United States Department of Agriculture	**Natural Resources Conservation Service**	**5 Radnor Corporate Center, Suite 200 Radnor, PA 19087-4585**

Subject: SOI -- Site-Specific Farming;
Electromagnetic Induction (EM) Assistance

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Purpose:
The purpose of this investigation was to prepare maps at a suitable scale for use with site-specific farming. The potential of using global positioning systems (GPS) and electromagnetic induction techniques (EM) to map the depths to bedrock across comparatively large units of management was also evaluated. This study demonstrated the value of integrating contemporary geophysical, geo-referencing, and computer technologies with traditional soil survey techniques to characterize soils over large areas.

Participating Agencies:
Pennsylvania State University
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Activities:
All field activities were completed during the period of 18 to 22 November 1996. The study was conducted at the Rockspring Agronomy Farm, Pennsylvania State University, Centre County, Pennsylvania.

Introduction:
The last decade has witness the rapid evolution of site-specific farming. The goal of site-specific farming is to produce optimal yields and to maximize efficiency by varying the rates of seeding and the applications of chemicals. Site-specific farming uses yield mapping, grid sampling, and variable-rate chemical applications. With site-specific farming, seeding and application rates can be tied to the characteristics of each soil type within a field. As specific requirements become known, site-specific farming seeks to adjust the application rates of chemicals to these conditions. Site-specific farming helps to reduce the off-site impact of chemicals, by adjusting and optimizing application rates.

Site-specific farming requires precise maps showing the distribution of soils and soil properties within fields. To apply varying seeding and chemical application rates, farmlands must be divided into management zones that have different requirements (Mulla, 1993). Site-specific farming relies on maps to show the location, size, shape and distribution of soils and soil properties within fields. Soil maps prepared by the USDA do not show in sufficient detail the variations in soils and soil properties needed for site-specific farming (Jaynes et al., 1995a). Conventional soil maps were not prepared nor intended for site specific farming. Most conventional soil maps were produced at a scale of 1:15840 or smaller.

Conventional soil maps are inappropriate for site-specific farming. Site-specific farming requires a new generation of soil maps. Mapping must be at a level of resolution that is comparable to the scale of chemical applications (Jaynes, 1995a). A new generation of soil maps will be prepared at more appropriate scales (1:6000 or larger) and will show in greater detail the variability of soils, soil properties, or capabilities across fields. The preparation of these maps will be a formidable and expensive task. Unless alternative field methods are developed, a more thorough mapping of soils will be prohibitively expensive, time-consuming, and labor-intensive. Alternative methods are needed to complement traditional survey techniques, provide more comprehensive coverage, and improve site assessments. To be effective, these methods must be relatively inexpensive, fast, and provide precise maps of soils or soil properties.

Alternative methods for mapping soils and soil properties are available. Electromagnetic induction (EM) is a noninvasive geophysical tool that has been used in high intensity surveys and for detailed site assessments. Electromagnetic induction has been used to assess and map soil salinity (Cook and Walker, 1992; Corwin and Rhoades, 1982, 1984, and 1990; Slavich and Petterson, 1990), sodium-affected soils (Ammons et al., 1989; Nettleton et al., 1994), depths to claypans (Doolittle et al., 1994; Stroh et al., 1993; Sudduth and Kitchen, 1993; and Sudduth et al., 1995), regional differences in soil mineralogy (Doolittle et al., 1995), and edaphic properties important to forest site productivity (McBride et al., 1990). In addition, electromagnetic induction has been used to measure soil water contents (Kachanoski et al., 1988), cation exchange capacity (McBride et al., 1990), and leaching rates of solutes (Jaynes et al., 1995b). Recently, EM has been used as a mapping tool for site-specific farming (Jaynes, 1995; Jaynes et al., 1995b; Sudduth et al., 1995).

Electromagnetic induction uses electromagnetic energy to measure the apparent conductivity of earthen materials. Values of apparent conductivity are seldom diagnostic in themselves, but lateral and vertical variations in these measurements have been used to infer changes in soils and soil properties. Advantages of EM are its portability, speed of operation, flexible observation depths (with commercially available systems from about 2.5 to 197 feet), and moderate resolution of subsurface features. This technique is relatively fast, inexpensive, and can provide the comprehensive coverage needed for site-specific farming. Results from EM surveys have been used to map soils and soil properties, guide sampling, and facilitate site assessments.

Equipment:

The electromagnetic induction meters used in this study were the EM38 and EM31 manufactured by Geonics Limited.* These meters are portable and require one person to operate. Principles of operation have been described by McNeill (1980a, 1986). No ground contact is required with these meters. Each meter provides limited vertical resolution and depth information. For each meter, lateral resolution is approximately equal to the intercoil spacing. The observation depth of an EM meter is dependent upon intercoil spacing, transmission frequency, and coil orientation. Table 1 lists the anticipated observation depths for the EM38 and EM31 meters with different coil orientations.

* Trade names are used to provide specific information.. Their mention does nor constitute endorsement by USDA-NRCS.

TABLE 1

Depth of Measurement
(All measurements are in feet)

Meter	Intercoil Spacing	Depth of Measurement Horizontal	Vertical
EM38	3.2	2.5	5.0
EM31	12.0	10.0	20.0

The EM38 meter has a fixed intercoil spacing of about 3.2 feet. It operates at a frequency of 13.2 kHz. The EM38 meter has theoretical observation depths of about 2.5 and 5 feet in the horizontal and vertical dipole orientations, respectively (McNeill, 1986). The EM31 meter has a fixed intercoil spacing of about 12 feet. It operates at a frequency of 9.8 kHz. The EM31 meter has theoretical observation depths of about 10 and 20 feet in the horizontal and vertical dipole orientations, respectively (McNeill, 1980a). Values of apparent conductivity are expressed in milliSiemens per meter (mS/m).

All field coordinates were obtained with a Trimble Pathfinder Professional GPS Receiver. * This six channel receiver was operated with a CMT-MCV data logger. The system was placed in an all terrain vehicle and operated in the continuous mode. The *Trimble P Finder* (version 3.0) and the *MC-V Asset Surveyor* (version 3.02) software were used to process the data. Positions were recorded in feet using the Pennsylvania State Plane Coordinate system. The selected horizontal datum was the North American Datum - 1983 (NAD-83).

To help summarize the results of this study, the SURFER for Windows program, developed by Golden Software, Inc.,* was used to construct two- and three-dimensional simulations. Grids were created using kriging methods with an octant search. All grids were smoothed using a cubic spline interpolation. Shadings and filled isolines have been used in most of the enclosed plots to help emphasize spatial patterns. Other than showing trends and patterns in values of apparent conductivity (i.e., zones of higher or lower electrical conductivity), no significance should be attached to the shades themselves.

Study Site

The site is located near Rockspring, Centre County, Pennsylvania (see Figure 1). The site is located in the Northern Ridge and Valley section of the Central Appalachian Broadleaf Forest Ecological Subregion (McNab and Avers, 1994). The region is characterized by a series of parallel, narrow valleys and ridges (McNab and Avers, 1994). Near the site, valleys and ridges trend in a northeast to southwest direction. The site was located in a valley formed in folded limestone and dolomite bedrock. Within the site, slopes ranged from 0 to 15 percent slopes.

The study site covered an area of about 87.6 acres. The site was irregularly shaped with a maximum length of about 3330 feet (measured in a northeast to southwest direction). The width of the site ranged from about 920 to 1380 feet (measured in a northwest to southeast direction). The site had been cropped to corn (about 20.8 acres) or soybeans (about 44.0 acres), with a small portion fallow (about 22.7 acres). Figure 2 shows the land use within the study site. In Figure 2, the locations of the field boundaries were approximated from a limited number of GPS waypoints.

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Soil delineations mapped within the site include phases of Hagerstown, Opequon, and Nolin soils (Braker, 1981). Hagerstown soils are members of the fine, mixed, mesic Typic Hapludalfs family. These deep, well-drained soils formed in limestone residuum on uplands. Depth to limestone bedrock ranges from 40 to 72 inches. Opequon soils are members of the clayey, mixed, mesic Lithic Hapludalfs family. These shallow, well-drained soils formed in limestone residuum on uplands. Depth to limestone bedrock ranges from 12 to 20 inches. Nolin soils are members of the fine-silty, mixed, mesic Dystric Fluventic Eutrochrepts family. These very deep, well-drained soils formed in alluvium washed from uplands underlain by limestone and shale bedrock. Depths to limestone bedrock are greater than 60 inches.

Field Procedures

An irregularly shaped grid was hastily paced-off across the site. The grid interval was about 30.5 m. This provided 458 grid intersections or observation points. Distances between observations and traverse lines varied slightly. Figure 2 shows the general dimensions and approximated field boundaries within the study site

At each observation point, measurements were taken with the EM31 meter in both the horizontal and vertical dipole orientations. For each measurement, the meter was held at hip height (about 36 inches above the ground surface) with the long axis oriented in a northeast to southwest direction. This alignment approximated the strike of the bedrock. At four hundred fifty-two observation points, measurements were taken with an EM38 meter placed on the ground surface in the vertical dipole orientation. The coordinates of each observation point were recorded with a GPS receiver.

Soil profiles were observed with a hydraulic probe at thirty-three grid intersections. At each observation site, a brief profile description was prepared. These descriptions specified the depth and texture of the soil horizons and the depth to bedrock or auger refusal. These data were used to confirm interpretations and develop predictive equations.

Discussion:

Electromagnetic induction uses electromagnetic energy to measure the apparent conductivity of earthen materials. Apparent conductivity is a weighted, average conductivity measurement for a column of earthen materials to a specific observation depth (Greenhouse and Slaine, 1983). Variations in apparent conductivity are produced by changes in the electrical conductivity of earthen materials. The electrical conductivity of soils is influenced by the type and concentration of ions in solution, the amount and type of clays in the soil matrix, the volumetric water content, and the temperature and phase of the soil water (McNeill, 1980b). The apparent conductivity of soils increases with increases in soluble salts, water, and clay contents (Kachanoski et al., 1988; Rhoades et al., 1976).

Electromagnetic induction measures variations in apparent electrical conductivity. Interpretations of the EM data are based on the identification of spatial patterns within data sets. Though seldom diagnostic in themselves, lateral and vertical variations in apparent conductivity have been used to infer changes in soils and soil properties. Electromagnetic induction integrates the bulk physical and chemical properties for a defined observation depth into a single value. As a consequence, measurements can be associated with changes in soils and soil map units (Hoekstra et al., 1992; Jaynes et al., 1993, Doolittle et al., 1996). For each soil, inherent physical and chemical properties, as well as temporal variations in soil water and temperature, establish a unique and characteristic range of apparent conductivity values. This range can be influenced by differences in use or management practices (Sudduth and Kitchen, 1993, Sudduth et al., 1995).

Electromagnetic induction is not suitable for use in all soil investigations. Generally, the use of EM has been most successful in areas where subsurface properties are reasonably homogeneous. This technique has been most effective in areas where the effects of one property (e.g., clay, water, or salt content) dominate over the other properties. In these areas, variations in apparent conductivity can be directly related to changes in the dominant property (Cook et al., 1989). In studies conducted by Jaynes and others (1995, 1995b) in Iowa, variations in more than one property weakened and obscured relationships. In these studies, collective changes in the moisture, clay, and carbonates weakened relationships between apparent conductivity and moisture stress or drainage classes.

An EM meter must be sensitive to the differences existing between soil horizons or layers. In other words, to be effective, a meter must be able to detect differences in electromagnetic properties between the layers. Many soils have subsurface layers with varying thicknesses and chemical and physical properties, but closely similar conductivity values. Where these dissimilar layers occur in the same landscape, they can produce equivalent solutions or measurements. Equivalent solutions obscure results and limit the effectiveness of EM.

The Rockspring site provided a favorable environment for the use of EM. Except for a small area of Nolin soils, the site consisted of well drained, fine-textured soils formed in similar materials. The area of Nolin soils was located in the extreme northeastern corner of the site. At the time of the survey, the area of Nolin soils was ponded. All other soils were moist throughout. Depth to bedrock was the principal difference among the soils. The site consisted of two dissimilar layers: an overlying mantle of predominantly fine-textured residual soils and the underlying limestone bedrock. The overlying residual soils were more electrically conductive than the underlying limestone. The contrast in electrical properties between these two layers was significant and measurable.

Results:

Basic statistics for the EM data collected at the Rockspring site are displayed in Table 1. For the shallower-sensing EM38 meter, values of apparent conductivity averaged 7.8 mS/m and ranged from 1.3 to 20.6 mS/m in the vertical dipole orientation. One-half of the observations had values of apparent conductivity between 5.7 and 9.5 mS/m. For the deeper-sensing EM31 meter, values of apparent conductivity averaged 7.2 mS/m and ranged from 2.8 to 16.0 mS/m in the horizontal dipole orientation. One-half of the observations had values of apparent conductivity between 6.2 and 8.2 mS/m. In the vertical dipole orientation, values of apparent conductivity averaged 8.9 mS/m and ranged from 3.2 to 21.2 mS/m. One-half of the observations had values of apparent conductivity between 7.2 and 10.4 mS/m.

Table 1
Basic Statistics
EM Survey
(all values are in mS/m)

				Quartiles			
Meter	Orientation	Minimum	Maximum	1st	Median	3rd	Average
EM38	Vertical	1.3	20.6	5.7	7.5	9.5	7.76
EM31	Horizontal	2.8	16.0	6.2	7.2	8.2	7.17
EM31	Vertical	3.2	21.2	7.2	8.6	10.4	8.87

Figure 3 is a two-dimensional plot of data collected with the EM38 meter in the vertical dipole orientation. Figures 4 and 5 are two-dimensional plots of data collected with the EM31 meter in the horizontal and vertical dipole orientations, respectively. In each of these plots, the isoline interval is 2 mS/m. Each plot shows the spatial distribution of apparent conductivity for a different observation depth.

