Electrical data release for the Owens Peak Wilderness study area (CA-010-026) Tulare and Kern Counties, California

by

Herbert A. Pierce, Donald B. Hoover, and Charlie Tippens

Open-File Report 87-134

1987

Studies Related to Wilderness

The Federal Land Policy and Management Act (Public Law 94-574, October 21, 1976) requires the U.S. Geological Survey and U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the data of two electrical prospecting techniques conducted in the Owens Peak (CA-010-126) Wilderness Study Area, Tulare and Kern Counties, California.

Introduction

During September 1985, two telluric traverses (TT) and fourteen audio-magnetotelluric (AMT) soundings were made in and near the proposed Owens Wilderness study area (CA-010-026). The soundings and traverses were performed in search of buried mineral potential within the proposed wilderness area. Electrical data helps to constrain the geologic parameters by mapping the electrical response and apparent resistivity of structures and defining boundaries not readily visible through other surface mapping techniques. This report presents the electrical data with a brief discussion of preliminary interpretations to effect timely release.

The Audio-magnetotelluric method

Magnetotellurics (MT) is an electromagnetic sounding method in which variations in earth resistivity are measured as a function of depth (Keller and Frischknecht, 1966). These soundings are obtained by measuring the earth's electromagnetic fields at different frequencies. Because electromagnetic waves at lower frequencies penetrate further into the earth before they are absorbed relative to higher frequencies, measurement of the electromagnetic fields over a broad frequency range gives information on resistivity variations with depth. If these measurements are made in the audio-frequency range then the technique is called the audio-magnetotelluric (AMT) method. This method is discussed in detail by Strangway and others (1973) and applications and details of the USGS AMT system are given by Hoover and others (1976, 1978) and Hoover and Long (1976).

Calculating the apparent resistivity for AMT is identical to the MT method. The AMT system measures both the electric field (E-field) and the magnetic field (H-field) at each frequency. Amplitudes of corresponding electric and magnetic field pulses are digitized and calculations of apparent resistivity are made, using the following Cagniard equation.

$$\rho_a = 1/5f[E/H]^2$$

where ρ_a is apparent resistivity in ohm-m and f is frequency in Hz. E is the E-field magnitude in mv/km and H is the H-field in gammas.

The depth of exploration of the AMT methods is not only a function of frequency, but also of the resistivity of the volume of earth sampled. For a homogeneous earth the maximum depth of exploration can be approximated by a relationship given by Bostick (1977),

$$D=355\sqrt{\rho_a/f}$$

where ρ_a is the half-space resistivity in ohm-m, f is the frequency, and D is depth in meters.

As in any sounding technique it should be remembered that the earth is being sampled laterally as well as vertically below the measuring station. Thus, in areas of complex geology, simple one-dimensional model interpretations may be significantly biased and not represent the vertical distribution of resistivity beneath the sounding site.

Signal sources for AMT investigations may be either artificial or natural. The USGS equipment used in this survey has been designed for use with natural sources. The principal source of natural electromagnetic energy in the audio-frequencies is electrical discharge during lightning storms. Typically, signal strength is low except when generated by local storms. The low signal strength can make data quality poor, especially in parts of the frequency spectrum (approximately 1 to 4 KHz) where the energy is attenuated through propagation in the earth-ionosphere waveguide. The limitations are discussed more fully in relation to natural source AMT exploration by Hoover and others (1978).

The Telluric Traverse Method

The telluric traverse (TT) method employs natural earth currents (telluric currents) at various frequencies to indirectly measure changes in earth resistivity along a traverse. The technique was used as early as 1921 (Leonardon, 1928) by C. Schlumberger, but until recently has not been used very much in the United States. Beyer (1977) discusses the method in some detail and presents a series of model results computed for two-dimensional structures. He concludes that the method is well suited for rapid reconnaissance of regions several hundred square-kilometers in area searching for targets such as hydrothermal systems. The method should be applicable as well to fossil hydrothermal systems and related mineral deposits, because rock alteration will remain after the hydrothermal convection cells have ceased. We have found that the technique is also very useful in defining faults and other boundaries.

In applying the technique, a receiving array of three electrodes is used, spaced equidistant and in line. This array is, in effect, two colinear dipoles sharing a common electrode. The potential difference across each dipole is then proportional to the component of the telluric field in the direction of the array. This configuration permits the measurement of the ratio of the telluric field at each dipole in the direction of the dipole line. The traverse data are extended by moving the three-electrode array forward one dipole length so that the forward electrode becomes the center electrode for the next ratio measurement. This process is repeated for as long as desired.

Telluric measurements are made in a narrow frequency band typically using micropulsations near 30 second periods (0.033 Hz), but may be made over a wide range of frequencies. Because lower frequency electromagnetic signals penetrate deeper than higher frequencies, one can, to some extent, select a maximum depth of exploration. The relationship for maximum exploration depth is the same as for AMT work. Frequencies selected for this telluric work were 7.5, 16.7, and 27 Hz. With apparent resistivities ranging from about 100 ohm-m to over 20,000 ohm-m at depth the depth of penetration varied from 0.7 to over 7 Km. The telluric receiver used was of USGS design and manufacture.

Discussion

The data, fourteen AMT soundings (appendix 1) and two TT lines (appendix 2), were acquired principally within intrusive granitic rocks of the southern Sierra Nevada Batholith (fig. 1). These data show a relatively conductive trough on the west side of the study area (fig. 6). The NNW trending low resistivity trough encompasses the mines on the north side of Cow Canyon (figs. 1 and 3) and correlates with an area of limonite alteration mapped from Landsat MSS data (Fred Kruse, 1985, unpublished map).

The electrical data imply that the conductive area represents possible hydrothermal alteration in the granites. Data from the two telluric lines (fig. 4 and 5) help define the eastern boundary of the low resistivity trough and correlate directly with the AMT data. The telluric line, along Cow Canyon (fig. 5), shows that the electrical boundary extends over a lateral distance of more than 1 km. This suggests a rather diffuse boundary for the inferred alteration within the intrusive rocks. An apparent resistivity contour map at 27 Hz (fig. 6) for the 14 AMT sites illustrates the width and trend of the conductive trough. The north and south ends of the conductive trough are not closed by the data on the contour map, suggesting that the trough extends beyond the study area. An electrical crossection of the inverted soundings 8, 9, and 10 (fig. 7) show that this conductive zone extends to a depth of 1 to 2 km.

REFERENCES

Beyer, J. H., 1977, Telluric and DC resistivity techniques applied to the geophysical investigation of Basin and Range geothermal systems: University of California, Lawrence Berkeley Laboratory Report LBL-6325.

Bostick, F. X., Jr., 1977, A simple and almost exact method of MT analysis: Geothermal Workshop Report, University of Utah, USGS Contract 14-08-0001-6-359, p. 175-177.

Hoover, D. B., Frischknecht, F. C., and Tippens, C. L., 1976, Audio-magnetotelluric soundings as a reconnaissance exploration technique in Long Valley, California: Journal of Geophysical Research, v. 81, p. 801-809.

Hoover, D. B., and Long, C. L., 1976, Audio-magnetotelluric methods in reconnaissance geothermal exploration: Proceedings, 2d U.N. Symposium, Developmental Geothermal Resources, p. 1059-1064.

Hoover, D. B., Long, C. L., and Senterfit, R. M., 1978, Some results from audio-magnetotelluric investigations in geothermal areas: Geophysics, v. 43, p. 1501-1514.

Keller, G. V., and Frischknecht, F. C., 1966, Electrical methods in geophysical prospecting: New York Pergamon Press, p. 197-250.

Leonardon, E. G., 1928, Source observations upon telluric currents and their applications to electrical prospecting: Terr. Mag., v. 33, p. 91-94.

Strangway, D. W., Swift, C. M., Jr., and Holmer, R. C., 1973, The application of audio-frequency magnetotelluric (AMT) to mineral exploration: Geophysics, v. 38, p. 1159-1175.

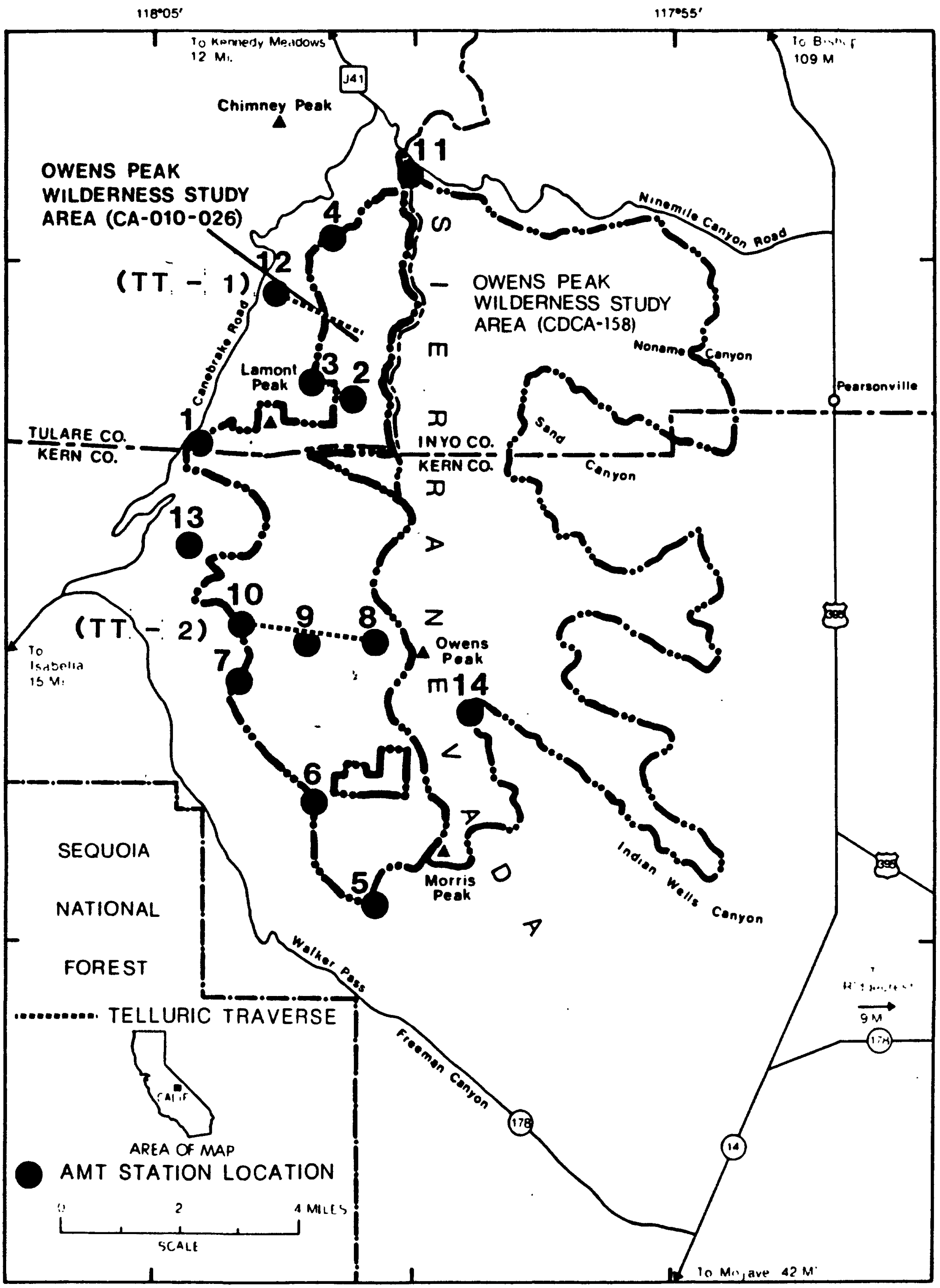


Figure 1. Location map for the Owens Peak Wilderness Study Area, AMT station locations, and telluric traverses.

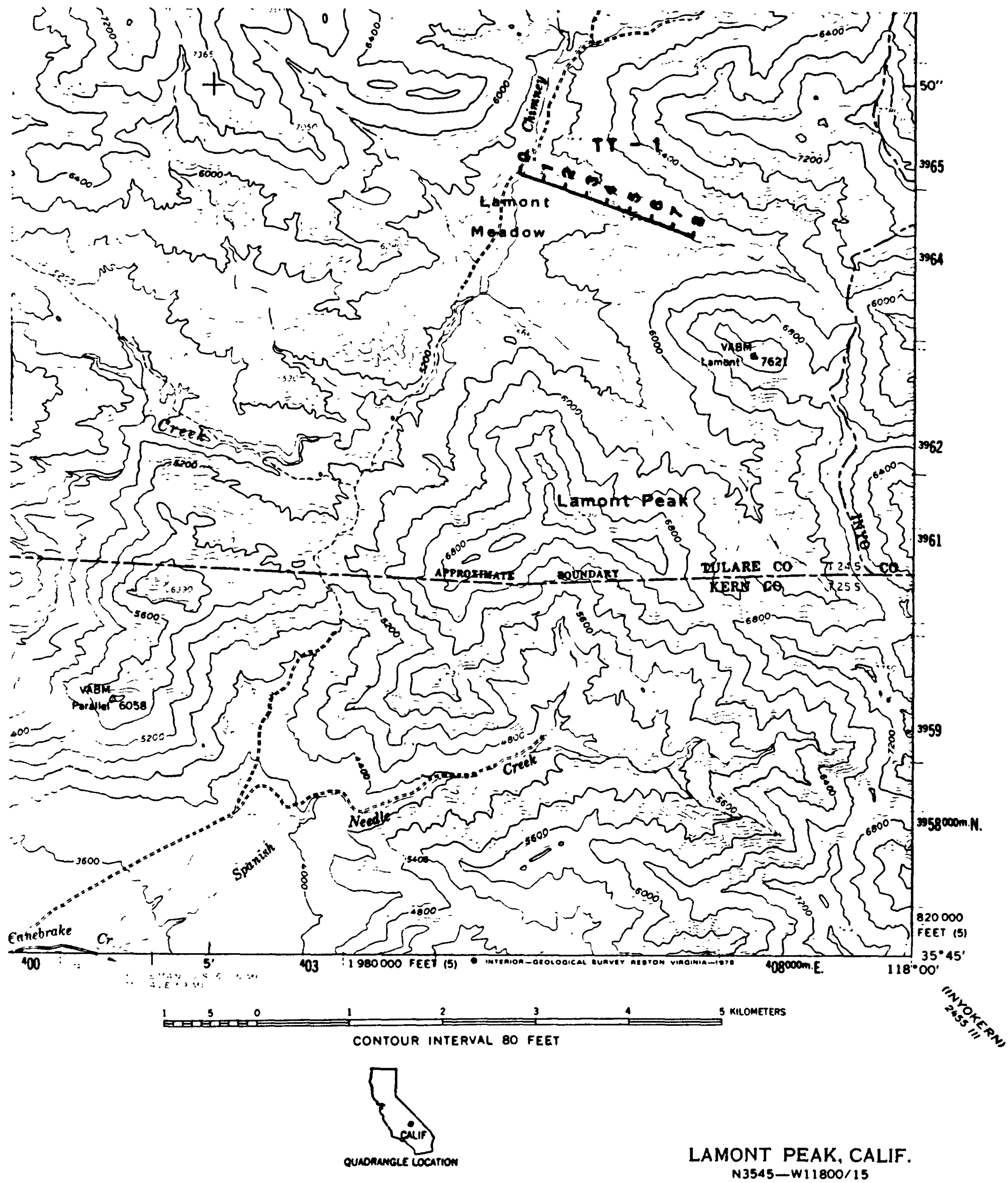


Figure 2. Tellurice traverse #1 location on the Lamont Peak, California 15 minute quadrangle.

