

(200)
R290
no. 80-384

✓
U.S. Geological Survey

[Reports-Open file series]



TM
cm
the anal ✓

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

°SCHLUMBERGER SOUNDINGS IN THE FISH SPRINGS FLAT
AREA, JUAB COUNTY, UTAH

BY

Robert J. Bisdorf and Adel A. R. Zohdy

Open-File Report 80-384

1980



303730

cell
4-17-81

Schlumberger soundings in the Fish Springs Flat
area, Juab County, Utah.

Robert J. Bisdorf and Adel A. R. Zohdy

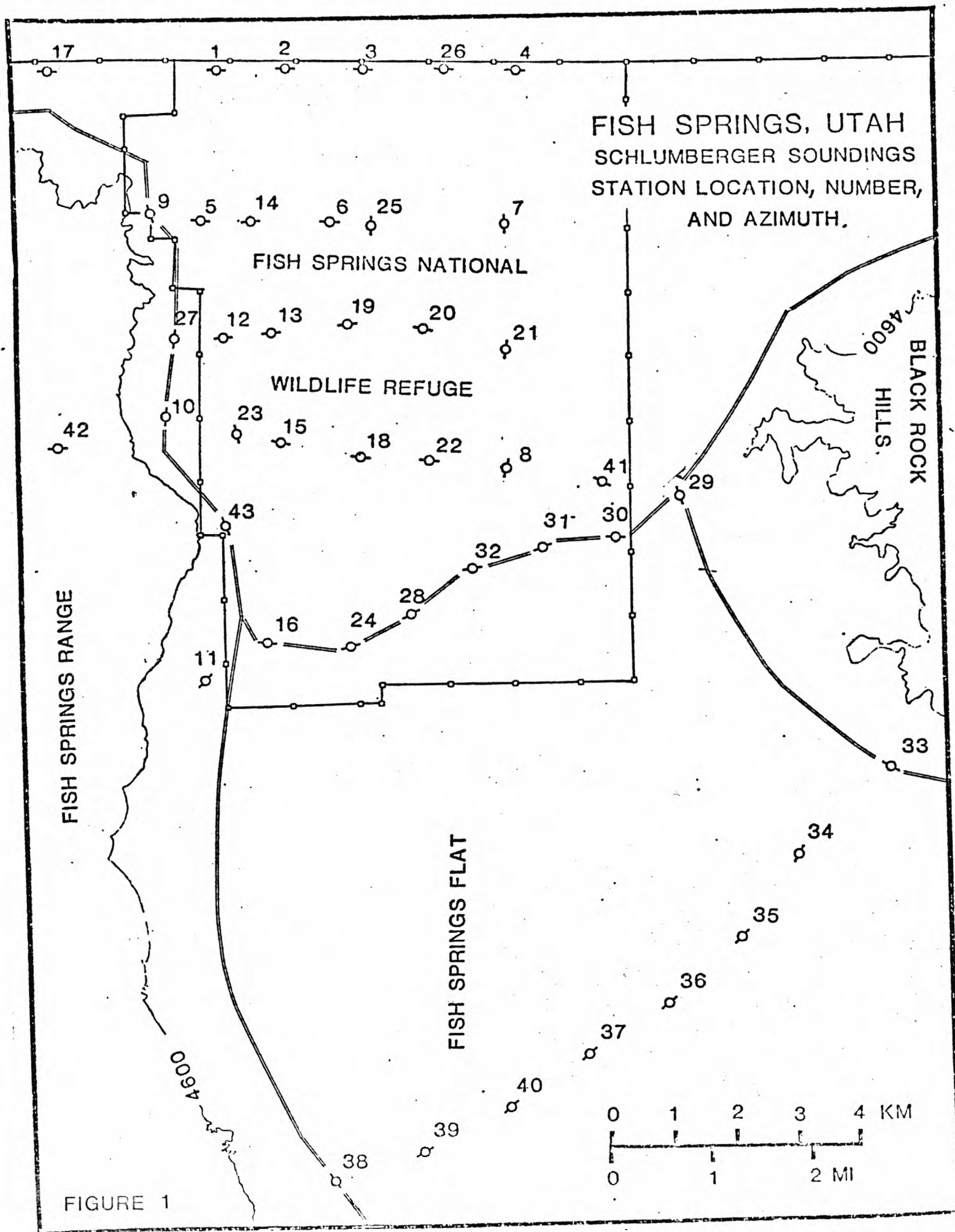
INTRODUCTION

In 1978 the U. S. Geological Survey made 43 Schlumberger soundings in the Fish Springs Flat area, Juab County, Utah. The purpose of this survey was to delineate water quality and obtain structural information. Fish Springs Flat consists mainly of Quaternary deposits of sand, gravel, clay, and silt. On the west Fish Springs Flat is bordered by the Fish Springs Range which is composed primarily of Paleozoic limestone. With the exception of a short section of metal fence and concrete culverts, disruptive cultural features did not appear to be present.

The purpose of this report is to release the field data obtained in this survey. In addition the automatic inversion of the sounding curves, computer-generated geoelectric cross sections, and interpreted resistivity maps are also given and briefly described.

SCHLUMBERGER SOUNDINGS

Figure 1 shows the Schlumberger sounding locations and their direction of expansion. All the sounding measurements were made



using a symmetric Schlumberger array. The sounding curves are given in the appendix and are numbered consecutively from Utah 1 to Utah 43. All the sounding curves were automatically processed and interpreted (Zohdy, 1973 and 1975) as shown in the graphs. Each graph shows the following:

1. Field data designated by a segmented, solid-line curve, with diamond symbols for observed data.
2. A shifted and digitized field curve designated by square symbols. The shifted field curve is obtained by shifting the various segments upward or downward generally with respect to the last segment on the segmented field curve (Zohdy and others, 1973). This shifted curve is then digitized at the rate of six points per logarithmic cycle. These points were computed using a subroutine in a computer program for bicubic spline functions (Anderson, 1971).
3. The theoretical best fitting sounding curve is designated by plus (+) symbols. This theoretical curve is the output of the automatic interpretation for the digitized curve. The computer program used here is an updated version of the one published in Zohdy(1973).
4. The detailed layering (step function curve of interpreted true resistivity versus depth) for which the theoretical curve is calculated.
5. The D.Z. (Dar Zarrouk) curve for the detailed layering. The ordinate values for the D.Z. curve are shifted upward or downward by one logarithmic cycle to avoid cluttering the graph. The D.Z. curve can be used to obtain equivalent and

simpler solutions containing fewer number of layers and in which certain constraints can be imposed on layer thicknesses and resistivities (Zohdy, 1974).

DATA QUALITY

On some soundings (2, 3, 17, 25, 28, 31, 32, 35, 36, 37, and 40) the end of the curve is distorted more than can be allowed for by the geologic setting. In most cases no cultural features that would cause such distortions can be seen; therefore the distorted points have been discarded. Discarding these points enables the computer program to run more efficiently and since these points are inaccurate they would have inhibited the program's interpretation of the first part of the curves.

In most instances interpreting the distorted curves without the distorted points resulted in interpretations that are consistent with nearby curves that were not distorted. Possible explanations for the presence of distorted sections are buried pipes or telephone lines, intermittent equipment malfunctions, leakage caused by a negligent crew (leakage was checked for and not found), operator error (since the first author was the operator he does not think that this is likely). It should be noted that on a later field trip a scale switch on a chart recorder was found to work intermittently.

GEOELECTRIC CROSS SECTIONS

Figures 3 through 15 show computer-generated geoelectric sections of interpreted true resistivity. The cross sections were constructed in the following manner.

For each sounding, the detailed layering (given as a step function) is converted to a smooth curve representing a continuous variation of resistivity with depth. This conversion is made by determining the coordinates of the logarithmic midpoint of each horizontal and vertical segment (fig. 2a). The logarithms of these points are splined (Anderson, 1971) to form a continuous curve. Then the computed spline coefficients are used to digitize this continuous curve at the rate of 30 points per decade of depth (fig. 2b). After this is done for each sounding interpretation, the digitized curves generated in this manner are spline-interpolated in the horizontal direction to generate resistivity values at four equally spaced locations between each pair of soundings. This produces a data set in the form of a mesh suitable for contouring. A computer program based on the work of Evenden(1975) was used for contouring the results. It should be noted that even though the logarithms of the resistivities were used for splining, some significant anomalies may still be generated by interpolation between sounding locations. Thus although the automatic contouring method used here is faithful to the interpreted resistivity values beneath each station, there are other equally acceptable methods of contouring these resistivity values. The reader is cautioned that anomalies created by interpolation between sounding stations may not be real. The cross sections are contoured

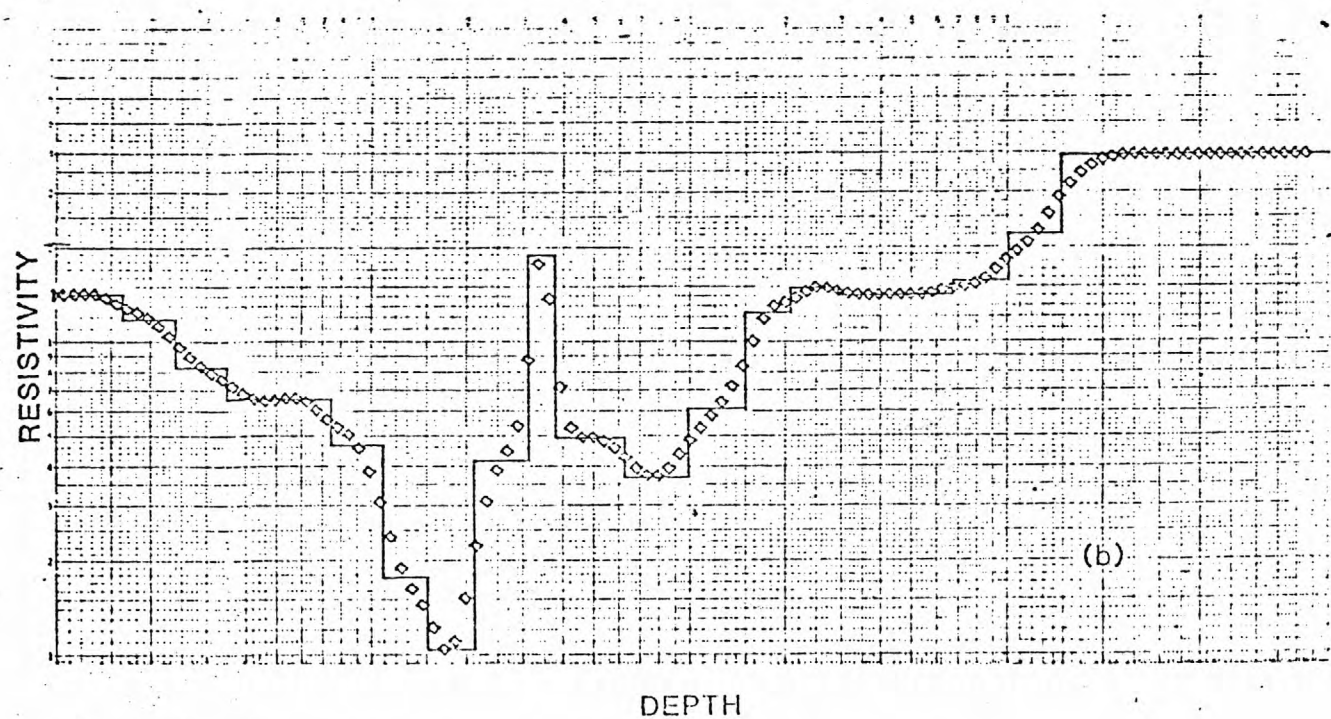
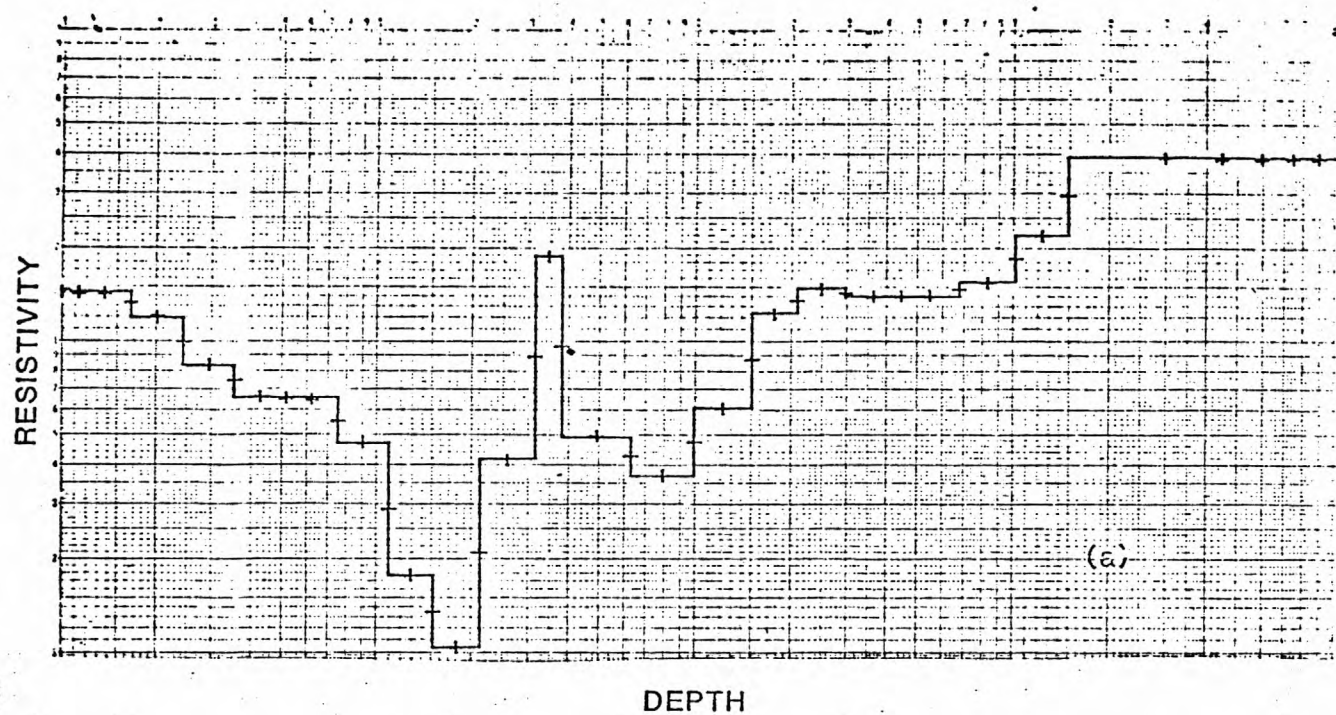


Figure 2.--(a) Detailed layering and coordinates of the logarithmic midpoint of each horizontal and vertical segment (represented by plus symbols);
 (b) Detailed layering and continuous curve digitized at the rate of 30 points per decade (represented by diamond symbols).

at a logarithmically quasi-equal interval of six points per decade, with contours at 1,1.5,2,3,4.5,7,10,15, 100,150,200,300, and 450, in ohm-meters.

Each section is composed of three parts. The top part shows a ten to one vertically exaggerated presentation of the upper 271 m; the middle part a four to one vertically exaggerated presentation of the upper 271 m; the lower part, a no vertical exaggeration presentation of the upper 271 m.

RESISTIVITY MAPS

Figures 16, 17, and 18 show maps of interpreted resistivity at depths of 50 m, 100 m, and 200 m respectively. The data points at each depth were picked from the continuous variation of resistivity versus depth (described above). The data were gridded and contoured using programs coded by the first author. The technique of looking at resistivity values at different depths can be useful in recognizing geologic structure as well as variations in ground water quality (Zohdy and others, 1978 and Zohdy and Bisdorf, 1979). For best results the data to be contoured should be quasi-uniformly distributed.

DISCUSSION

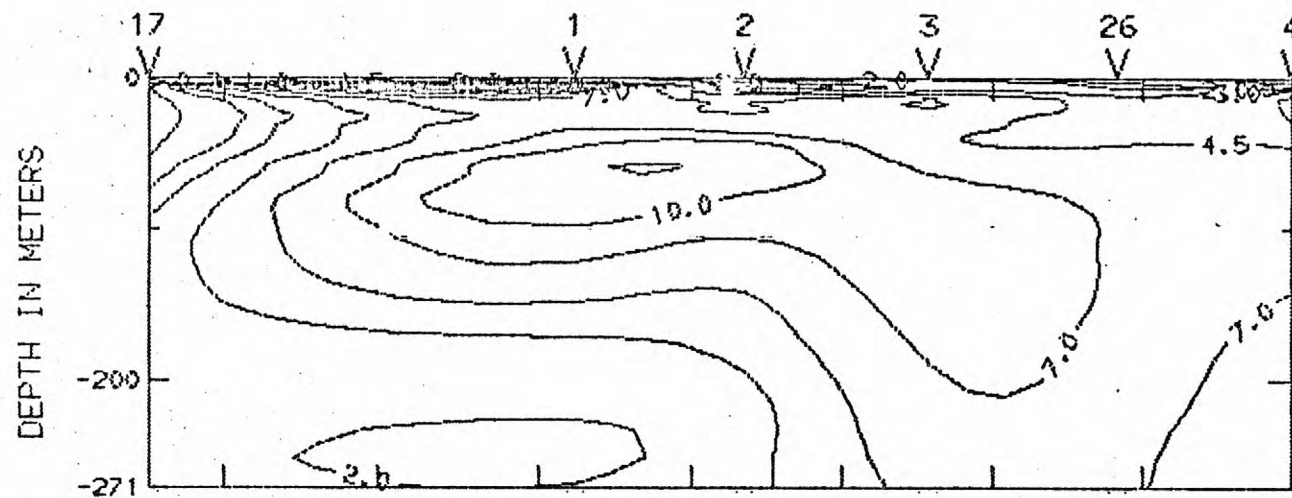
The following table relating resistivity to ground-water quality or lithology should be applicable to the study area:

Resistivity	Lithology
ohm-m	
<4.5	clay or sand and silt with very salty water
4.5-10	clay or sand and silt with salty water
10-20	clayey-sand or sand with brackish water
20-150	sand or gravel with fresh water
>150	limestone or dry sand

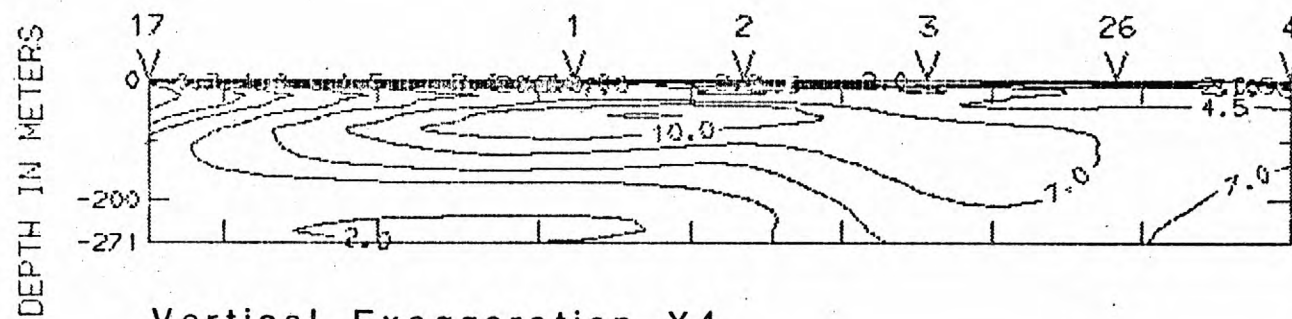
Figure 3 shows the northernmost east-west geoelectric cross section. Material with resistivities of less than 10 ohm-m predominates.

Figure 4 shows an east-west geoelectric cross section located about 2.25 km south of the section in figure 3. A lens of 4.5 to 10 ohm-m material extends from sounding 7 to sounding 6. This lens is about 110 m thick under sounding 7 thinning to less than 10 m under sounding 6. In the upper 100 m intermediate resistivities (10-20 ohm-m) are present from sounding 6 to sounding 5. Higher resistivities are present under soundings 5 and 9 indicating the possible presence of gravel or fresh water saturated sediments. Also the sharp transition from low resistivities to higher values could indicate the presence of a fault between soundings 5 and 9.

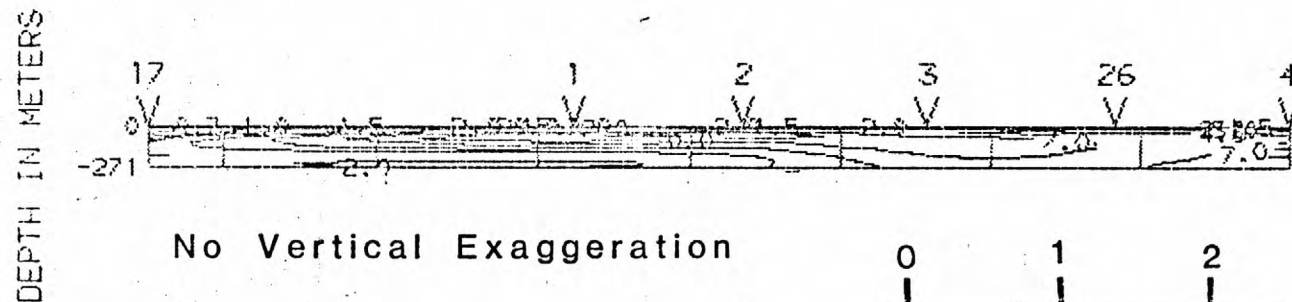
Figure 5 shows an east-west geoelectric cross section located about 2 km south of the section in figure 4. From sounding 21 to sounding 13 the upper 100 m contains material of less than 10 ohm-m. Under sounding 20 a 40 m thick lens of greater than 20 ohm-m material is present. Under soundings 13, 12, and 27 resistivities of greater



Vertical Exaggeration X10



Vertical Exaggeration X4



No Vertical Exaggeration

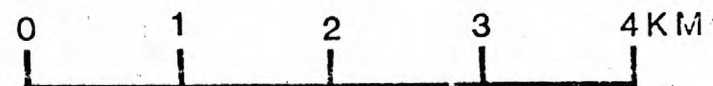
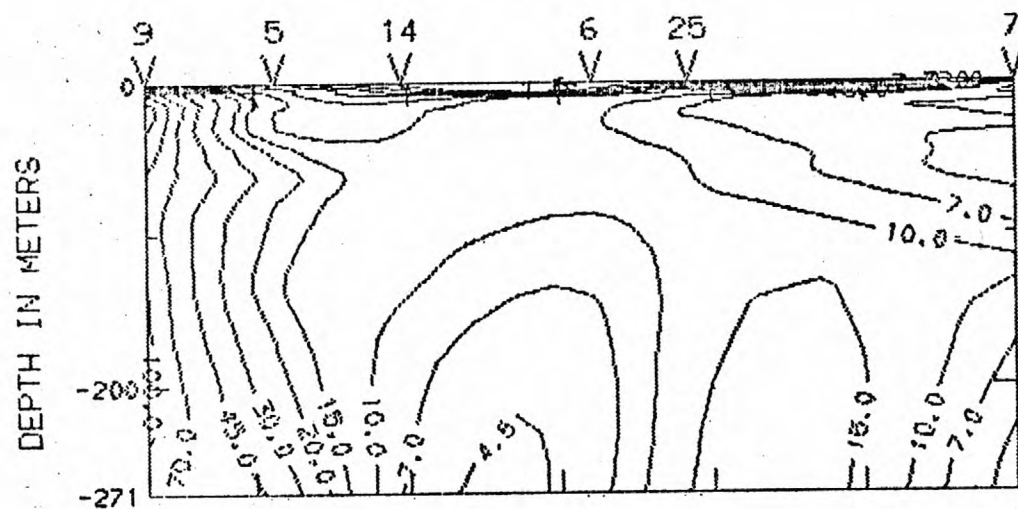
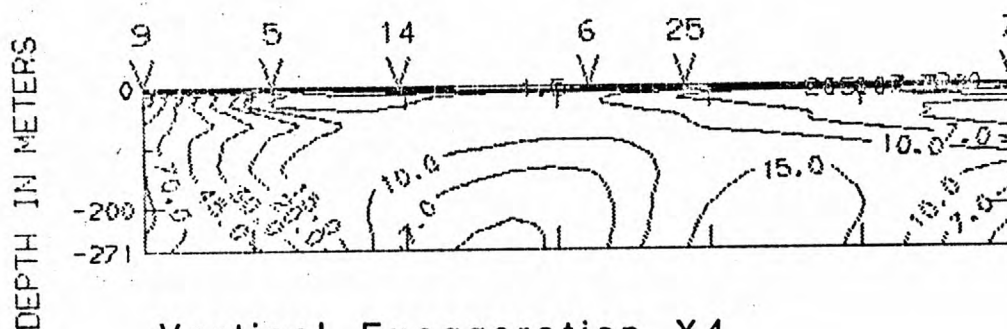


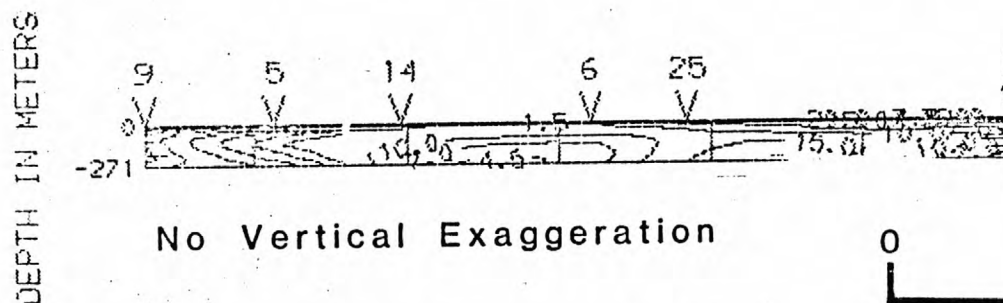
Figure 3.--Computer-generated geoelectric cross section. The top and middle parts are vertically exaggerated ten and four times, respectively. The bottom part is without vertical exaggeration. Contours are of interpreted true resistivity in ohm-meters.



Vertical Exaggeration X10



Vertical Exaggeration X4



No Vertical Exaggeration

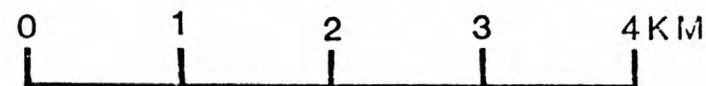
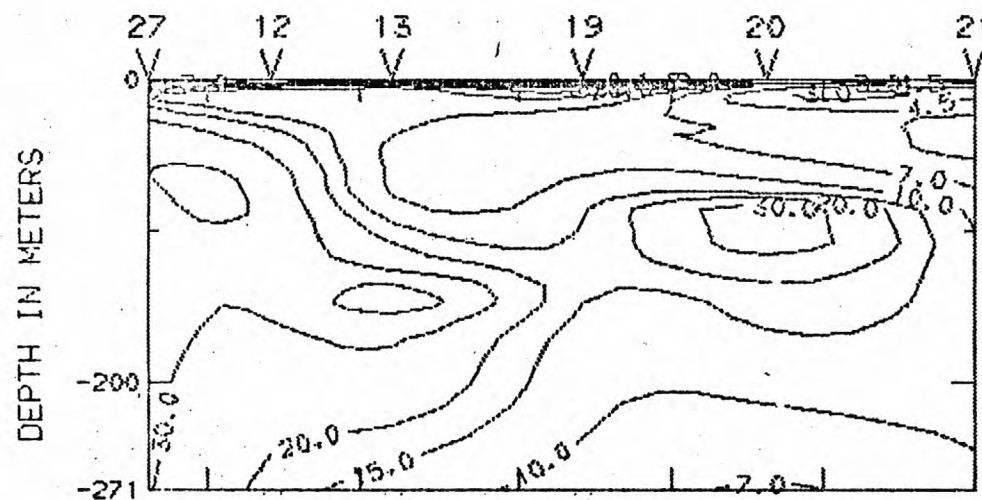
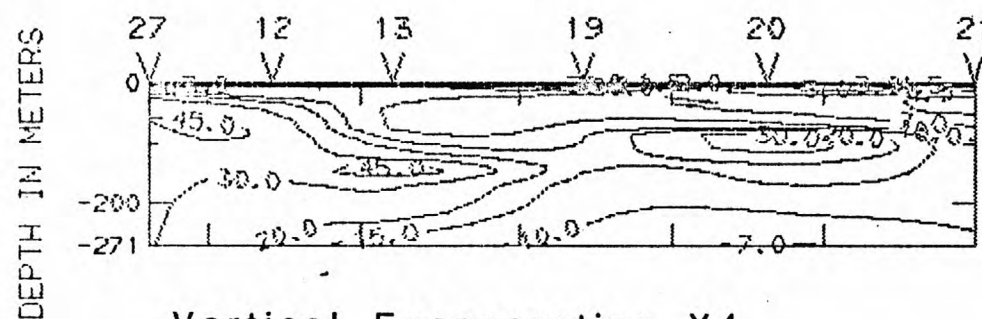


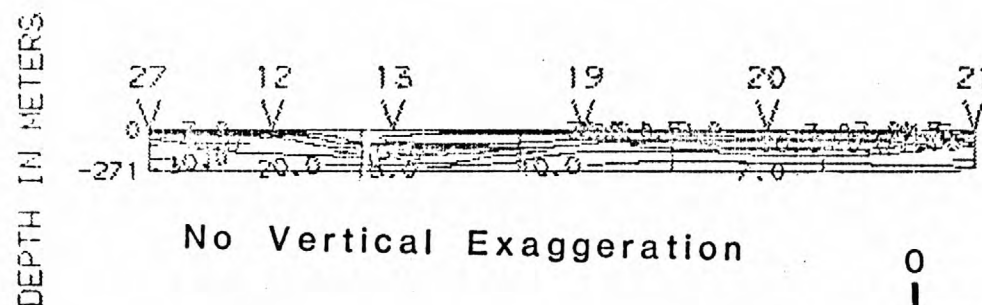
Figure 4.--Computer-generated geoelectric cross section. The top and middle parts are vertically exaggerated ten and four times, respectively. The bottom part is without vertical exaggeration. Contours are of interpreted true resistivity in ohm-meters.



