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REPORT

Integrated Geophysical Investigation
Material Disposal Area C, TA-~~21~~ 50
Los Alamos National Laboratory
Los Alamos, New Mexico

September 31, 2002

Prepared for:
Los Alamos National Laboratory ER Project

Los Alamos
NATIONAL LABORATORY

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1.0 EXECUTIVE SUMMARY

Advanced Geological Services, Inc. (AGS) performed an integrated geophysical survey for Los Alamos National Laboratory (LANL) at the Material Disposal Area (MDA) C (TA-50) site on September 23 through 30, 2002. Previous geophysical work was performed by AGS in September 2001 to delineate existing disposal pits and to map the thickness of cover materials. The results of that investigation were successful; however, interference from the chain link fence obscured the southern and eastern pit boundaries. The chain link fence was removed in September 2002 so that additional geophysical data could be acquired to confirm the southern and eastern pit boundaries and determine if the pits extended beyond the fence line.

The geophysical survey was performed using terrain conductivity (EM31), high-sensitivity metal detector (EM61), and digital ground-penetrating radar (GPR) techniques. The methodology and instrumentation used during this survey was consistent with the previous survey to allow integrated data processing and interpretation.

The EM data acquired in the eastern survey area show low values and laterally homogenous materials typically observed in natural sediments and rocks. Similarly, the GPR data suggest the presence of native subsurface conditions over the majority of this area. EM interference created by utilities was encountered along the southern site boundary, which obfuscated delineation of the southern boundary of Pit 1. However, a subtle decrease in values is observed in the terrain conductivity, in-phase, and EM61 data between the interpreted trench location and the apparent location of the utilities. The location of the decrease suggests the pit boundary occurs inside the fence line. GPR lines run across this boundary support this conclusion. EM and GPR anomalies observed outside the fence line in the southern portion of the survey area are attributed to buried utilities and excavations that appear unrelated to disposal pits.

In conclusion, the geophysical data acquired during this investigation show no evidence of disposal pits outside the fence line in the surveyed areas.

2.0 INTRODUCTION

Advanced Geological Services, Inc. (AGS) performed an integrated geophysical survey for Los Alamos National Laboratory (LANL) at the Material Disposal Area (MDA) C (TA-50) site. Previous geophysical work was performed by AGS at MDA C in September 2001. The objectives of the previous survey were to delineate existing disposal pits and shafts and to map the thickness of cover materials. The results of that investigation were successful; however, interference from the chain link fence obscured the southern and eastern pit boundaries. The chain link fence was removed in September 2002 in an attempt to eliminate the interference so that additional geophysical data could be acquired to confirm the southern and eastern pit boundaries and determine if the pits extended beyond the fence line.

The additional fieldwork was performed on September 23 through 30, 2002 using terrain conductivity (EM31), high-sensitivity metal detector (EM61), and digital ground-penetrating radar (GPR) techniques. The methodology and instrumentation used during this survey was consistent with the previous survey to allow integrated data processing and interpretation.

3.0 METHODOLOGY

3.1. GEODETIC POSITIONING

All geophysical instruments were integrated with a differential global positioning (DGPS) system to allow real-time navigation, provide accurate location of geophysical measurements, eliminate the need to establish a local reference grid, and allow direct integration with LANL's geographic information system (GIS). The geographic positions of all measurement points were acquired as the geophysical data were collected. The data were acquired using a Trimble Pathfinder Pro XRS system, which allowed accurate positioning with real-time accuracy better than 1 meter. Coordinates are presented in US State Plan 1983 system, New Mexico Central 3002 zone, NAD 1983 (Conus) datum.

3.2. TERRAIN CONDUCTIVITY (EM31)

3.2.1. Data Collection

The terrain conductivity method uses the principle of electromagnetic induction to measure the electrical conductivity of earth/fill materials. Lateral changes in terrain conductivity can indicate the presence of disturbed ground, disposal areas, buried metallic and non-metallic waste, and impacted ground water. In addition, it is also useful in detecting linear objects such as utilities.

A Geonics EM31-MK2 was used to conduct the survey. The EM31 operates in accordance with the theory of operation at low induction numbers. An alternating current is passed through transmitter coil to induce eddy currents into the ground below the instrument. These eddy currents generate a secondary magnetic field. The quadrature-phase component of the induced secondary magnetic field is detected by a receiver coil and measured by the instrument. The measured response is linearly related to the terrain conductivity. The instrument converts the measured signal and displays it as terrain conductivity in milliSeimens per meter (mS/m).

EM31 data were recorded at approximately 1-ft intervals along lines spaced approximately 10-ft apart. Geodetic coordinates were recorded at 1-second intervals using an integrated GPS system. A base station, which was free from cultural interference, was occupied at the beginning and end of each survey day to calibrate the instrument and perform system functional tests. During these tests, battery, phasing, and sensitivity checks were performed.

3.2.2. General Data Interpretation

Terrain conductivity (EM31) data are commonly used to map the lateral changes in electrical conductivity. These changes can indicate the presence of disturbed ground, buried waste, changes in soil moisture, and the occurrence of many dissolved constituents in soil moisture and ground water. In this environment, disturbed terrain, disposal areas, dissolved constituents in soil moisture often produce elevated terrain conductivity anomalies.

The character of EM anomalies can be complex when produced by buried metal objects. Anomalies can be positive, negative, or both depending upon the location and orientation of the object with respect to the instrument orientation. If sufficient lateral resolution is achieved, shallow anomalies caused by significant metal objects are typically represented as a negative anomaly directly over the object that is surrounded by a "halo" of elevated conductivity.

3.3. HIGH-SENSITIVITY METAL DETECTOR (EM61)

3.3.1. Data Collection

Buried metal objects can be effectively located using a Geonics EM61-MK2 High-Sensitivity Metal Detector. The EM61 is a time domain electromagnetic (EM) system that can discriminate between conductive soils and metal objects. It has numerous advantages over other commonly used metal detection devices. For example, it is significantly less sensitive to cultural interference such as aboveground metal objects and overhead power lines.

The EM61 generates rapid electromagnetic pulses and measures the response of the subsurface between pulses. Secondary EM fields are generated in the ground after each pulse. These fields dissipate rapidly in earth materials but remain for a longer time in buried metal objects. The EM61 measures the prolonged metal response only after the earth response has dissipated. This response is measured and displayed in milliVolts (mV).

Very high-resolution data are automatically recorded as the sensors are pulled along the ground surface. Survey wheels attached to the sensors facilitate data collection by allowing direct measurement of the distance traveled. The lateral position of each measurement is automatically recorded using a data logger. This method allows data to be recorded virtually as fast as the operator can walk. Consequently, detailed site coverage can be achieved in a cost-effective manner.

For this investigation, data were collected at less than 1-ft intervals along lines spaced approximately 10-ft apart. Geodetic coordinates were recorded at 1-second intervals using an integrated GPS system so that each measurement point could be accurately located. A base station, which was free from cultural interference, was occupied at the

beginning and end of each survey day to calibrate the instrument and perform system functional tests. During these tests, battery, data repeatability, and sensitivity checks were performed.

3.3.2. General Data Interpretation

The EM61 anomaly maps represent the instrument's response to metal objects. Theoretically, if no metal objects were present, the instrument reading would be zero. The amplitude of any anomaly is a function of the distance (depth) to the object and the amount of metal present. Several data channels are recorded at each measurement point. The upper and lower coil channels indicate the response from each coil in milliVolts (mV). The presence of buried metal would produce only positive responses from each of these coils. The differential channel, which is the difference between the upper and lower receivers, can be used to reduce the unwanted effects from small, near-surface metal objects and enhance the response from more significant objects. Buried metal objects produce a positive differential response. Objects located above the ground surface often produce a negative value since the response from the upper coil is higher than normal. The differential data therefore not only reduces the effects of small, near surface metal objects; it also provides an indication of the presence of cultural interference as well.

3.4. GROUND PENETRATING RADAR (GPR)

The GPR technique uses the transmission and reflection of radio waves to image objects beneath the ground surface. The technique responds to changes in the electrical properties of the earth or buried materials. A GPR target must possess electrical characteristics that are different from the surrounding media in order to be detected. When the transmitted wave encounters an anomalous object or layer, the wave is reflected back to the surface where it is recorded and analyzed. The waves are transmitted rapidly such that a continuous subsurface image is generated as the transmitter is pulled along the ground surface.

The GPR survey was performed using a digital SIR-2 Subsurface Interface Radar System, manufactured by Geophysical Survey Systems, Inc. Following initial field tests to determine maximum penetration and sufficient resolution, a 200 MHz transducer was chosen to perform the survey. Data were digitally recorded, displayed, and analyzed during acquisition to allow real-time interpretation. Geodetic coordinates were recorded at 1-second intervals using an integrated GPS system so that each measurement point could be accurately located.

In-field signal velocity calculations and calibrations were performed by hyperbolic fitting on a notebook computer. This calibration was performed to verify that sufficient penetration was achieved.

4.0 RESULTS AND DISCUSSION

Figure 1 presents a shaded-relief contour map of the in-phase EM data. The boundary of the area surveyed during this investigation is shown in the eastern and southern portion of the site. The eastern portion exhibit low values consistent with background readings. The same general character is observed in the terrain conductivity data (Figure 2). However, a linear anomaly coincident with the location of the chain link fence is present along the eastern site boundary. This anomaly is attributed to interference from the metal posts and horizontal support rods that remained at the top of the posts after the chain-link fencing had been removed. The effects are more noticeable in the terrain conductivity data than the in-phase data since the former is more sensitive to long metallic objects.

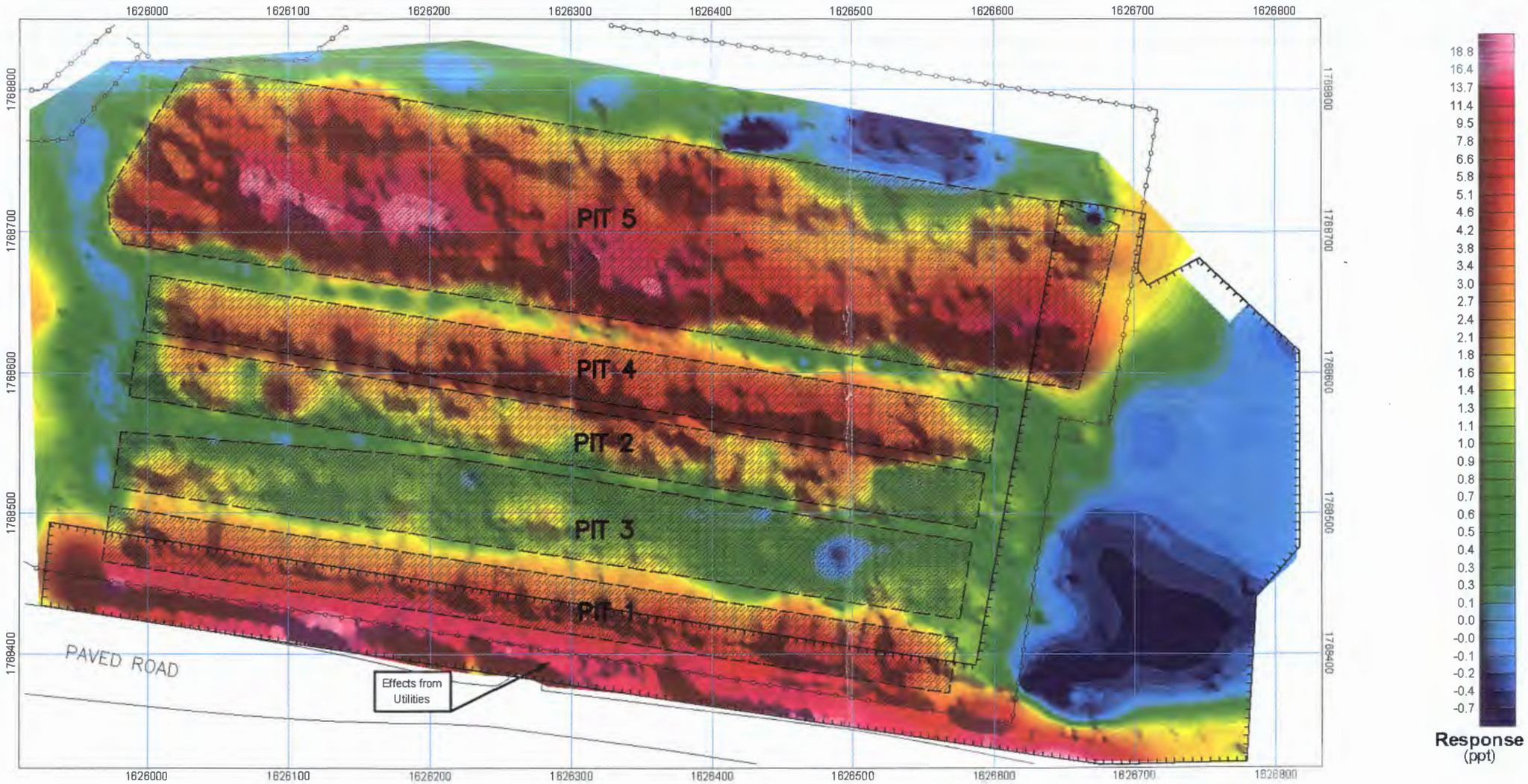
An area of elevated terrain conductivity (Figure 2) is also observed in the southeast corner of the survey area. In addition to effects from nearby utilities, it appears some of the response is due to disturbed sediments or the presence of fill materials. It is likely that this disturbance is associated with the utilities or road construction since the GPR data showed no evidence of disposal trenches or buried waste.