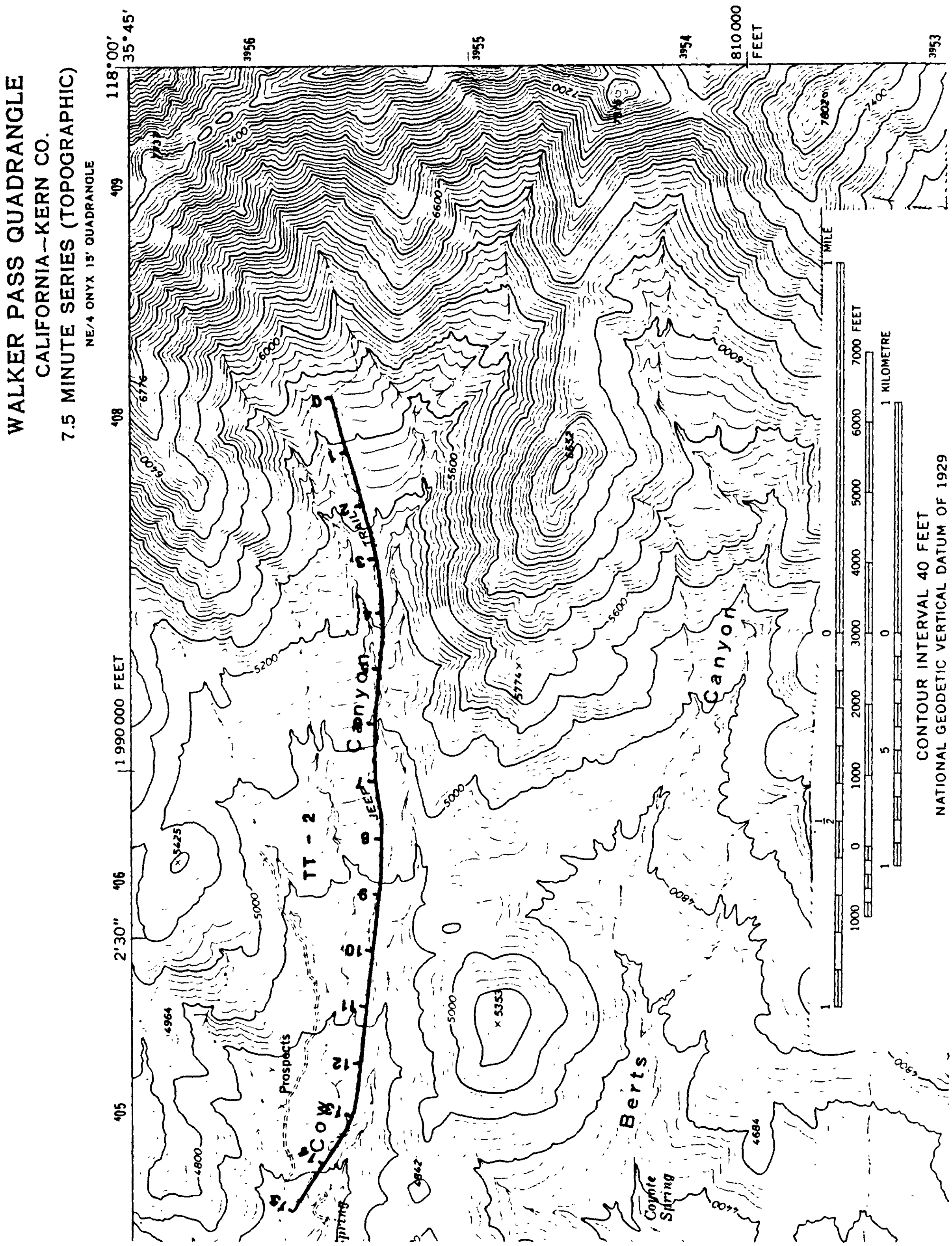


Figure 3. Telluric traverse #2 location on the Walker Pass, California 7.5 minute quadrangle.

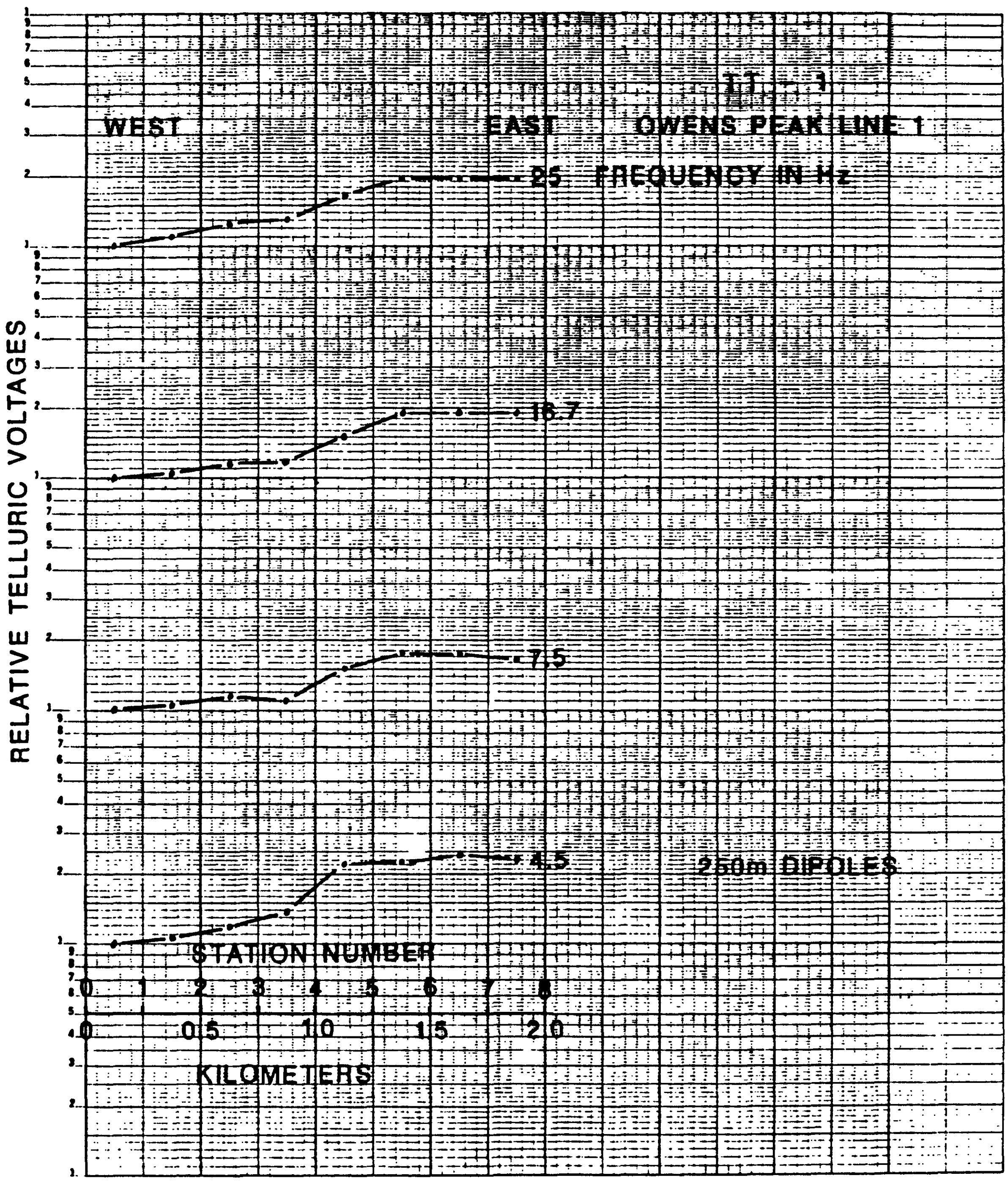


Figure 4. Plot of relative telluric voltages verses station numbers for telluric traverse #1. Station 0-1 assigned a value of 1 for the four frequencies. Offset between frequencies is one decade for legibility. Dipoles are 250 m long.

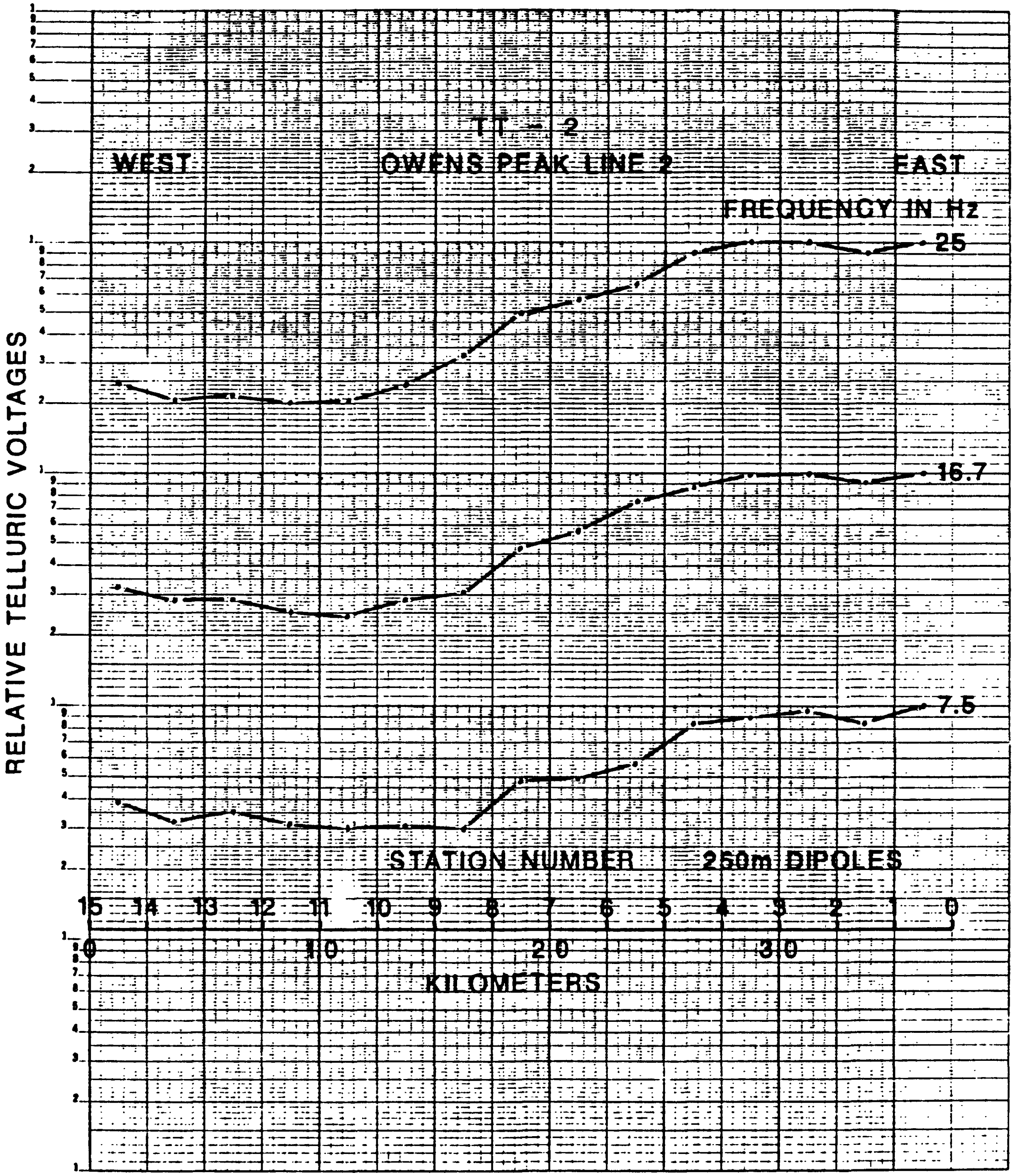


Figure 5. Plot of relative telluric voltages verses station numbers for telluric traverse #2. Station 1-0 assigned a value of 1 for the three frequencies. Offset between frequencies is one decade for legibility. Dipoles are 250 m long.

