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1141 SAGE REPORTS

Applications of GPR at a Radioactive Waste Disposal Facility

Greg Young
Western Michigan University
SAGE 1999

Introduction

Ground Penetrating Radar (GPR) was used at a Manhattan Era plutonium disposal site at Los Alamos National Laboratory. Summer of Applied Geophysical Experience (SAGE) students characterized the subsurface of Material Disposal Site A (MDA-A) using three geophysical techniques: GPR, magnetics, and electrical resistivity. Eight GPR lines were recorded. The GPR data, as interpreted, show anomalies along several of the surveyed lines but do not produce reflections with high confidence along one line where expected. Depth of penetration was relatively low through the Bandelier tuff. Therefore, bottom features of the disposal pits are not recognized and contamination run-off conclusions have not been reached with this survey. However, tanks and pits, along with some debris and trenching are recognized on the scans.

Geology

Los Alamos National Laboratory (LANL), near Santa Fe, New Mexico, is situated on the Pajarito Plateau, on the east flank of the Jemez Mountains. The mountains are the western boundary of the Rio Grande rift's Espanola basin. MDA-A is located on one of the plateau's finger mesas, DP Mesa. DP Mesa is flanked by DP Canyon to the north and Los Alamos Canyon to the south. Drainage patterns at MDA-A indicate that surface runoff flows into DP Canyon. DP Mesa consists primarily of Pleistocene Bandelier tuff. Rhyolitic ash deposits originating from the Valles Caldera of the Jemez volcanic field formed the Bandelier tuff.

History

During the Manhattan Project, MDA-A was the primary plutonium storage site for LANL. In 1945 the area was converted into a waste disposal area. Two or three tanks known as the General Tanks were laid underground at the western edge of the site to receive plutonium waste (Figure 1). The majority of the liquid was removed in 1975 and 1983 but was reportably low in radioactive concentrations. This suggests that large concentrations of radiation remained in the sludge that was left in the tanks. Intake pipes were covered and sealed in 1985 when it was observed that rainwater was entering the tanks. An eight inch concrete cap was placed over the tanks and the area was bermed with fill. Also in 1945 two or four trench pits were dug at the eastern end of MDA-A to receive radioactive laboratory debris (Figure 1). The pits were covered in 1946 (LANL report, 1991).

The confusing information on the number of tanks and pits comes exclusively from the LANL report. The report's first paragraph attempts to clarify the confusion about the number of pits on the eastern end of the site by stating that the discrepancy originated from a singular early engineering drawing that showed four pits. Later drawings, reports, and memos referred only to the existence of two pits at the location. The LANL report concludes its first paragraph declaring that it will assume only two pits exist. However, later in the report, when the chronological history of the area is given, the first event cited is the construction of four pits. The confusion about the number of General Tanks is also from the LANL report. While the report states that two storage tanks were placed, several maps included in the report show a third tank at the same location. No explanation for its inclusion in the maps is offered in the text (LANL report, 1991).

During the early 1950's, hundreds of 55 gallon drums containing concentrated sodium hydroxide (NaOH), plutonium, and uranium were stored at the site. The drums corroded and an unknown volume of contaminants leached into the subsurface. In 1960 the drums were removed and the area was paved in an attempt to contain the contaminants. The pavement material, presumably asphalt or concrete, was not specified in the report (LANL report, 1991).

A large open pit was constructed at the center of MDA-A in 1969 and later enlarged in 1970 for the purpose of collecting demolition debris, including radioactive materials, from LANL sites. It was covered in 1985 when all of MDA-A received site stabilization activity including the previously mentioned 8 inch concrete cap over the General Tanks. Surface contamination was removed and the entire area was reseeded (LANL report, 1991).

Survey/Processing Methods

A Sensors and Software PulseEKKO radar unit with 100 MHz antennas powered with 400 volts was used for the GPR survey. Eight lines, all run in a north to south direction, were surveyed in reflection mode with 1 m antenna separation and 1/4 m step sizes. Data were collected with a laptop computer running an autogain filter. Depth was computed using a velocity of .1 m/ns through the Bandelier tuff. Simple DEWOW corrections were applied in post processing.

Results

Line 4, the western most line, shows a strong vertical reflector at the north end of the line (Figures 3,4) This corresponds with a large electrical wire laid across the surface. The strong horizontal reflector at 1 m across the record and a second strong reflector at 2 m with hyperbolic tails at 12 m and 32 m across the line are the most striking subsurface features. The reflections appear to verify the presence of the western most General Tank and a concrete cap. Straight reflections at 45° angles across the records are due to either fences at both the north and south ends of the lines or overhead wires along the north fence as indicated on the figures.

The next four lines, 19, 20, 21, and 22 also show strong reflectors at 1 m (Figures 6,7,9,10,12,13,15,16). They also show a single broad hyperbolic event beginning in line 19, increasing in strength at lines 20 and 21 and weakening but still clearly defined again in line 22. If the General Tanks locations are correct on the LANL report maps, these four lines run directly over the eastern tank and line 4 runs along the west edge of the western tank. These results seem to verify the existence of the two General Tanks that are described in the LANL report along with the 8 inch cap. What is curious, however, is that the shape of the lowest reflector in line 4, presumably just off the edge of the western most tank, is not similar to the lower reflector in either lines 19 or 22, also presumably just off their tanks respective edges. One possible explanation offered was that line 4 was run just 5 m from and running parallel to the western fence line and this would affect the survey results (Young, SAGE presentation, 1999). This explanation does not follow the travel time for radio waves in air. At 10 m (5 m with two way travel time) a radio wave in air would arrive back at the receiver in 33 ns. While there is a reflection at this time on the

record it does not arrive at the same time as the top of tank reflector at 40 ns. All five lines in this location do not, however, support the existence of a third tank to the south.

Lines 44 and 49, 5 m apart, both show continuous reflectors at the top of the record, a variety of hyperbolic reflectors at the northern ends of the lines, and some evidence of trenching towards to south (Figures 18,19,20,21). These lines are over the mapped location of the large central pit. The strong top reflector corresponds well with a cap. This, perhaps, is the location of the pavement laid in an attempt to contain the waste leaking from the 55 gallon drums that were removed in 1960.

The eighth line, line 89, shows little easily identifiable subsurface information (Figure 24,25). There is some evidence of trenching at horizontal position 12.5 m and again at about 35 m both down to a depth of about 4 m. These and minor hyperbolic events are the only noteworthy information that can be obtained from the data along this line with any degree of confidence.

Conclusions

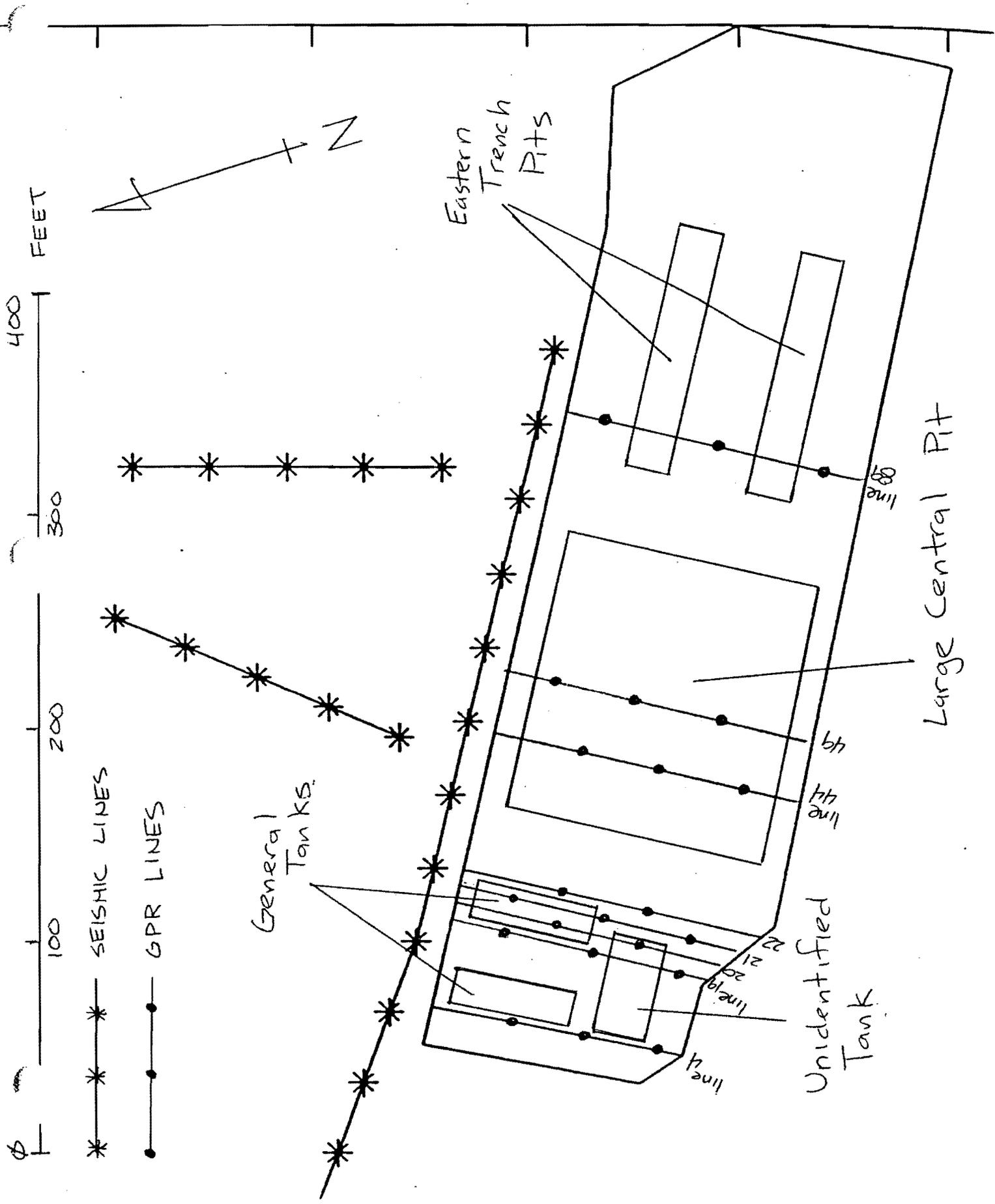
The GPR survey at MDA-A yielded information supporting some LANL report information and discrediting other, less reliable, information. The presence of two General Tanks was confirmed. The third tank was not seen and is most probably not present. The reflection seen at 1 m along lines 44 and 49 was most probably the cap placed to contain the contamination from the leaking 55 gallon drums. The two trench pits on the eastern end of the site were not confirmed with a high degree of confidence although some evidence of trenching at the mapped location does appear on the record. Perhaps most importantly, distinctions between reflections caused by fences and those caused by overhead wires were identified with forceful authority.

