

**ELECTRICAL RESISTIVITY STUDIES RELATED TO THE PROPOSED LOW-LEVEL
RADIOACTIVE WASTE REPOSITORY, HUDSPETH COUNTY, TEXAS**

by

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Final Contract Report

Prepared for

Texas Low-Level Radioactive Waste Disposal Authority

by

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As part of the site characterization effort for the proposed low-level nuclear waste disposal site north of Fort Hancock, Texas, the University of Texas at El Paso conducted an electrical resistivity survey of the area. This survey was contracted by the Texas Low-Level Radioactive Waste Authority. The intent is to repeat this survey annually if the site is licensed in order to monitor leachate migration.

A series of soundings were made and profile readings were made around the entire perimeter of the proposed site. The locations of these measurements are shown in Figure 1. The procedures outlined in Draft Regulatory Guide 6.7 of the Texas Department of Health were followed. A Price array configuration was used to make the measurements and the Barnes layer method (Barnes, 1953) was used to calculate apparent subsurface resistivities. The voltage readings were generally the average of 4 measurements but in a few cases 16 measurements were averaged. Repeatability was excellent (1 or 2%) for a specific placement of the electrodes. However, movement of any electrode by 1 m created variations in readings of up to 100% and variations of 50% were common. These results are to be expected considering the near surface variability in terms of soil composition and water saturation, but they must be kept in mind if the survey is repeated in the future.

For the soundings, the outer current electrodes (I_1 and I_2) were spaced 210 m apart. The first voltage electrode (V_1) was placed in the center of the array, and the second (V_2) was first placed 35 m from V_1 and moved in increments (5 m, 2 m, or 1 m; see attached data sheets) toward I_2 . After some experimentation in the field, it was clear that one-sided soundings would be adequate.

The field data sheets are attached in the Appendix of this report, and the apparent resistivities obtained are plotted versus depth in Figures 2-6. In each case, the resistivity generally decreases with depth. Higher resistivities were encountered at electrode spacings in

the range of 30-40 m. These probably reflect the presence of gravels. The lacustrine sediments of the Fort Hancock Formation should have low resistivities, and we interpret values of 5-7 ohm-meters encountered at spacings of 60-65 m to reflect penetration of this formation. Drill holes in area place the top of this formation at 30 m or less.

The profile measurements were intended to evaluate lithologic variability in the site area and were made with the two current electrodes (I_1 and I_2) spaced 98 m apart. The first voltage electrode (V_1) was placed at the middle of the array and the second (V_2) was placed first at a distance of 16 m from V_1 and then at a distance of 32 m. Thus, two depth intervals were sampled. The resistivity values obtained are plotted on three profiles which appear in Figures 7-9. The correlation with the soundings is good, and the field data sheets are included in the appendix. The first profile (Fig. 7) extends along the west side of the site. The major feature evident on this profile is the northward dip as stratigraphic units deepen as they approach the center of the small basin in the area. The second profile (Fig. 8) extends across the north side and short east side of the almost triangular site. Caliche outcrops along the western end of this profile, and it strongly effects stations 17-20. The consistently high values at stations 24-26 probably indicates the presence of a gravel-filled channel. On the southern profile (Fig. 9), high resistivity values also indicate channels at stations 38-42 and 51-55. The dip to the northeast is consistent with profile 1 and the seismic results. With the possible exception of the caliche outcrop area, the resistivity values produced consistent patterns which should make it possible to detect leachate migration with confidence in the future. A major variable would be recent rainfall and care should be taken that future surveys be undertaken under the same dry conditions encountered during this survey. This normally would be easy considering the climate if the late summer months are avoided.

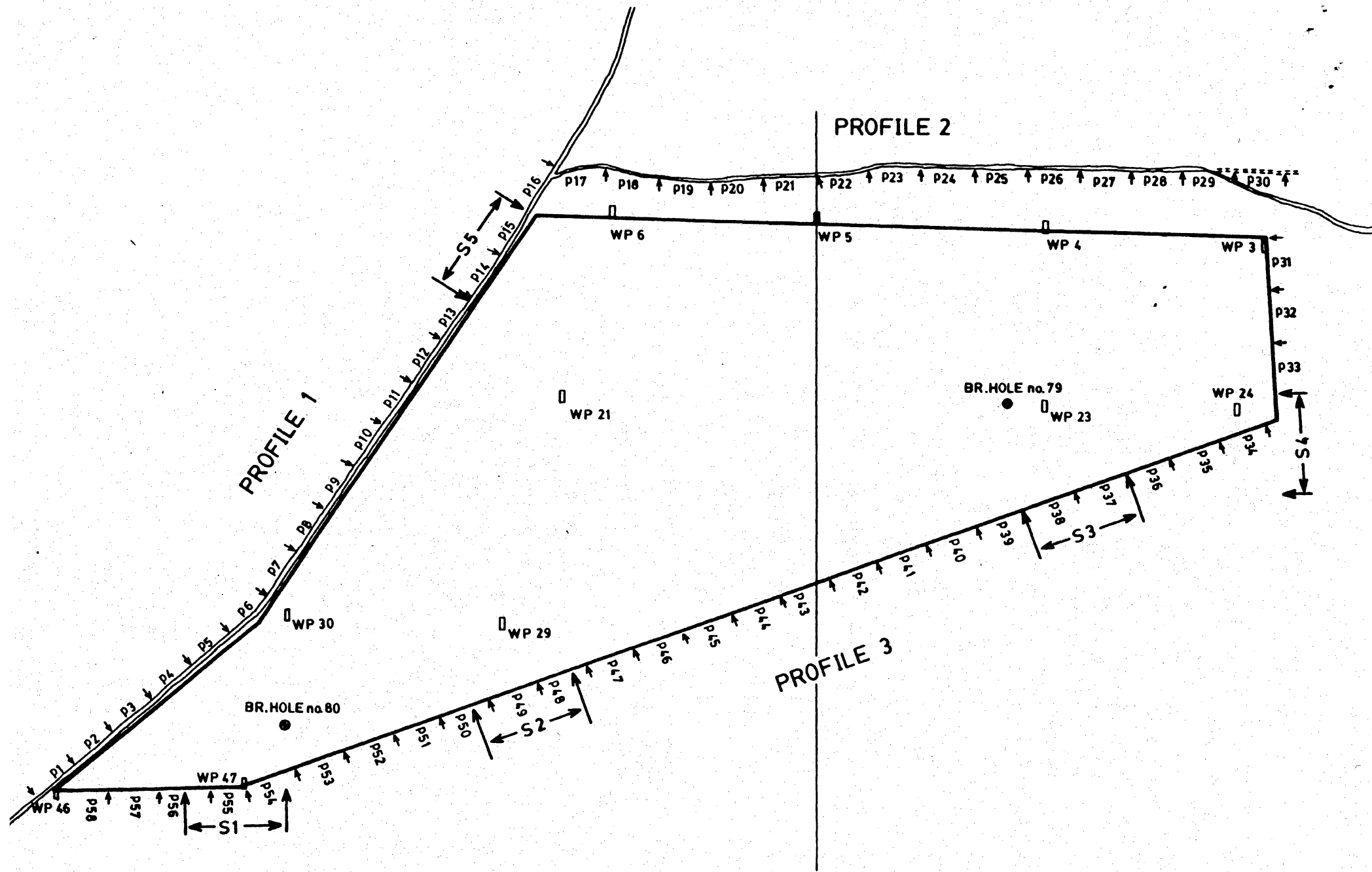


Figure 1: Index map of the proposed site showing locations for the soundings and profiles.