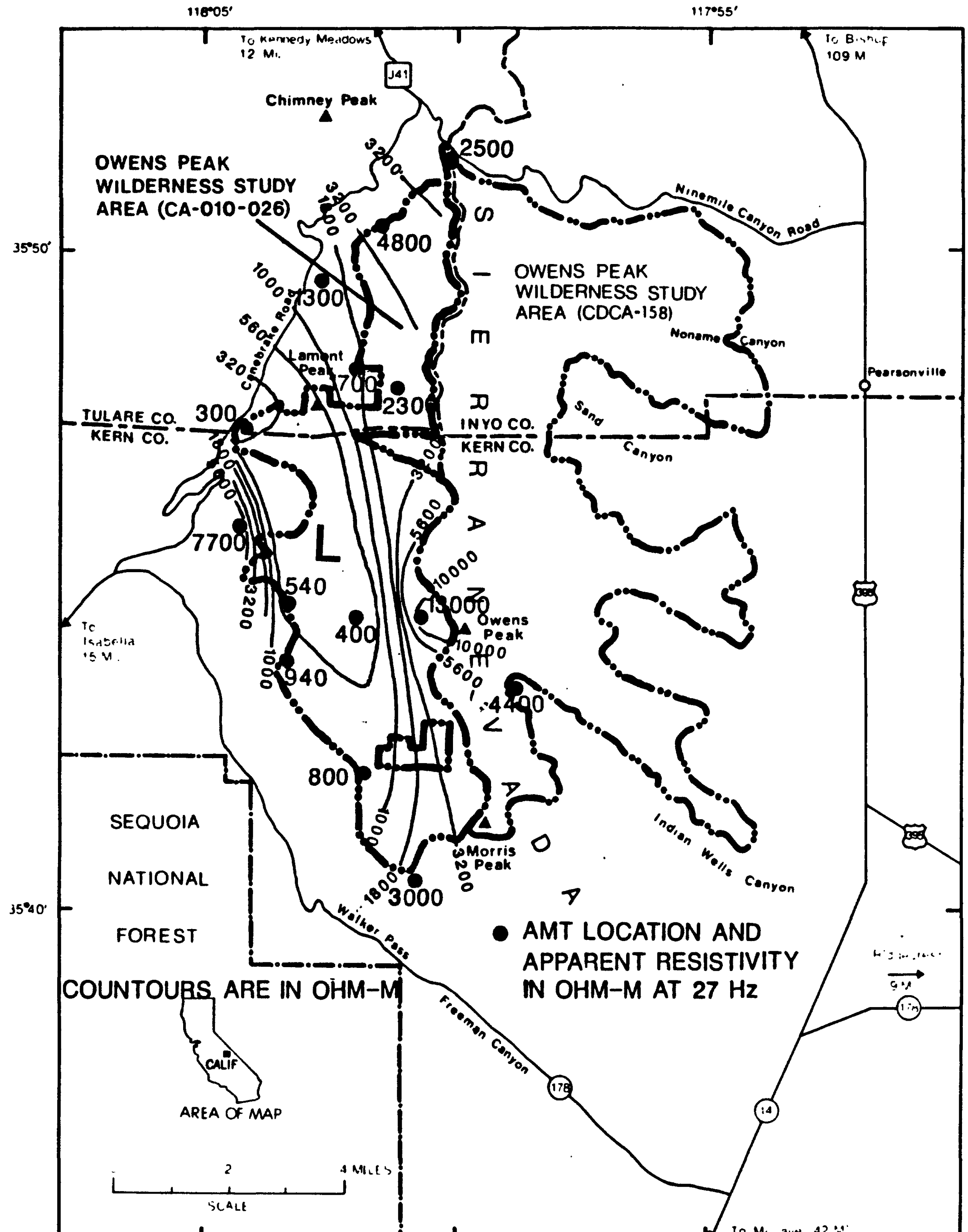


Figure 6. Resistivity map for the Owens Peak wilderness study area at 27 Hz. Contours are in ohm-m. Low resistivity area (large L) is just left of center.

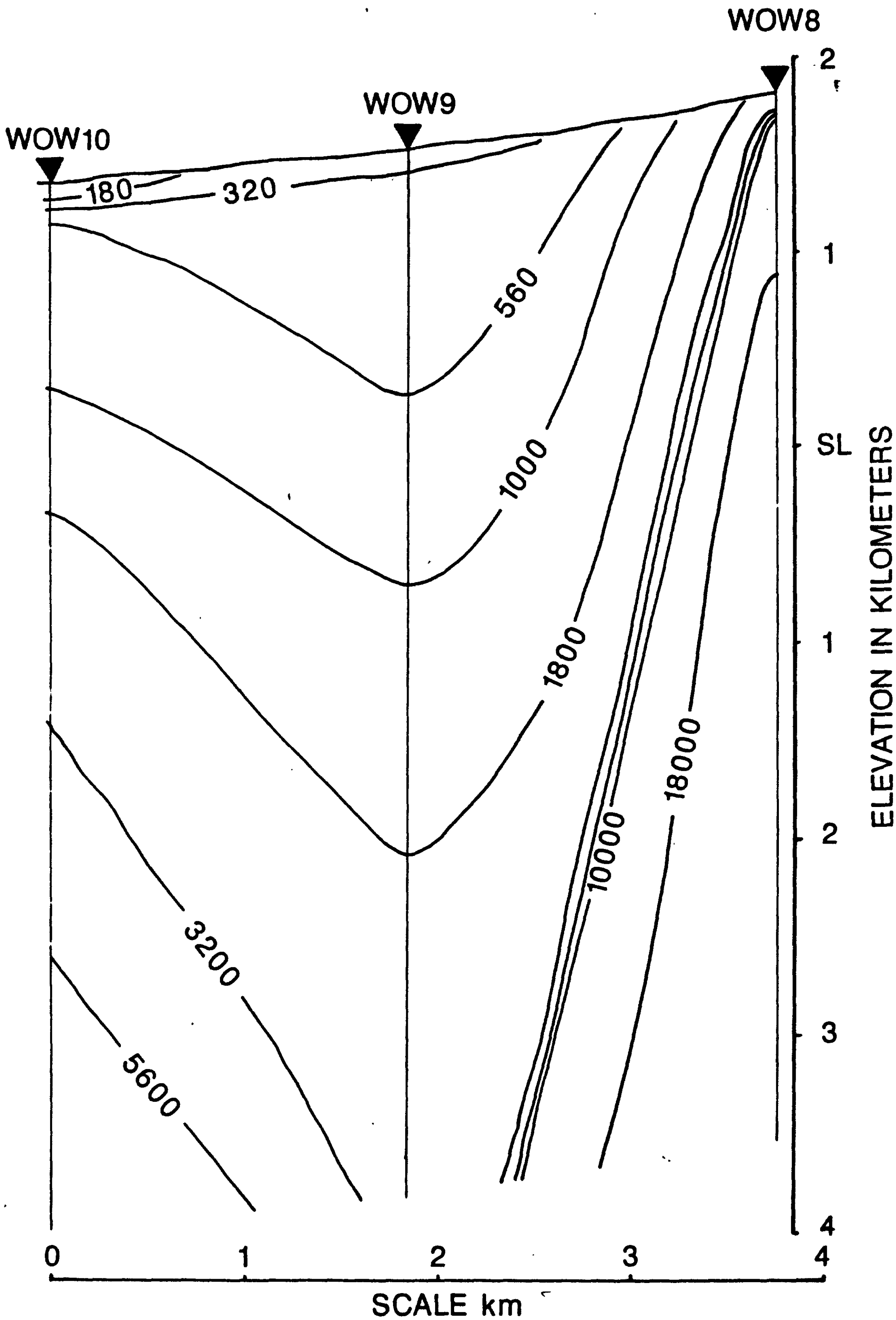
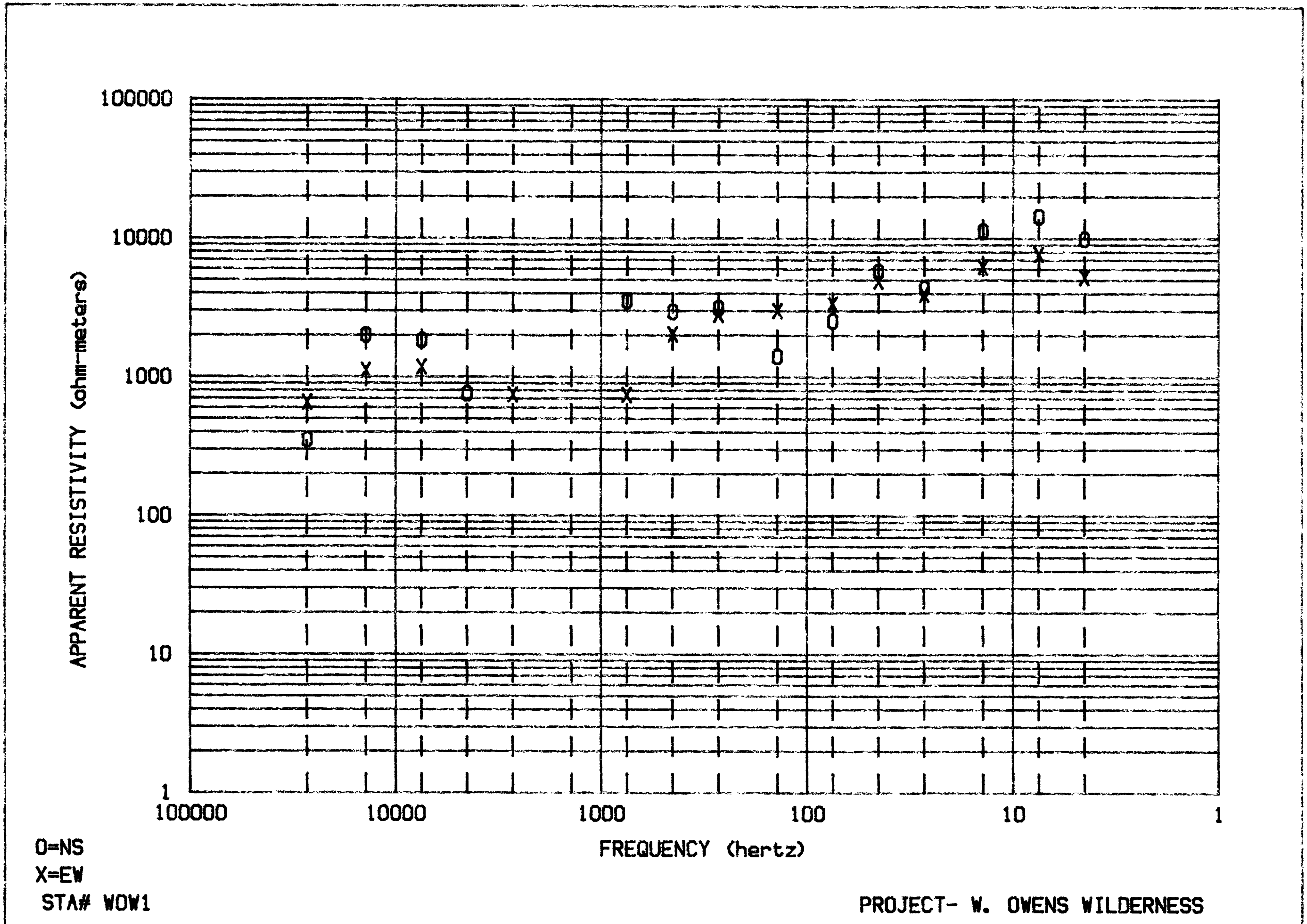


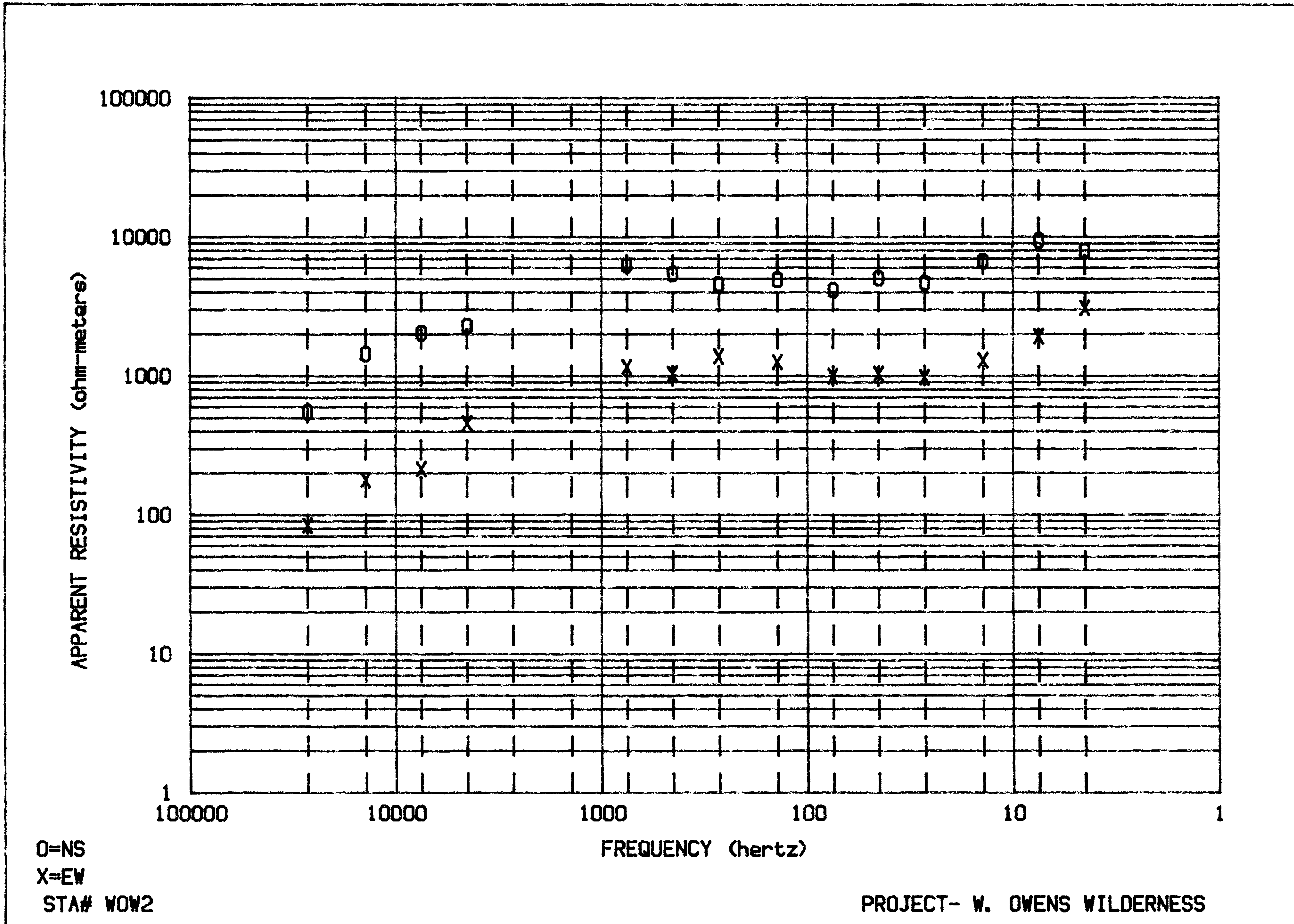
Figure 7. Resistivity cross section of inverted AMT stations 8, 9, and 10. with no vertical exaggeration. Low resistivity zone is centered on station 9 (WOW9). Contours are a logarithmic interval of four divisions per decade in ohm-meters.