Bibliography

_____, May 1991. LANL Report. Material Disposal Areas Description and Sampling Plan, Ch. 16; TA-21 Operable Unit RFI Work Plan for ER.

Thank you to all of the SAGE 1999 faculty and staff for their instruction on both the fundamental and finer points of geophysical theory and application. In particular, thank you to George Jiracek for spending over an hour with me one on one going over electromagnetic theory. Thank you also to David Ahumbaugh for his help interpreting the results of our survey and to Peter Annan for coming to SAGE with his equipment and helping with the field work. Finally, thank you to Bill Sauck, my advisor at WMU for giving me a solid background in GPR and for introducing me to the SAGE program.

FIGURE 1



PulseEKKO Data Sheet

DATA FILE #1 PARAMETERS:

Data File = C:\SAGE99\LINE4A.hd

line 4

Line 4

19/06/99

NUMBER OF TRACES = 125
 NUMBER OF PTS/TRC = 312
 TIMEZERO AT POINT = 49
 TOTAL TIME WINDOW = 250
 STARTING POSITION = 2.0000
 FINAL POSITION = 33.0000
 STEP SIZE USED = 0.2500
 POSITION UNITS = metres
 NOMINAL FREQUENCY = 100.00
 ANTENNA SEPARATION = 1.0000
 PULSER VOLTAGE (V) = 400
 NUMBER OF STACKS = 32
 SURVEY MODE = Reflection
 COLLECTED BY PE100 - CON: 950910 RX: 950623
 TX: 950707 ANT: ??

PROCESSING SELECTED:

Trace Stacking : 1
 Points Stacking : 3
 Trace Differencing: N
 Correction : DEWOW
 Gain Type : AUTOGAIN
 Selection : Time = all
 Position = all
 Picture Id : 06/20/99-23:16:53

PLOT LAYOUT PARAMETERS:

Traces per Inch : 25.000
 Width/Spacing Ratio: 2.000
 Trace Position : 1.000" to 6.500"
 Left/Right Margin : 0.500" / 0.000"
 Border Size : 0.500"
 Page Length/Width : 11.000" / 8.500"
 Printer Name : HP LaserJet II 300dpi

FIGURE 3

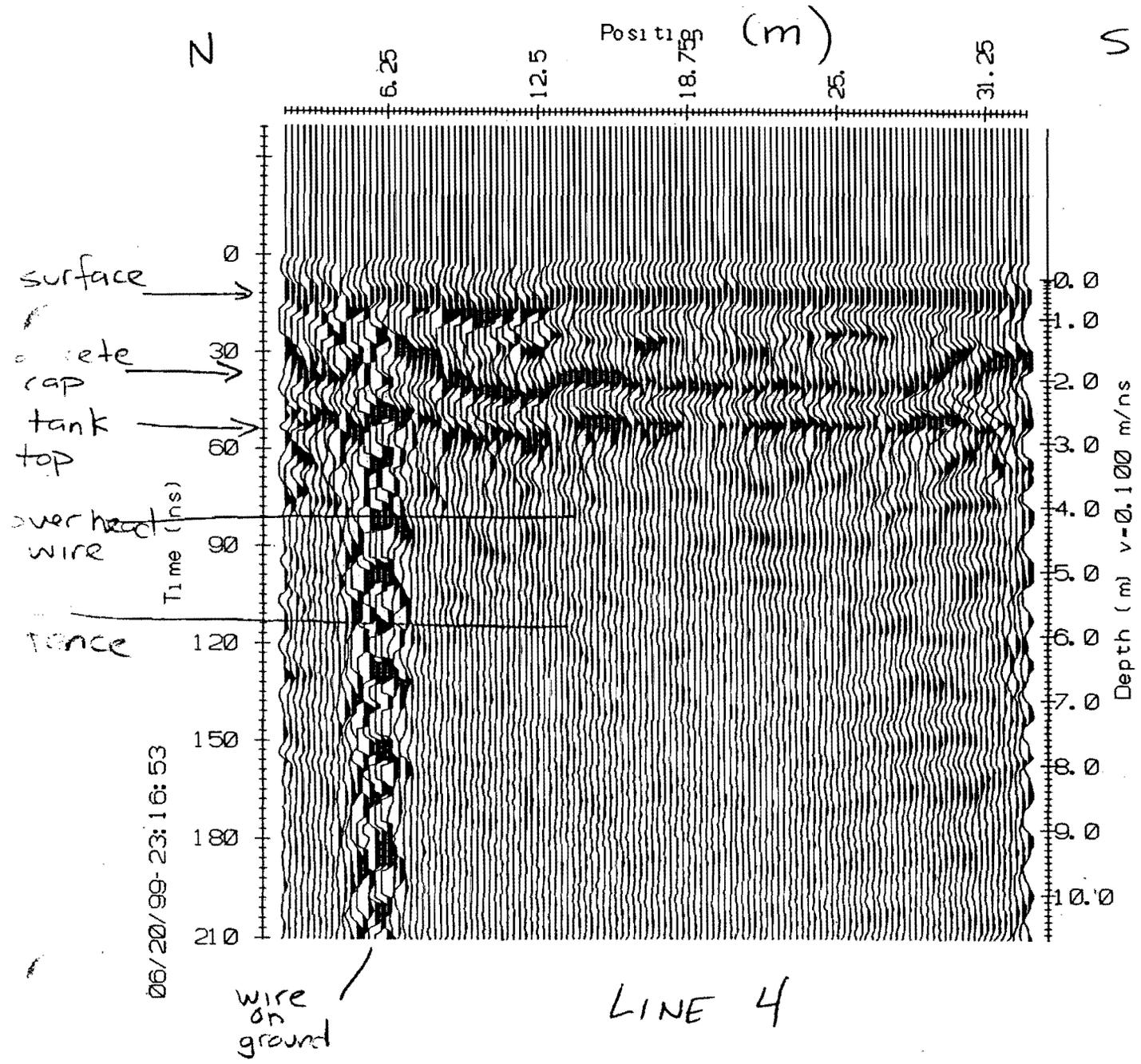
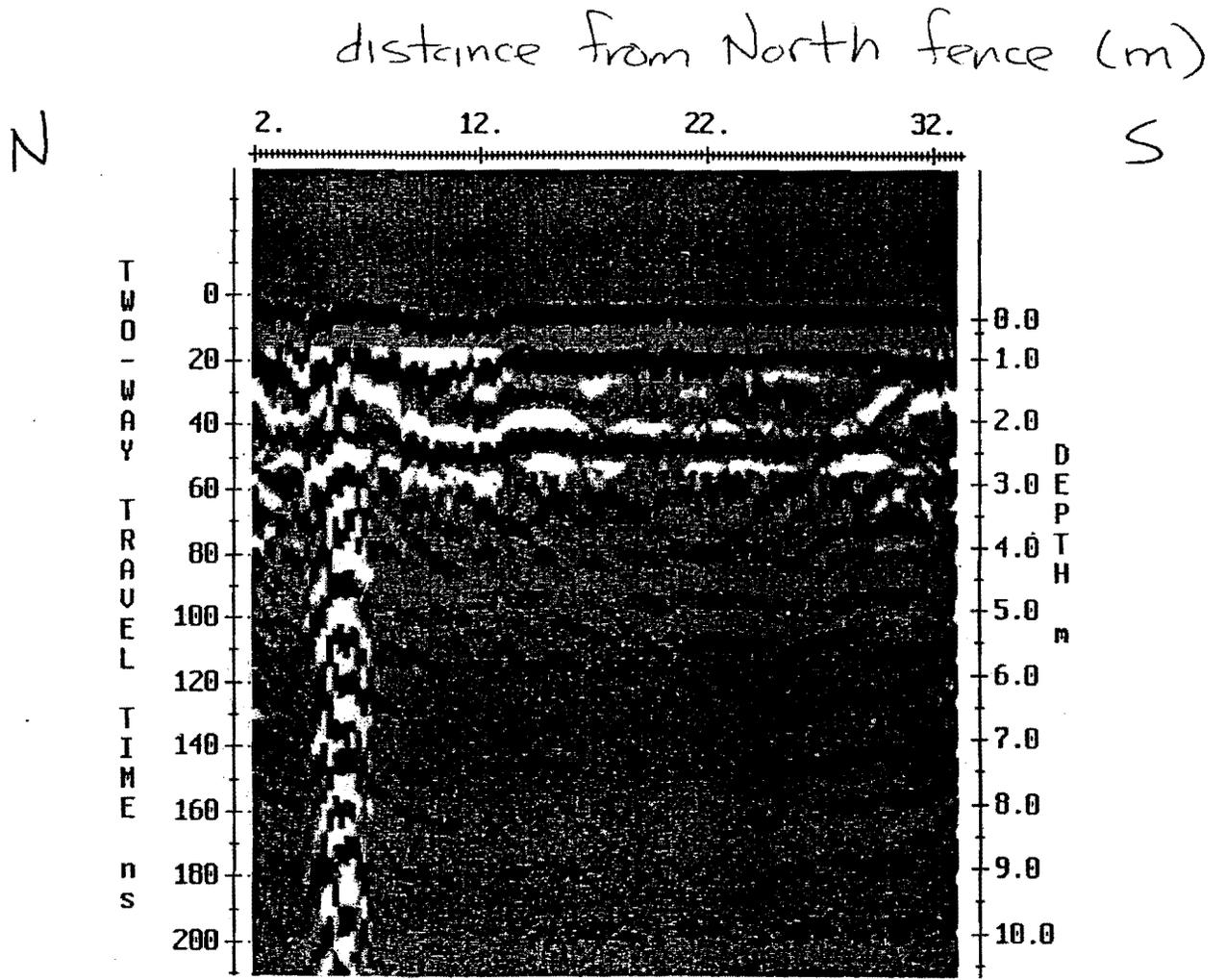


FIGURE 4



LINE 4

PulseEKKO Data Sheet

DATA FILE #1 PARAMETERS:

Data File = C:\SAGE99\LINE19A.hd

line 19
19/06/99

Line 19

NUMBER OF TRACES = 132
 NUMBER OF PTS/TRC = 312
 TIMEZERO AT POINT = 49
 TOTAL TIME WINDOW = 250
 STARTING POSITION = 2.0000
 FINAL POSITION = 34.7500
 STEP SIZE USED = 0.2500
 POSITION UNITS = metres
 NOMINAL FREQUENCY = 100.00
 ANTENNA SEPARATION = 1.0000
 PULSER VOLTAGE (V) = 400
 NUMBER OF STACKS = 32
 SURVEY MODE = Reflection
 COLLECTED BY PE100 - CON: 950910 RX: 950623
 TX: 950707 ANT: ??

