

**GEOPHYSICAL SURVEY
GROUND WATER EVALUATION
AT MAC FARMS
ISLAND OF HAWAII**

PROPERTY
of
TERRA

**GEOPHYSICAL SURVEY
GROUND WATER EVALUATION
AT MAC FARMS
ISLAND OF HAWAII**

Prepared For:

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(Our Project #90023)

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Appendix A - Brief Description of TDEM

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1.0 INTRODUCTION

This report contains the results of a geophysical survey to assist the evaluation of fresh water resources for Kapua Ventures at Mac Farms. The work was performed by Blackhawk Geosciences, Inc. (BGI) for Kapua Ventures on April 20, 21, 22 and 26, 1990.

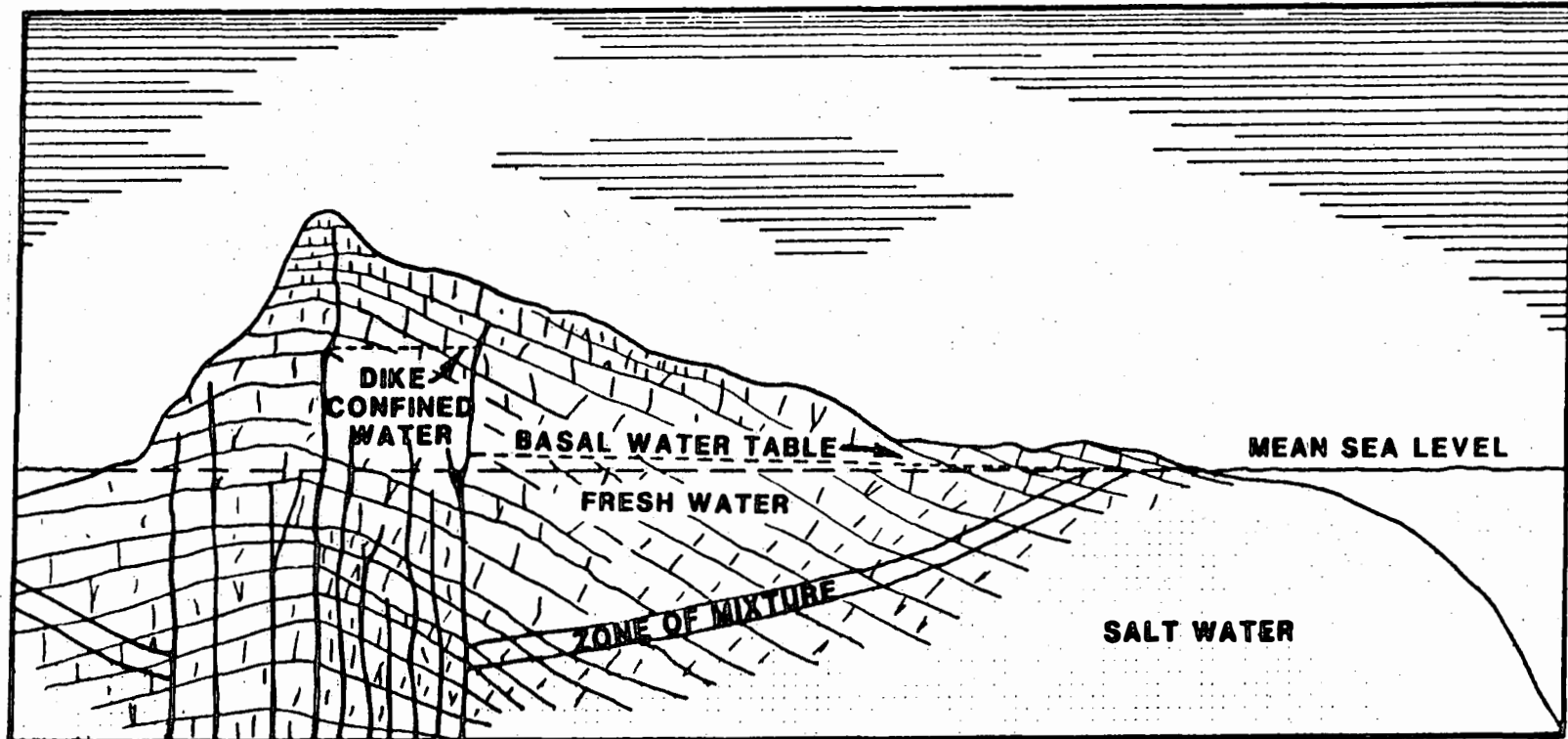
The objectives for the geophysical survey can be understood from the hydrogeologic cross-section, typical of a volcanic island, shown in Figure 1-1. The volcanic rocks are generally highly permeable allowing rainfall to rapidly infiltrate into the ground and migrate downward to the water table, and eventually discharge into the ocean. Fresh water in these settings is found in two environments:

1. Dike confined waters. Above the rift zone intrusive dikes originating from a magma source below can form ground water dams, and behind these natural dams significant quantities of ground water can be stored.
2. Basal fresh water. The high permeability of the volcanic rocks allows sea water to enter freely under the island, and a delicate balance is reached where a lens of fresh water floats on sea water. The Ghyben-Herzberg relation states that for every foot of fresh water head above sea level there will be 40 ft of fresh water below sea level.

The basal water resource was the focus in the investigations for Kapua Ventures. The drilling depth to the basal fresh water lens rapidly increases with elevation, and the objective of geophysical surveys is to determine the drilling depth to fresh water and the thickness of the fresh water lens. The impetus for using geophysics is that the cost of a geophysical station is about one-five-hundredth of the cost of drilling a well at elevations above 1,000 ft. Geophysical surveys, combined with other hydrogeologic information, are used to provide optimum locations for well placement and well completion depths.

The geophysical method employed was time domain electromagnetic (TDEM) soundings. This method was selected because it has proven effective in prior surveys in similar settings in Hawaii.

The specific objective of the geophysical survey over the Mac Farm area was to derive the thickness of the basal fresh water zone in the study area.



BLACKHAWK GEOSCIENCES, INC.

**SCHEMATIC HYDRO-GEOLOGIC
CROSS SECTION
KAPUA VENTURES
Mac Farms, Hawaii**

PROJECT NO.: 90023

FIGURE 1-1

2.0 LOGISTICS AND DATA ACQUISITION

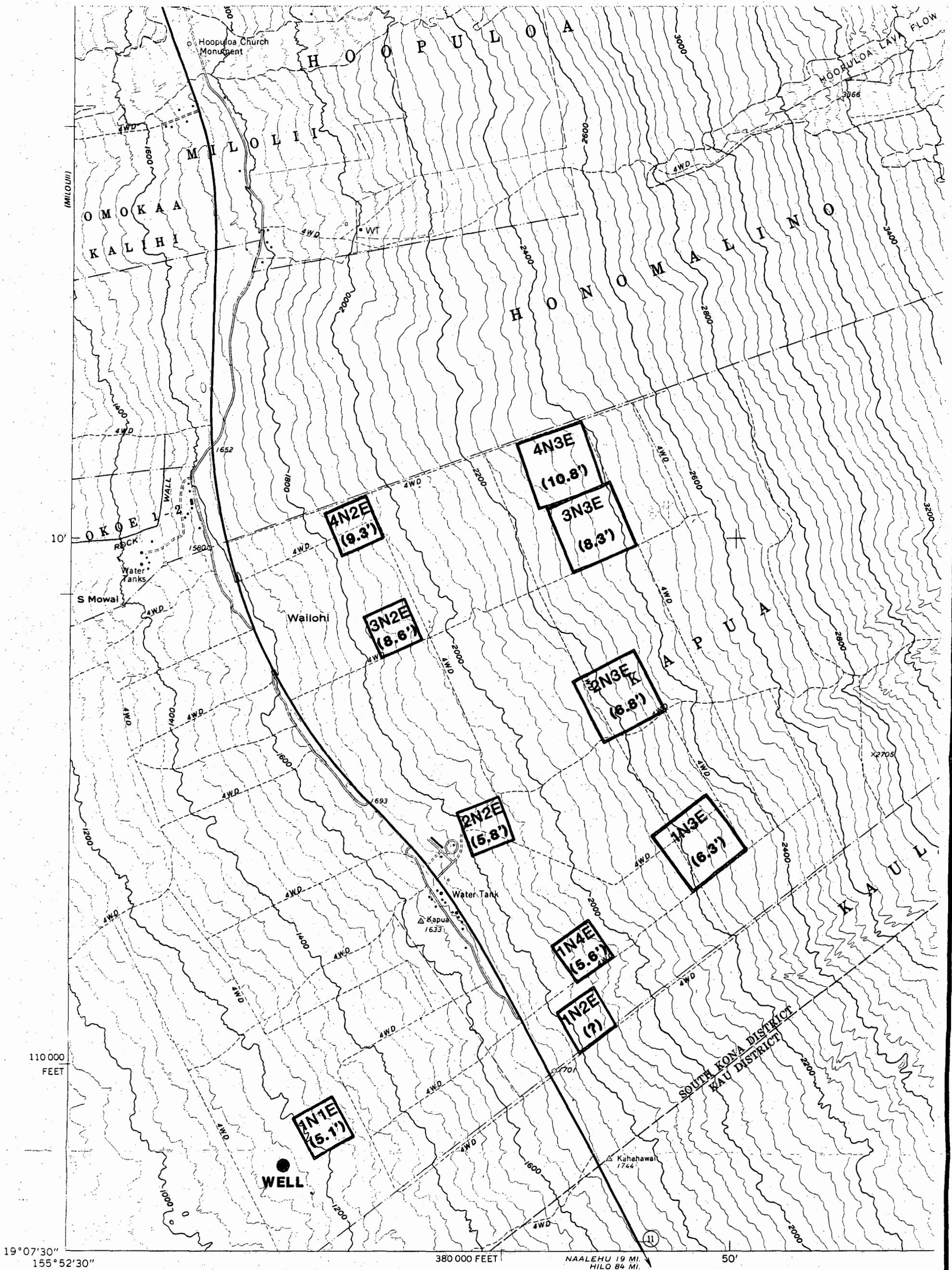
A brief description of the fundamentals of TDEM is given in Appendix A. Briefly, the logistics of a TDEM measurement consist of:

1. Laying out a square loop of insulated wire. A generator placed in the loop is used to drive current pulses through this closed loop. The dimensions of the square loops employed depend on the exploration depth requirements. The dimensions of the loops used for the survey were 1,500 ft by 1,500 ft on each side and 1,000 ft by 1,000 ft.
2. Making a measurement with a receiver in the center of the loop. The data acquired at each station was stored in the field on a solid state data logger and subsequently dumped to a computer at the end of each field day. The data acquired at each station usually consisted of measurements at several receiver gain settings and transmitter frequencies in order to assure data quality and to obtain data over the largest time range possible. Data quality was generally very good.