Anomalous terrain conductivity and in-phase values are present along the southern border of the survey area. The character of these anomalies suggests they are created by buried utilities. The presence of manhole covers and utility markers, which were visually observed in this area, serves as evidence to corroborate the interpretation.

Figure 3 presents a shaded-relief contour map of the EM61 data. The eastern area exhibits relatively low background values and shows few significant buried metal objects. Buried metal anomalies are observed near the fence line, but they do not appear to be associated with the former pits. Linear anomalies are observed along the southern border of the survey area. As in the EM31 data, these also appear to be caused by buried pipes.

GPR lines were run to obtain subsurface images. All processed GPR profiles are presented in Appendix A. Figure 4 presents a line path plot that shows the line locations. The distance or station markers along each line correspond to the distance shown on the top of the GPR profiles. Since EM interference was encountered along the southern site boundary, the GPR data was reviewed to confirm the southern boundary of Pit 1, and to verify that it does not extend outside of the fence. Figure 5 shows GPR profiles for Lines A through D. These results suggest the southern boundary of Pit 1 occurs inside the fence line as inferred from the EM data.

Lines 13 through 17 were acquired on the south side of the interpreted location of Pit 1. These data show no anomalies similar to those produced by the disposal pits. They do suggest the presence of disturbed subsurface materials, although the disruption may be related to utility excavations and road construction. Two hyperbolic anomalies are



N

50 0 50 100
feet

Survey Coordinates
System: U.S State Plane 1983
Zone: New Mexico Central 3002
Datum: NAD 1983 (Conus)
Units: Feet

LEGEND

Boundary of New Survey Area

Chain-link fence

Interpreted pit location

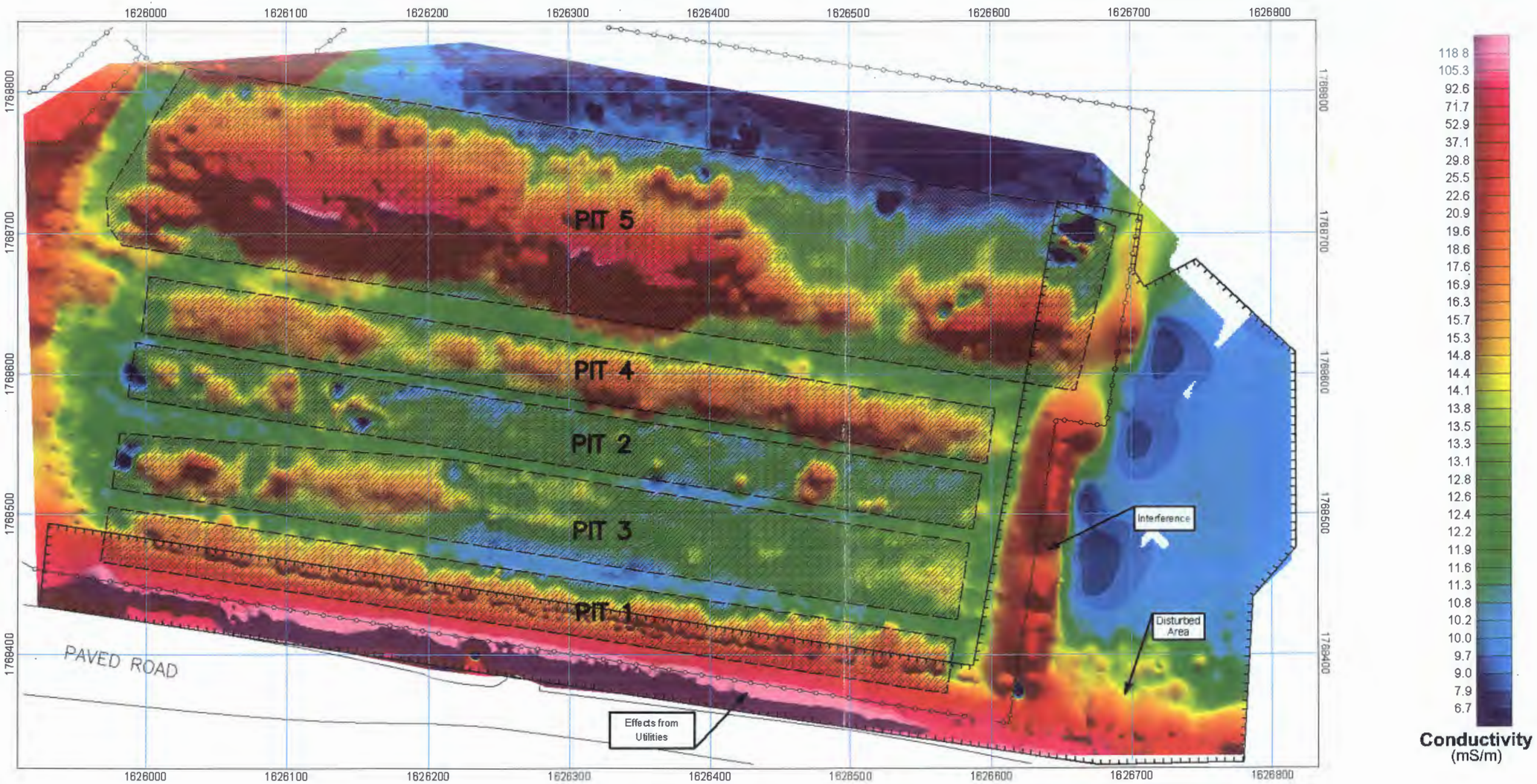
Los Alamos National Laboratory ER Project

Figure 1: Shaded Relief Map of In-phase EM31 Data
Survey Area MDA C
Los Alamos, New Mexico

Prepared for: Los Alamos ER

Prepared by: ADVANCED GEOLOGICAL SERVICES

October 31, 2002



N

50 0 50 100
feet

Survey Coordinates
System: U.S State Plane 1983
Zone: New Mexico Central 3002
Datum: NAD 1983 (Conus)
Units: Feet

LEGEND

Boundary of New Survey Area

Chain-link fence

Interpreted pit location

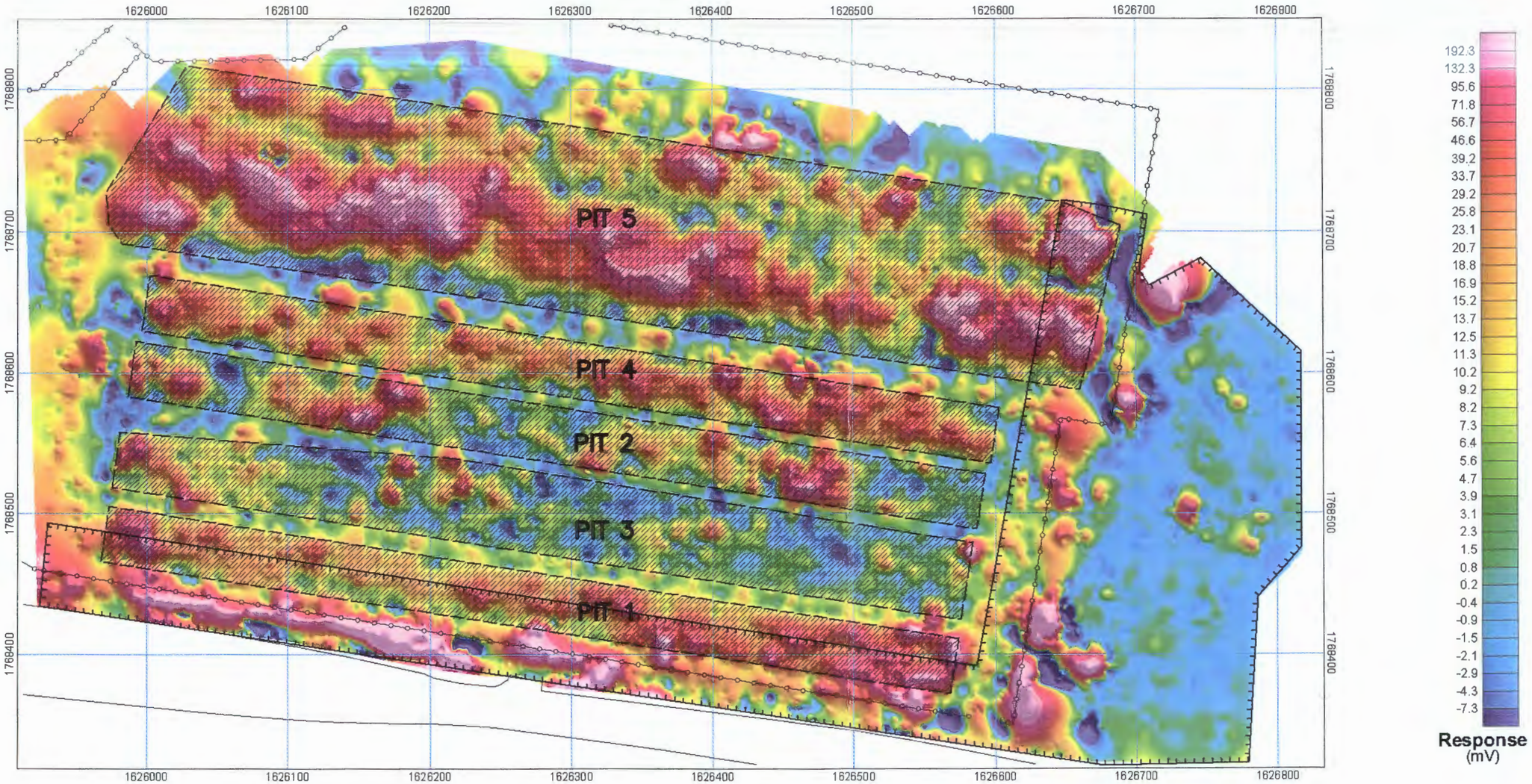
Los Alamos National Laboratory ER Project

Figure 2: Shaded Relief Map of Conductivity Data
Survey Area MDA C
Los Alamos, New Mexico

Prepared for: Los Alamos National Laboratory ER

Prepared by: ADVANCED GEOLOGICAL SERVICES

October 31, 2002



N

50 0 50 100
feet

Survey Coordinates
System: U.S State Plane 1983
Zone: New Mexico Central 3002
Datum: NAD 1983 (Conus)
Units: Feet

LEGEND

Boundary of New Survey Area

Chain-link fence

Interpreted pit location

Los Alamos National Laboratory ER Project

Figure 3: Shaded Relief Map of EM61 Data
Survey Area MDA C
Los Alamos, New Mexico