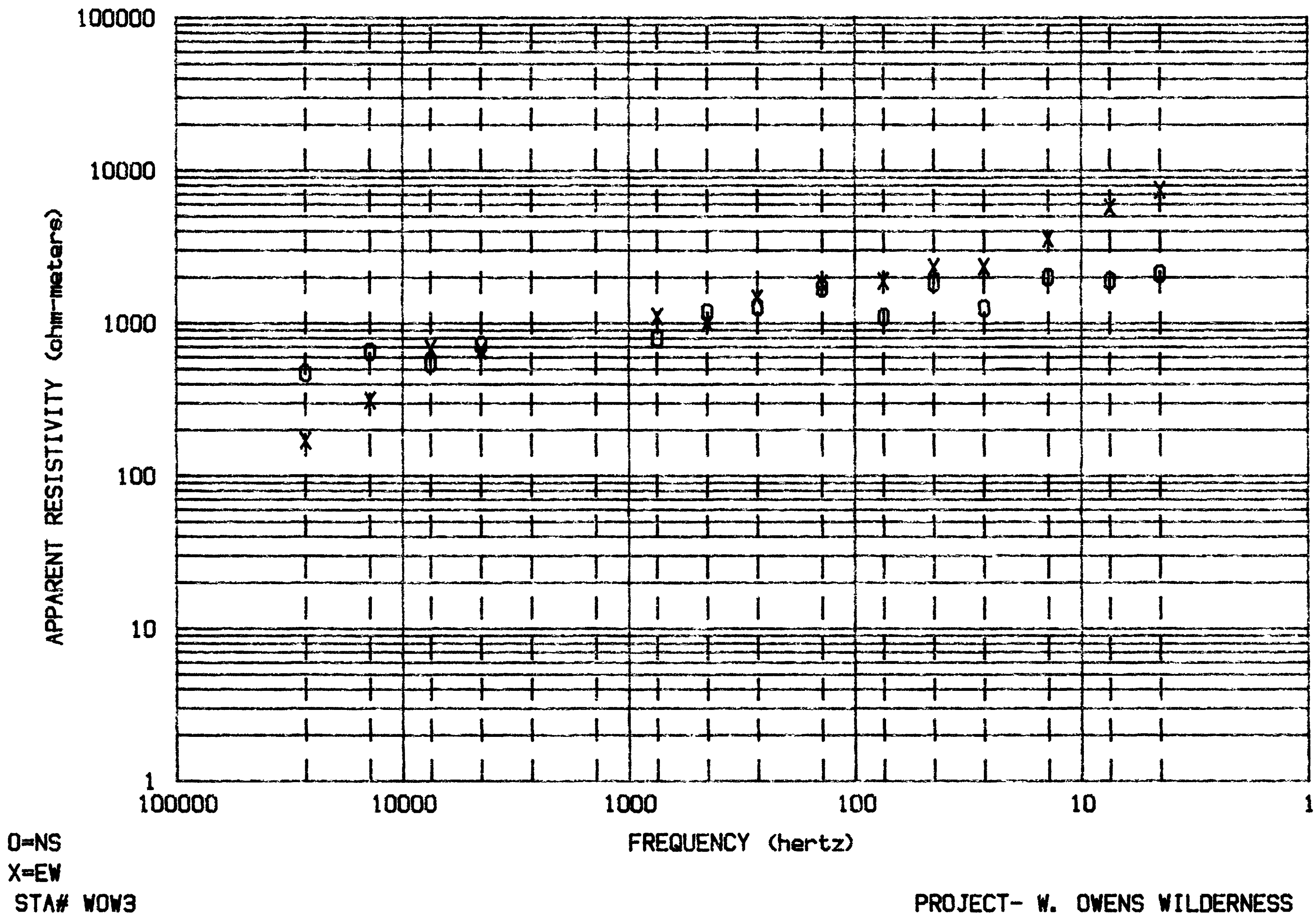
APPENDEX 1

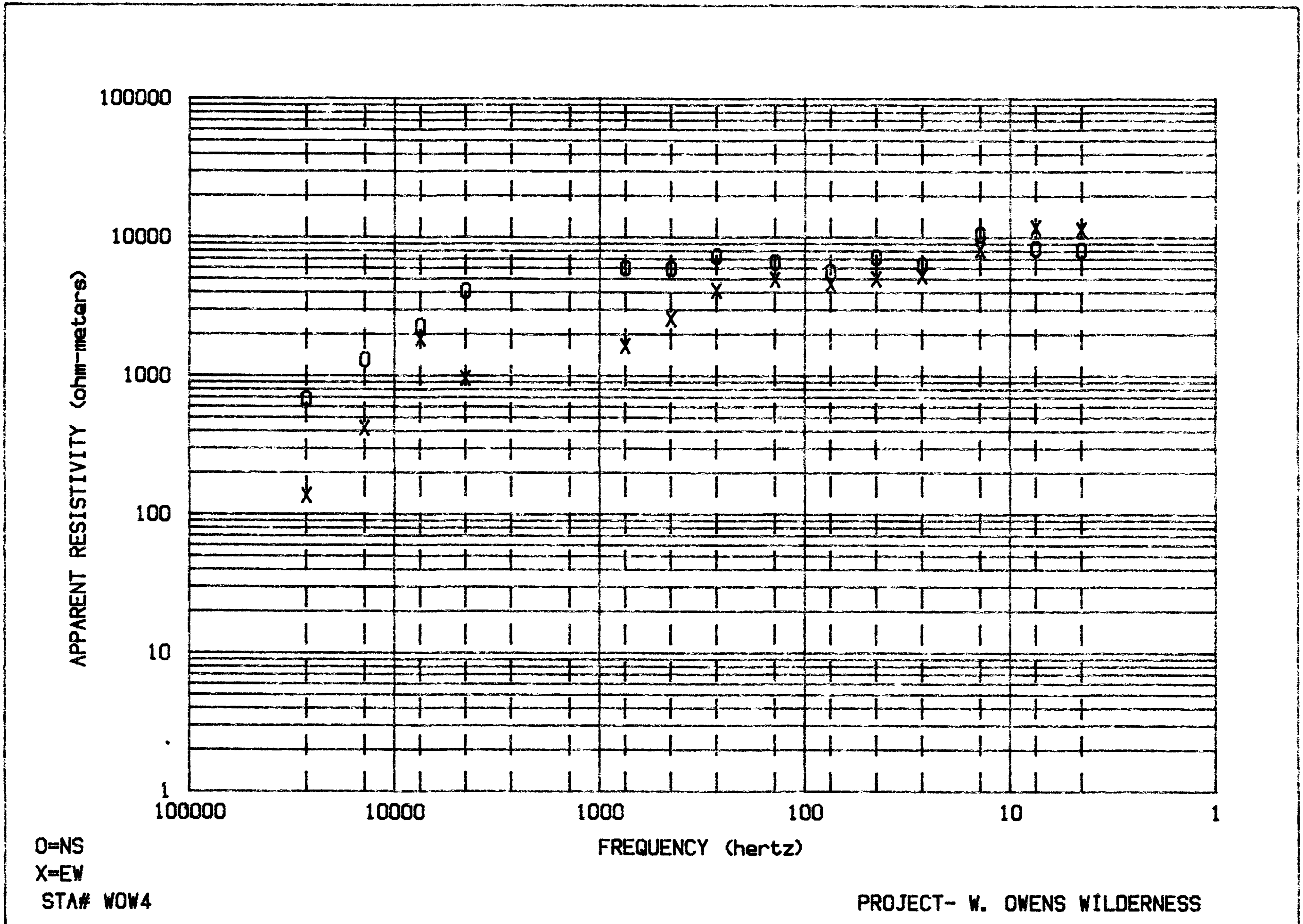
AMT DATA

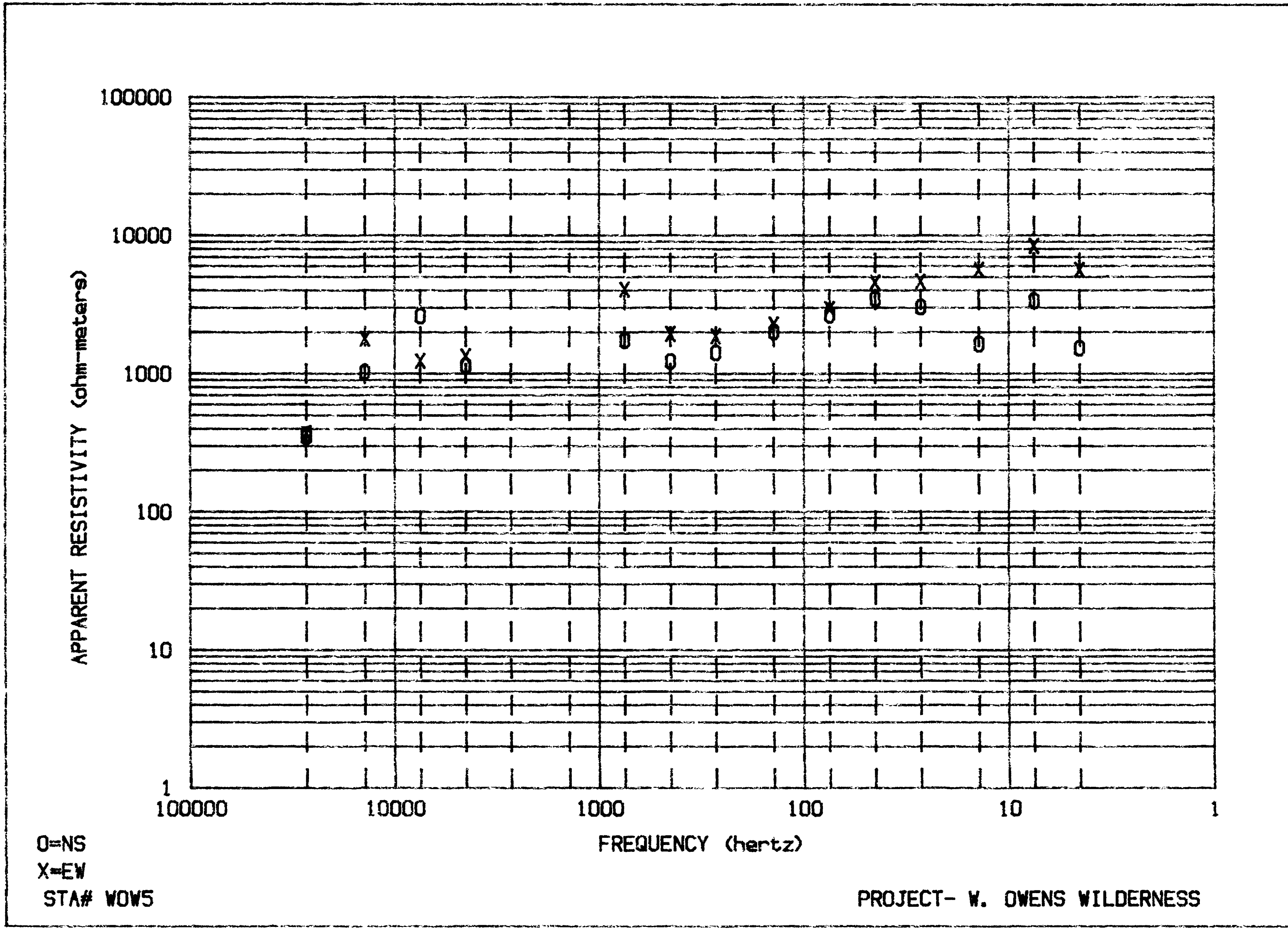


100000
10000
1000
100
10
1
APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
FREQUENCY (hertz)
O=NS
X=EW
STA# WOW1
PROJECT- W. OWENS WILDERNESS