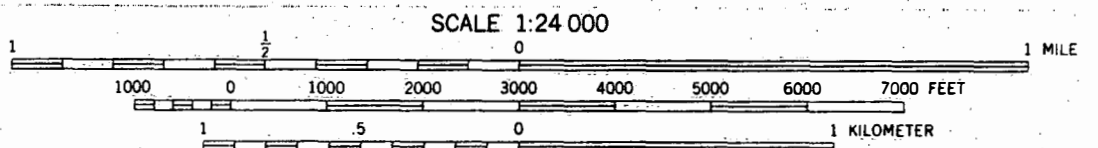
During the four days of field work ten stations (soundings) were completed. A daily log of field activity is given in Table 2-1. Figure 2-1 shows the location of the soundings conducted for Kapua Ventures.

Table 2-1. Daily log of field activities

<u>Date (1990)</u>	<u>Activity</u>
April 18-19	Mobilization of BGI personnel from Golden, CO to Hawaii.
April 20	Recorded loop 1N1E and 1N2E.
April 21	Recorded loop 1N3E, 2N3E and 2N2E.
April 22	Recorded loop 3N2E, 3N3E and 1N4E.
April 23-25	Performed geophysical surveys elsewhere on the Island of Hawaii.
April 26	Recorded loop 4N3E and 4N2E.
April 27-May 4	Performed geophysical surveys elsewhere in Hawaii.
May 5	Demobilize crew from Hawaii to Golden, CO.



1N1E Station Notations
(7.6') Head of Freshwater above Sea Level (ft)



CONTOUR INTERVAL 40 FEET
 DATUM IS MEAN SEA LEVEL

11°
 TRUE NORTH
 MAGNETIC NORTH
 APPROXIMATE MEAN
 DECLINATION, 1981



BLACKHAWK GEOSCIENCES, INC.
TDEM STATION LOCATION MAP AND RESULTS
KAPUA VENTURES
Mac Farms, Hawaii
PROJECT NO.: 90023 **FIGURE 2-1**

3.0 DATA PROCESSING

3.1 GENERAL

The objective of data processing is to derive from the TDEM measurements in the center of the loop the resistivity layering in the earth. The procedures of data processing are discussed in Appendix A. The results from data processing for each station are contained in Appendix B. An example data set is given in Figures 3-1 and 3-2 for loop 2N3E. Figure 3-1 shows the measured data points (in terms of apparent resistivity) superimposed on a solid line. The solid line represents the computed behavior of the true resistivity layering shown on the right. Figure 3-2 lists in column 4 the error between measured and computed data in each time gate.

Figure 3-1 shows that the geoelectric section consists of two layers. The first layer has a thickness of 766 m with a resistivity of greater than 1,000 ohm-m. All loops were interpreted with two layer models, except for loop 1N1E for which a three layer model was appropriate.

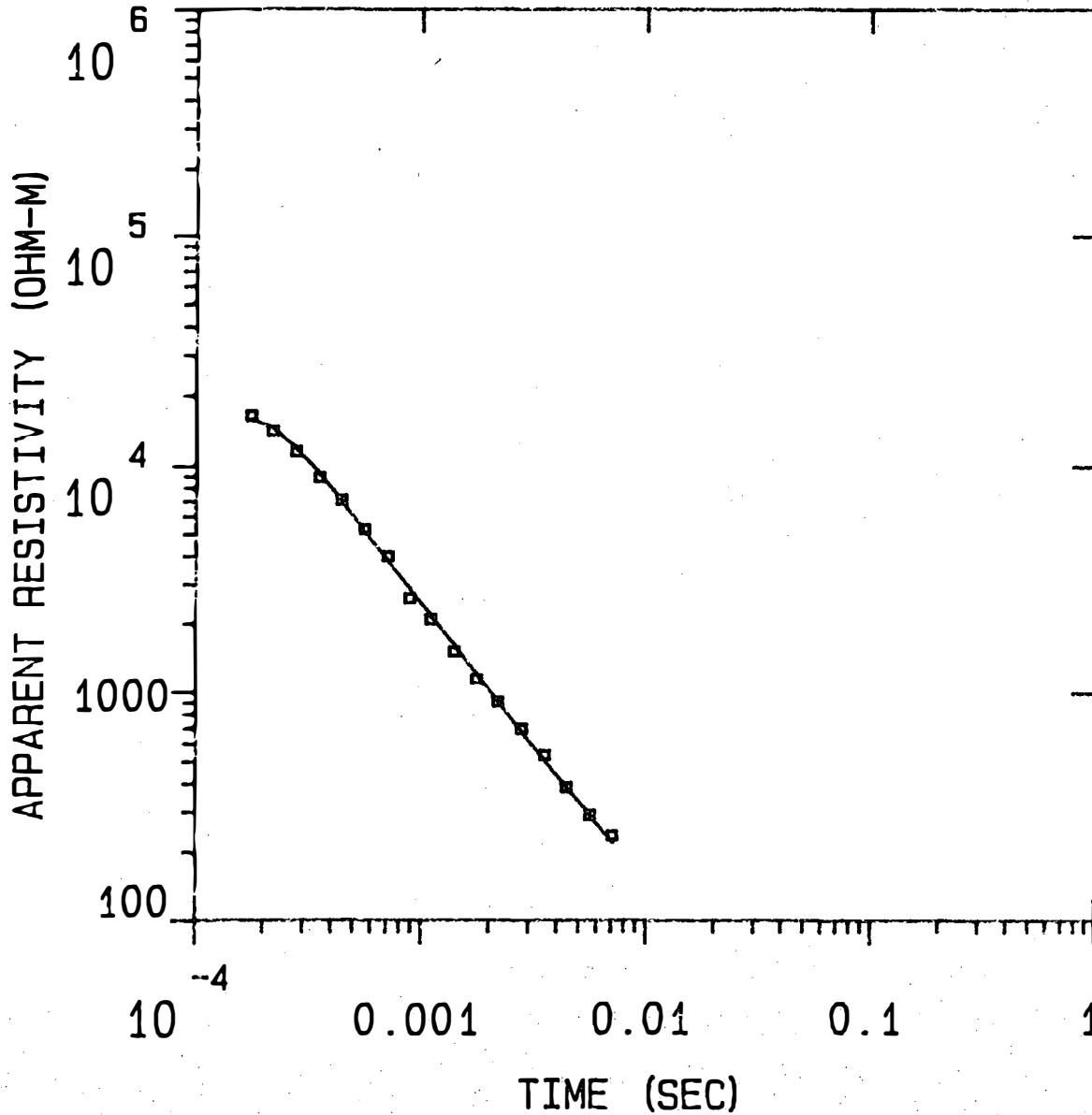
3.2 GEOELECTRIC SECTION

In the geoelectric section the near surface layer (> 1,000 ohm-m) is interpreted to represent unsaturated and fresh/brackish water saturated volcanics. Generally, it is difficult to discriminate between a dry volcanic and fresh water zone or a brackish water (less than 250 ppm chloride) saturated volcanic zone. The reason is that, in addition to salinity, changes in porosity and lithology also influence formation resistivity, particularly at low values of chloride concentration.

The second layer in the section likely represents saline water saturated volcanics. Loop 1N1E was used to calculate the resistivity of the saline water saturated volcanics as here the contact is closest to the surface. The resistivity calculated for saline saturated volcanics at loop 1N1E was 2.52 ohm-m. Since it is the depth to this layer that is of primary concern to this study, the low resistivity layer can be fixed at a value of 2.5 ohm-m for all other soundings in the survey.

M2N3E

MODEL:



Blackhawk Geosciences, Incorporated

3297.
OHM-M

766. M

2.50
OHM-M

BLACKHAWK GEOSCIENCES, INC.
EXAMPLE
APPARENT RESISTIVITY CURVE
SOUNDING 2N3E
KAPUA VENTURES
Mac Farms, Hawaii
PROJECT NO.: 90023 FIGURE 3-1

% ERROR: 6.91
CALIBRATION: 1
OFFSET: 229. M
RAMP: 290.0

M2N3E

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE LAYER	(S) TOTAL
3296.68	766.1	682.8	2240.0	0.2	0.2
2.50		-83.4	-273.5		

	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.77E-04	1.65E+04	1.60E+04	3.617	
2	2.20E-04	1.42E+04	1.46E+04	-2.530	
3	2.80E-04	1.16E+04	1.19E+04	-2.491	
4	3.55E-04	8.95E+03	9.21E+03	-2.881	
5	4.43E-04	7.10E+03	7.03E+03	1.001	
6	5.64E-04	5.28E+03	5.11E+03	3.347	
7	7.13E-04	3.99E+03	3.79E+03	5.206	
8	8.90E-04	2.60E+03	2.86E+03	-8.934	
9	1.10E-03	2.10E+03	2.18E+03	-3.458	
10	1.40E-03	1.51E+03	1.60E+03	-5.627	
11	1.77E-03	1.15E+03	1.20E+03	-4.180	
12	2.20E-03	9.14E+02	9.09E+02	0.567	
13	2.80E-03	7.03E+02	6.76E+02	3.937	
14	3.55E-03	5.40E+02	5.06E+02	6.590	
15	4.43E-03	3.90E+02	3.88E+02	0.522	
16	5.64E-03	2.94E+02	2.92E+02	0.859	
17	7.13E-03	2.39E+02	2.22E+02	7.846	


R: 229. X: 0. Y: 229. DL: 457. REQ: 254. CF: 1.0000
 TDHZ ARRAY, 17 DATA POINTS, RAMP: 290.0 MICROSEC, DATA: M2N3E
 2104 002N 003E Z OPR XTL H 6 8+100
 Ch.21 = 0.29 Ch.22 = 0.089 Ch.23 = 17 Ch.24 = 2
 RMS LOG ERROR: 2.90E-02, ANTILOG YIELDS 6.9112 %
 LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:

"F" MEANS FIXED PARAMETER

P 1 0.03
 F 2 0.00 0.00
 T 1 0.01 0.00 0.49
 P 1 F 2 T 1



BLACKHAWK GEOSCIENCES, INC.

