File
Doolittle

United States Department of Agriculture | Soil Conservation Service | 160 East 7th Street Chester, PA 19013-6092

Subject: Ground-penetrating radar (GPR) and electromagnetic induction (EM) studies on claypan soils at MSEA Site near Centralia, MO, 25 August 1992

Date: 30 September 1992

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Purpose:
To further evaluate the suitability of using ground-penetrating radar (GPR) and electromagnetic induction (EM) techniques to map the depth to the argillic horizon in claypan soils at the MSEA site near Centralia, Missouri

Participants:
James Doolittle, Soil Specialist, SCS, Chester, PA
Kim Doolittle, Earth Team Volunteer, SCS, Chester, PA
Sam Indorante, MLRA Update Leader, SCS, Belleville, IL
Newell Kitchen, MSEA Project Manager, U. of Missouri, Columbia, MO
Ken Sudduth, Agric. Engineer, ARS, Columbia, MO
Ken Vogt, Soil Specialist, SCS, Columbia, MO

Activities:
I arrived in Columbia, Missouri, during the afternoon of 24 August 1992. Field studies were conducted at the Centralia MSEA Site on 25 August 1992. I returned to Chester, Pennsylvania, on 26 and 27 August.

Equipment:
The ground-penetrating radar unit is the Subsurface Interface Radar (SIR) System-8 manufactured by Geophysical Survey Systems, Inc. [1]. Components of the SIR System-8 used in this study were the model 4800 control unit, model SR-8004H graphic recorder, power distribution unit, transmission cable (30 m), and the model 3110 (120 MHz) antenna. The system was powered by a 12-volt vehicular battery. The electromagnetic induction meter used was the EM38 manufactured by Geonics, Limited [1].

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1. Use of trade names in this report is for identification purposes only and does not constitute endorsement.

Discussion:
Previous studies with the GPR were highly interpretive as the claypan was poorly expressed on graphic profiles. In these studies, the 120 MHz antenna could discern the upper boundary of the claypan only in the exceptionally dry "CRP" plots and where it occurred between depths of 13 and 36 inches. At depths shallower than 13 inches, the upper boundary of the clay pan was masked on radar profiles by the strong reflections from the soil surface. Below depths of about 36 inches, reflections were too indistinct to be observed on unprocessed radar profiles. The high clay content and the dominance of 2:1 expanding lattice clays severely restricted the profiling depth and appropriateness of using radar techniques at the Centralia MSEA Site.

In an attempt to improve interpretations at shallow depths (< 13 inches) of the depth to claypan, a dielectric spacer was used in the present study. The spacer consisted of about 6 inches of similar soil materials which was placed in the bottom of the antenna sled. This spacer proved to be to attenuating to the radar signal and no improvements in interpretations were noted. The use of a more resistive dielectric spacer could improve probing depths and the resolution of the clay pan.

Results from the EM survey were very impressive. Along the transect line, the depth to claypan averaged 39.6 cm and ranged from about 7 to 105 cm (see Fig. 1A). In Figure 1A, the claypan typically appears between depths of 10 and 20 cm with noticeable troughs extending to depths of about 100 cm in several areas.

Values of apparent conductivity averaged 32 mS/m and ranged from 18 to 44 mS/m in the horizontal dipole orientation. In the vertical dipole orientation, values of apparent conductivity averaged 54 mS/m and ranged from 36 to 68 mS/m. Values of apparent conductivity increase with soil depth (in Fig. 1B, compare values of apparent conductivity obtained with the EM38 meter in the horizontal and vertical orientations). This relationship is believed to be a manifestation of increasing clay and volumetric moisture contents with depth.

In Figure 1, close similarities exist between the depth to claypan and values of apparent conductivity. Generally, depth to claypan and values of apparent conductivity are inversely related (see Fig. 2). The sample correlation coefficient, r, between the depth to claypan and values of apparent conductivity was -0.797 (significant at the 0.005 level) in the horizontal dipole orientation and -0.853 (significant at the 0.005 level) in the vertical dipole orientation. Considering the relatively large volume of soil integrated with the EM38 meter and the relatively small volume of soil sampled with the probe, the correlation is considered remarkable.