Vertical Exaggeration X10



Vertical Exaggeration X4



No Vertical Exaggeration

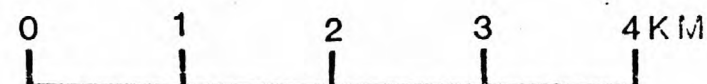


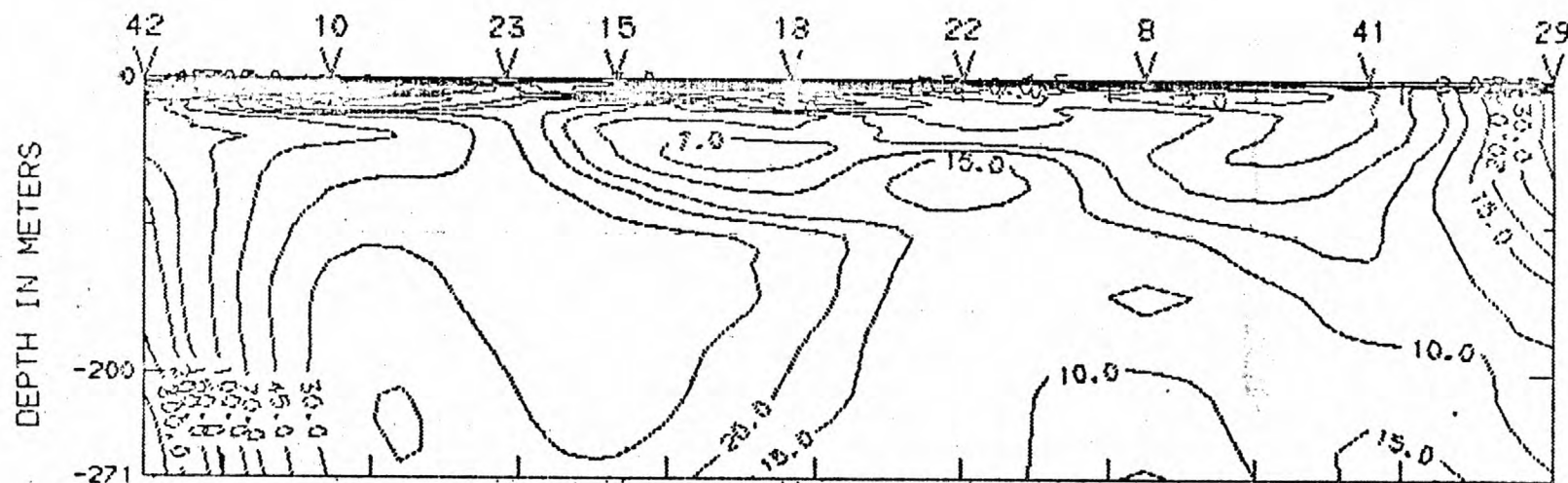
Figure 5.--Computer-generated geoelectric cross section. The top and middle parts are vertically exaggerated ten and four times, respectively. The bottom part is without vertical exaggeration. Contours are of interpreted true resistivity in ohm-meters.

than 20 ohm-m are present indicating the presence of gravel or fresh water saturated sand and sediments. The depth to this greater than 20 ohm-m layer is about 100 m under sounding 13 and less than 5 m under sounding 27.

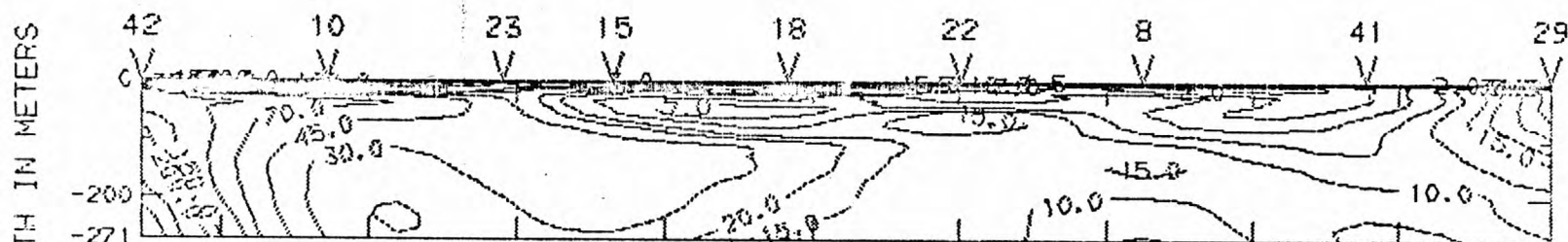
Figure 6 shows a geoelectric cross section located about 2 km south of the section in figure 5. A near surface layer about 100 m thick, of less than 10 ohm-m is present from sounding 41 to sounding 15. Higher resistivities are present under sounding 29 indicating, at this locality, the presence of volcanics. Resistivities of greater than 20 ohm-m are present at depths greater than 100 m under sounding 18. The top of the greater than 20 ohm-m layer becomes shallower to the west where it is less than 20 m deep under sounding 23. The transition from low resistivities to higher resistivities that occurs between soundings 10 and 42 could indicate the presence of a fault in the vicinity of sounding 10 or just to the west of it.

Figure 7 shows a northeast-southwest geoelectric cross section from sounding 11 to 29. Resistivities of less than 10 ohm-m are present from sounding 30 to sounding 24. Volcanics are indicated under sounding 29 by the presence of resistivities of greater than 20 ohm-m. Under sounding 16 there is about 50 m of less than 10 ohm-m material underlain by greater than 20 ohm-m material the top of which gets shallower (less than 20 m) under sounding 11.

Figure 8 shows a northeast-southwest geoelectric cross section which is located about 8 km southeast of the section in figure 7. A near surface layer ranging in thickness from 20 to 100 m of less than 10 ohm-m material is present from sounding 38 to sounding 34. This layer is underlain by 10 to 20 ohm-m material ranging in thickness



Vertical Exaggeration X10



Vertical Exaggeration X4



No Vertical Exaggeration

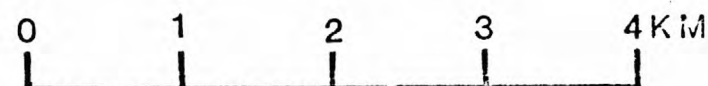
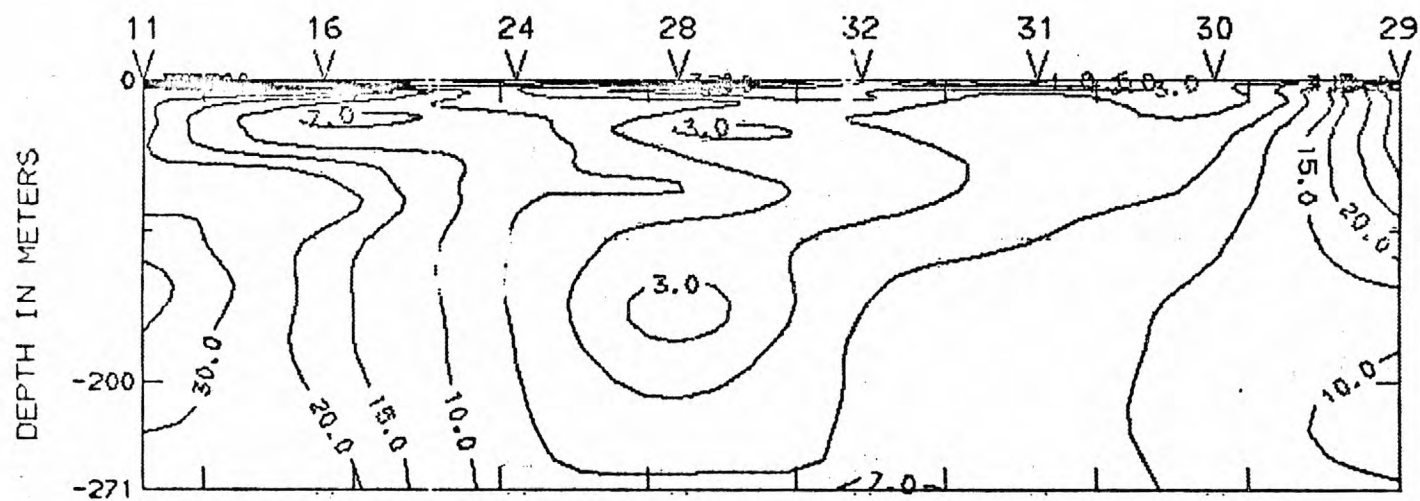
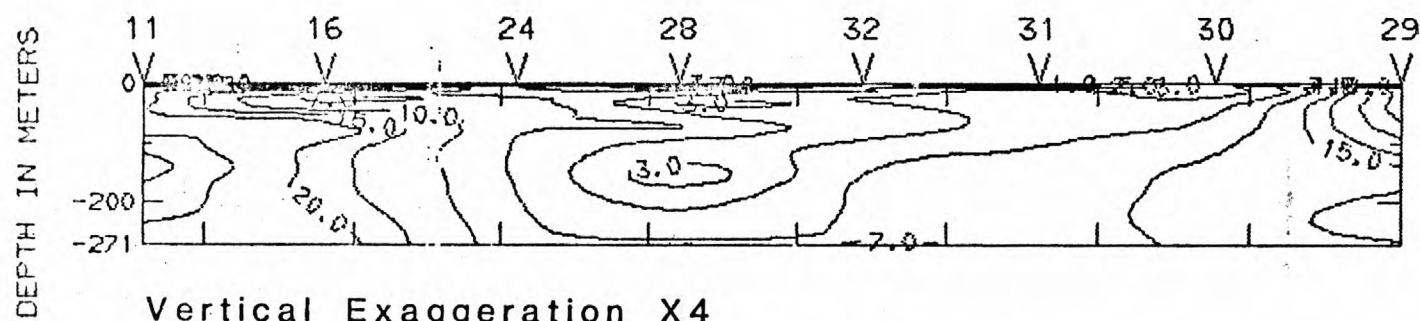


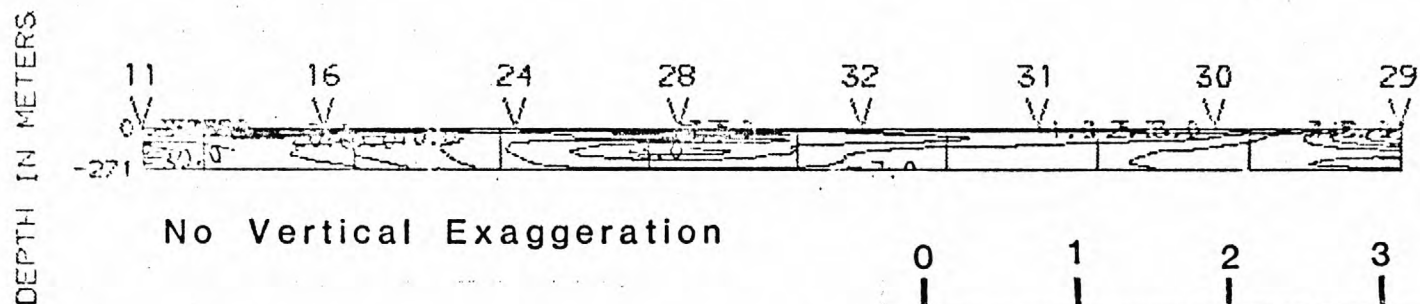
Figure 6.--Computer-generated geoelectric cross section. The top and middle parts are vertically exaggerated ten and four times, respectively. The bottom part is without vertical exaggeration. Contours are of interpreted true resistivity in ohm-meters.



Vertical Exaggeration X10



Vertical Exaggeration X4



No Vertical Exaggeration

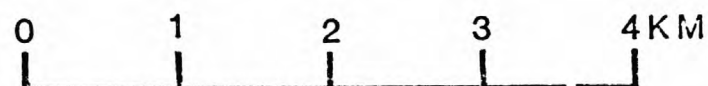
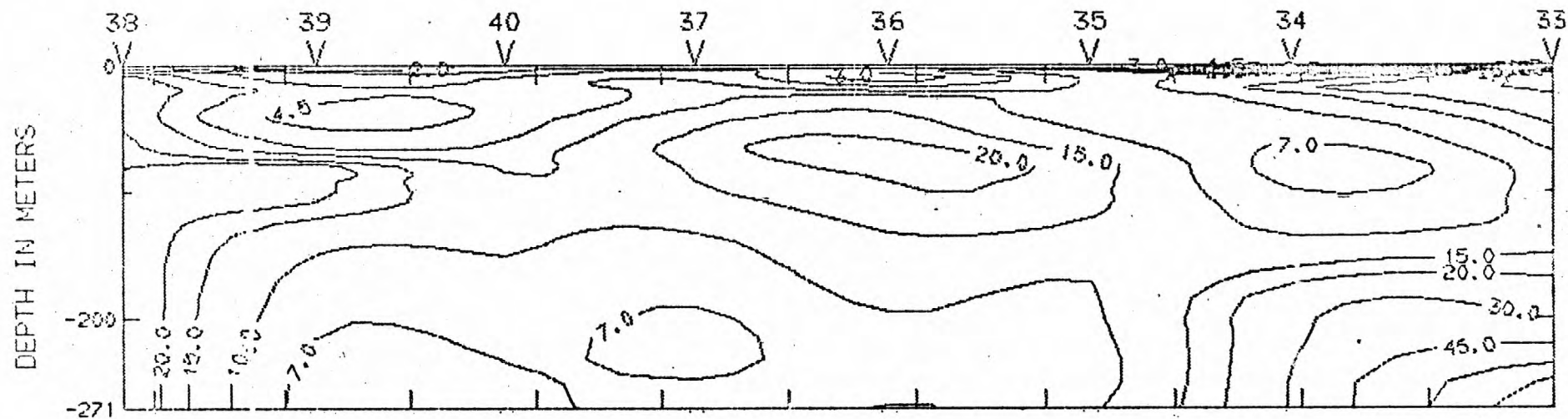
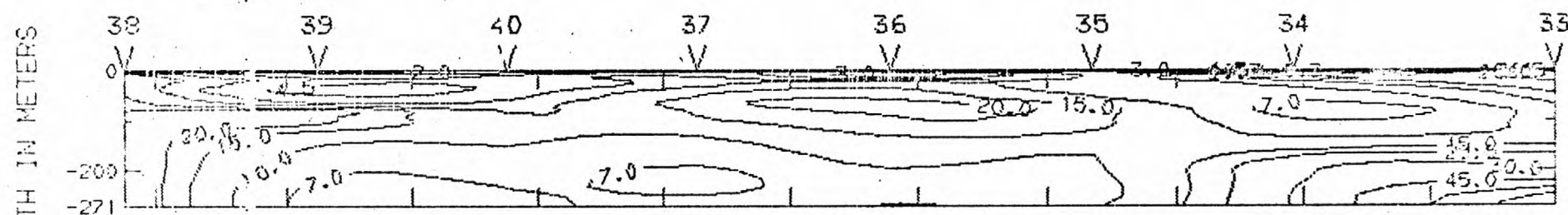


Figure 7.--Computer-generated geoelectric cross section. The top and middle parts are vertically exaggerated ten and four times, respectively. The bottom part is without vertical exaggeration. Contours are of interpreted true resistivity in ohm-meters.



Vertical Exaggeration X10



Vertical Exaggeration X4

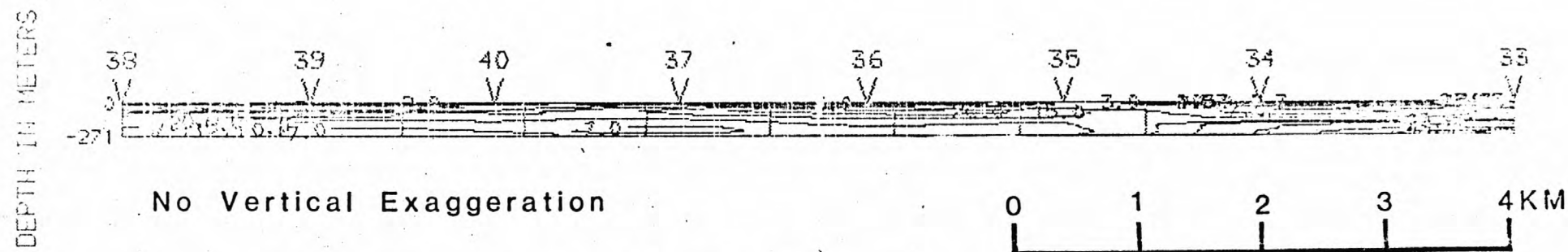
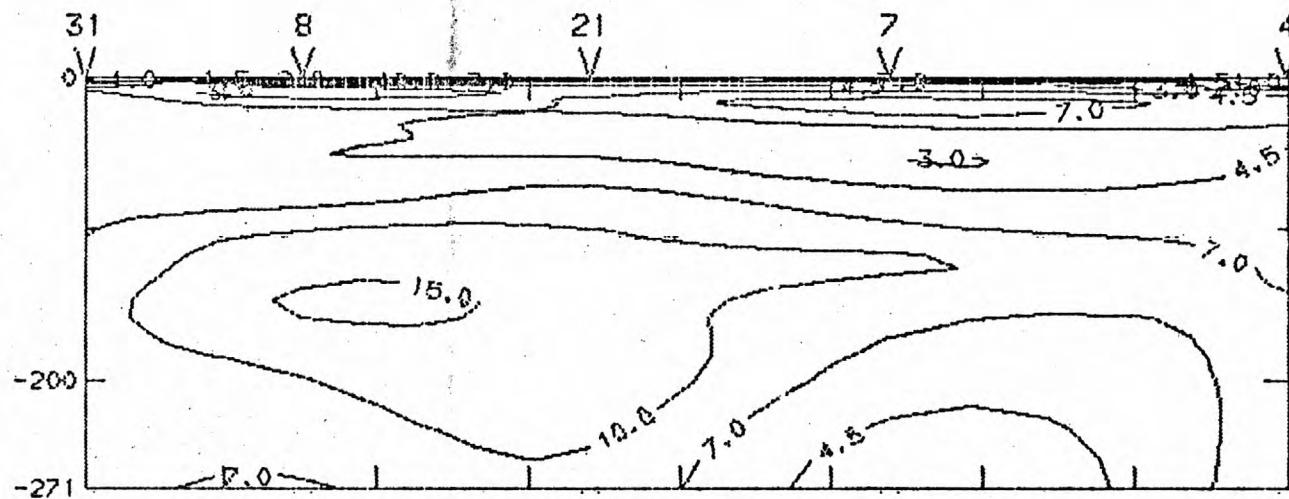
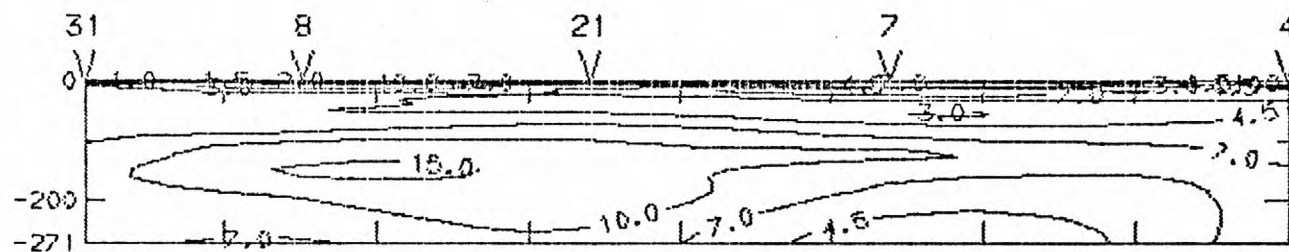
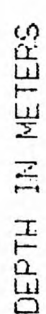


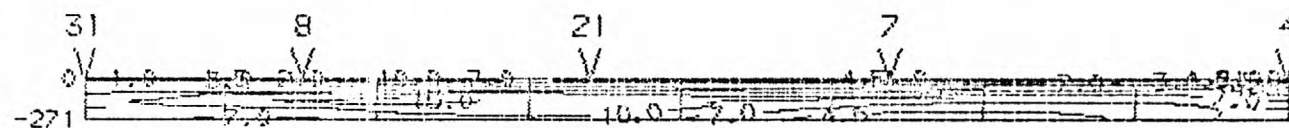
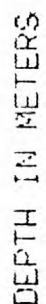
Figure 8 --Computer-generated geoelectric cross section. The top and middle parts are vertically exaggerated ten and four times, respectively. The bottom part is without vertical exaggeration. Contours are of interpreted true resistivity in ohm-meters.



Vertical Exaggeration X10



Vertical Exaggeration X4



No Vertical Exaggeration

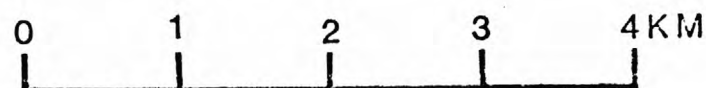


Figure 9.--Computer-generated geoelectric cross section. The top and middle parts are vertically exaggerated ten and four times, respectively. The bottom part is without vertical exaggeration. Contours are of interpreted true resistivity in ohm-meters.

from 50 to 180 m. Under soundings 39 to 35 a layer of less than 10 ohm-m underlies the section.

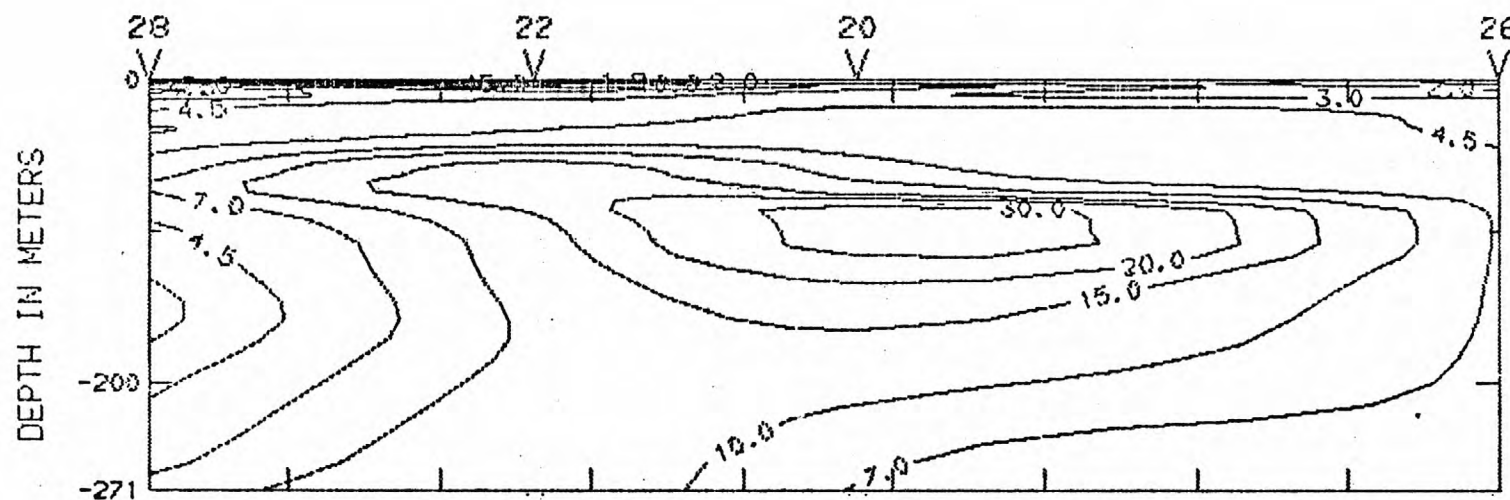
Figure 9 shows a north-south geoelectric cross section. This section is generally composed of less than 10 ohm-m material. Under soundings 7, 21, and 8 at a depth of about 100 m a layer of 10 to 20 ohm-m material is present. This layer has a thickness of about 20 m under sounding 7, 150 m under sounding 21, and 100 m under sounding 8.

Figure 10 shows a north-south geoelectric cross section located about 1 km west of the section in figure 9. Generally this section is composed of less than 10 ohm-m material. A lens of 10 to 20 ohm-m material at a depth of about 50 m is present under soundings 22 and 20. Its thickness is about 120 m under sounding 20 and greater than 200 m under sounding 22.

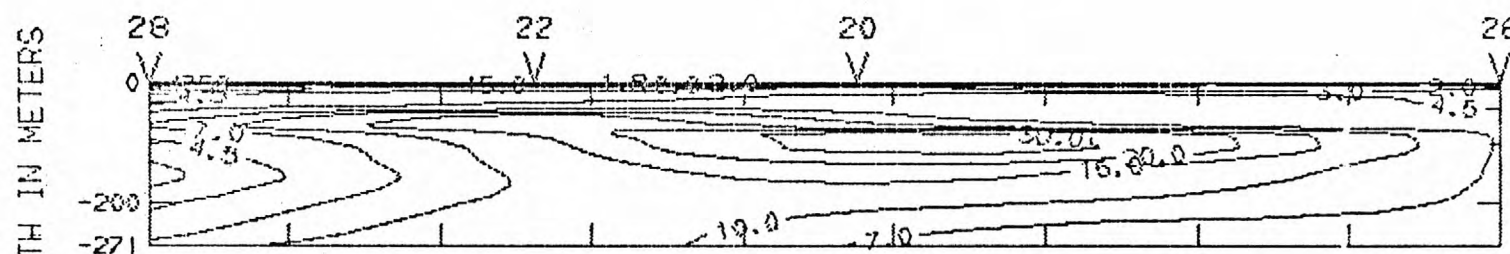
Figure 11 shows a north-south geoelectric cross section located about 1 km west of the section in figure 10. The upper 100 m is mostly composed of less than 10 ohm-m material. Under soundings 18, 19, and 25 from about 100 m, 10 to 25 ohm-m material is present.

Figure 12 shows a north-south geoelectric cross section located about 1 km west of the section in figure 11. Low resistivity material (less than 15 ohm-m) exists in the upper 50 m under soundings 16 and 15 deepening to about 100 m under sounding 13 and comprising the entire section under soundings 14 and 2. More resistive material (greater than 20 ohm-m) exists from 50 to greater than 270 m under soundings 16 and 15 and from 100 to greater than 270 m under sounding 13.