The patterns appearing in figures 3,4, and 5 were believed to principally reflect the thickness of the residuum or the depth to limestone. Areas having low values of apparent conductivity were inferred to have thin caps of residuum and shallow depths to limestone bedrock. Areas with higher values of apparent conductivity were inferred to have thicker caps of residuum or deeper depths to bedrock.

The spatial patterns appearing in these figures are closely similar. Values of apparent conductivity appear to conform to a predictable spatial relationship and pattern. While surveying, visual correlations were made between landscape positions and EM measurements. Lower values of apparent conductivity were recorded on higher-lying and more sloping areas. These areas were located principally in the central portion of the site. The higher-lying and more sloping areas were shallower to bedrock. Bedrock was exposed in these areas. Higher values of apparent conductivity were recorded on lower-lying, less sloping areas. These areas were located principally in the southern, western and extreme northeastern portions of the site. These areas were presumed to be deeper to bedrock. Higher values of apparent conductivity were also recorded on a higher-lying but nearly level area in the central portion of the site. This area paralleled and was located immediately north of a higher-lying ridge line. Depths to bedrock were assumed to be greater in this area.

Terrain influences soil moisture and the apparent conductivity of soils. In similar materials, values of apparent conductivity increase with increasing soil moisture contents. Typically, in similar materials, values of apparent conductivity will be lower on higher-lying, better drained areas than on lower-lying, more poorly drained areas. Small areas of wetter soils were observed in the extreme northeastern corner and in the southwest portion of the site. Soils were ponded in the northeast corner. In these areas, higher moisture contents increased the apparent conductivity of the soils.

The EM meters were influenced by "cultural noise" caused by buried utility lines and a fence located along the northern border of the site. Cultural noise is unwanted interference that is averaged into EM measurements whenever buildings, fences, or utility lines fall within the electromagnetic field of a meter. Cultural noise is a source of observation error. The buried utility lines and the fence caused apparent conductivity to increase. Because of cultural noise, some measurements were removed from the data set and analysis. A transmitter, located in a meteorological station to the west of the site, interfered with the induced electromagnetic fields of both meters. This source of cultural noise caused measurements to fluctuated more radically in the western portion of the site.

At thirty-three observation points, depths to Bt horizon and bedrock were measured with a hydraulic probe. At these observation points, the depth to argillic (Bt) horizon averaged 8 inches and ranged from 0 to 12 inches. At these observation points, the depth to bedrock averaged 4.5 feet and ranged from 1.1 to 9.1 feet.

A comparison of soil probe and EM data collected at these observation points revealed positive relationships between the observed depths to bedrock and apparent conductivity. Relationships were weakened by variations in soil properties (e.g., texture, thickness, and depth of subsoil; amount of coarse fragments; and moisture contents) and irregular bedrock surfaces. In addition, measurement error was introduced into the data set because of differences in the area profiled with the meters versus the point of soil observed with the hydraulic probe. The correlations between depth to bedrock and apparent conductivity was 0.540 (significant at the 0.001 level) for the EM38 meter in the vertical dipole orientation. Correlation coefficients were 0.772 and 0.873 (both significant at the 0.001 level) for the EM31 meter in the horizontal and vertical dipole orientations, respectively. These variations in the degree of correlation demonstrate the importance of selecting the most appropriate meter and coil orientation to obtain the desired observation depth and maximum resolution.

The observed depths to bedrock were compared with EM data and used to develop a regression equation to predict depths to bedrock (or thickness of clayey residuum) from values of apparent conductivity. The highest correlation was found between the depth to bedrock and data collected with the EM31 meter in the vertical dipole orientation. The coefficient of determination, r^2, between depth to bedrock and apparent conductivity was 0.762 (significant at the 0.001 level) in the vertical dipole orientation. Data collected with the EM31 meter in the vertical dipole orientation had the strongest correlation with the depth to bedrock and were used to develop a predictive regression equation:

$$D = -2.42304 + (0.944172 * EM31V) \qquad [1]$$

Where "D" is depth to bedrock (feet) and "EM31V" is the apparent conductivity (mS/m) measured with the EM31 meter in the vertical dipole orientation.

Equation [1] was used to estimate the depth to bedrock at each grid intersection. At the thirty-three probed observation points, the average difference in the depth to bedrock as measured by the hydraulic probe and predicted from EM measurements and equation [1] was 0.87 feet. Differences between observed and predicted depths ranged from 0.02 to 2.82 feet. These relationships are remarkable considering the large volume of soil averaged into the EM measurements and the irregular nature of the bedrock surface.

Based on 458, EM measurements and the predictive equation [1], the average depth to bedrock was estimated to be 5.93 feet with a range of 0.6 to 17.5 feet. One-half of the observations had depths to bedrock between 4.36 and 7.38 feet. Within the study site, bedrock was shallow (0 to 20 inches) at 3 percent, moderately deep (20 to 40 inches) at 10 percent, deep (40 to 60 inches) at 21 percent, and very deep (>60 inches) at 66 percent of the observation points.

Figure 6 is a two-dimensional plot showing the distribution of depths to limestone bedrock within the study site. Areas of shallow to deep soils (0 to 60 inches) form narrow, elongated bands. Many of these bands appear to be interconnected. Most bands trend in an east-west direction. These bands occur on higher-lying ridges and benches. Depths to bedrock were shallowest on higher-lying summit, shoulder, and upper sideslopes components. Here erosion was most severe and the mantle of residuum was least. Depths to bedrock were greatest in lower-lying portion of the site. These areas were located along the southern, western, and northeastern portion of the site.

Conclusions:

1. This field study provided a great wealth of data: EM measurements (at three separate depth intervals) and spatial coordinates at 458 observation points. The data have been summarized on pages 12 to 17 of this report. Simple contouring of the data was used to display the areal extent of similar and dissimilar areas at the three separate depth intervals (figures 3, 4, and 5). Soil observations were used to help confirm interpretations and to develop a predictive equation. This information was used to infer the depths to bedrock across the 88 acre study site.

2. Values of apparent conductivity were related to variations in the depth to bedrock. Apparent conductivity measured with the EM31 meter in the vertical dipole orientation was strongly correlated with observed depths to bedrock (r^2 of 0.762). A map showing the distribution of bedrock depths within the study site has been prepared (Figure 6).

3. Under conditions similar to those in the study area, it should be possible to infer depths to bedrock from values of apparent conductivity using a suitable EM meter. EM can be used to map depth to bedrock and soil types. Advantages of EM include speed of operation, flexible observation depths, and moderate resolution of subsurface features. Results of EM surveys are interpretable in the field.

This technique can provide in a relatively short time the large number of observations needed for the characterization and assessment of sites and to support site-specific farming. Simulations prepared from correctly interpreted EM data provide the basis for assessing site conditions and for designing sampling and monitoring schemes.

4. The survey produced beneficial information that can be used with site-specific farming. This study has raised apprehension as to how site-specific or precise is site-specific or precision farming. Much has been learned about field techniques. This knowledge will increase efficiency and accuracy of future studies.

5. The study is not complete. Results of this survey have been stored on disc. This information must be integrated with yield data in a geographical information system. Yield data should be compared with EM data. If a strong correlation exists, EM data can be used as a surrogate for yield mapping (Jaynes et al., 1994). The successful integration and analysis of these data sets can increase our understanding of the variability of soils within soil map units. Electromagnetic induction can be used as a mapping tool to produce a new generation of soil maps need for site-specific farming.

It was my pleasure to work with and to be of assistance to your staff.

With kind regards,

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EASTING	NORTHING	EM38V	EM31H	EM31V	DEPTH(M)
1918748	202206	6.8	6.4	7.0	1.28
1918844	202237	8.4	6.4	7.0	1.28
1918932	202266	6.5	5.6	7.4	1.39
1919035	202298	8.6	6.8	9.2	1.91
1919124	202326	7.8	7.4	8.4	1.68
1919223	202350	7.2	7.2	9.2	1.91
1919301	202382	7.7	7.4	9.2	1.91
1919376	202407	7.3	7.4	9.2	1.91
1919468	202434	8.3	7.6	10.0	2.14
1919552	202461	9.5	8.8	11.0	2.43
1919629	202486	10.0	8.0	10.6	2.31
1919743	202519	9.7	9.2	11.6	2.60
1919827	202549	9.7	9.6	12.2	2.77
1919898	202575	6.9	8.2	11.0	2.43
1919985	202606	6.4	7.0	10.6	2.31
1920106	202643	10.7	9.2	13.0	3.00
1920191	202665	9.8	8.6	12.0	2.71
1920277	202694	8.9	7.8	11.4	2.54
1920358	202720	7.8	7.2	11.4	2.54
1920443	202748	6.5	8.0	13.6	3.18
1920629	202773	9.3	8.2	12.2	2.77
1920629	202806	10.1	9.2	12.8	2.95
1920724	202841	6.6	9.6	12.6	2.89
1920823	202870	8.9	9.2	13.2	3.06
1920906	202897	9.6	8.8	13.4	3.12
1920986	202922	8.4	9.2	12.6	2.89
1921068	202951	7.7	8.6	12.6	2.89
1921163	202984	6.6	7.6	10.8	2.37
1921246	203012	6.2	7.6	9.2	1.91
1921325	203045	5.6	6.8	9.4	1.97
1921401	203073	3.6	6.4	9.6	2.02
1921489	203108	4.4	6.0	8.4	1.68
1921575	203139	4.6	6.2	9.2	1.91
1921665	203173	5.7	7.0	10.4	2.25
1921744	203209	6.6	7.8	11.8	2.66
1921805	203236	8.9	7.6	10.6	2.31
1921769	203311	7.9	7.4	9.0	1.85
1921703	203277	7.6	7.6	9.4	1.97
1921619	203244	6.8	7.4	9.2	1.91
1921529	203207	5.3	6.8	8.8	1.79
1921446	203175	6.8	8.0	9.6	2.02
1921353	203141	11.5	10.6	14.4	3.41
1921277	203111	5.6	7.0	9.6	2.02
1921193	203081	8.4	7.4	8.2	1.62
1921107	203051	6.4	6.6	8.0	1.56
1921018	203020	7.1	6.0	8.8	1.79
1920928	202989	8.2	9.0	12.0	2.71
1920846	202962	5.8	7.0	9.6	2.02
1920768	202937	6.9	7.2	9.8	2.08
1920675	202906	6.6	8.2	10.4	2.25
1920592	202875	6.9	8.4	10.6	2.31
1920495	202844	7.5	8.4	10.6	2.31
1920413	202814	7.1	7.6	9.8	2.08
1920322	202788	6.8	7.8	10.0	2.14

EASTING	NORTHING	EM38V	EM31H	EM31V	DEPTH(M)
1920238	202765	7.7	8.6	9.6	2.02
1920161	202741	6.5	8.2	9.0	1.85
1920078	202715	8.1	7.8	9.4	1.97
1919954	202677	7.6	8.2	10.0	2.14
1919867	202651	9.6	8.8	10.2	2.20
1919791	202628	8.0	8.4	10.6	2.31
1919703	202599	7.1	7.4	8.6	1.74
1919592	202562	7.4	7.4	9.0	1.85
1919509	202535	4.9	8.2	9.4	1.97
1919421	202507	4.9	7.0	8.2	1.62
1919329	202476	4.5	7.6	9.8	2.08
1919256	202453	8.2	8.4	10.6	2.31
1919179	202429	6.4	8.4	9.2	1.91
1919084	202401	5.4	6.8	8.0	1.56
1918984	202371	6.8	6.4	8.0	1.56
1918887	202342	4.4	6.2	7.4	1.39
1918799	202312	5.4	6.6	8.2	1.62
1918707	202282	7.6	8.4	10.4	2.25
1918667	202369	12.4	9.8	11.4	2.54
1918753	202396	10.1	8.6	11.2	2.48
1918840	202421	11.5	10.0	13.2	3.06
1918936	202449	11.3	9.6	13.2	3.06
1919041	202478	14.2	10.8	12.2	2.77
1919132	202510	10.7	10.0	12.2	2.77
1919204	202534	9.3	8.8	11.4	2.54
1919284	202559	7.0	8.0	10.0	2.14
1919379	202591	6.2	7.6	9.0	1.85
1919469	202618	4.5	6.4	8.6	1.74
1919551	202641	8.0	8.0	9.6	2.02
1919666	202677	7.5	8.4	10.0	2.14
1919754	202701	7.2	8.0	9.8	2.08
1919830	202723	12.8	11.2	14.4	3.41
1919918	202754	8.1	8.2	11.6	2.60
1920040	202793	8.3	8.2	11.0	2.43
1920121	202817	9.6	8.4	10.4	2.25
1920196	202841	9.5	7.4	9.4	1.97
1920270	202863	8.0	8.8	8.4	1.68
1920362	202892	7.2	6.8	8.6	1.74
1920435	202917	6.1	8.2	7.6	1.45
1920527	202947	7.4	7.4	9.4	1.97
1920590	202967	10.4	8.4	10.0	2.14
1920680	202999	11.8	8.6	8.8	1.79
1920764	203025	7.8	6.8	8.2	1.62
1920863	203061	9.5	8.8	10.6	2.31
1920959	203095	8.6	8.0	8.4	1.68
1921046	203123	5.4	6.4	7.0	1.28
1921133	203156	9.6	8.4	10.2	2.20
1921216	203188	8.9	8.2	10.4	2.25
1921299	203215	13.6	11.8	15.6	3.75
1921396	203250	8.8	8.8	10.8	2.37
1921480	203283	6.8	7.2	11.4	2.54
1921577	203318	8.4	7.8	9.0	1.85
1921661	203355	6.3	7.2	9.6	2.02
1921741	203392	8.4	9.2	9.4	1.97
1921690	203476	10.7	8.6	11.8	2.66

