REPORT ON CROSSHOLE SONIC LOGGING NONDESTRUCTIVE TESTING SERVICES

West Test Shaft
East Test Shaft

US 36 over Republican River
Scandia, Kansas

Prepared for: **Kansas Department of Transportation**
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Topeka, Kansas 66612

Attention: **Mr. Steve Burnett**

PROJECT NUMBER: LT-8718-CSL **April 10, 2001**

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LOADTEST INC.

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1.0 EXECUTIVE SUMMARY

This is the report on the nondestructive integrity evaluation of the concrete drilled test shaft that was installed as part of the, US 36 over the Republican River, Scandia, Kansas test program. LOADTEST, Inc. has been contracted by the Kansas Department of Transportation to provide nondestructive testing services for quality assurance of the integrity of the drilled shaft foundation on this project.

This report conveys the results of the Crosshole Sonic Logging (CSL) of the West Test Shaft and the East Test Shaft. This report also presents the principle of the CSL method, which was used to evaluate the integrity of the shaft.

The Non-Destructive Testing of the West and East Test Shaft summarized in this report involved Crosshole Sonic Logging (CSL) from top to bottom of the shaft for nine (9) tube pair paths between the six (6) water-filled access tubes.

The CSL results from the shafts tested are summarized in Table 1. The results indicate that the West Test Shaft is sound with minor anomalies. The results indicate that the East Test Shaft is sound with no anomalies. The West Test Shaft indicated a slight defect on three of the logs. This defect was probably created by a blast of air exhausted from the bottom of the pump line as it was being extracted from the top of the concrete. This defect can be seen in Figures 5,6,and 7. The East Test Shaft indicated that tube 2 was not parallel to tubes 1 and 3. This variation can be seen in Figures 1 and 2. General condition ratings used to evaluate the concrete conditions are detailed in section 3.0 of this report.

2.0 INVESTIGATION BACKGROUND

This investigation was performed by LOADTEST, Inc. for the Kansas Department of Transportation to provide quality assurance of the integrity of the concrete placement in the drilled shafts tested. The shafts were constructed as part of the test program for the US 36 Bridge over the Republican River. The tested shafts were nominally 72-inches in diameter. The shaft lengths were approximately 50 feet. The west and east shafts were tested on April 5, 2001. The age of the shafts at the time of testing is included in Table 1 along with the CSL test results. The six 2-inch diameter PVC tubes were cast in-place around the inside of the shaft cage. At the time of concrete placement the tubes were filled with water. The tubes extended to the top of the Osterberg cell. Nine (9) CSL Loggings were performed for the shaft between the tube pairs with tube 1 being the northernmost tube and numbered increasing in a clockwise direction. Mr. William Ryan and Mr. Michael Ahrens performed the field NDT investigation.

Table 1

CSL RESULTS SUMMARY

Velocities, Length, Test Date, and Anomalous Zones

Test Shaft No.	COMPRESSION VELOCITY, V_c (FPS)	LOG DEPTH (FT)	DATE TESTED (mm/dd/yy)	AGE AT LOGGING (DAYS)	FIGURE NUMBERS APPENDIX A	CONCRETE CONDITION RATING	ANOMALOUS CONCRETE ZONES (TUBES, DEPTH, & V_c REDUCTION)
West	12,000	39.25	2/05/01	8	1-9	G	1 & 6 /19.5'/ > 20%
East	12,000	39.25	2/05/01	6	1-9	G	N/A

3.0 CROSSHOLE SONIC LOGGING (CSL) CONDITION RATING CRITERIA

This CSL rating criteria categorizes abrupt increases in the signal arrival times that correspond to decreases in the average signal velocity of the material between the test probes. These abrupt changes are a result of one or more of the following three conditions: (1) increased signal path length as the signal travels around a flaw; (2) a decrease in the signal velocity as it travels through a lower velocity material such as Weber concrete, honeycomb, or contaminated concrete; and (3) deterioration of the bond between the access tube and the concrete. Of the three conditions that cause increased signal arrival times, the deterioration of the tube-concrete bond is the least common and is typically identified only in the upper portions of shafts and in shafts with PVC access tubes.

This CSL rating criteria is based on the percentage reduction of the signal velocity through the flawed area versus the signal velocity through sound material immediately adjacent to the flaw. This insures that the signal arrival times used to calculate the signal velocities are measured through the same amount of material, which is very important if a tube pair is not evenly spaced from shaft top to bottom. This CSL criteria is in large part based on experience with ultrasonic pulse velocity measurements of structural concrete, which uses signal velocities to determine material integrity. However, the calculated signal velocities in the CSL testing are reduced by inherent delays due to the slower water, and PVC tube materials. This signal delay yields artificially lower signal velocities for path lengths of 24 inches or less. In contrast, the percentage change in signal velocity between good and flawed material is unaffected by inherent signal delays. Our general rating criteria for CSL results appears below.