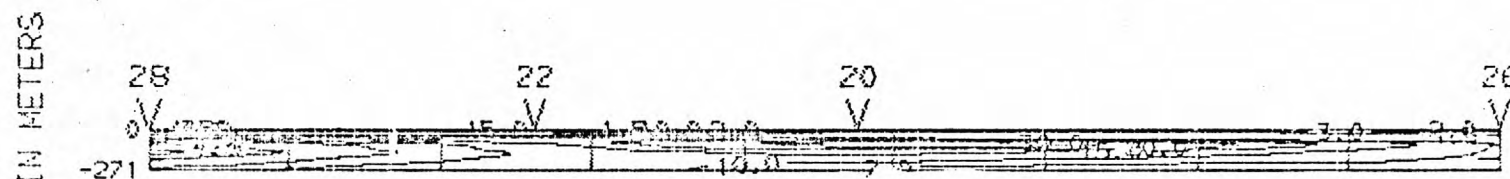
Figure 13 shows a north-south geoelectric cross section located about 1 km west of the section in Fig 12. Under soundings 16, 13, 23,



Vertical Exaggeration X10



Vertical Exaggeration X4



No Vertical Exaggeration

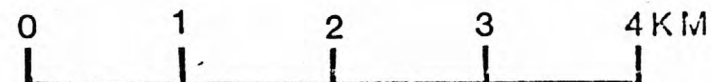
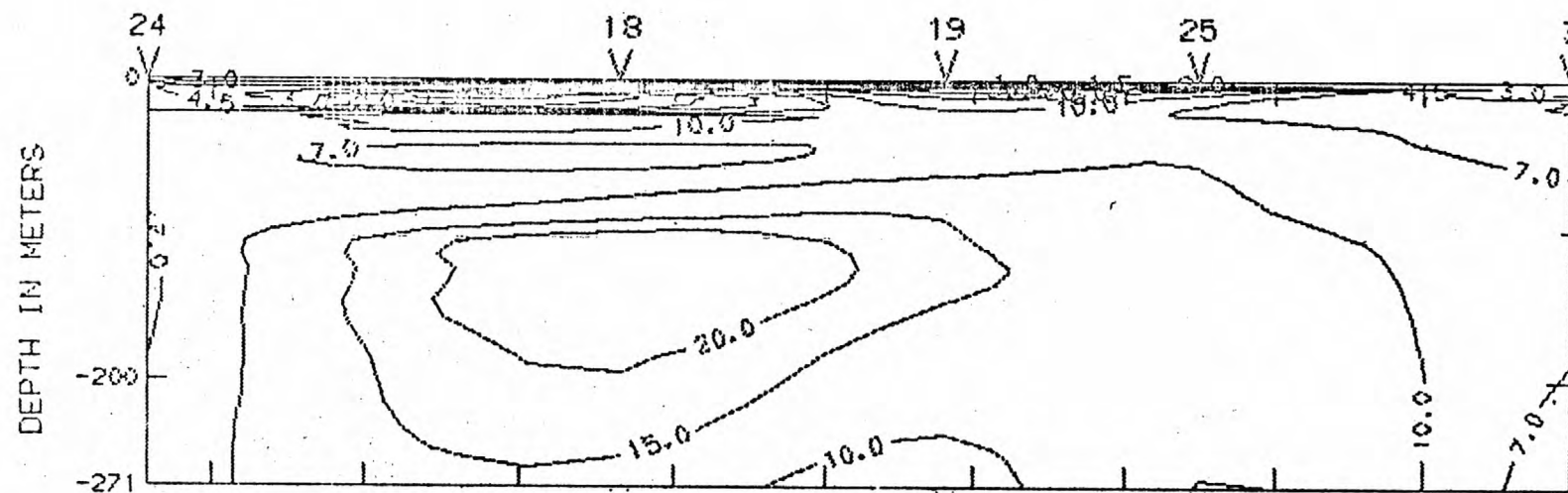
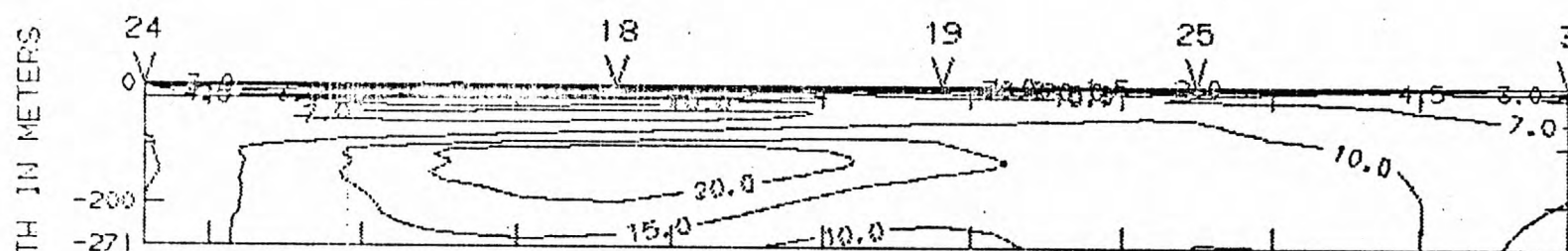


Figure 10 -- Computer-generated geoelectric cross section. The top and middle parts are vertically exaggerated ten and four times, respectively. The bottom part is without vertical exaggeration. Contours are of interpreted true resistivity in ohm-meters.



Vertical Exaggeration X10



Vertical Exaggeration X4



No Vertical Exaggeration

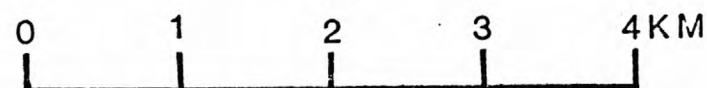
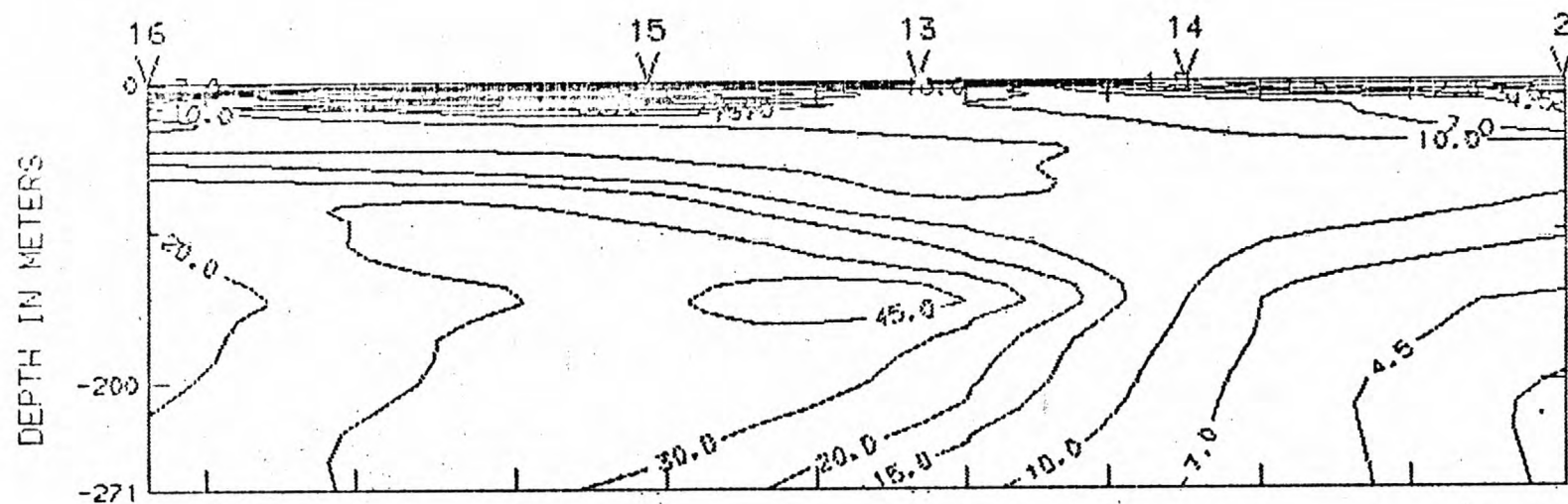
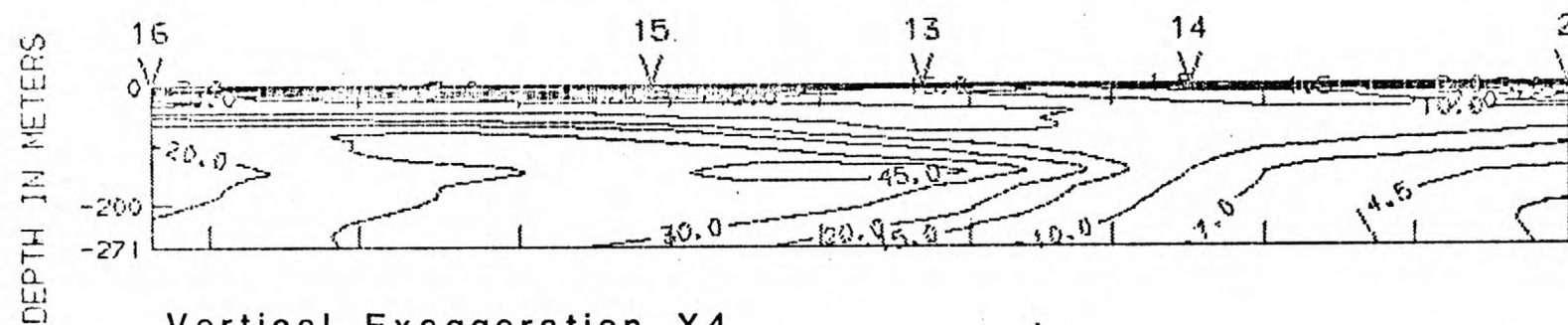


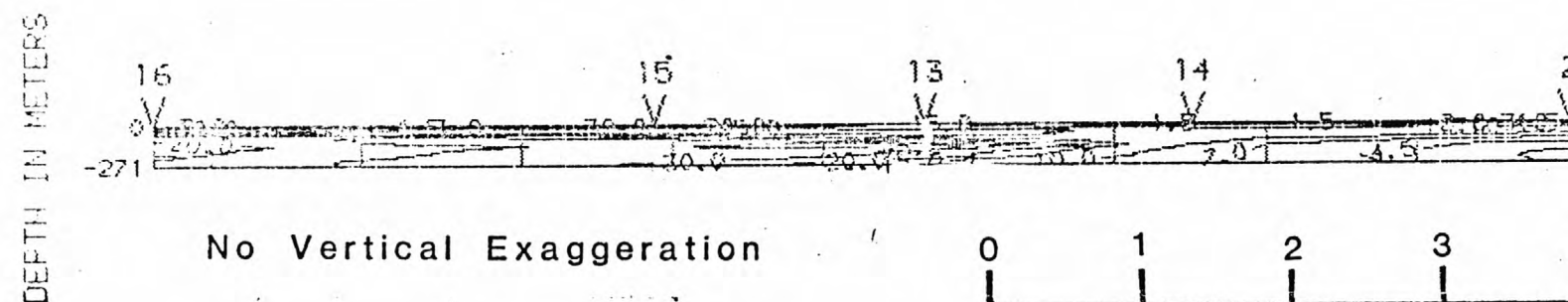
Figure 11--Computer-generated geoelectric cross section. The top and middle parts are vertically exaggerated ten and four times, respectively. The bottom part is without vertical exaggeration. Contours are of interpreted true resistivity in ohm-meters.



Vertical Exaggeration X10



Vertical Exaggeration X4



No Vertical Exaggeration

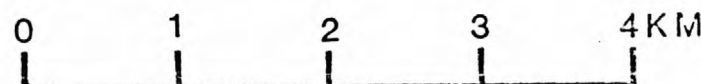
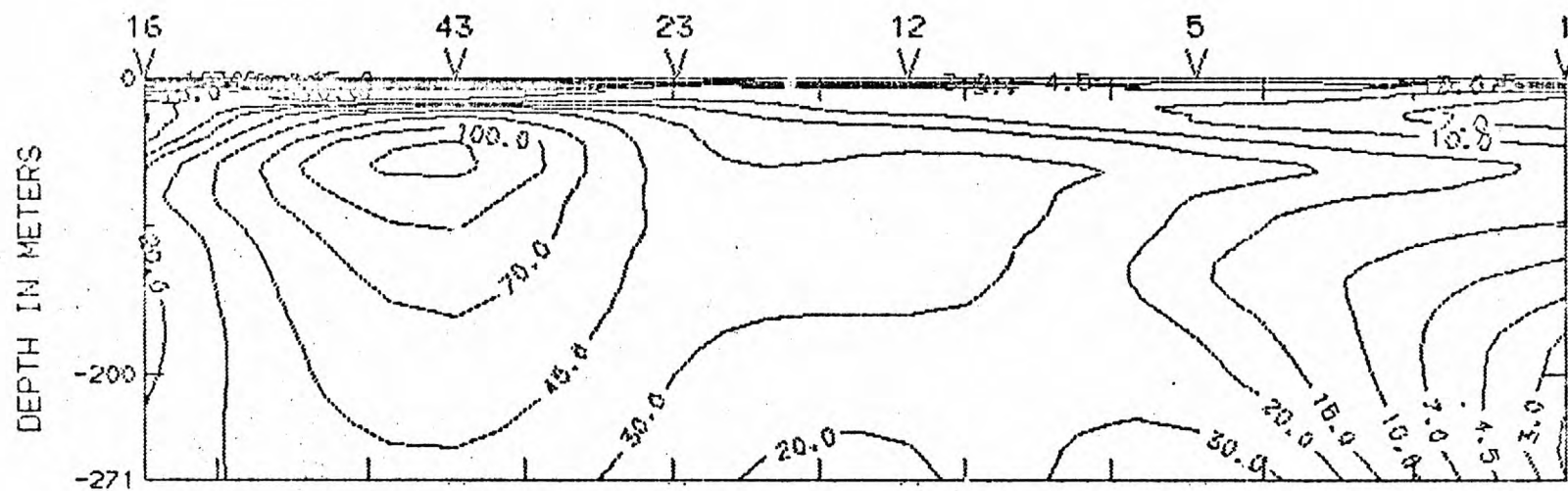
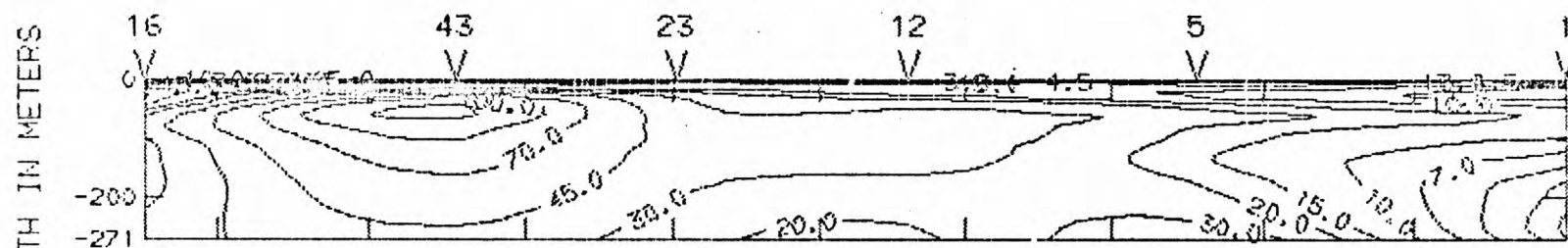


Figure 12--Computer-generated geoelectric cross section. The top and middle parts are vertically exaggerated ten and four times, respectively. The bottom part is without vertical exaggeration. Contours are of interpreted true resistivity in ohm-meters.



Vertical Exaggeration X10



Vertical Exaggeration X4



No Vertical Exaggeration

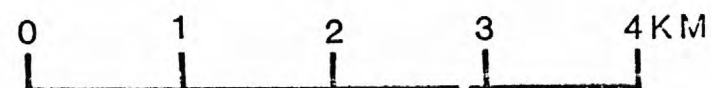


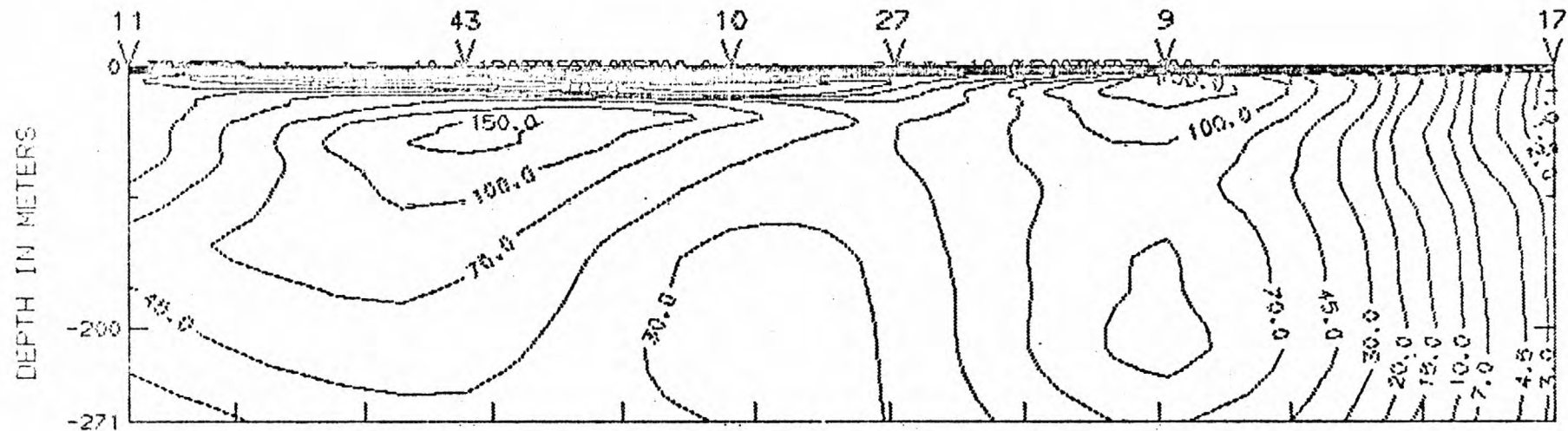
Figure 13--Computer-generated geoelectric cross section. The top and middle parts are vertically exaggerated ten and four times, respectively. The bottom part is without vertical exaggeration. Contours are of interpreted true resistivity in ohm-meters.

12, and 5 the upper 20 to 50 m consists of less than 10 ohm-m material, followed by greater than 20 ohm-m material. Less than 10 ohm-m material is present under sounding 1 with less than 4.5 ohm-m material from 150 m to greater than 270 m.

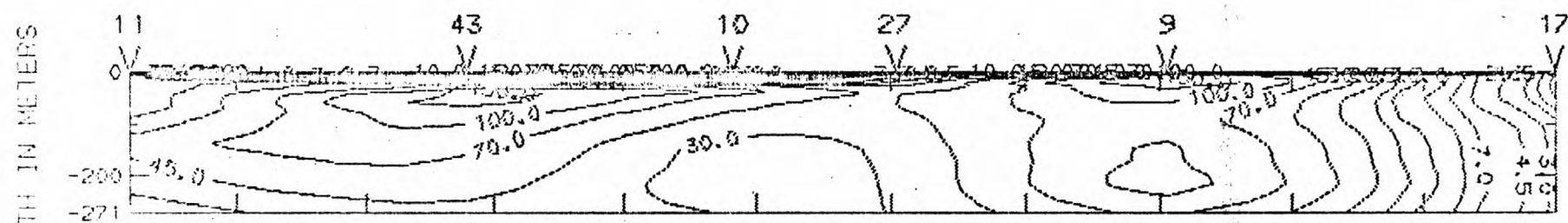
Figure 14 shows a generally north-south geoelectric cross section from sounding 11 to 17. Material of greater than 20 ohm-m is present under soundings 11, 43, 10, 27, and 9. Very low (less than 3 ohm-m) resistivity material is present under sounding 17. This could be due to the presence of hot springs nearby.

Figure 15 is a map of interpreted true resistivity at a depth of 50 m. In general there exists low resistivity material in the central region with the higher resistivity material being located closer to the mountains. The higher resistivity material manifests itself farther into the plain than would be indicated by topography. The somewhat circular features of higher resistivity around soundings 43, and 9 might be good prospects for fresh-water springs or well locations. On the right hand side of map the crowding of the 10, 15, 20, 30, and 45 ohm-m contours represents a transition from the clays and sediments of Fish Springs Flat to the volcanics associated with Black Rock Hills.

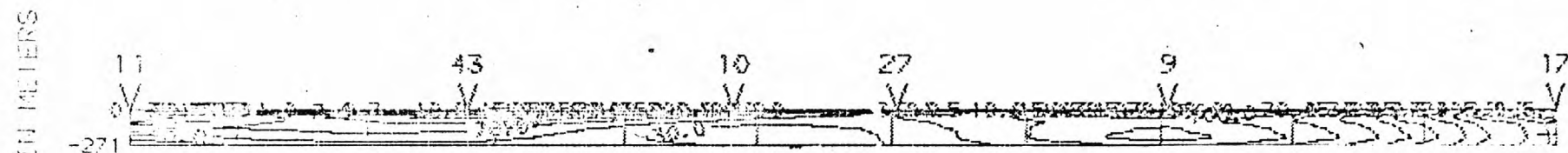
Figure 16 is a map of interpreted true resistivity at a depth of 100 m. The major portion of the plain at this depth consists of less than 15 ohm-m material, but unlike figure 15 an anomalous area of greater than 15 ohm-m material is present in the central portion of the plain. This feature could be due to transported coarse material from heavy rainfall or flooding, or it could be due to fresh-water saturated sediments. The latter explanation would require that at



Vertical Exaggeration X10



Vertical Exaggeration X4



No Vertical Exaggeration

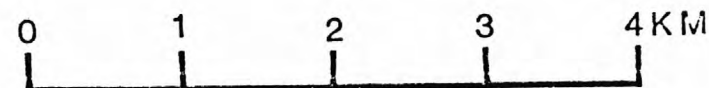
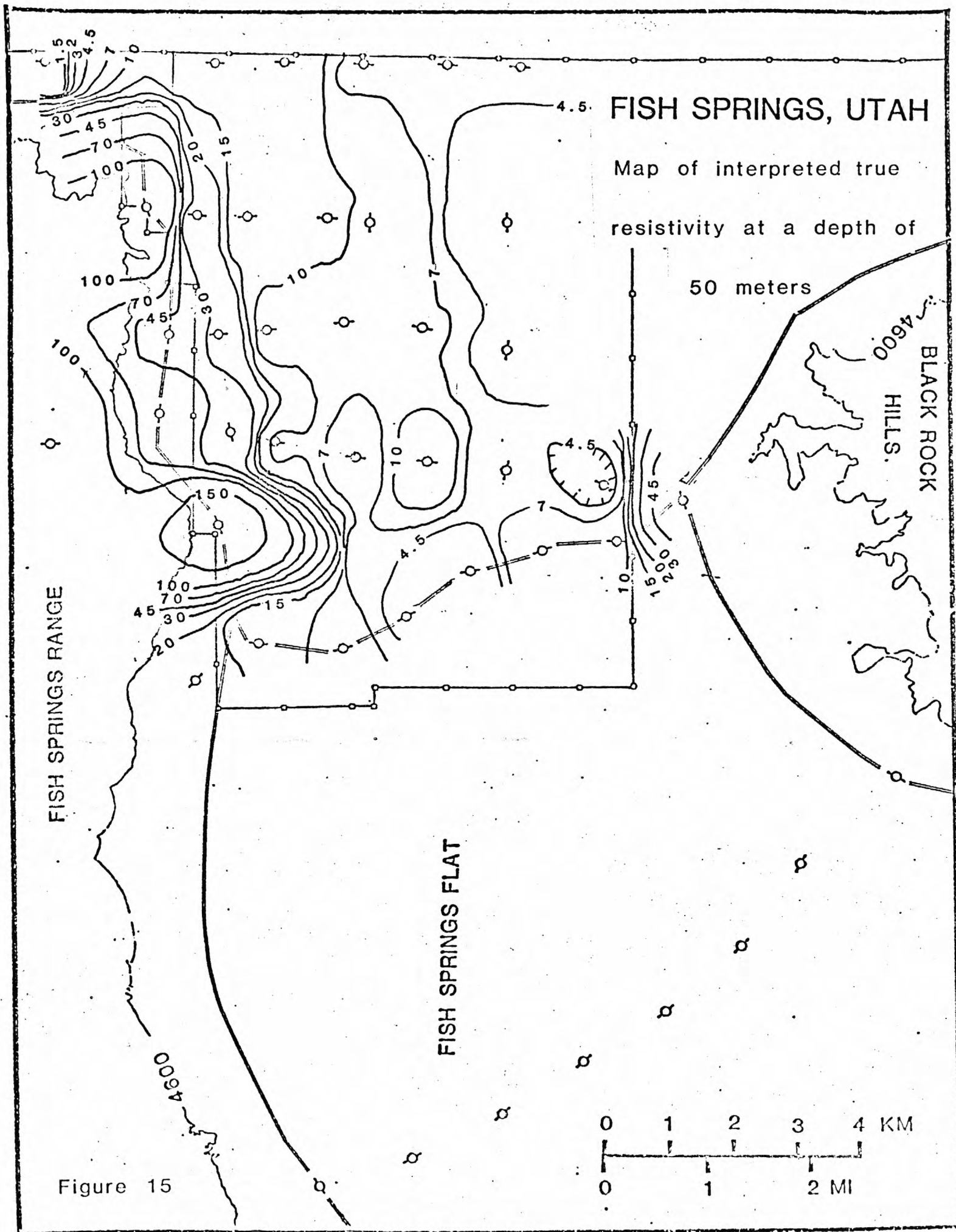


Figure 14--Computer-generated geoelectric cross section. The top and middle parts are vertically exaggerated ten and four times, respectively. The bottom part is without vertical exaggeration. Contours are of interpreted true resistivity in ohm-meters.



FISH SPRINGS, UTAH

Map of interpreted true
resistivity at a depth of

100 meters

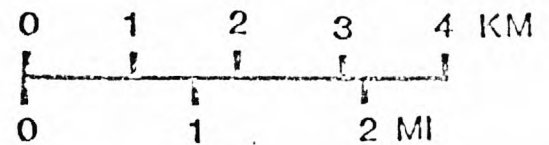
FISH SPRINGS RANGE

FISH SPRINGS FLAT

BLACK ROCK
HILLS.

4600

Figure 16



least some of the low resistivities seen in figure 15 be caused by clays. On the right side of the map the presence of volcanics is not as pronounced.

Figure 17 is a map of interpreted true resistivity at a depth of 200 m. Again the major portion of the plain is composed of less than 15 ohm-m material, with higher resistivities to the west. As in figure 16 the less than 15 ohm-m material has extended up to 4 km in to Fish Springs Flat. On the right side of the figure the effect of the volcanics is gone, indicating that near sounding 29 their thickness is less than 200 and probably greater than 100 m.

CONCLUSIONS

Schlumberger sounding data obtained on Fish Springs Flat, Utah can be used to delineate groundwater quality. In the area of the Fish Springs National Wildlife Refuge water quality is generally quite poor. In the southwestern quarter of the refuge the possibilities of potable groundwater are increased due to the presence of higher resistivities at depth. In addition, the possibility of potable groundwater increases as one approaches Fish Springs Range.

An area of possible fresh water exists in the Wildlife Refuge from 100 to 200 m in depth (fig. 16). This zone has as a possible source a topographic extension of the Fish Springs Range near sounding 43. Whether this more resistive zone reflects a change in water quality or coarser material is not known.

FISH SPRINGS, UTAH

Map of interpreted true
resistivity at a depth of

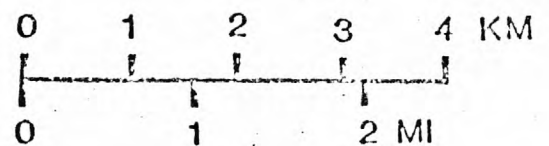
200 meters

FISH SPRINGS RANGE

FISH SPRINGS FLAT

BLACK ROCK
HILLS.

