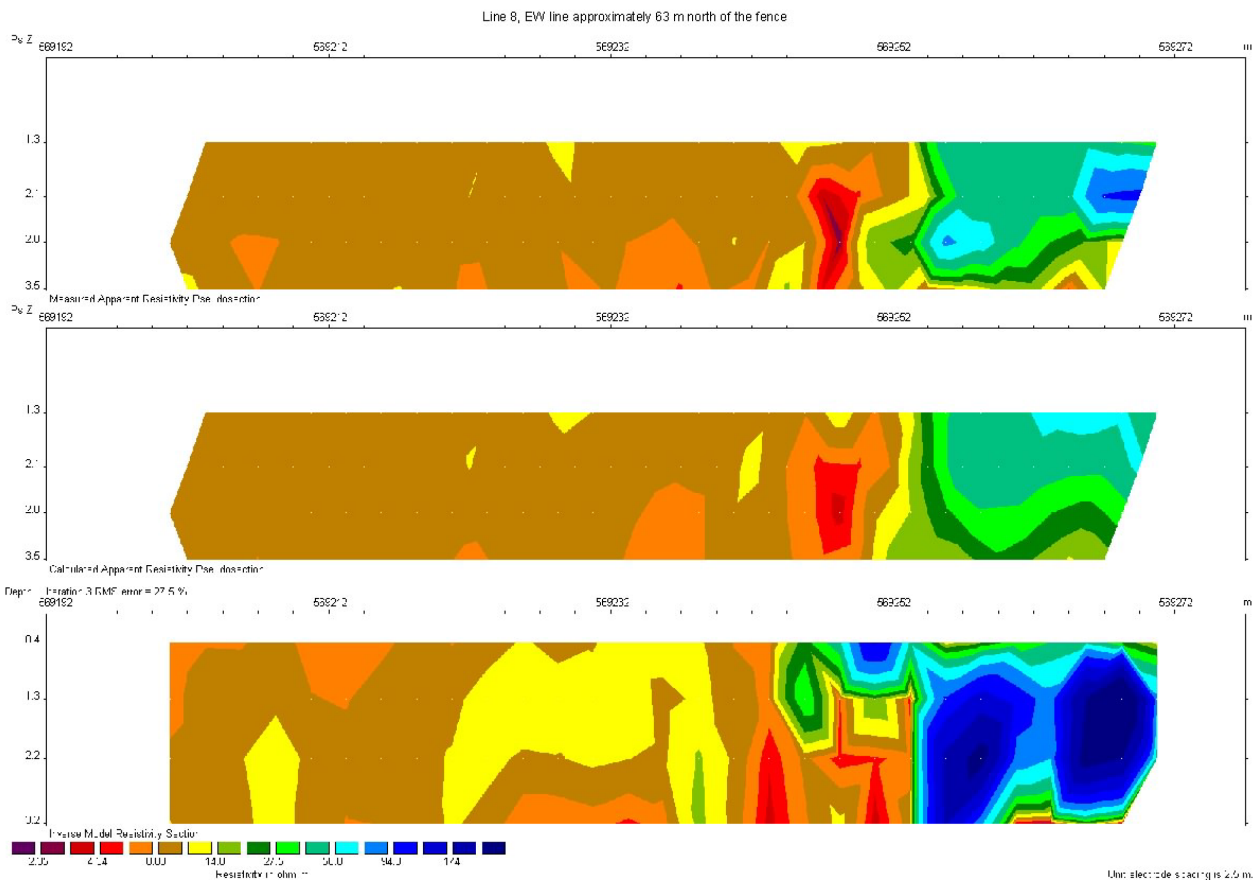

Figure 12. From top to bottom, pseudo-section of the field data, the model data, and the corresponding 2D inverse model along Line 8, which is an EW line roughly 63 m north of the fence.

7 CONCLUSIONS

8 ACKNOWLEDGEMENTS

9 REFERENCES

Geometrics, 2001, DataMap OhmMapper User Guide, 29006-01, Rev 3.0, Manual 29007-01 Rev. A.

Loke, M.H., and barker, R., 1996, Rapid least-squares inversion of apparent resistivity pseudo-sections using a quasi-Newton method. Geophysical Prospecting, **44**, 131-152.

Loke, M.H., 1999, RES2DINV ver. 3.42, Geolectrical Imaging 2D & 3D, User Manual

USACHPPM, 2002, Site Inspection No, 38-EH-22938-02, Former Tank Farm (PRFTA13) PPFTA, Dublin, CA, 15-21 May 2002