EASTING	NORTHING	EM38V	EM31H	EM31V	DEPTH(M)
1921603	203440	10.1	7.8	10.6	2.31
1921510	203401	11.1	8.8	10.0	2.14
1921412	203362	4.9	6.2	9.8	2.08
1921315	203333	9.3	8.2	11.8	2.66
1921234	203303	10.7	9.0	11.6	2.60
1921145	203268	5.7	6.2	7.4	1.39
1921042	203231	15.2	9.6	9.0	1.85
1920958	203198	3.4	4.4	6.6	1.16
1920855	203163	3.3	4.0	5.0	0.70
1920766	203137	6.2	5.4	5.6	0.87
1920770	203170	10.8	7.2	8.2	1.62
1920683	203107	9.8	6.8	7.4	1.39
1920586	203076	12.4	8.6	9.8	2.08
1920500	203044	11.3	7.2	7.8	1.51
1920391	203008	10.9	8.2	9.8	2.08
1920302	202980	10.3	7.6	10.0	2.14
1920218	202949	9.0	6.4	8.0	1.56
1920144	202926	11.1	6.8	8.0	1.56
1920056	202897	11.5	9.2	12.2	2.77
1919976	202874	12.5	9.6	10.6	2.31
1919857	202835	13.8	8.0	9.2	1.91
1919774	202810	10.6	7.0	6.6	1.16
1919702	202787	5.3	5.2	6.4	1.10
1919612	202760	6.8	6.0	7.8	1.51
1919501	202728	8.9	7.4	9.8	2.08
1919418	202703	7.8	8.6	11.0	2.43
1919329	202671	9.8	9.8	13.0	3.00
1919223	202640	14.4	11.4	14.8	3.52
1919148	202616	14.2	11.2	15.0	3.58
1919079	202594	17.1	10.6	13.0	3.00
1918991	202569	20.6	12.6	14.4	3.41
1918886	202535	12.1	8.6	10.6	2.31
1918790	202506	15.2	10.2	11.6	2.60
1918707	202473	11.8	8.6	11.6	2.60
1918620	202448			11.0	2.43
1918574	202536	12.2	8.2	10.6	2.31
1918663	202560	13.4	8.2	10.2	2.20
1918748	202584	13.3	9.0	12.2	2.77
1918841	202613	14.1	11.0	11.2	2.48
1918951	202646	11.2	9.0	11.6	2.60
1919037	202671	9.8	8.2	8.2	1.62
1919101	202690	4.9	6.8	7.6	1.45
1918179	202714	7.4	6.4	8.0	1.56
1919287	202748	6.6	6.6	9.4	1.97
1919377	202776	8.4	7.4	9.6	2.02
1919461	202799	8.4	7.6	8.6	1.74
1919571	202838	8.6	6.6	8.6	1.74
1919657	202861	7.9	7.0	8.4	1.68
1919732	202885	7.3	5.6	8.0	1.56
1919824	202912	9.6	6.8	7.4	1.39
1919939	202953	9.0	6.6	10.6	2.31
1920016	202978	9.4	7.4	7.6	1.45
1920110	203012	9.1	7.0	10.2	2.20
1920173	203034	12.0	7.6	9.2	1.91
1920257	203063	13.0	8.6	5.8	0.93

EASTING	NORTHING	EM38V	EM31H	EM31V	DEPTH(M)
1920338	203091	2.7	3.8	6.0	0.99
1920441	203129	7.3	6.4	4.4	0.53
1920527	203154	3.9	3.8	7.6	1.45
1920610	203177	6.4	5.2	5.8	0.93
1920689	203203	3.1	3.6	4.0	0.41
1920770	203226	1.8	3.4	7.4	1.39
1920873	203265	10.7	6.2	9.4	1.97
1920970	203296	9.7	7.4	9.0	1.85
1921057	203329	9.3	7.0	8.8	1.79
1921163	203364	9.6	7.6	7.2	1.33
1921240	203400	5.2	5.6	6.6	1.16
1921327	203430	4.0	4.8	7.0	1.28
1921458	203484	8.4	6.2	8.0	1.56
1921556	203520	5.6	5.6	5.4	0.82
1921643	203553	7.0	5.0	8.8	1.79
1921612	203627	8.7	7.2	8.0	1.56
1921517	203596	8.1	6.8	7.8	1.51
1921428	203563	9.3	7.4	8.4	1.68
1921340	203525	8.9	6.6	7.4	1.39
1921253	203487	8.0	6.0	7.6	1.45
1921187	203456	6.1	5.8	5.0	0.70
1921104	203423	2.4	3.4	5.4	0.82
1921002	203385	3.8	4.4	5.0	0.70
1920904	203354	4.4	4.0	5.0	0.70
1920811	203322	8.1	5.0	4.4	0.53
1920704	203294	3.4	4.0	3.2	0.18
1920623	203275	2.8	3.2	4.0	0.41
1920527	203249	3.7	3.6	3.8	0.36
1920478	203235	5.8	4.6	4.0	0.41
1920389	203203	2.8	3.8	4.0	0.41
1920287	203175	3.8	4.4	4.4	0.53
1920207	203148	4.2	3.8	4.8	0.64
1920140	203122	4.5	4.8	9.2	1.91
1920072	203095	8.3	7.2	7.8	1.51
1919979	203061	8.2	6.0	7.0	1.28
1919900	203033	8.4	6.4	8.2	1.62
1919780	202996	8.5	6.8	8.4	1.68
1919698	202972	11.5	8.2	6.4	1.10
1919607	202947	4.1	4.4	8.4	1.68
1919523	202924	8.5	8.0	8.2	1.62
1919411	202888	7.6	7.0	7.8	1.51
1919330	202858	6.6	6.6	7.2	1.33
1919240	202827	4.0	5.8	7.2	1.33
1919137	202797	7.1	6.2	7.4	1.39
1919056	202772	7.7	6.6	8.4	1.68
1918995	202753	6.2	6.4	7.0	1.28
1918912	202727	7.2	5.8	8.0	1.56
1918797	202694	6.4	6.6	11.8	2.66
1918703	202666	11.3	8.8	10.2	2.20
1918618	202642	12.2	9.0	9.4	1.97
1918534	202615	13.2	8.0	11.8	2.66
1918487	202693	13.4	10.0	11.4	2.54
1918570	202720	10.2	8.8	11.6	2.60
1918661	202744	10.2	9.0	10.8	2.37
1918755	202778	9.1	8.4	10.8	2.37

EASTING	NORTHING	EM38V	EM31H	EM31V	DEPTH(M)
1918866	202810	6.8	8.4	7.4	1.39
1918949	202835	5.1	6.8	7.8	1.51
1919005	202851	11.0	7.6	8.2	1.62
1919088	202875	7.5	7.2	7.8	1.51
1919196	202905	9.5	7.0	7.6	1.45
1919285	202933	5.3	5.8	8.2	1.62
1919370	202961	7.2	6.8	8.6	1.74
1919479	202996	7.6	6.4	11.0	2.43
1919561	203022	10.4	8.2	6.8	1.22
1919654	203054	6.8	6.2	5.2	0.76
1919735	203073	8.1	5.4	8.2	1.62
1919852	203109	12.2	7.4	5.8	0.93
1919943	203141	5.7	5.2	5.8	0.93
1920032	203173	6.5	4.4	11.2	2.48
1920095	203197	10.4	8.2	6.8	1.22
1920162	203215	10.0	7.2	5.2	0.76
1920240	203243	5.6	4.6	3.4	0.24
1920330	203273	2.8	2.8	3.6	0.30
1920404	203299	2.6	2.8	3.8	0.36
1920486	203325	4.6	4.4	3.8	0.36
1920572	203349	3.0	3.0	6.8	1.22
1920664	203383	9.0	5.2	5.6	0.87
1920764	203412	10.8	7.4	6.8	1.22
1920864	203440	10.6	5.6	7.8	1.51
1920952	203466	9.7	7.4	9.2	1.91
1921049	203496	12.1	8.2	7.8	1.51
1921138	203523	9.3	6.4	6.0	0.99
1921224	203556	9.3	5.8	8.0	1.56
1921311	203594	8.6	6.4	5.4	0.82
1921398	203631	6.6	5.4	8.6	1.74
1921487	203666	7.5	7.4	10.8	2.37
1921559	203689	9.4	7.8	9.6	2.02
1921530	203764	10.0	7.8	10.4	2.25
1921455	203735	11.1	7.8	11.8	2.66
1921365	203704	12.1	9.4	11.8	2.66
1921277	203674	10.7	9.0	9.4	1.97
1921189	203645	10.2	7.4	7.2	1.33
1921085	203606	13.0	7.4	7.8	1.51
1921005	203572	12.6	7.6	10.8	2.37
1920913	203545	11.5	8.2	10.0	2.14
1920817	203520	12.6	7.8	9.8	2.08
1920720	203497	13.6	8.4	9.0	1.85
1920622	203469	10.1	7.6	9.4	1.97
1920537	203437	10.8	6.8	12.6	2.89
1920445	203408	15.6	11.0	9.4	1.97
1920362	203378	12.1	6.8	12.4	2.83
1920276	203358	15.9	10.4	9.8	2.08
1920183	203327	13.3	8.2	6.0	0.99
1920112	203298	4.8	3.8	6.4	1.10
1920044	203273	8.7	5.8	4.0	0.41
1919991	203253	3.2	3.4	6.4	1.10
1919896	203220	9.9	6.2	6.2	1.05
1919809	203190	3.3	3.4	7.8	1.51
1919692	203154	10.5	6.8	9.6	2.02
1919609	203127	9.6	7.2	9.6	2.02

EASTING	NORTHING	EM38V	EM31H	EM31V	DEPTH(M)
1919519	203097	8.5	7.6	9.2	1.91
1919433	203070	8.7	7.2	9.6	2.02
1919320	203030	9.7	6.6	9.2	1.91
1919237	203006	8.4	6.6	9.2	1.91
1919148	202982	7.3	6.4	9.8	2.08
1919042	202956	8.3	8.0	10.0	2.14
1918961	202930	9.9	8.0	8.8	1.79
1918910	202919	7.5	7.0	7.4	1.39
1918819	202894	6.2	5.8	7.2	1.33
1918709	202865	8.4	6.0	7.2	1.33
1918606	202836	0.2	6.6	8.6	1.74
1918525	202811	10.6	7.0	12.4	2.83
1918444	202788	16.9	10.0	12.8	2.95
1918398	202870	13.9	9.8	8.6	1.74
1918478	202904	6.6	7.0	5.2	0.76
1918574	202927	2.8	4.0	6.8	1.22
1918666	202956	7.7	5.6	7.4	1.39
1918771	202977	4.7	6.8	8.4	1.68
1918869	202998	5.4	6.4	11.2	2.48
1918912	203009	8.9	8.8	12.6	2.89
1918997	203033	10.5	9.2	9.2	1.91
1919095	203055	6.0	6.8	7.4	1.39
1919191	203087	5.8	6.0	8.2	1.62
1919270	203110	4.7	6.2	9.8	2.08
1919384	203152	6.5	7.4	7.8	1.51
1919467	203181	4.8	6.0	7.0	1.28
1919556	203211	6.3	6.0	7.6	1.45
1919646	203240	4.9	6.2	7.2	1.33
1919755	203273	8.0	6.6	4.4	0.53
1919830	203308	7.9	3.0	6.2	1.05
1919936	203348	7.9	6.6	7.0	1.28
1919993	203363	7.7	6.4	8.2	1.62
1920061	203392	6.9	7.4	11.0	2.43
1920150	203425	9.5	9.0	11.8	2.66
1920186	203422	8.4	8.4	11.4	2.54
1920230	203458	9.5	8.8	8.6	1.74
1920304	203484	7.0	6.4	9.6	2.02
1920400	203515	7.1	7.2	8.6	1.74
1920494	203545	5.9	6.6	9.4	1.97
1920572	203573	5.9	6.8	8.4	1.68
1920674	203596	5.6	6.0	7.2	1.33
1920770	203619	7.7	7.4	7.6	1.45
1920870	203645	9.2	7.6	7.8	1.51
1920959	203669	5.7	5.8	5.8	0.93
1921037	203690	4.5	4.8	7.2	1.33
1921155	203727	5.8	6.2	6.8	1.22
1921327	203784	6.3	5.8	7.0	1.28
1921423	203813	6.4	6.4	11.4	2.54
1921454	203916	8.0	9.0	7.6	1.45
1921392	203900	6.6	6.0	10.0	2.14
1921288	203862	8.6	7.2	8.8	1.79
1921119	203811	6.4	7.4	8.4	1.68
1920989	203770	7.4	7.4	7.0	1.28
1920914	203753	2.6	4.4	5.8	0.93
1920828	203723	6.2	5.8	7.4	1.39