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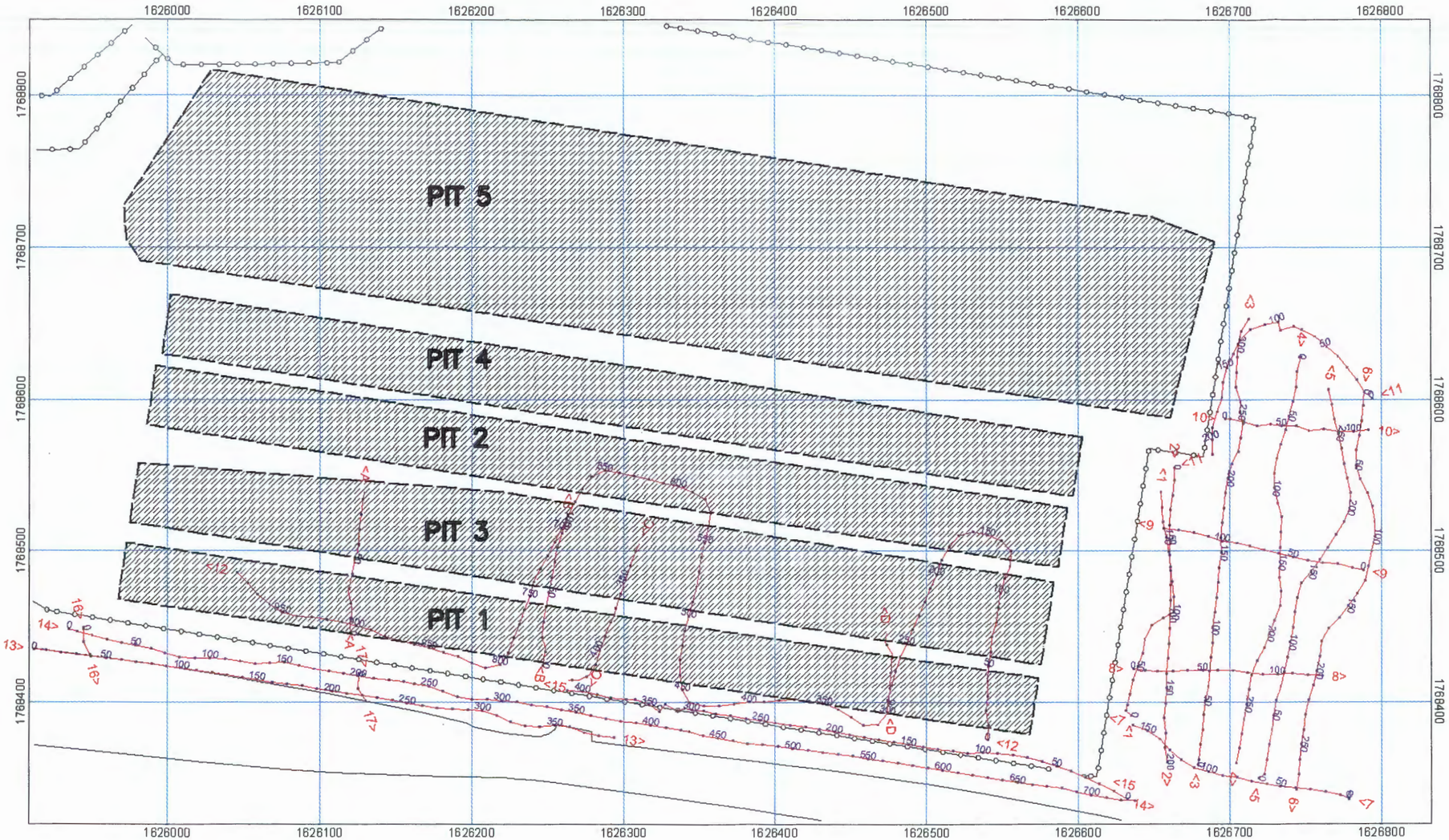

50 0 50 100
feet

Survey Coordinates
System: U.S State Plane 1983
Zone: New Mexico Central 3002
Datum: NAD 1983 (Conus)
Units: Feet

LEGEND

Boundary of New Survey Area

Chain-link fence

Former pit location based on historical data

8> 350 GPR survey line showing line number, direction, and distance (station number).

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Figure 4: GPR Line Path Plot
Survey Area MDA C
Los Alamos, New Mexico

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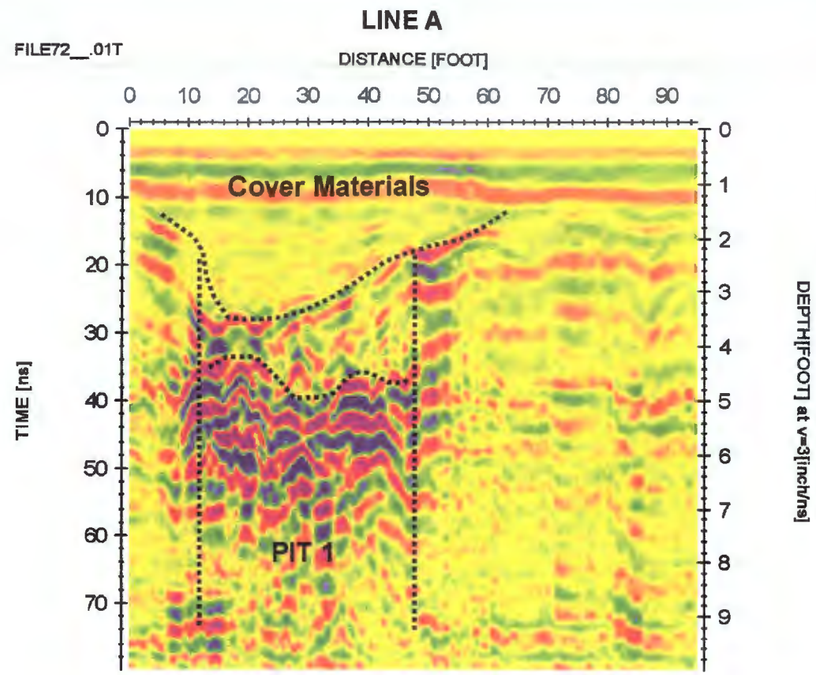
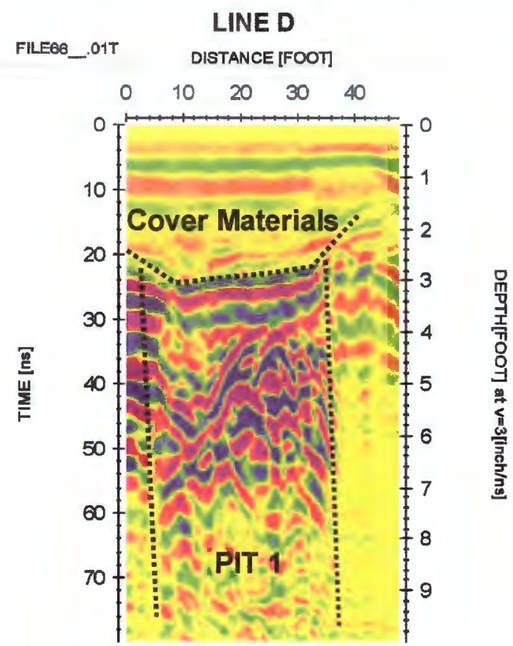
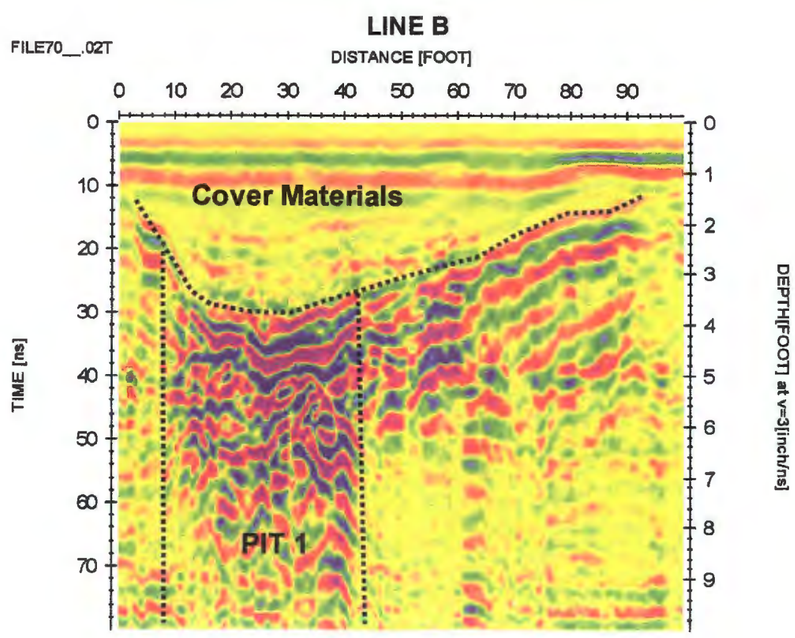
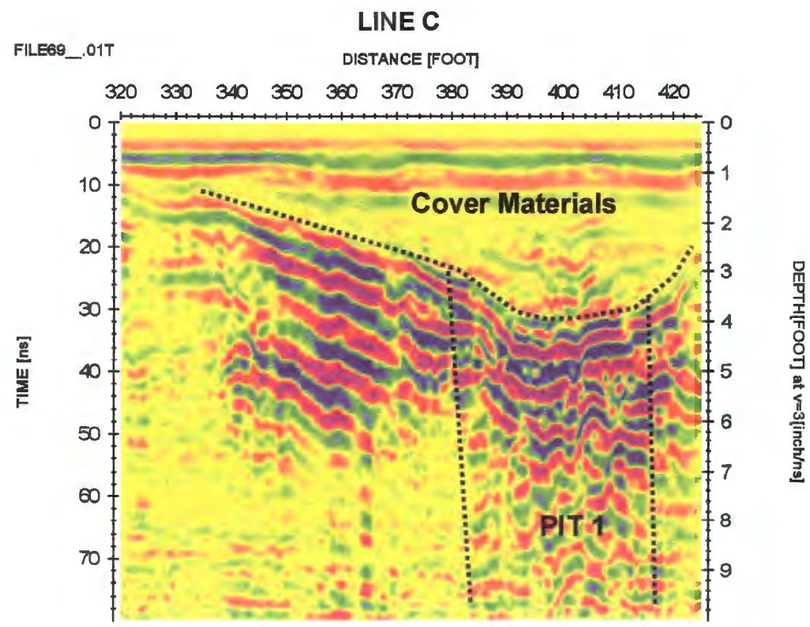
October 31, 2002

Figure 5
GPR Profile Lines A through D
Area TA-21, MDA C
Los Alamos National Laboratory, New Mexico









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observed along Line 13 at approximately 100 and 200 ft. The character of these anomalies is similar to those caused by utilities.

The GPR lines acquired in the eastern portion of the survey area were generally consistent with background data. They show laterally homogenous reflections that appear to represent native conditions. Anomalies occur near the fence line but are associated with a change in topography related to the edge of the cover materials. Examples of these anomalies are observed along Lines 1, 2, and 3.

5.0 CONCLUSIONS

The EM interference encountered along the road obfuscates delineation of the southern boundary of Pit 1. However, a decrease in values is observed in the terrain conductivity, in-phase, and EM61 data between the interpreted trench location and the apparent location of the utilities. The location of the decrease suggests the pit boundary occurs inside the fence line. GPR lines run across this boundary support this conclusion.