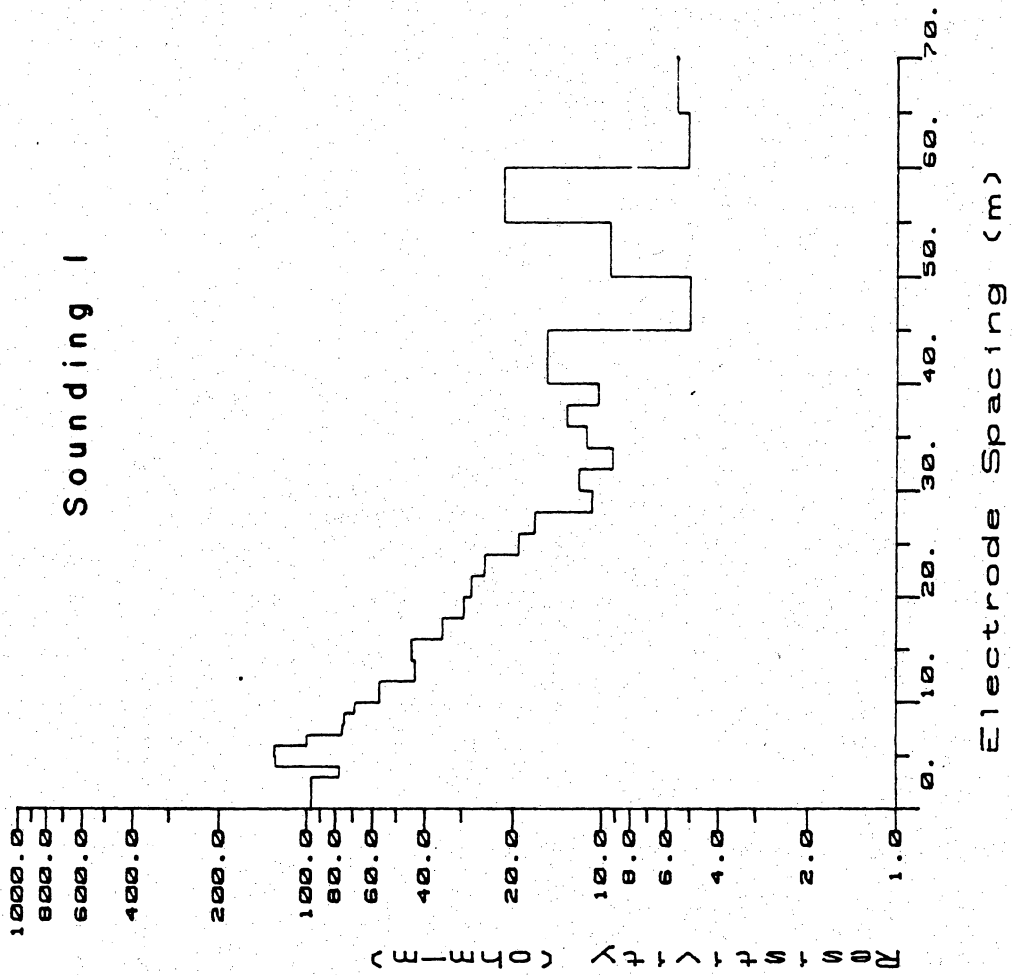


Figure 2: Resistivity profile for sounding 1

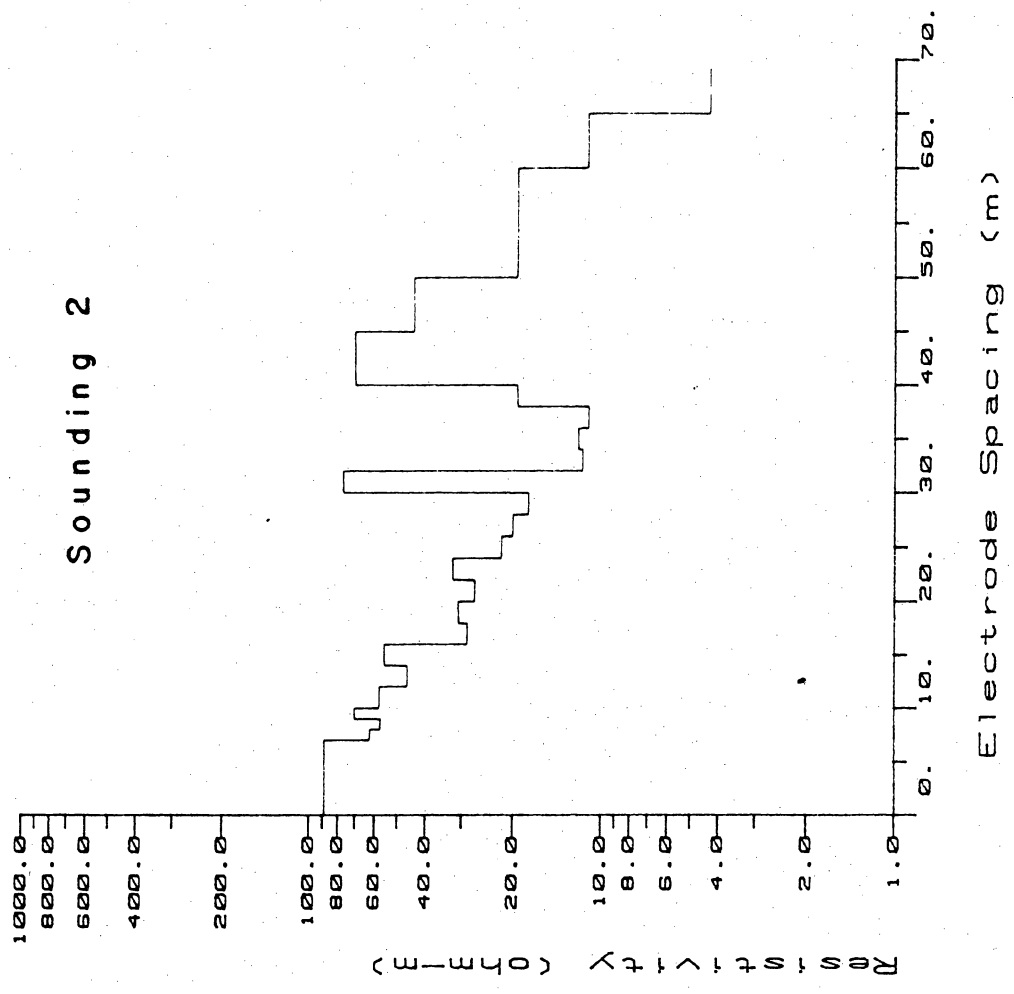


Figure 3: Resistivity profile for sounding 2

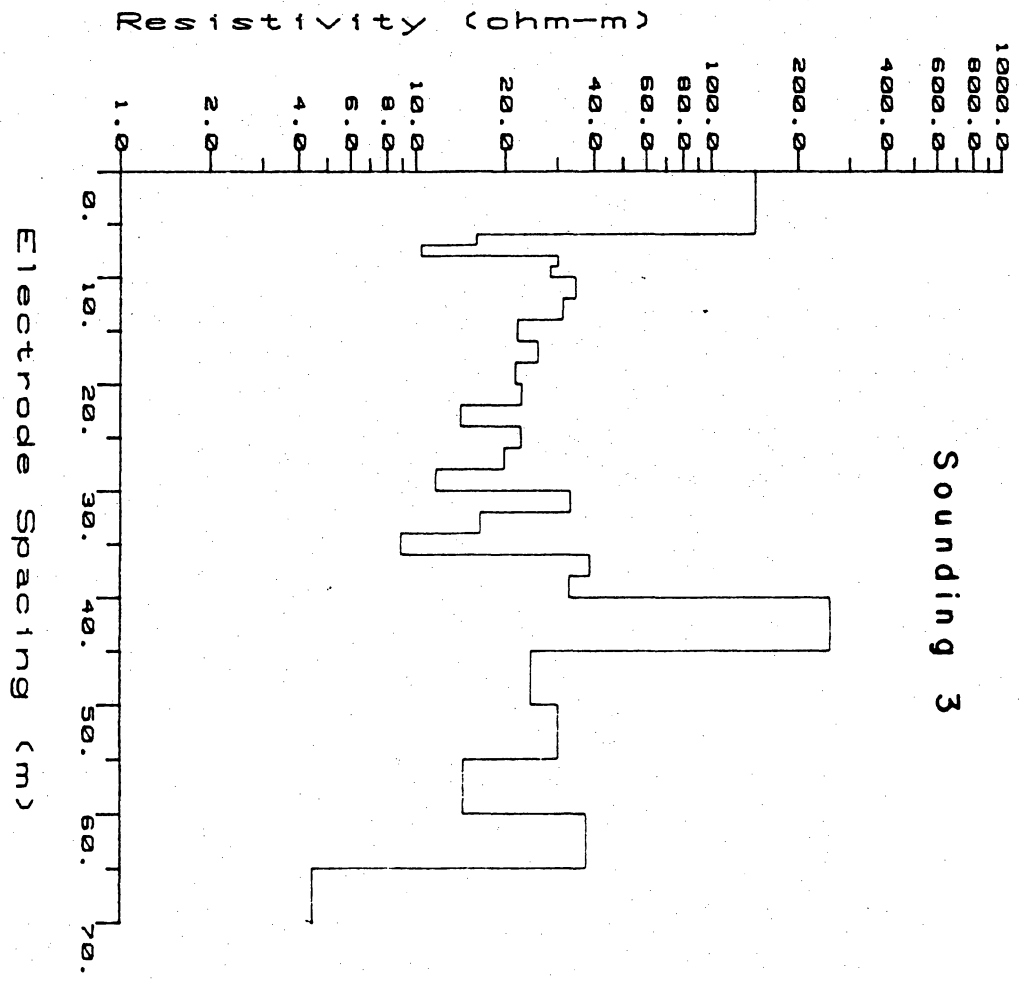


Figure 4: Resistivity profile for sounding 3

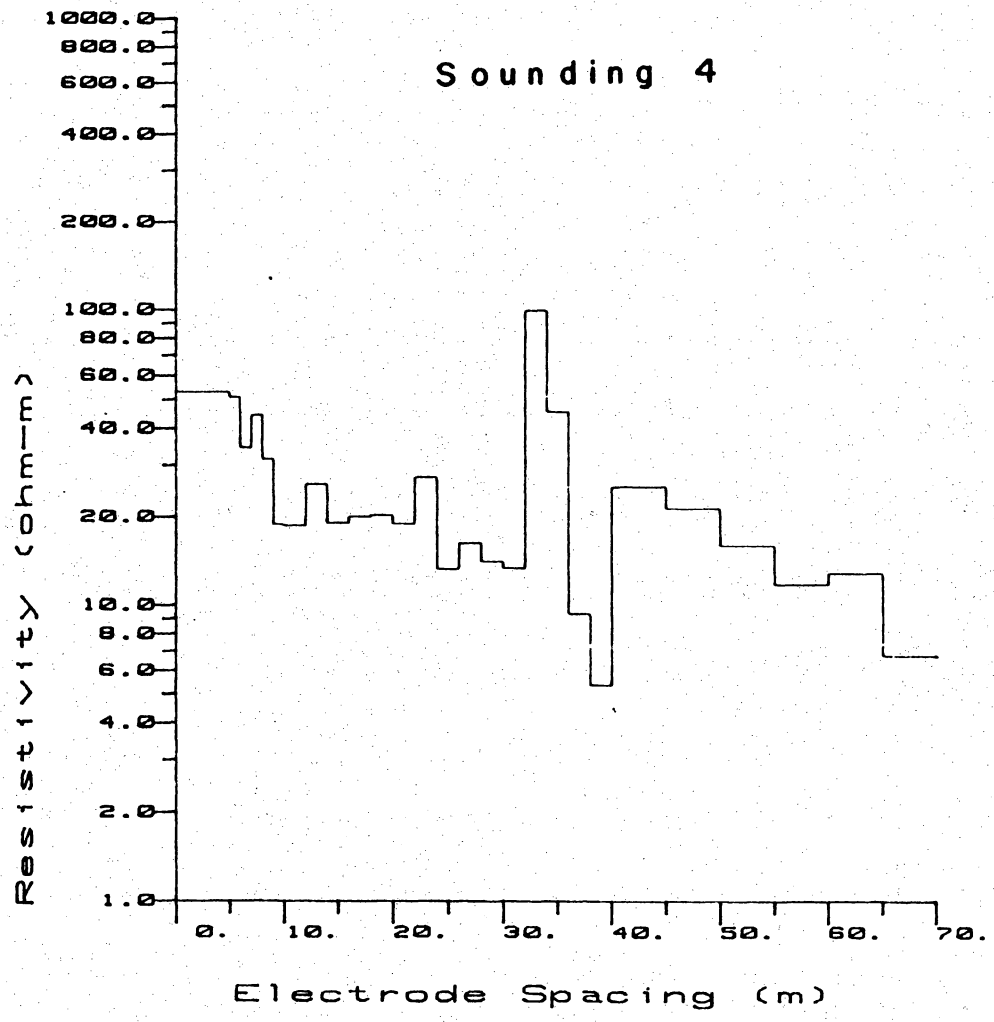


Figure 5: Resistivity profile for sounding 4

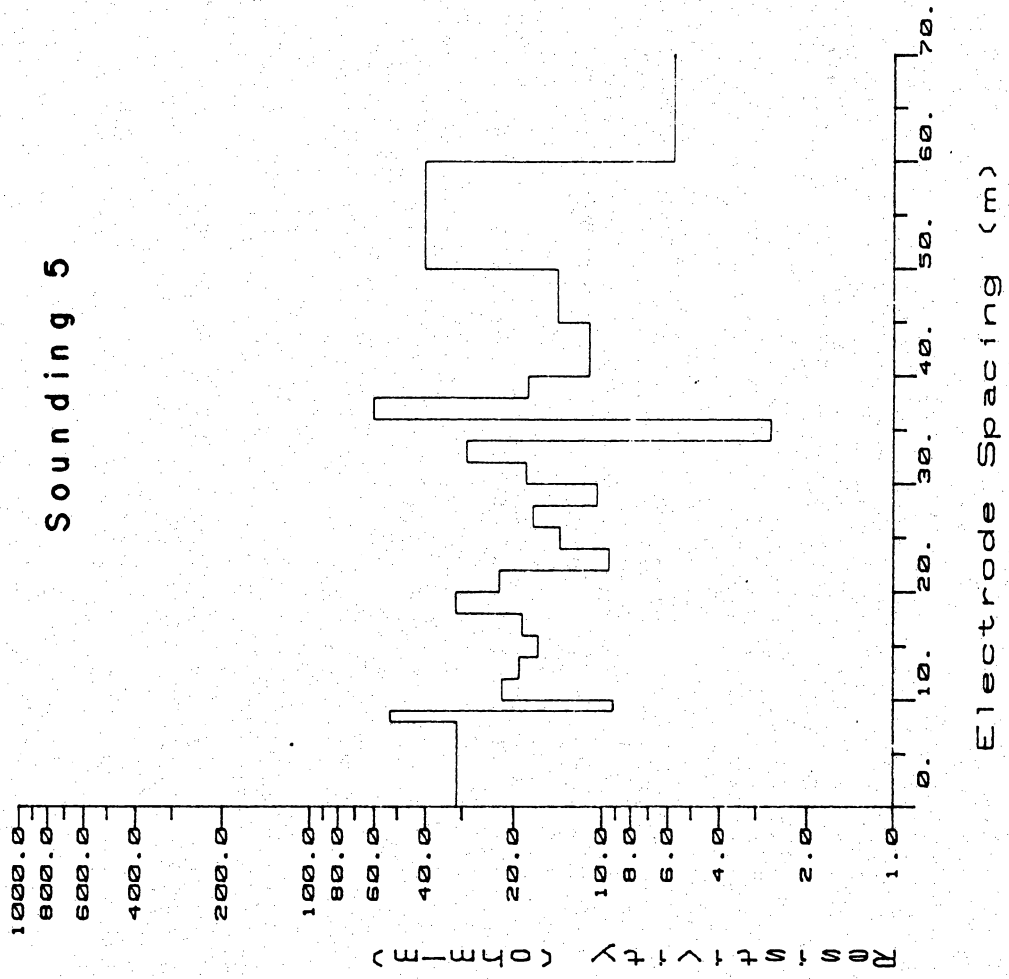


Figure 6: Resistivity profile for sounding 5

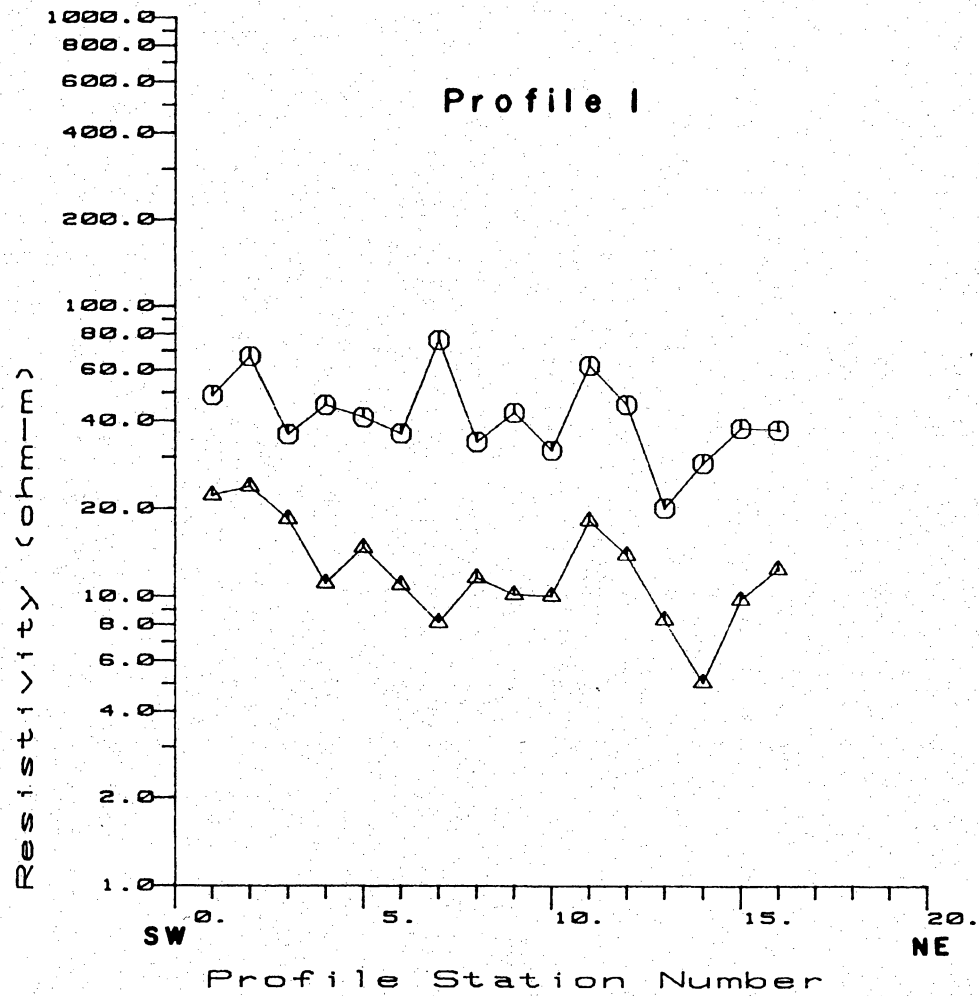


Figure 7: Resistivity values along profile 1

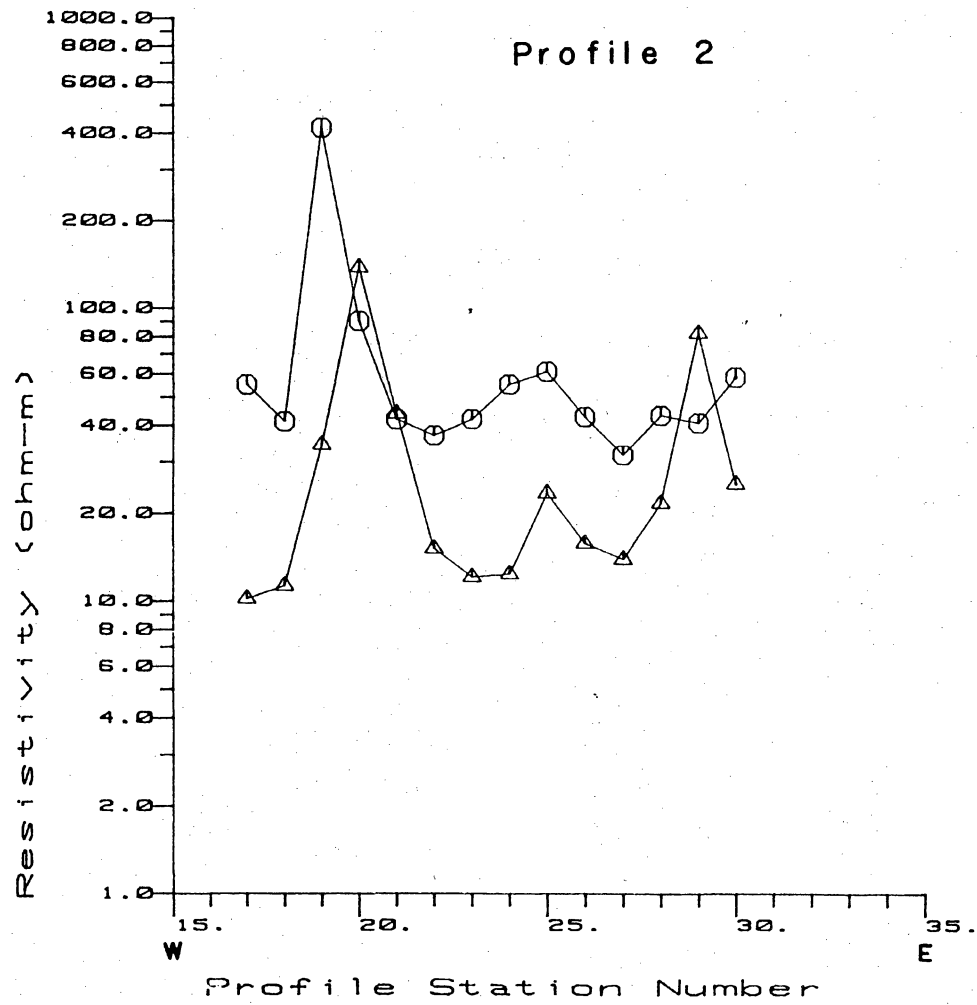


Figure 8: Resistivity values along profile 2

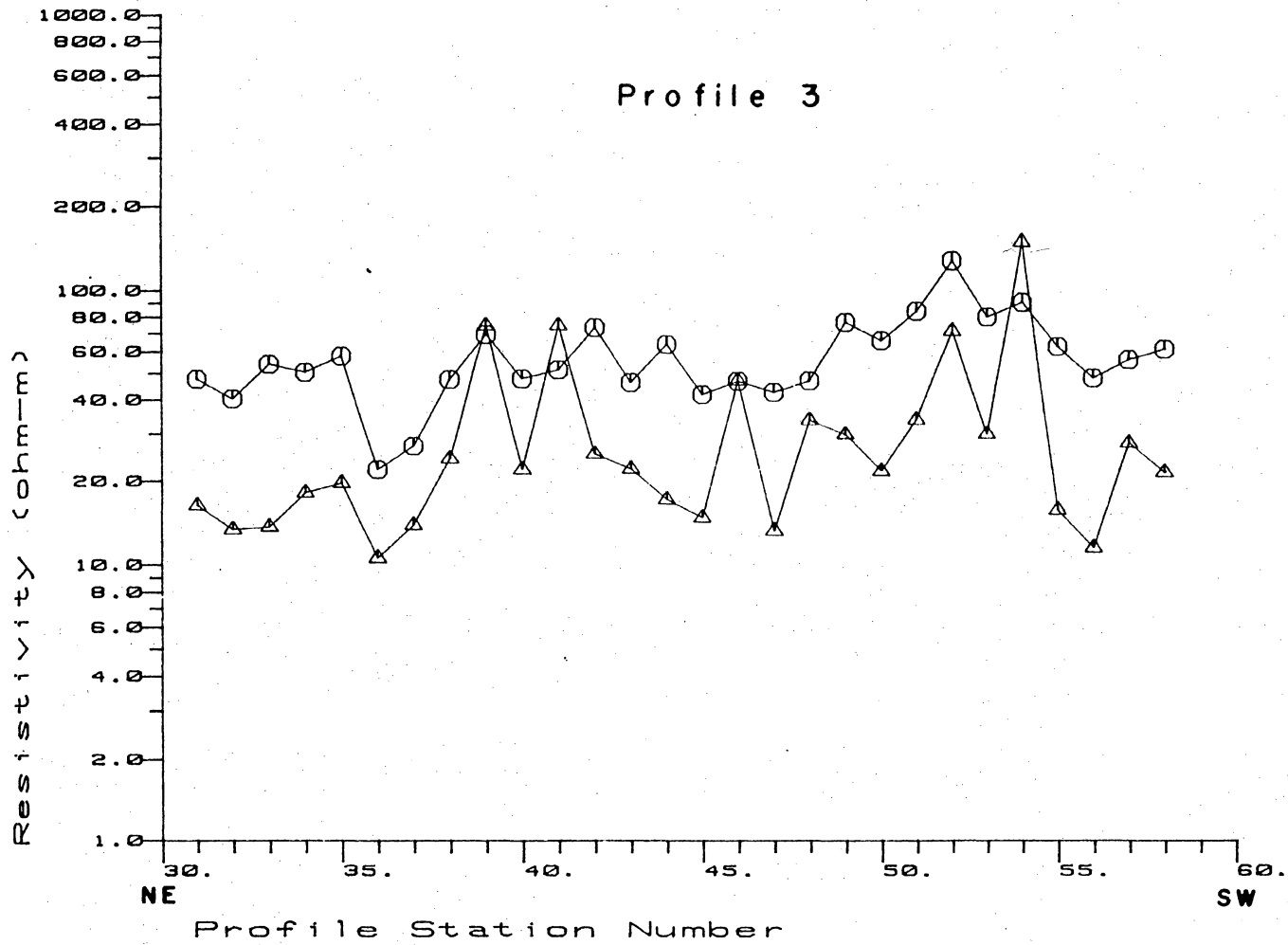


Figure 9: Resistivity values along profile 3

PROJECT Fort Hancock
 PROFILE NO. L ARRAY Pride
 DATE 6/8/90

RESISTIVITY DATA SHEET PROFILE

UNIT ABEM
 CALIBRATION OK
 OPERATOR ACCOUNTAR, Baker

| Station No. | A | | B | | M Meter Reading 1. 2x VI 2. VI 3. V | I Current | S Scale | M x S | Q Warp Factor For Price Array | D Dial Value in Ohms Wenner Array 1. MS 2. 2x MS 3. 2x MS4 Price Array 1. 2 MS O 2. 4x MS O 3. 4x MS OM | R Resistivity in Ohm-Cm Barnes Layer Method Layer 1 AD 30.5 Layer 2 $A_2 - A_1 \frac{(D_1 + D_2)}{(D_1 - D_2)} 30.5$ | Sketch Soil Condition/Elevation |
|-------------|---|---|---|---|---|--------------|------------|----------|-------------------------------------|---|--|---|
| | Electrode Spacing (Depth) in Feet meters | Electrode Placement From Center in Feet meters | V | I | | | | | | | | |
| P1 | 32 | 16 | | | 0.0759 | 20 | | 0.0759 | 1.0 | 0.954 | 22.2 | from WP46 10 meters west Stake 3633 |