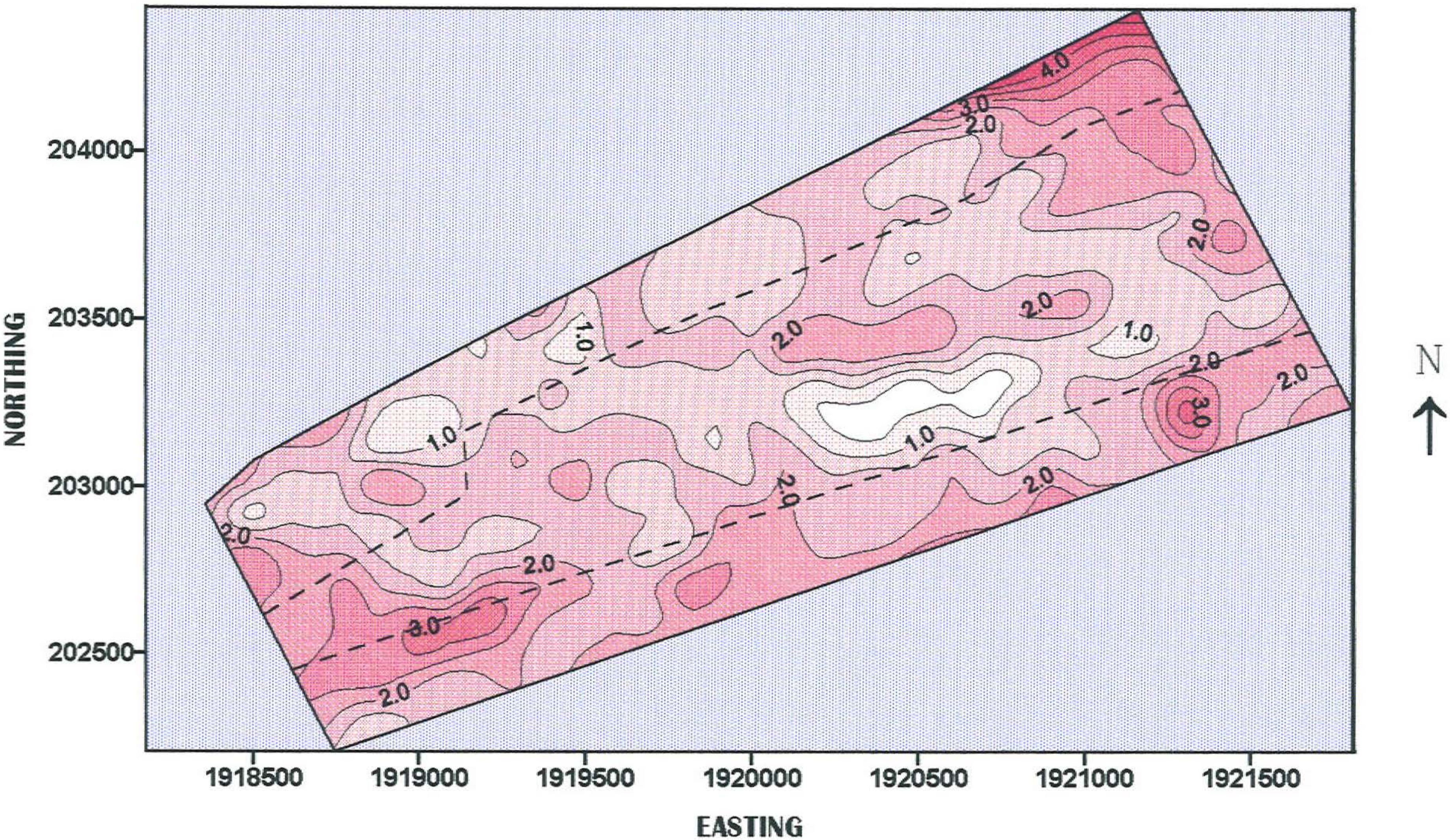
EASTING	NORTHING	EM38V	EM31H	EM31V	DEPTH(M)
1920728	203704	7.0	6.8	6.2	1.05
1920634	203673	6.3	7.0	7.6	1.45
1920538	203646	4.9	5.0	8.8	1.79
1920457	203622	8.0	7.6	4.8	0.64
1920364	203595	1.3	4.0	7.2	1.33
1920274	203566	5.9	6.0	8.4	1.68
1920196	203539	5.6	6.2	9.4	1.97
1920099	203497	6.7	7.0	8.2	1.62
1920017	203467	5.1	6.4	6.8	1.22
1919941	203446	5.8	5.8	6.0	0.99
1919886	203426	6.4	5.8	10.2	2.20
1919781	203385	6.5	7.6	9.0	1.85
1919704	203363	4.9	7.0	7.8	1.51
1919599	203326	8.5	7.4	7.0	1.28
1919506	203288	6.8	7.4	8.2	1.62
1919418	203256	4.4	6.8	7.8	1.51
1919331	203227	2.4	5.0	7.6	1.45
1919215	203193	5.4	6.2	7.8	1.51
1919133	203165	6.6	6.6	5.8	0.93
1919044	203144	4.6	3.4	6.0	0.99
1918949	203119	6.0	5.8	4.8	0.64
1918871	203104	5.7	5.4	5.2	0.76
1918824	203089	5.9	5.0	6.2	1.05
1918726	203062	5.8	5.8	7.2	1.33
1918623	203034	5.9	5.8	7.2	1.33
1918534	203004	7.3	6.4	7.6	1.45
1918437	202973	7.8	6.6	11.2	2.48
1918355	202947	12.6	9.2	10.2	2.20
1918679	203145	9.7	6.6	10.6	2.31
1918776	203171	12.3	8.6	10.4	2.25
1918819	203179	11.8	8.6	8.4	1.68
1918904	203202	8.7	7.0	5.0	0.70
1919000	203227	3.6	4.8	5.6	0.87
1919080	203239	4.1	4.6	5.2	0.76
1919171	203271	7.7	6.2	8.0	1.56
1919279	203306	8.0	7.0	6.4	1.10
1919365	203333	7.5	5.8	8.8	1.79
1919452	203371	12.3	8.0	4.0	0.41
1919554	203414	3.0	4.6	8.0	1.56
1919653	203448	7.3	7.0	10.0	2.14
1919737	203472	7.3	8.2	6.8	1.22
1919832	203509	7.8	6.4	6.6	1.16
1919878	203527	8.0	6.2	7.6	1.45
1919961	203557	4.8	6.0	7.8	1.51
1920056	203589	6.4	6.6	7.2	1.33
1920154	203623	5.8	6.2	7.6	1.45
1920234	203641	4.6	6.0	8.4	1.68
1920329	203670	5.3	7.0	9.6	2.02
1920419	203697	7.5	7.6	6.8	1.22
1920496	203726	4.4	5.2	6.0	0.99
1920598	203755	4.5	5.2	6.6	1.16
1920686	203786	4.7	5.6	6.6	1.16
1920779	203812	4.9	5.6	7.2	1.33
1920861	203841	7.8	7.2	9.8	2.08
1920937	203865	7.5	7.4	12.8	2.95

EASTING	NORTHING	EM38V	EM31H	EM31V	DEPTH(M)
1921073	203904	9.3	9.0	11.4	2.54
1921241	203960	6.1	8.0	11.4	2.54
1921338	203995	8.2	8.4	13.4	3.12
1921395	204015	7.6	9.0	9.0	1.85
1921353	204095	4.7	6.8	10.6	2.31
1921296	204077	6.7	7.6	10.0	2.14
1921204	204047	5.4	7.2	11.6	2.60
1921033	203992	6.5	7.6	10.0	2.14
1920890	203943	7.2	7.8	7.0	1.28
1920814	203917	5.0	5.6	6.0	0.99
1920740	203890	5.3	6.0	8.0	1.56
1920647	203864	8.7	7.4	8.6	1.74
1920557	203839	7.0	7.2	8.4	1.68
1920455	203810	4.3	6.4	9.0	1.85
1920376	203783	6.0	6.6	7.4	1.39
1920288	203754	4.4	7.2	9.0	1.85
1920200	203728	7.4	7.0	8.8	1.79
1920116	203709	9.9	8.6	6.4	1.10
1920007	203678	12.1	8.6	5.4	0.82
1919912	203643	3.3	5.0	7.4	1.39
1919829	203614	7.9	6.8	7.0	1.28
1919781	203599	7.5	7.4	6.0	0.99
1919689	203566	6.6	6.0	6.2	1.05
1919604	203534	5.8	6.0	9.8	2.08
1919498	203498	7.5	8.6	5.4	0.82
1919400	203454	3.3	4.0	4.6	0.59
1919316	203421	5.2	4.8	8.6	1.74
1919231	203389	3.6	5.6	4.8	0.64
1919133	203355	2.4	4.6	7.2	1.33
1919032	203330	4.3	5.0	7.0	1.28
1919269	203486	8.4	5.2	6.6	1.16
1919350	203518	8.2	5.2	12.6	2.89
1919448	203569	8.1	7.2	7.0	1.28
1919552	203611	4.2	6.6	8.6	1.74
1919650	203647	7.8	8.0	9.0	1.85
1919728	203673	8.4	7.8	7.4	1.39
1919788	203695	4.9	6.2	7.6	1.45
1919862	203723	5.6	7.0	6.6	1.16
1919968	203759	5.1	6.6	7.0	1.28
1920076	203795	7.9	6.6	8.2	1.62
1920161	203821	6.9	7.6	7.4	1.39
1920252	203848	5.5	6.4	8.6	1.74
1920327	203866	4.9	7.2	7.6	1.45
1920411	203892	3.3	6.4	7.2	1.33
1920514	203923	5.3	6.4	6.8	1.22
1920610	203949	5.7	6.4	6.0	0.99
1920689	203979	4.0	4.8	9.2	1.91
1920765	204007	4.0	6.0	11.4	2.54
1920840	204035	5.7	8.8	11.8	2.66
1920996	204082	6.7	8.6	10.2	2.20
1921161	204137	4.4	7.0	13.0	3.00
1921259	204163	6.6	9.2	9.8	2.08
1921309	204185	3.8	7.4	14.0	3.29
1921270	204262	8.3	10.6	14.0	3.29
1921228	204251	6.5	10.2	12.2	2.77

EASTING	NORTHING	EM38V	EM31H	EM31V	DEPTH(M)
1921121	204222	4.6	8.8	11.4	2.54
1920956	204167	5.9	8.6	12.0	2.71
1920795	204111	5.4	9.2	10.2	2.20
1920725	204088	4.5	9.4	5.0	0.70
1920639	204069	1.4	4.4	7.2	1.33
1920559	204046	4.9	6.8	7.8	1.51
1920469	204012	4.5	5.6	8.0	1.56
1920373	203981	6.6	7.2	8.4	1.68
1920291	203949		6.4	9.2	1.91
1920211	203935		7.4	7.4	1.39
1920122	203910		6.4	7.6	1.45
1920469	204009		5.4	12.4	2.83
1920588	204141	11.4	10.6	14.6	3.46
1920674	204173	10.3	9.8	18.2	4.50
1920755	204201	10.7	12.6	18.0	4.44
1920915	204258	11.6	12.2	16.8	4.10
1921081	204313	12.5	12.6	14.8	3.52
1921194	204346	9.3	10.4	16.0	3.87
1921165	204425	12.1	12.0	21.2	5.36

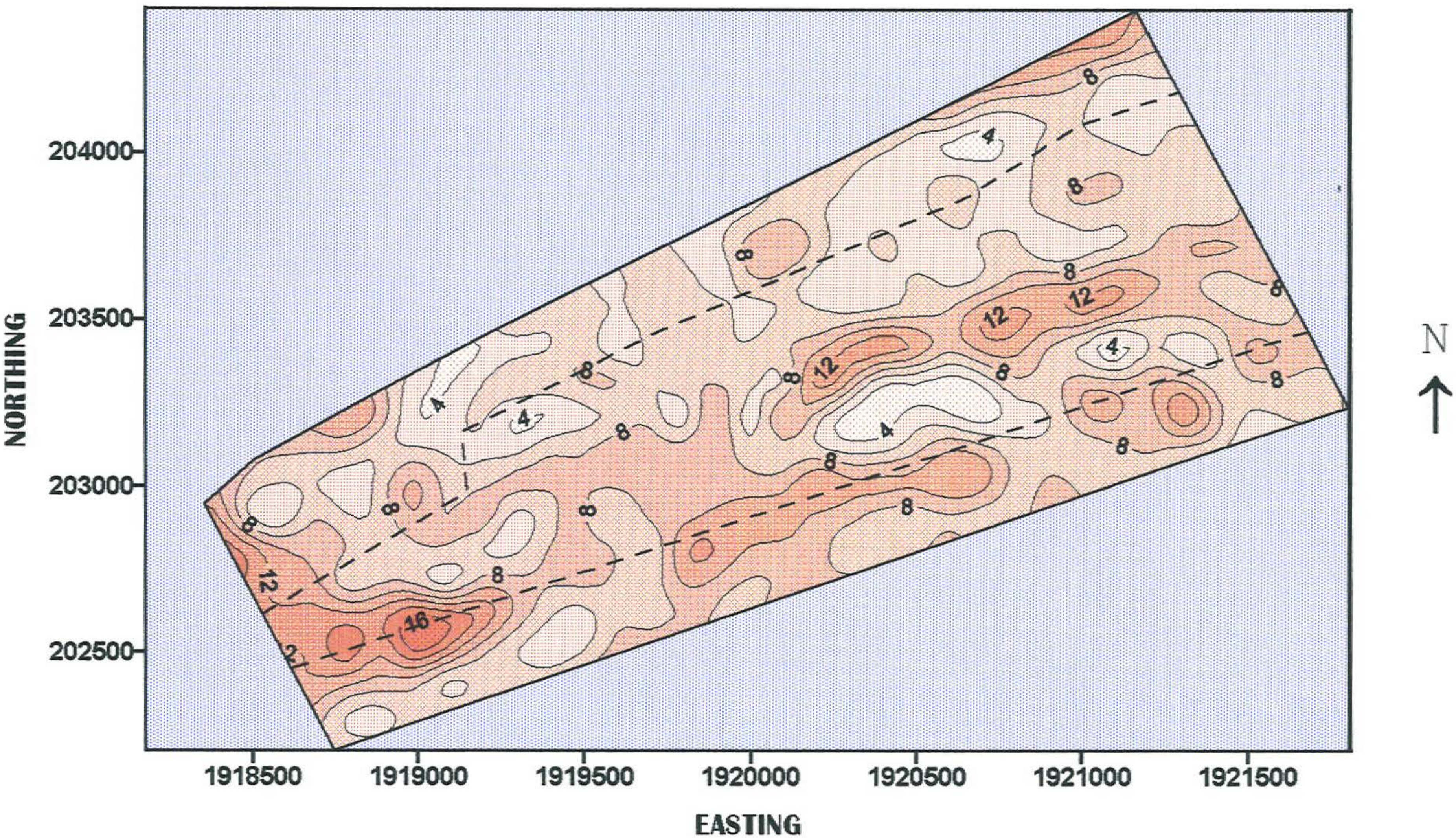
EM SURVEY
ROCKSPRING RESEARCH FARM

INTERPRETED DEPTH TO BEDROCK
(meters)