EXAMPLE DATA SHEET
 SOUNDING 2N3E
 KAPUA VENTURES
 Mac Farms, Hawaii

PROJECT NO.: 90023 FIGURE 3-2

4.0 INTERPRETATION RESULTS

The objective of Kapua Ventures and its ground water consultants is not to obtain the resistivity layering of the subsurface, but to infer from the resistivity information, the depth to salt water and the thickness of the basal fresh water lens. The translation of resistivity layering into hydrogeologic information is generally accomplished by using available knowledge about the relation between resistivity values and hydrogeology. For example, in the volcanic rocks of Hawaii, rocks saturated with salt water will have resistivities less than 5 ohm-m. On the other hand, dry volcanic rocks can have very high resistivities (greater than 1,000 ohm-m).

The results of the TDEM interpretations are presented as the elevation of salt water contact and lens thickness in Table 4-1. The calculated head of fresh water is also indicated on Figure 2-1.

Table 4-1. Results of TDEM Survey

Sounding #	Surface Elevation (ft)	Elevation of Salt Water Contact (ft)	Head of Fresh/Brackish Water Above Sea Level (ft)	Minimum Thickness of Fresh/Brackish Water Lens (ft)
4N3E	2330	-431	10.8	442
3N3E	2350	-336	8.4	344
2N3E	2240	-273	6.8	280
1N3E	2235	-251	6.3	257
4N2E	1900	-370	9.3	379
3N2E	1890	-345	8.6	354
2N2E	1850	-230	5.8	236
1N4E	1920	-224	5.6	230
1N2E	1840	?	?	?
1N1E	1220	-203	5.1	208

The results for sounding 1N2E indicated a high noise level, possibly caused by its location in proximity of a power line. The interpretation of this sounding was, therefore, questionable, and so the adjacent loop 1N4E was measured for a cross check.

5.0 CONCLUSIONS

The TDEM survey shows a gradual increase in head of fresh water above sea level from about 6 ft in the south end of the study area to about 10 ft on the north end. While the absolute error in depth to sea water is undetermined without ground truth provided by well data, the relative error in depth to sea water between soundings is expected to be less than $\pm 5\%$. The thickness of the fresh water lens in the study area is expected to vary from about 400 ft on the north end to 240 ft on the south.

MIN1E

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE LAYER	(S) TOTAL
1084.92	257.6	371.9	1220.0		
89.47	176.2	114.2	374.8	0.2	0.2
2.52		-62.0	-203.3	2.0	2.2

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	2.54E+03	2.53E+03	0.647	
2	1.10E-04	2.10E+03	2.08E+03	0.756	
3	1.40E-04	1.68E+03	1.69E+03	-0.277	
4	1.77E-04	1.40E+03	1.41E+03	-0.637	
5	2.20E-04	1.21E+03	1.22E+03	-0.604	
6	2.80E-04	1.05E+03	1.07E+03	-2.008	
7	3.55E-04	9.71E+02	9.64E+02	0.772	
8	4.43E-04	8.97E+02	8.78E+02	2.171	
9	5.64E-04	7.74E+02	7.81E+02	-0.911	
10	7.13E-04	6.84E+02	6.73E+02	1.652	
11	8.81E-04	5.69E+02	5.68E+02	0.264	
12	8.90E-04	5.52E+02	5.63E+02	-1.840	
13	1.10E-03	4.63E+02	4.62E+02	0.120	
14	1.10E-03	4.57E+02	4.61E+02	-0.722	
15	1.40E-03	3.38E+02	3.59E+02	-5.840	
16	1.41E-03	3.66E+02	3.56E+02	2.657	
17	1.77E-03	2.78E+02	2.79E+02	-0.579	
18	1.80E-03	2.82E+02	2.75E+02	2.354	
19	2.20E-03	2.16E+02	2.21E+02	-2.180	
20	2.22E-03	2.21E+02	2.18E+02	1.579	
21	2.80E-03	1.68E+02	1.70E+02	-0.975	
22	2.85E-03	1.72E+02	1.67E+02	3.213	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
 TDHZ ARRAY, 22 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: MIN1E
 2004 001N 001E Z OPR XTL L 6 8+100
 Ch.21 = 0.21 Ch.22 = 0.89 Ch.23 = 19 Ch.24 = 92
 RMS LOG ERROR: 1.29E-02, ANTILOG YIELDS 3.0072 %
 LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

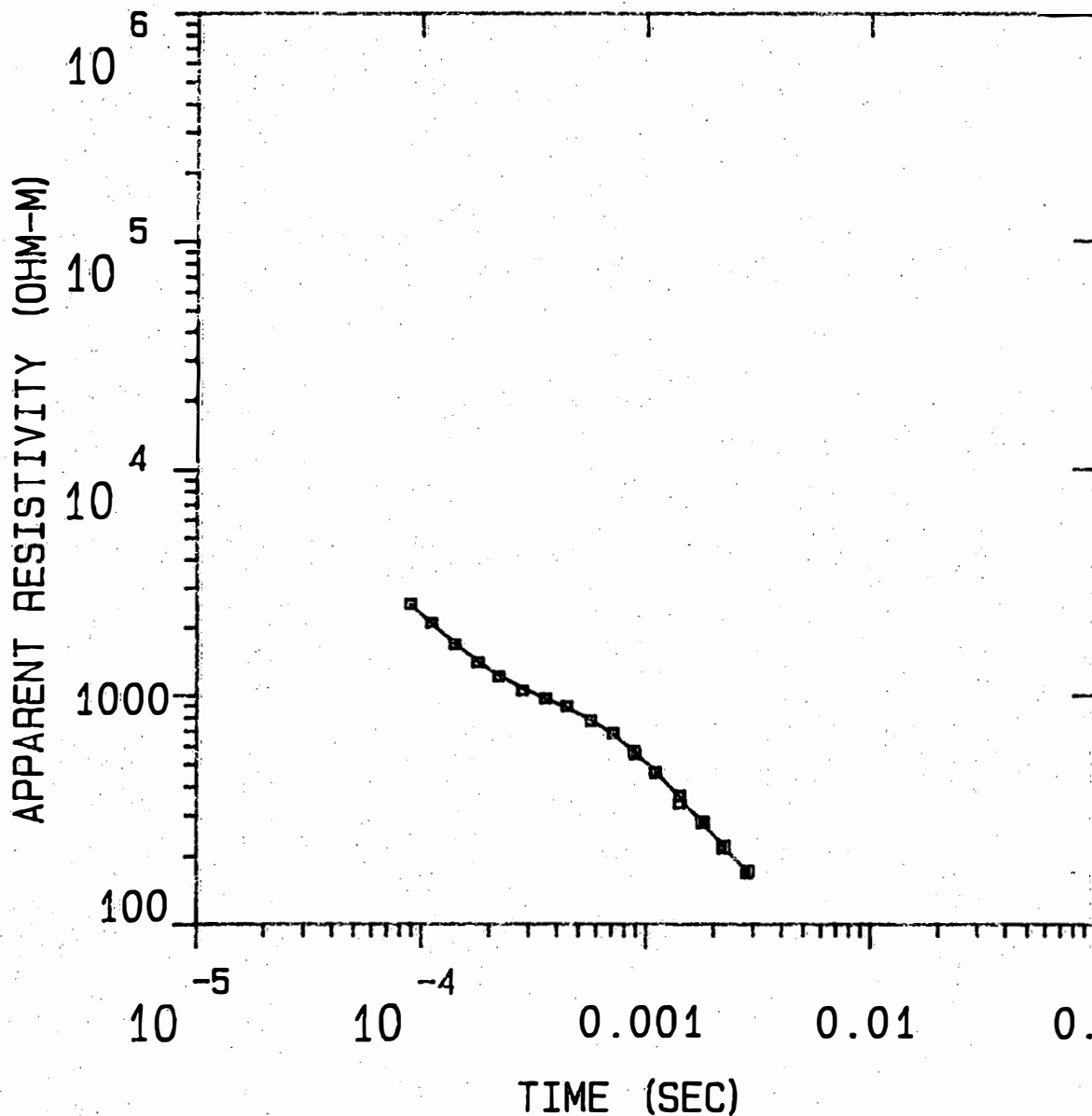
PARAMETER RESOLUTION MATRIX:

"F" MEANS FIXED PARAMETER

P 1	0.56			
P 2	-0.26	0.65		
P 3	0.14	-0.10	0.57	
T 1	0.15	0.12	-0.04	0.94

M1N1E

MODEL:



Incorporated	1085. OHM-M	258. M
Blackhawk Geosciences,	89.5 OHM-M	176. M
	2.52 OHM-M	
% ERROR: 3.01		
CALIBRATION: 1		
OFFSET: 152. M		
RAMP: 210.0		

MT4N2E

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION		CONDUCTANCE	(S)
		(M)	(FEET)	LAYER	TOTAL
28038.25	692.2	579.1	1900.0	0.0	0.0
2.50		-113.1	-371.1		

TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-04	1.94E+03	1.95E+03	-0.459
2	1.10E-03	1.47E+03	1.46E+03	1.162
3	1.40E-03	1.07E+03	1.05E+03	2.592
4	1.77E-03	7.81E+02	7.62E+02	2.518
5	2.20E-03	6.27E+02	5.68E+02	10.353
6	2.80E-03	4.19E+02	4.10E+02	2.284
7	3.55E-03	2.74E+02	2.95E+02	-7.246
8	4.43E-03	2.16E+02	2.18E+02	-0.858
9	5.64E-03	1.45E+02	1.57E+02	-7.999
10	7.13E-03	1.12E+02	1.15E+02	-2.805

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
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 2604 004N 002E Z OFR XTL L 6 8+100
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 RMS LOG ERROR: 3.27E-02, ANTILOG YIELDS 7.8104 %
 LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