| | 16 | 32 | | | 0.301 | 20 | | 0.301 | 0.81 | 3.064 | 49.0 | |
| P2 | 32 | 16 | | | 0.0873 | 20 | | 0.0873 | 1.0 | 1.097 | 23.3 | |
| | 16 | 32 | | | 0.411 | 20 | | 0.411 | 0.81 | 4.18 | 66.9 | |
| P3 | 32 | 16 | | | 0.0606 | 10 | | 0.0606 | 1.0 | 0.761 | 13.4 | |
| | 16 | 32 | | | 0.221 | 10 | | 0.221 | 0.81 | 2.249 | 35.9 | |
| P4 | 32 | 16 | | | 0.0445 | 20 | | ? 0.0445 | 1.0 | 0.559 | 11.1 | |
| | 16 | 32 | | | 0.279 | 20 | | 0.279 | 0.81 | 2.54 | 45.4 | |
| P5 | 32 | 16 | | | 0.0539 | 20 | | 0.0539 | 1.0 | 0.677 | 14.7 | |
| | 16 | 32 | | | 0.253 | 20 | | 0.253 | 0.81 | 2.575 | 41.2 | |
| P6 | 32 | 16 | | | 0.0419 | 20 | | 0.0419 | 1.0 | 0.526 | 10.97 | It is due west of 100 meter flow WP30 |
| | 16 | 32 | | | 0.222 | 20 | | 0.222 | 0.81 | 2.26 | 36.2 | |
| P7 | 32 | 16 | | | 0.0366 | 10 | | 0.0366 | 1.0 | 0.460 | 8.14 | |
| | 16 | 32 | | | 0.469 | 10 | | 0.469 | 0.81 | 4.77 | 76.3 | |
| P8 | 32 | 16 | | | 0.0431 | 10 | | 0.0431 | 1.0 | 0.542 | 11.6 | |
| | 16 | 32 | | | 0.208 | 10 | | 0.208 | 0.81 | 2.117 | 33.9 | |

PROJECT Fort Hancock
 PROFILE NO. 1 ARRAY Profile
 DATE 6-8-1990

RESISTIVITY DATA SHEET PROFILE

UNIT ABCM
 CALIBRATION OK
 OPERATOR ACWINNER

| Station No. | A Electrode Spacing (Depth) in <u>East</u> meters | | B Electrode Placement From Center in <u>East</u> meters | | M Meter Reading $\frac{1.2 \pi V I}{2. V I}$ 3. V | I Current | S Scale | M x S | Q Warp Factor For Price Array | D Dial Value In Ohms Wenner Array 1. MS 2. 2x MS 3. 2x MS4 Price Array 1. 2 MS O 2. 4x MS O 3. 4x MS O4 | R Resistivity In Ohm-Cm Barnes Layer Method Layer 1 AD 30.5 Layer 2 $A_2 - A_1 \frac{(D_1 + D_2)}{(D_1 - D_2)} 30.6$ | Sketch Soil Condition/Elevation |