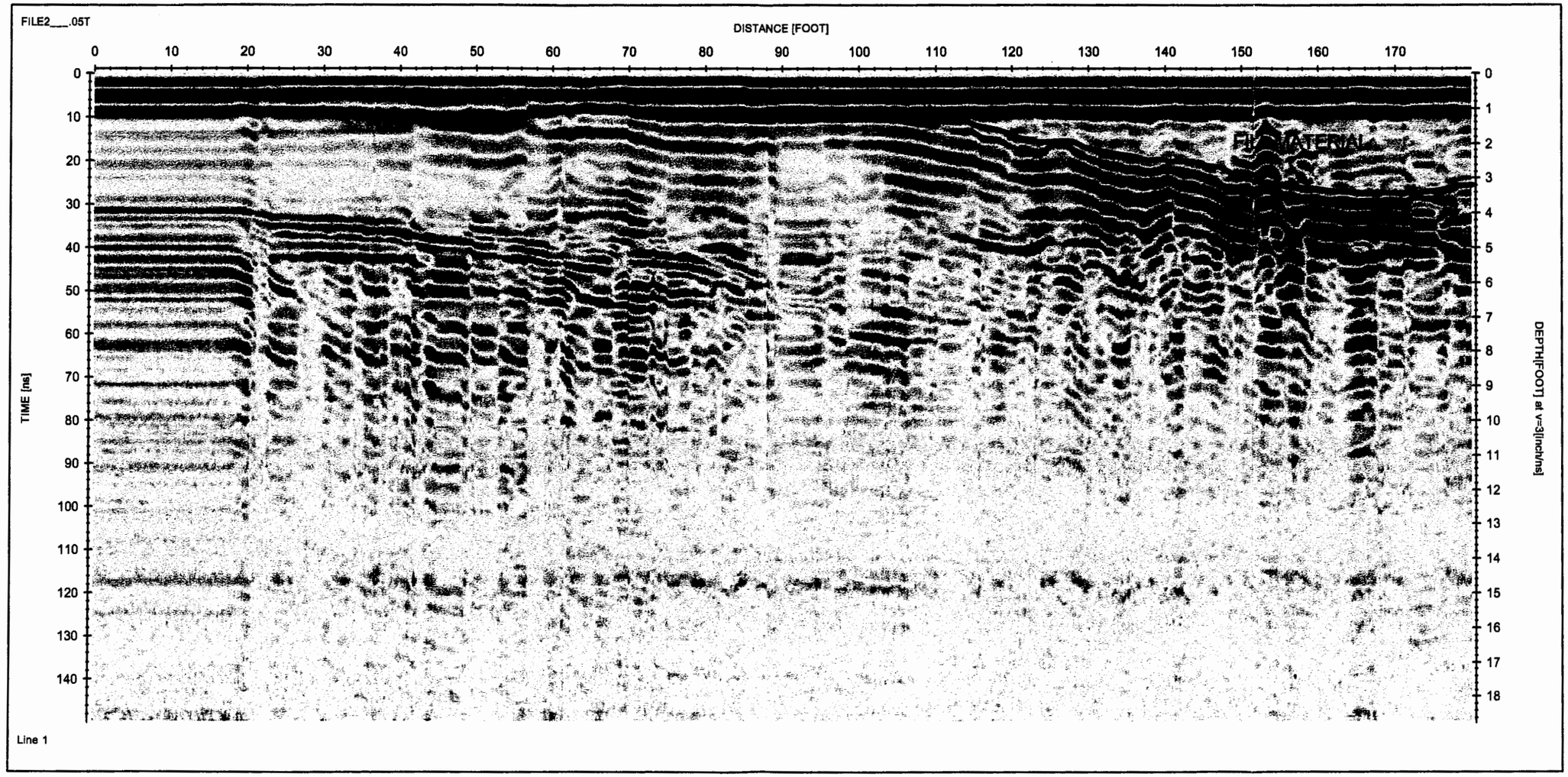
EM and GPR anomalies observed outside the fence line in the southern portion of the survey area are attributed to buried utilities and excavations that appear unrelated to disposal pits.

The EM data acquired in the eastern survey area show low values consistent with background readings. The consistency of the data suggests the presence of laterally homogenous materials typically observed in natural sediments and rocks. Similarly, the GPR data suggest the presence of native subsurface conditions over the majority of this area. Exceptions due occur near the fence line but are attributed to cover materials that extent beyond the fence line.

In conclusion, the geophysical data acquired during this investigation show no evidence of disposal pits occurring outside the fence line.

APPENDIX A
GROUND PENETRATING RADAR PROFILES

GPR PROFILE- LINE 1



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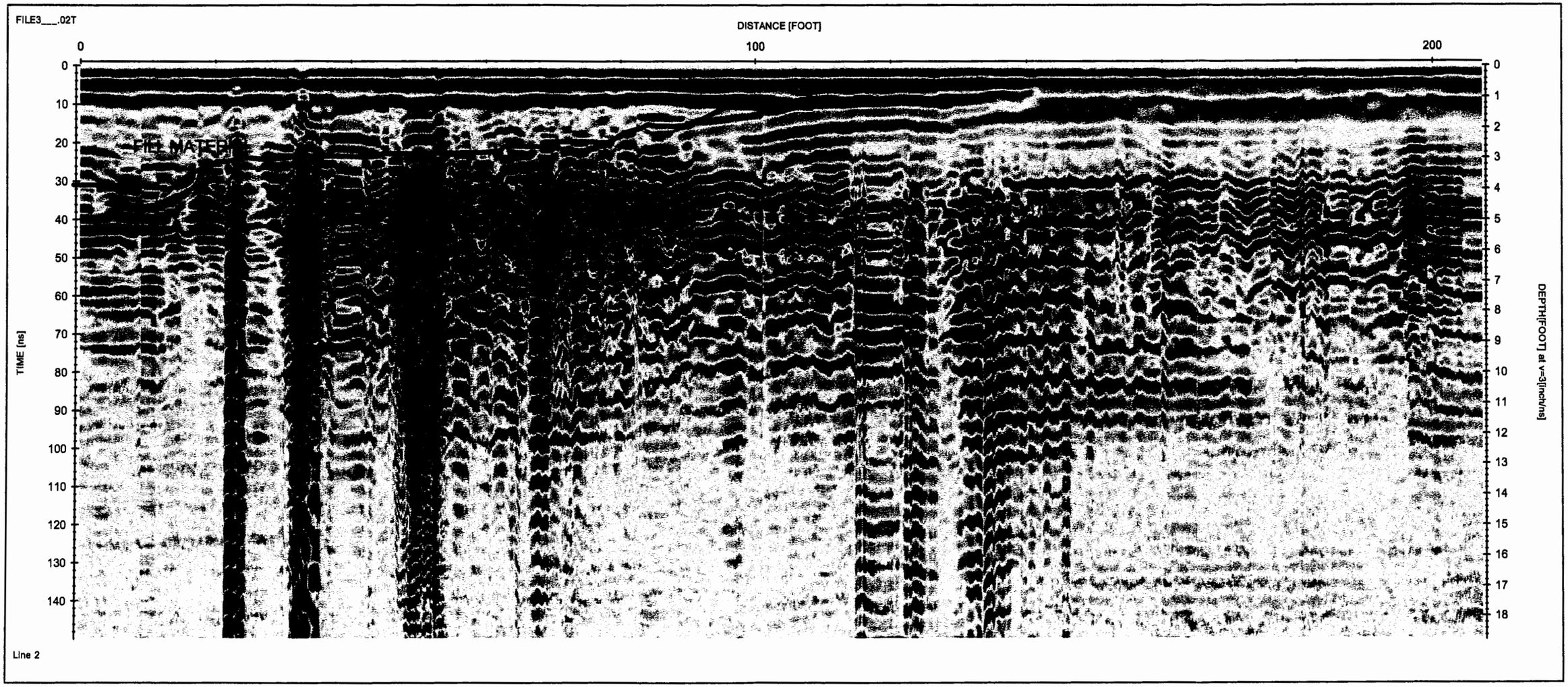
GPR PROFILE- LINE 2



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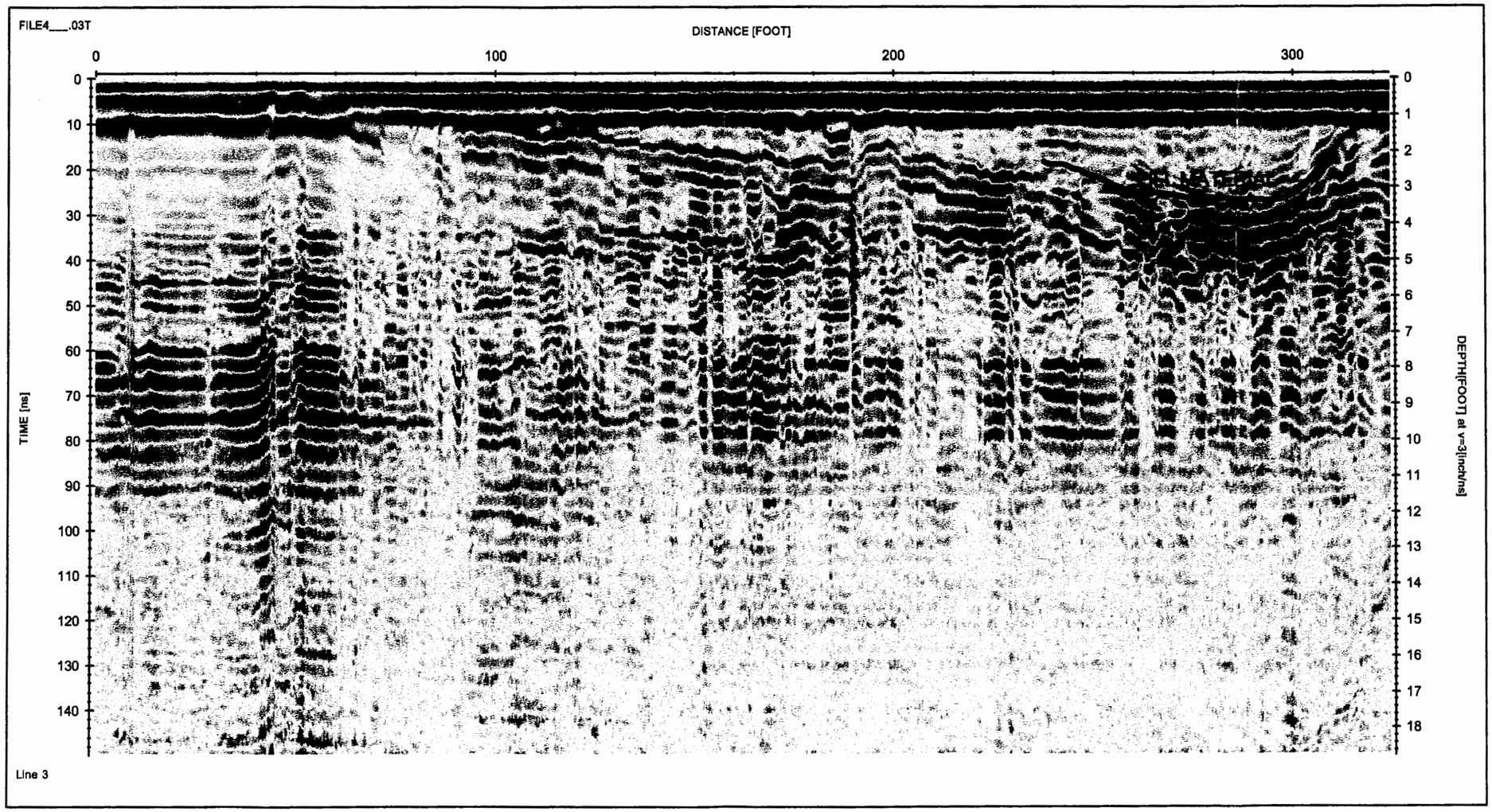
GPR PROFILE- LINE 3