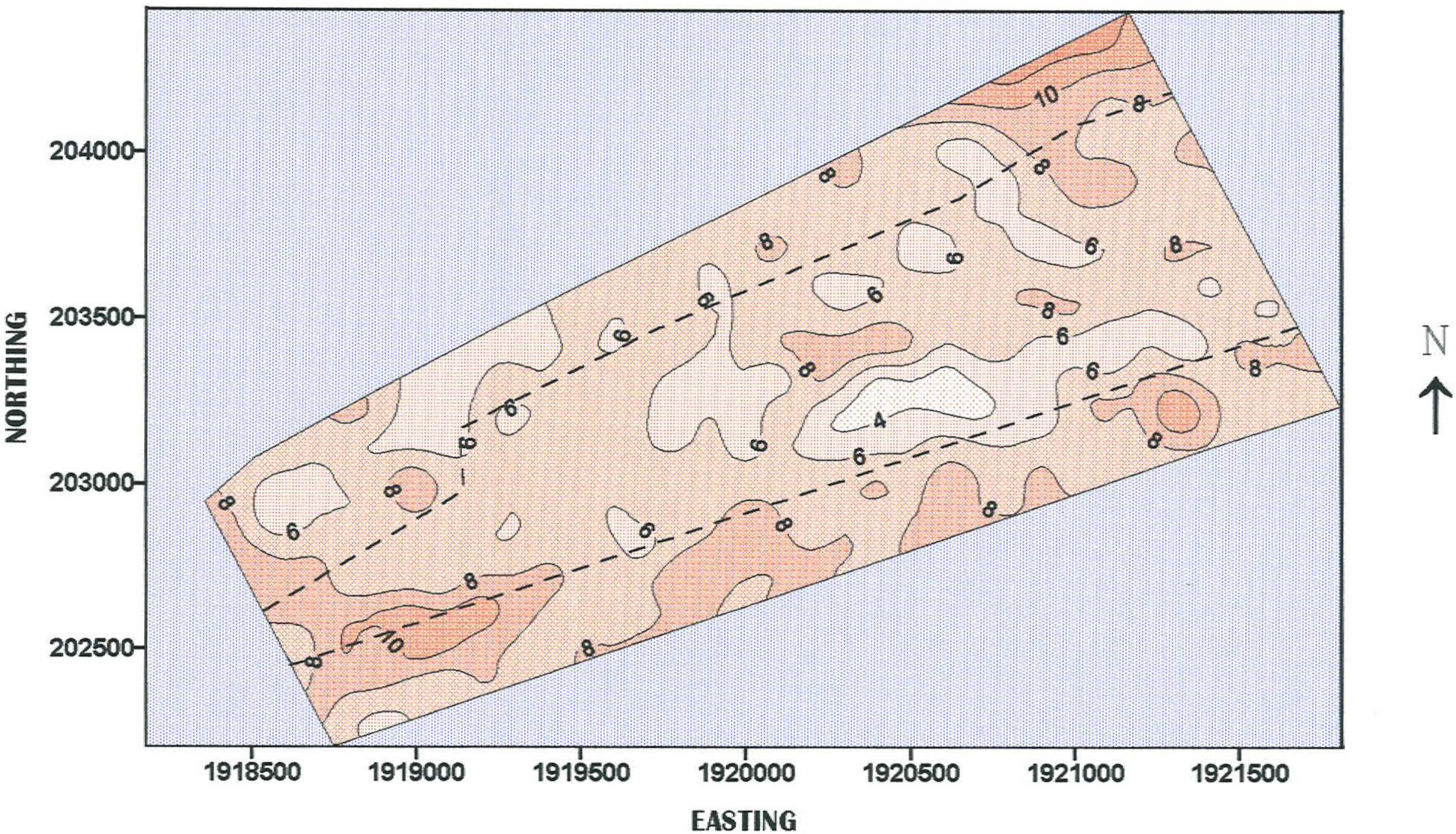
EM SURVEY
ROCKSPRING RESEARCH FARM

EM38 METER
VERTICAL DIPOLE ORIENTATION



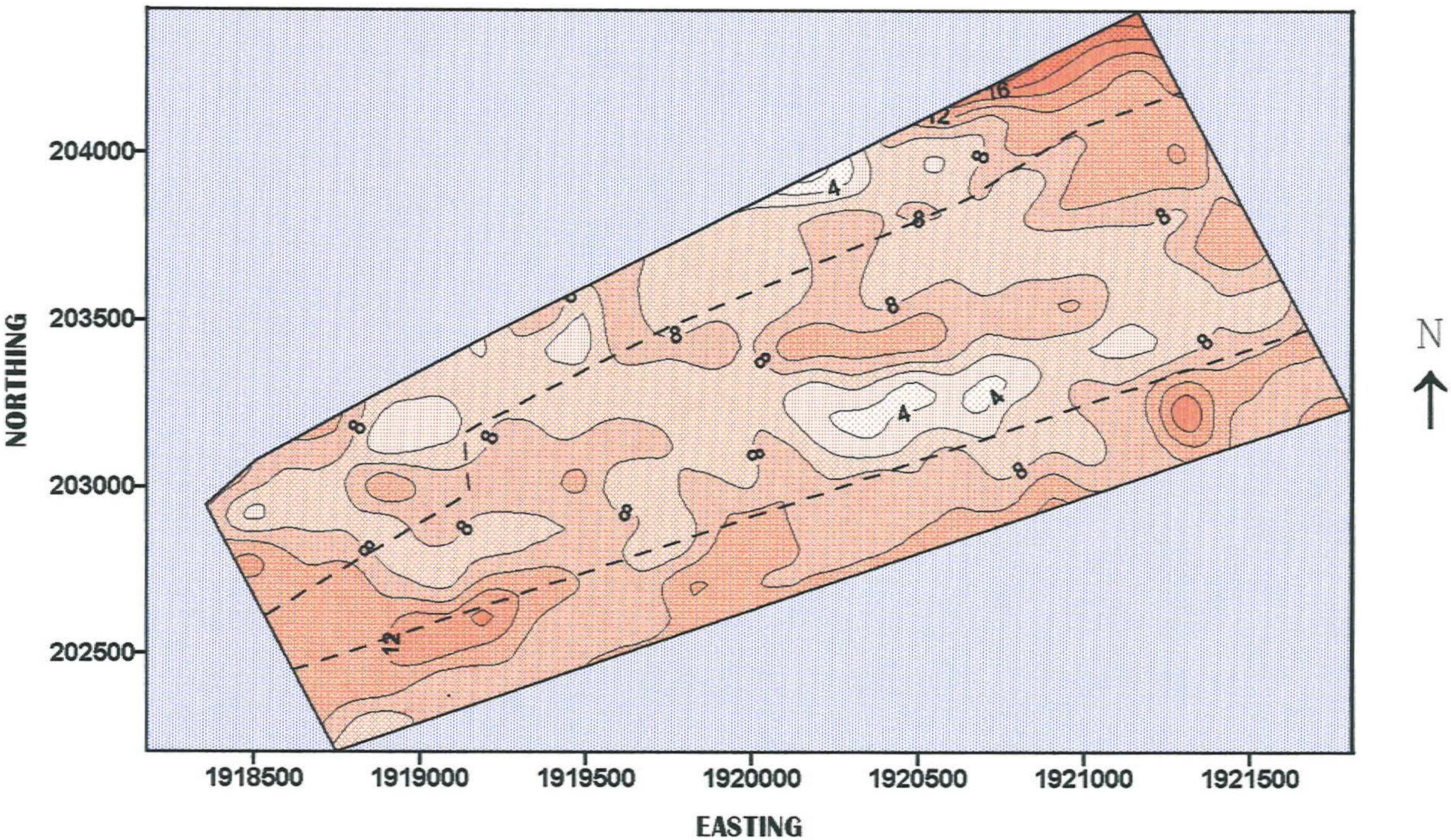
EM SURVEY
ROCKSPRING RESEARCH FARM

EM31 METER
HORIZONTAL DIPOLE ORIENTATION



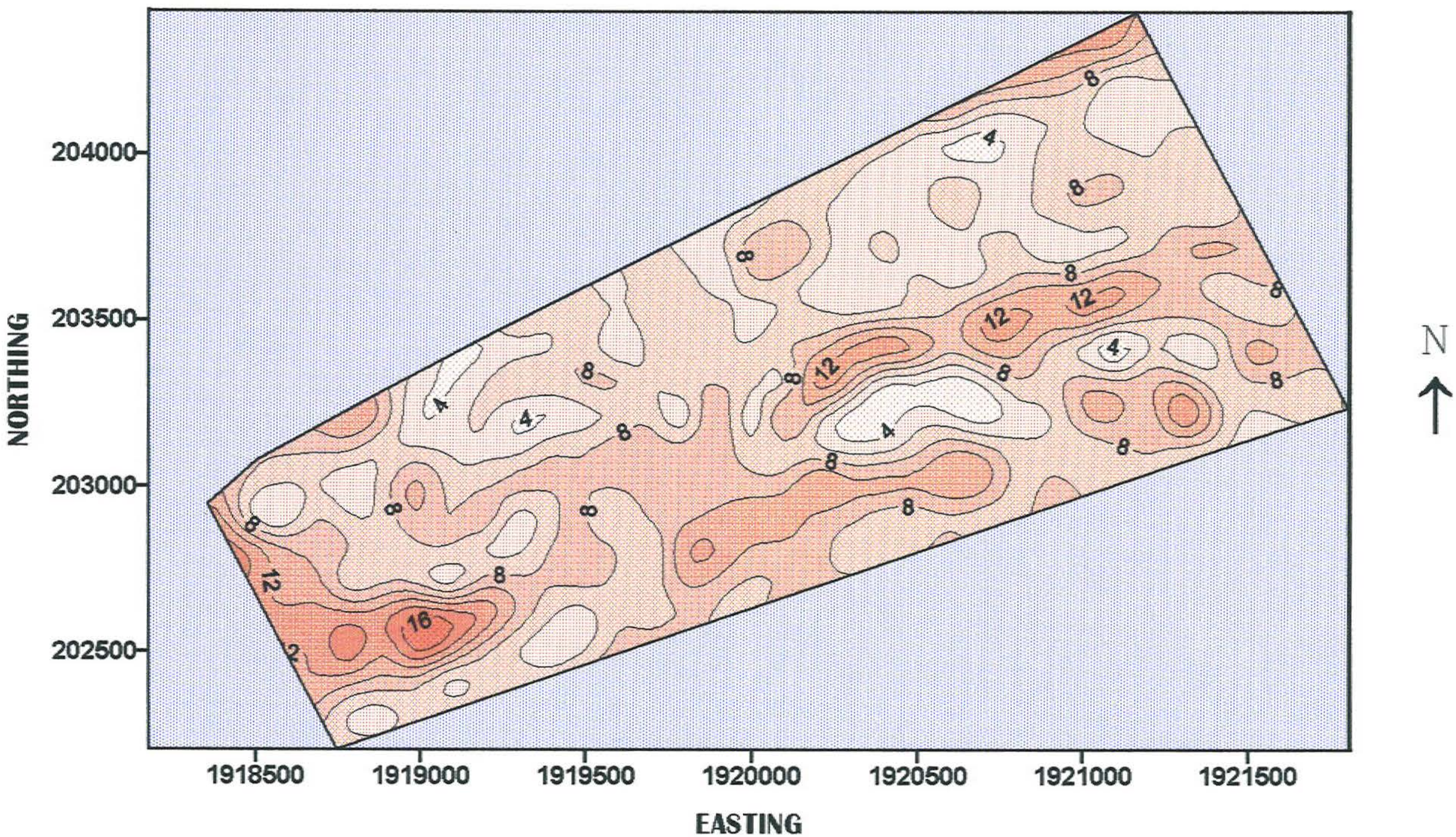
EM SURVEY
ROCKSPRING RESEARCH FARM

EM31 METER
VERTICAL DIPOLE ORIENTATION



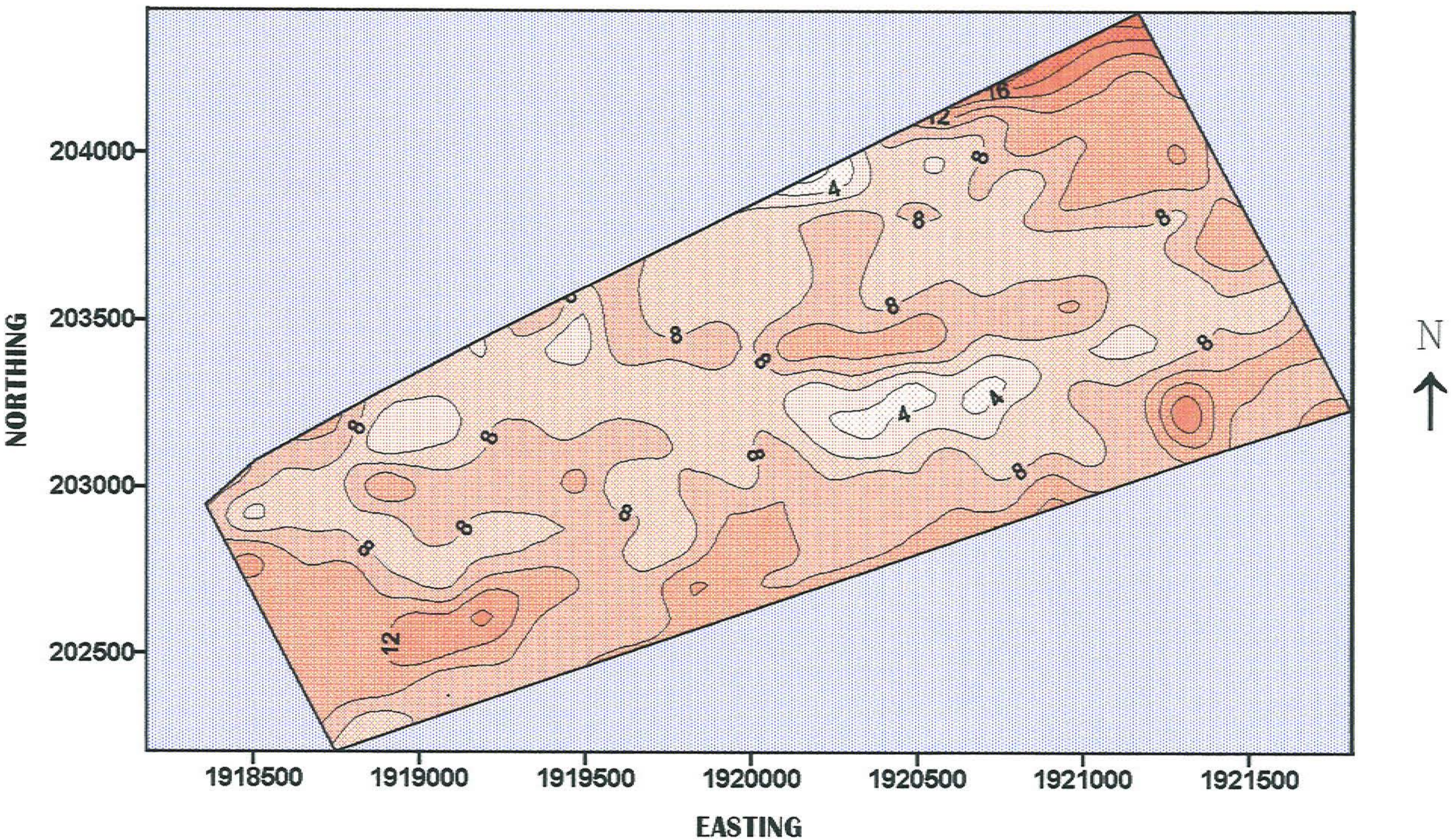
EM SURVEY