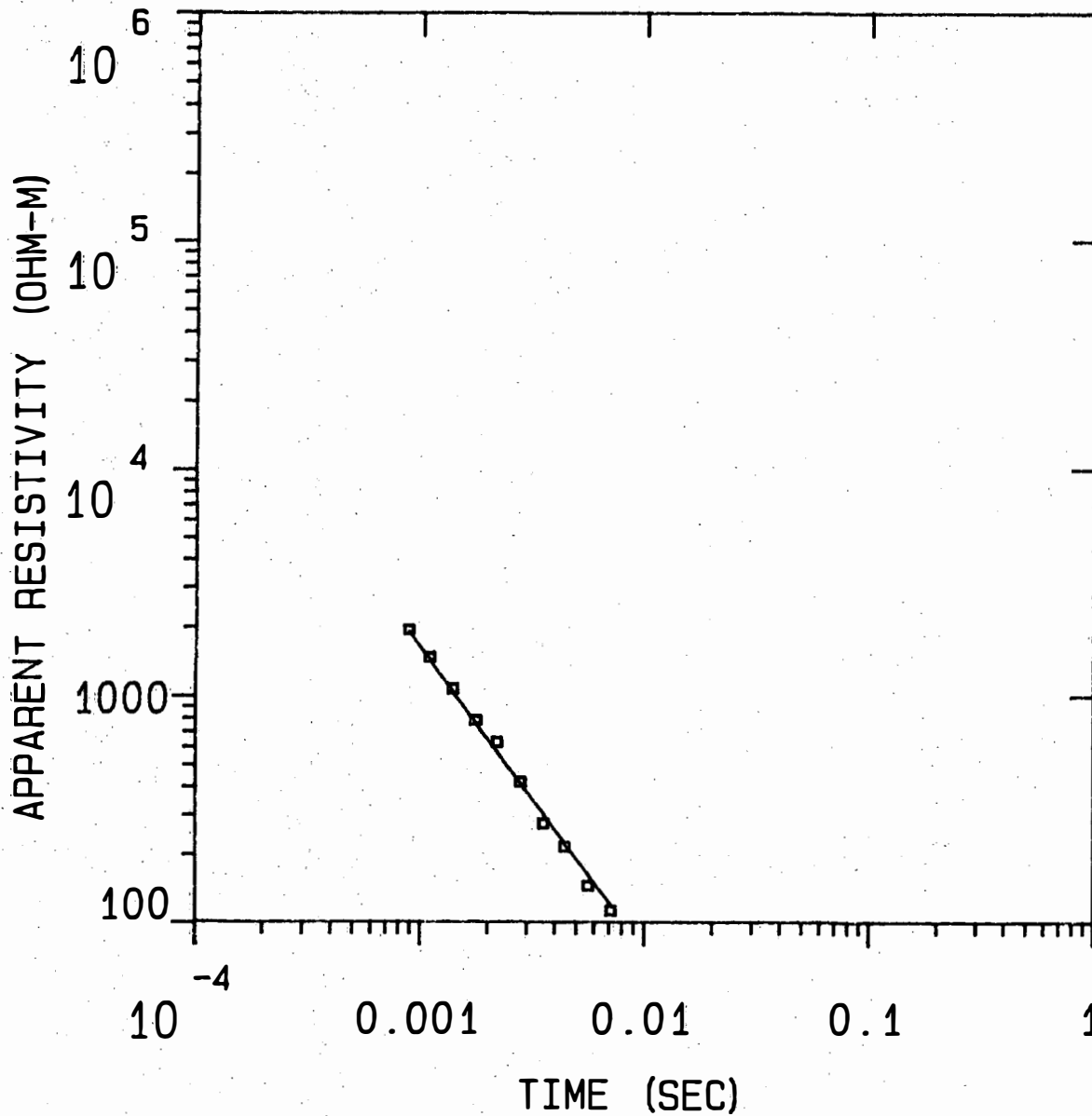
PARAMETER RESOLUTION MATRIX:

"F" MEANS FIXED PARAMETER

P 1	0.08		
F 2	0.00	0.00	
T 1	0.00	0.00	1.00
	P 1	F 2	T 1

M4N2E

MODEL:



Blackhawk Geosciences, Incorporated

21910.
OHM-M 675. M

2.50
OHM-M

% ERROR: 9.85
CALIBRATION: 1
OFFSET: 152. M
RAMP: 220.0

MT3N2E

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE LAYER	(S) TOTAL
35091.75	681.3	576.1	1890.0	0.0	0.0
2.50		-105.3	-345.3		

TIMES	DATA	CALC	% ERROR	STD ERR
1	2.80E-04	9.07E+03	8.05E+03	12.776
2	3.55E-04	6.28E+03	5.83E+03	7.811
3	4.43E-04	4.60E+03	4.33E+03	6.327
4	5.64E-04	3.34E+03	3.12E+03	6.940
5	7.13E-04	2.43E+03	2.27E+03	6.908
6	8.90E-04	1.60E+03	1.68E+03	-4.366
7	1.10E-03	1.16E+03	1.25E+03	-7.373
8	1.40E-03	8.67E+02	8.99E+02	-3.643
9	1.77E-03	6.45E+02	6.51E+02	-0.949
10	2.20E-03	5.18E+02	4.83E+02	7.056
11	2.80E-03	3.52E+02	3.44E+02	2.215
12	3.55E-03	2.37E+02	2.47E+02	-3.930
13	4.43E-03	1.86E+02	1.82E+02	2.024
14	5.64E-03	1.48E+02	1.31E+02	13.534
15	7.13E-03	9.56E+01	9.60E+01	-0.513
16	8.81E-03	6.81E+01	7.26E+01	-6.094
17	1.10E-02	5.16E+01	5.62E+01	-8.164

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
 TDHZ ARRAY, 17 DATA POINTS, SYSTEM: NONE DATA: MT3N2E
 2204 003N 002E Z OPR XTL H 7 8+100
 Ch.21 = 0.22 Ch.22 = 0.089 Ch.23 = 19 Ch.24 = 9
 RMS LOG ERROR: 4.37E-02, ANTILOG YIELDS 10.5969 %
 LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

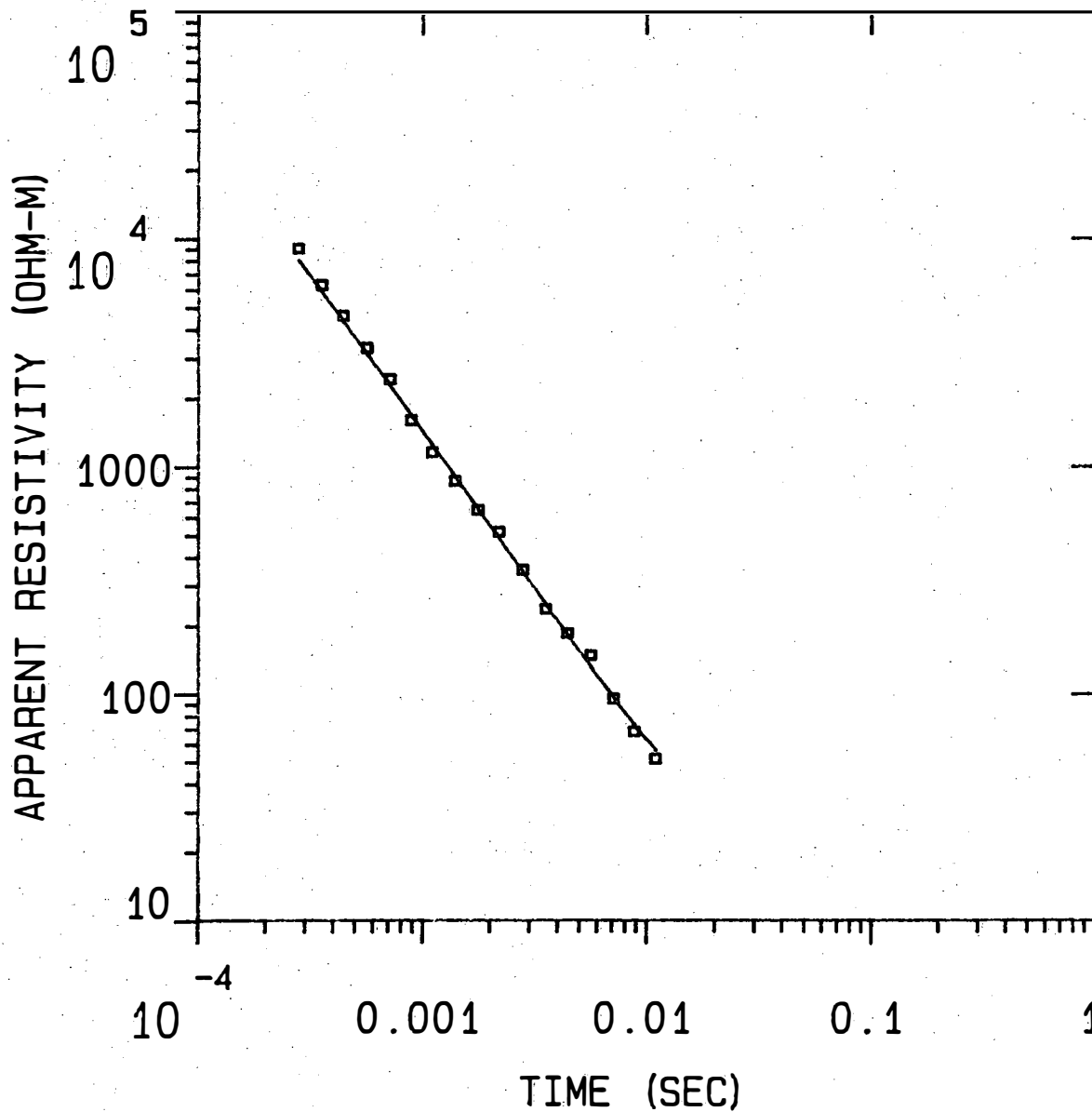
PARAMETER RESOLUTION MATRIX:

"F" MEANS FIXED PARAMETER

P 1	0.42		
F 2	0.00	0.00	
T 1	-0.16	0.00	0.94
	P 1	F 2	T 1

MT3N2E

MODEL:



35092.	
OHM-M	681. M

2.50
OHM-M

Blackhawk Geosciences, Incorporated

% ERROR: 10.6
CALIBRATION: 1
OFFSET: 152. M
SYSTEM: NONE

MT2N2E

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE LAYER	(S) TOTAL
9119.18	634.1	563.9	1850.0	0.1	0.1
2.50		-70.2	-230.3		