|-------------|--|----|--|--|--|--------------|------------|--------|----------------------------------|--|--|--|
| | V | I | | | | | | | | | | |
| P9 | 32 | 16 | | | 0.0410 | 20 | 1 | 0.0410 | 1.0 | 0.512 | 10.14 | |
| | 16 | 32 | | | 0.262 | 20 | 1 | 0.262 | 0.81 | 2.667 | 42.7 | |
| P10 | 32 | 16 | | | 0.380 | 20 | 1 | 0.0380 | 1.0 | 0.477 | 10.65 | I ₁ is due East (50 meters) from WP 20 |
| | 16 | 32 | | | 0.1944 | 20 | 1 | 0.1944 | 0.81 | 1.978 | 31.65 | |
| P11 | 32 | 16 | | | 0.0700 | 10 | 1 | 0.0700 | 1.0 | 0.879 | 13.19 | |
| | 16 | 32 | | | 0.382 | 10 | 1 | 0.382 | 0.81 | 3.89 | 62.2 | |
| P12 | 32 | 16 | | | 0.0529 | 5 | 1 | 0.0529 | 1.0 | 0.665 | 13.87 | |
| | 16 | 32 | | | 0.280 | 5 | 1 | 0.280 | 0.81 | 2.85 | 45.6 | |
| P13 | 32 | 16 | | | 0.0362 | 10 | 1 | 0.0362 | 1.0 | 0.368 | 8.32 | Center due west of the trench |
| | 16 | 32 | | | 0.1234 | 10 | 1 | 0.1234 | 0.81 | 1.256 | 20.1 | |
| P14 | 32 | 16 | | | 0.0214 | 20 | 1 | 0.0214 | 1.0 | 0.269 | 5.06 | |
| | 16 | 32 | | | 0.1763 | 20 | 1 | 0.1763 | 0.81 | 1.794 | 28.7 | |
| P15 | 32 | 16 | | | 0.0386 | 10 | 1 | 0.0386 | 1.0 | 0.485 | 9.77 | |
| | 16 | 32 | | | 0.232 | 10 | 1 | 0.232 | 0.81 | 2.361 | 37.8 | |
| P16 | 32 | 16 | | | 0.0464 | 10 | 1 | 0.0464 | 1.0 | 0.583 | 12.44 | Center is due west from the East-west Road for the next line |
| | 16 | 32 | | | 0.229 | 10 | 1 | 0.229 | 0.81 | 2.331 | 37.3 | |

PROJECT Fort Hancock RESISTIVITY DATA SHEET
 PROFILE NO. 2 ARRAY Profile
 DATE 5-8-1996