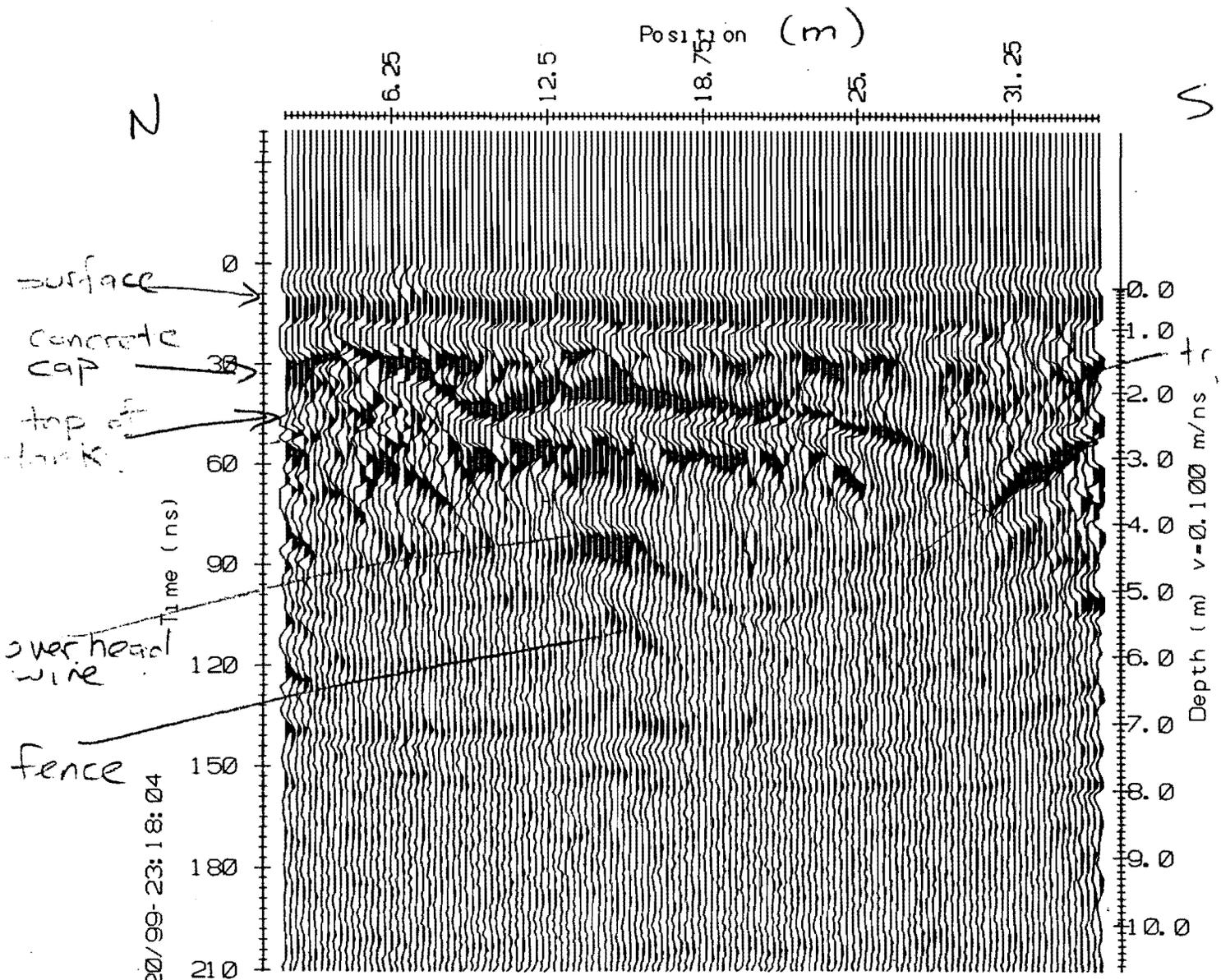
PROCESSING SELECTED:

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 Points Stacking : 3
 Trace Differencing: N
 Correction : DEWOW
 Gain Type : AUTOGAIN
 Selection : Time = all
 Position = all
 Picture Id : 06/20/99-23:18:04

PLOT LAYOUT PARAMETERS:

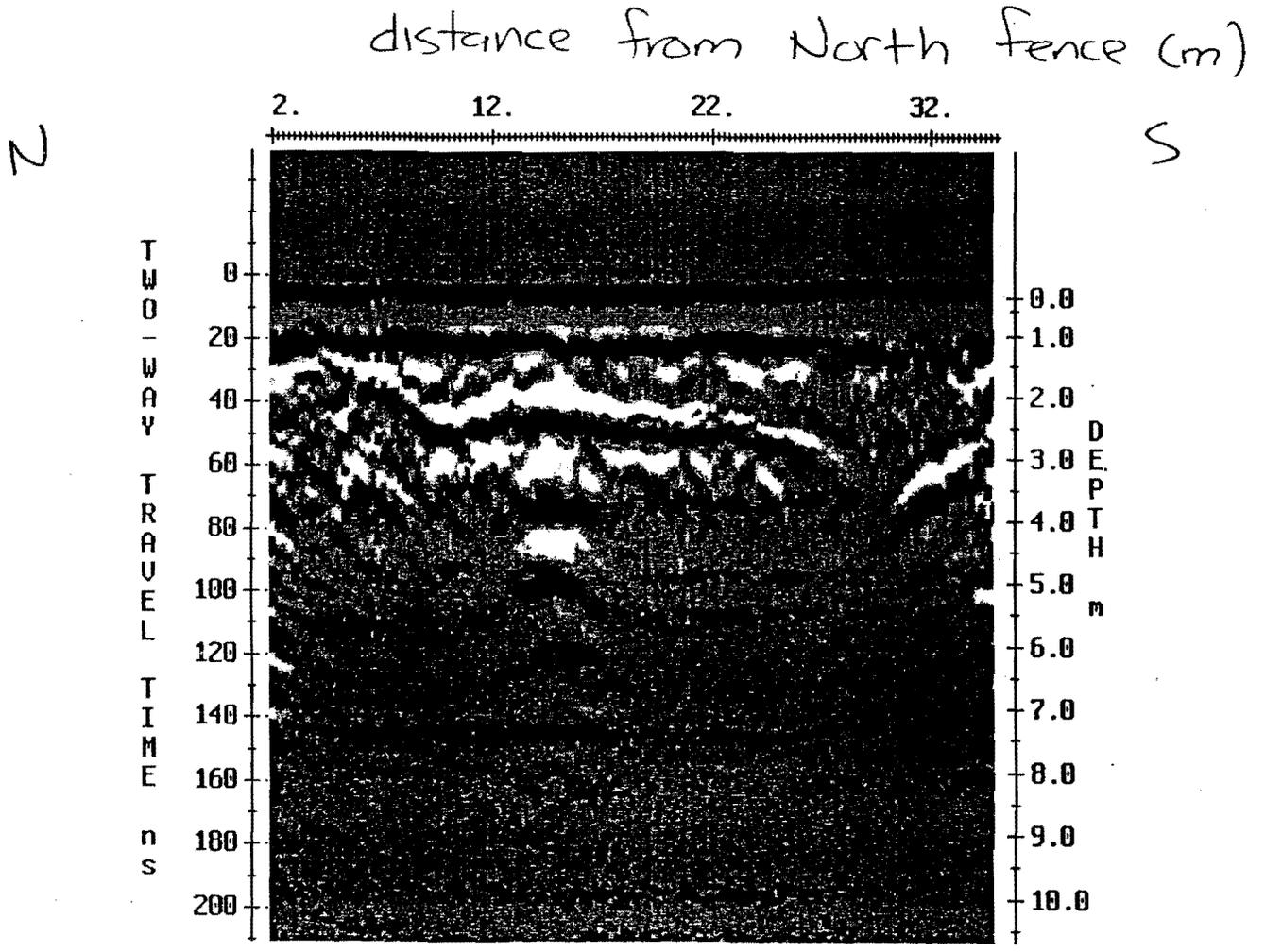
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 Width/Spacing Ratio: 2.000
 Trace Position : 1.000" to 6.500"
 Left/Right Margin : 0.500" / 0.000"
 Border Size : 0.500"
 Page Length/Width : 11.000" / 8.500"
 Printer Name : HP LaserJet II 300dpi

FIGURE 6



LINE 19

FIGURE 7



LINE 19

PulseEKKO - Data Sheet

DATA FILE #1 PARAMETERS:

Data File = C:\SAGE99\DATA1.hd

line 20

Line 20

20/06/99

NUMBER OF TRACES = 150
 NUMBER OF PTS/TRC = 312
 TIMEZERO AT POINT = 45
 TOTAL TIME WINDOW = 250
 STARTING POSITION = 2.0000
 FINAL POSITION = 39.2500
 STEP SIZE USED = 0.2500
 POSITION UNITS = metres
 NOMINAL FREQUENCY = 100.00
 ANTENNA SEPARATION = 1.0000
 PULSER VOLTAGE (V) = 400
 NUMBER OF STACKS = 32
 SURVEY MODE = Reflection
 COLLECTED BY PE100 - CON: 950910 RX: 950623
 TX: 950707 ANT: ??