	TIMES	DATA	CALC	% ERROR	STD ERR
1	2.20E-04	1.25E+04	1.15E+04	8.736	
2	2.80E-04	8.02E+03	8.22E+03	-2.547	
3	3.55E-04	6.27E+03	5.95E+03	5.309	
4	4.43E-04	4.71E+03	4.43E+03	6.494	
5	5.64E-04	3.23E+03	3.21E+03	0.662	
6	7.13E-04	2.25E+03	2.36E+03	-4.322	
7	8.81E-04	1.59E+03	1.79E+03	-10.888	
8	1.10E-03	1.31E+03	1.35E+03	-2.429	
9	1.41E-03	9.38E+02	9.74E+02	-3.753	
10	1.80E-03	7.48E+02	7.19E+02	4.092	
11	2.22E-03	5.78E+02	5.49E+02	5.196	
12	2.85E-03	4.19E+02	4.04E+02	3.741	
13	3.60E-03	3.29E+02	3.02E+02	8.700	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
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 2104 002N 002E Z DPR XTL H 6 8+100
 Ch.21 = 0.22 Ch.22 = 0.089 Ch.23 = 19 Ch.24 = 9
 RMS LOG ERROR: 3.80E-02, ANTILOG YIELDS 9.1349 %
 LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

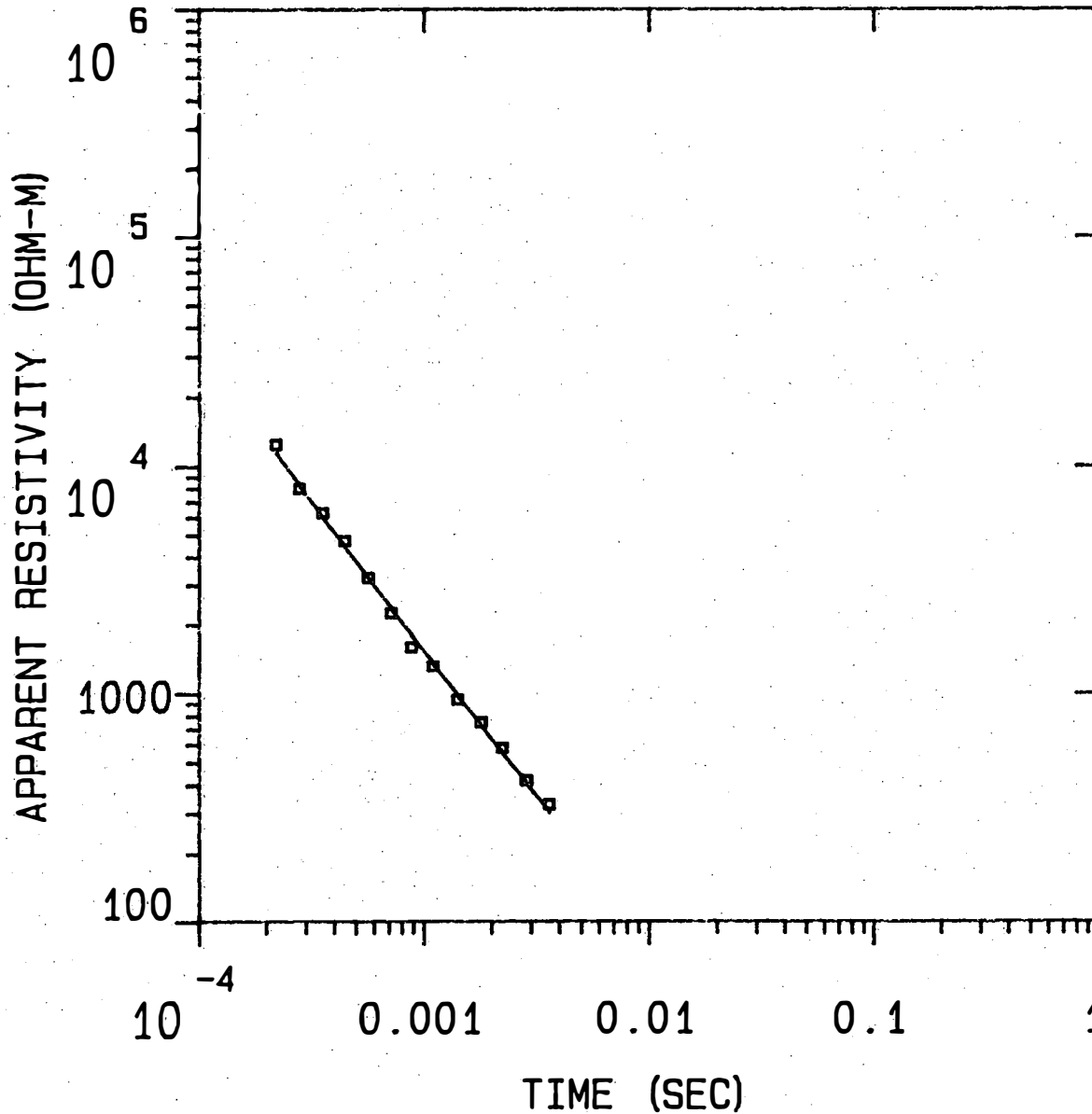
PARAMETER RESOLUTION MATRIX:

"F" MEANS FIXED PARAMETER

P 1	0.73		
F 2	0.00	0.00	
T 1	-0.02	0.00	1.00
	P 1	F 2	T 1

MT2N2E

MODEL:



9119.
OHM-M 634. M

2.50
OHM-M

Blackhawk Geosciences, Incorporated

% ERROR: 9.13
CALIBRATION: 1
OFFSET: 152. M
RAMP: 220.0

MT1N4E

MODEL: 2 LAYERS

	RESISTIVITY	THICKNESS	ELEVATION		CONDUCTANCE	(S)
	(OHM-M)	(M)	(M)	(FEET)	LAYER	TOTAL
	19879.71	653.5	585.2	1920.0		
	2.50		-68.3	-224.2	0.0	0.0

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-04	2.05E+03	1.76E+03	15.998	
2	1.10E-03	1.52E+03	1.33E+03	14.600	
3	1.40E-03	9.80E+02	9.62E+02	1.896	
4	1.77E-03	7.19E+02	7.02E+02	2.419	
5	2.20E-03	5.29E+02	5.26E+02	0.531	
6	2.80E-03	4.48E+02	3.83E+02	17.046	
7	3.55E-03	2.88E+02	2.81E+02	2.399	
8	4.43E-03	2.20E+02	2.09E+02	5.140	
9	5.64E-03	1.56E+02	1.52E+02	2.569	
10	7.13E-03	9.14E+01	1.11E+02	-17.834	

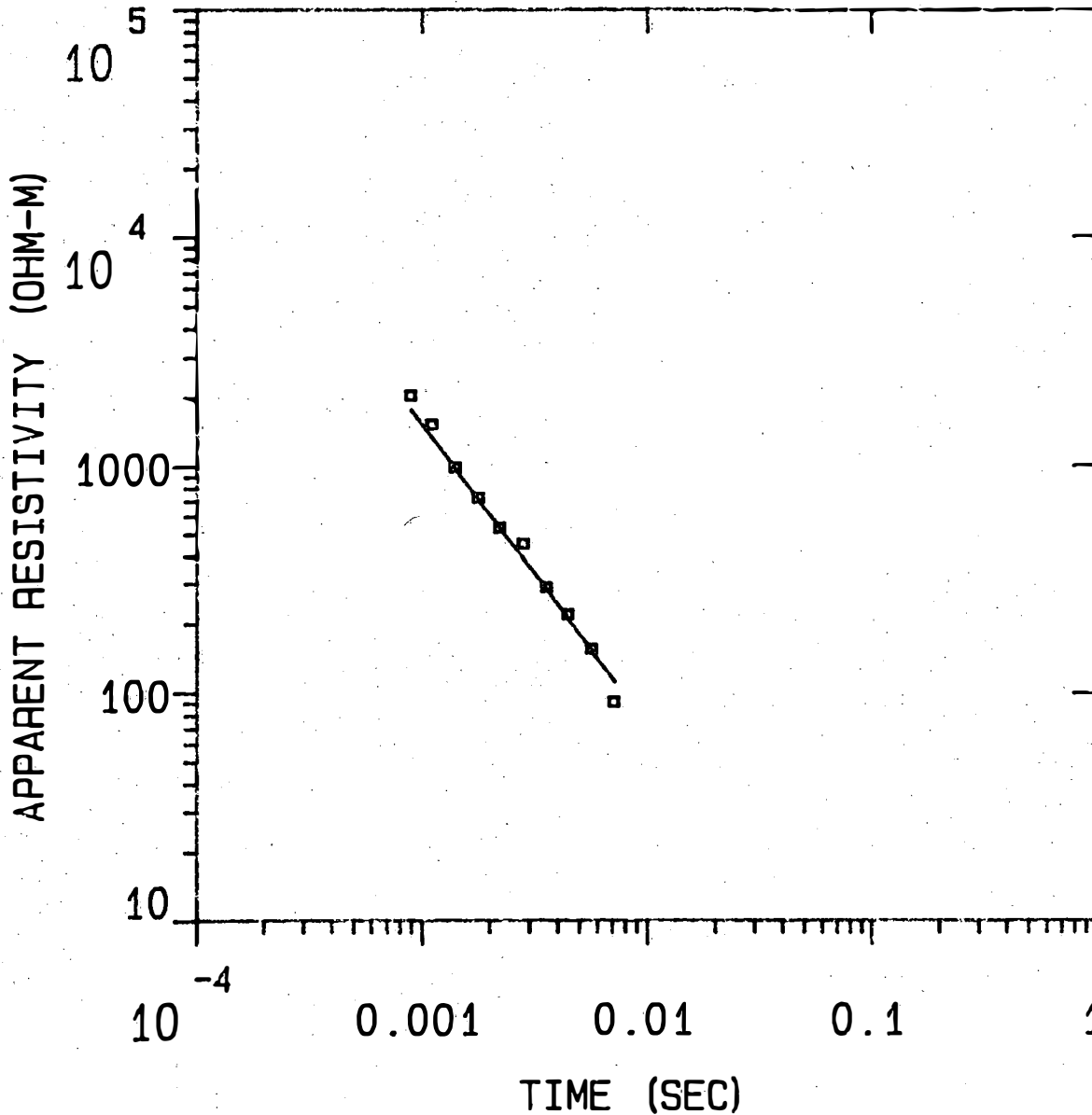
R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
 TDHZ ARRAY, 10 DATA POINTS, RAMP: 220.0 MICROSEC, DATA: MT1N4E
 2204 001N 004E Z OPR XTL L 6 8-100
 Ch.21 = 0.22 Ch.22 = 0.89 Ch.23 = 20 Ch.24 = 92
 RMS LOG ERROR: 6.79E-02, ANTILOG YIELDS 16.9218 %
 LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
 "F" MEANS FIXED PARAMETER
 P 1 0.06
 F 2 0.00 0.00
 T 1 0.00 0.00 1.00
 P 1 F 2 T 1