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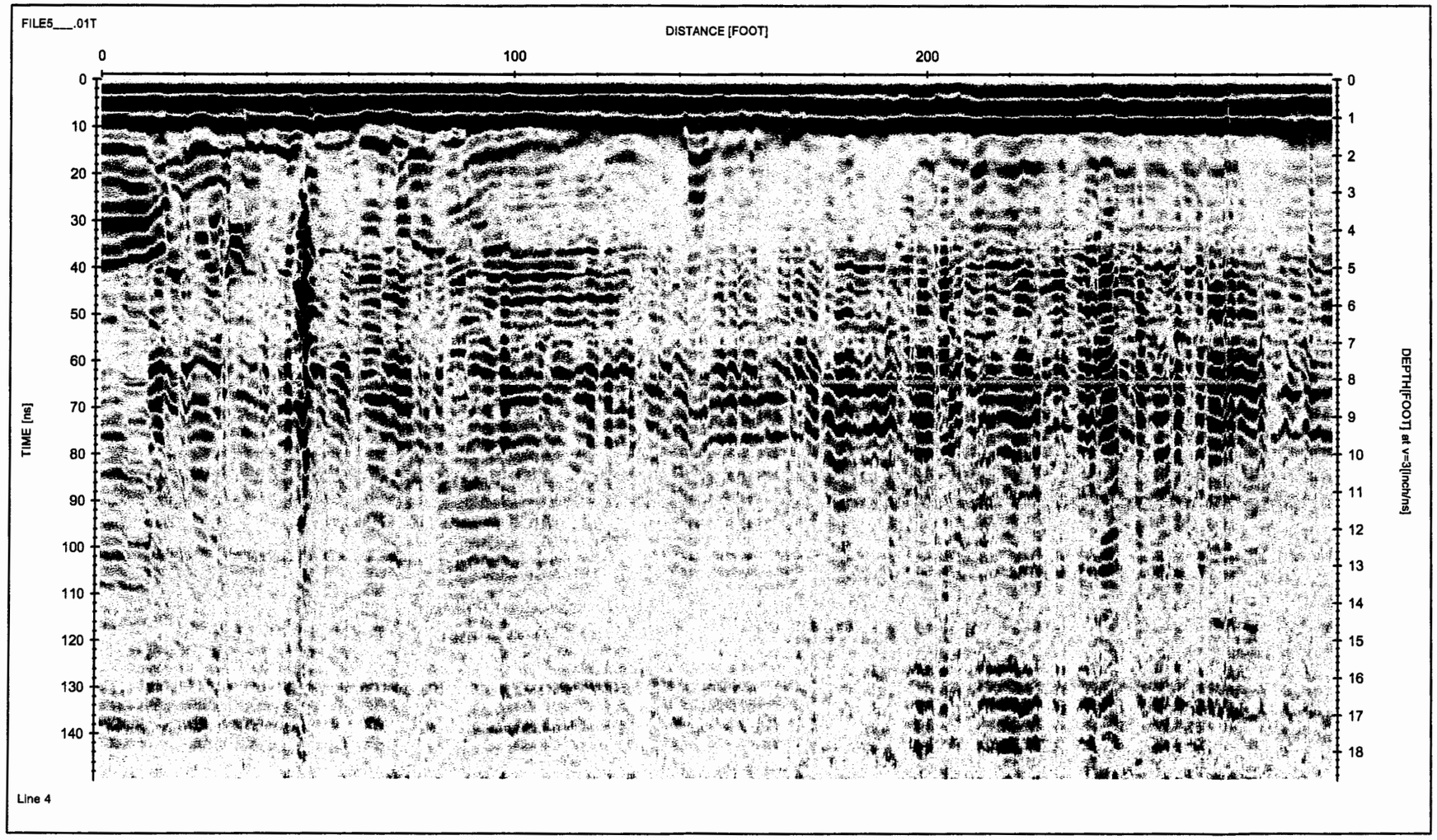
GPR PROFILE- LINE 4



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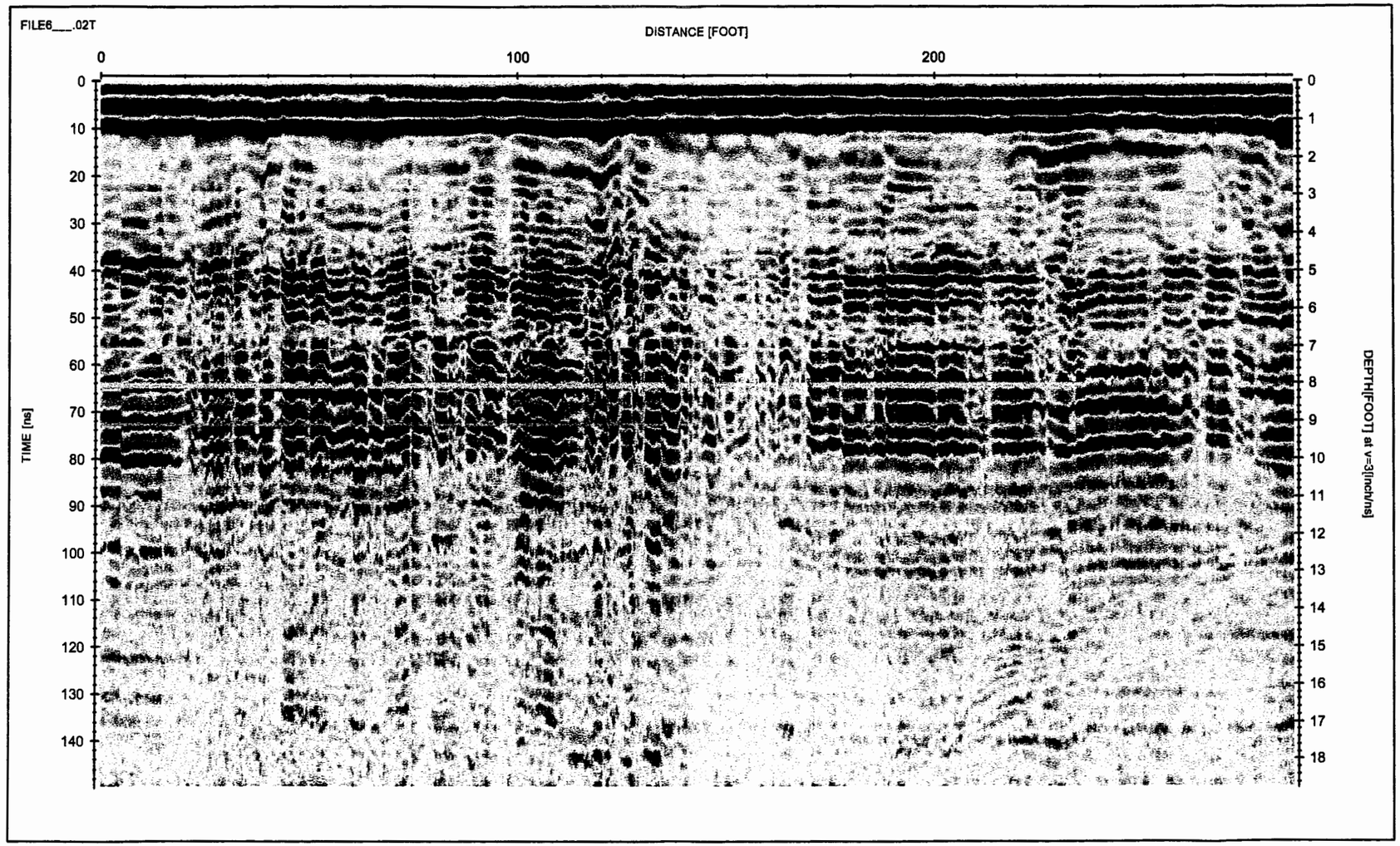
GPR PROFILE- LINE 5



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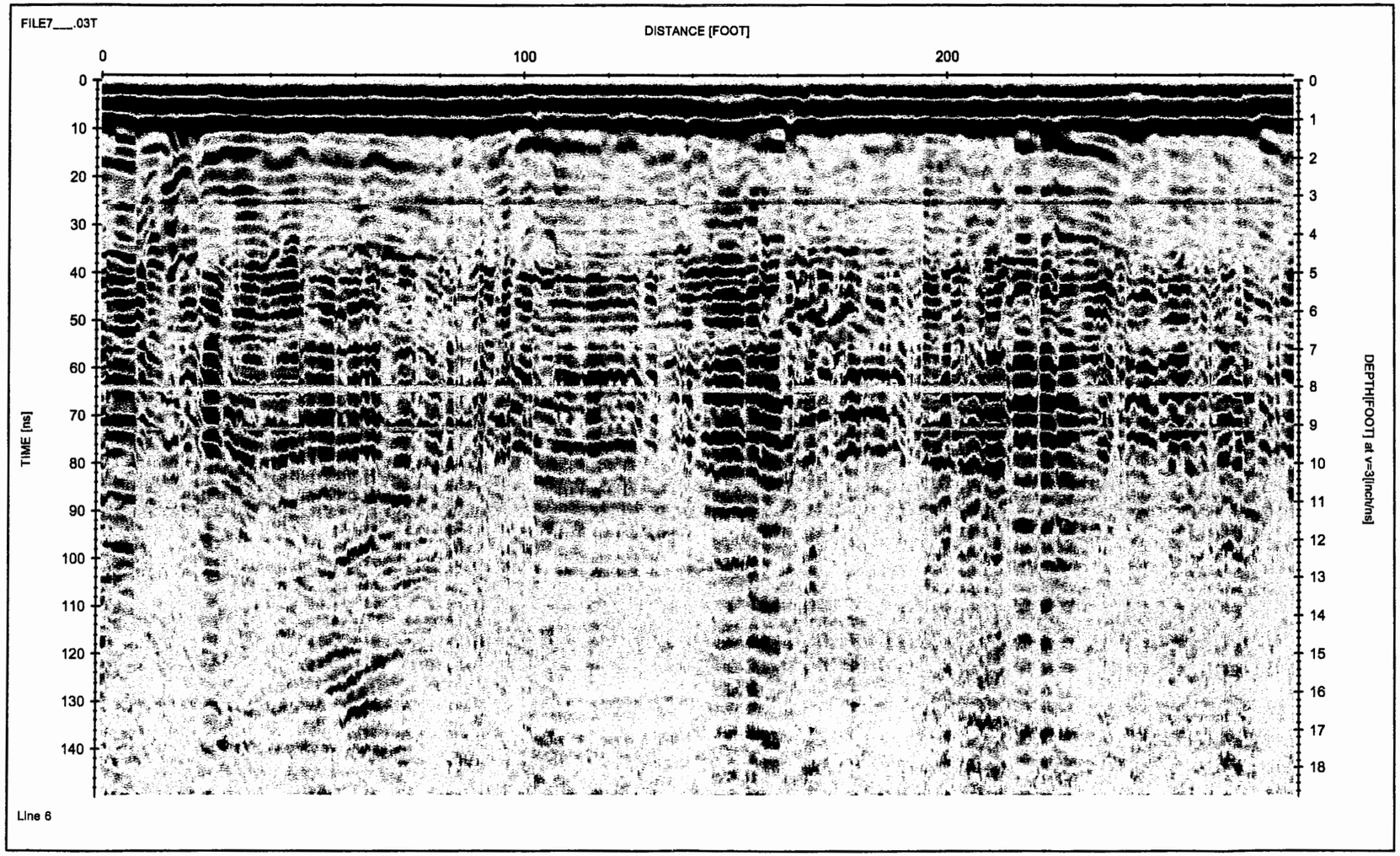
GPR PROFILE- LINE 6