PROCESSING SELECTED:

Trace Stacking : 1
 Points Stacking : 3
 Trace Differencing: N
 Correction : DEWOW
 Gain Type : AUTOGAIN
 Selection : Time = all
 Position = all
 Picture Id : 06/20/99-23:15:02

PLOT LAYOUT PARAMETERS:

Traces per Inch : 25.000
 Width/Spacing Ratio: 2.000
 Trace Position : 1.000" to 6.500"
 Left/Right Margin : 0.500" / 0.000"
 Border Size : 0.500"
 Page Length/Width : 11.000" / 8.500"
 Printer Name : HP LaserJet II 300dpi

FIGURE 9

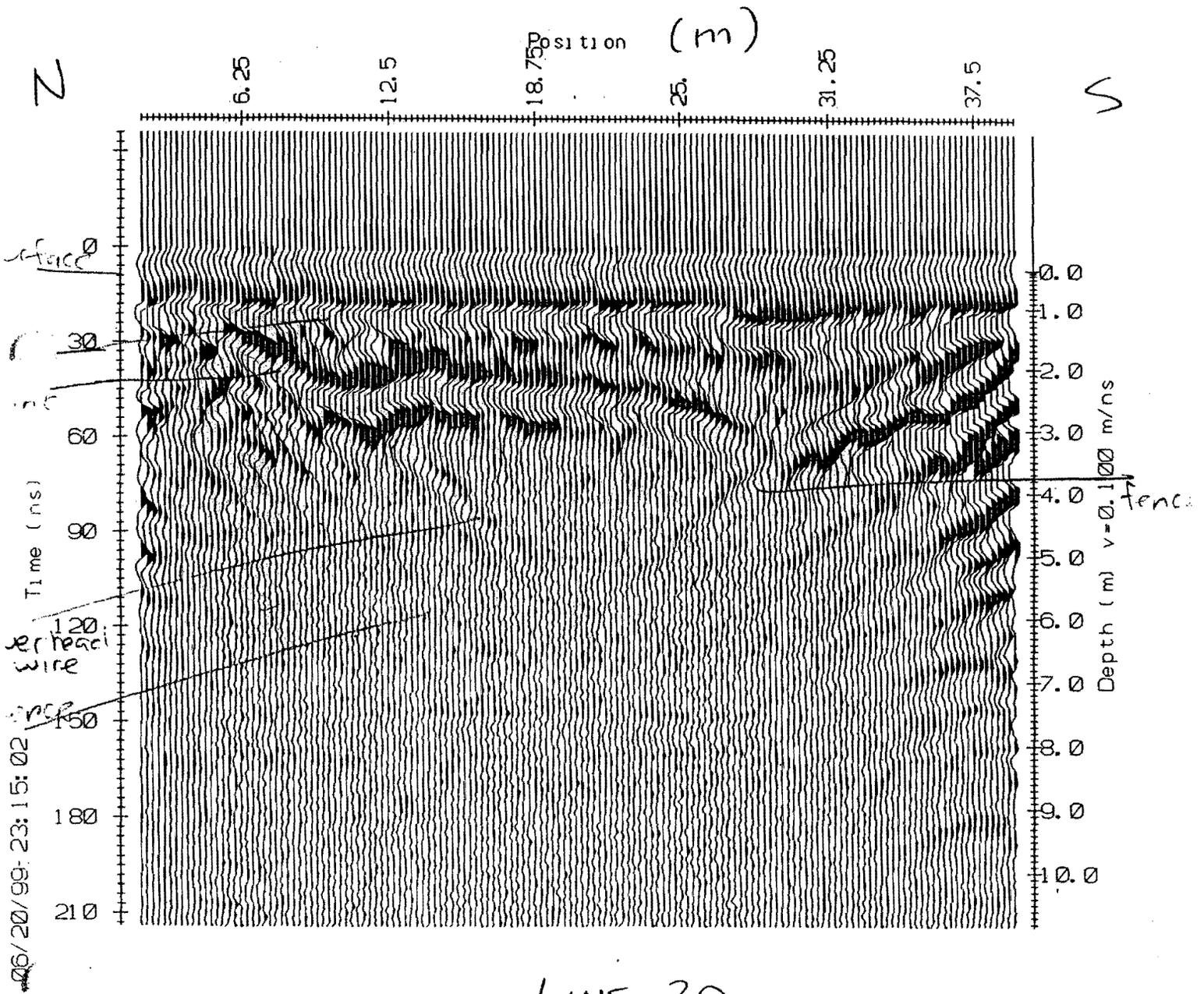
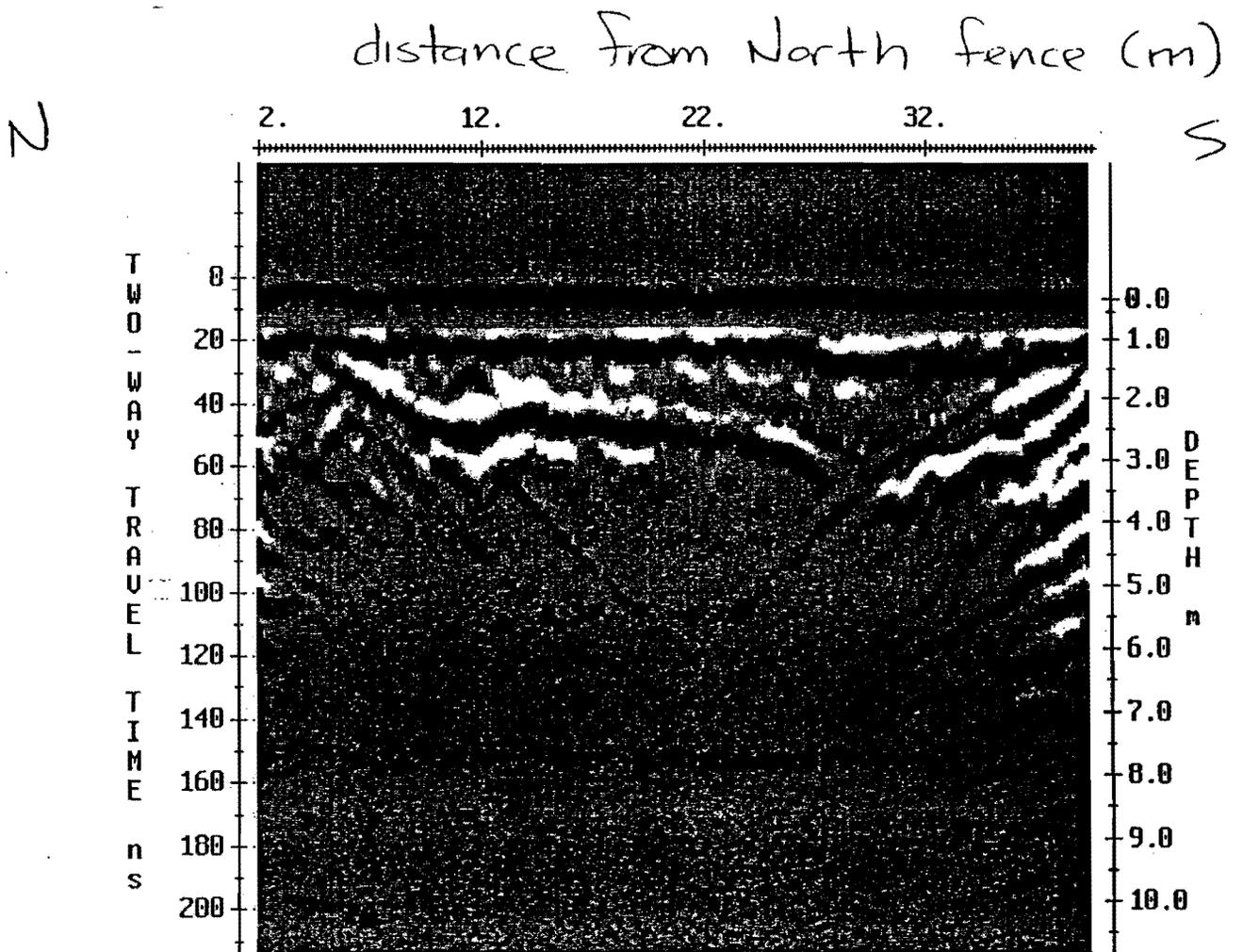


FIGURE 10



LINE 20

PulseEKKO Data Sheet

DATA FILE #1 PARAMETERS:

Data File = C:\SAGE99\DATA2.hd

line 20 Line 21
 20/06/99
 NUMBER OF TRACES = 153
 NUMBER OF PTS/TRC = 312
 TIMEZERO AT POINT = 52
 TOTAL TIME WINDOW = 250
 STARTING POSITION = 2.0000
 FINAL POSITION = 40.0000
 STEP SIZE USED = 0.2500
 POSITION UNITS = metres
 NOMINAL FREQUENCY = 100.00
 ANTENNA SEPARATION = 1.0000
 PULSER VOLTAGE (V) = 400
 NUMBER OF STACKS = 32
 SURVEY MODE = Reflection
 COLLECTED BY PE100 - CON: 950910 RX: 950623
 TX: 950707 ANT: ??