MT1N4E

MODEL:



Blackhawk Geosciences, Incorporated

19880.	
OHM-M	654. M

2.50
OHM-M

% ERROR: 16.9
CALIBRATION: 1
OFFSET: 152. M
RAMP: 220.0

MT1N2E

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE LAYER	(S) TOTAL
1070.78	663.0	560.8	1840.0	0.6	0.6
2.50		-102.2	-335.2		

	TIMES	DATA	CALC	% ERROR	STD ERR
1	7.13E-04	2.16E+03	1.97E+03	9.377	
2	8.81E-04	1.54E+03	1.64E+03	-6.240	
3	1.10E-03	1.34E+03	1.36E+03	-1.611	
4	1.41E-03	9.17E+02	1.01E+03	-9.282	
5	1.80E-03	7.71E+02	7.62E+02	1.148	
6	2.22E-03	5.43E+02	5.97E+02	-9.034	
7	2.85E-03	4.64E+02	4.47E+02	3.873	
8	3.60E-03	3.70E+02	3.40E+02	8.771	
9	4.49E-03	2.90E+02	2.65E+02	9.560	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
 TDHZ ARRAY, 9 DATA POINTS, SYSTEM: NONE DATA: MT1N2E
 2004 001N 002E Z OPR XTL H 6 8+100
 Ch.21 = 0.21 Ch.22 = 0.089 Ch.23 = 19 Ch.24 = 9
 RMS LOG ERROR: 4.75E-02, ANTILOG YIELDS 11.5618 %
 LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

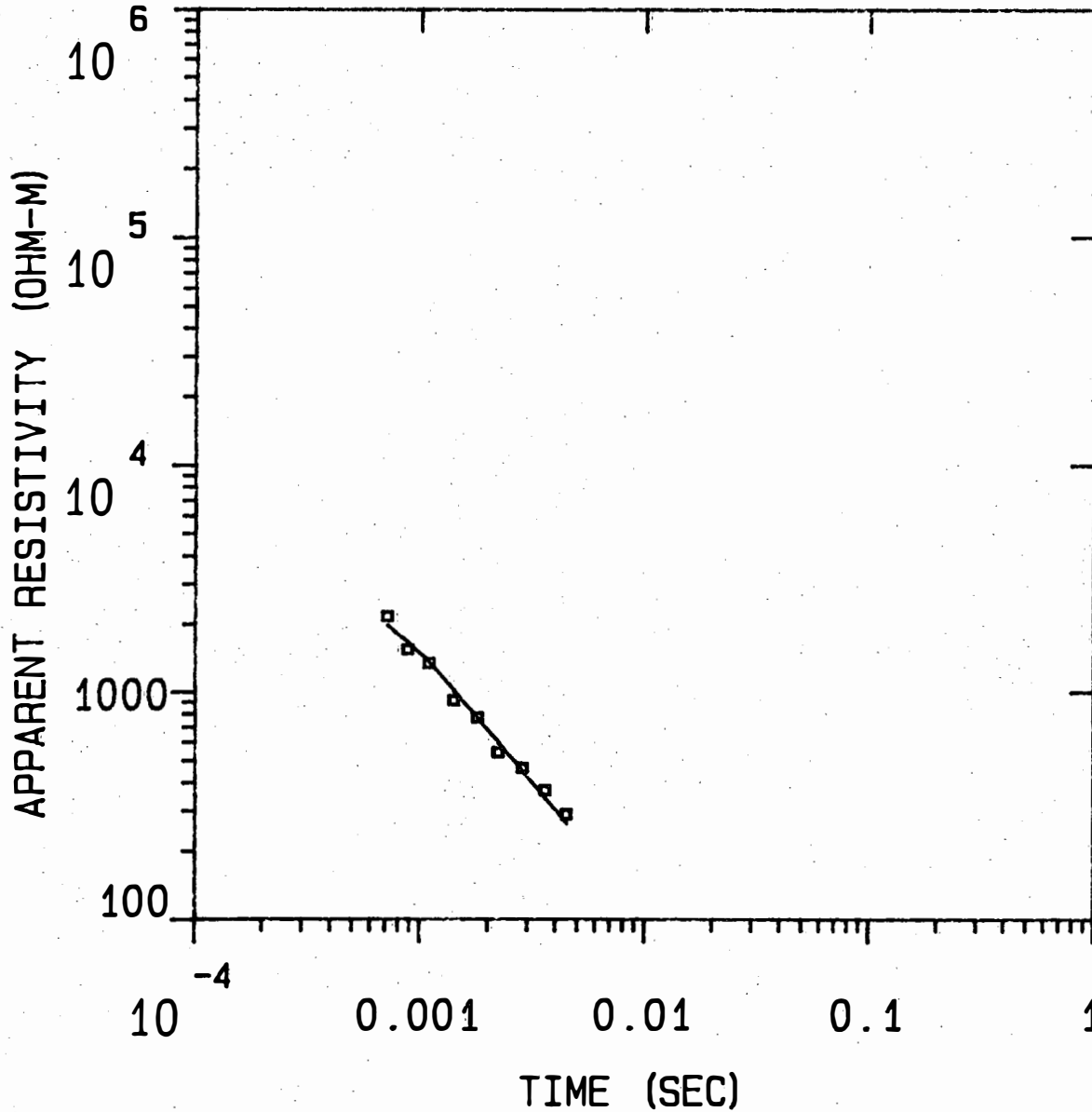
PARAMETER RESOLUTION MATRIX:

"F" MEANS FIXED PARAMETER

P 1	0.94		
F 2	0.00	0.00	
T 1	0.00	0.00	1.00
	P 1	F 2	T 1

MT 1N2E

MODEL:



Blackhawk Geosciences, Incorporated
1071.
OHM-M
2.50
OHM-M

663. M

% ERROR: 11.6
CALIBRATION: 1
OFFSET: 152. M
SYSTEM: NONE

M4N3E

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE LAYER	(S) TOTAL
1138.96	841.5	710.2	2330.0	0.7	0.7
2.50		-131.3	-430.8		

	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.10E-03	2.39E+03	2.32E+03	3.088	
2	1.40E-03	1.90E+03	1.84E+03	3.176	
3	1.77E-03	1.28E+03	1.38E+03	-6.892	
4	2.20E-03	9.92E+02	1.08E+03	-8.261	
5	2.80E-03	8.78E+02	8.12E+02	8.090	
6	3.55E-03	6.96E+02	6.10E+02	14.044	
7	4.43E-03	5.20E+02	4.70E+02	10.752	
8	5.64E-03	3.48E+02	3.55E+02	-1.998	
9	7.13E-03	2.70E+02	2.70E+02	0.220	
10	8.81E-03	1.78E+02	2.12E+02	-16.038	

R: 229. X: 0. Y: 229. DL: 457. REQ: 254. CF: 1.0000
 TDHZ ARRAY, 10 DATA POINTS, RAMP: 240.0 MICROSEC, DATA: M4N3E
 2604 004N 003E Z OPR XTL L 6 8+100
 Ch.21 = 0.24 Ch.22 = 0.89 Ch.23 = 14 Ch.24 = 20
 RMS LOG ERROR: 5.80E-02, ANTILOG YIELDS 14.2771 %
 LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

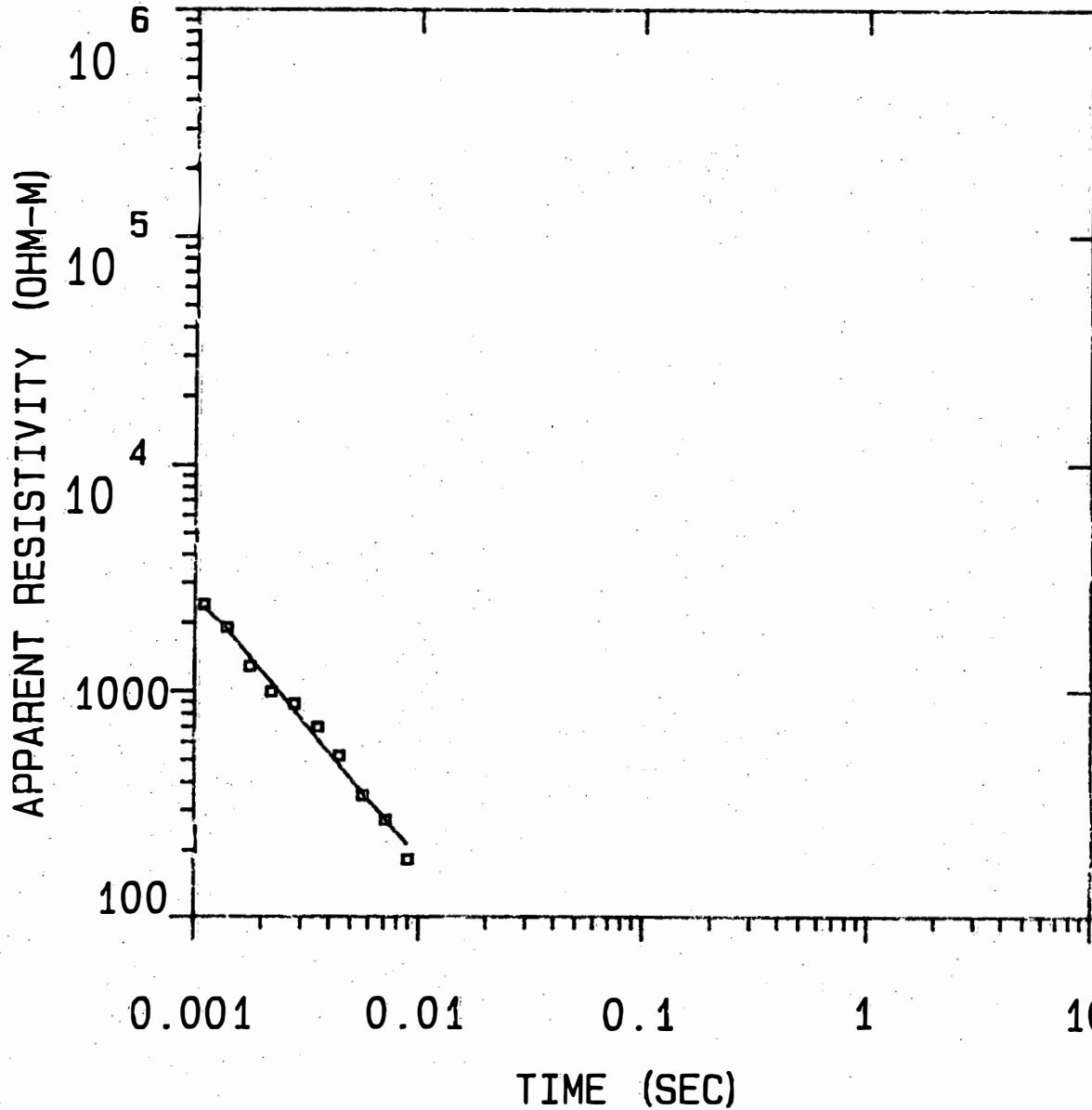
PARAMETER RESOLUTION MATRIX:

"F" MEANS FIXED PARAMETER

P 1	0.79		
F 2	0.00	0.00	
T 1	0.01	0.00	1.00
	P 1	F 2	T 1

M4N3E

MODEL:



1139.
OHM-M

841. M

2.50
OHM-M

Blackhawk Geosciences, Incorporated

% ERROR: 14.3
CALIBRATION: 1
OFFSET: 229. M
RAMP: 240.0

MT3N3E

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE LAYER	(S) TOTAL
38495.46	818.9	716.3	2350.0	0.0	0.0
2.50		-102.7	-336.8		

	TIMES	DATA	CALC	% ERROR	STD ERR
1	2.80E-04	1.32E+04	1.36E+04	-3.205	
2	3.55E-04	1.11E+04	9.95E+03	11.404	
3	4.43E-04	8.49E+03	7.43E+03	14.334	
4	7.13E-04	4.57E+03	3.93E+03	16.185	
5	8.90E-04	2.77E+03	2.93E+03	-5.518	
6	8.90E-04	2.77E+03	2.93E+03	-5.518	
7	1.10E-03	2.18E+03	2.21E+03	-1.476	
8	1.10E-03	2.18E+03	2.21E+03	-1.476	
9	1.40E-03	1.57E+03	1.61E+03	-2.243	
10	1.40E-03	1.57E+03	1.61E+03	-2.243	
11	1.77E-03	1.22E+03	1.17E+03	4.420	
12	1.77E-03	1.22E+03	1.17E+03	4.420	
13	2.20E-03	9.32E+02	8.72E+02	6.872	
14	2.20E-03	9.32E+02	8.72E+02	6.872	
15	2.80E-03	6.42E+02	6.32E+02	1.531	
16	2.80E-03	6.42E+02	6.32E+02	1.531	
17	3.55E-03	4.45E+02	4.59E+02	-3.131	
18	3.55E-03	4.45E+02	4.59E+02	-3.131	
19	4.43E-03	3.17E+02	3.42E+02	-7.195	
20	4.43E-03	3.17E+02	3.42E+02	-7.195	
21	5.64E-03	2.66E+02	2.46E+02	8.088	
22	5.64E-03	2.66E+02	2.46E+02	8.088	
23	7.13E-03	1.72E+02	1.78E+02	-3.438	
24	8.81E-03	1.29E+02	1.34E+02	-3.934	
25	1.10E-02	9.39E+01	1.00E+02	-6.420	
26	1.41E-02	6.42E+01	7.25E+01	-11.500	
27	1.80E-02	4.92E+01	5.32E+01	-7.428	
28	2.22E-02	3.65E+01	4.16E+01	-12.370	

R: 229. X: 0. Y: 229. DL: 457. REQ: 254. CF: 1.0000
 TDHZ ARRAY, 28 DATA POINTS, SYSTEM: NONE DATA: MT3N3E

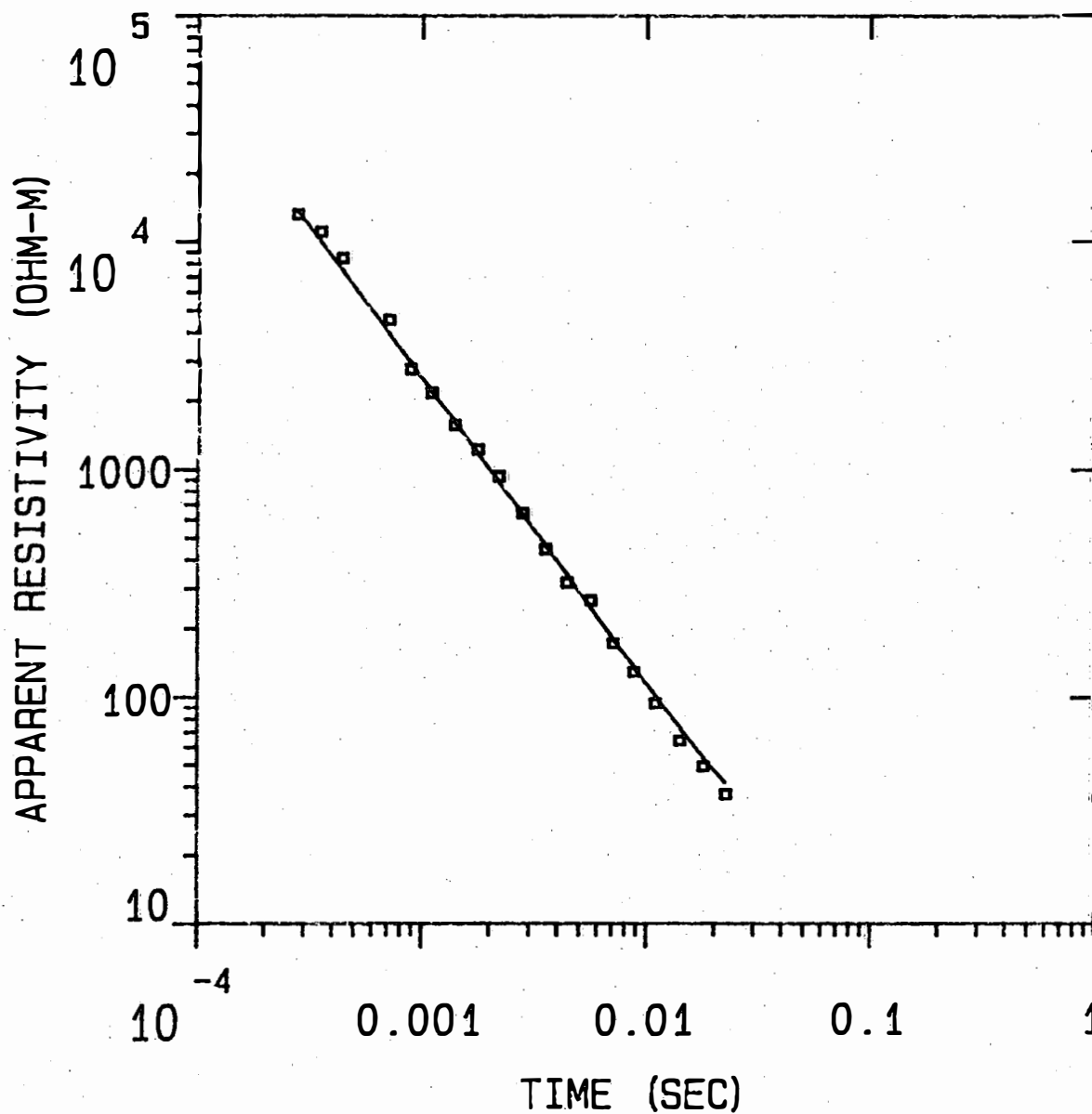
Ch.21 = 0.29 Ch.22 = 0.89 Ch.23 = 17.5 Ch.24 =
 RMS LOG ERROR: 4.69E-02, ANTILOG YIELDS 11.3964 %
 LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
 "F" MEANS FIXED PARAMETER
 P 1 0.07

MT3N3E

MODEL:



38495.
OHM-M 819. M

2.50
OHM-M

Blackhawk Geosciences, Incorporated

% ERROR: 11.4
CALIBRATION: 1
OFFSET: 229. M
SYSTEM: NONE

M2N3E

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
3296.68	766.1	682.8	2240.0	0.2	0.2
2.50		-83.4	-273.5		

	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.77E-04	1.65E+04	1.60E+04	3.617	
2	2.20E-04	1.42E+04	1.46E+04	-2.530	
3	2.80E-04	1.16E+04	1.19E+04	-2.491	
4	3.55E-04	8.95E+03	9.21E+03	-2.881	
5	4.43E-04	7.10E+03	7.03E+03	1.001	
6	5.64E-04	5.28E+03	5.11E+03	3.347	
7	7.13E-04	3.99E+03	3.79E+03	5.206	
8	8.90E-04	2.60E+03	2.86E+03	-8.934	
9	1.10E-03	2.10E+03	2.18E+03	-3.458	
10	1.40E-03	1.51E+03	1.60E+03	-5.627	
11	1.77E-03	1.15E+03	1.20E+03	-4.180	
12	2.20E-03	9.14E+02	9.09E+02	0.567	
13	2.80E-03	7.03E+02	6.76E+02	3.937	
14	3.55E-03	5.40E+02	5.06E+02	6.590	
15	4.43E-03	3.90E+02	3.88E+02	0.522	
16	5.64E-03	2.94E+02	2.92E+02	0.859	
17	7.13E-03	2.39E+02	2.22E+02	7.846	