ROCKSPRING RESEARCH FARM

EM38 METER
VERTICAL DIPOLE ORIENTATION



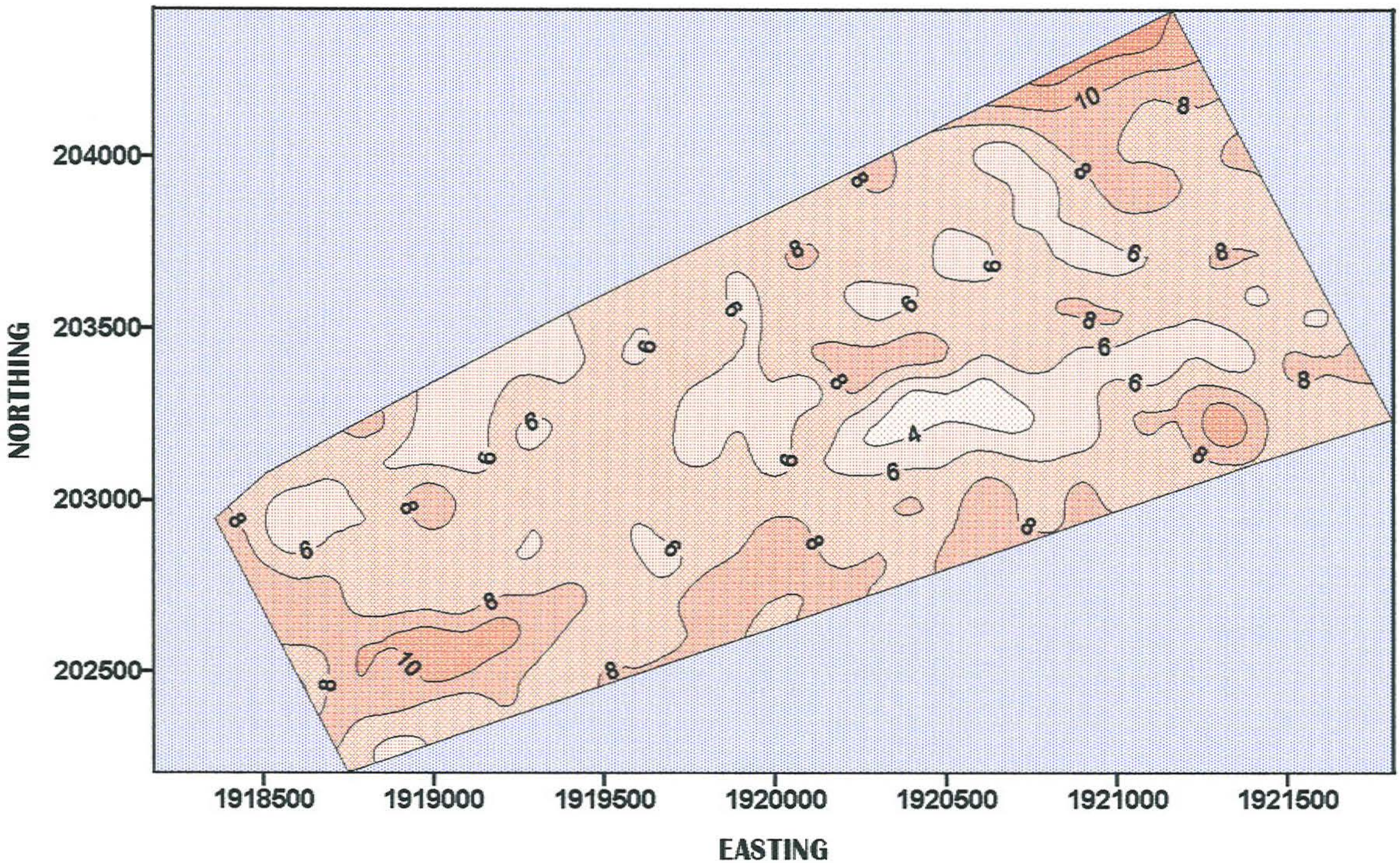
EM SURVEY
ROCKSPRING RESEARCH FARM

EM31 METER
VERTICAL DIPOLE ORIENTATION



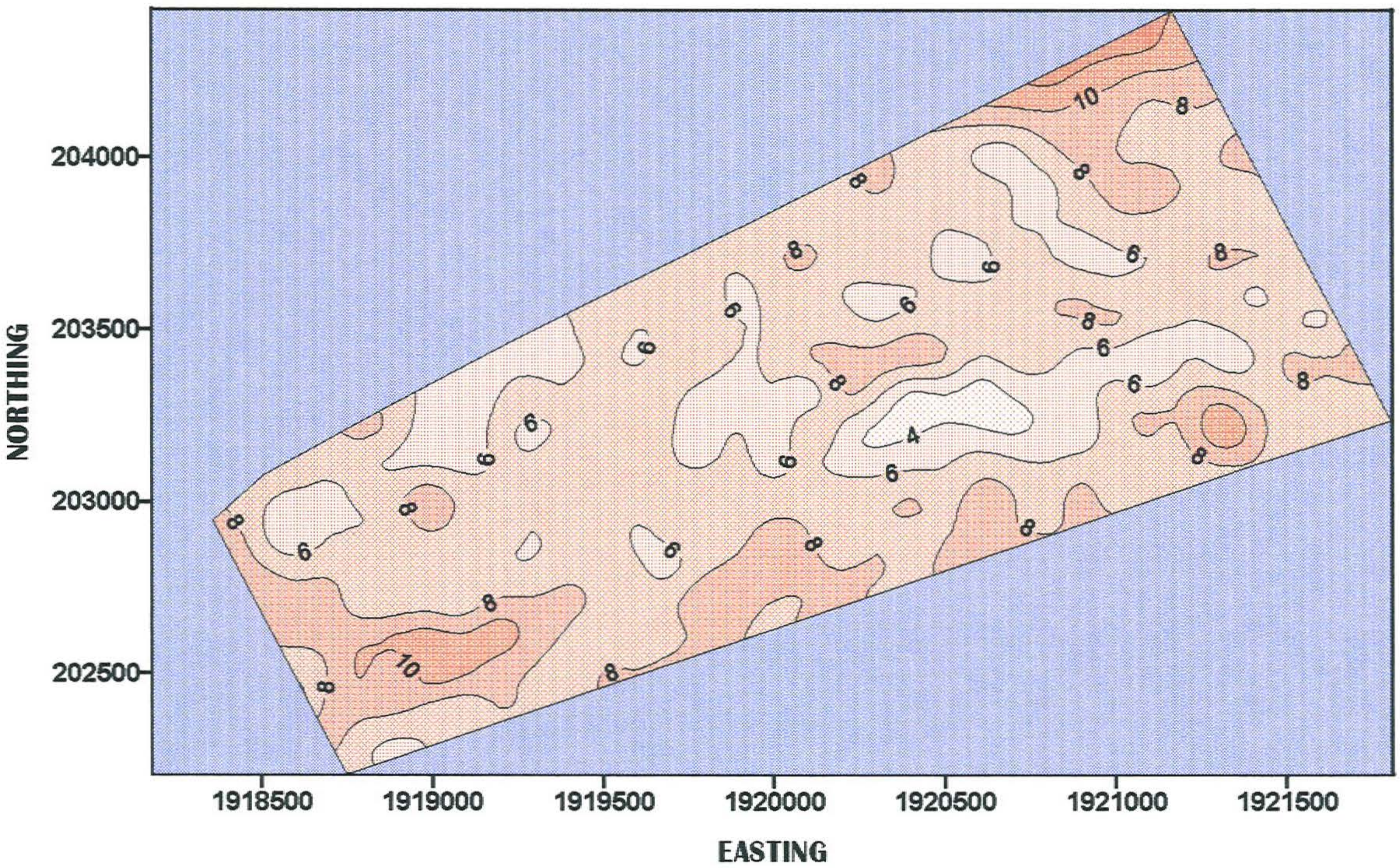
EM SURVEY
ROCKSPRING RESEARCH FARM

EM31 METER
HORIZONTAL DIPOLE ORIENTATION



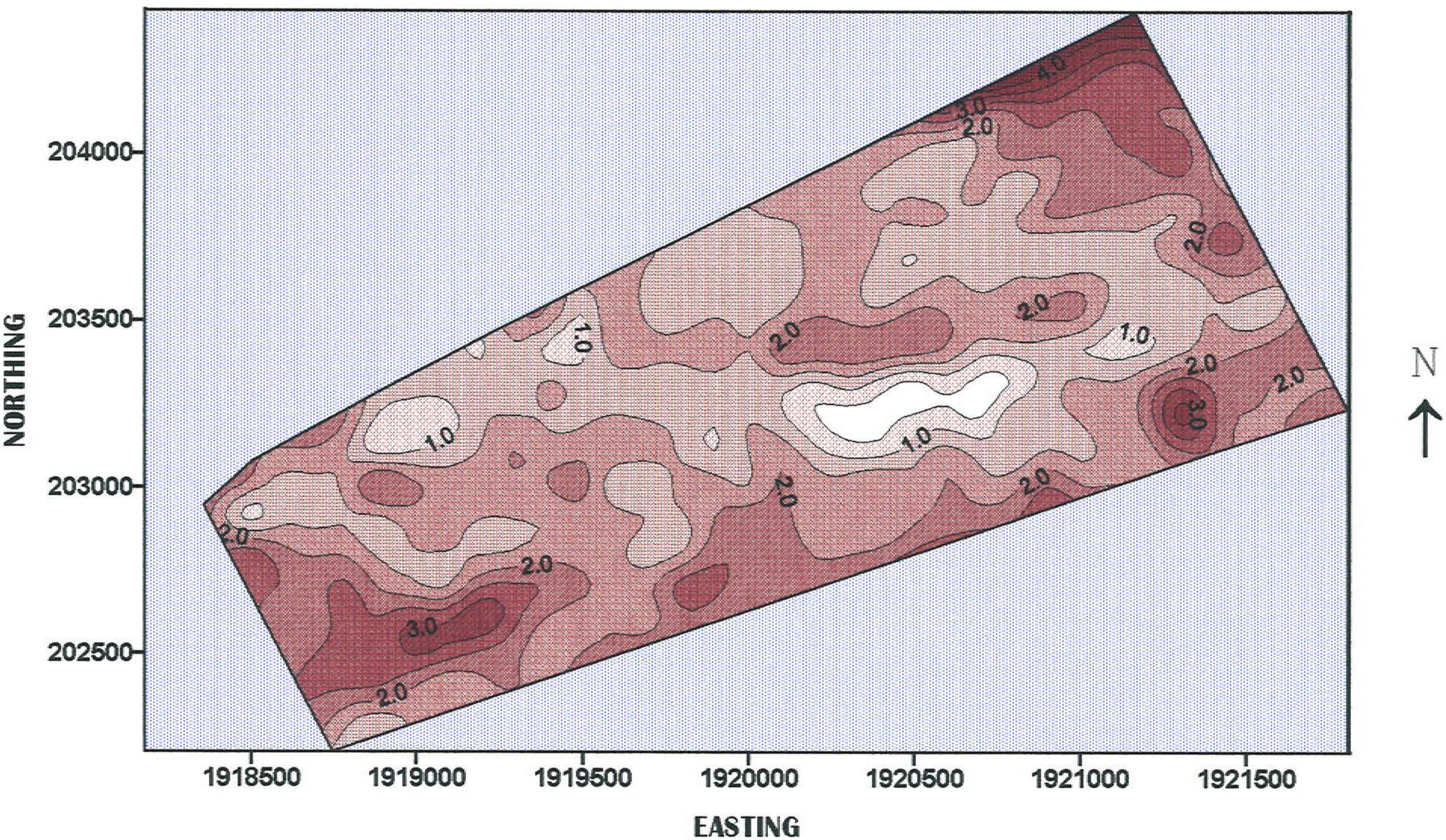
EM SURVEY
ROCKSPRING RESEARCH FARM

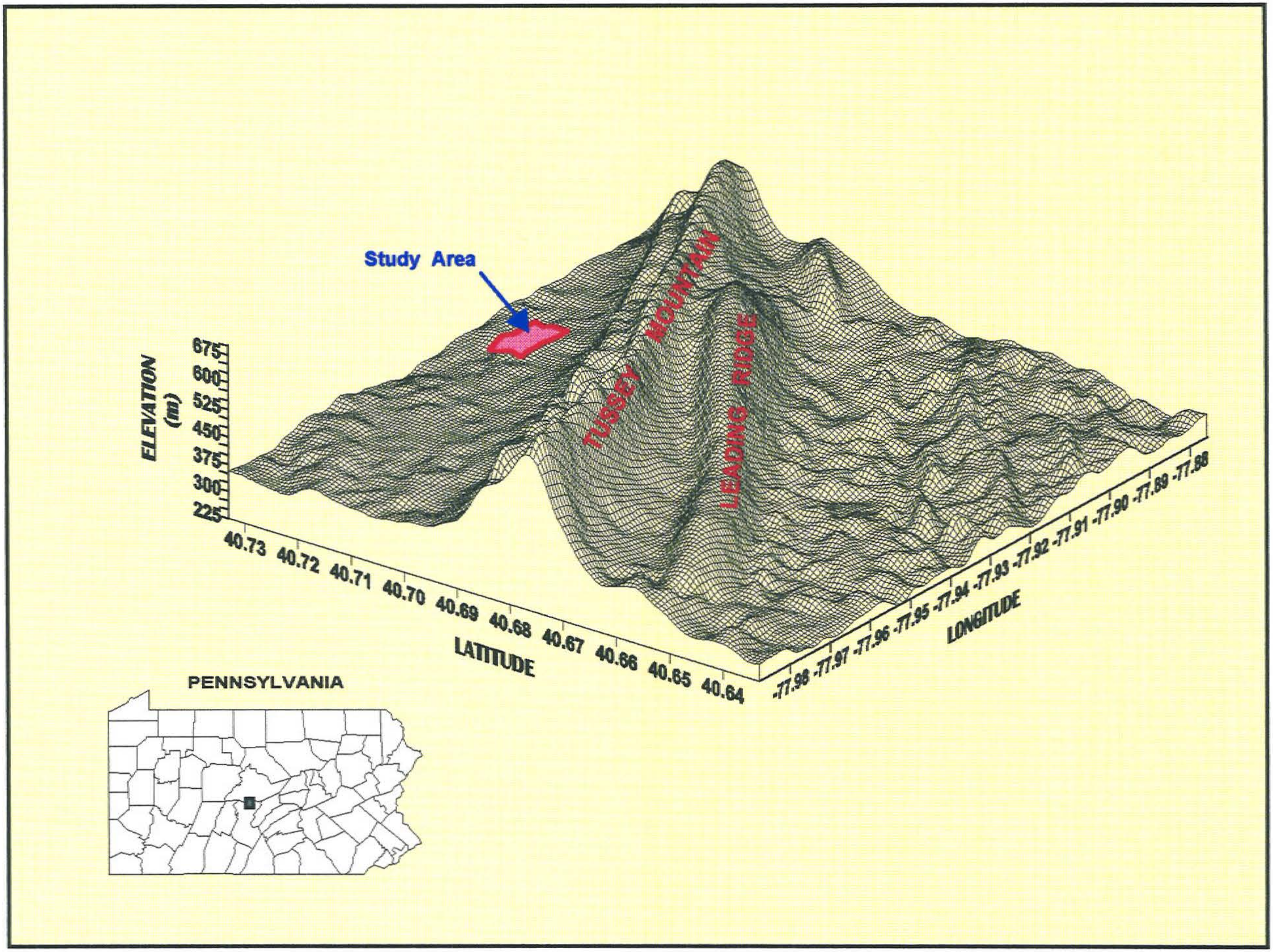