At a given location, values of apparent conductivity obtained with the different coil orientations were strongly inter-dependent (r = 0.928). Since a stronger relationship exited between the vertical dipole measurements and the depth to claypan, these measures were used to develop a regression equation to predict depth to claypan from values of apparent conductivity. Based on thirty-one observation points, the following equation was developed for the study site:

$$D = 194.94 - (2.878 * X) \qquad (1)$$

where "D" is the depth to claypan; and "X" is the EM38 measurement in vertical dipole orientation

Figure 3 is a contour plot of the depth to claypan within the grid site as estimated using equation (1). The contour interval is 5 cm. Generally, depths to claypan are less along the northern portion and greater in the central and southern portions of the study site. Variations in the EM response and the inferred depth to claypan occur over short distances with a distinct "swell and swale" subsurface topography (see Fig. 4).

I enjoyed this opportunity to once again work with you, Newell, and Sam.

With kind regards.

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Soil Specialist

cc:
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J. Culver, National Leader, SSQAS, NSSC, SCS, Lincoln, NE
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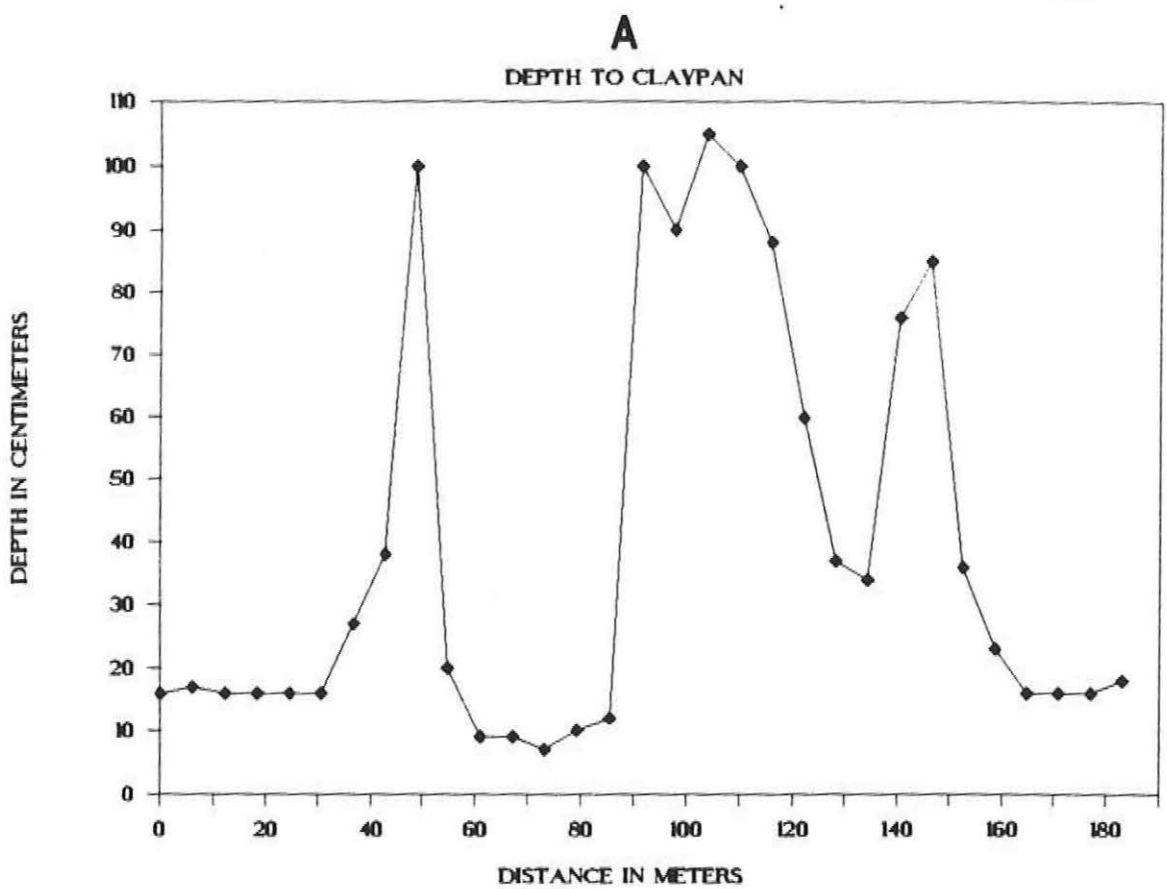
Figure 1