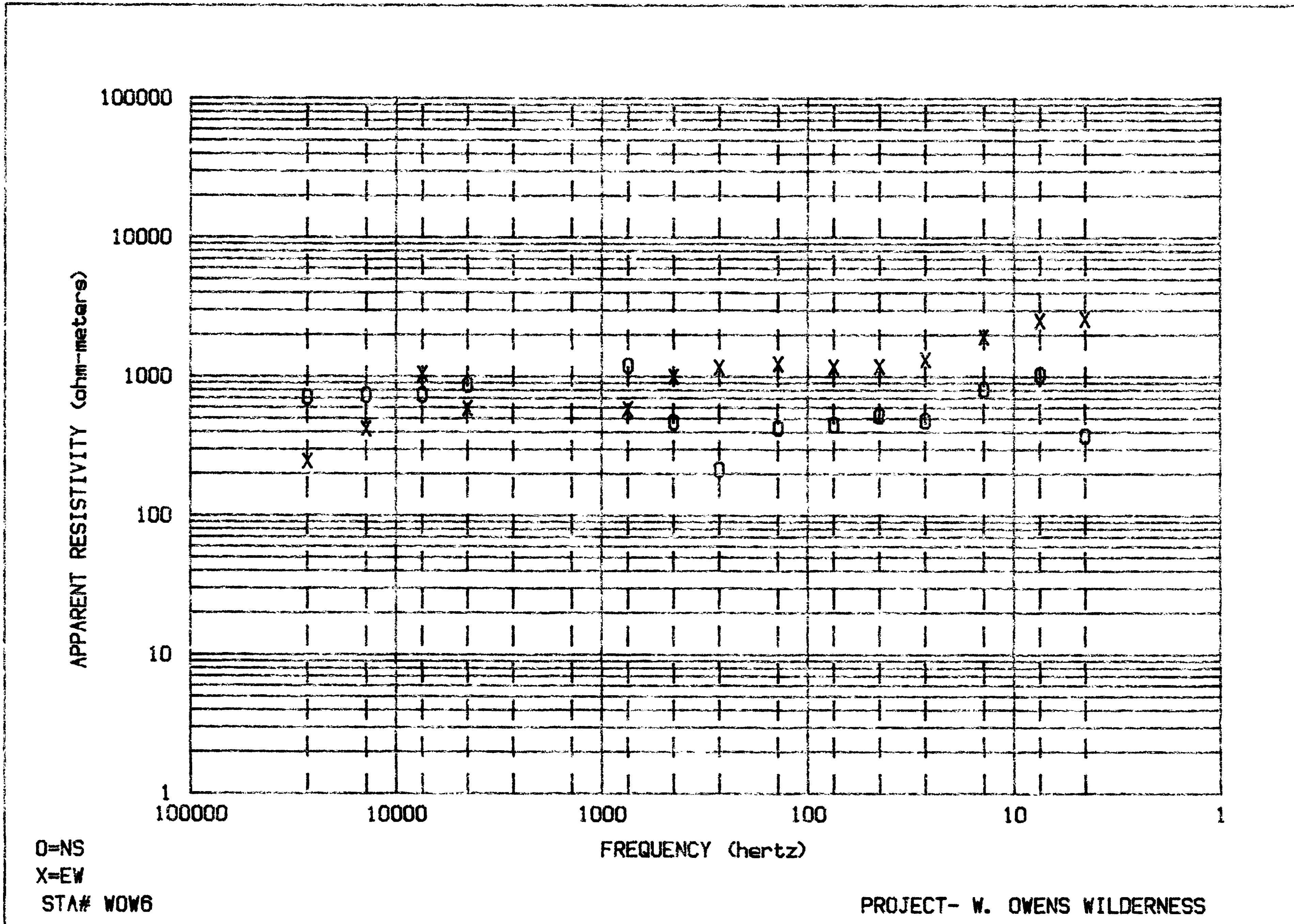

APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
100000
10000
1000
100
10
1
FREQUENCY (hertz)
O=NS
X=EW
STA# WOW2
PROJECT- W. OWENS WILDERNESS

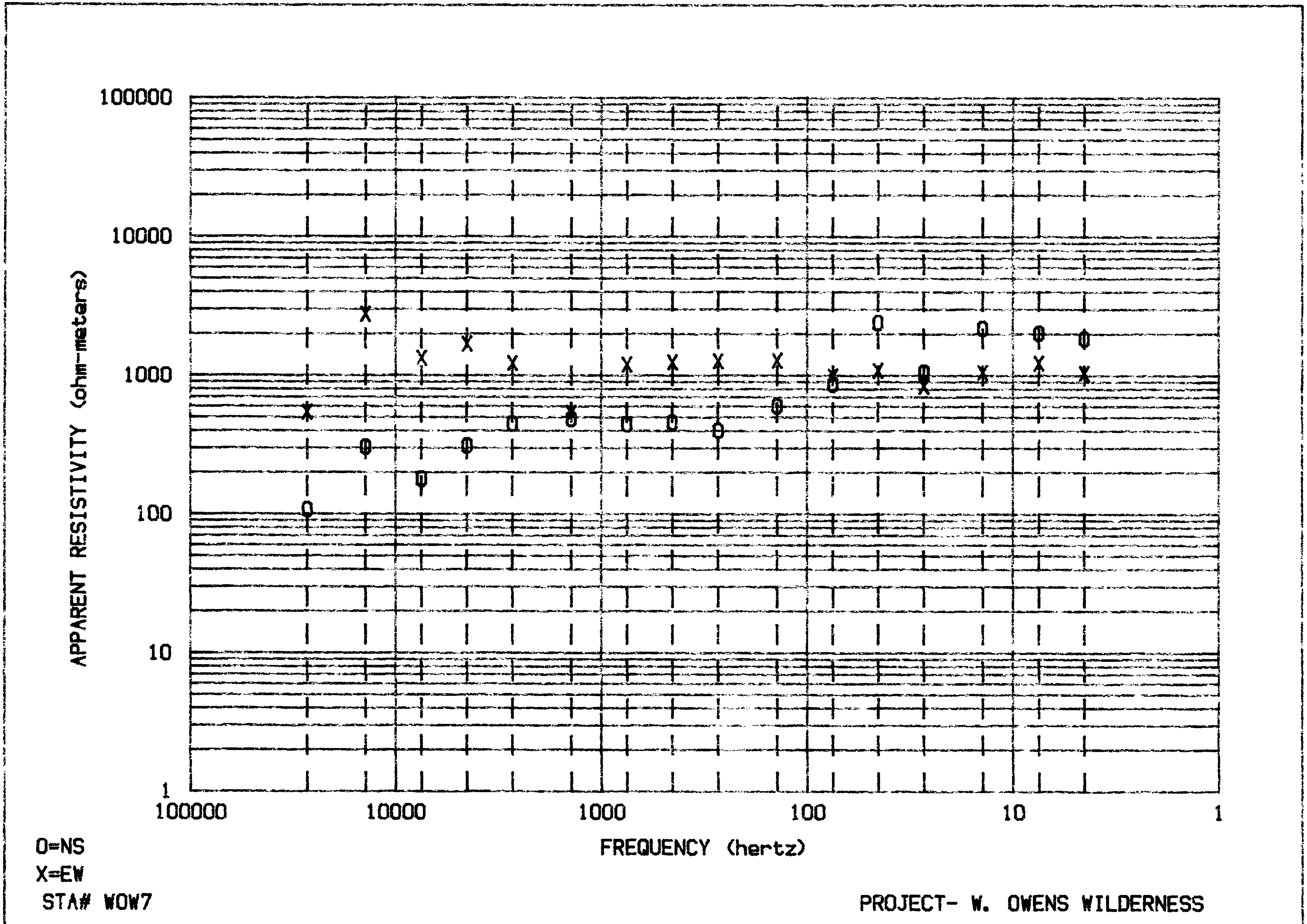

100000
10000
1000
100
10
1
APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
FREQUENCY (hertz)
O=NS
X=EW
STA# WOW3
PROJECT- W. OWENS WILDERNESS

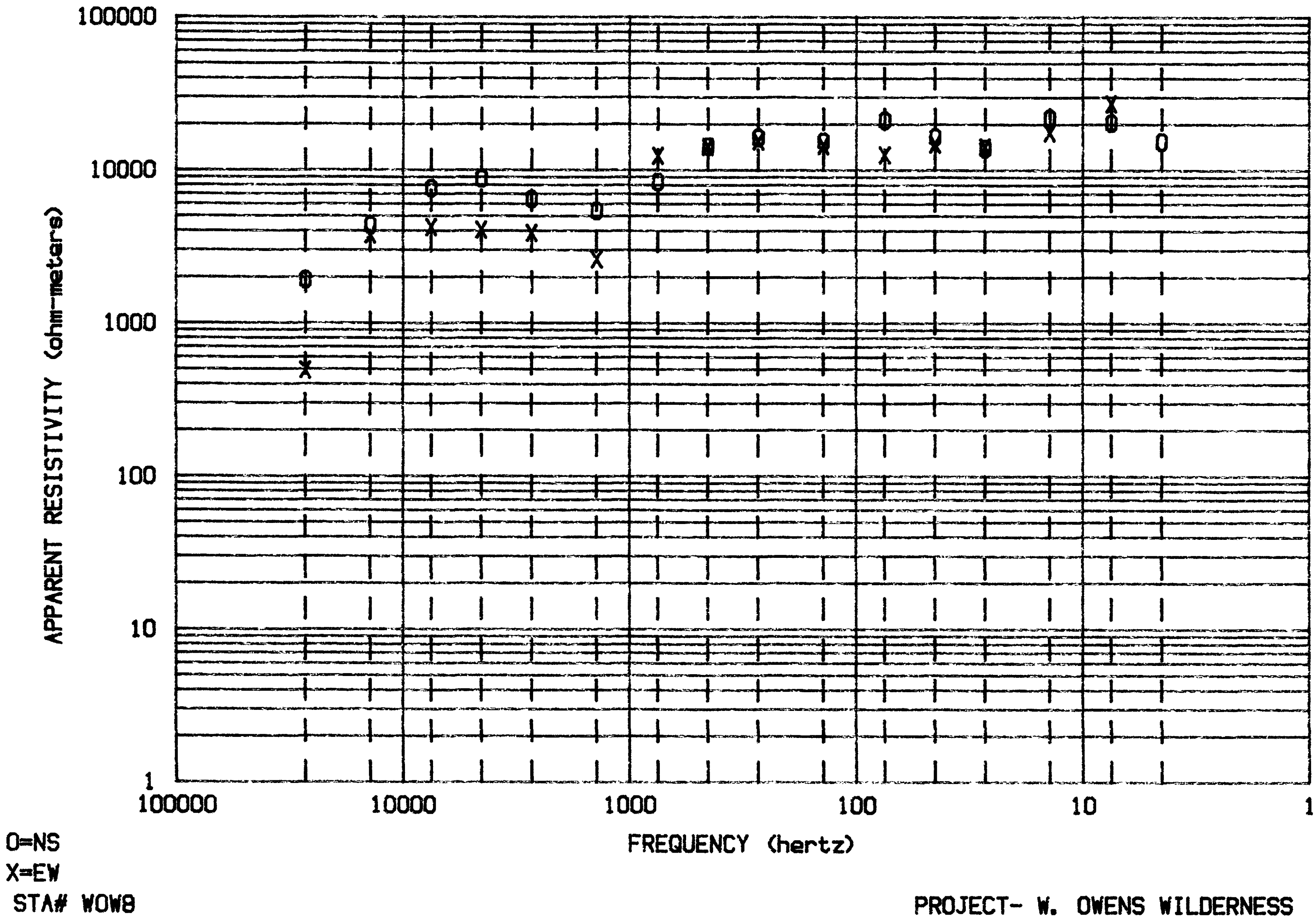

100000
10000
1000
100
10
1
APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
FREQUENCY (hertz)
O=NS
X=EW
STA# WOW4
PROJECT- W. OWENS WILDERNESS