EM31 METER
HORIZONTAL DIPOLE ORIENTATION



EM SURVEY
ROCKSPRING RESEARCH FARM

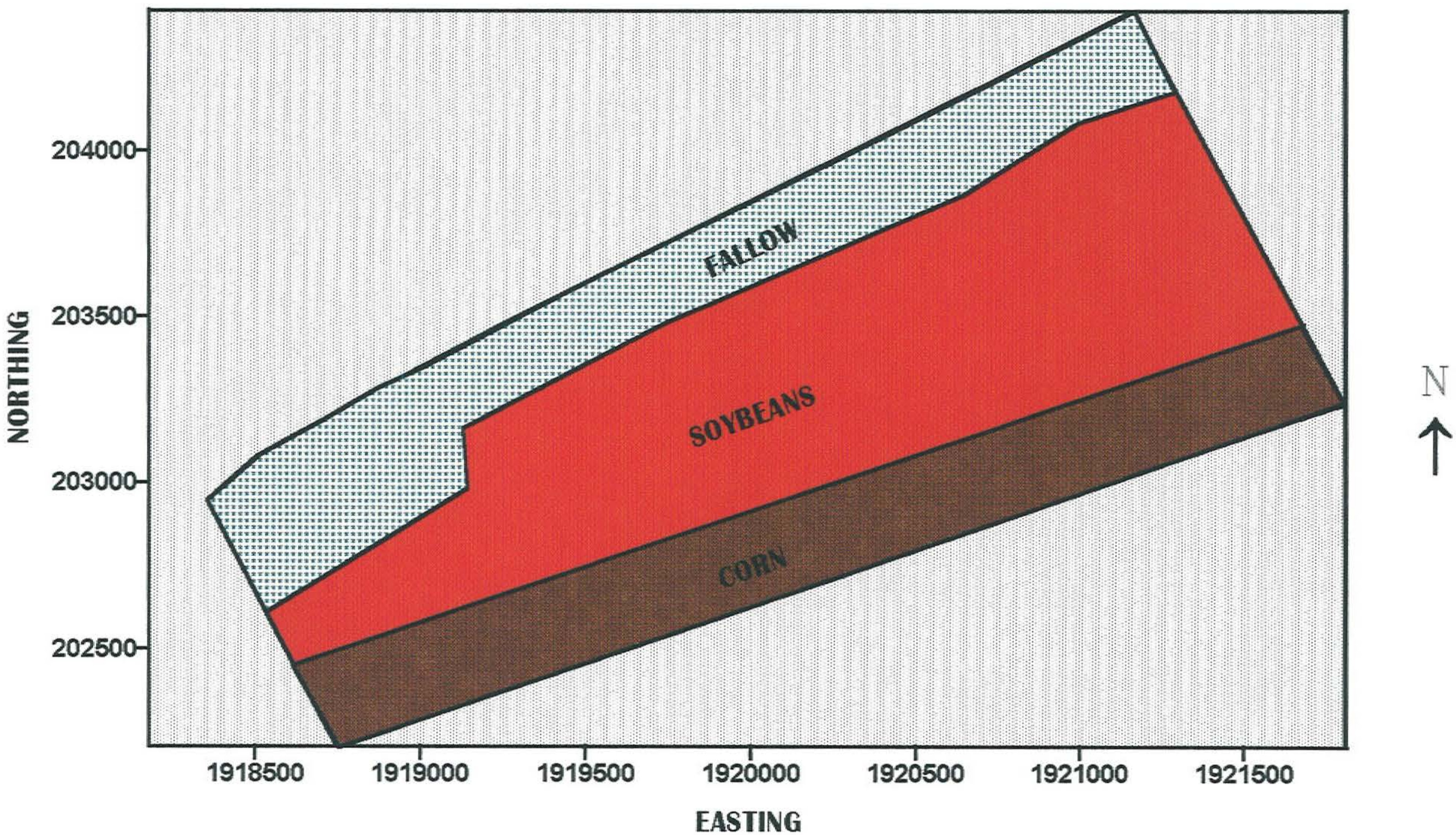
INTERPRETED DEPTH TO BEDROCK
(meters)




Study Area
TUSSEY MOUNTAIN
LEADING RIDGE
ELEVATION
(m)
225
300
375
450
525
600
675
40.73 40.72 40.71 40.70 40.69 40.68 40.67 40.66 40.65 40.64
LATITUDE
-77.98 -77.97 -77.96 -77.95 -77.94 -77.93 -77.92 -77.91 -77.90 -77.89 -77.88
LONGITUDE
PENNSYLVANIA