Rating	NDT Results indicative of Drilled Shaft Concrete Condition
Good (G)	No signal distortion and decrease in signal velocity of 10% or less are indicative of good quality concrete.

Questionable (Q) Minor signal distortion and a lower signal amplitude with a decrease in signal velocity between 10% and 20%. Results indicative of minor contamination or intrusion and/or questionable quality concrete. Investigations of anomalies with 10-15% reductions in velocity have identified sound concrete at some sites and flawed concrete at others.

Poor/Defect (P/D) Severe signal distortion and much lower, signal amplitude with a decrease in signal velocity of 20% or more. Results indicative of water slurry contamination or soil intrusion and/or poor quality concrete.

No Signal (NS) No signal was received. Highly probable that a soil intrusion or other severe defect has absorbed the signal (assumes good bonding of the tube-concrete interface), If PVC tubes are used or if the measurement is from near the shaft top the tube-concrete bonding is more suspect.

Water (W) A measured signal velocity of nominally V = 4,800 to 5,000 fps. This is indicative of a water intrusion or of a water filled gravel intrusion with few or no fines present.

4.0 CLOSURE

The field portion of this NDT investigation was performed in accordance with generally accepted testing procedures. If we can provide any additional information, please feel free to contact us.

Respectfully submitted,

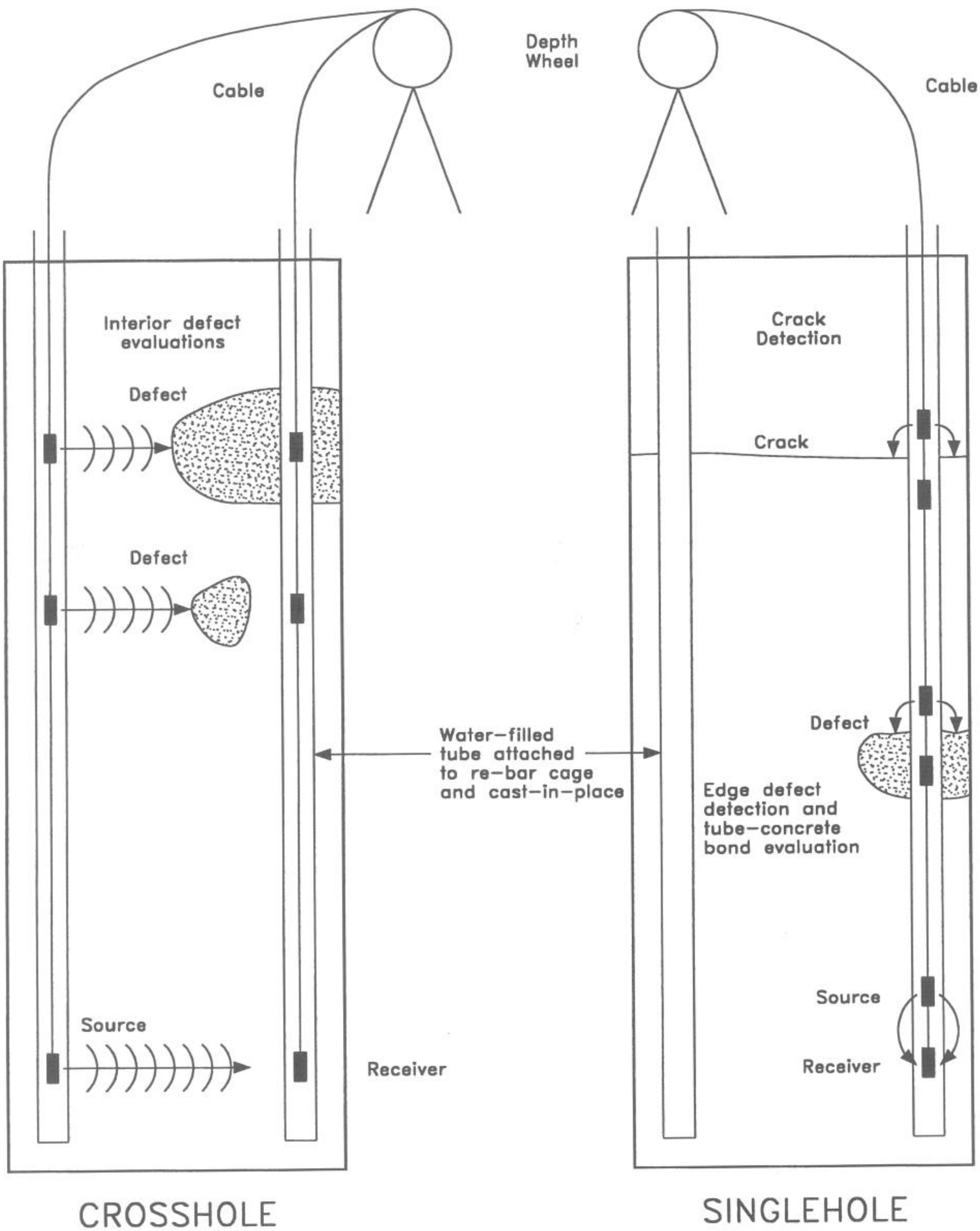
LOADTEST, Inc.