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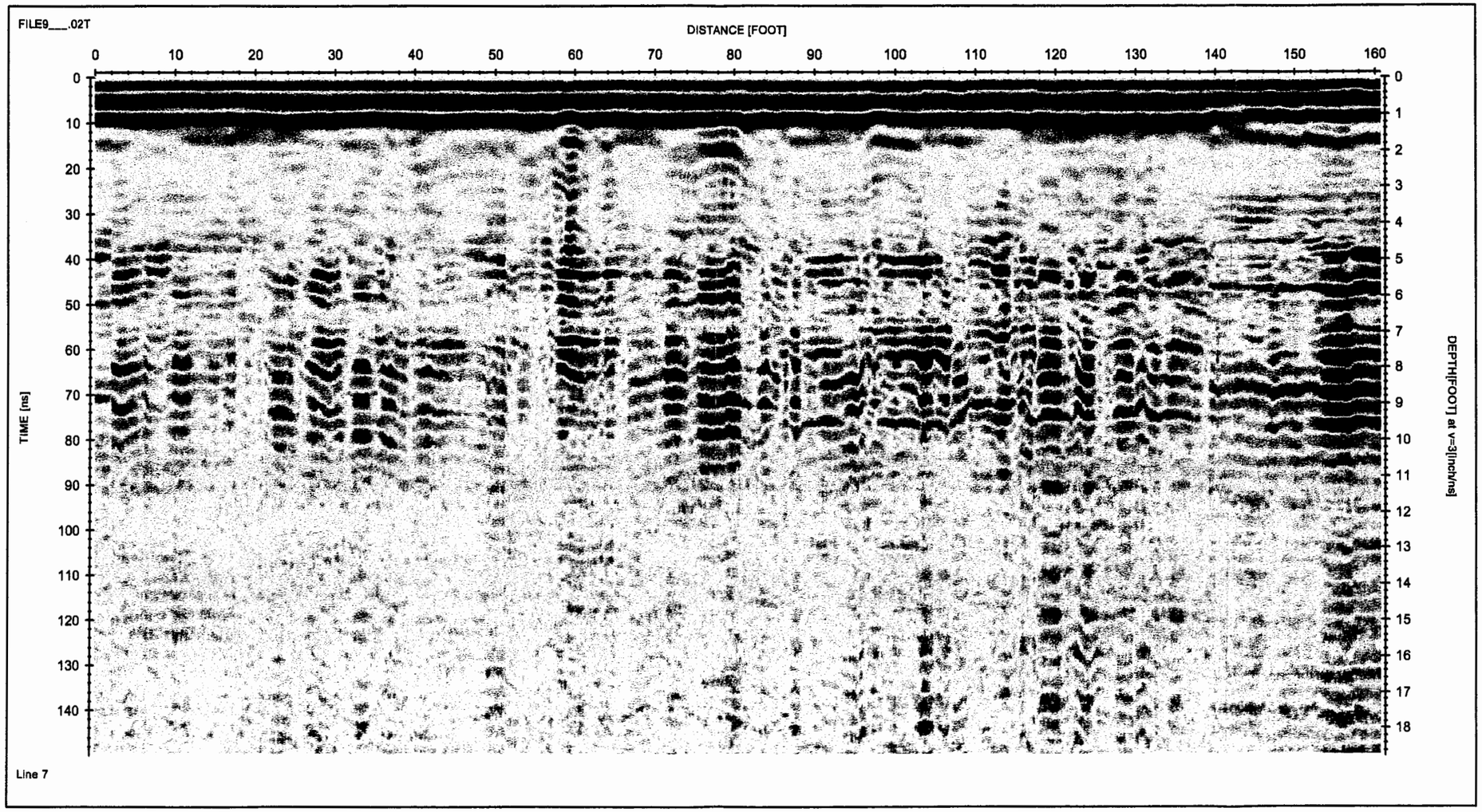
GPR PROFILE- LINE 7



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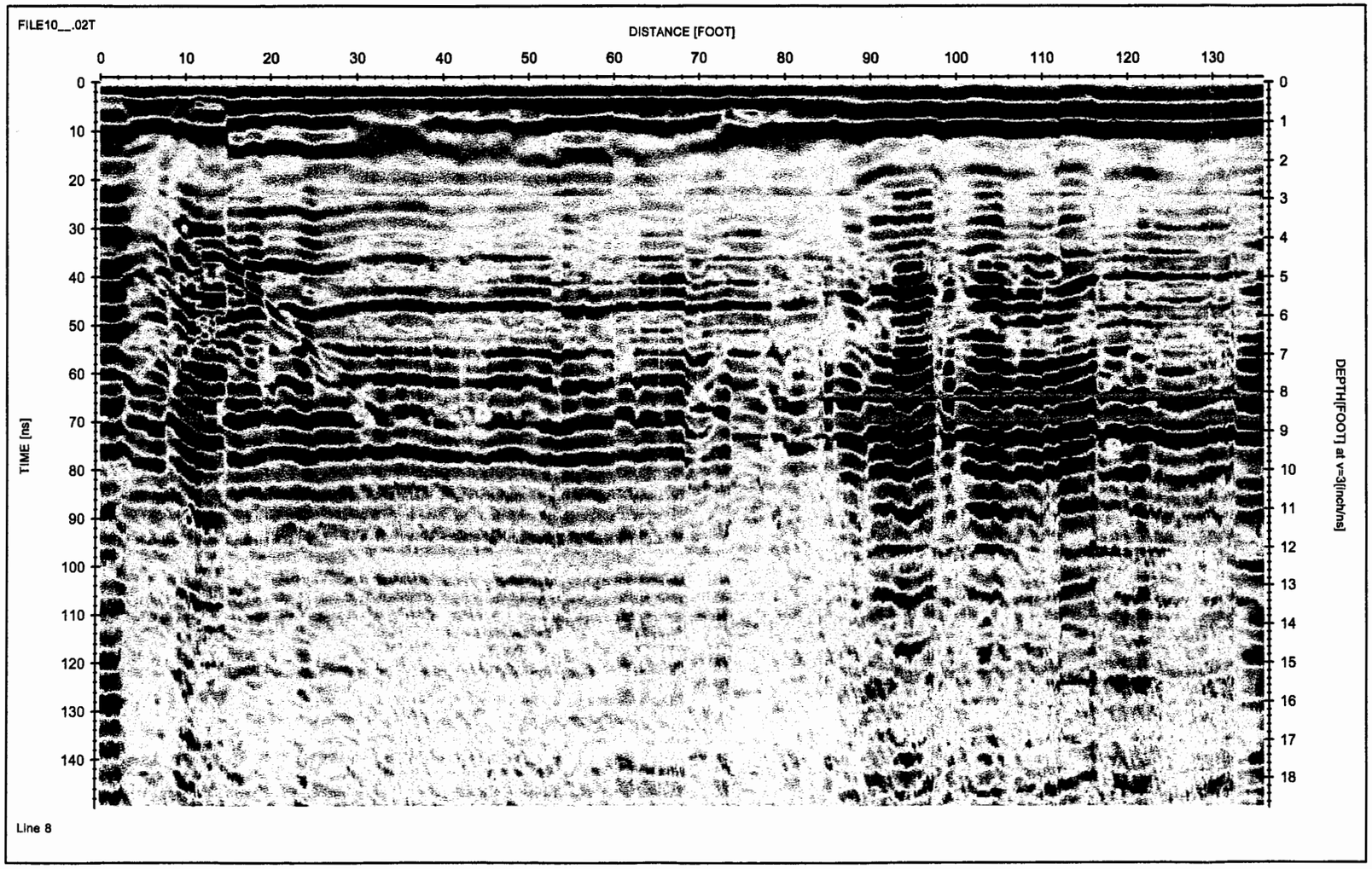
GPR PROFILE- LINE 8



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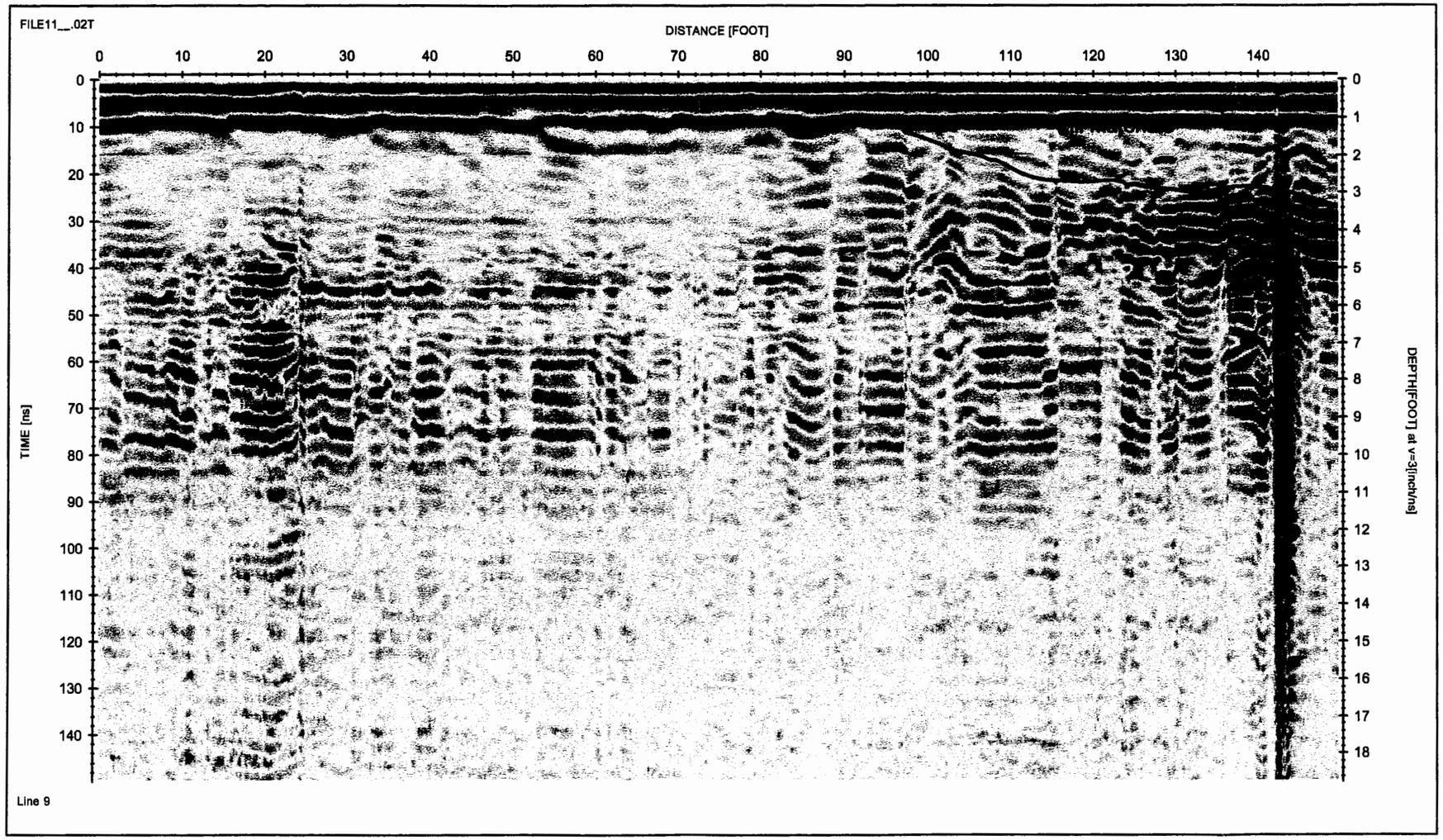
GPR PROFILE- LINE 9



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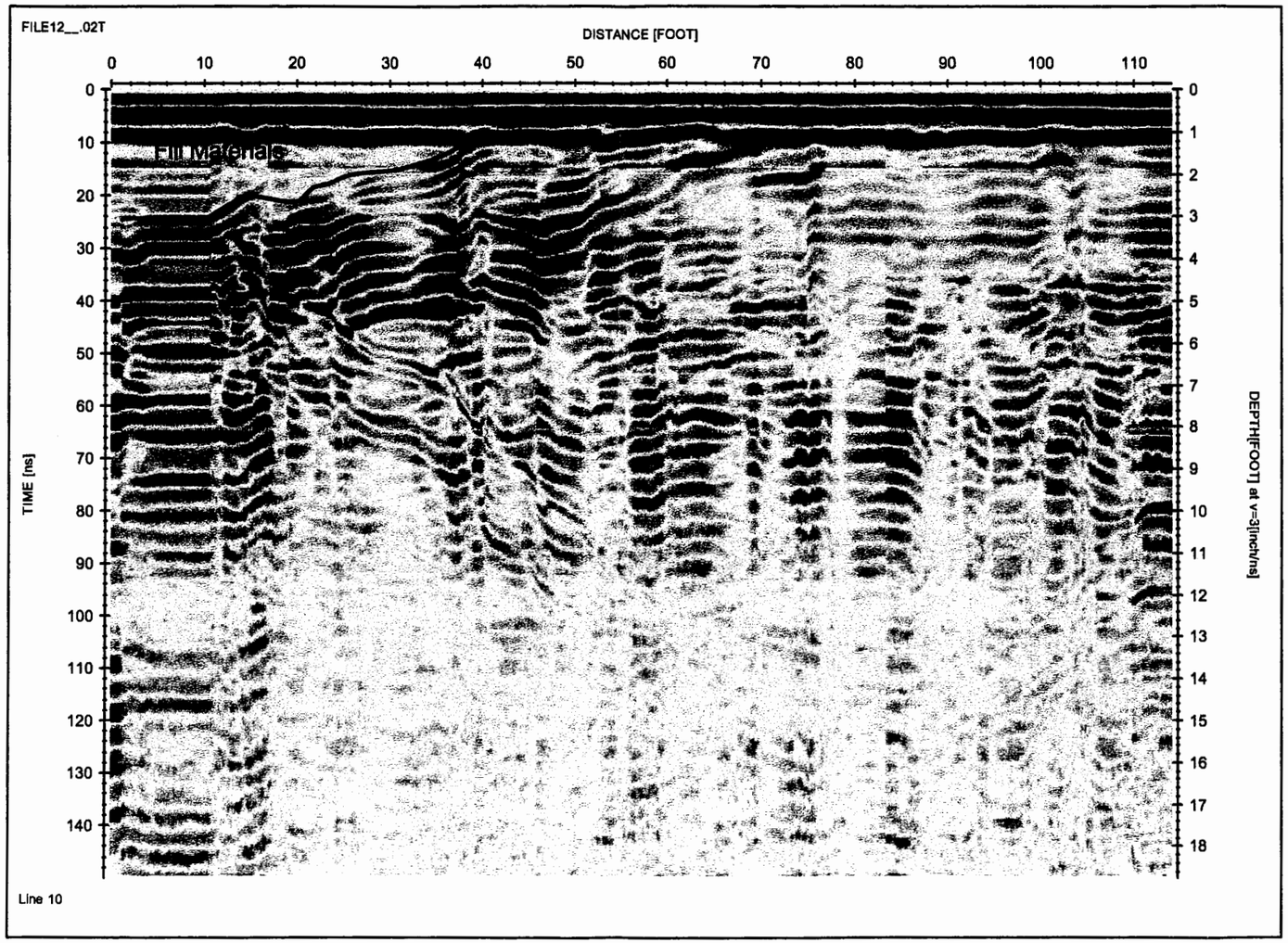
GPR PROFILE- LINE 10