UNIT ARCM
 CALIBRATION OK
 OPERATOR ARONNAP / BAKER

| Station No. | A Electrode Spacing (Depth) in Feet M | B Electrode Placement From Center in Feet M | | M Meter Reading 1. 2x V/I 2. V/I 3. V | I Current | S Soil | M x S | Q Warp Factor For Price Array | D Dial Value in Ohms Wenner Array 1. MS 2. 2x MS 3. 2x MS4 Price Array 1. 3 MS O 2. 4x MS O 3. 4x MS O4 | R Resistivity in Ohm-Cm Barnes Layer Method Layer 1 AD 30.5 Layer 2 $A_2 - A_1 \frac{(D_1 + D_2) 30.5}{(D_1 - D_2)}$ | Sketch Soil Condition/Elevation |
|-------------|---|--|---|---|--------------|-----------|--------|----------------------------------|--|--|--|
| | | V | I | | | | | | | | |
| P17 | 32 | 16 | | 0.0429 | 20 | 1 | 0.0429 | 1.0 | 0.539 | 10.2 | The start of the East-West line. |
| | 16 | 32 | | 0.339 | 20 | 1 | 0.339 | .21 | 3.45 | 55.2 | |
| P18 | 32 | 16 | | 0.0441 | 10 | 1 | 0.0441 | 1.0 | 0.554 | 11.3 | Center due East 16.25 meters from gate |
| | 16 | 32 | | 0.254 | 5 | 1 | 0.254 | .21 | 2.585 | 41.3 | |
| | | 16 | | | | | | | | | |
| | | | | | | | | | | | |
| 6/16/90 | | | | | | | | | | | |
| P18 | 32 | 16 | | 0.0380 | 10 | 1 | 0.0380 | 1.0 | 0.478 | 10.7 | Duplicate at start |
| | 16 | 32 | | 0.164 | 10 | 1 | 0.164 | 0.81 | 1.669 | 26.7 | |
| P19 | 32 | 16 | | 0.158 | 2 | 1 | 0.158 | 1.0 | 1.98 | 34.4 | |
| | 16 | 32 | | 2.57 | 2 | 1 | 2.580 | 0.81 | 26.26 | 420. | |
| P20 | 32 | 16 | | 0.273 | 2 | 1 | 0.273 | 1.0 | 3.43 | 138.6 | |
| | 16 | 32 | | 0.558 | 2 | 1 | 0.558 | 0.81 | 5.68 | 90.8 | |
| P21 | 32 | 16 | | 0.107 | 2 | 1 | 0.107 | 1.0 | 1.34 | 44.1 | |
| | 16 | 32 | | 0.258 | 2 | 1 | 0.258 | 0.81 | 2.63 | 42.1 | |
| P22 | 32 | 16 | | 0.0536 | 16 | 1 | 0.0536 | 1.0 | 0.674 | 15.18 | |
| | 16 | 32 | | 0.228 | 10 | 1 | 0.228 | 0.81 | 2.32 | 37.1 | |

PROJECT Ft Hancock
 PROFILE NO. 2 ARRAY Profile
 DATE 6/16/90

RESISTIVITY DATA SHEET PROFILE

UNIT ABEM
 CALIBRATION OK
 OPERATOR BAKER

| Station No. | A Electrode Spacing (Depth) in Feet <i>m</i> | B Electrode Placement From Center in Feet <i>m</i> | | M Meter Reading $1.2 \pi V/I$ $2 \cdot VA$ 3. V | I C u r r e n t | S c a l e | M x S | Q Warp Factor For Price Array | D Dial Value in Ohms Wenner Array 1. MS 2. 2x MS 3. 3x MS Price Array 1. 2 MS Q 2. 4x MS Q 3. 4x MS QA | R Resistivity in Ohm-Cm Bernes Layer Method Layer 1 AD 30.5 Layer 2 $A_2 - A_1 \frac{(D_1 + D_2)}{(D_1 - D_2)} 30.5$ | Sketch |
|-------------|--|---|---|---|--------------------------------------|-----------------------|--------|----------------------------------|---|--|--------------------------|
| | | V | I | | | | | | | | Soil Condition/Elevation |
| P23 | 32 | 16 | | 0.0469 | 10 | 1 | 0.0469 | 1.0 | 0.589 | 12.14 | |
| | 16 | 32 | | 0.259 | 10 | 1 | 0.259 | 0.81 | 2.64 | 42.2 | to south side of Rd |
| P24 | 32 | 16 | | 0.0505 | 10 | 1 | 0.0505 | 1.0 | 0.635 | 12.42 | |
| | 16 | 32 | | 0.341 | 10 | 1 | 0.341 | 0.81 | 3.47 | 55.5 | |
| P25 | 32 | 16 | | 0.0844 | 10 | 1 | 0.0844 | 1.0 | 1.061 | 23.5 | |
| | 16 | 32 | | 0.376 | 10 | 1 | 0.376 | 0.81 | 3.83 | 61.3 | |
| P26 | 32 | 16 | | 0.0574 | 10 | 1 | 0.0574 | 1.0 | 0.721 | 15.8 | Center V2 line WP4 |
| | 16 | 32 | | 0.264 | 10 | 1 | 0.264 | 0.81 | 2.687 | 43.0 | |
| P27 | 32 | 16 | | 0.0482 | 10 | 1 | 0.0482 | 1.0 | 0.606 | 13.95 | |
| | 16 | 32 | | 0.1950 | 10 | 1 | 0.195 | 0.81 | 1.985 | 31.8 | |
| P28 | 32 | 16 | | 0.0721 | 10 | 1 | 0.0721 | 1.0 | 0.906 | 21.75 | |
| | 16 | 32 | | 0.267 | 10 | 1 | 0.267 | 0.81 | 2.718 | 43.5 | |
| P29 | 32 | 16 | | 0.1365 | 10 | 1 | 0.1365 | 1.0 | 1.715 | 22.8 | |
| | 16 | 32 | | 0.252 | 10 | 1 | 0.252 | 0.81 | 2.56 | 41.0 | |
| P30 | 32 | 16 | | 0.0881 | 5 | 1 | 0.0881 | 1.0 | 1.107 | 25.3 | |
| | 16 | 32 | | 0.361 | 5 | 1 | 0.361 | 0.81 | 3.67 | 58.7 | |

PROJECT F + Harack
 PROFILE NO. 3 ARRAY Pical
 DATE 6/16/90

RESISTIVITY DATA SHEET PROFILE

UNIT APCM
 CALIBRATION OK
 OPERATOR Baker

| Station No. | A | | B | | M Meter Reading 1.2 V/V 2. V/V 3-V | I C u r r e n t | S o i l | M x S | Q Warp Factor For Pric Array | D Dial Value in Ohms Wenner Array 1. MS 2. 2x MS 3. 2x MSA Pric Array 1. 2 MS Q 2. 4x MS Q 3. 4x MS Q4 | R Resistivity in Ohm-Cm Barnes Layer Method Layer 1 AD 30.5 Layer 2 A ₂ -A ₁ (D ₁ x D ₂) 30.5 (D ₁ - D ₂) | Sketch |
|-------------|---|----|--|--|--|--------------------------------------|------------------|--------|---------------------------------------|--|--|--------|
| | Electrode Spacing (Depth) in Feet meters | | Electrode Placement From Center in Feet meters | | | | | | | | | |
| P46 | 32 | 16 | 16 | | 0.1169 | 10 | 1 | 0.1169 | 1.0 | 1.469 | 47.1 | |
| | 16 | 32 | | | 0.288 | 10 | 1 | 0.288 | 0.81 | 2.93 | 46.9 | |
| P45 | 32 | 16 | 16 | | 0.0544 | 10 | 1 | 0.0544 | 1.0 | 0.684 | 14.8 | |
| | 16 | 32 | | | 0.258 | 10 | 1 | 0.253 | 0.81 | 2.626 | 42.0 | |
| P44 | 32 | 16 | 16 | | 0.0674 | 10 | 1 | 0.0674 | 1.0 | 0.847 | 17.2 | |
| | 16 | 32 | | | 0.393 | 10 | 1 | 0.393 | 0.81 | 4.00 | 64.0 | |
| P43 | 32 | 16 | 16 | | 0.0747 | 10 | 1 | 0.0747 | 1.0 | 0.939 | 22.2 | |
| | 16 | 32 | | | 0.285 | 10 | 1 | 0.285 | 0.81 | 2.901 | 46.4 | |
| P42 | 32 | 16 | 16 | | 0.0935 | 10 | 1 | 0.0935 | 1.0 | 1.175 | 25.2 | |
| | 16 | 32 | | | 0.453 | 16 | 1 | 0.453 | 0.81 | 4.61 | 73.7 | |
| P41 | 32 | 16 | 16 | | 0.152 | 10 | 1 | 0.152 | 1.0 | 1.910 | 74.9 | |
| | 16 | 32 | | | 0.317 | 10 | 1 | 0.317 | 0.81 | 3.227 | 51.6 | |
| P40 | 32 | 16 | 16 | | 0.0753 | 10 | 1 | 0.0753 | 1.0 | 0.946 | 22.1 | |
| | 16 | 32 | | | 0.294 | 10 | 1 | 0.294 | 0.81 | 2.992 | 47.9 | |
| P39 | 32 | 16 | 16 | | 0.179 | 10 | 1 | 0.179 | 1.0 | 2.299 | 74.8 | |
| | | | | | 0.426 | 10 | 1 | 0.426 | 0.81 | 4.34 | 69.4 | |