D. Tilson
for William G. Ryan
Regional Manager

Reviewed by:

Michael D. Ahrens
Michael D. Ahrens, P.E.
Regional Manager

SONIC LOGGING

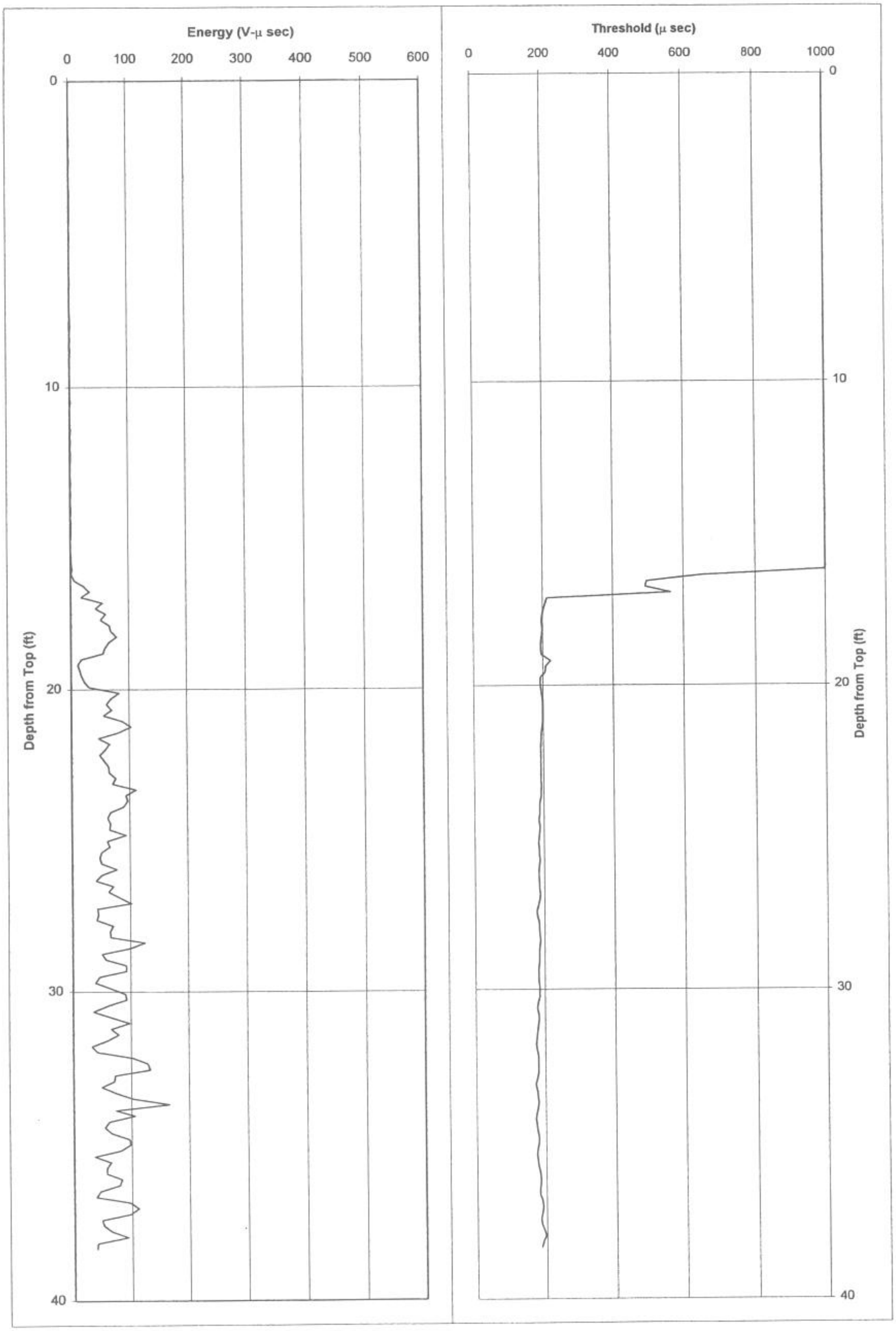


LOADTEST INC	2631-D NW 41st St. Gainesville, FL 32606 Phone 800-368-1138 FAX (352) 378-3934	Crosshole and Singlehole Sonic Logging Test Methods	FIGURE A