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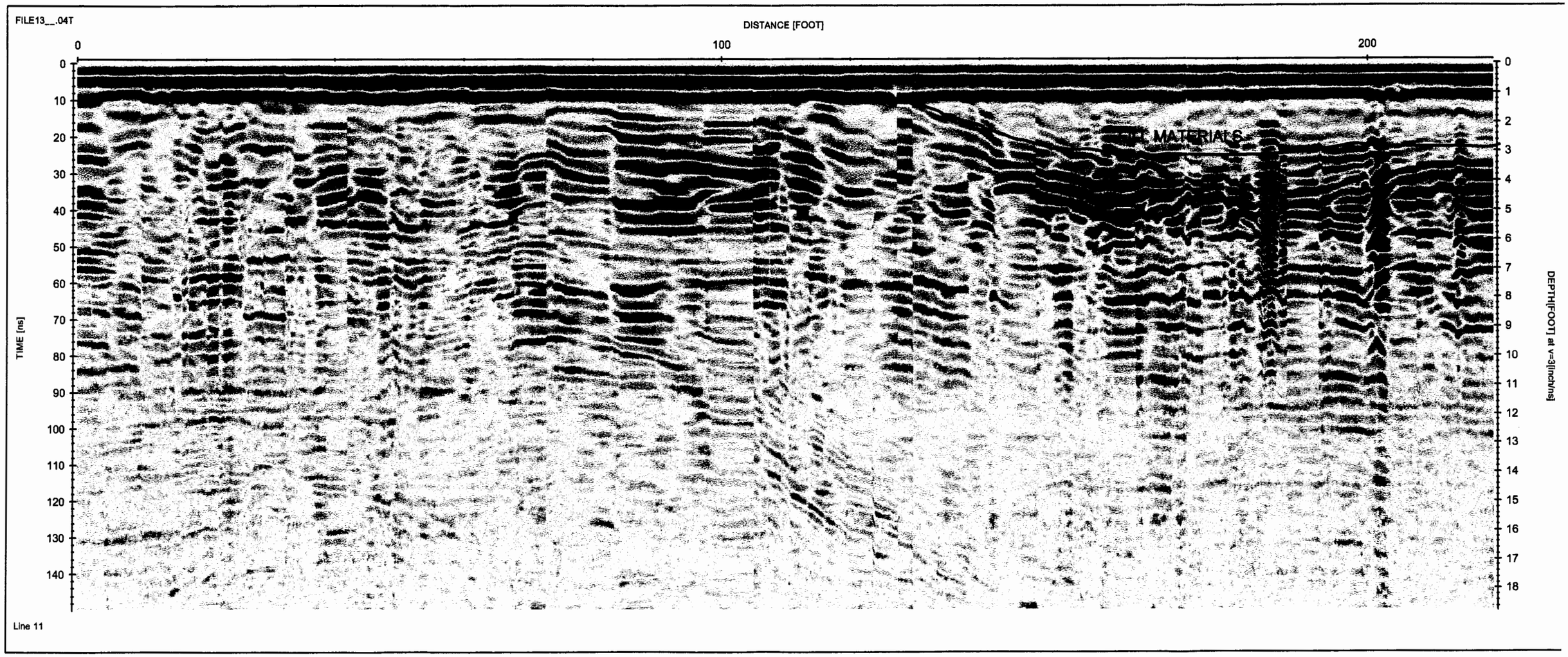
GPR PROFILE- LINE 11



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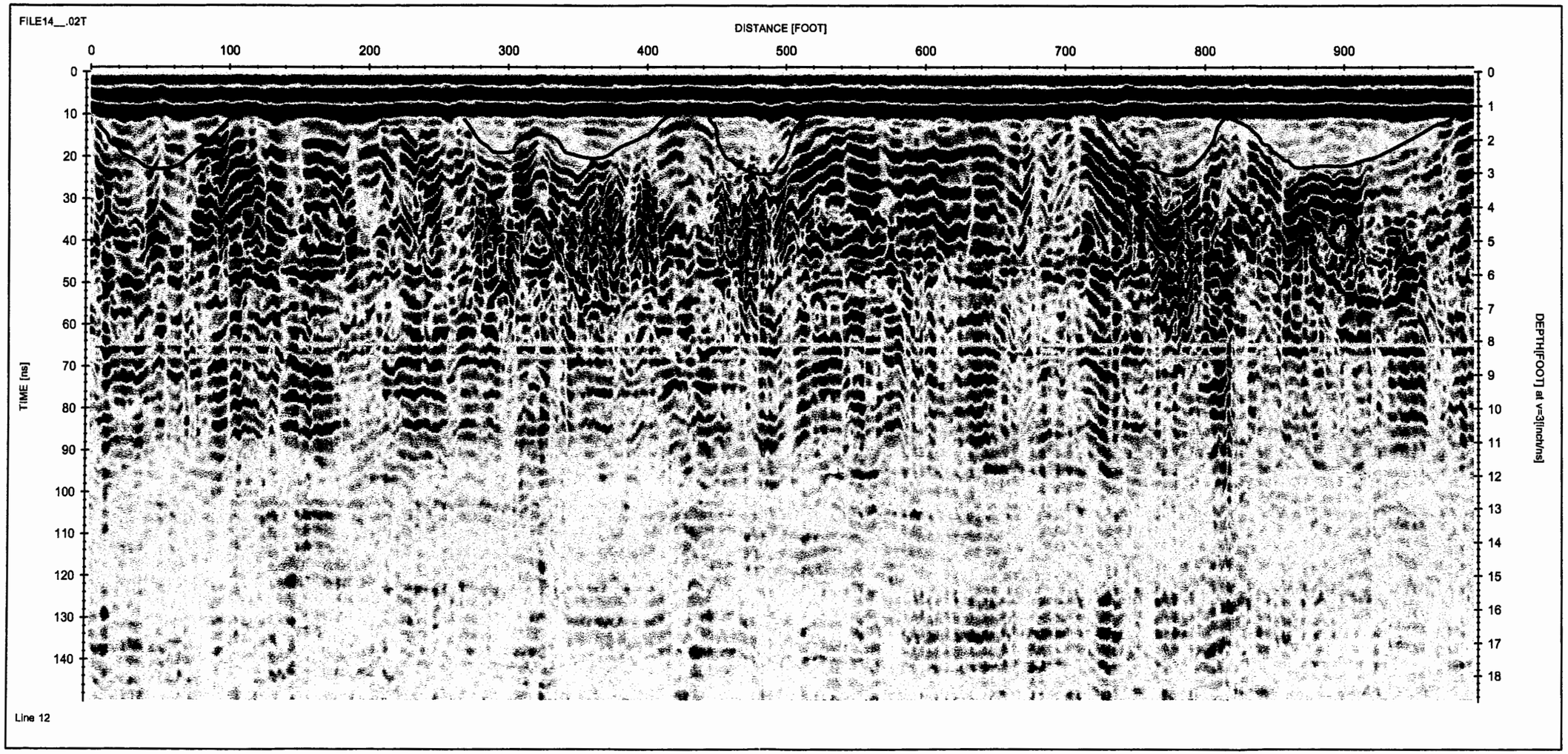
GPR PROFILE- LINE 12



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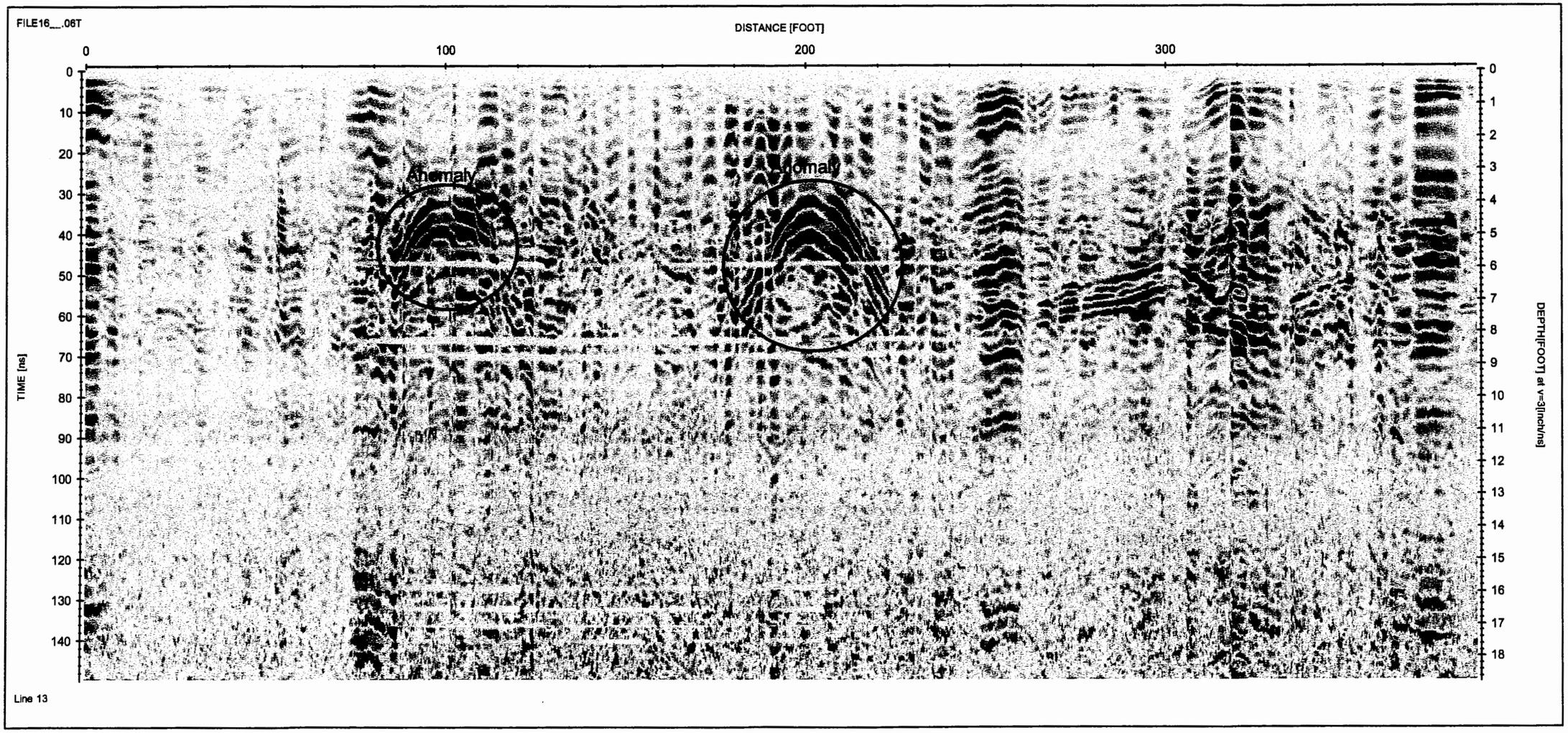
GPR PROFILE- LINE 13