PROJECT FT HANCOCK
 PROFILE NO. 3 ARRAY PRICE
 DATE 6/16/90

RESISTIVITY DATA SHEET PROFILE

UNIT ABEM
 CALIBRATION OK
 OPERATOR BAKER

| Station No. | A | | B | | M Meter Reading 1.2 π V/I 2. V/I 3. V | I Current | S Scale | M x S | Q Warp Factor For Price Array | D Dial Value in Ohms Wenner Array 1. MS 2. 2x MS 3. 2x MS/4 Price Array 1. 2 MS Q 2. 4x MS Q 3. 4x MS Q/4 | R Resistivity in Ohm-Cm M Barnes Layer Method Layer 1 AD 30.5 Layer 2 $A_2 - A_1 \frac{(D_1 + D_2) 30.5}{(D_1 - D_2)}$ | Sketch Soil Condition/Elevation |
|-------------|---|--|---|---|---|--------------|------------|--------|----------------------------------|--|--|------------------------------------|
| | Electrode Spacing (Depth) in Feet Meters | Electrode Placement From Center in Feet Meters | V | I | | | | | | | | |
| P54 | 32 | 16 | | | 0.280 | 5 | 1 | 0.280 | 1.0 | 3.52 | 149. | WP47 |
| | 16 | 32 | | | 0.556 | 5 | 1 | 0.556 | 0.81 | 5.66 | 90.6 | I I ₂ I ₁ |
| P53 | 32 | 16 | | | 0.1083 | 10 | 1 | 0.1083 | 1.0 | 1.36 | 29.9 | I ₂ I ₁ |
| | 16 | 32 | | | 0.493 | 10 | 1 | 0.493 | 0.81 | 5.018 | 80.28 | |
| P52 | 32 | 16 | | | 0.228 | 5 | 1 | 0.228 | 1.0 | 2.86 | 71.3 | |
| | 16 | 32 | | | 0.784 | 5 | 1 | 0.784 | 0.81 | 7.98 | 127.7 | |
| P51 | 32 | 16 | | | 0.1207 | 5 | 1 | 0.1207 | 1.0 | 1.509 | 33.8 | |
| | 16 | 32 | | | 0.517 | 5 | 1 | 0.517 | 0.81 | 5.26 | 84.2 | |
| P50 | 32 | 16 | | | 0.0813 | 10 | 1 | 0.0813 | 1.0 | 1.022 | 21.75 | I ₂ at intersection |
| | 16 | 32 | | | 0.404 | 10 | 1 | 0.404 | 0.81 | 4.112 | 65.8 | of some lines |
| P49 | 32 | 16 | | | 0.1068 | 10 | 1 | 0.1068 | 1.0 | 1.342 | 29.8 | |
| | 16 | 32 | | | 0.472 | 10 | 1 | 0.472 | 0.81 | 4.804 | 76.8 | |
| P48 | 32 | 16 | | | 0.0977 | 10 | 1 | 0.0977 | 1.0 | 1.23 | 33.7 | |
| | 16 | 32 | | | 0.289 | 10 | 1 | 0.289 | 0.81 | 2.94 | 47.0 | |
| P47 | 32 | 16 | | | 0.0503 | 10 | 1 | 0.0503 | 1.0 | 0.632 | 13.25 | |
| | 16 | 32 | | | 0.262 | 10 | 1 | 0.262 | 0.81 | 2.67 | 42.7 | |

PROJECT Fert Harcock
 PROFILE NO. 31 ARRAY Pr, de
 DATE 6/6/90

RESISTIVITY DATA SHEET PROFILE

UNIT ABEM
 CALIBRATION OK
 OPERATOR Baker

| Station No. | A Electrode Spacing (Depth) in Feet meter | B Electrode Placement From Center in Feet meter | | M Meter Reading 1.2π V/I 2. V/I 3. V | I Current | S Scale | M x S | Q Warp Factor For Price Array | D Dial Value in Ohms Wenner Array 1. MS 2. 2x MS 3. 2x MS/4 Price Array 1. 2 MS Q 2. 4x MS Q 3. 4x MS OH | R Resistivity in Ohm-Cm m Barnes Layer Method Layer 1 AD 30.5 Layer 2 $A_2 - A_1 \frac{(D_1 \times D_2)}{(D_1 - D_2)} 30.5$ | Sketch |
|-------------|---|--|---|--|--------------|------------|--------|----------------------------------|---|---|---|
| | | V | I | | | | | | | | |
| P58 | 32 | 16 | | 0.079 | 20 | 1 | 0.079 | 1.0 | 0.993 | 21.5 | Soil Condition/Elevation WP46 |
| | 16 | 32 | | 0.375 | 20 | 1 | 0.375 | 0.81 | 3.817 | 61.0 | |
| P57 | 32 | 16 | | 0.0894 | 10 | 1 | 0.0894 | 1.0 | 1.123 | 27.6 | |
| | 16 | 32 | | 0.343 | 10 | 1 | 0.343 | 0.81 | 3.491 | 55.8 | |
| P56 | 32 | 16 | | 0.0461 | 20 | 1 | 0.0461 | 1.0 | 0.579 | 11.5 | |
| | 16 | 32 | | 0.294 | 20 | 1 | 0.294 | 0.81 | 2.992 | 47.9 | |
| P55 | 32 | 16 | | 0.0623 | 20 | 1 | 0.0623 | 1.0 | 0.783 | 15.7 | WP47 E |
| | 16 | 32 | | 0.384 | 20 | 1 | 0.384 | 0.81 | 3.908 | 62.5 | |
| P31 | 32 | 16 | | 0.0606 | 10 | 1 | 0.0606 | 1.0 | 0.761 | 16.34 | WP3 25 I ₁ I ₂ |
| | 16 | 32 | | 0.293 | 10 | 1 | 0.293 | 0.81 | 2.982 | 47.7 | |
| P32 | 32 | 16 | | 0.0502 | 10 | 1 | 0.0502 | 1.0 | 0.631 | 13.4 | |
| | 16 | 32 | | 0.249 | | | 0.249 | 0.81 | 2.534 | 40.5 | |
| P33 | 32 | 16 | | 0.0544 | 10 | 1 | 0.0544 | 1.0 | 0.684 | 13.7 | |
| | 16 | 32 | | 0.332 | 10 | 1 | 0.332 | 0.81 | 3.379 | 54.1 | |

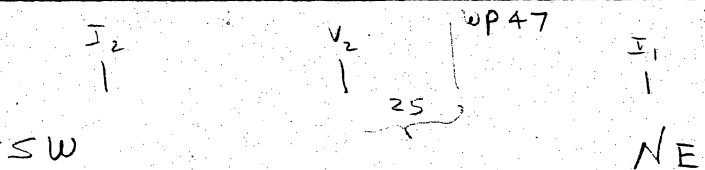
End of Profile
2

Texas LLRWDS Sounding

| | A | B | C | D | E | F | G | H |
|----|----------|-------------|---------|---------|-------|--------|---------------|--------------|
| 1 | Electrod | Price Array | Meter | Current | Scale | Price | Price Array | Resistivity |
| 2 | Spacing | Center to V | Reading | | | Array | 4 π C E F | Barnes Layer |
| 3 | | | | | | Warp | | |
| 4 | METERS | METERS | V/I | ma | | Factor | Ohms | Ohm-cm M |
| 5 | 1 | 104 | | | | 0.491 | | |
| 6 | 2 | 103 | | | | 0.505 | | |
| 7 | 3 | 102 | 4.92 | 10 | 1 | 0.519 | 32.1 | 96.3 |
| 8 | 4 | 101 | 3.40 | 10 | 1 | 0.531 | 22.7 | 77.5 |
| 9 | 5 | 100 | 2.83 | 10 | 1 | 0.544 | 19.3 | 128 |
| 10 | 6 | 99 | 2.40 | 10 | 1 | 0.556 | 16.8 | 129 |
| 11 | 7 | 98 | 2.02 | 10 | 1 | 0.568 | 14.4 | 100 |
| 12 | 8 | 97 | 1.658 | 10 | 1 | 0.580 | 12.1 | 75.7 |
| 13 | 9 | 96 | 1.414 | 10 | 1 | 0.591 | 10.5 | 74.7 |
| 14 | 10 | 95 | 1.205 | 10 | 1 | 0.602 | 9.11 | 65.8 |
| 15 | 11 | 94 | | | | 0.613 | | |
| 16 | 12 | 93 | 0.881 | 10 | 1 | 0.623 | 6.90 | 56.8 |
| 17 | 13 | 92 | | | | 0.633 | | |
| 18 | 14 | 91 | 0.647 | 10 | 1 | 0.643 | 5.23 | 43.2 |
| 19 | 15 | 90 | | | | 0.653 | | |
| 20 | 16 | 89 | 0.509 | 10 | 1 | 0.663 | 4.24 | 44.3 |
| 21 | 17 | 88 | | | | 0.672 | | |
| 22 | 18 | 87 | 0.398 | 10 | 1 | 0.681 | 3.41 | 34.8 |
| 23 | 19 | 86 | | | | 0.690 | | |
| 24 | 20 | 85 | 0.315 | 10 | 1 | 0.699 | 2.77 | 29.5 |
| 25 | 22 | 83 | 0.257 | 10 | 1 | 0.716 | 2.31 | 27.8 |
| 26 | 24 | 81 | 0.212 | 10 | 1 | 0.732 | 1.95 | 25.0 |
| 27 | 26 | 79 | 5.172 | 10 | 1 | 0.748 | 1.62 | 19.1 |
| 28 | 28 | 77 | 8.142 | 10 | 1 | 0.763 | 1.36 | 16.9 |
| 29 | 30 | 75 | 0.112 | 10 | 1 | 0.778 | 1.095 | 10.8 |
| 30 | 32 | 73 | 0.093 | 10 | 1 | 0.792 | 0.926 | 12.0 |
| 31 | 34 | 71 | 0.083 | 10 | 1 | 0.806 | 0.841 | 9.16 |
| 32 | 36 | 69 | 0.071 | 10 | 1 | 0.820 | 0.732 | 11.3 |
| 33 | 38 | 67 | 0.063 | 10 | 1 | 0.833 | 0.659 | 13.2 |
| 34 | 40 | 65 | 0.055 | 10 | 1 | 0.845 | 0.584 | 10.3 |
| 35 | 42 | 63 | | | | 0.857 | | |
| 36 | 44 | 61 | | | | 0.869 | | |
| 37 | 46 | 59 | | | | 0.881 | | |
| 38 | 45 48 | 60 57 | 0.0447 | 10 | 1 | 0.892 | 0.875 0.491 | 15.4 |
| 39 | 50 | 55 | 0.029 | 10 | 1 | 0.903 | 0.329 | 5.00 |
| 40 | 55 | 50 | 0.024 | 10 | 1 | 0.929 | 0.280 | 4.40 |
| 41 | 60 | 45 | 0.022 | 10 | 1 | 0.954 | 0.263 | 21.6 |
| 42 | 65 | 40 | 0.017 | 10 | 1 | 0.978 | 0.209 | 5.09 |
| 43 | 70 | 35 | 0.014 | 10 | 1 | 1.000 | 0.176 | 5.57 |