PROCESSING SELECTED:

Trace Stacking : 1
 Points Stacking : 3
 Trace Differencing: N
 Correction : DEWOW
 Gain Type : AUTOGAIN
 Selection : Time = all
 Position = all
 Picture Id : 06/20/99-23:13:16

PLOT LAYOUT PARAMETERS:

Traces per Inch : 25.000
 Width/Spacing Ratio: 2.000
 Trace Position : 1.000" to 6.500"
 Left/Right Margin : 0.500" / 0.000"
 Border Size : 0.500"
 Page Length/Width : 11.000" / 8.500"
 Printer Name : HP LaserJet II 300dpi

FIGURE 12

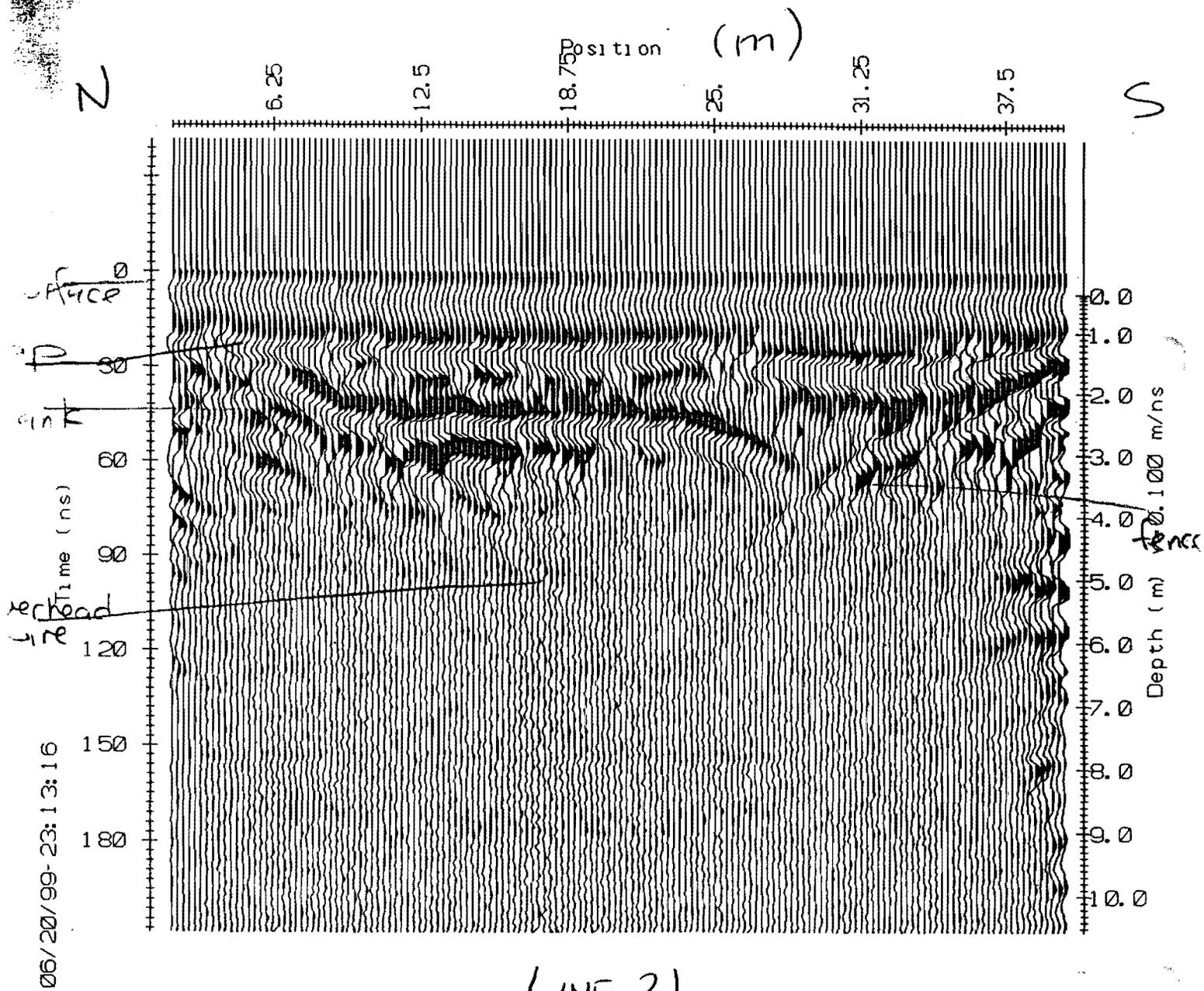
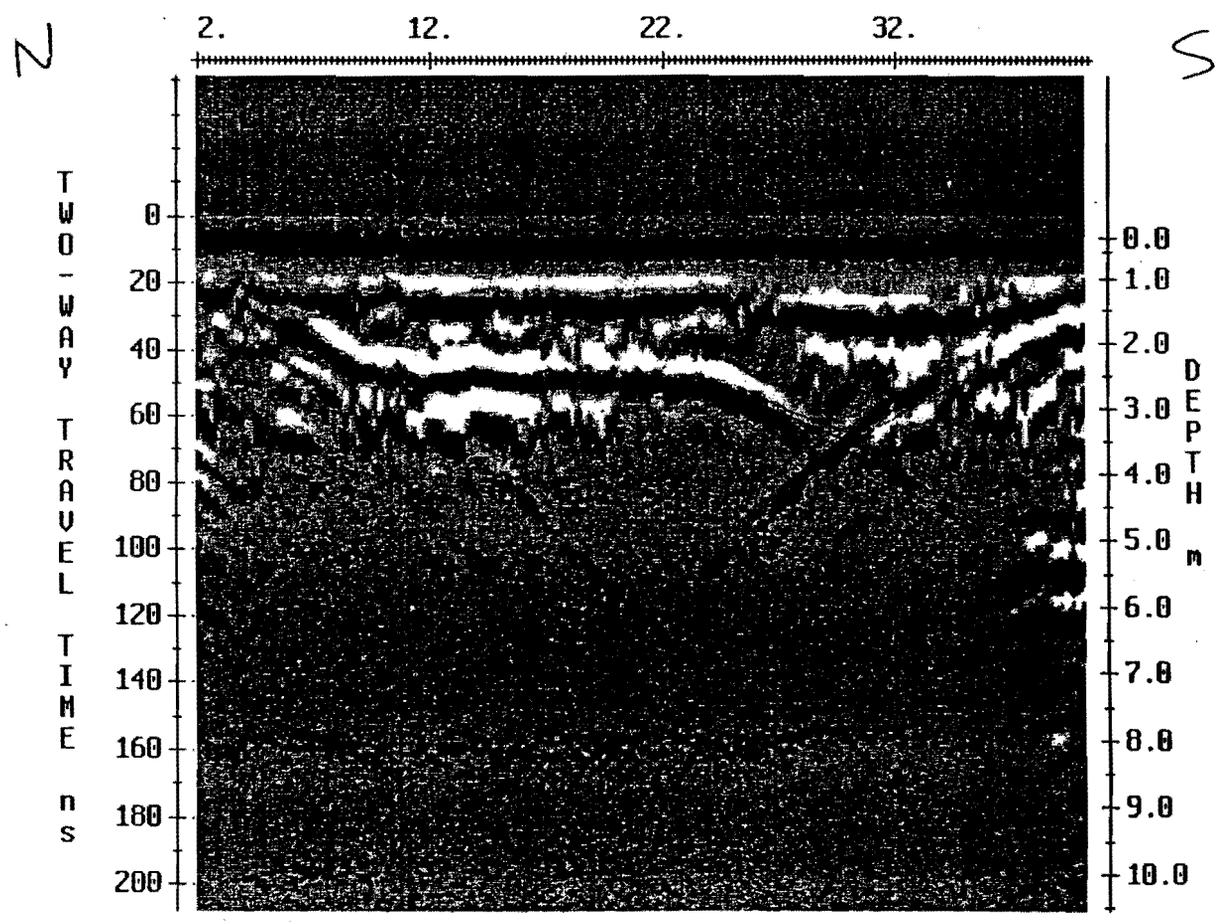


FIGURE 13

distance from North fence (m)



LINE 21

PulseEKKO Data Sheet

DATA FILE #1 PARAMETERS:

Data File = C:\SAGE99\DATA3.hd

line 20

Line 22

20/06/99

NUMBER OF TRACES = 157
 NUMBER OF PTS/TRC = 312
 TIMEZERO AT POINT = 49
 TOTAL TIME WINDOW = 250
 STARTING POSITION = 2.0000
 FINAL POSITION = 41.0000
 STEP SIZE USED = 0.2500
 POSITION UNITS = metres
 NOMINAL FREQUENCY = 100.00
 ANTENNA SEPARATION = 1.0000
 PULSER VOLTAGE (V) = 400
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 TX: 950707 ANT: ??

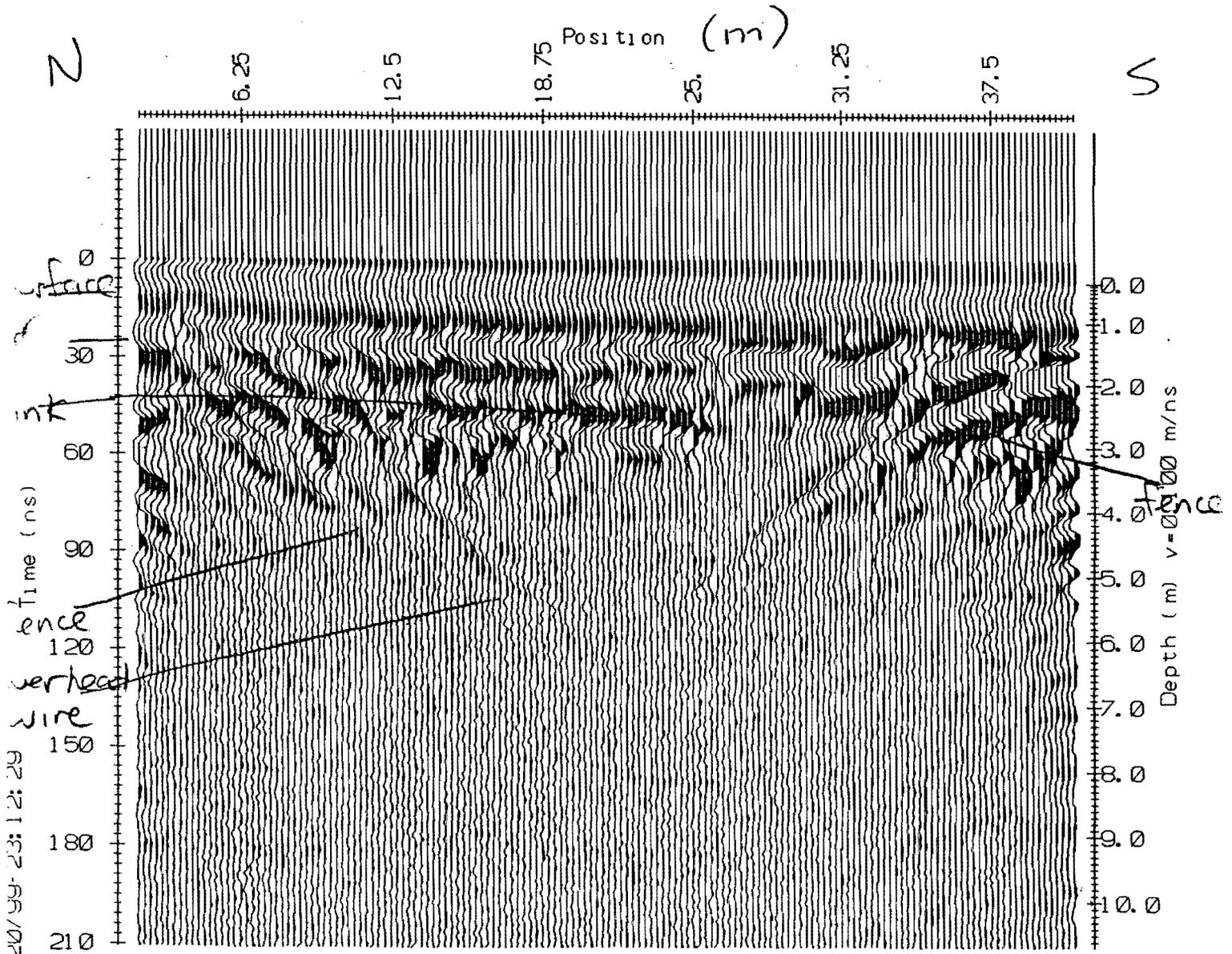
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 Gain Type : AUTOGAIN
 Selection : Time = all
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 Picture Id : 06/20/99-23:12:29