Figure 17



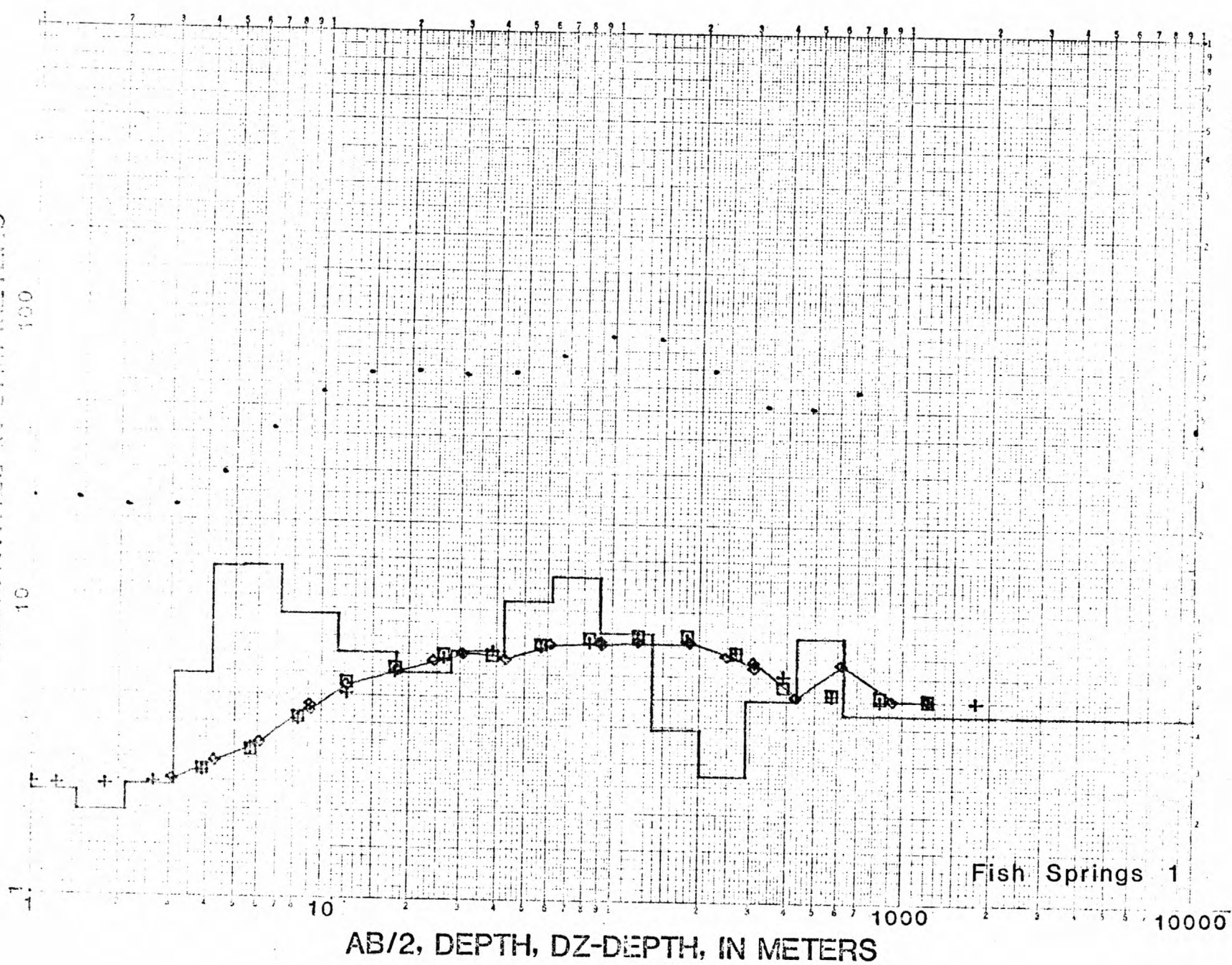
REFERENCES

- Anderson, W. L., 1971, Application of bicubic spline functions to two dimensional gridded data: NTIS (Natl. Tech. Inf. Service), PB-203 579, Springfield, Va.
- Evenden, G. I., 1975, A general purpose contouring system: U. S. Geol. Survey Open-File Report 75-317, 106p.
- Zohdy, A. A. R., 1973, A computer program for the automatic interpretation of Schlumberger sounding curves over horizontally layered media: NTIS (Natl. Tech. Inf. Service) PB-232 703/AS, 25 p., Springfield, Va.
- _____, 1974, The use of Dar Zarrouk curves in the interpretation of VES data: U. S. Geol. Survey Bull. 1313-D, 41 p.
- _____, 1975, Automatic interpretation of Schlumberger sounding curves using modified Dar Zarrouk functions: U. S. Geol. Survey Bull. 1313-E, 39 p.
- Zohdy, A. A. R., Anderson, L. A., and Muffler, L., J., P., 1973, Resistivity, self potential, and induced polarization surveys of a vapor dominated system: Geophysics, v. 38, p. 1130-1144.
- Zohdy, Adel A. R., Bisdorf, Robert J., and Jackson, Dallas B., 1978, Simple total field and Schlumberger soundings near Sugar City, Idaho; US Geological Survey Open-File Report 78-709, 101p.
- Zohdy, Adel A.R., and Bisdorf Robert J, 1979, Geoelectric investigation with Schlumberger soundings at the Buffalo River aquifer, near Moorhead, Minnesota; US Geological Survey Open-File Report 79-299, 243p.
- Zohdy, A. A. R., and Eaton, G. P., and Mabey, B. R., 1974,

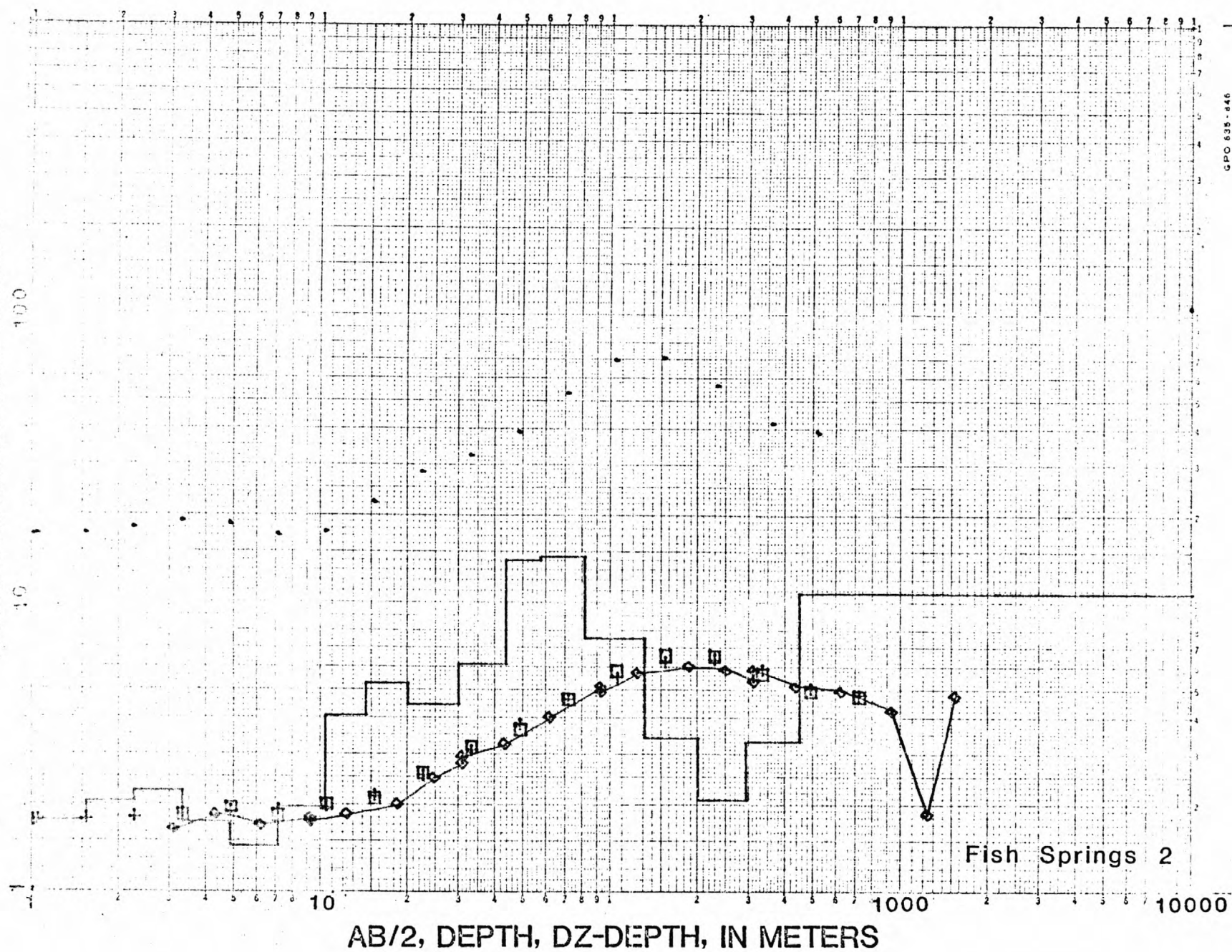
Application of surface geophysics to ground-water investigations:
Techniques of Water Resources Investigations of the US Geol.
Survey, Book 2, Chapter D1, 116p.