SKETCH, SOIL CONDITION/ELEVATION

Location of P 34 Center electrode
Sandy soil dry



SOUNDING RESISTIVITY DATA SHEET

DATE 6/6/90 CALIBRATION OK UNIT ABEM
 PROJECT Ft Hancock OPERATOR Baker ARRAY Price
 SOUNDING NO. 1

Texas LLRWDS Sounding

| | A | B | C | D | E | F | G | H |
|----|----------|-------------|------------------|---------------|-------|------------------------|---------------|--------------|
| 1 | Electrod | Price Array | Meter | Current | Scale | Price | Price Array | Resistivity |
| 2 | Spacing | Center to V | Reading | | | Array | 4 π C E F | Barnes Layer |
| 3 | | | | | | Warp | | |
| 4 | METERS | METERS | V/I | ma | | Factor | Ohms | Ohm-cm m |
| 5 | 1 | 104 | | | | 0.491 | | |
| 6 | 2 | 103 | | | | 0.505 | | |
| 7 | 3 | 102 | | | | 0.519 | | |
| 8 | 4 | 101 | | | | 0.531 | | |
| 9 | 5 | -100 | | | | 0.544 | | |
| 10 | 6 | 99 | | | | 0.556 | | |
| 11 | 7 | 98 | 6.780 | 10 | | 0.568 | 12.70 | 88.9 |
| 12 | 8 | 97 | 1.447 | 10 | | 0.580 | 10.54 | 62.1 |
| 13 | 9 | 96 | 1.198 | 10 | | 0.591 | 8.89 | 57.1 |
| 14 | 10 | -95 | 1.043 | 10 | | 0.602 | 7.89 | 70.2 |
| 15 | 11 | 94 | | | | 0.613 | | |
| 16 | 12 | -93 | 0.791 | 10 | | 0.623 | 6.19 | 57.6 |
| 17 | 13 | 92 | | | | 0.633 | | |
| 18 | 14 | -91 | 0.604 | 10 | | 0.643 | 4.88 | 46.1 |
| 19 | 15 | 90 | | | | 0.653 | | |
| 20 | 16 | -89 | 0.498 | 10 | | 0.663 | 4.15 | 55.4 |
| 21 | 17 | 88 | | | | 0.672 | | |
| 22 | 18 | -87 | 0.376 | 10 | | 0.681 | 3.22 | 28.6 |
| 23 | 19 | 86 | 0.376 | 10 | | 0.690 | | |
| 24 | 20 | -85 | 0.303 | 10 | | 0.699 | 2.66 | 30.7 |
| 25 | 22 | 83 | 0.247 | 10 | | 0.716 | 2.22 | 27.0 |
| 26 | 24 | 81 | 0.212 | 10 | | 0.732 | 1.950 | 30.1 |
| 27 | 26 | 79 | 0.176 | 10 | | 0.748 | 1.654 | 21.8 |
| 28 | 28 | 77 | 0.148 | 10 | | 0.763 | 1.419 | 19.97 |
| 29 | 30 | 75 | 0.125 | 10 | | 0.778 | 1.222 | 17.6 |
| 30 | 32 | 73 | 0.119 | 10 | | 0.792 | 1.184 | 76.9 |
| 31 | 34 | 71 | 0.0970 | 10 | | 0.806 | 0.982 | 11.5 |
| 32 | 36 | 69 | 0.0813 | 10 | | 0.820 | 0.843 | 11.9 |
| 33 | 38 | 67 | 0.0693 | 10 | | 0.833 | 0.731 | 11.0 |
| 34 | 40 | -65 | 0.0640 | 10 | | 0.845 | 0.679 | 19.3 |
| 35 | 42 | 63 | | | | 0.857 | | |
| 36 | 44 | 61 | | | | 0.869 | | |
| 37 | 46 | 59 | | | | 0.881 | | |
| 38 | 45 48 | 60.57 | 0.0589 | 10 | | 0.892 0.875 | 0.647 | 70.1 |
| 39 | 50 | -55 | 0.0531 | 10 | | 0.903 | 0.602 | 43.8 |
| 40 | 55 | -50 | 0.0520 | 10 | | 0.929 | 0.607 | |
| 41 | 60 | -45 | 0.0384 | 10 | | 0.954 | 0.462 | 19.3 |
| 42 | 65 | -40 | 0.0311 | 10 | 1 | 0.978 | 0.322 | 11.1 |
| 43 | 70 | -35 | 0.0211 | 10 | 1 | 1.000 | 0.265 | 4.3 |

SKETCH, SOIL CONDITION/ELEVATION

SW - I₁
1

WP 29

V₁ V₂ V₁
K 33m K 35m

I₂ NE
1

← 105m →

SOUNDING RESISTIVITY DATA SHEET

DATE 6/18/90

CALIBRATION OK

UNIT ABEM

PROJECT Ft. Hancock

OPERATOR Keller

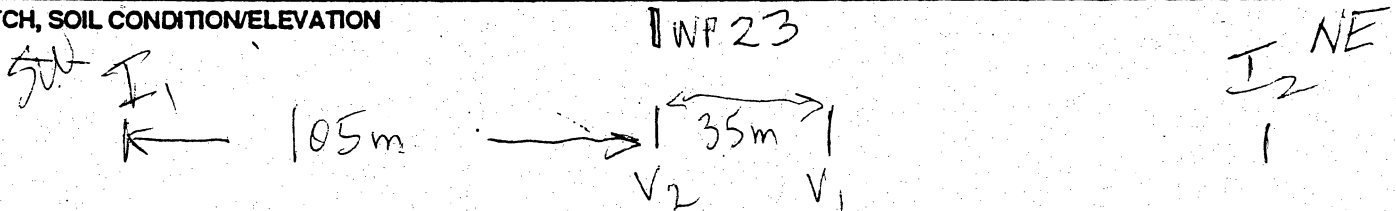
ARRAY Price

SOUNDING NO. 2

Texas LLRWDS Sounding

| | A | B | C | D | E | F | G | H |
|----|----------|-------------|---------|---------|-------|--------|-------------|--------------|
| 1 | Electrod | Price Array | Meter | Current | Scale | Price | Price Array | Resistivity |
| 2 | Spacing | Center to V | Reading | | | Array | 4π C E F | Barnes Layer |
| 3 | | | | | | Warp | | |
| 4 | METERS | METERS | V/I | ma | | Factor | Ohms | Ohm-cm |
| 5 | 1 | 104 | | | | 0.491 | | |
| 6 | 2 | 103 | | | | 0.505 | | |
| 7 | 3 | 102 | | | | 0.519 | | |
| 8 | 4 | 101 | | | | 0.531 | | |
| 9 | 5 | 100 | | | | 0.544 | | |
| 10 | 6 | 99 | 3.39 | | | 0.556 | 23.68 | 142 |
| 11 | 7 | 98 | 2.24 | | | 0.568 | 15.99 | 16.02 |
| 12 | 8 | 97 | 1.417 | 10 | | 0.580 | 13.33 | 10.4 |
| 13 | 9 | -96 | 1.037 | 10 | | 0.591 | 7.70 | 30.24 |
| 14 | 10 | -95 | 0.801 | 10 | | 0.602 | 6.06 | 28.4 |
| 15 | 11 | 94 | | | | 0.613 | | |
| 16 | 12 | -93 | 0.573 | 10 | | 0.623 | 4.49 | 34.66 |
| 17 | 13 | 92 | | | | 0.633 | | |
| 18 | 14 | -91 | 0.432 | 10 | | 0.643 | 3.49 | 31.34 |
| 19 | 15 | 90 | | | | 0.653 | | |
| 20 | 16 | -89 | 0.318 | 10 | | 0.663 | 2.65 | 22.0 |
| 21 | 17 | 88 | | | | 0.672 | | |
| 22 | 18 | -87 | 0.257 | 10 | | 0.681 | 2.199 | 25.8 |
| 23 | 19 | 86 | | | | 0.690 | | |
| 24 | 20 | -85 | 0.208 | 10 | | 0.699 | 1.827 | 21.6 |
| 25 | 22 | 83 | 0.195 | 10 | | 0.716 | 1.574 | 22.7 |
| 26 | 24 | 81 | 0.140 | 10 | | 0.732 | 1.288 | 14.17 |
| 27 | 26 | 79 | 0.123 | 10 | | 0.748 | 1.156 | 22.6 |
| 28 | 28 | 77 | 0.108 | 10 | | 0.763 | 1.035 | 19.7 |
| 29 | 30 | 75 | 0.0900 | 10 | | 0.778 | 0.880 | 11.7 |
| 30 | 32 | 73 | 0.0840 | 10 | | 0.792 | 0.836 | 33.4 |
| 31 | 34 | 71 | 0.0750 | 10 | | 0.806 | 0.759 | 16.5 |
| 32 | 36 | 69 | 0.0630 | 10 | | 0.820 | 0.649 | 8.9 |
| 33 | 38 | 67 | 0.0600 | 10 | | 0.833 | 0.628 | 32.2 |
| 34 | 40 | -65 | 0.0570 | 10 | | 0.845 | 0.605 | 33.0 |
| 35 | 42 | 63 | | | | 0.857 | | |
| 36 | 44 | 61 | | | | 0.869 | | |
| 37 | 46 | 59 | | | | 0.881 | | |
| 38 | 45 48 | 60 57 | 0.0544 | 10 | | 0.892 | 0.598 | 253.4 |
| 39 | 50 | 55 | 0.0470 | 10 | | 0.903 | 0.533 | 24.5 |
| 40 | 55 | 50 | 0.0420 | 10 | | 0.929 | 0.490 | 20.3 |
| 41 | 60 | 45 | 0.0350 | 10 | | 0.954 | 0.419 | 14.5 |
| 42 | 65 | 40 | 0.0323 | 10 | | 0.978 | 0.397 | 37.2 |
| 43 | 70 | 35 | 0.0219 | 10 | | 1.000 | 0.275 | 4.47 |