PLOT LAYOUT PARAMETERS:

Traces per Inch : 25.000
 Width/Spacing Ratio: 2.000
 Trace Position : 1.000" to 6.500"
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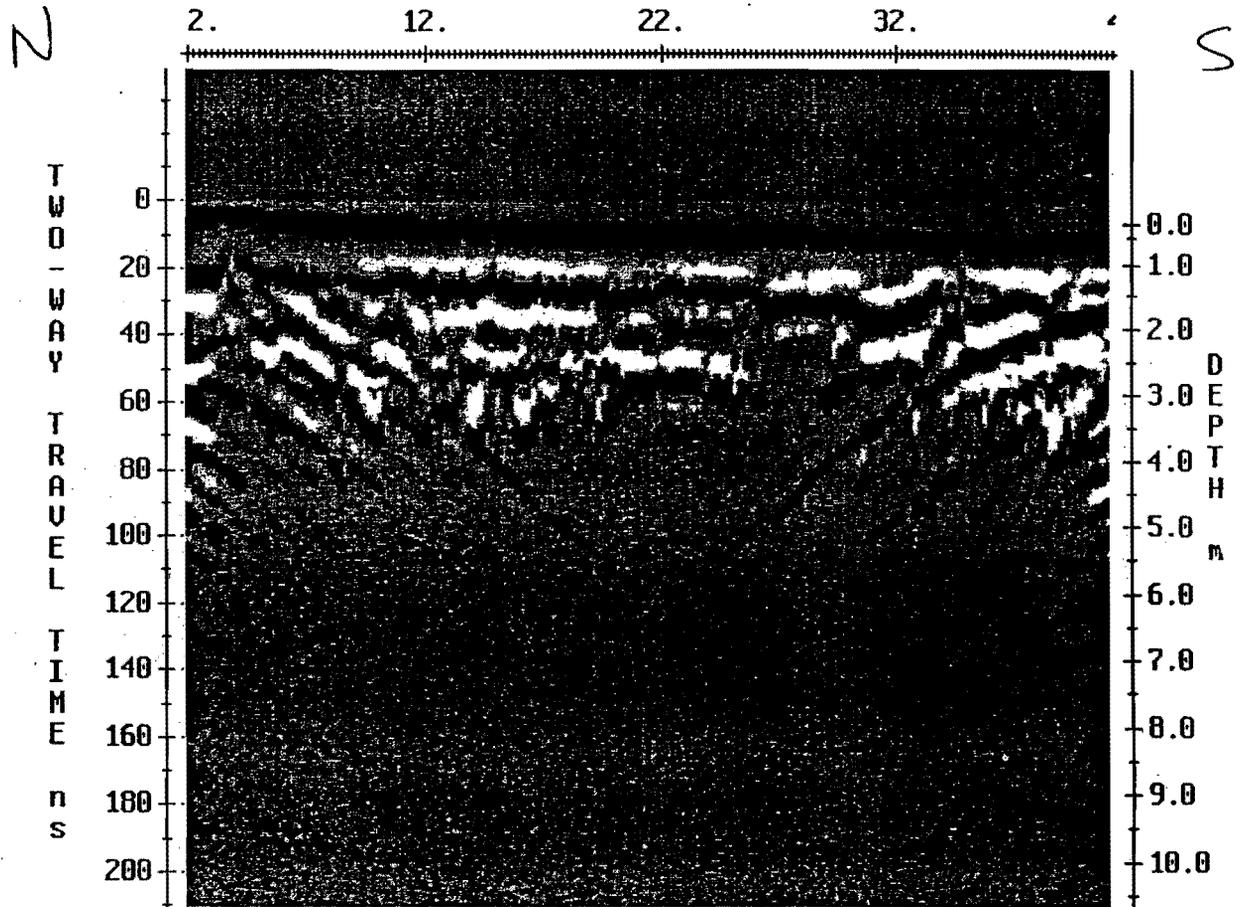
FIGURE 15



LINE 22

FIGURE 16

distance from North fence (m)



LINE 22

PulseEKKO Data Sheet

DATA FILE #1 PARAMETERS:

Data File = C:\SAGE99\DATA5.hd

line 20

Line 44

20/06/99

NUMBER OF TRACES = 170
 NUMBER OF PTS/TRC = 312
 TIMEZERO AT POINT = 52
 TOTAL TIME WINDOW = 250
 STARTING POSITION = 2.0000
 FINAL POSITION = 44.2500
 STEP SIZE USED = 0.2500
 POSITION UNITS = metres
 NOMINAL FREQUENCY = 100.00
 ANTENNA SEPARATION = 1.0000
 PULSER VOLTAGE (V) = 400
 NUMBER OF STACKS = 32
 SURVEY MODE = Reflection
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 TX: 950707 ANT: ??

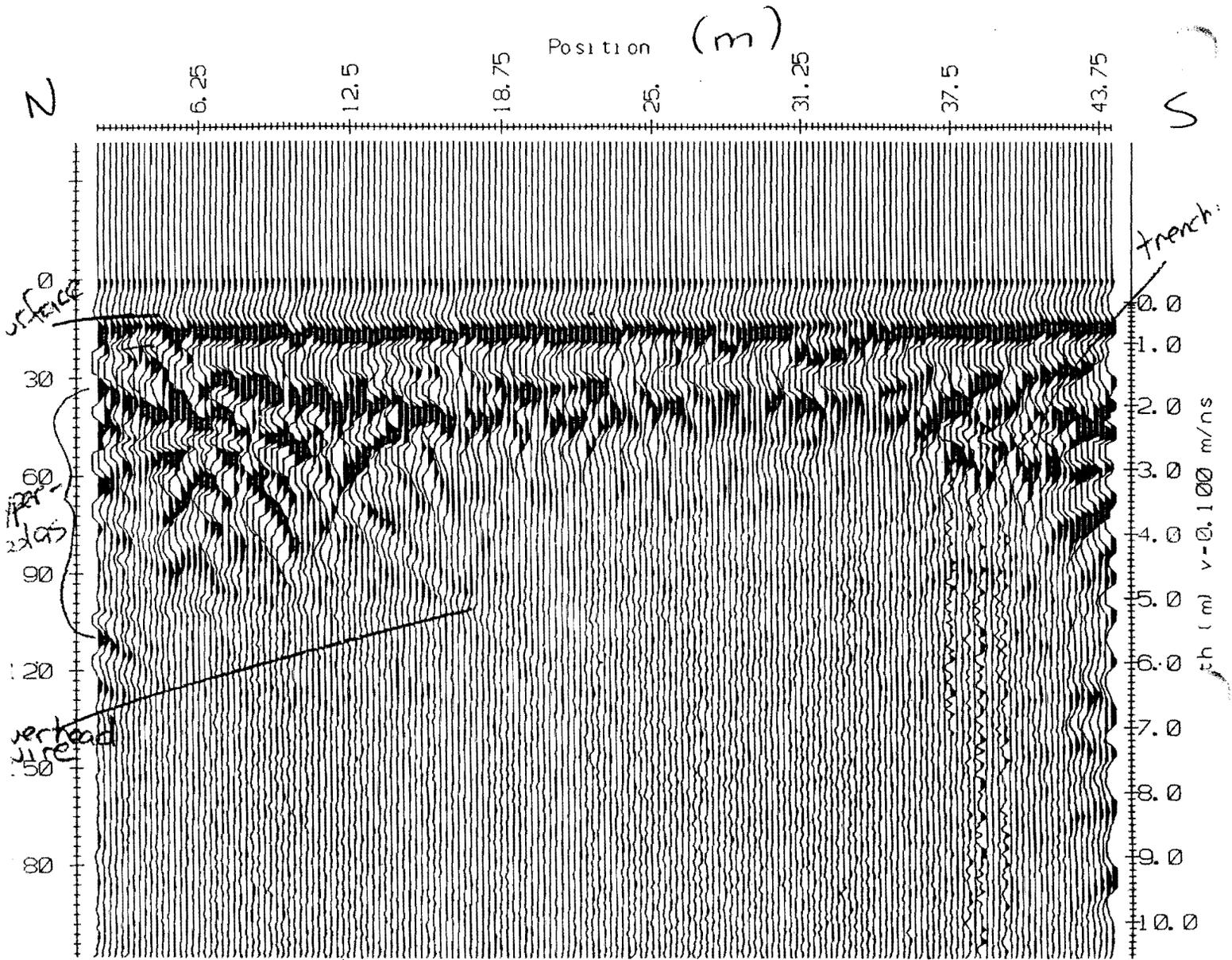
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 Position = all
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PLOT LAYOUT PARAMETERS:

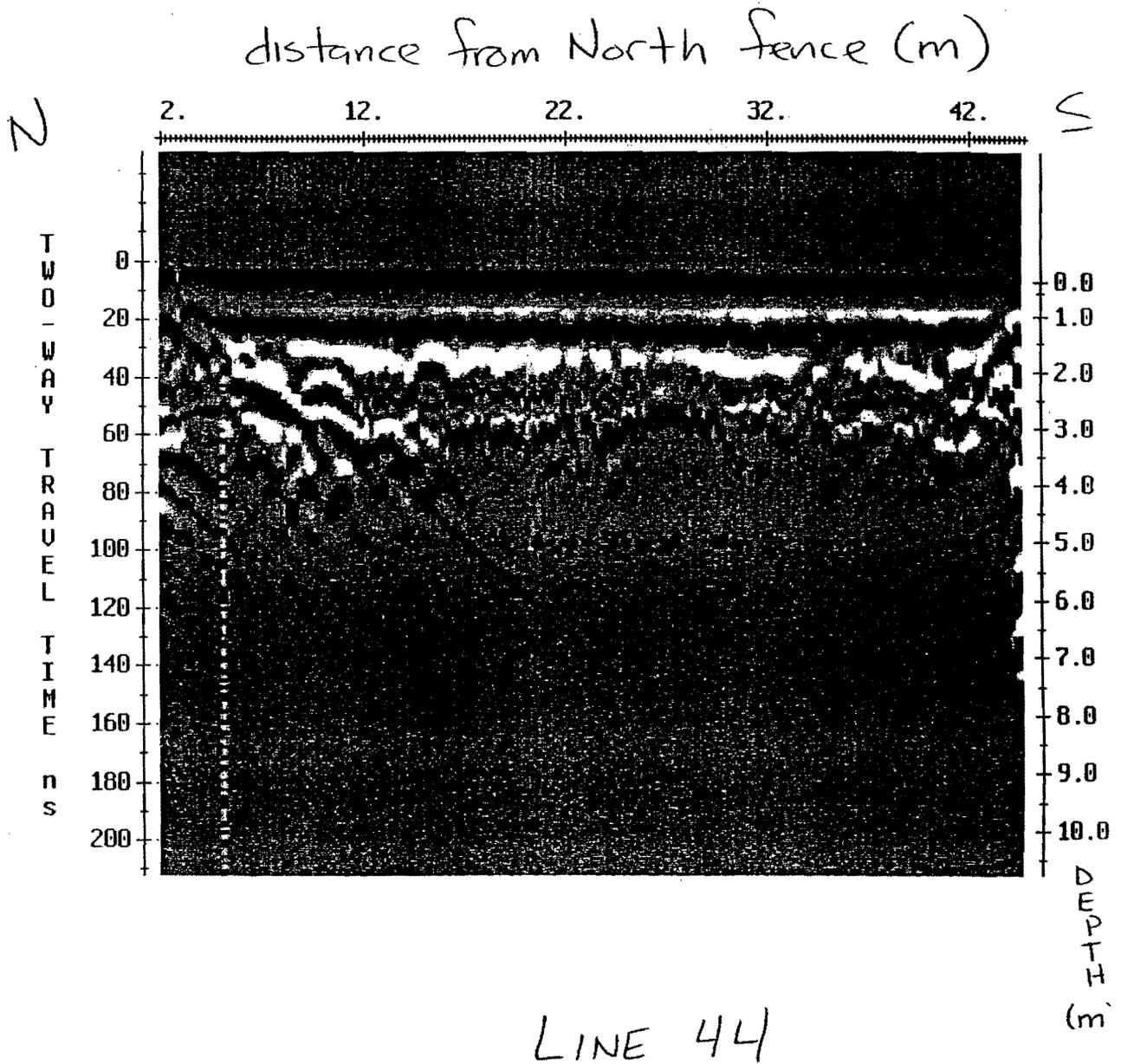
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 Printer Name : HP LaserJet II 300dpi

FIGURE 18



LINE 44

FIGURE 19



PulseEKKO Data Sheet

DATA FILE #1 PARAMETERS:

Data File = C:\SAGE99\DATA4.hd

line 20

Line 49

20/06/99

NUMBER OF TRACES = 171
 NUMBER OF PTS/TRC = 312
 TIMEZERO AT POINT = 47
 TOTAL TIME WINDOW = 250
 STARTING POSITION = 2.0000
 FINAL POSITION = 44.5000
 STEP SIZE USED = 0.2500
 POSITION UNITS = metres
 NOMINAL FREQUENCY = 100.00
 ANTENNA SEPARATION = 1.0000
 PULSER VOLTAGE (V) = 400
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 SURVEY MODE = Reflection
 COLLECTED BY PE100 - CON: 950910 RX: 950623
 TX: 950707 ANT: ??

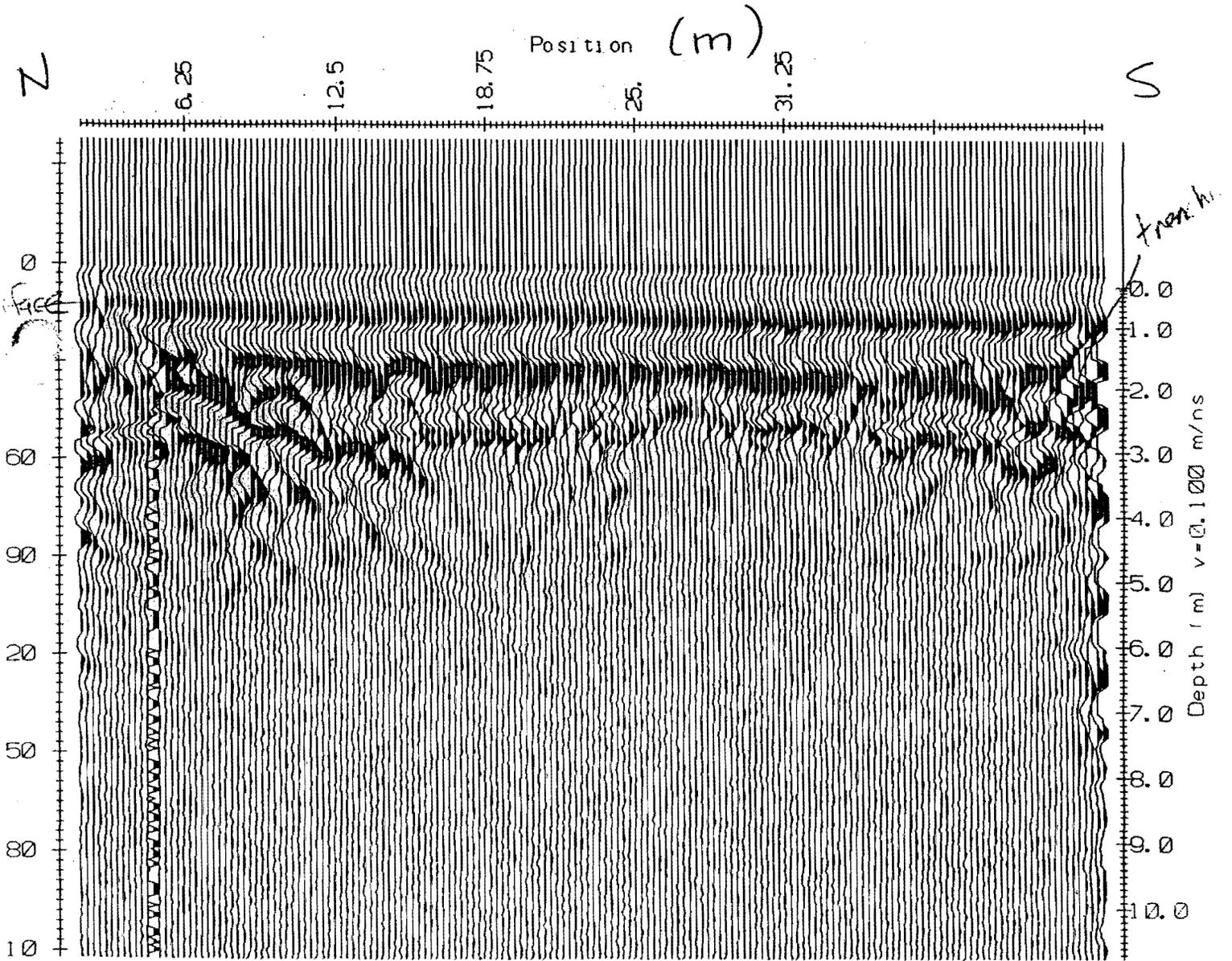
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PLOT LAYOUT PARAMETERS:

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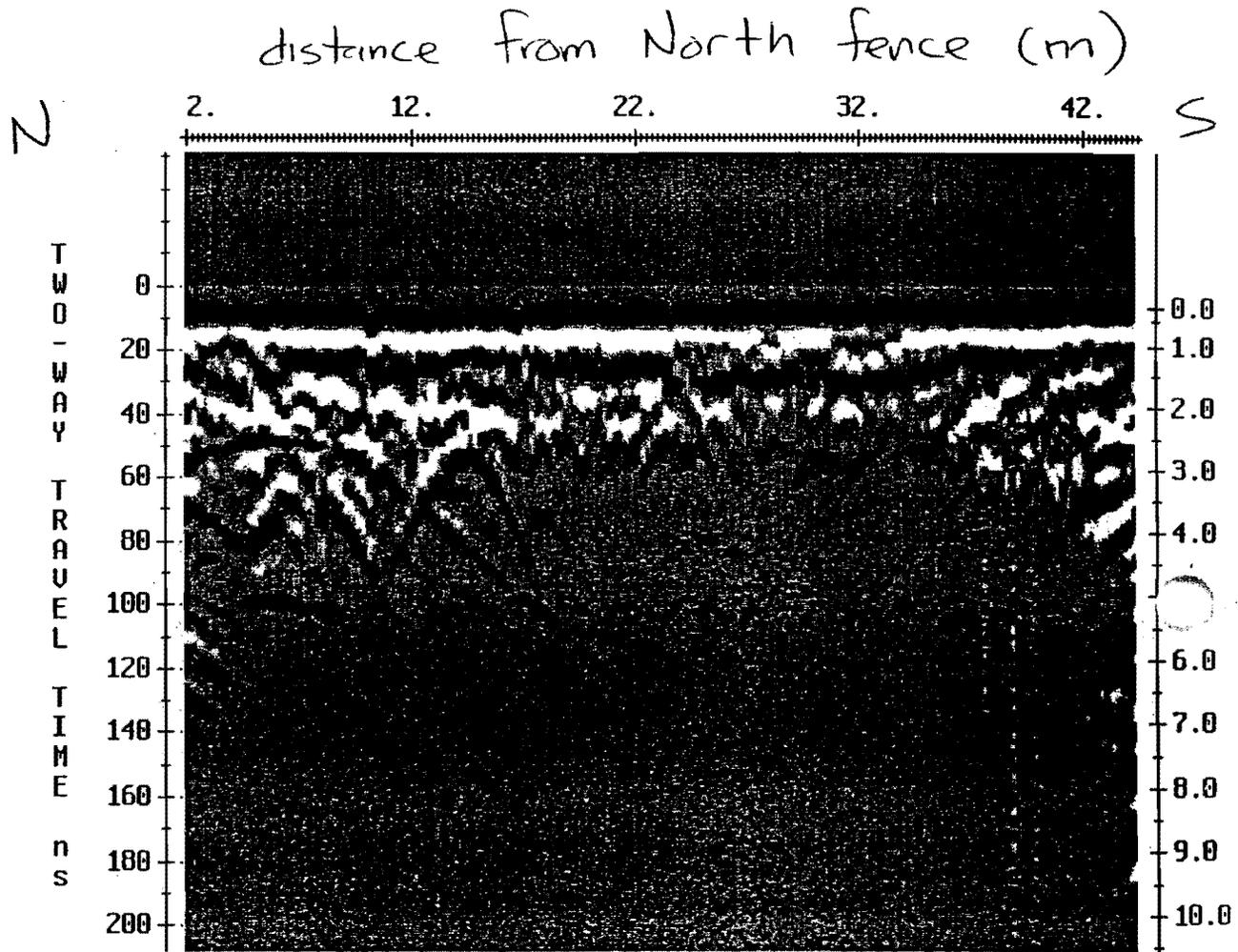
FIGURE 21