A
DEPTH TO CLAYPAN
DEPTH IN CENTIMETERS
DISTANCE IN METERS
0
10
20
30
40
50
60
70
80
90
100
110
0
20
40
60
80
100
120
140
160
180

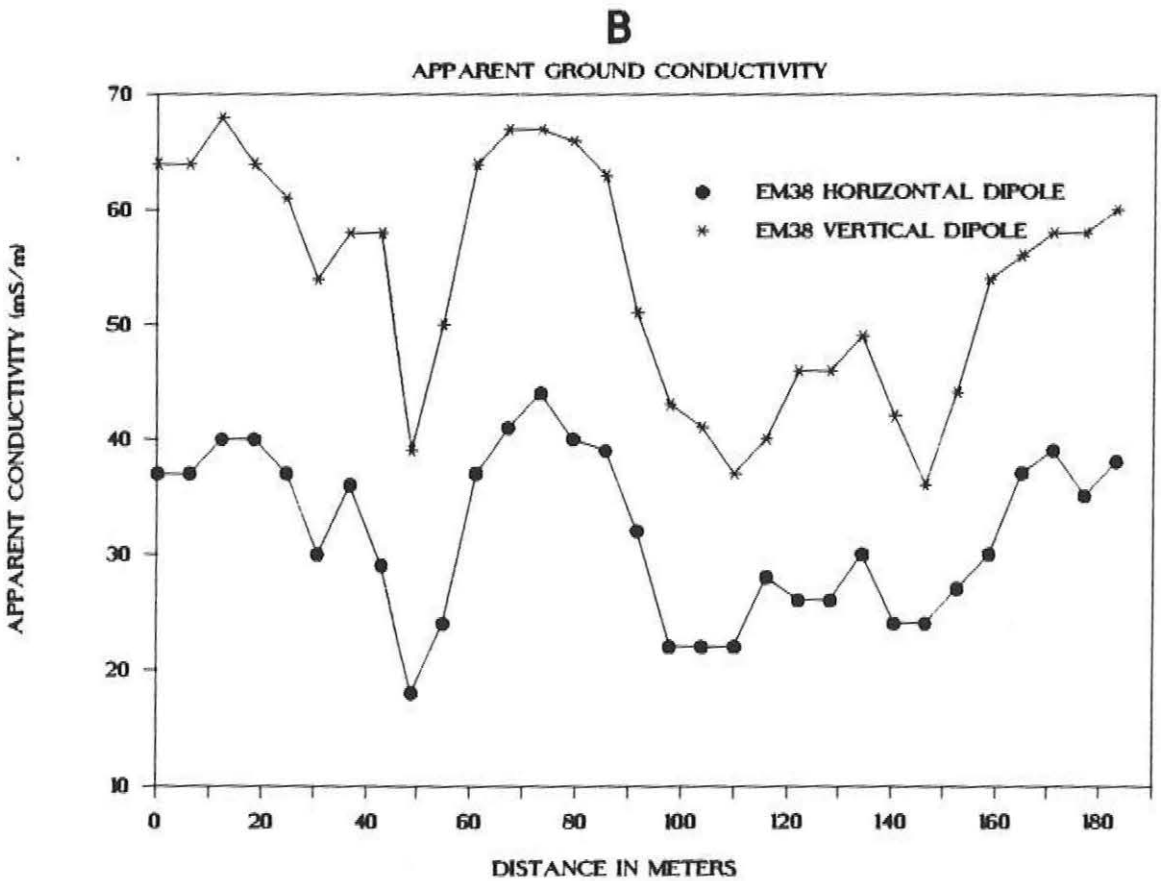

B
APPARENT GROUND CONDUCTIVITY
APPARENT CONDUCTIVITY (mS/m)
EM38 HORIZONTAL DIPOLE
EM38 VERTICAL DIPOLE
DISTANCE IN METERS
10
20
30
40
50
60
70
0
20
40
60
80
100
120
140
160
180