SKETCH, SOIL CONDITION/ELEVATION



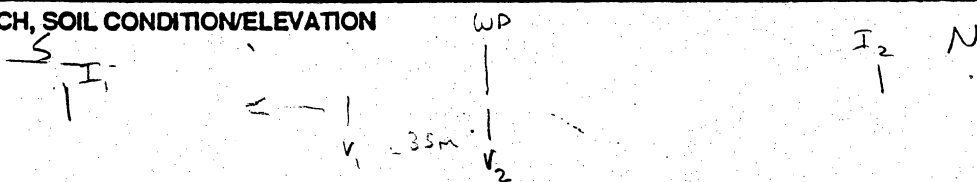
SOUNDING RESISTIVITY DATA SHEET

DATE 6/18/90 CALIBRATION OK UNIT ABEM
 PROJECT It. Hancock OPERATOR Keller ARRAY Price
 SOUNDING NO. 3

Texas LLRWDS Sounding

| | A | B | C | D | E | F | G | H |
|----|----------|-------------|---------|---------|-------|--------|---------------|--------------|
| 1 | Electrod | Price Array | Meter | Current | Scale | Price | Price Array | Resistivity |
| 2 | Spacing | Center to V | Reading | | | Array | 4 π C E F | Barnes Layer |
| 3 | | | | | | Warp | | |
| 4 | METERS | METERS | V/I | ma | | Factor | Ohms | Ohm-cm m |
| 5 | 1 | 104 | | | | 0.491 | | |
| 6 | 2 | 103 | | | | 0.505 | | |
| 7 | 3 | 102 | | | | 0.519 | | |
| 8 | 4 | 101 | | | | 0.531 | | |
| 9 | 5 | 100 | 1.545 | | | 0.544 | 10.6 | 53.0 |
| 10 | 6 | 99 | 1.264 | 10 | 1 | 0.556 | 8.83 | 51.1 |
| 11 | 7 | 98 | 0.985 | 10 | 1 | 0.568 | 7.03 | 34.5 |
| 12 | 8 | 97 | 0.833 | 10 | 1 | 0.580 | 6.07 | 44.4 |
| 13 | 9 | 96 | 5.685 | 10 | 1 | 0.591 | 5.09 | 31.5 |
| 14 | 10 | 95 | 0.530 | 10 | 1 | 0.602 | 4.01 | 18.9 |
| 15 | 11 | 94 | | | | 0.613 | | |
| 16 | 12 | 93 | 0.359 | 10 | 1 | 0.623 | 2.81 | 18.7 |
| 17 | 13 | 92 | | | | 0.633 | | |
| 18 | 14 | 91 | 0.286 | 10 | 1 | 0.643 | 2.37 | 25.9 |
| 19 | 15 | 90 | | | | 0.653 | | |
| 20 | 16 | 89 | 0.223 | 10 | 1 | 0.663 | 1.86 | 19.1 |
| 21 | 17 | 88 | | | | 0.672 | | |
| 22 | 18 | 87 | 0.184 | 10 | 1 | 0.681 | 1.57 | 20.1 |
| 23 | 19 | 86 | | | | 0.690 | | |
| 24 | 20 | 85 | 0.155 | 10 | 1 | 0.699 | 1.36 | 20.3 |
| 25 | 22 | 83 | 0.132 | 10 | 1 | 0.716 | 1.19 | 19.0 |
| 26 | 24 | 81 | 0.119 | 10 | 1 | 0.732 | 1.095 | 27.4 |
| 27 | 26 | 79 | 0.100 | 10 | 1 | 0.748 | 0.940 | 13.3 |
| 28 | 28 | 77 | 0.082 | 10 | 1 | 0.763 | 0.843 | 16.3 |
| 29 | 30 | 75 | 0.077 | 10 | 1 | 0.778 | 0.753 | 14.1 |
| 30 | 32 | 73 | 0.068 | 10 | 1 | 0.792 | 0.677 | 13.4 |
| 31 | 34 | 71 | 0.066 | 10 | 1 | 0.806 | 0.668 | 100 |
| 32 | 36 | 69 | 0.063 | 10 | 1 | 0.820 | 0.649 | 45.6 |
| 33 | 38 | 67 | 0.058 | 10 | 1 | 0.833 | 0.607 | 9.38 |
| 34 | 40 | 65 | 0.0466 | 10 | 1 | 0.845 | 0.495 | 5.36 |
| 35 | 42 | 63 | | | | 0.857 | | |
| 36 | 44 | 61 | | | | 0.869 | | |
| 37 | 46 | 59 | | | | 0.881 | | |
| 38 | 45-48 | 60-57 | 0.041 | 10 | 1 | 0.892 | 0.875 0.451 | 25.4 |
| 39 | 50 | 55 | 0.036 | 10 | 1 | 0.903 | 0.408 | 21.4 |
| 40 | 55 | 50 | 0.031 | 10 | 1 | 0.929 | 0.362 | 16.0 |
| 41 | 60 | 45 | 0.0262 | 10 | 1 | 0.954 | 0.314 | 11.8 |
| 42 | 65 | 40 | 0.0228 | 10 | 1 | 0.978 | 0.280 | 12.9 |
| 43 | 70 | 35 | 0.0185 | 10 | 1 | 1.000 | 0.232 | 6.76 |

SKETCH, SOIL CONDITION/ELEVATION



SOUNDING RESISTIVITY DATA SHEET

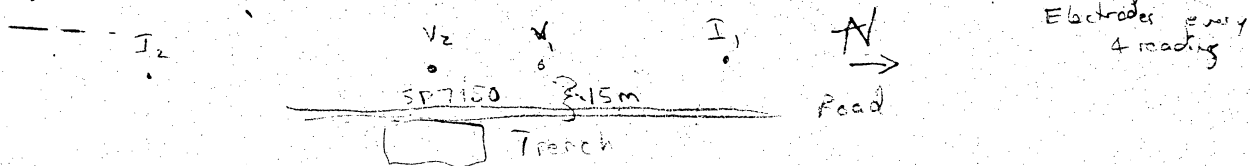
DATE 6/6/90 CALIBRATION OK UNIT ABEM
 PROJECT Ft Hancock OPERATOR Baker ARRAY Price
 SOUNDING NO. 4

Texas LLRWDS Sounding

| | A | B | C | D | E | F | G | H |
|----|----------|-------------|---------|---------|-------|--------|-------------|--------------|
| 1 | Electrod | Price Array | Meter | Current | Scale | Price | Price Array | Resistivity |
| 2 | Spacing | Center to V | Reading | | | Array | 4π C E F | Barnes Layer |
| 3 | | | | | | Warp | | |
| 4 | METERS | METERS | V/I | ma | | Factor | Ohms | Ohm-cm m |
| 5 | 1 | 104 | | | | 0.491 | | |
| 6 | 2 | 103 | | | | 0.505 | | |
| 7 | 3 | 102 | | | | 0.519 | | |
| 8 | 4 | 101 | | | | 0.531 | | |
| 9 | 5 | 100 | | | | 0.544 | | |
| 10 | 6 | 99 | | | | 0.556 | | |
| 11 | 7 | 98 | | | | 0.568 | | |
| 12 | 8 | 97 | 0.539 | 10 | 1 | 0.580 | 3.92 | 31.7 |
| 13 | 9 | 96 | 0.492 | 10 | 1 | 0.591 | 3.65 | 53.0 |
| 14 | 10 | 95 | 0.345 | 10 | 1 | 0.602 | 2.61 | 9.16 |
| 15 | 11 | 94 | | | | 0.613 | | |
| 16 | 12 | 93 | 0.269 | 10 | 1 | 0.623 | 2.11 | 22.0 |
| 17 | 13 | 92 | | | | 0.633 | | |
| 18 | 14 | 91 | 0.214 | 10 | 1 | 0.643 | 1.73 | 19.2 |
| 19 | 15 | 90 | | | | 0.653 | | |
| 20 | 16 | 89 | 0.172 | 10 | 1 | 0.663 | 1.43 | 16.5 |
| 21 | 17 | 88 | | | | 0.672 | | |
| 22 | 18 | 87 | 0.145 | 10 | 1 | 0.681 | 1.24 | 18.7 |
| 23 | 19 | 86 | | | | 0.690 | | |
| 24 | 20 | 85 | 0.131 | 10 | 1 | 0.699 | 1.15 | 31.6 |
| 25 | 22 | 83 | 0.116 | 10 | 1 | 0.716 | 1.044 | 22.45 |
| 26 | 24 | 81 | 0.093 | 10 | 1 | 0.732 | 0.855 | 9.47 |
| 27 | 26 | 79 | 0.081 | 10 | 1 | 0.748 | 0.761 | 13.9 |
| 28 | 28 | 77 | 0.072 | 10 | 1 | 0.763 | 0.699 0.761 | 17.2 |
| 29 | 30 | 75 | 0.063 | 10 | 1 | 0.778 | 0.616 | 10.37 |
| 30 | 32 | 73 | 0.058 | 10 | 1 | 0.792 | 0.577 | 18.2 |
| 31 | 34 | 71 | 0.0548 | 10 | 1 | 0.806 | 0.555 | 29.1 |
| 32 | 36 | 69 | 0.038 | 10 | 1 | 0.820 | 0.392 | 2.67 |
| 33 | 38 | 67 | 0.037 | 10 | 1 | 0.833 | 0.387 | 60.7 |
| 34 | 40 | 65 | 0.025 | 10 | 1 | 0.845 | 0.371 | 17.9 |
| 35 | 42 | 63 | | | | 0.857 | | |
| 36 | 44 | 61 | | | | 0.869 | | |
| 37 | 46 | 59 | | | | 0.881 | | |
| 38 | 45 48 | 60 57 | 0.029 | 10 | 1 | 0.892 | 0.875 0.318 | 11.1 |
| 39 | 50 | 55 | 0.026 | 10 | 1 | 0.903 | 0.295 | 14.2 |
| 40 | 55 | 50 | 0.026 | 10 | 1 | 0.929 | 0.303 | |
| 41 | 60 | 45 | 0.023 | 2 | 1 | 0.954 | 0.275 | 40.5 |
| 42 | 65 | 40 | 0.0252 | 20 | 1 | 0.978 | 0.309 | |
| 43 | 70 | 35 | 0.0148 | 20 | 1 | 1.000 | 0.186 | 5.75 |

← Show evidence of fracture (A. 3d)

SKETCH, SOIL CONDITION/ELEVATION



SOUNDING RESISTIVITY DATA SHEET

DATE 6/6/90 CALIBRATION _____ UNIT ABEM
 PROJECT Ft. Har-ee k OPERATOR _____ ARRAY Price
 SOUNDING NO. 5 Resist Bed Sounding