hyper bolus

LINE 49

FIGURE 22



LINE 49

PulseEKKO Data Sheet

DATA FILE #1 PARAMETERS:

Data File = C:\SAGE99\DATA6.hd

line 20

Line 89

20/06/99

NUMBER OF TRACES = 169
NUMBER OF PTS/TRC = 312
TIMEZERO AT POINT = 52
TOTAL TIME WINDOW = 250
STARTING POSITION = 2.0000
FINAL POSITION = 44.0000
STEP SIZE USED = 0.2500
POSITION UNITS = metres
NOMINAL FREQUENCY = 100.00
ANTENNA SEPARATION = 1.0000
PULSER VOLTAGE (V) = 400
NUMBER OF STACKS = 32
SURVEY MODE = Reflection
COLLECTED BY PE100 - CON: 950910 RX: 950623
TX: 950707 ANT: ??

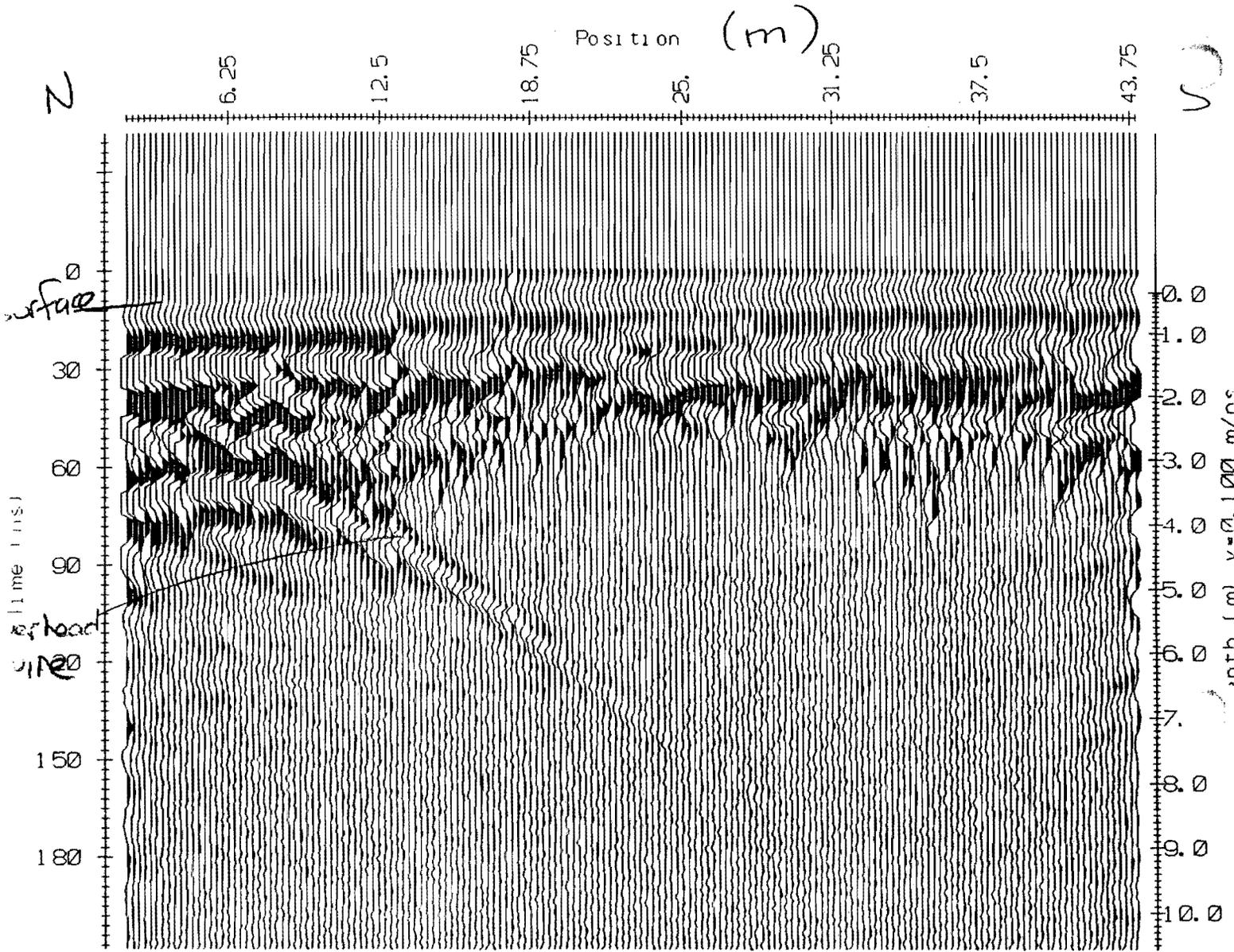
PROCESSING SELECTED:

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Points Stacking : 3
Trace Differencing: N
Correction : DEWOW
Gain Type : AUTOGAIN
Selection : Time = all
Position = all
Picture Id : 06/20/99-23:09:39

PLOT LAYOUT PARAMETERS:

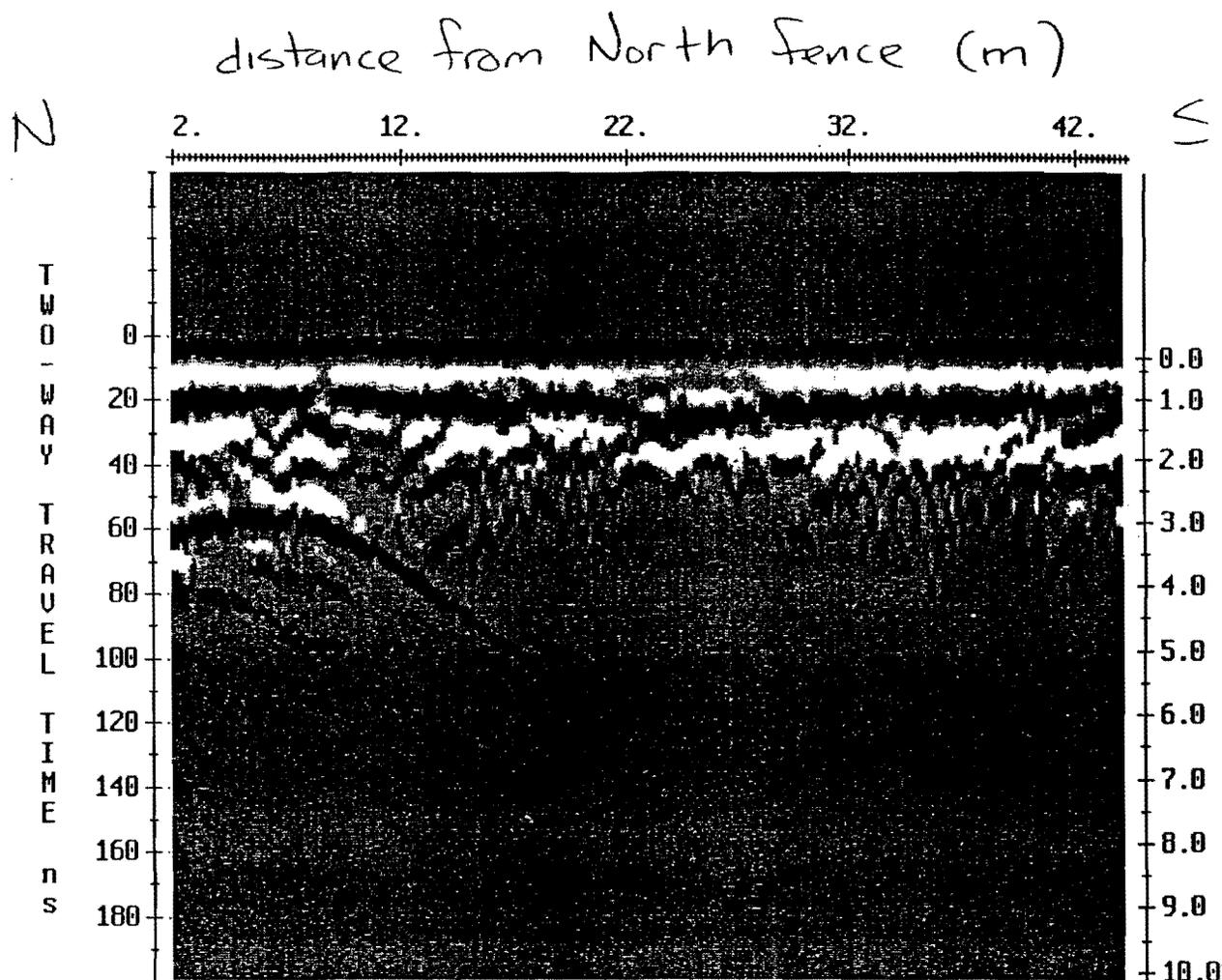
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Printer Name : HP LaserJet II 300dpi

FIGURE 24



LINE 89

FIGURE 25



LINE 89