figure 2

EM RESPONSE VS DEPTH TO CLAY PAN

WITH EM38 METER

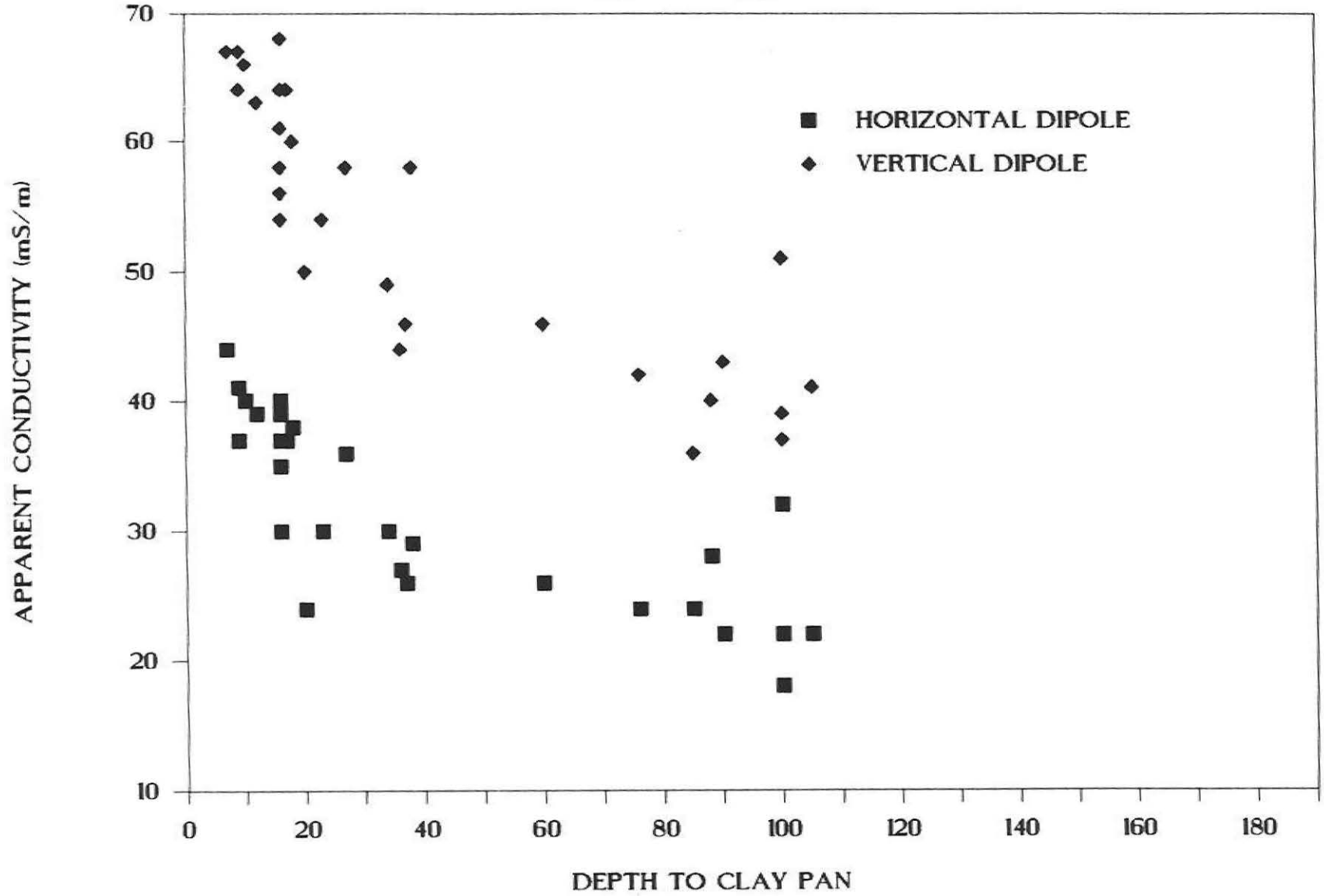


Figure 3

DEPTH TO CLAYPAN
(CM)