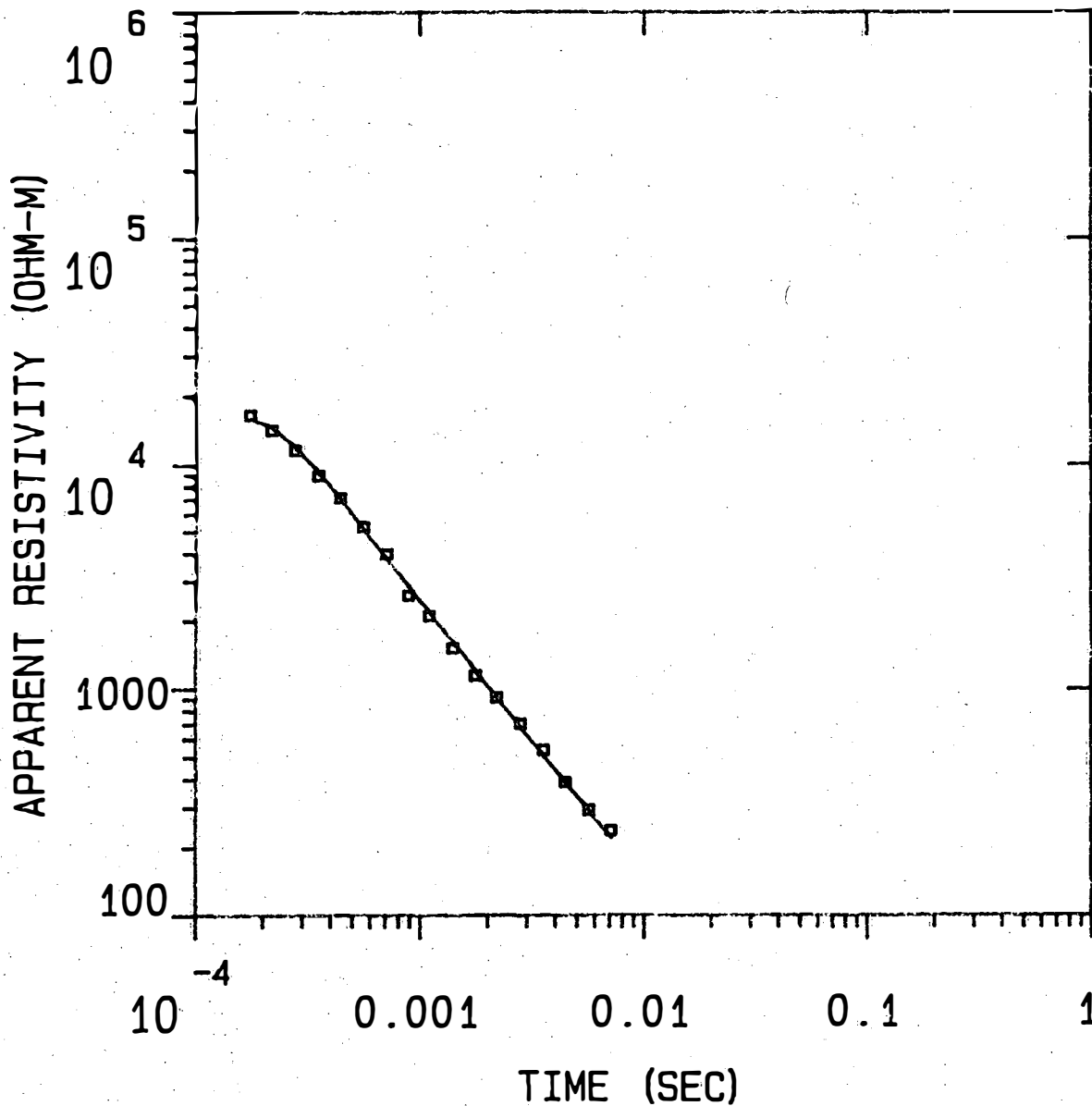
R: 229. X: 0. Y: 229. DL: 457. REQ: 254. CF: 1.0000
 TDHZ ARRAY, 17 DATA POINTS, RAMP: 290.0 MICROSEC, DATA: M2N3E
 2104 002N 003E Z OPR XTL H 6 8+100
 Ch.21 = 0.29 Ch.22 = 0.089 Ch.23 = 17 Ch.24 = 2
 RMS LOG ERROR: 2.90E-02, ANTILOG YIELDS 6.9112 %
 LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
 "F" MEANS FIXED PARAMETER
 P 1 0.03
 F 2 0.00 0.00
 T 1 0.01 0.00 0.49
 P 1 F 2 T 1

M2N3E

MODEL:



3297.	
OHM-M	766. M

2.50
OHM-M

Blackhawk Geosciences, Incorporated

% ERROR: 6.91
CALIBRATION: 1
OFFSET: 229. M
RAMP: 290.0

M1N3E

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	TOTAL
5220.59	757.9	681.2	2235.0	0.1	0.1
2.50		-76.7	-251.6		

TIMES	DATA	CALC	% ERROR	STD ERR
1	2.80E-04	1.30E+04	1.30E+04	-0.161
2	3.55E-04	9.50E+03	9.42E+03	0.938
3	4.43E-04	7.16E+03	7.03E+03	1.779
4	5.64E-04	5.06E+03	5.12E+03	-1.048
5	7.13E-04	3.84E+03	3.75E+03	2.431
6	8.81E-04	2.93E+03	2.85E+03	2.711
7	8.90E-04	2.55E+03	2.81E+03	-9.329
8	1.10E-03	2.28E+03	2.15E+03	5.729
9	1.10E-03	1.98E+03	2.14E+03	-7.808
10	1.40E-03	1.41E+03	1.57E+03	-10.263
11	1.41E-03	1.70E+03	1.55E+03	9.602
12	1.77E-03	1.15E+03	1.17E+03	-1.173
13	1.80E-03	1.31E+03	1.15E+03	13.690
14	2.20E-03	8.62E+02	8.90E+02	-3.118
15	2.80E-03	6.42E+02	6.59E+02	-2.649
16	3.55E-03	5.29E+02	4.94E+02	7.040
17	4.43E-03	3.65E+02	3.77E+02	-3.128
18	5.64E-03	2.66E+02	2.83E+02	-6.158
19	7.13E-03	2.21E+02	2.15E+02	2.688
20	1.10E-02	1.39E+02	1.32E+02	5.723
21	1.41E-02	9.86E+01	9.94E+01	-0.795
22	1.80E-02	7.44E+01	7.65E+01	-2.799
23	2.22E-02	6.51E+01	6.10E+01	6.694
24	2.85E-02	4.38E+01	4.72E+01	-7.126

R: 229. X: 0. Y: 229. DL: 457. REQ: 254. CF: 1.0000
 TDHZ ARRAY, 24 DATA POINTS, RAMP: 280.0 MICROSEC, DATA: M1N3E
 2104 001N 003E Z OPR XTL H 6 8+100
 Ch.21 = 0.28 Ch.22 = 0.089 Ch.23 = 17.5 Ch.24 =
 RMS LOG ERROR: 3.84E-02, ANTILOG YIELDS 9.2553 %
 LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

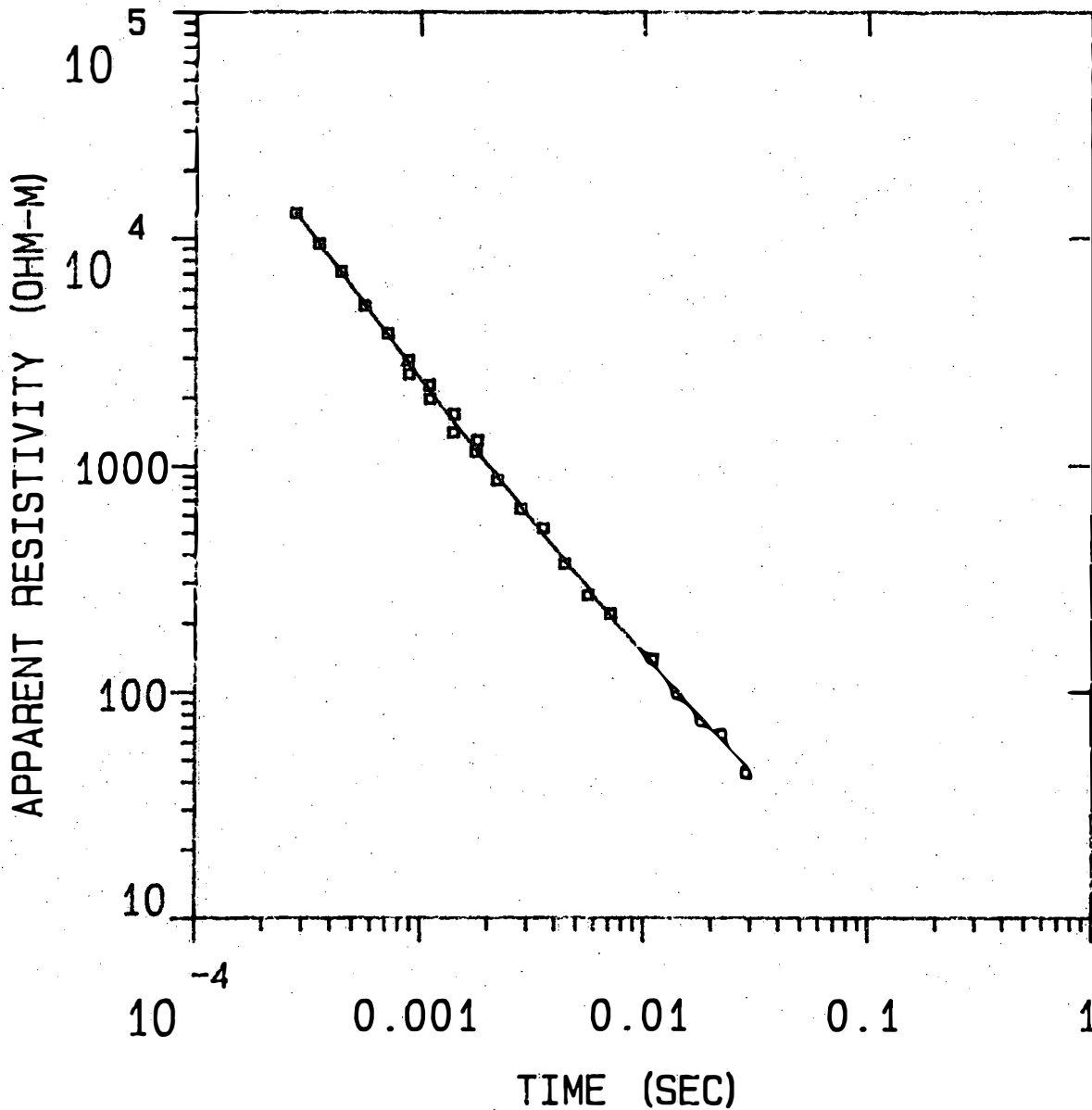
PARAMETER RESOLUTION MATRIX:

"F" MEANS FIXED PARAMETER

F 1 0.62
 F 2 0.00 0.00
 T 1 0.00 0.00 1.00

M1N3E

MODEL:



5221.
OHM-M

758. M

2.50
OHM-M

Blackhawk Geosciences, Incorporated

% ERROR: 9.26
CALIBRATION: 1
OFFSET: 229. M
RAMP: 280.0