APPENDIX

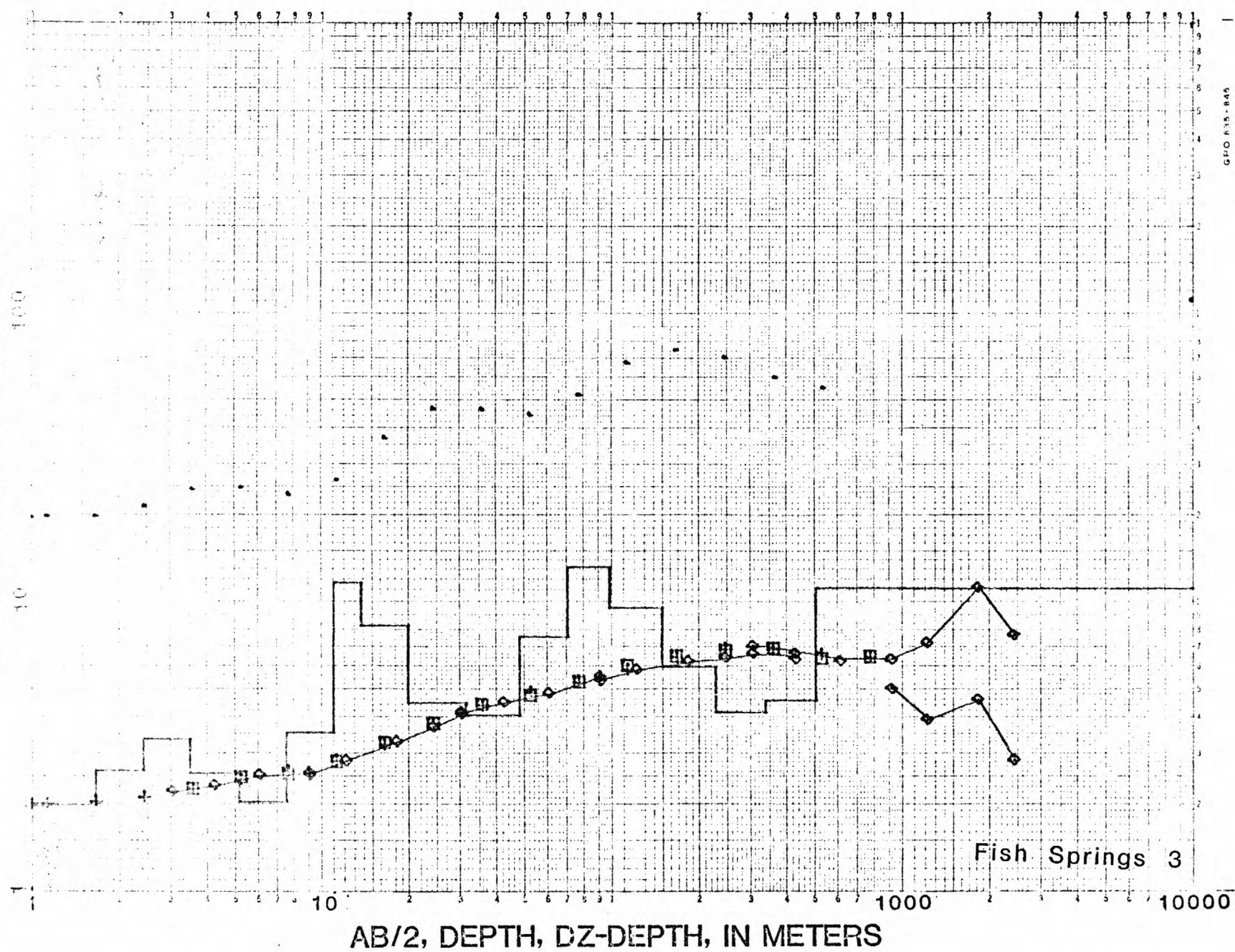
PROCTIVITY IN PERCENT

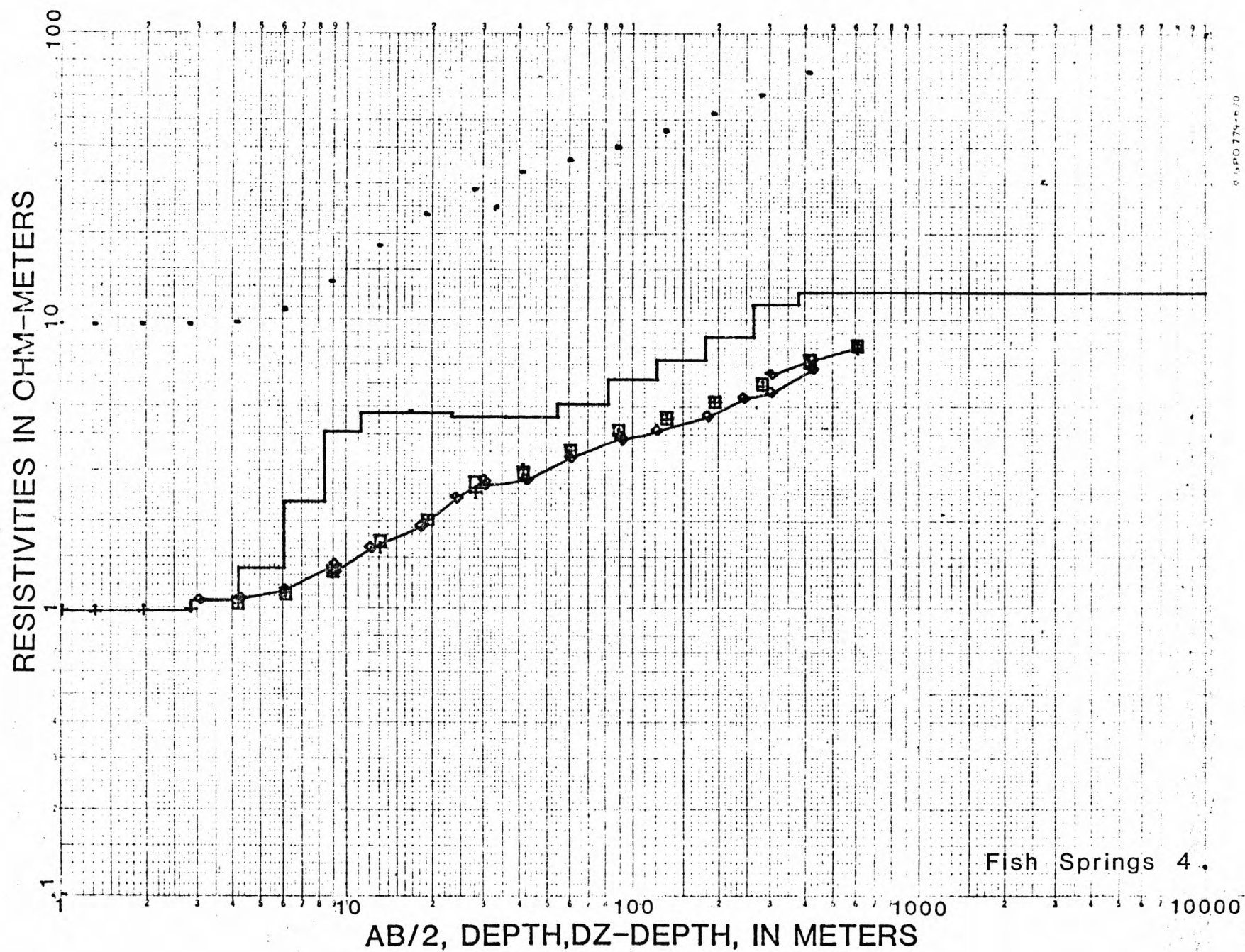


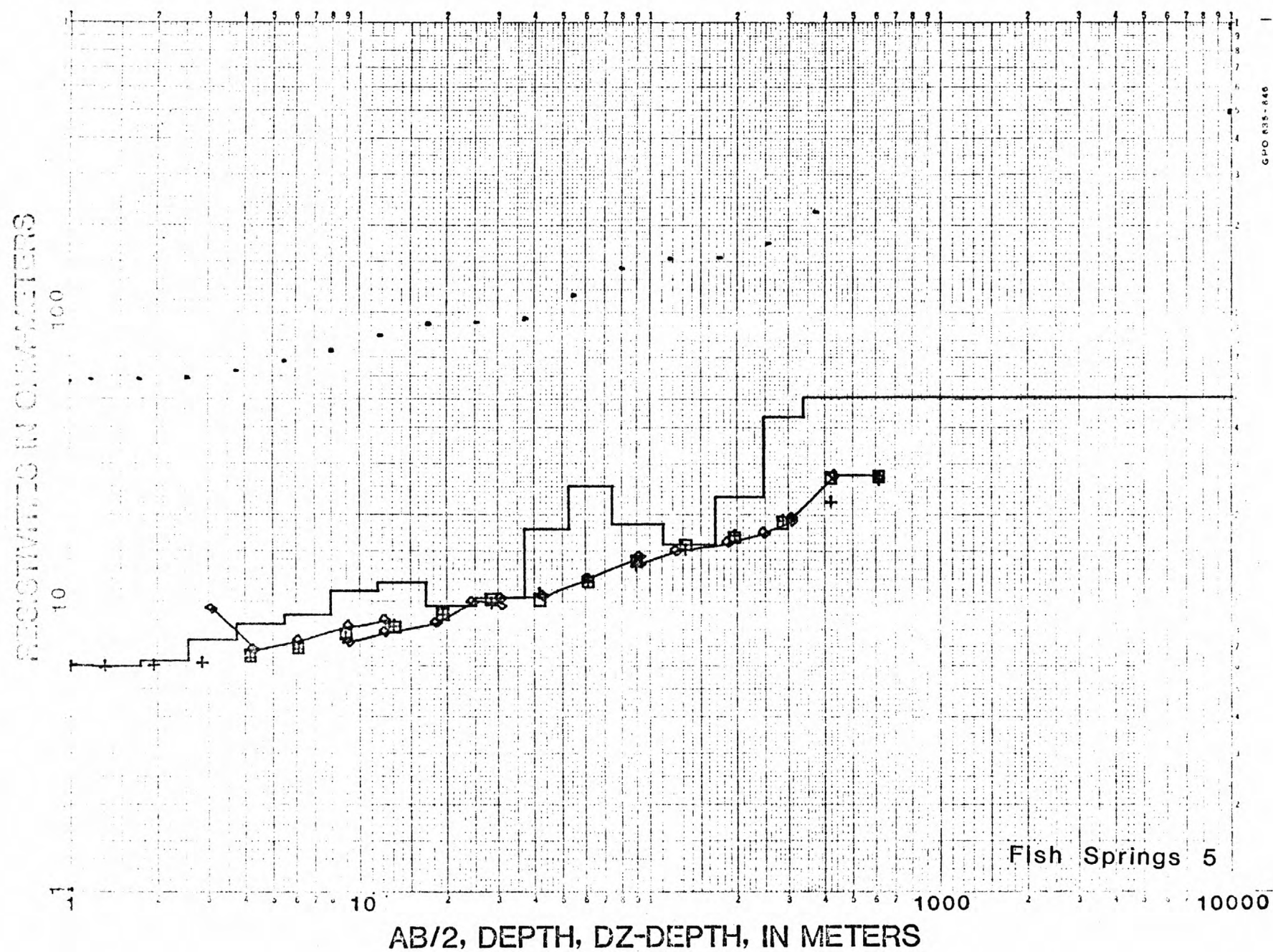
SPECIAL REPORT NO. 10



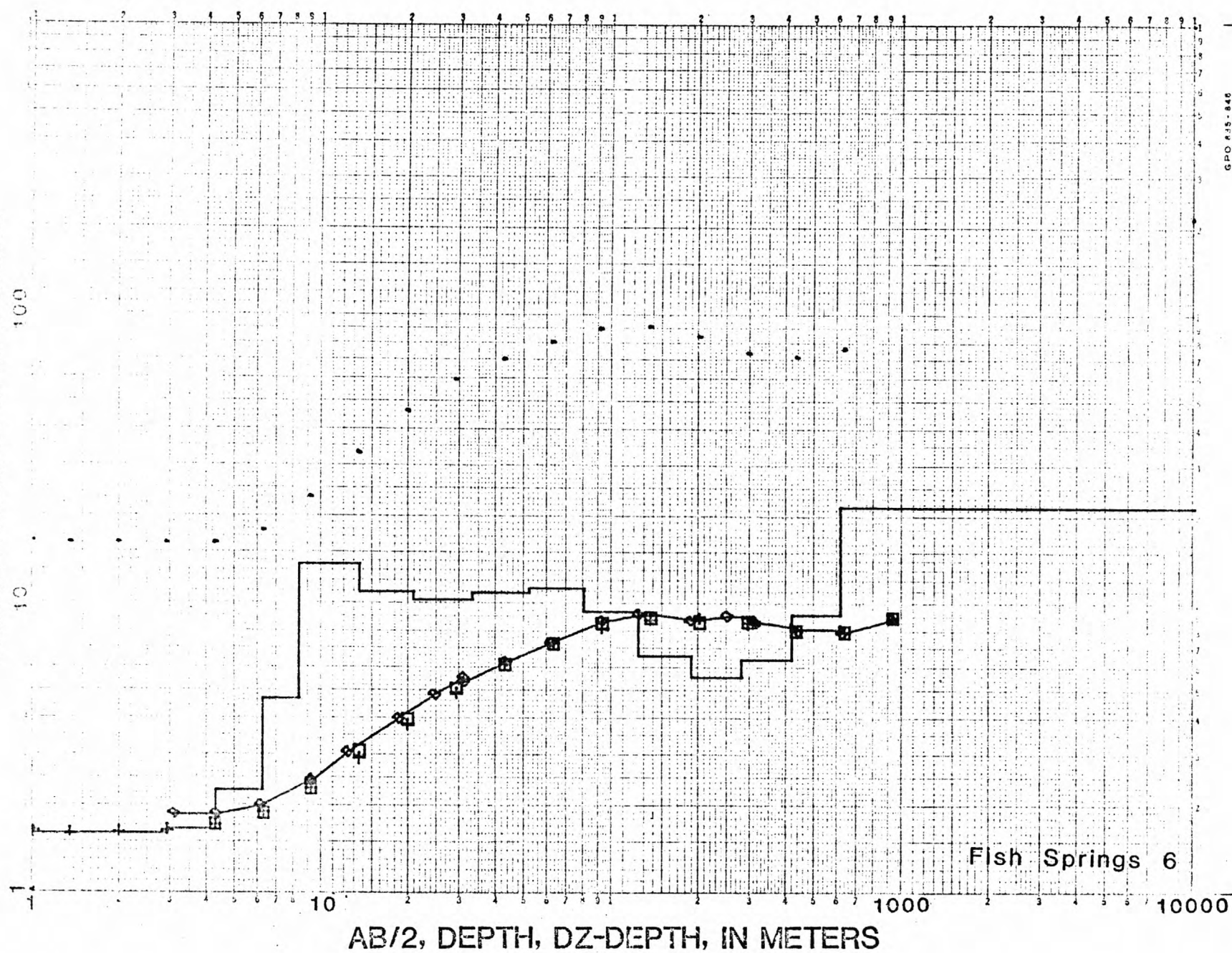
PROPORTION IN CENTIMETERS



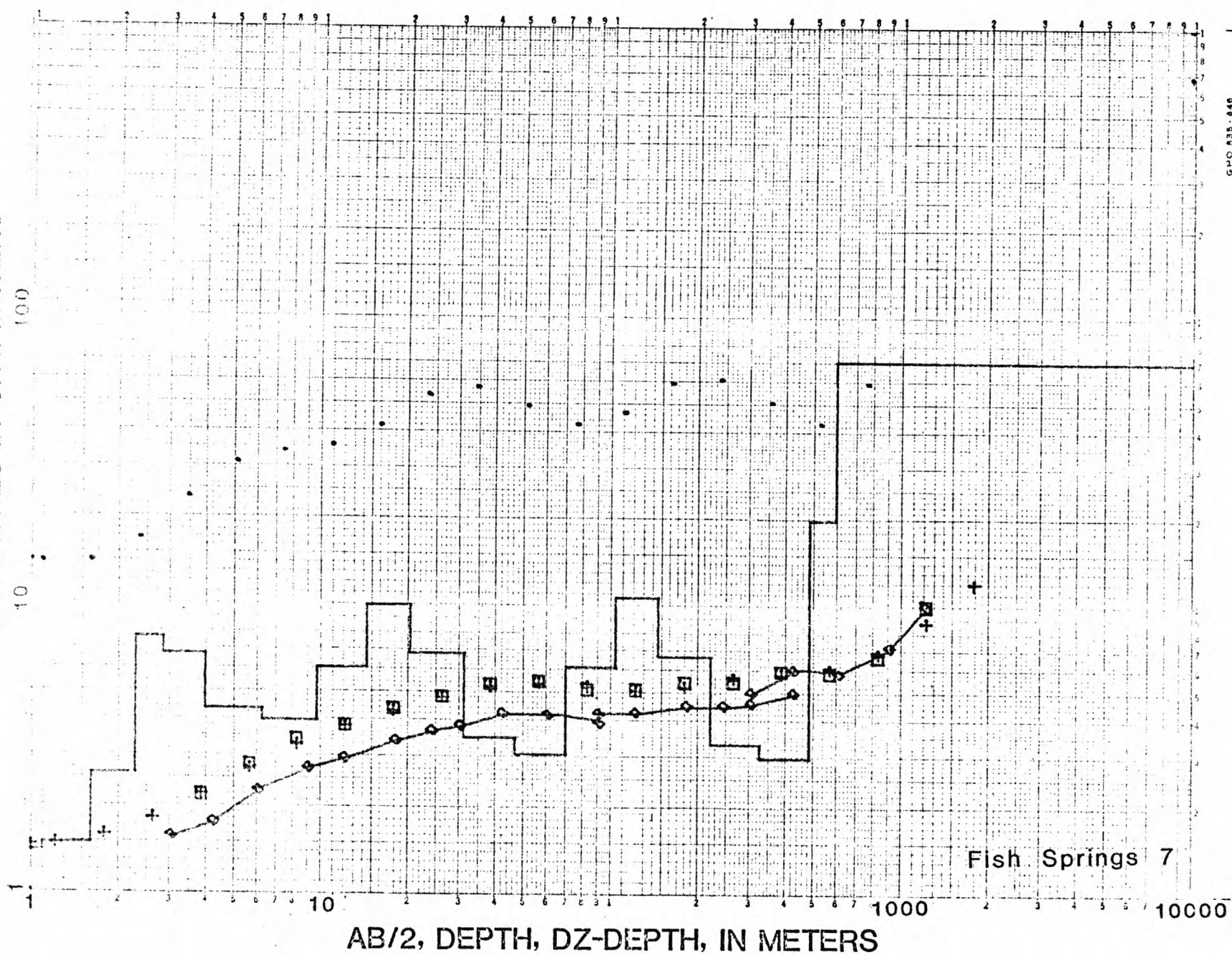




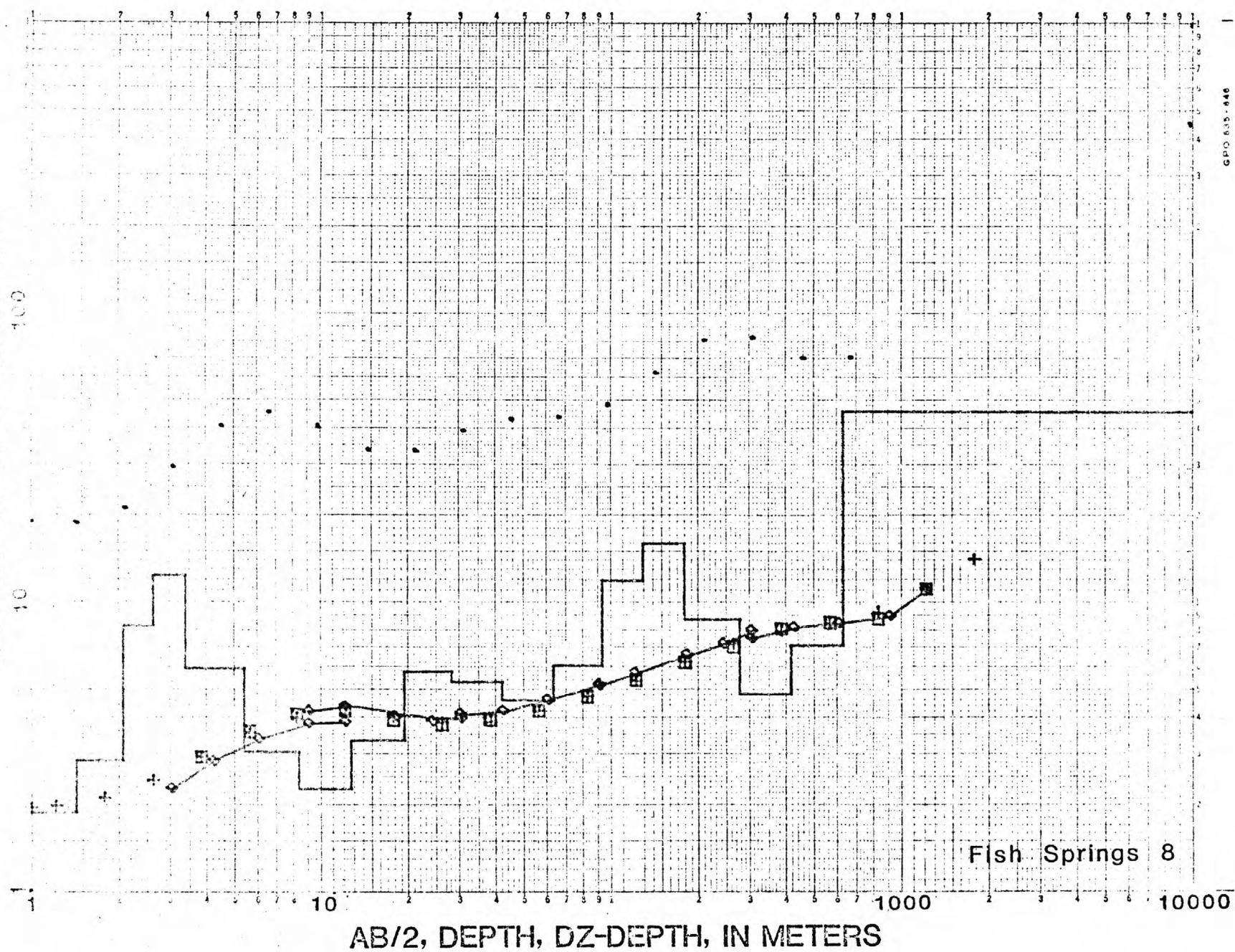
RESISTIVITY IN OHM-METERS

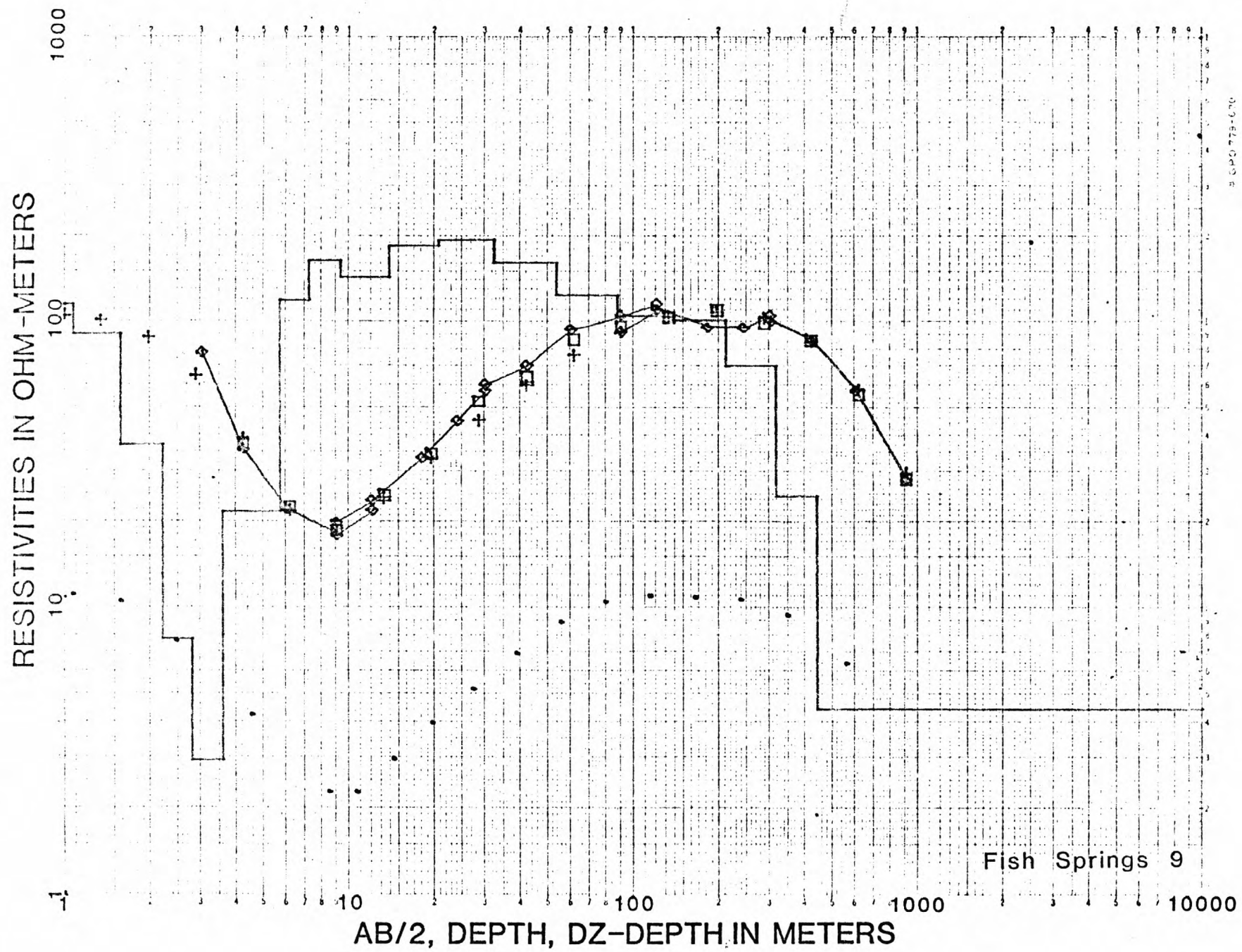


RESISTIVITY IN OHM-METERS



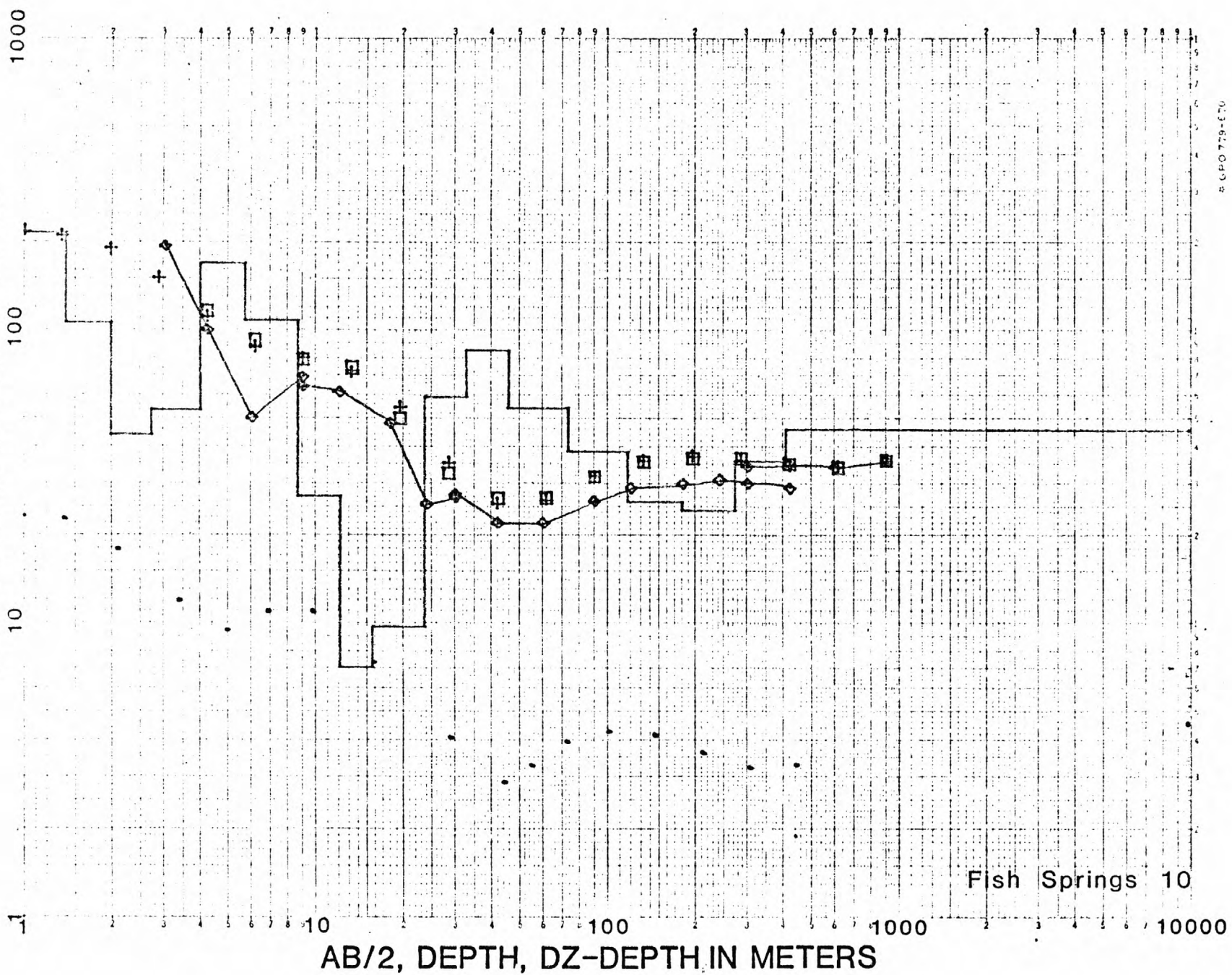