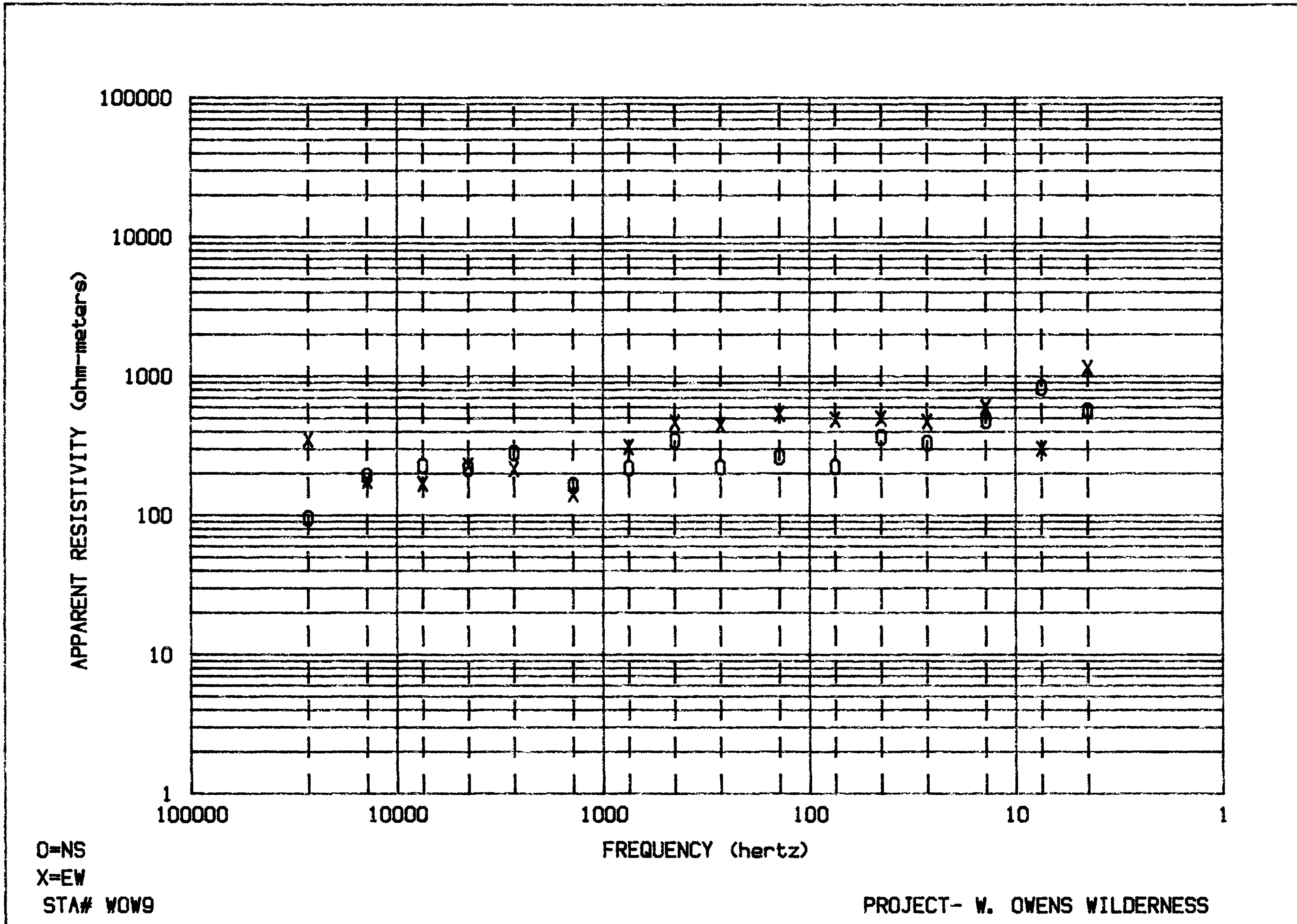


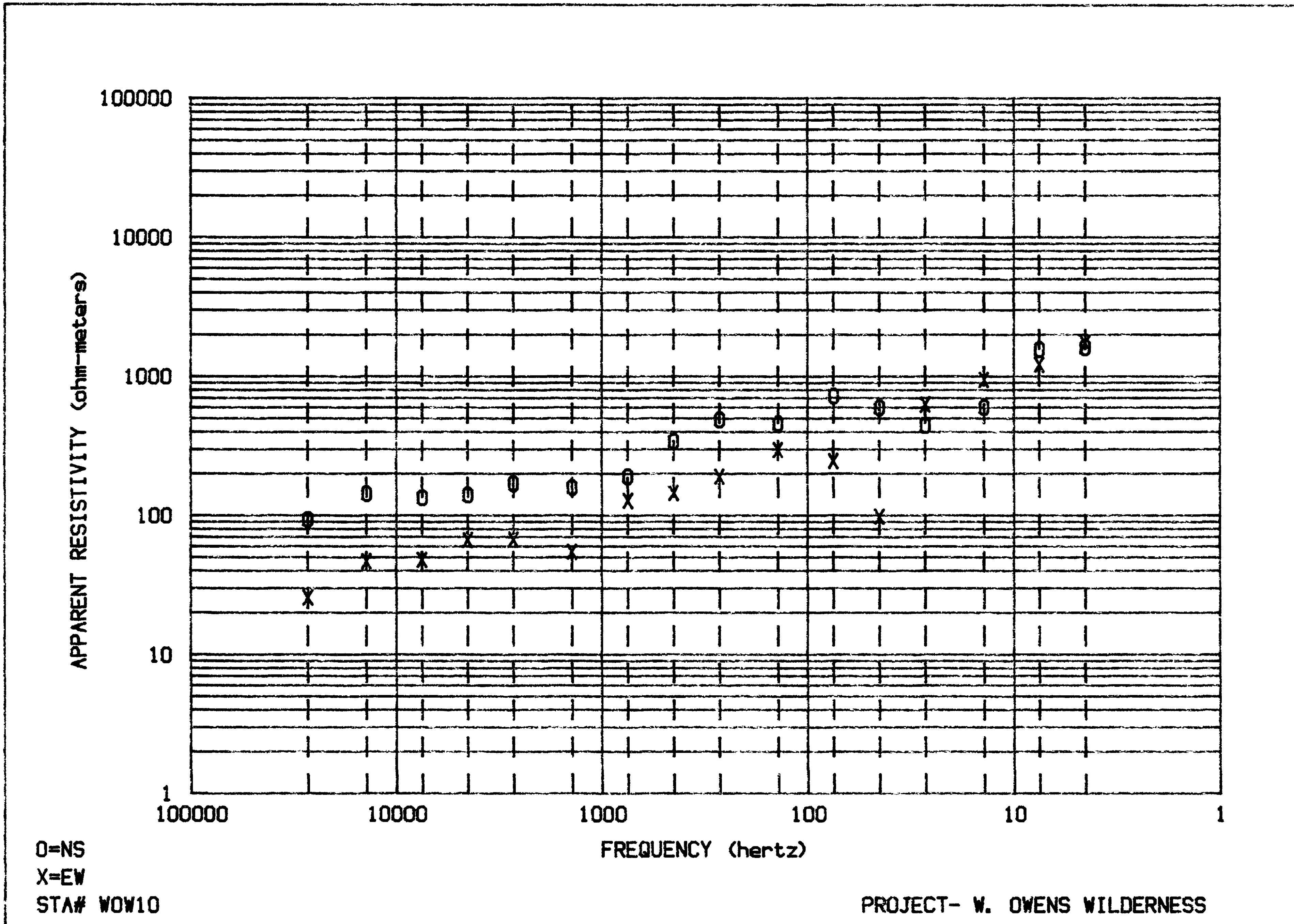
APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
100000
10000
1000
100
10
1
FREQUENCY (hertz)
O=NS
X=EW
STA# WOW5
PROJECT- W. OWENS WILDERNESS


APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
100000
10000
1000
100
10
1
FREQUENCY (hertz)
O=NS
X=EW
STA# WOW6
PROJECT- W. OWENS WILDERNESS

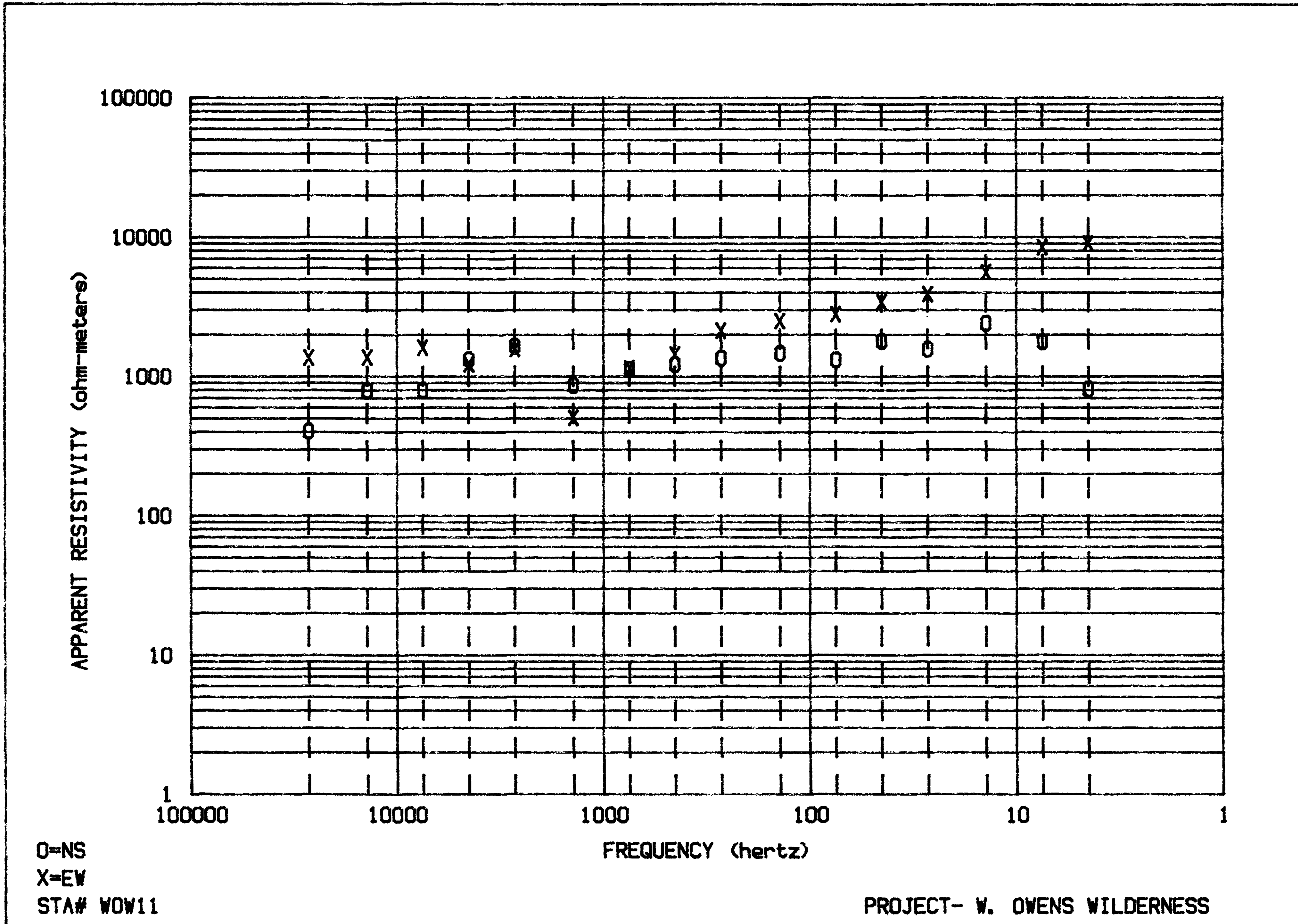

100000
10000
1000
100
10
1
APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
FREQUENCY (hertz)
O=NS
X=EW
STA# WOW7
PROJECT- W. OWENS WILDERNESS

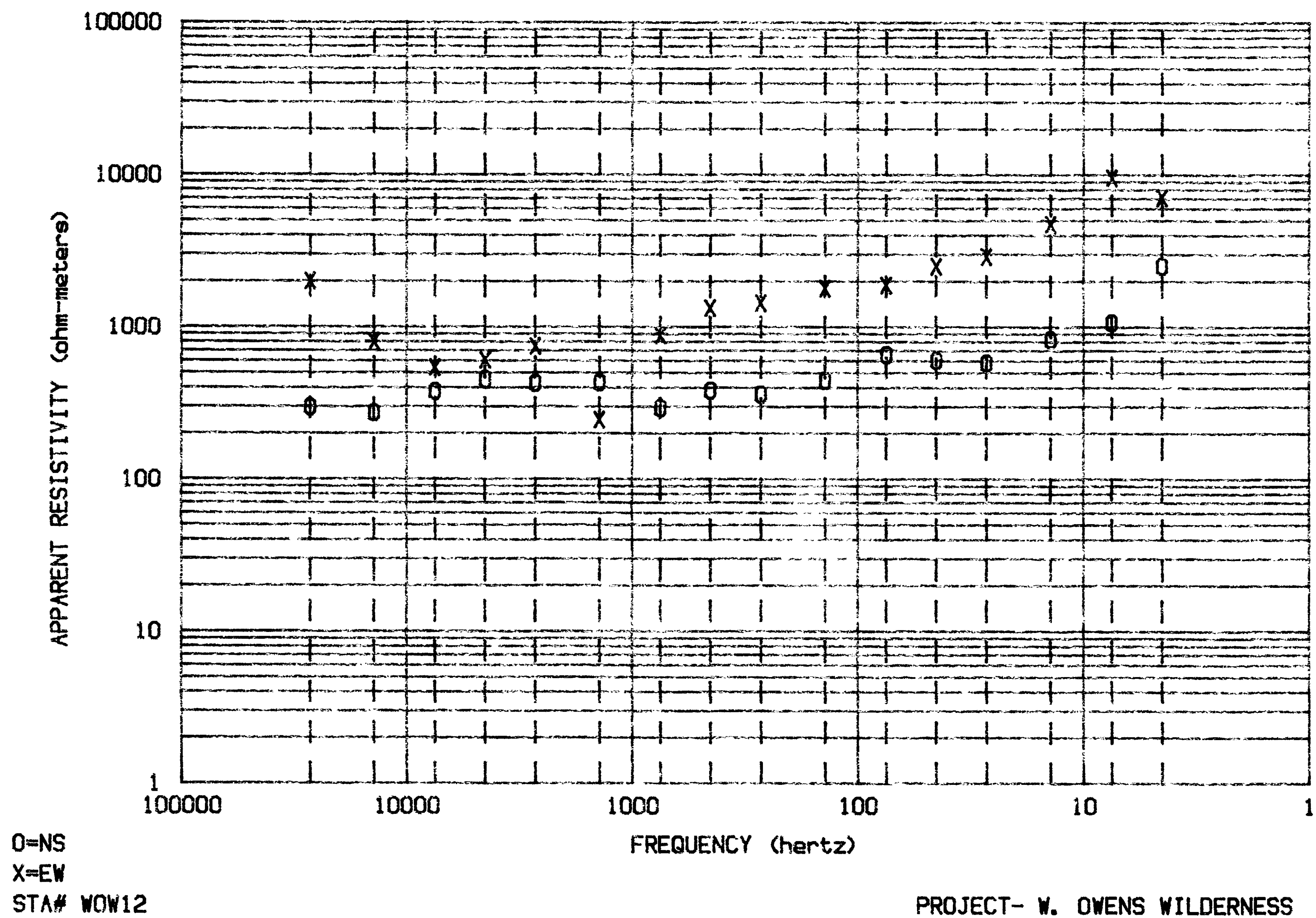

100000
10000
1000
100
10
1
APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
FREQUENCY (hertz)
O=NS
X=EW
STA# WOW8
PROJECT- W. OWENS WILDERNESS


100000
10000
1000
100
10
1
APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
FREQUENCY (hertz)
O=NS
X=EW
STA# WOW9
PROJECT- W. OWENS WILDERNESS