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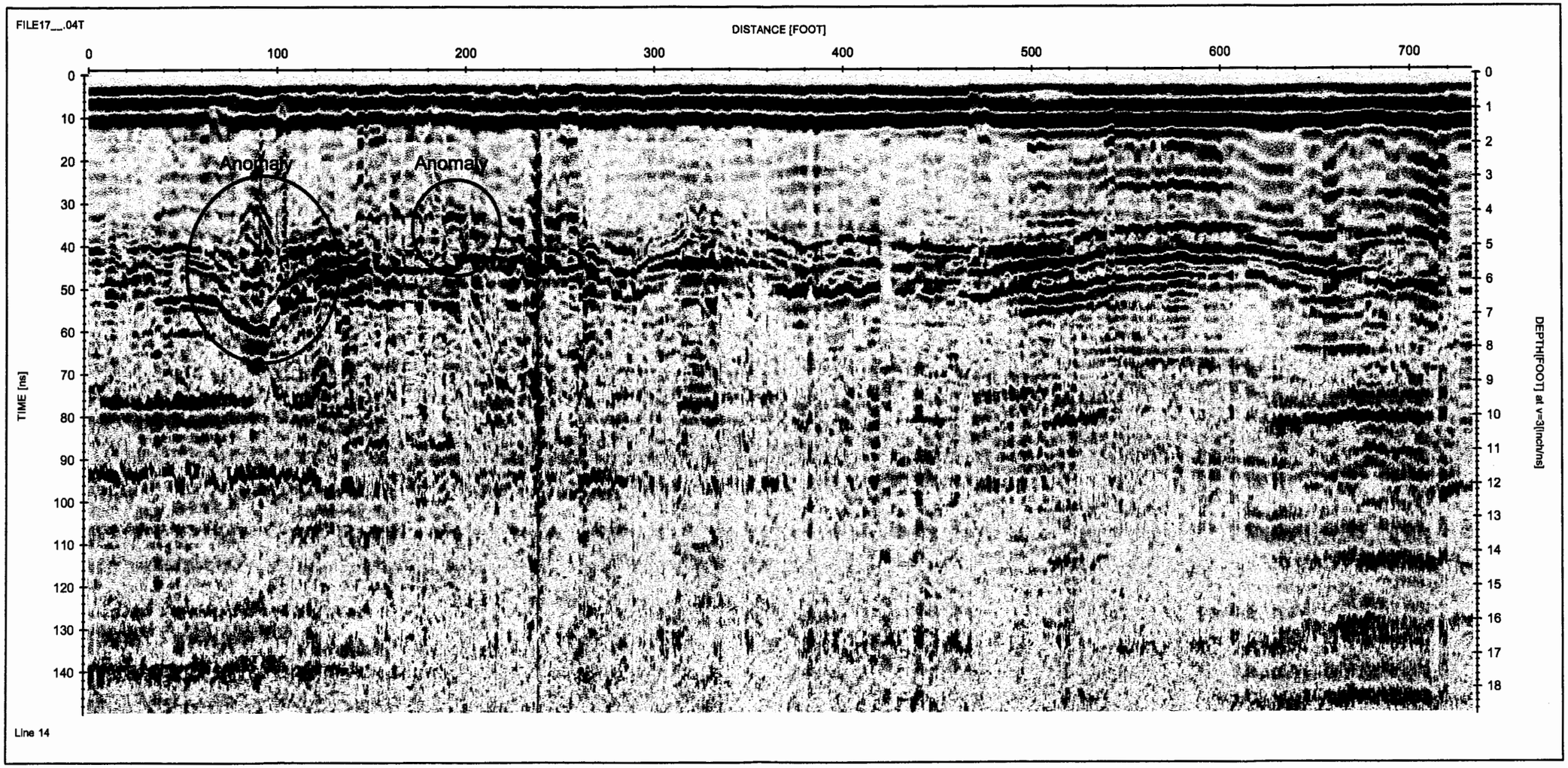
GPR PROFILE- LINE 14



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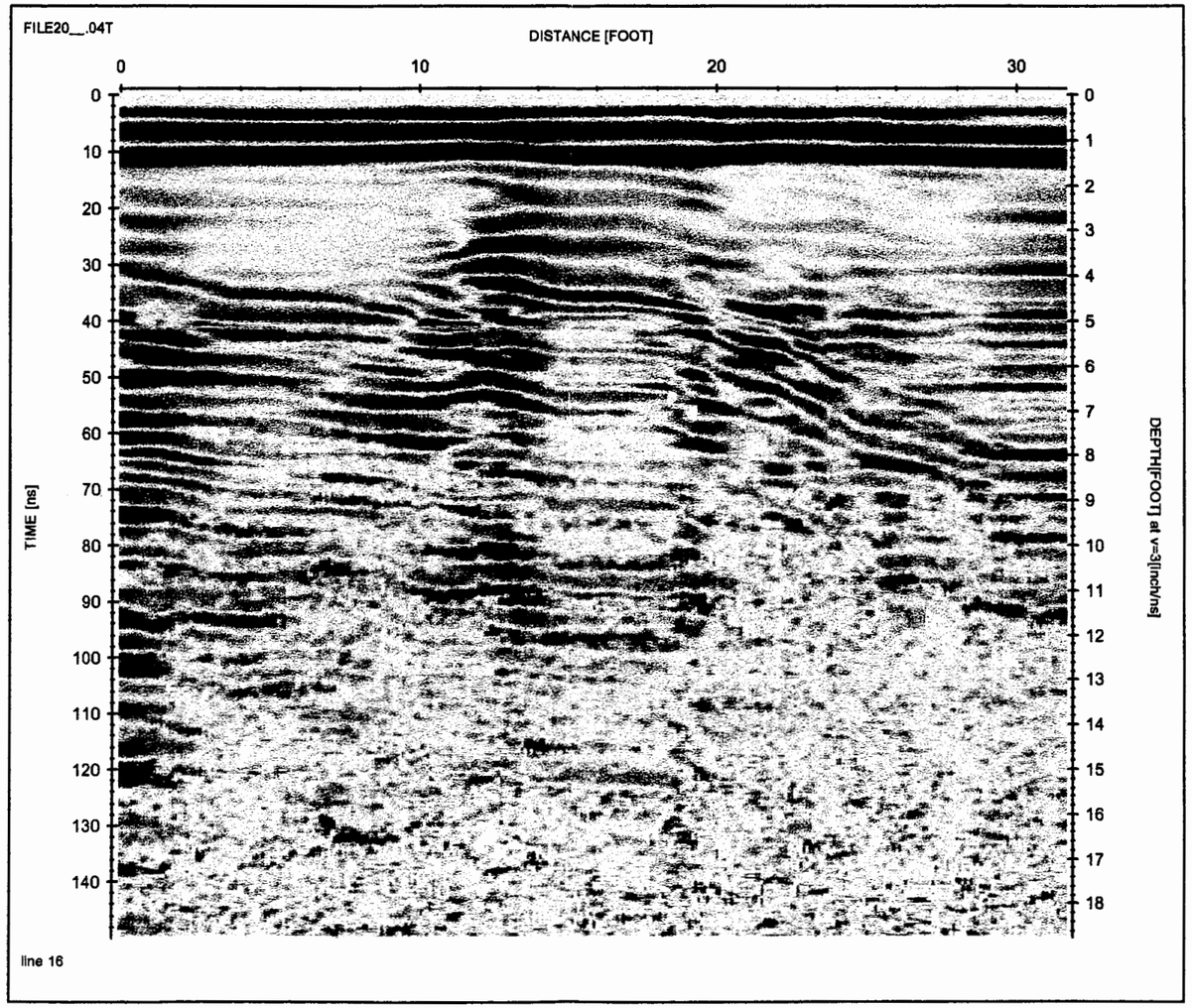
GPR PROFILE- LINE 16



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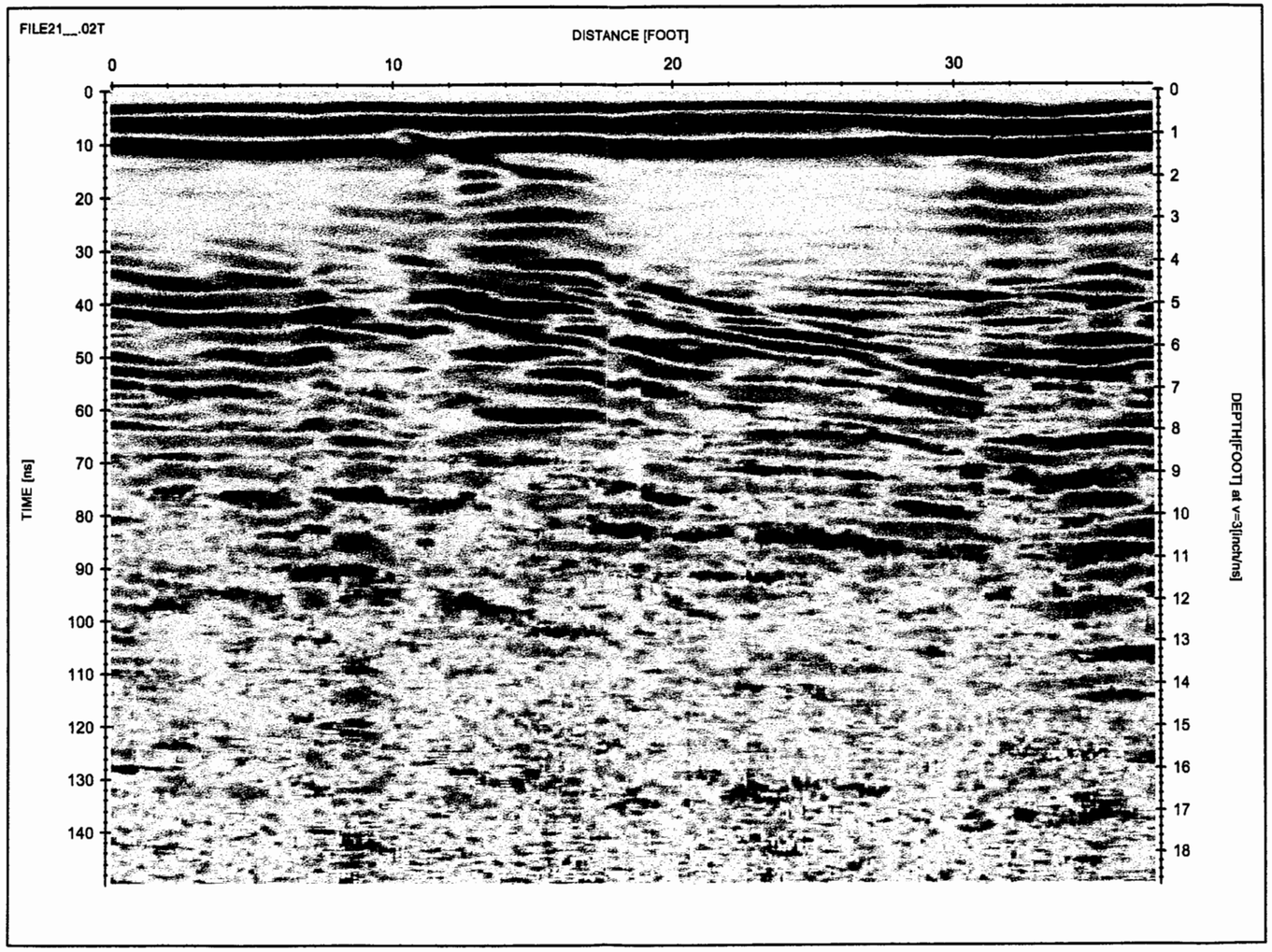
GPR PROFILE- LINE 17



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