RECONSTRUCTED IN CHM-ARTERS

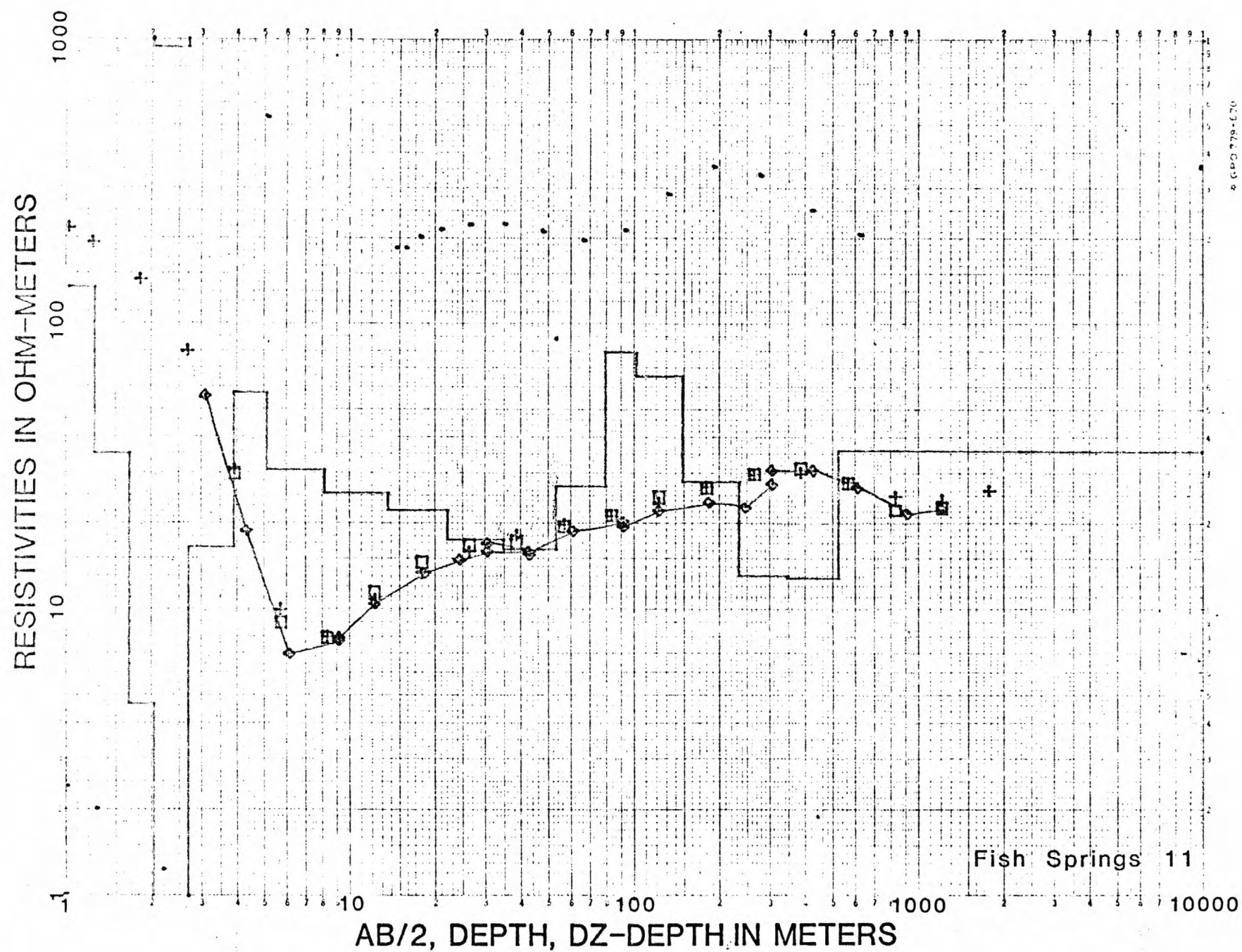


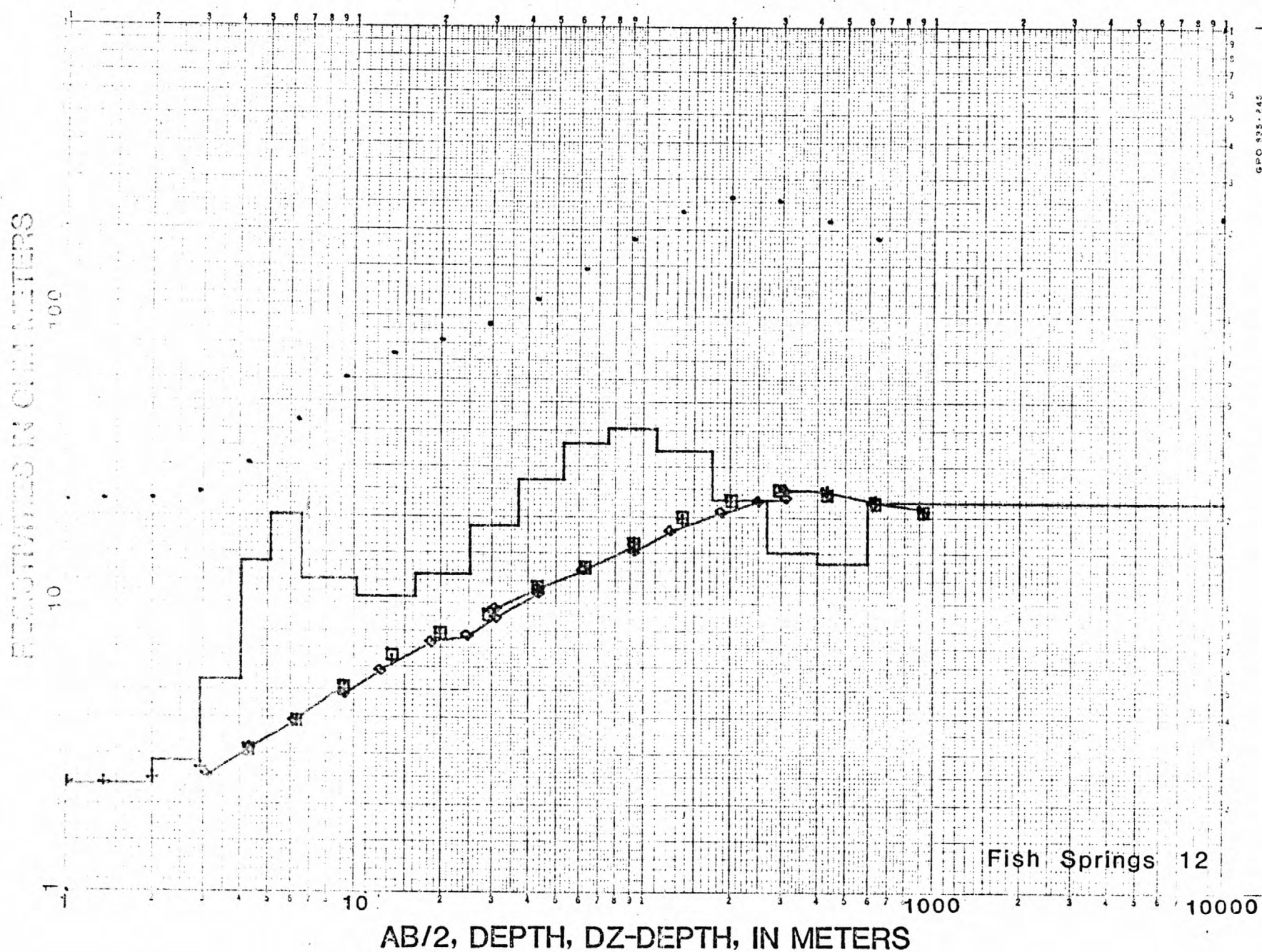


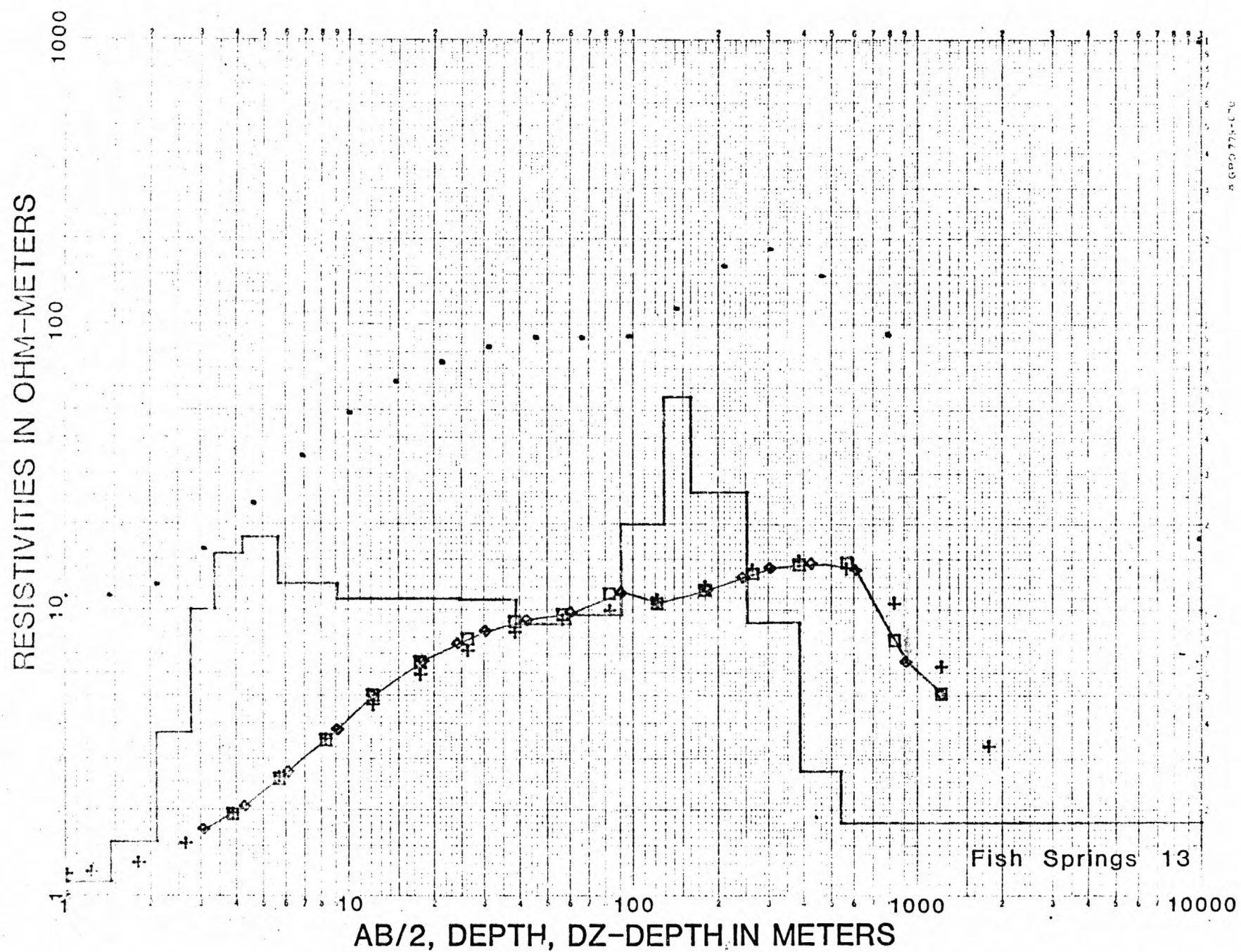
40

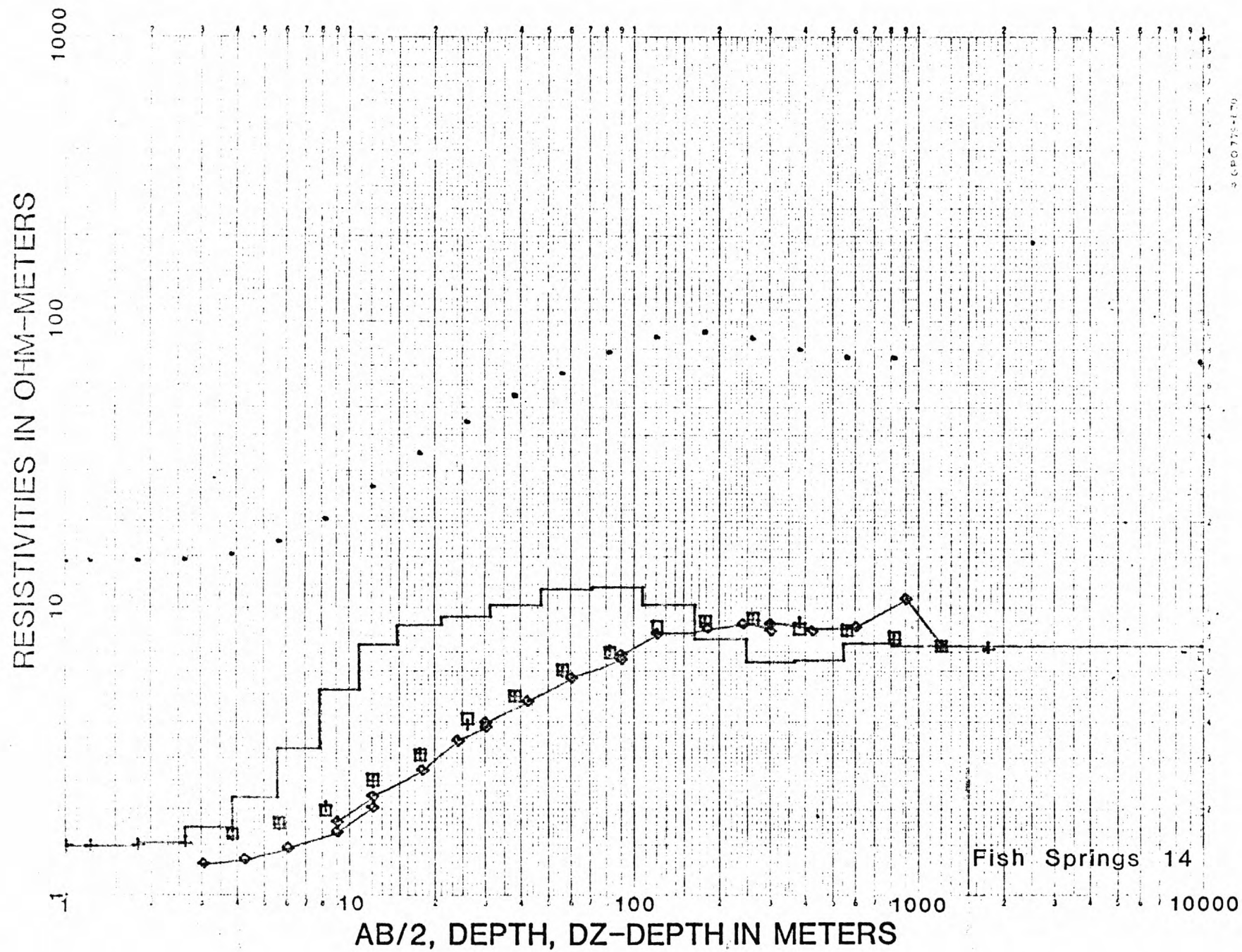
RESISTIVITIES IN OHM-METERS

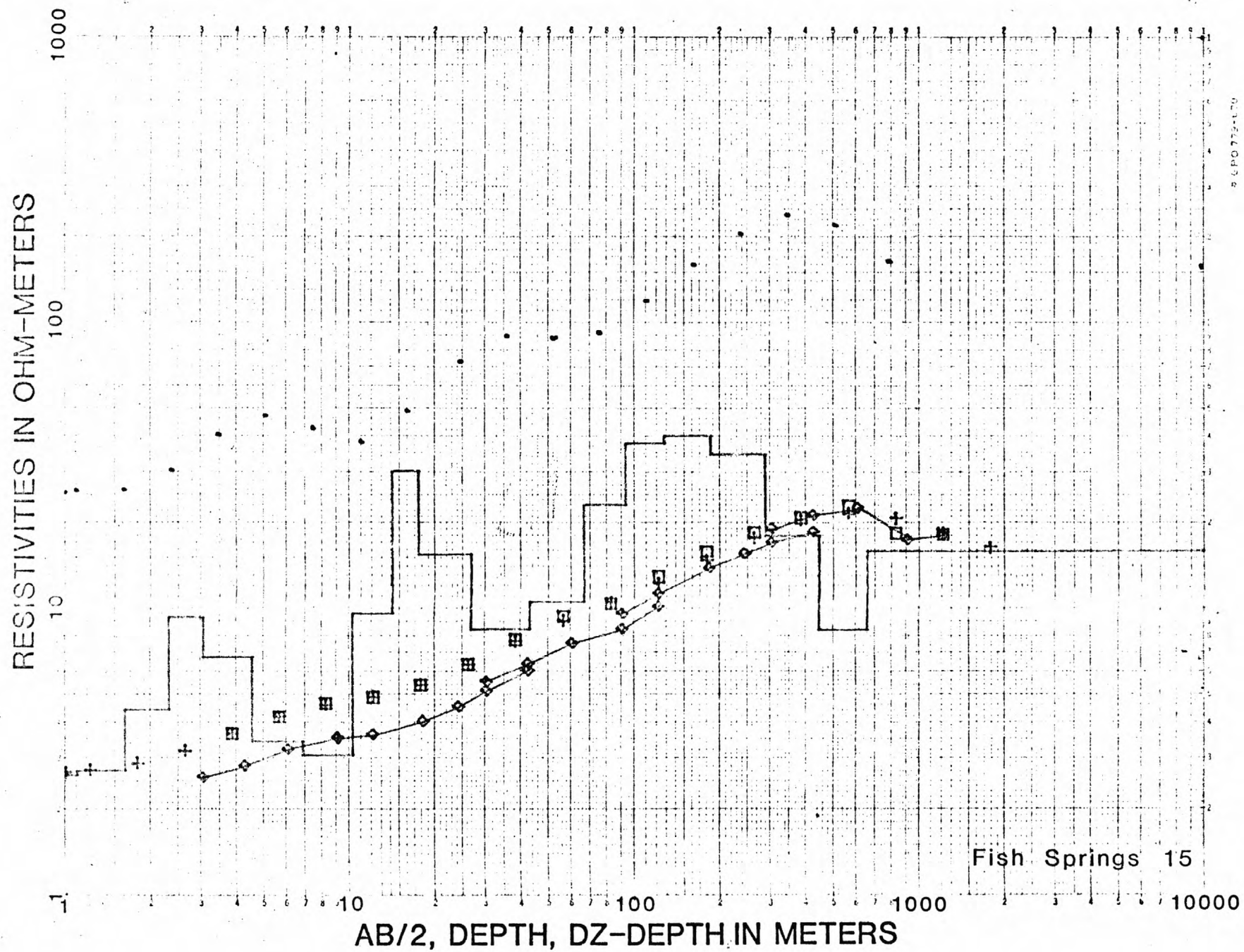


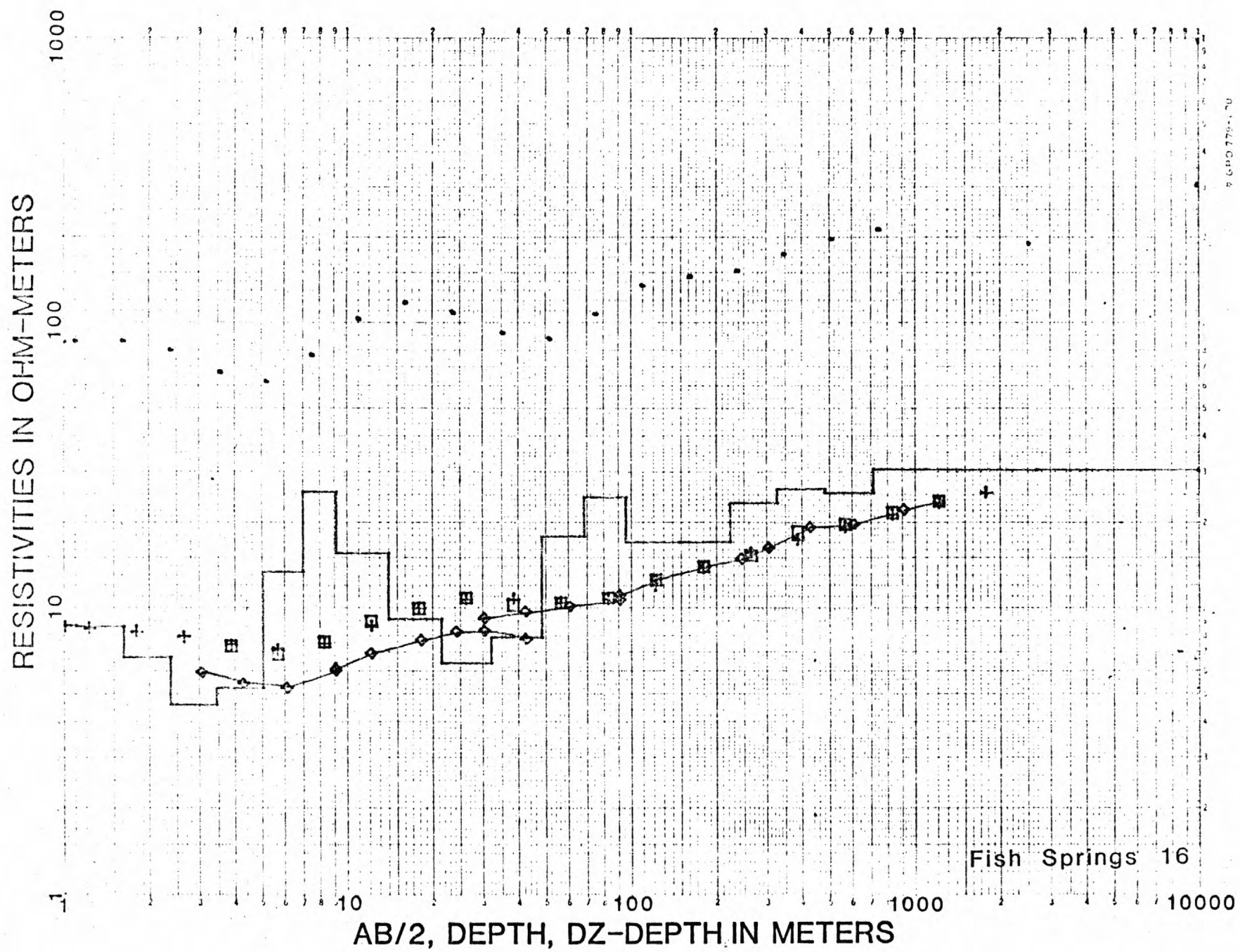


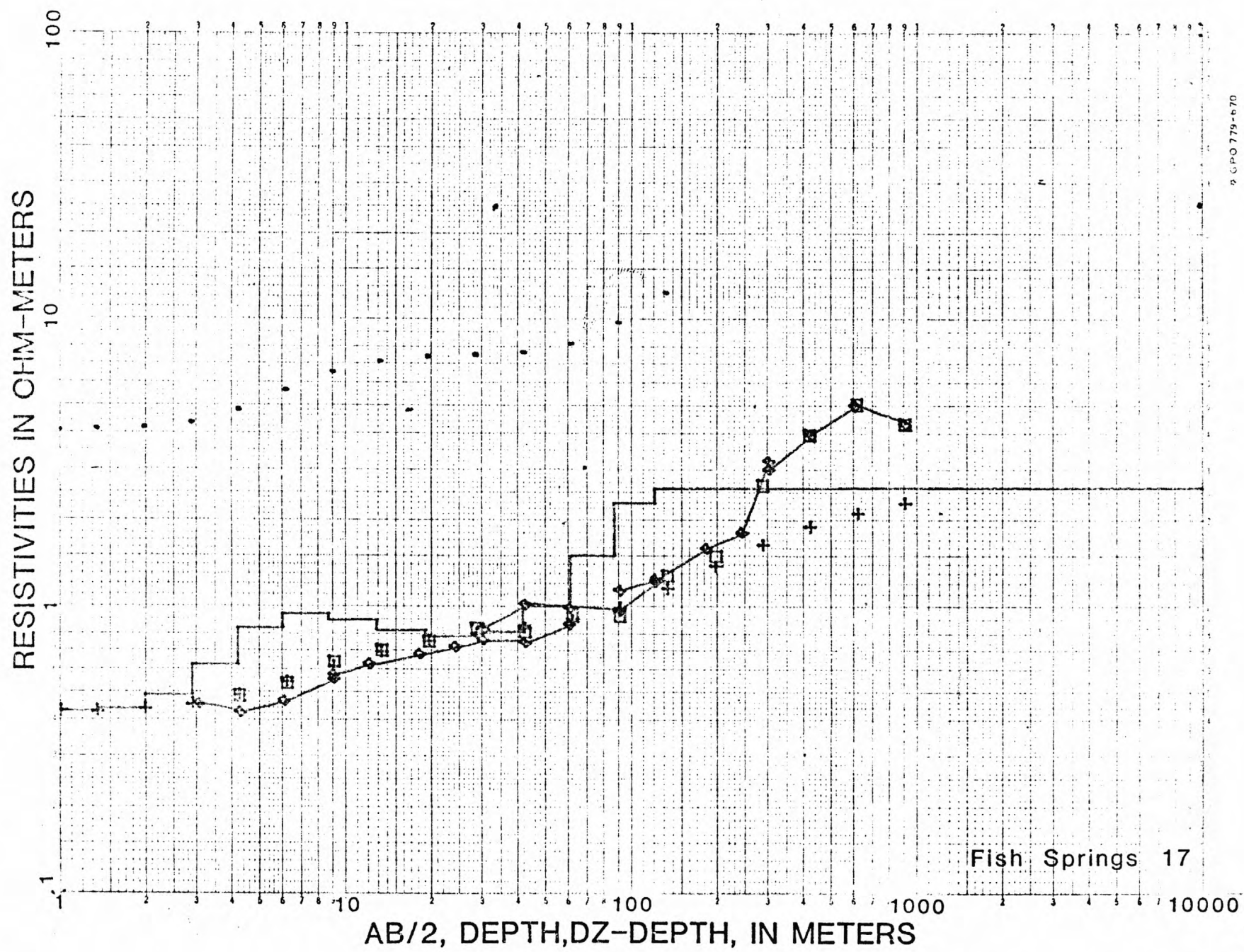


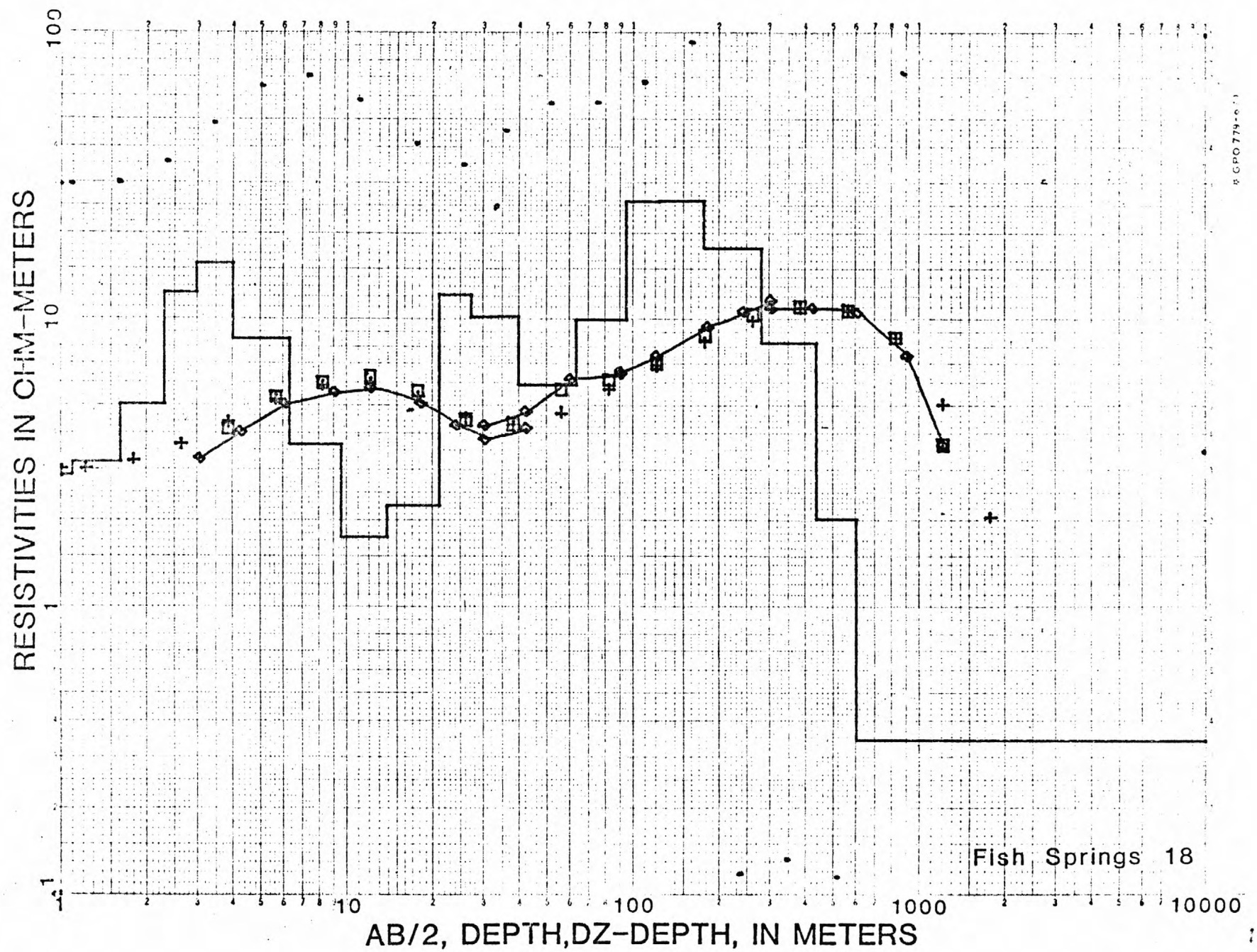


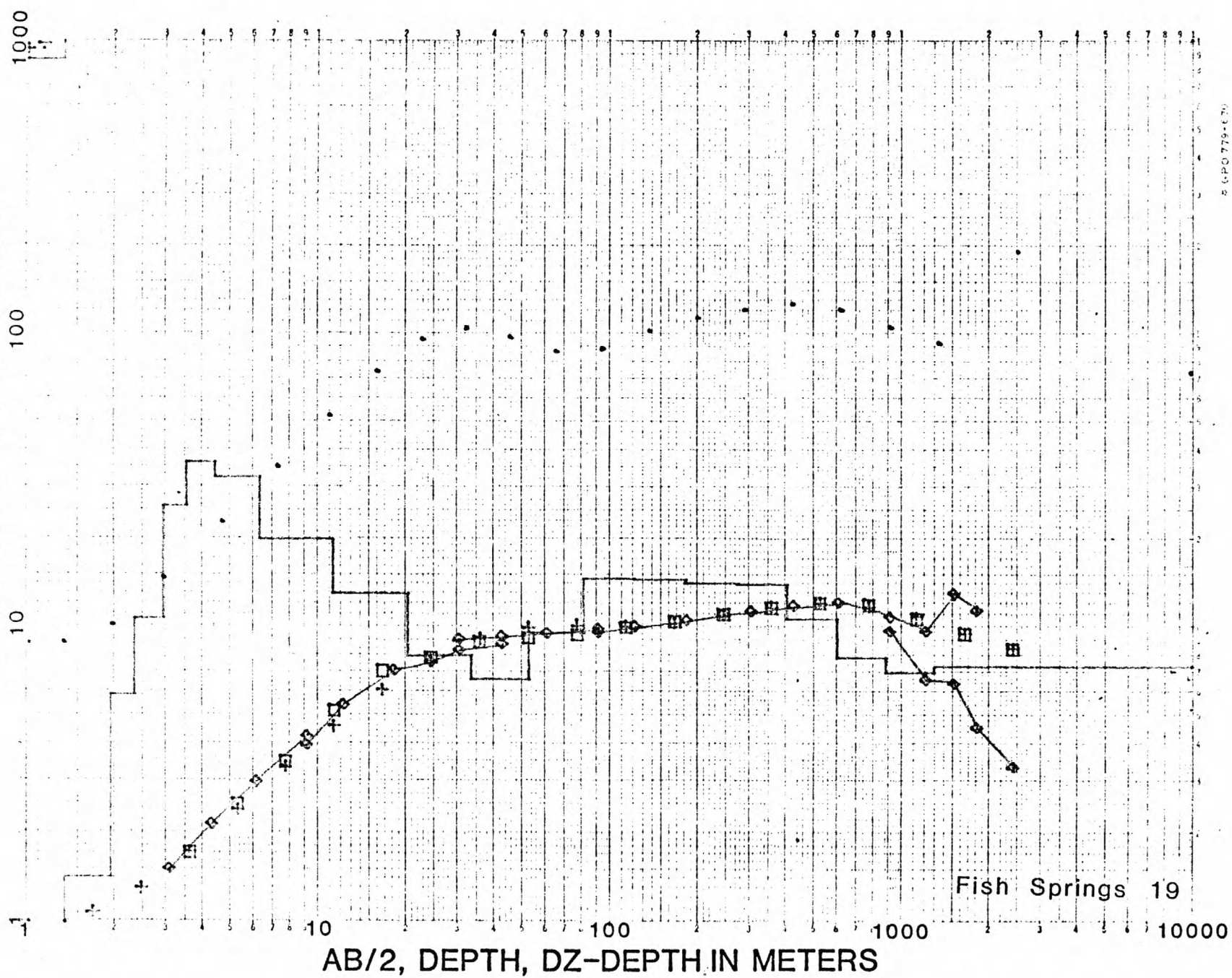