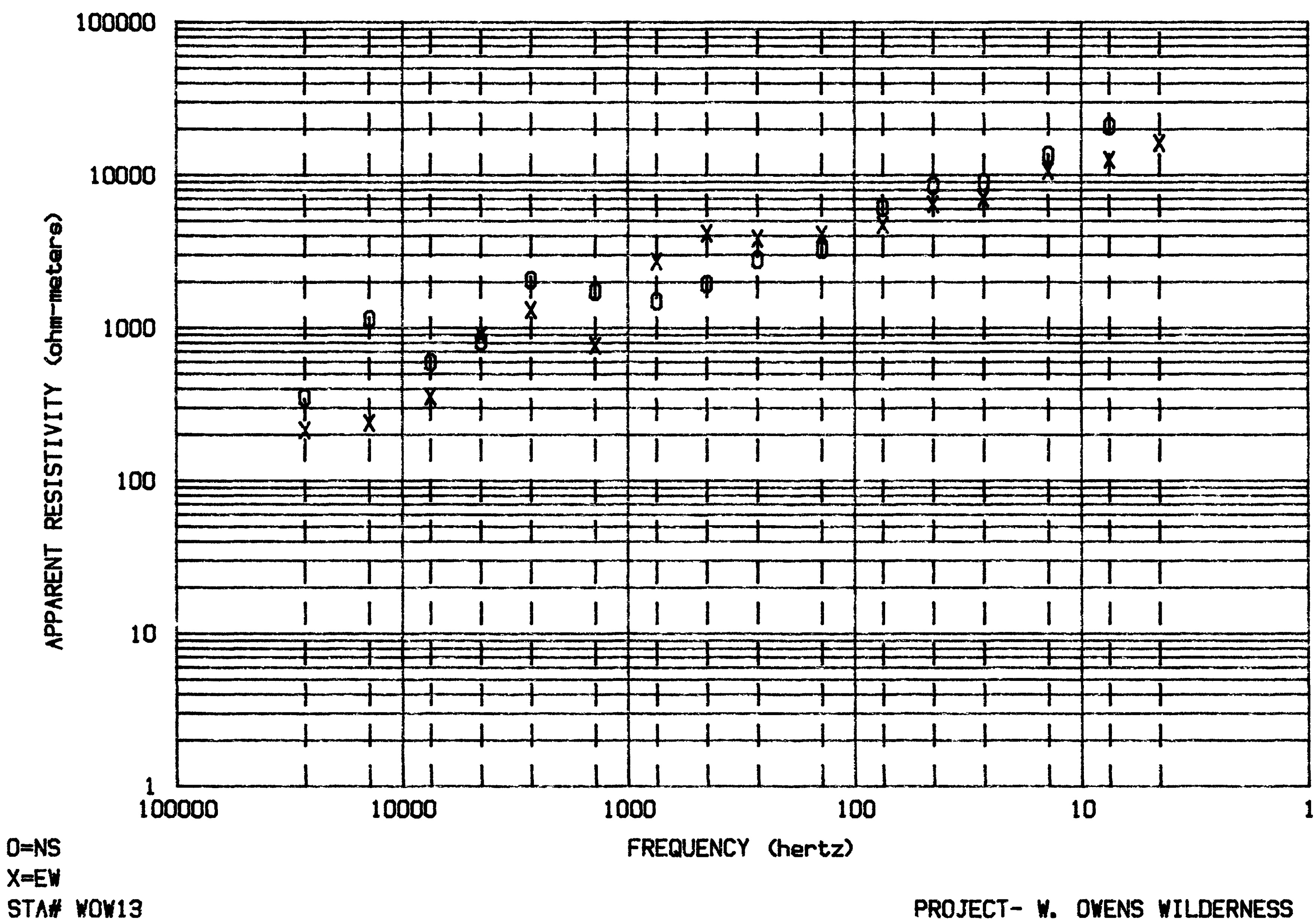


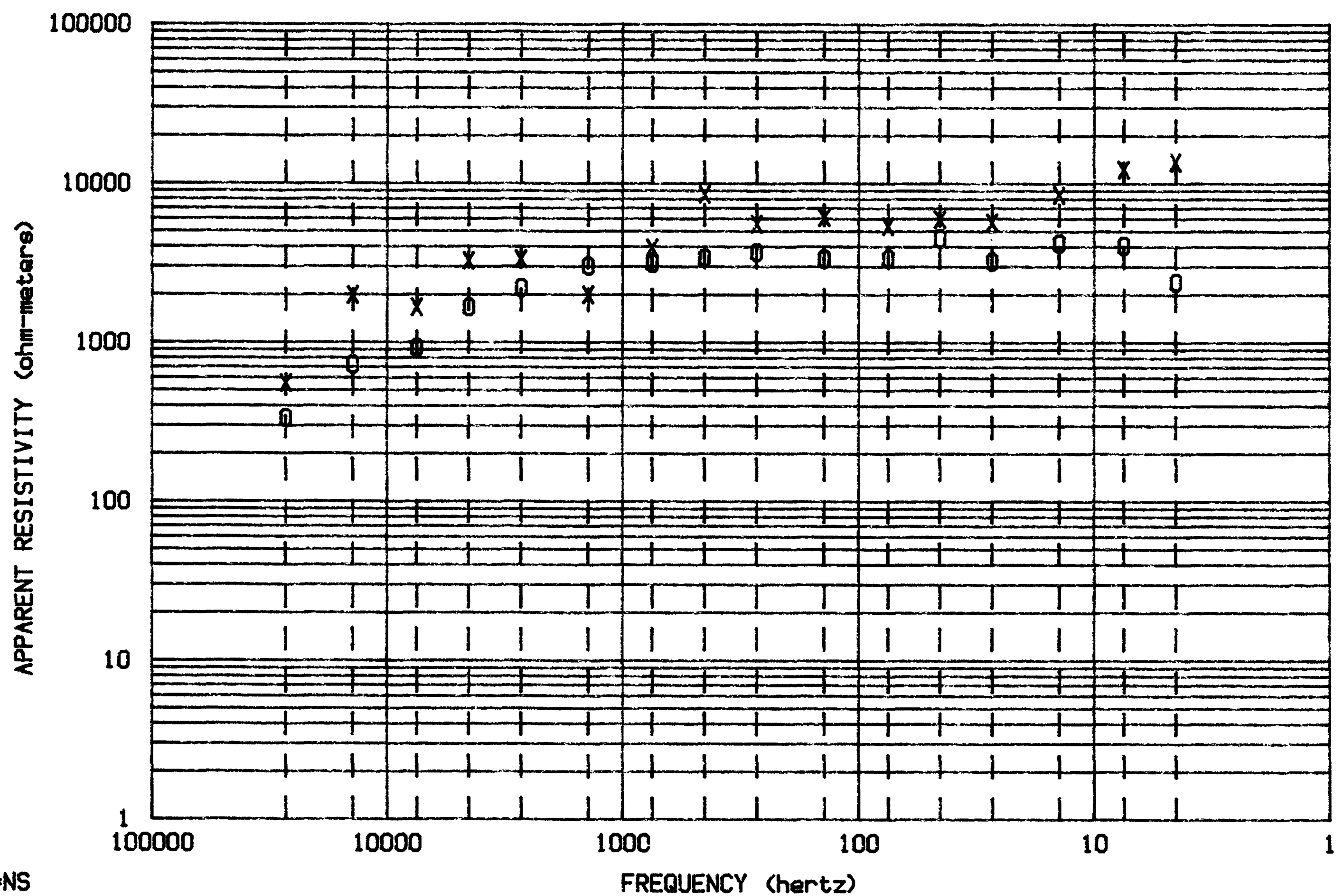
APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
100000
10000
1000
100
10
1
FREQUENCY (hertz)
O=NS
X=EW
STA# WOW10
PROJECT- W. OWENS WILDERNESS


APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
FREQUENCY (hertz)
100000
10000
1000
100
10
1
O=NS
X=EW
STA# WOW11
PROJECT- W. OWENS WILDERNESS



APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
100000
10000
1000
100
10
1
FREQUENCY (hertz)
O=NS
X=EW
STA# WOW12
PROJECT- W. OWENS WILDERNESS


100000
10000
1000
100
10
1
APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
FREQUENCY (hertz)
O=NS
X=EW
STA# WOW13
PROJECT- W. OWENS WILDERNESS



O=NS
X=EW
STA# WOW14

PROJECT- W. OWENS WILDERNESS

PROJECT=W. OWENS WILDERNESS

STATION ID_WOW1 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	9906.50	8	2342.20
7.5	14374.00	14	1813.90
14.0	11236.00	10	1164.50
27.0	4356.60	11	625.61
45.0	5767.90	10	490.67
75.0	2526.40	7	650.07
140.0	1402.60	10	96.27
270.0	3123.40	10	409.18
450.0	2938.20	11	162.01
750.0	3508.80	1	0.00
4500.0	751.49	6	223.92
7500.0	1828.10	10	813.56
14000.0	1989.50	9	31.94
27000.0	349.45	2	102.02

STATION ID_WOW1 EW NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	5229.60	7	977.59
7.5	7692.40	13	450.17
14.0	6200.90	17	465.28
27.0	3925.60	13	455.68
45.0	4906.80	14	287.12
75.0	3360.00	11	304.47
140.0	2989.60	13	279.75
270.0	2800.40	14	215.11
450.0	2030.40	10	124.82
750.0	736.55	3	200.28
2700.0	744.50	6	75.52
7500.0	1176.70	11	99.45
14000.0	1108.00	10	67.68
27000.0	652.15	8	125.15

PROJECT=W. OWENS WILDERNESS

STATION ID_WOW2 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	7918.90	8	646.14
7.5	9423.30	11	697.88
14.0	6656.40	16	244.57
27.0	4648.60	11	270.15
45.0	5021.60	14	335.63
75.0	4120.10	14	205.84
140.0	4891.90	11	366.90
270.0	4548.60	14	414.25
450.0	5397.90	13	351.55
750.0	6238.80	8	1950.00
4500.0	2270.40	8	314.90
7500.0	2033.80	12	155.99
14000.0	1437.60	10	24.47
27000.0	548.92	11	46.70

STATION ID_WOW2 EW NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	3072.70	7	886.80
7.5	1918.60	13	123.38
14.0	1295.10	17	35.91
27.0	972.04	17	24.64
45.0	1030.40	9	31.86
75.0	994.11	10	24.43
140.0	1257.20	12	42.57
270.0	1378.70	13	72.34
450.0	1031.30	11	49.36
750.0	1156.80	10	201.59
4500.0	454.15	7	122.81
7500.0	213.36	14	6.78
14000.0	177.50	8	32.31
27000.0	83.75	11	7.16

PROJECT=W. OWENS WILDERNESS

STATION ID_WOW3 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	2097.90	8	211.03
7.5	1894.00	11	120.57
14.0	2000.60	11	128.03
27.0	1249.60	11	71.29
45.0	1833.10	12	109.83
75.0	1095.00	10	50.06
140.0	1692.70	11	91.98
270.0	1269.20	10	97.56
450.0	1179.00	10	51.38
750.0	790.43	6	122.06
4500.0	719.10	10	84.52
7500.0	539.48	11	25.65
14000.0	649.24	9	25.73
27000.0	471.34	11	26.36

STATION ID_WOW3 EW NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	7427.40	10	616.11
7.5	5709.40	11	257.38
14.0	3557.90	12	80.36
27.0	2342.40	13	78.24
45.0	2323.60	10	97.97
75.0	1880.30	10	75.60
140.0	1812.00	12	44.55
270.0	1449.30	12	35.05
450.0	1001.80	10	57.71
750.0	1103.70	11	74.88
4500.0	661.21	11	86.64
7500.0	680.73	11	16.16
14000.0	310.57	10	21.83
27000.0	169.22	6	15.42

PROJECT=W. OWENS WILDERNESS

STATION ID_WOW4 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	8094.30	7	1501.60
7.5	8310.30	11	729.20
14.0	10513.00	11	618.52
27.0	6321.10	14	259.50
45.0	7162.60	13	422.90
75.0	5619.90	13	374.29
140.0	6595.40	11	485.45
270.0	7288.10	12	538.84
450.0	5895.00	12	349.31
750.0	5974.60	8	996.78
4500.0	4077.80	10	400.53
7500.0	2279.40	10	81.82
14000.0	1305.20	11	56.29
27000.0	676.26	11	31.92

STATION ID_WOW4 EW NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	11417.00	11	975.44
7.5	11774.00	12	826.33
14.0	8155.60	11	317.79
27.0	5231.10	12	173.63
45.0	4978.10	16	194.66
75.0	4593.70	11	137.92
140.0	4928.00	14	151.37
270.0	4108.70	10	174.80
450.0	2565.40	10	144.43
750.0	1637.60	5	418.22
4500.0	956.26	10	160.36
7500.0	1839.60	13	88.42
14000.0	417.10	9	69.77
27000.0	136.20	11	30.52

PROJECT=W. OWENS WILDERNESS

STATION ID_WOW5 NS NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	1520.80	5	414.04
7.5	3349.70	10	439.61
14.0	1632.00	10	154.10
27.0	3010.50	12	435.74
45.0	3444.10	10	348.33
75.0	2624.50	10	283.17
140.0	1997.30	10	130.06
270.0	1412.60	10	129.91
450.0	1222.70	10	106.27
750.0	1732.40	9	121.97
4500.0	1134.10	8	290.36
7500.0	2604.80	10	320.08
14000.0	1021.10	10	31.81
27000.0	363.75	1	0.00
27000.0	347.92	7	74.40

STATION ID_WOW5 EW NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	5607.80	10	543.48
7.5	8384.90	13	624.20
14.0	5627.20	11	270.10
27.0	4624.20	11	210.15
45.0	4539.90	10	248.75
75.0	2919.70	10	128.19
140.0	2258.50	11	101.03
270.0	1863.70	11	88.54
450.0	1933.20	11	170.61
750.0	4046.70	2	242.75
4500.0	1331.00	9	96.04
7500.0	1235.50	8	121.96
14000.0	1783.40	5	745.55
27000.0	369.33	11	28.49