EM SURVEY
ROCKSPRING RESEARCH FARM

LAND USE



EM SURVEY
ROCKSPRING RESEARCH FARM

EM38 METER
VERTICAL DIPOLE ORIENTATION

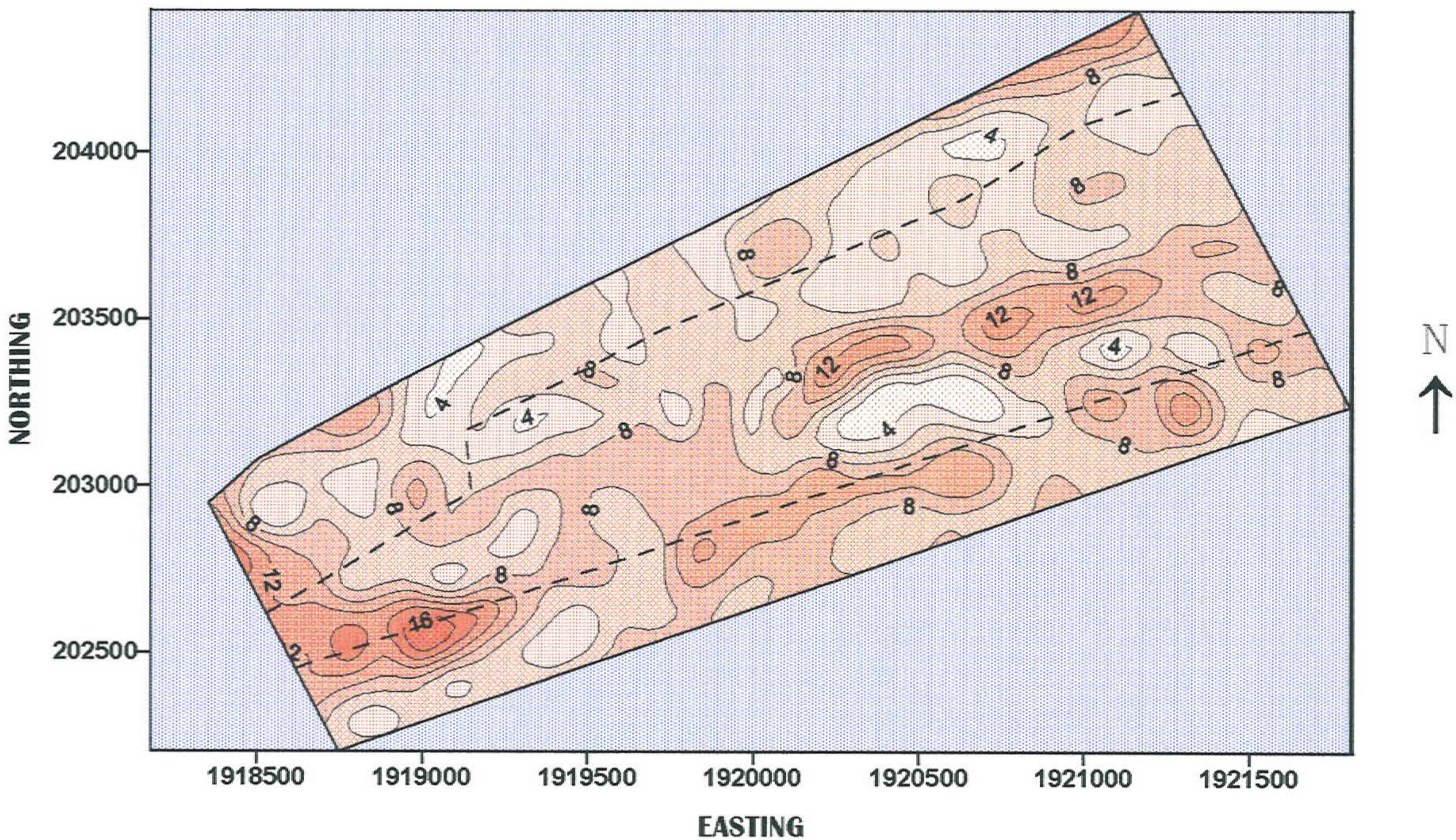


FIGURE 3

EM SURVEY
ROCKSPRING RESEARCH FARM

EM31 METER
HORIZONTAL DIPOLE ORIENTATION

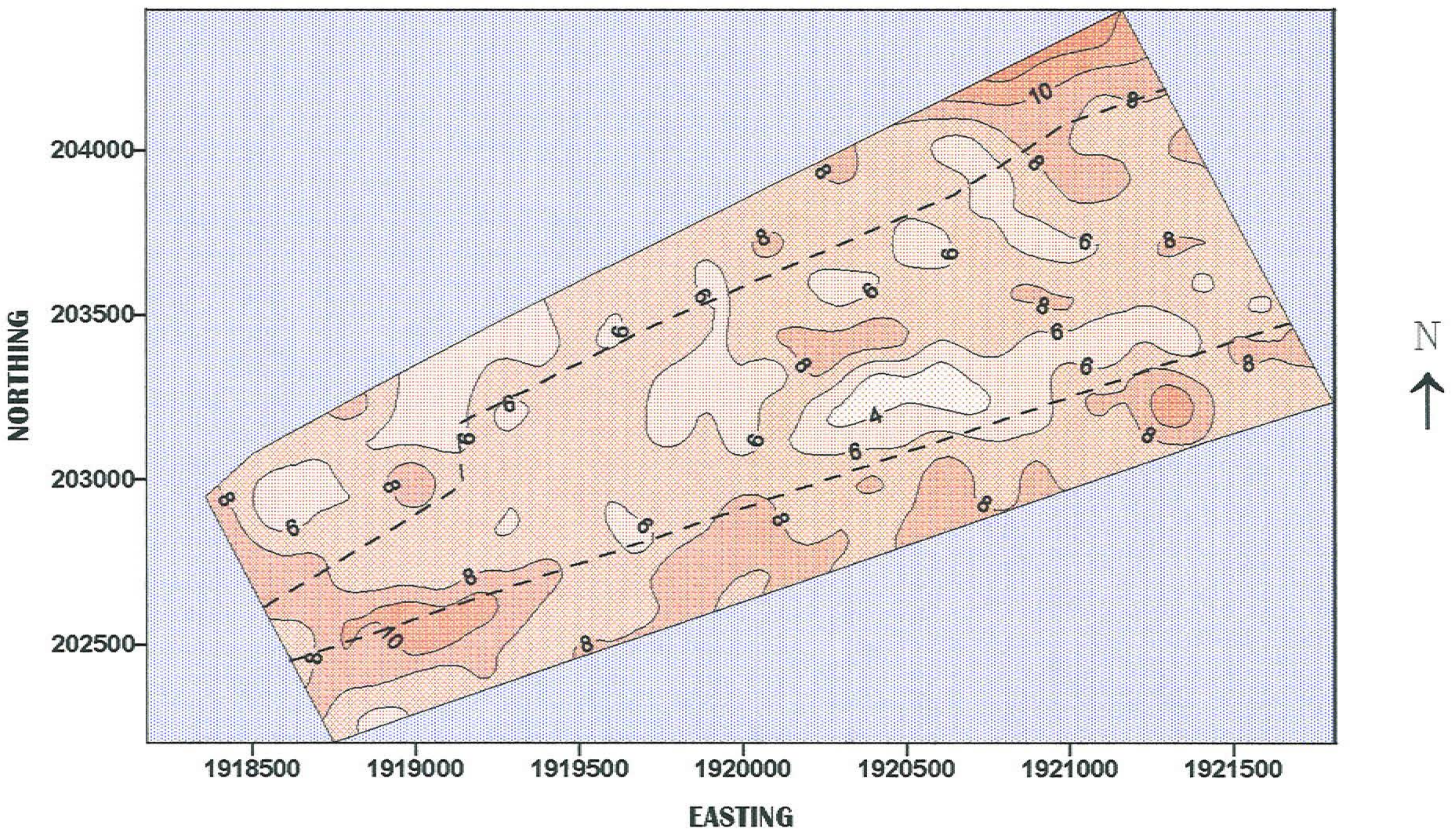


FIGURE 4

EM SURVEY
ROCKSPRING RESEARCH FARM

EM31 METER
VERTICAL DIPOLE ORIENTATION

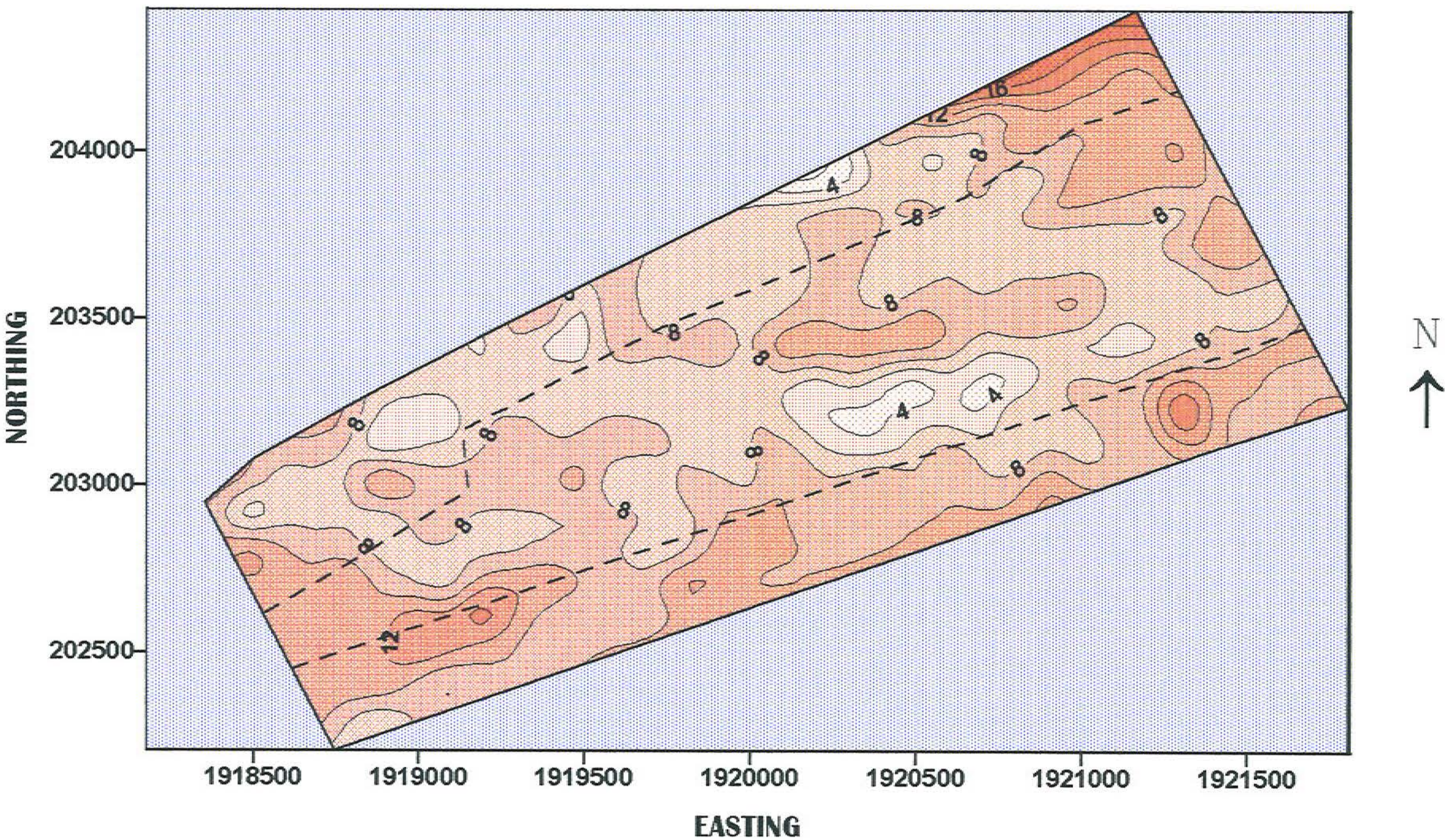


FIGURE 5

EM SURVEY
ROCKSPRING RESEARCH FARM

INTERPRETED DEPTH TO BEDROCK
(inches)

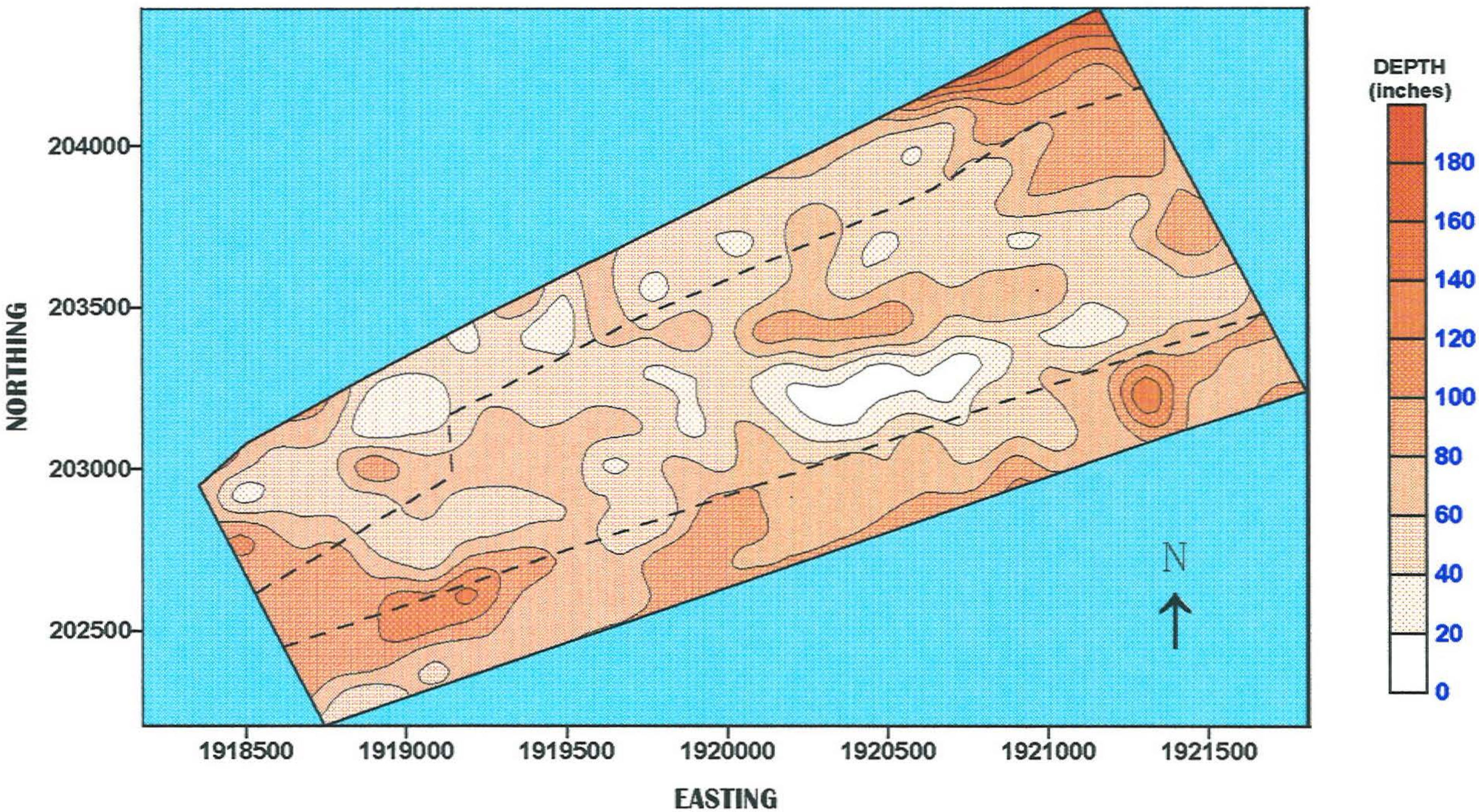
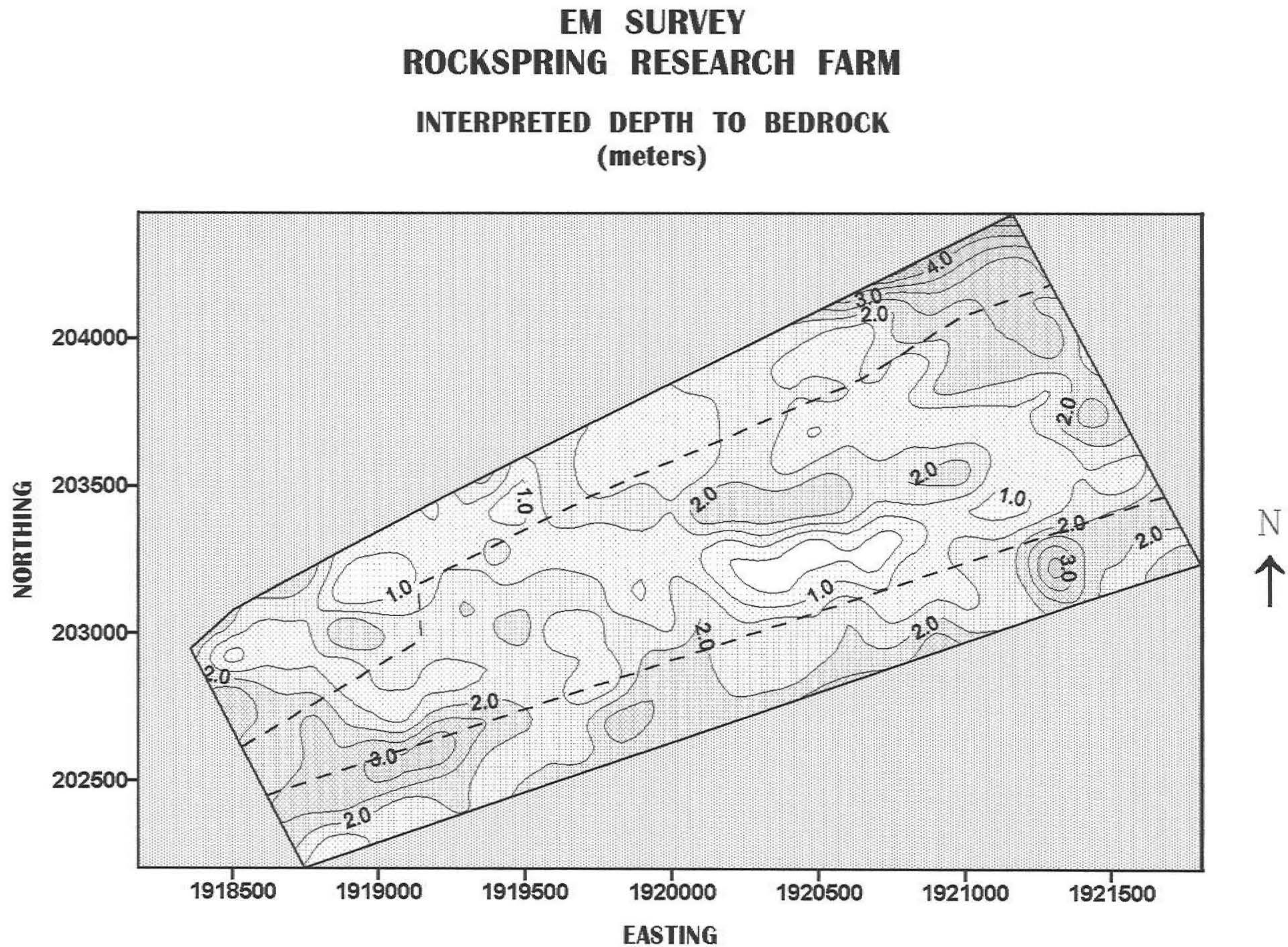


FIGURE 6


EM SURVEY
ROCKSPRING RESEARCH FARM
INTERPRETED DEPTH TO BEDROCK
(meters)
NORTHING
204000
203500
203000
202500
EASTING
1918500
1919000
1919500
1920000
1920500
1921000
1921500
N
4.0
3.0
2.0
1.0