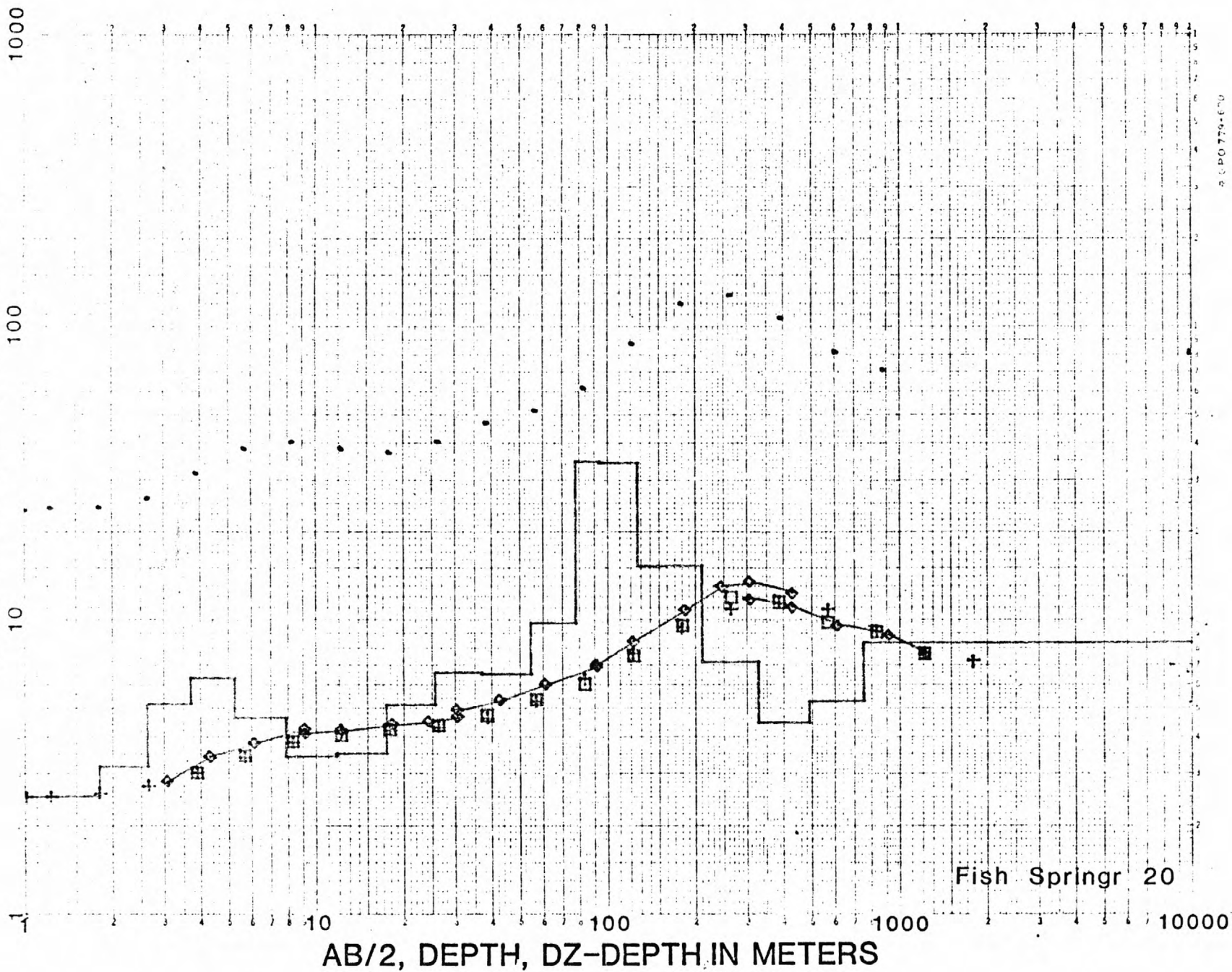






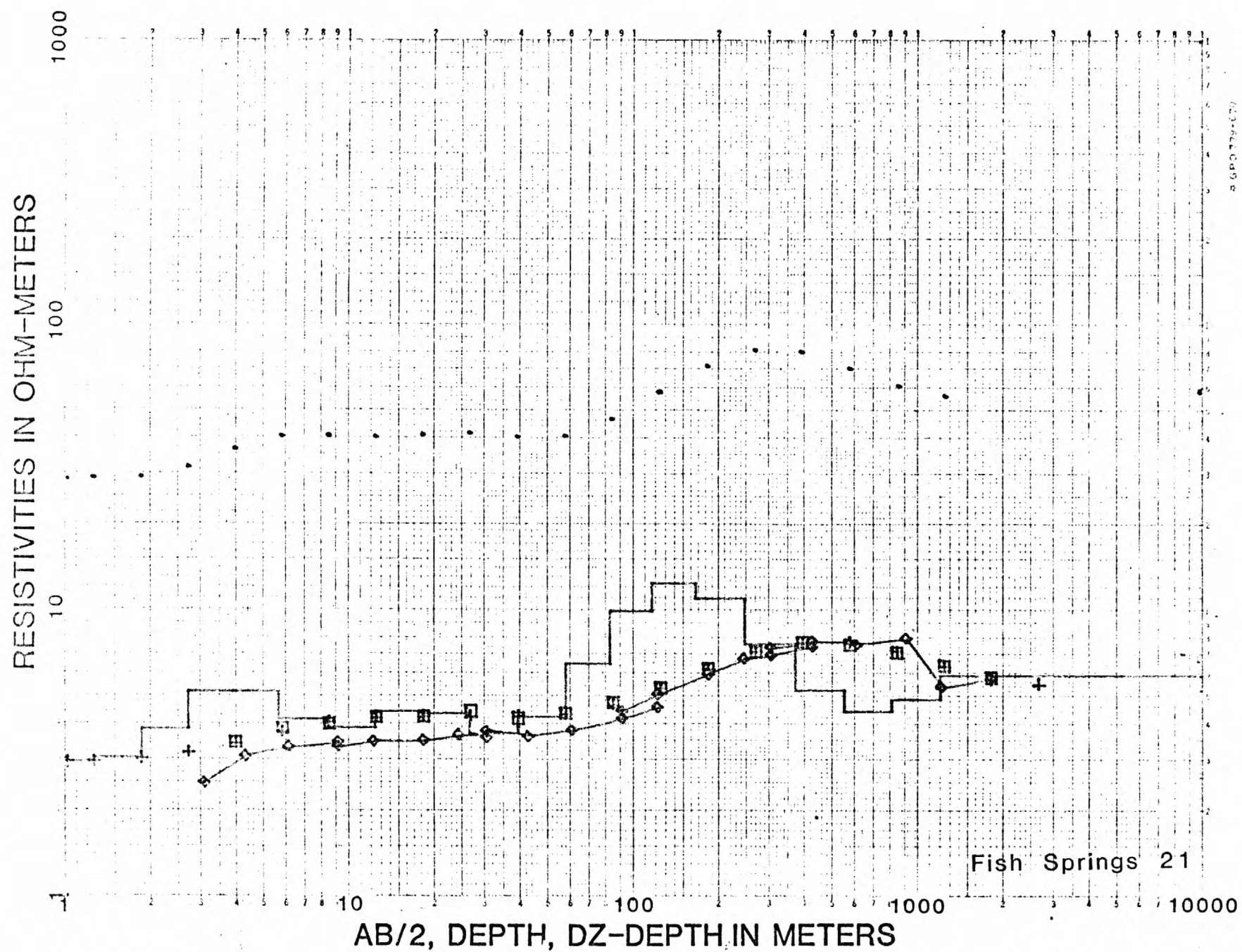
09

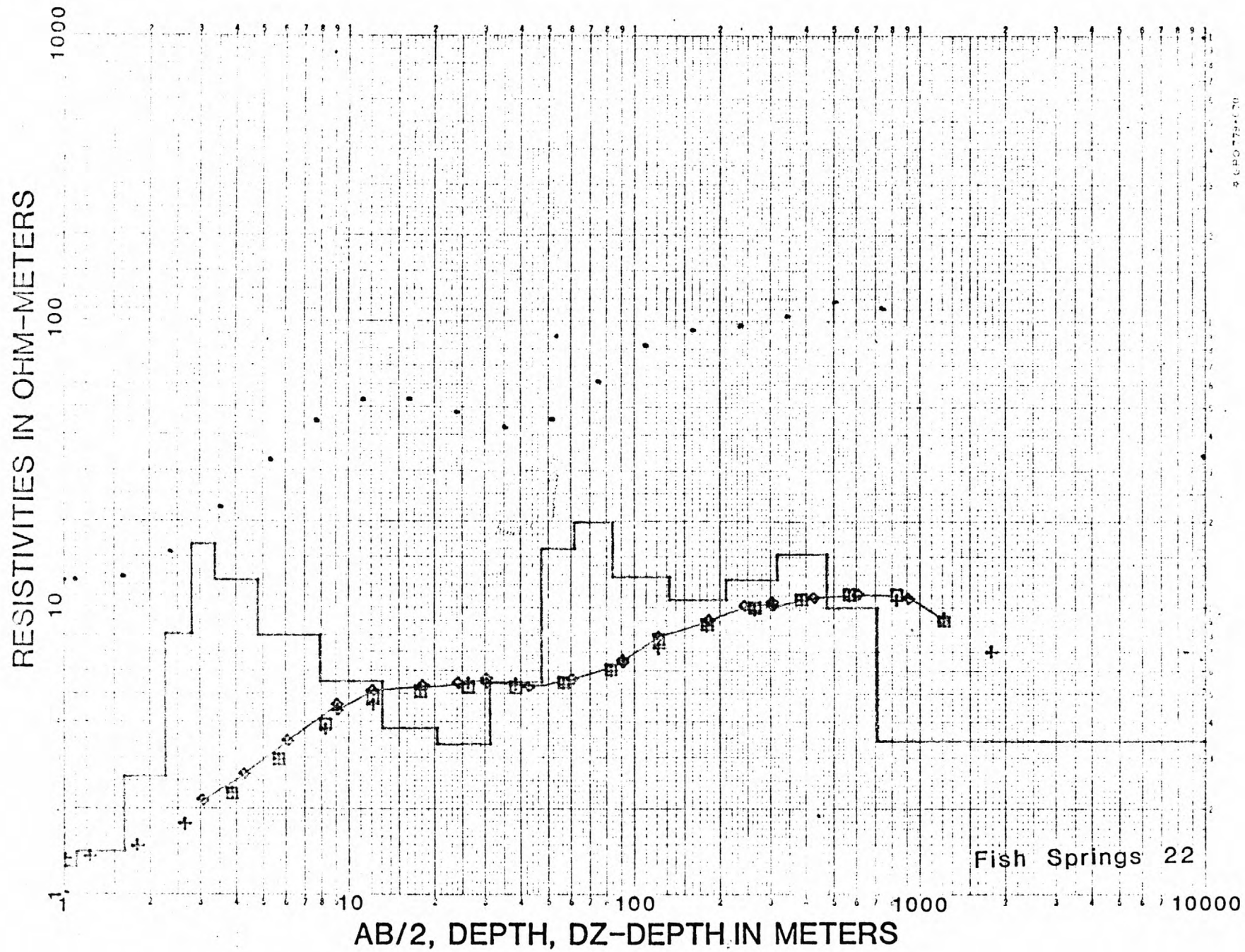
RESISTIVITIES IN OHM-METERS

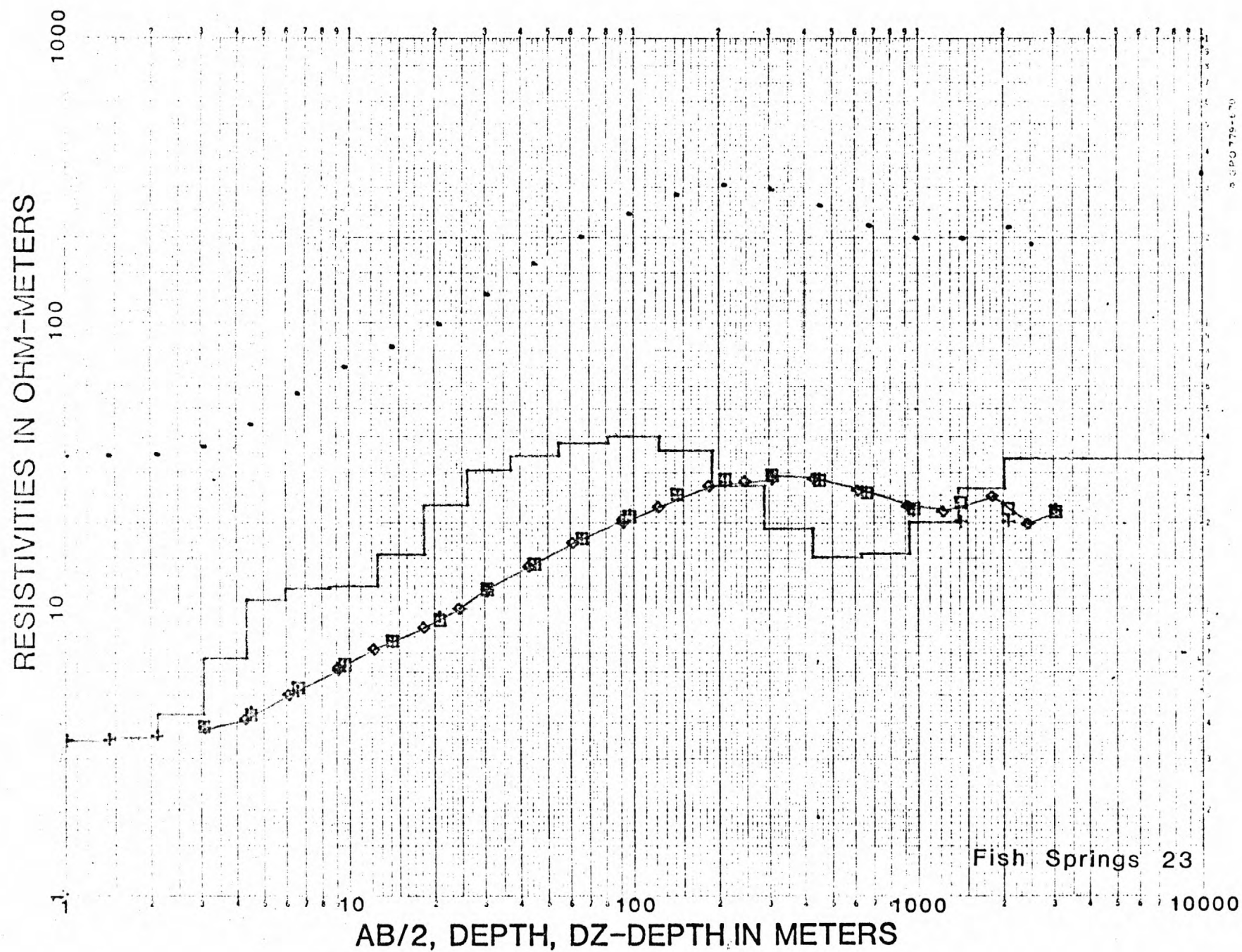


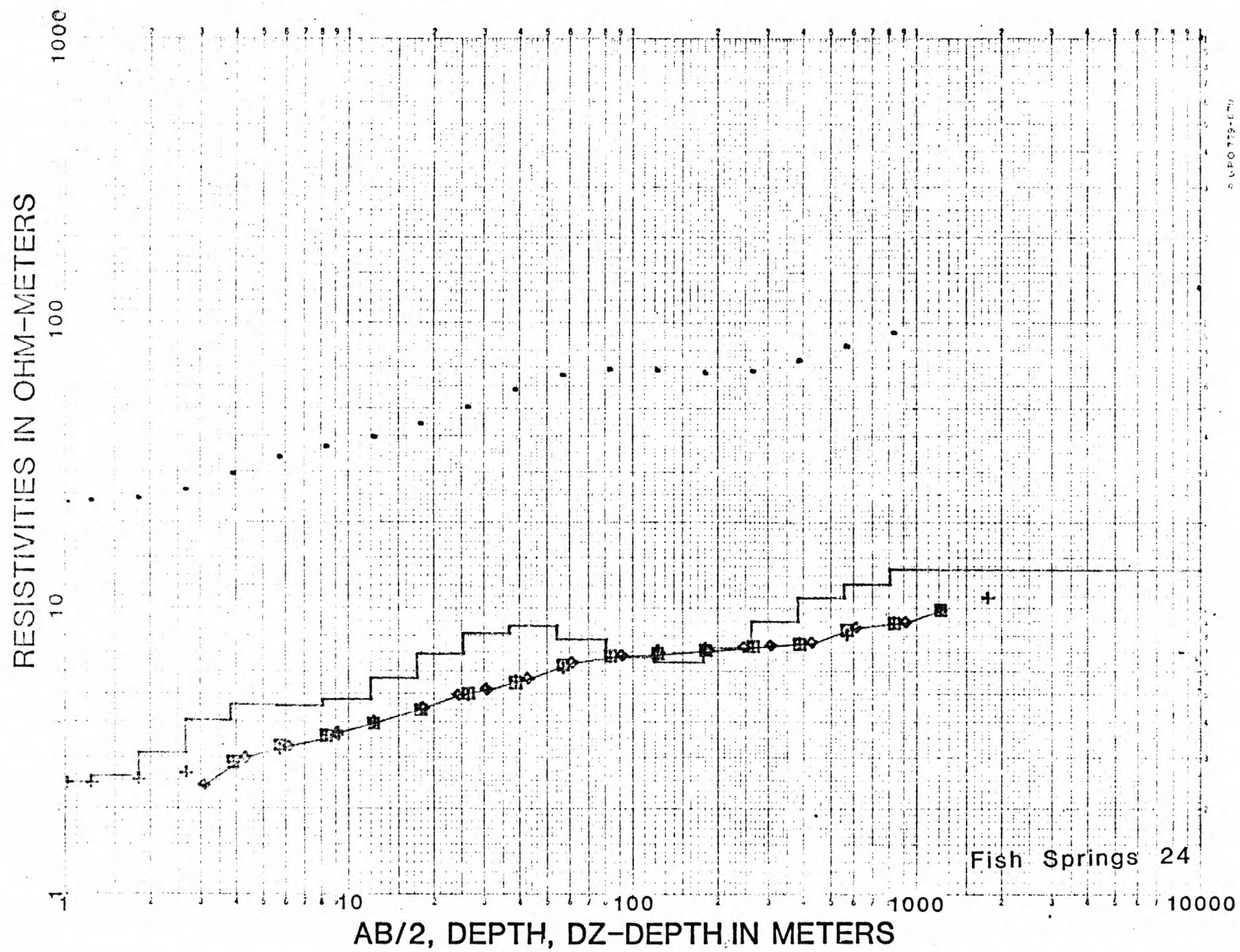
9 000 770-670

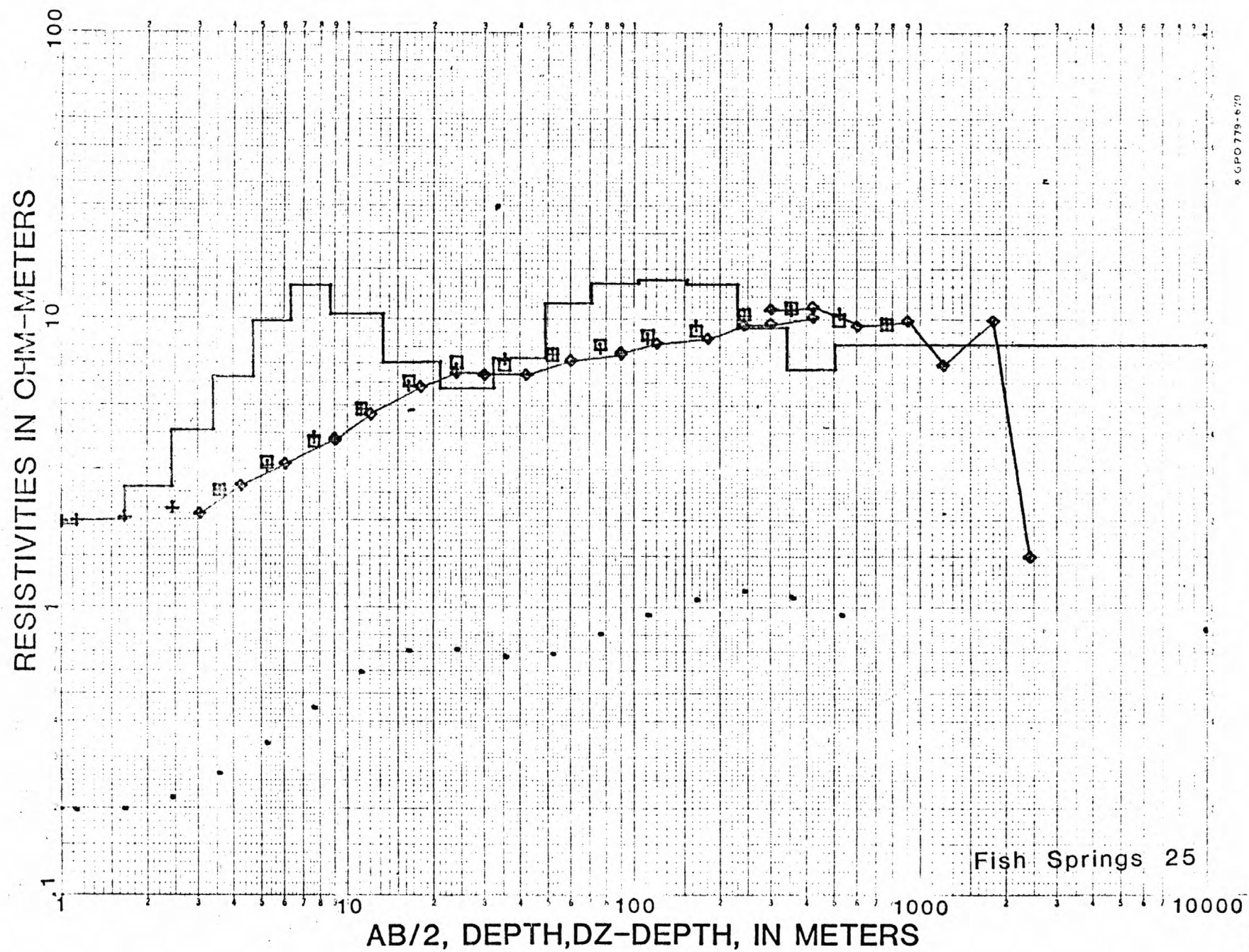
Fish Springr 20

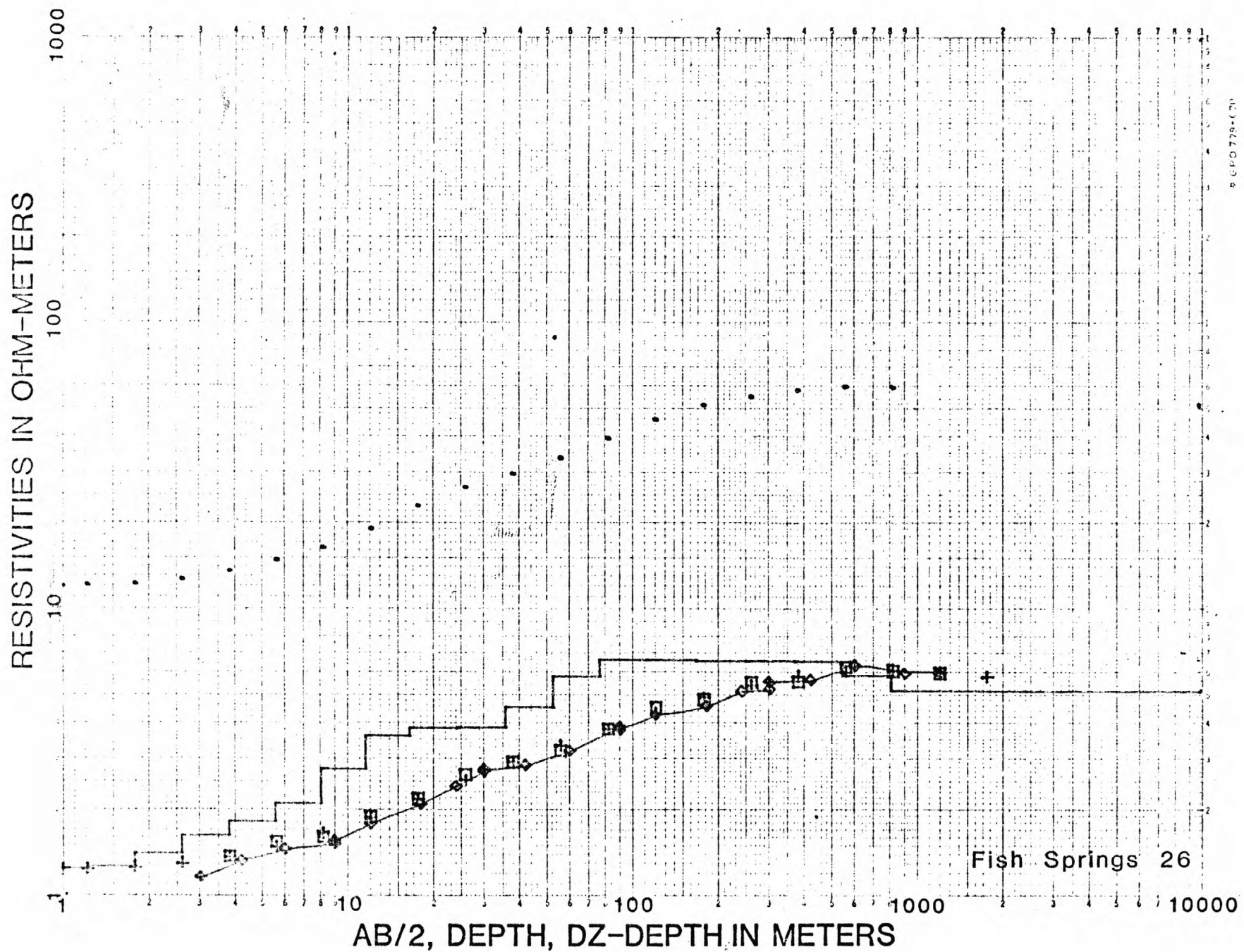


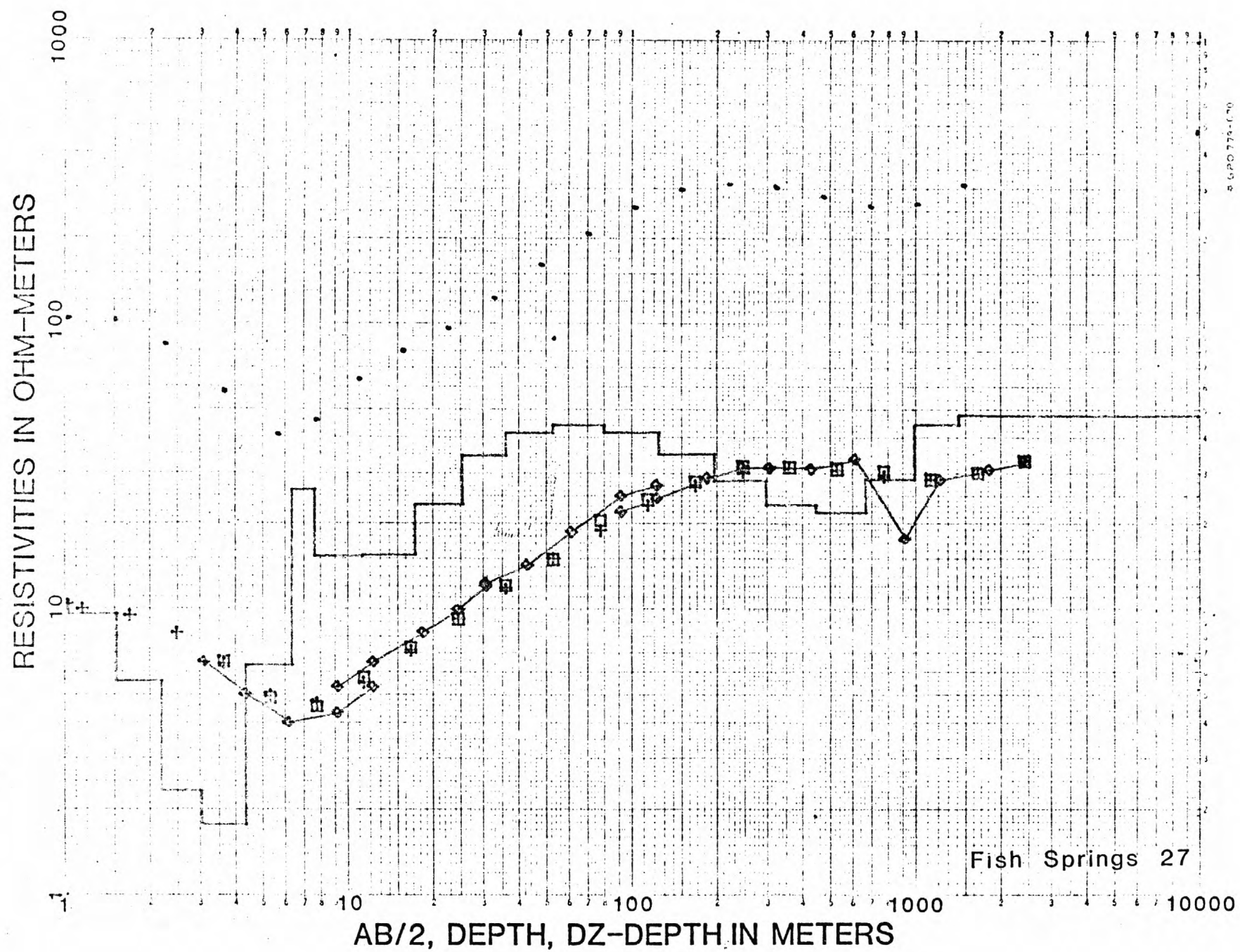


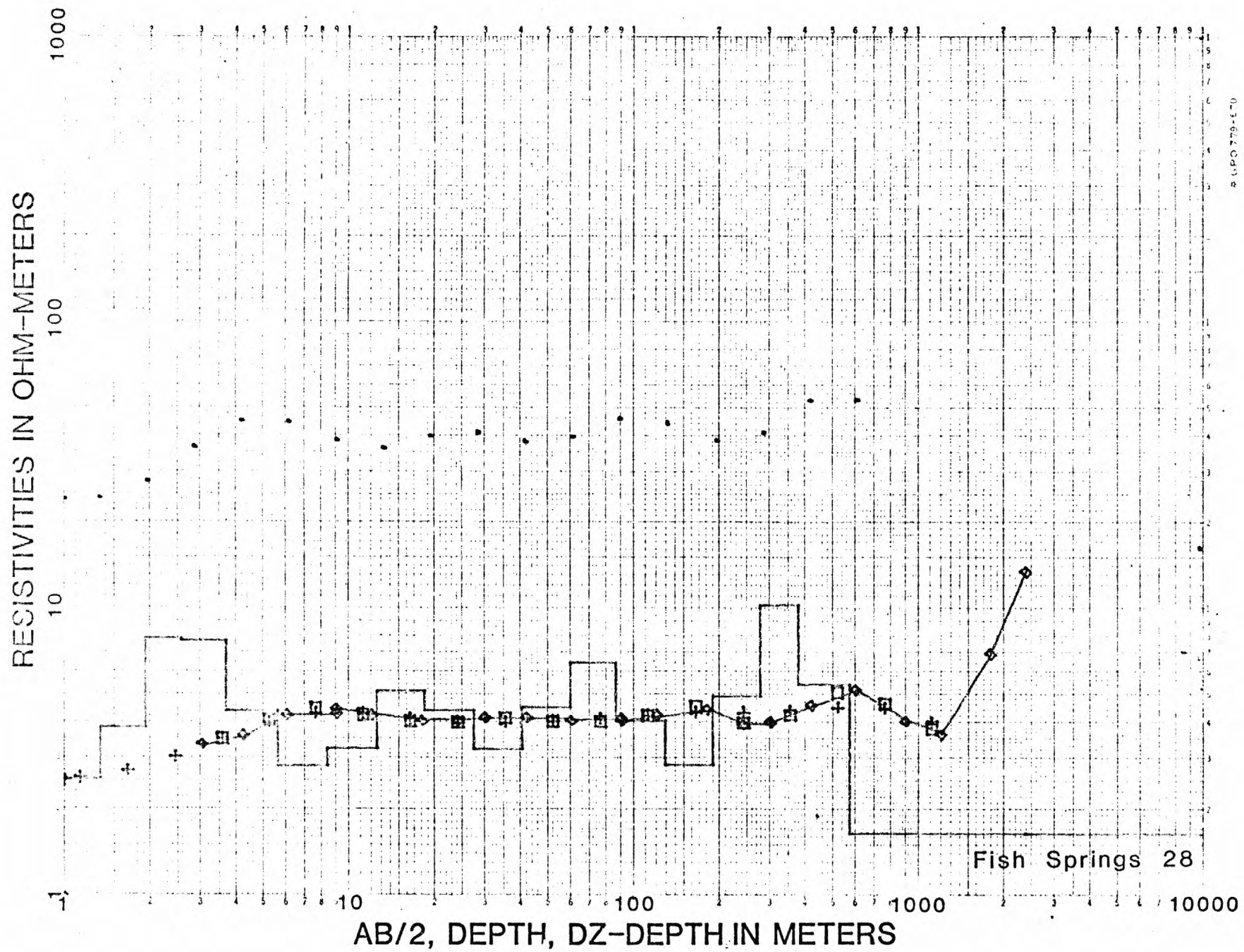