PROJECT=W. OWENS WILDERNESS

STATION ID_WOW6 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	375.10	4	72.42
7.5	1028.30	11	84.48
14.0	802.98	11	56.05
27.0	478.95	9	28.37
45.0	519.91	11	20.38
75.0	446.84	12	33.05
140.0	425.76	12	33.50
270.0	213.42	5	52.54
450.0	467.99	12	54.33
750.0	1193.20	7	216.77
4500.0	864.69	9	198.45
7500.0	735.57	11	109.55
14000.0	731.97	6	32.57
27000.0	706.83	11	75.40

STATION ID_WOW6 EW NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	2585.50	10	324.10
7.5	2512.40	10	96.08
14.0	1918.80	10	168.06
27.0	1318.40	11	75.64
45.0	1181.90	10	59.12
75.0	1169.20	11	36.30
140.0	1229.80	10	58.39
270.0	1160.30	10	68.52
450.0	994.96	10	75.84
750.0	580.81	3	363.81
4500.0	587.53	15	119.51
7500.0	1042.20	10	39.28
14000.0	418.48	10	39.37
27000.0	244.80	10	21.84

PROJECT=W. OWENS WILDERNESS

STATION ID_WOW7 NS NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	1839.90	9	226.04
7.5	2018.30	10	134.19
14.0	2183.90	10	122.60
27.0	1055.30	11	74.77
45.0	2392.80	3	431.26
75.0	858.99	10	73.57
140.0	603.21	9	31.25
270.0	398.15	11	28.54
450.0	457.26	10	28.71
750.0	442.34	16	40.46
1400.0	484.43	11	36.29
2700.0	446.30	9	37.25
4500.0	310.91	11	48.92
7500.0	178.35	12	8.20
14000.0	304.95	9	7.70
27000.0	107.27	9	5.16

STATION ID_WOW7 EW NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	1035.90	8	362.90
7.5	1231.80	13	92.53
14.0	1050.00	12	58.19
27.0	836.99	13	29.88
45.0	1085.20	13	30.69
75.0	986.10	14	36.55
140.0	1284.30	11	111.45
270.0	1265.30	13	52.25
450.0	1243.60	12	76.12
750.0	1195.00	4	120.23
1400.0	534.35	11	30.25
2700.0	1221.50	3	45.46
4500.0	1687.20	11	72.12
7500.0	1334.00	10	58.15
14000.0	2753.00	12	391.46
27000.0	541.00	10	101.63

PROJECT=W. OWENS WILDERNESS

STATION ID_WOW8 NS NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	15321.00	9	2080.60
7.5	20402.00	12	1013.40
14.0	21908.00	9	1392.90
27.0	13866.00	11	834.12
45.0	16482.00	11	733.33
75.0	21143.00	11	2618.00
140.0	15385.00	11	468.38
270.0	16295.00	12	1177.50
450.0	14258.00	13	612.99
750.0	8361.90	10	460.63
1400.0	5393.60	11	566.85
2700.0	6427.50	13	455.38
4500.0	8789.50	10	2663.80
7500.0	7586.00	10	442.26
14000.0	4308.50	10	296.10
27000.0	1908.30	10	266.29

STATION ID_WOW8 EW NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
7.5	27254.00	13	924.22
14.0	17597.00	12	870.05
27.0	14225.00	12	506.54
45.0	14787.00	10	680.91
75.0	12552.00	10	322.48
140.0	14416.00	10	735.95
270.0	15448.00	11	909.39
450.0	14207.00	11	682.84
750.0	12385.00	11	691.79
1400.0	2600.40	10	207.53
2700.0	3859.20	10	439.77
4500.0	4043.40	14	306.67
7500.0	4205.80	10	198.67
14000.0	3752.40	10	458.93
27000.0	490.44	11	52.85

PROJECT=W. OWENS WILDERNESS

STATION ID_WOW9 NS NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	565.75	8	95.49
7.5	827.41	12	101.76
14.0	478.56	11	69.84
27.0	330.70	11	55.16
45.0	364.26	12	31.50
75.0	221.78	11	24.21
140.0	262.93	11	14.31
270.0	220.87	10	20.90
450.0	346.01	12	60.55
750.0	217.03	11	11.50
1400.0	163.49	10	7.76
2700.0	279.81	11	26.85
4500.0	216.87	11	10.95
7500.0	225.96	10	12.95
14000.0	191.44	11	15.67
27000.0	94.99	12	3.97

STATION ID_WOW9 EW NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	1153.00	10	108.31
7.5	301.27	10	39.92
14.0	597.77	17	33.19
27.0	472.59	10	21.53
45.0	497.50	11	28.49
75.0	487.19	13	29.24
140.0	536.75	11	39.31
270.0	443.39	11	28.79
450.0	467.07	12	38.57
750.0	308.80	16	11.08
1400.0	141.27	12	8.33
2700.0	214.30	14	10.50
4500.0	228.77	14	8.17
7500.0	167.76	15	5.09
14000.0	176.59	12	4.17
27000.0	352.38	12	54.41

PROJECT=W. OWENS WILDERNESS

STATION ID_WOW10 NS NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	1614.70	8	284.34
7.5	1562.40	9	249.17
14.0	598.63	12	125.18
27.0	441.60	11	76.35
45.0	594.99	12	97.49
75.0	722.05	10	97.21
140.0	456.47	8	42.90
270.0	487.97	6	167.18
450.0	340.18	10	51.54
750.0	189.12	10	26.98
1400.0	158.12	10	12.59
2700.0	168.42	10	15.80
4500.0	140.11	12	19.47
7500.0	133.73	10	6.83
14000.0	142.54	10	8.43
27000.0	93.05	10	4.07

STATION ID_WOW10 EW NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	1742.50	10	235.82
7.5	1215.00	10	369.98
14.0	943.28	8	142.93
27.0	625.43	11	50.53
45.0	97.73	13	7.40
75.0	245.71	10	19.78
140.0	295.78	12	19.27
270.0	190.16	10	7.01
450.0	144.85	10	7.30
750.0	127.14	10	14.97
1400.0	54.52	10	3.21
2700.0	67.01	11	5.94
4500.0	66.47	9	6.33
7500.0	47.77	10	2.64
14000.0	46.47	13	1.76
27000.0	25.57	8	4.73

PROJECT=W. OWENS WILDERNESS

STATION ID_WOW11 NS NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	809.69	4	176.59
7.5	1775.20	10	176.67
14.0	2409.50	10	267.27
27.0	1566.30	12	93.14
45.0	1790.20	12	88.14
75.0	1314.90	11	172.66
140.0	1467.80	10	114.47
270.0	1349.10	11	124.22
450.0	1215.80	10	108.09
750.0	1128.70	11	61.35
1400.0	861.05	12	127.78
2700.0	1646.10	10	122.02
4500.0	1318.60	10	202.46
7500.0	790.36	11	22.58
14000.0	787.03	13	13.51
27000.0	403.31	10	15.53

STATION ID_WOW11 EW NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	8997.60	14	372.32
7.5	8446.30	11	342.39
14.0	5570.20	15	208.93
27.0	3874.00	14	81.95
45.0	3401.10	11	103.82
75.0	2780.80	11	67.01
140.0	2492.10	13	63.05
270.0	2120.80	10	233.06
450.0	1438.10	10	260.63
750.0	1144.00	10	203.49
1400.0	502.49	10	38.78
2700.0	1568.20	10	136.56
4500.0	1218.90	12	92.80
7500.0	1602.40	8	225.40
14000.0	1368.90	10	134.91
27000.0	1361.40	11	441.56

PROJECT=W. OWENS WILDERNESS

STATION ID_WOW12 NS NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	2505.20	8	689.80
7.5	1064.40	9	79.32
14.0	826.08	11	78.72
27.0	578.24	10	44.14
45.0	601.72	11	63.73
75.0	657.09	11	158.01
140.0	442.06	10	57.62
270.0	358.99	12	26.82
450.0	382.64	11	27.24
750.0	292.34	13	12.53
1400.0	429.67	10	39.62
2700.0	426.44	10	61.84
4500.0	452.19	13	52.44
7500.0	375.58	12	14.43
14000.0	270.63	12	25.91
27000.0	296.81	11	10.67

STATION ID_WOW12 EW NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	7086.20	12	421.49
7.5	9542.60	10	453.55
14.0	4700.20	17	219.83
27.0	2889.90	12	80.82
45.0	2489.50	14	82.84
75.0	1883.00	15	80.11
140.0	1787.50	14	46.03
270.0	1427.50	13	46.28
450.0	1324.50	11	72.47
750.0	872.04	10	54.38
1400.0	243.84	12	25.39
2700.0	745.60	11	48.62
4500.0	605.49	11	21.35
7500.0	537.77	10	17.59
14000.0	794.63	14	22.95
27000.0	1999.30	10	361.27

PROJECT=W. OWENS WILDERNESS

STATION ID_WOW14 NS NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	2389.20	2	276.44
7.5	4054.70	7	685.20
14.0	4199.60	11	474.86
27.0	3216.90	11	213.62
45.0	4483.60	11	696.35
75.0	3372.70	10	402.65
140.0	3347.20	10	236.14
270.0	3665.90	12	368.65
450.0	3392.30	13	179.60
750.0	3127.30	11	328.59
1400.0	3008.20	14	326.24
2700.0	2194.00	10	341.16
4500.0	1662.10	11	96.58
7500.0	920.04	11	40.98
14000.0	722.71	12	43.42
27000.0	332.31	11	17.06

STATION ID_WOW14 EW NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	13661.00	12	962.38
7.5	12241.00	12	534.86
14.0	8474.30	8	401.96
27.0	5674.10	11	323.48
45.0	5926.70	11	126.55
75.0	5361.80	9	83.36
140.0	6089.70	10	90.25
270.0	5516.30	13	249.78
450.0	8503.70	10	712.10
750.0	3911.40	12	355.42
1400.0	1985.70	11	187.55
2700.0	3325.30	13	202.05
4500.0	3240.40	10	463.84
7500.0	1654.10	10	148.28
14000.0	1982.80	11	185.06
27000.0	551.90	10	96.47

PROJECT=W. OWENS WILDERNESS

STATION ID_WOW13 NS NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
7.5	20801.00	11	2950.20
14.0	13548.00	11	1517.00
27.0	8948.90	10	1745.00
45.0	8525.20	10	1245.60
75.0	6113.10	7	1683.70
140.0	3228.60	14	854.48
270.0	2779.60	11	451.72
450.0	1934.10	10	691.23
750.0	1493.40	11	225.89
1400.0	1731.20	12	239.07
2700.0	2054.20	11	181.11
4500.0	814.31	10	117.55
7500.0	593.59	11	109.73
14000.0	1141.90	8	201.66
27000.0	349.82	11	16.41

STATION ID_WOW13 EW NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	16233.00	11	1965.70
7.5	12572.00	12	997.24
14.0	10628.00	10	514.66
27.0	7013.70	10	483.66
45.0	6416.50	12	646.64
75.0	4694.50	11	311.50
140.0	4065.10	15	221.23
270.0	3834.30	12	219.55
450.0	4140.30	11	314.60
750.0	2706.70	10	268.33
1400.0	764.06	11	87.08
2700.0	1307.10	11	165.66
4500.0	894.02	12	23.91
7500.0	353.76	9	19.38
14000.0	238.68	13	12.68
27000.0	213.96	11	5.05

APPENDEX 2

TELLURIC DATA

West Owens Peak, California
Telluric Line 1 (TT-1)
250 m dipoles

Station No.	Ratio/Std. deviation				Relative voltage			
	25Hz	16.7Hz	7.5Hz	4.5Hz	25Hz	16.7Hz	7.5Hz	4.5Hz
					1.00	1.00	1.00	1.00
0	1.10/.07	1.05/.10	1.04/.07	1.08/.06				
					1.10	1.05	1.04	1.08
1	1.14/.02	1.10/.05	1.11/.04	1.10/.29				
					1.26	1.15	1.15	1.18
2	1.03/.04	1.24/.06	.95/.09	1.18/.12				
					1.30	1.18	1.09	1.39
3	1.28/.13	1.26/.13	1.37/.62	1.57/.37				
					1.66	1.49	1.50	2.19
4	1.17/.06	1.30/.04	1.15/.26	1.02/.22				
					1.94	1.93	1.73	2.24
5	1.43/.05	.99/.04	.99/.03	1.08/.24				
					1.97	1.92	1.71	2.4
6	.97/.02	.98/.01	.98/.07	.96/.11				
					1.91	1.88	1.66	2.30

West Owens Peak, California
Telluric Line 2 (TT-2)
250 m dipole

Station No.	Ratio/Std. deviation			Relative voltage		
	25Hz	16.7Hz	7.5Hz	25Hz	16.7Hz	7.5Hz
				1.00	1.00	1.00
0	.89/.03	.91/.04	.87/.03			
				.89	.91	.87
1	1.13/.09	1.11/.05	1.08/.12			
				1.00	1.01	.94
2	.99/.02	.98/.03	.95/.07			
				.99	.98	.89
3	.90/.03	.88/.01	.92/.04			
				.89	.87	.83
4	.78/.04	.75/.05	.68/.06			
				.66	.65	.57
5	.85/.04	.86/.02	.87/.06			
				.560	.56	.49
6	.86/.05	.83/.16	.97/.08			
				.48	.47	.48
7	.65/.06	.64/.02	--?			
				.31	.30	.30
8	.76/.08	.93/.10	1.02/.24			
				.24	.28	.31
9	.87/.04	.86/.04	.99/.13			
				.21	.24	.30
10	.94/.08	1.07/.08	1.02/.02			
				.20	.25	.31
11	1.10/.04	1.11/.05	1.12/.07			
				.22	.28	.35
12	.94/.09	.99/.03	.92/.12			
				.20	.28	.32
13	1.18/.02	1.15/.09	1.20/.05			
				.24	.32	.38