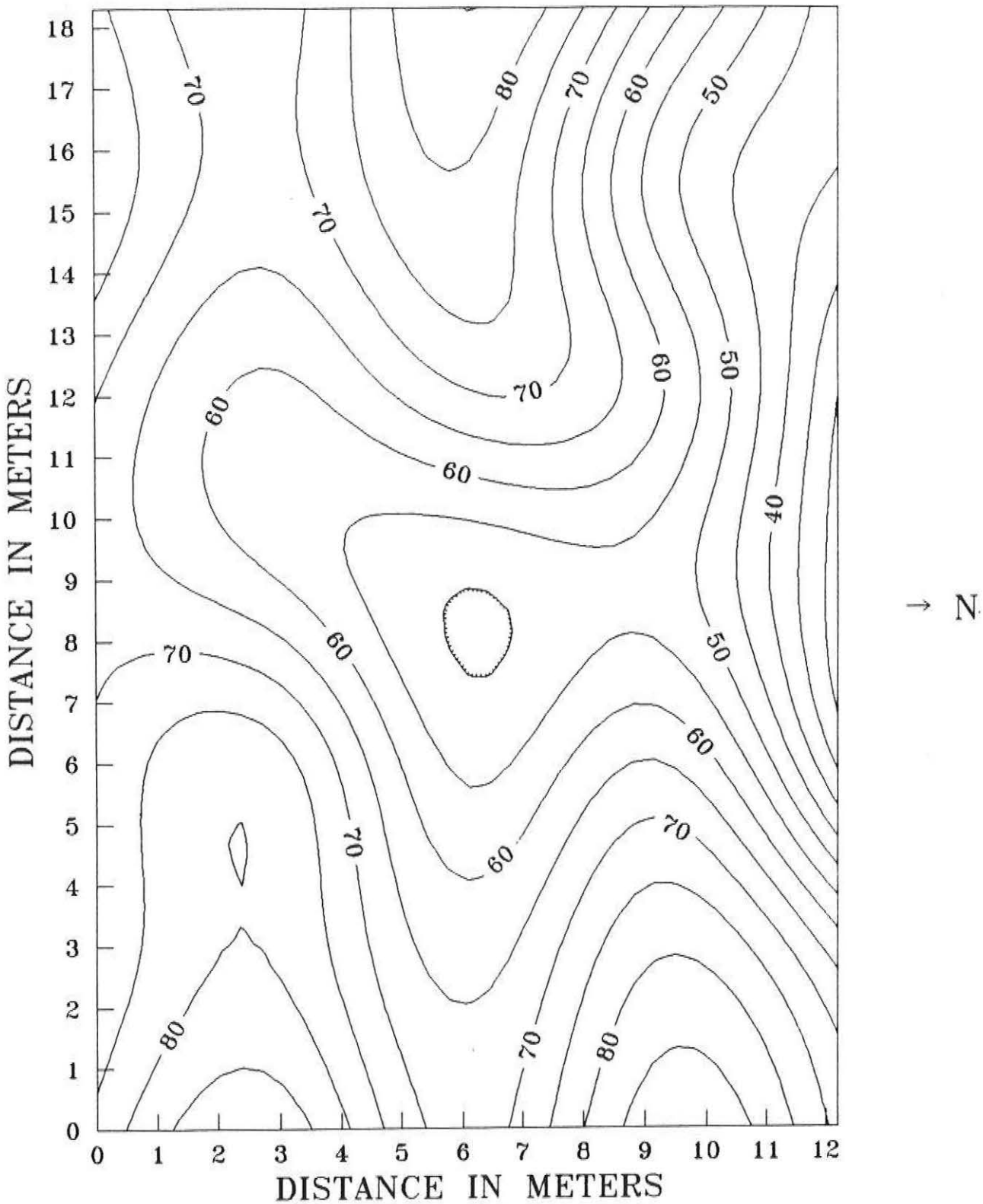
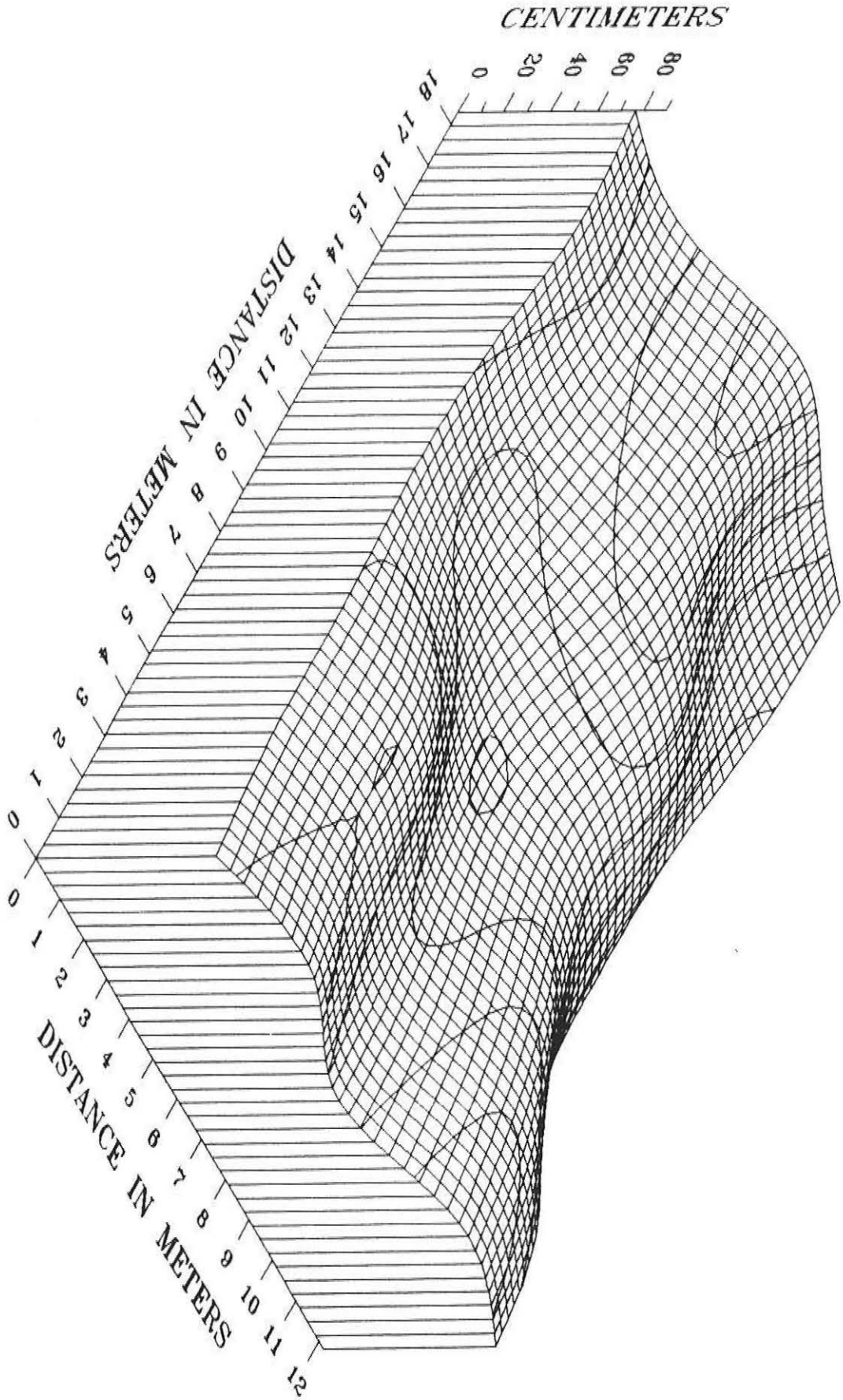


Figure 4


CENTIMETERS
0
20
40
60
80
DISTANCE IN METERS
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
DISTANCE IN METERS
0
1
2
3
4
5
6
7
8
9
10
11
12