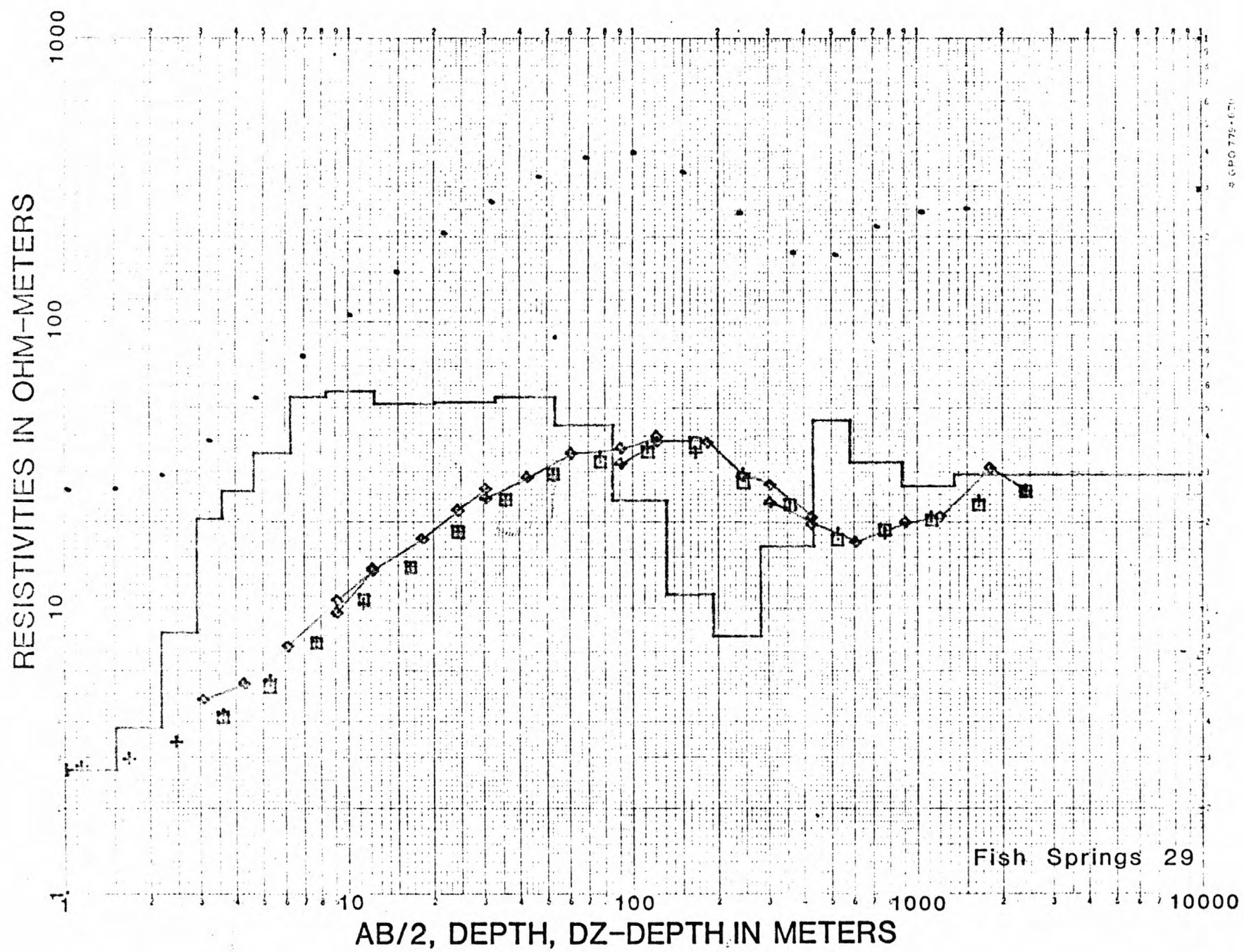


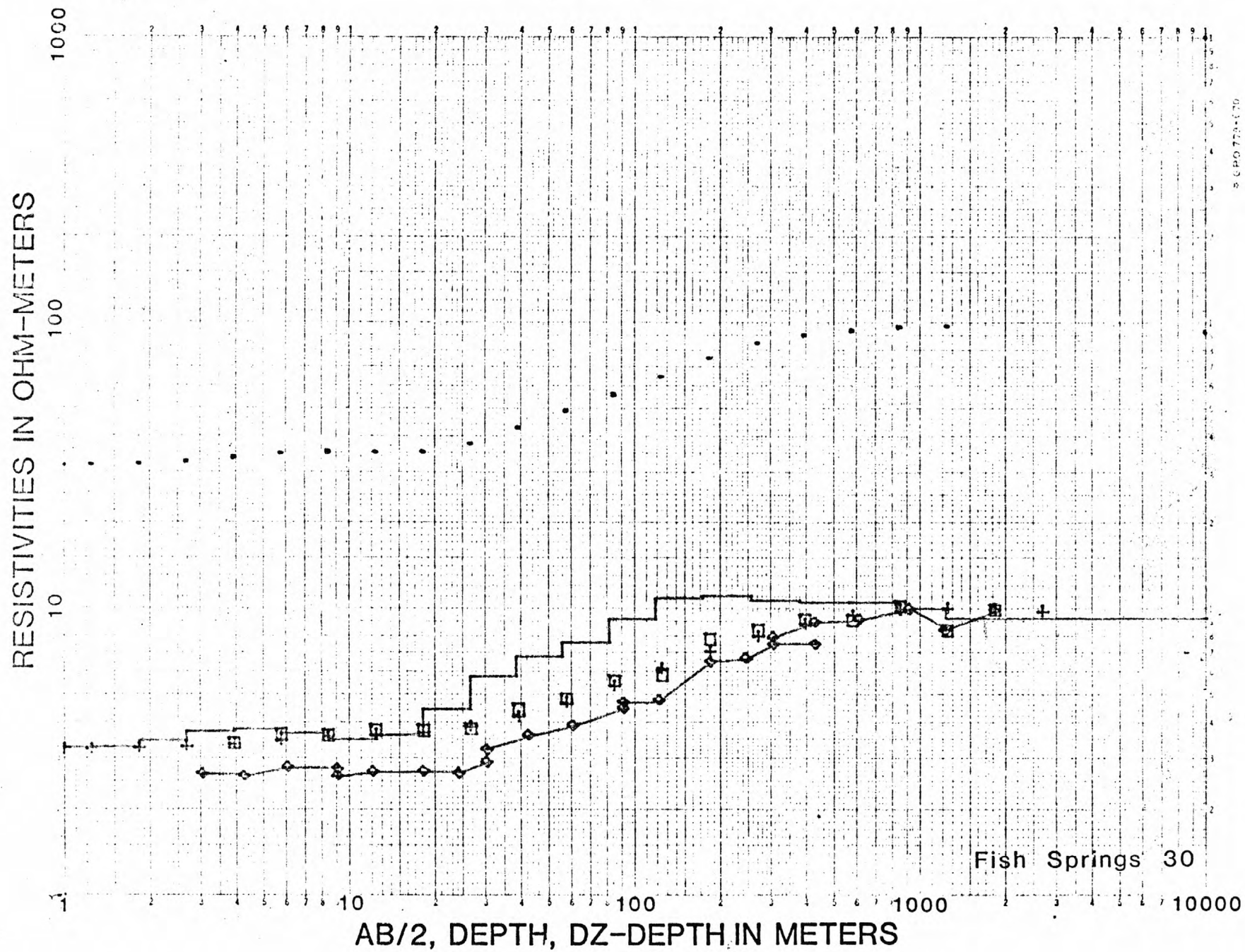


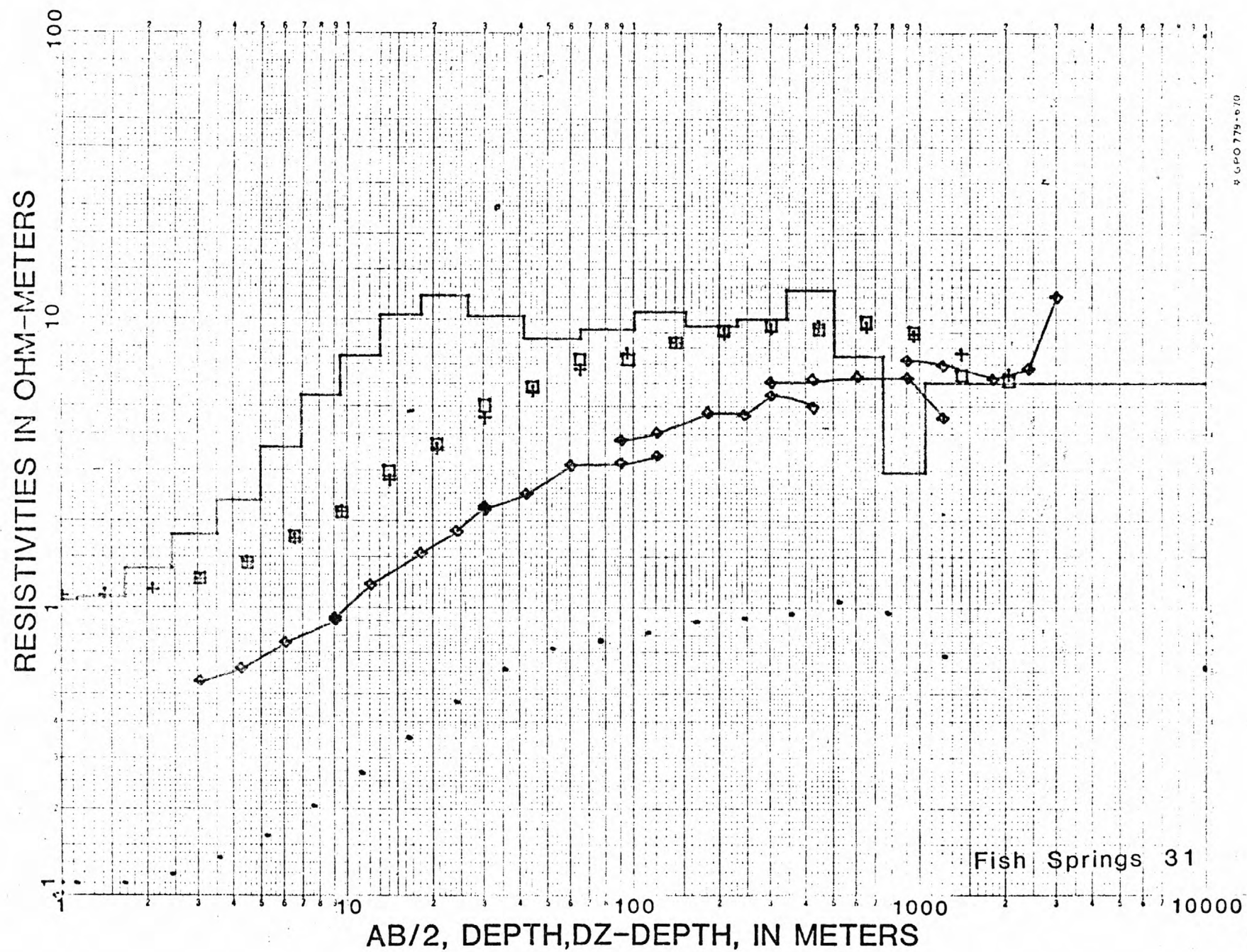


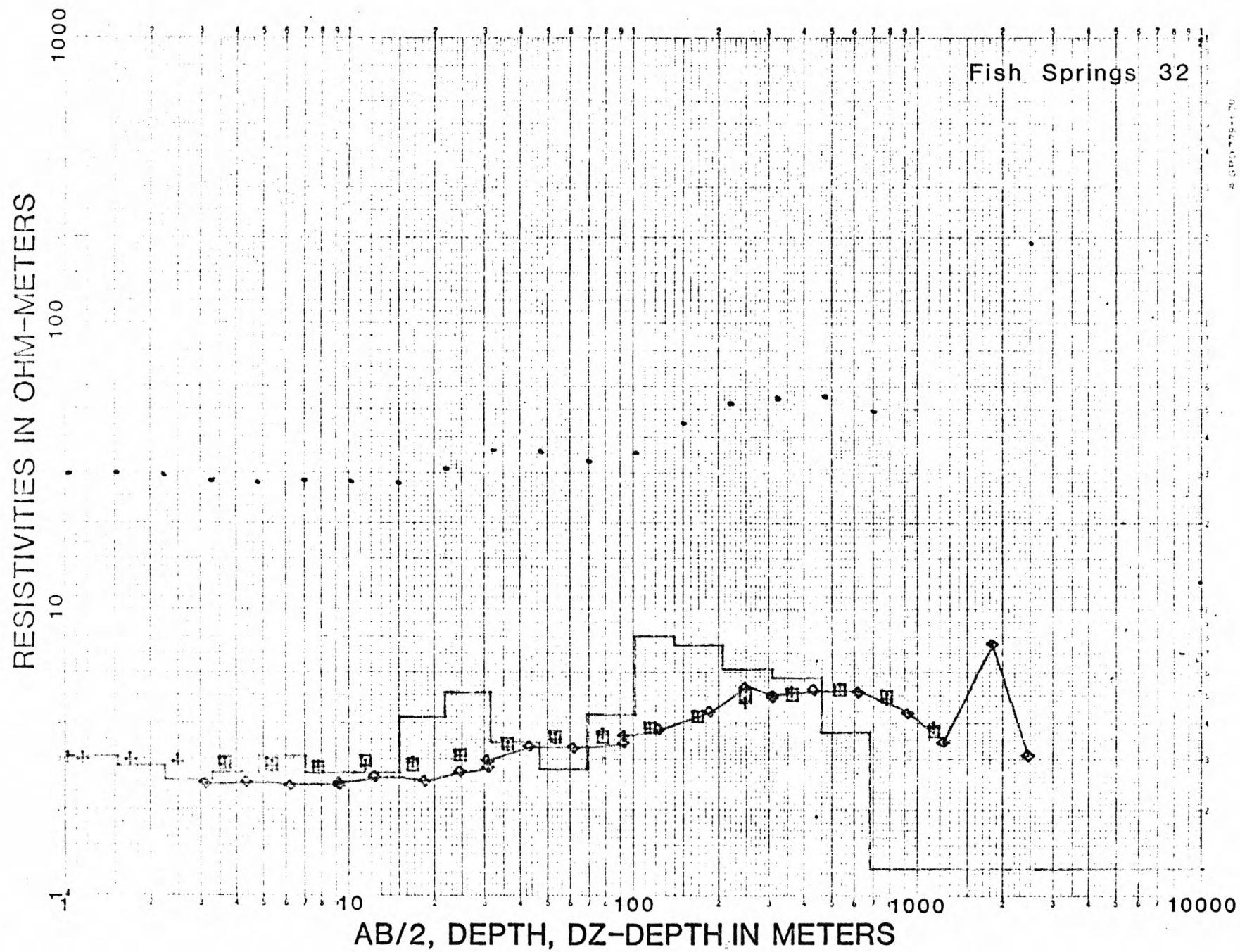


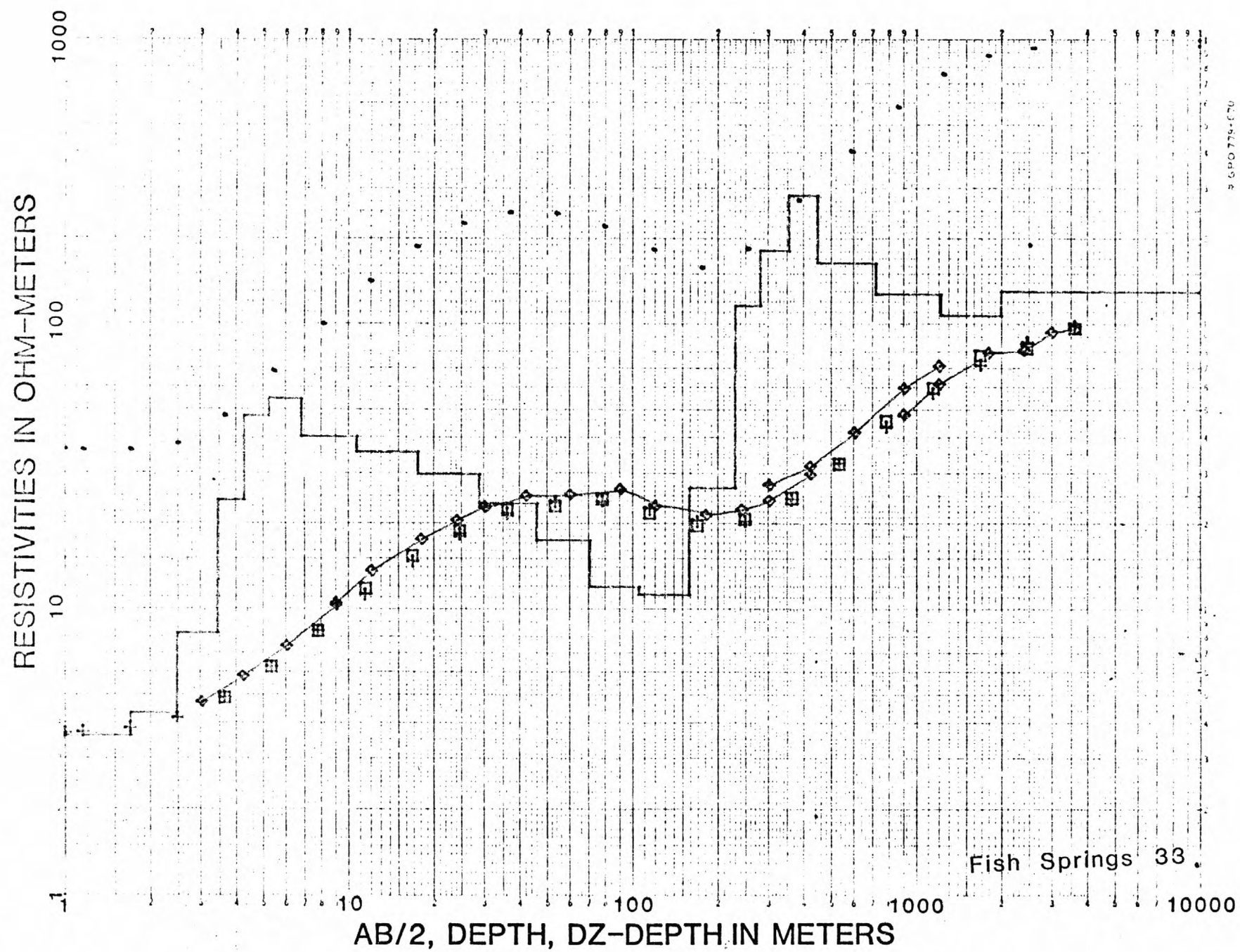


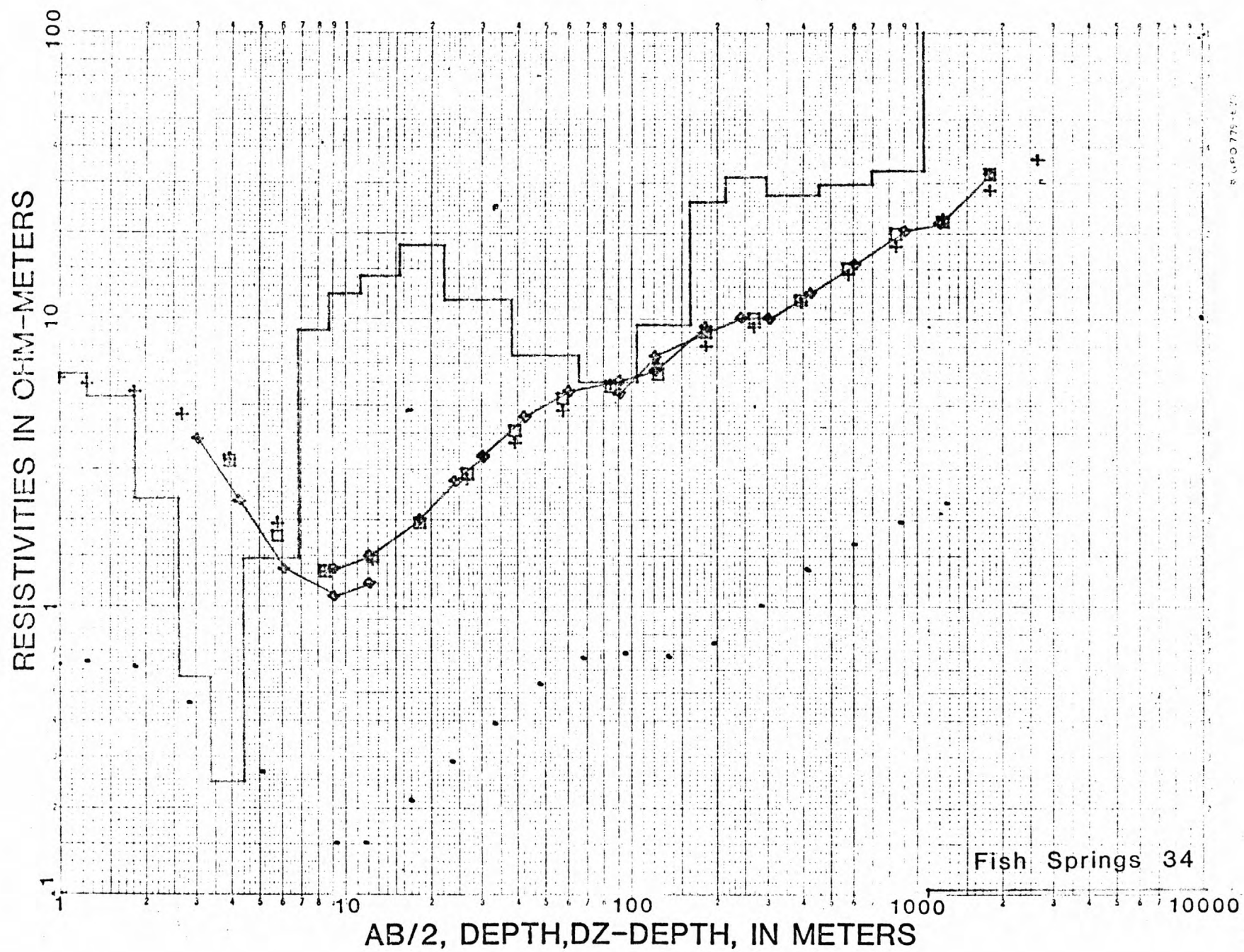


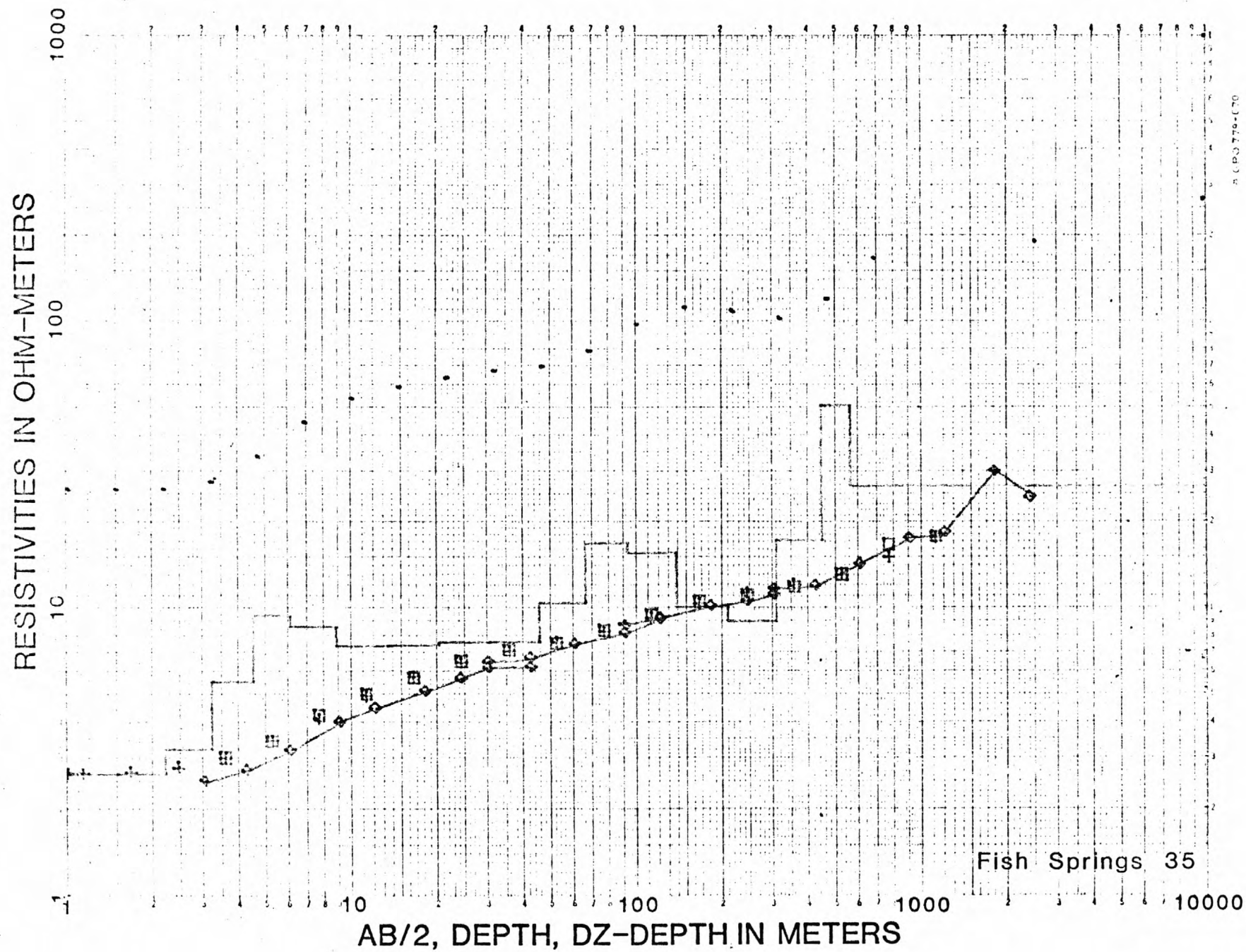


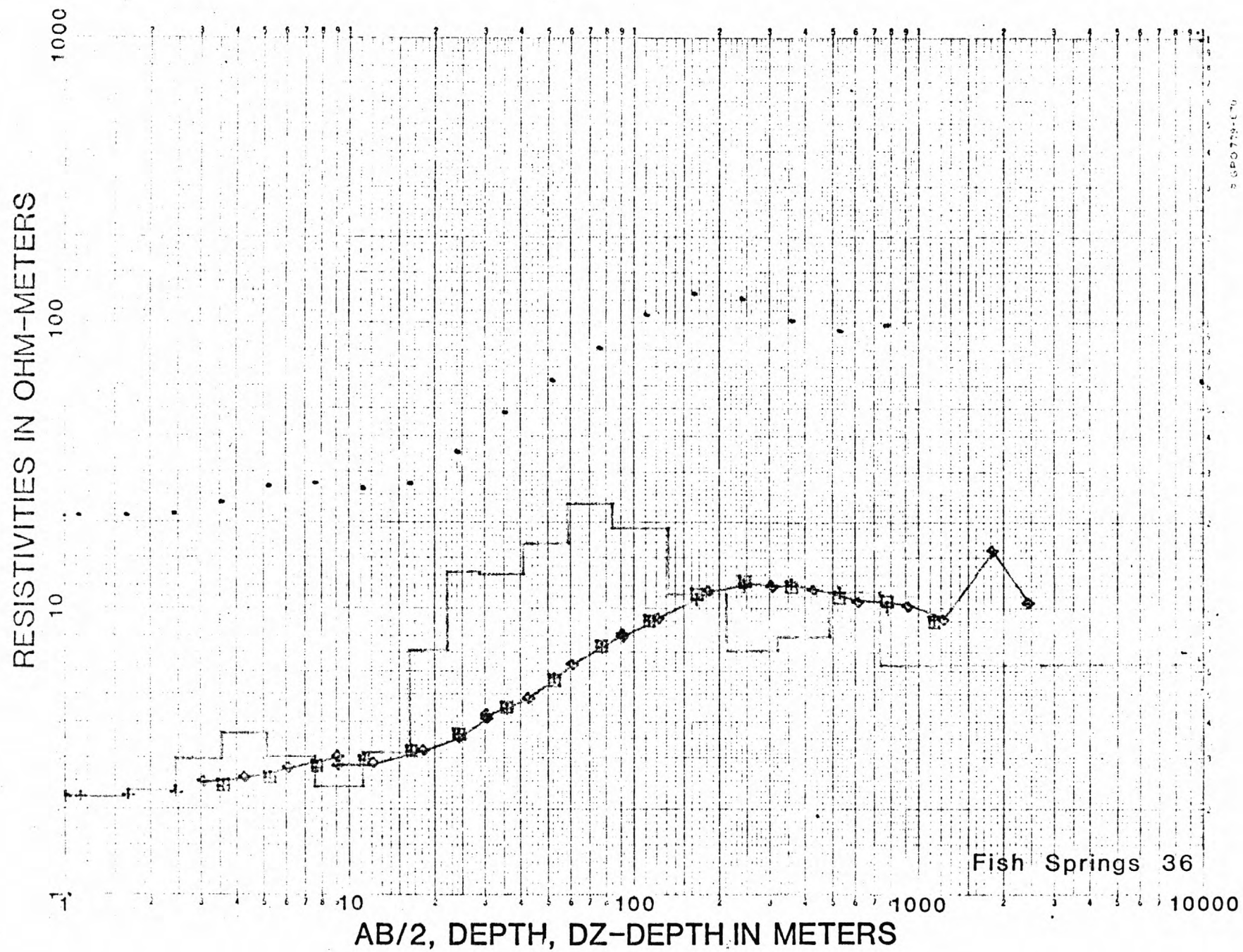


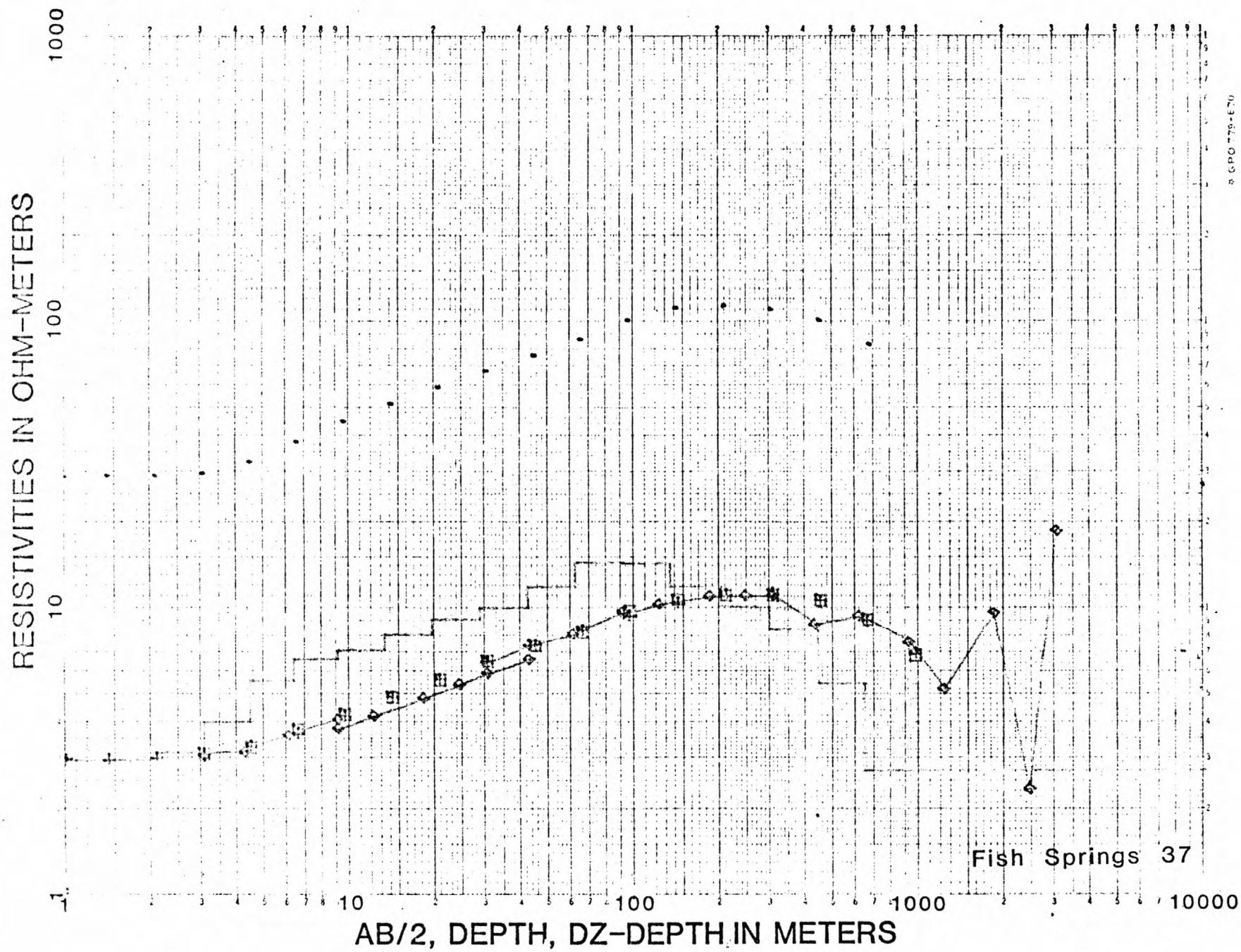


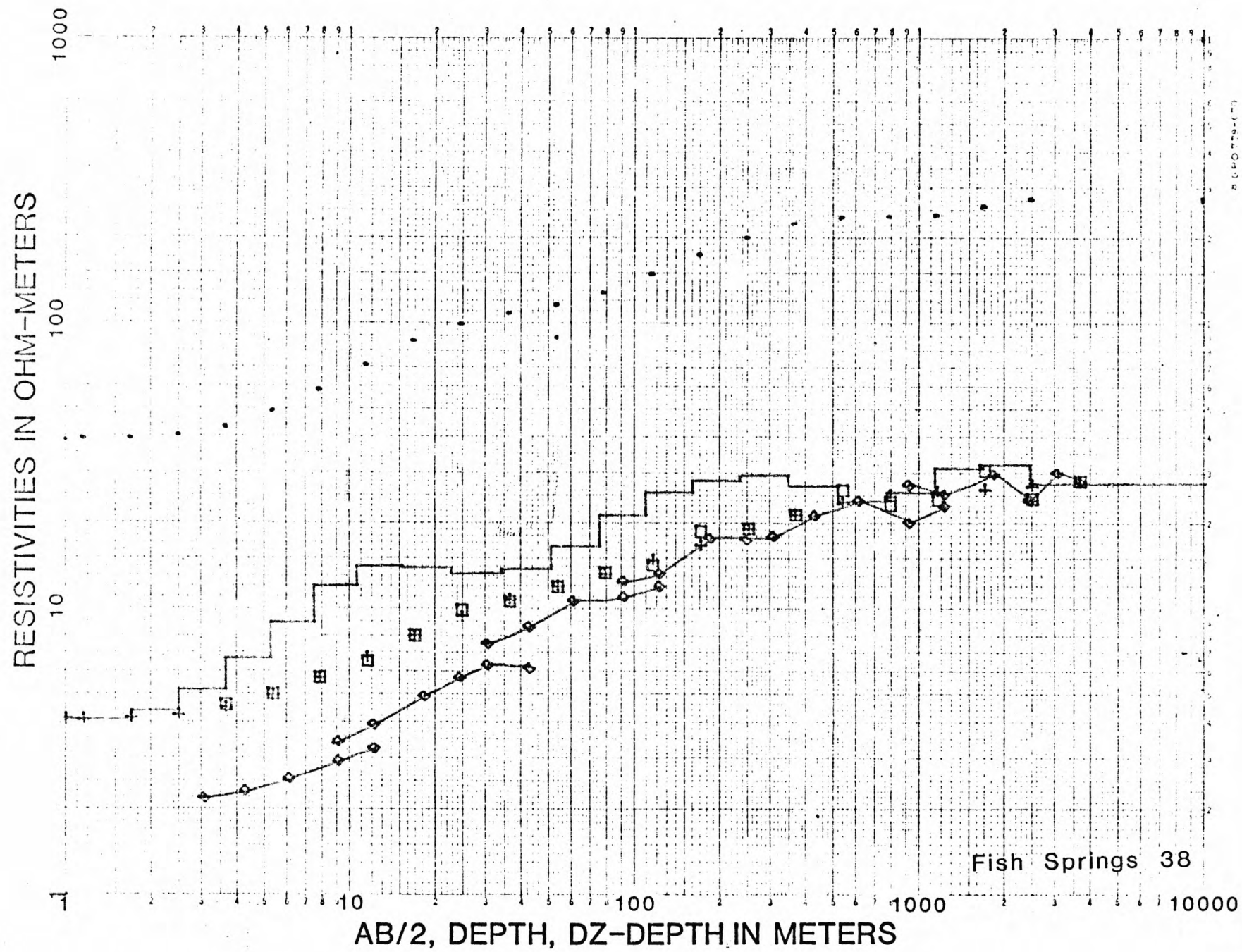


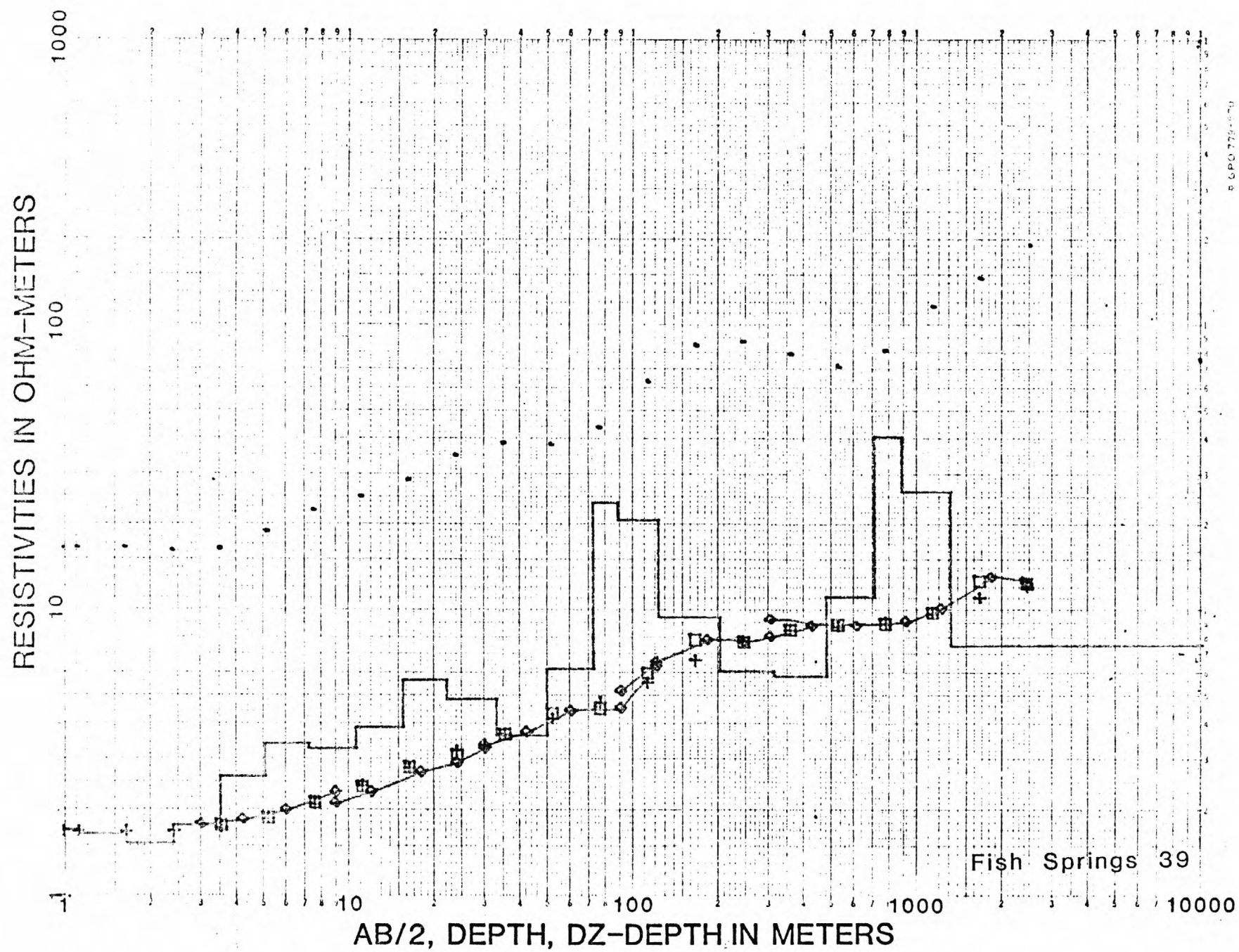












07