APPENDIX A

CROSSHOLE SONIC LOGS

West Test Shaft Tube pair 1 - 2
Spacing = 29.0 in.



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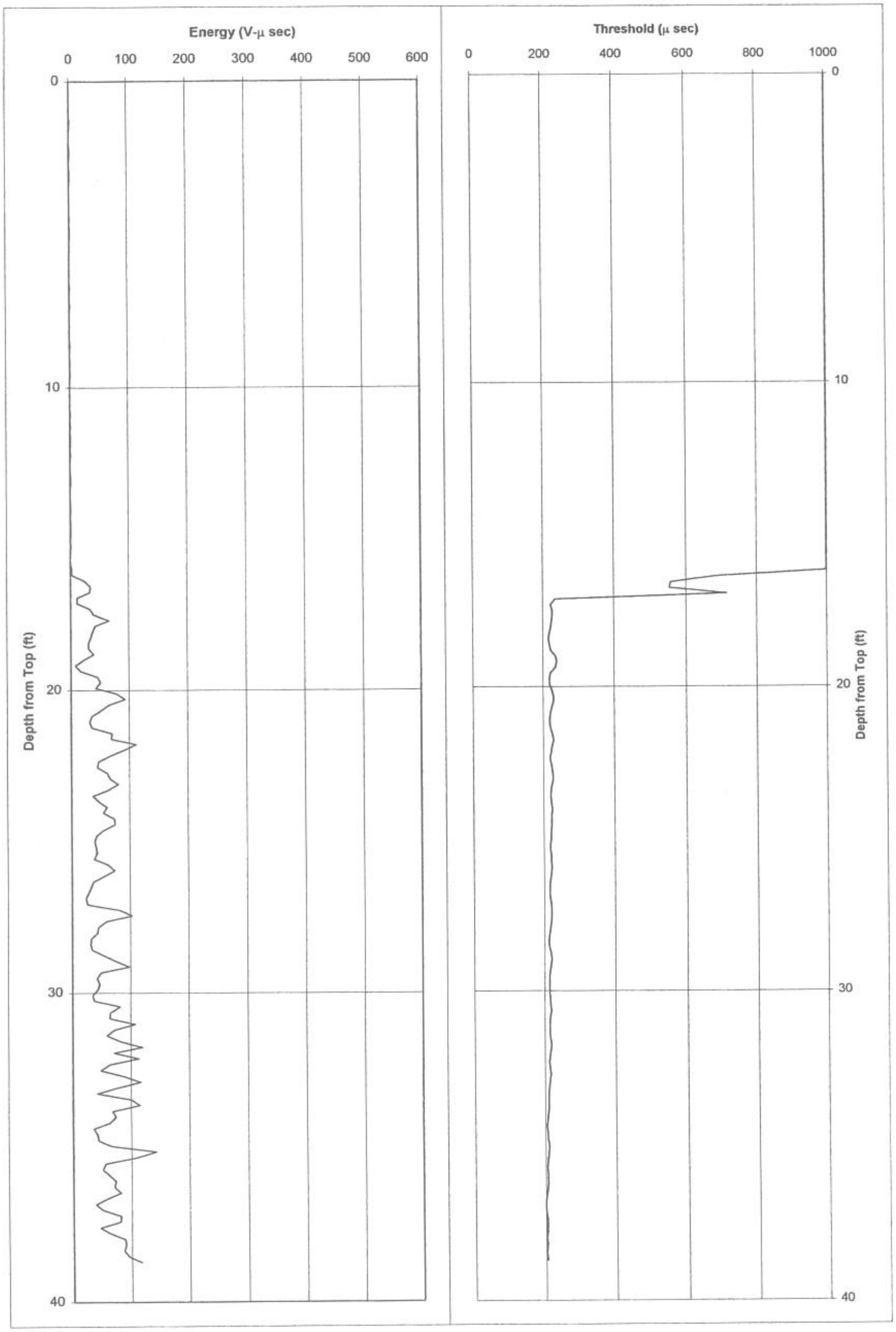

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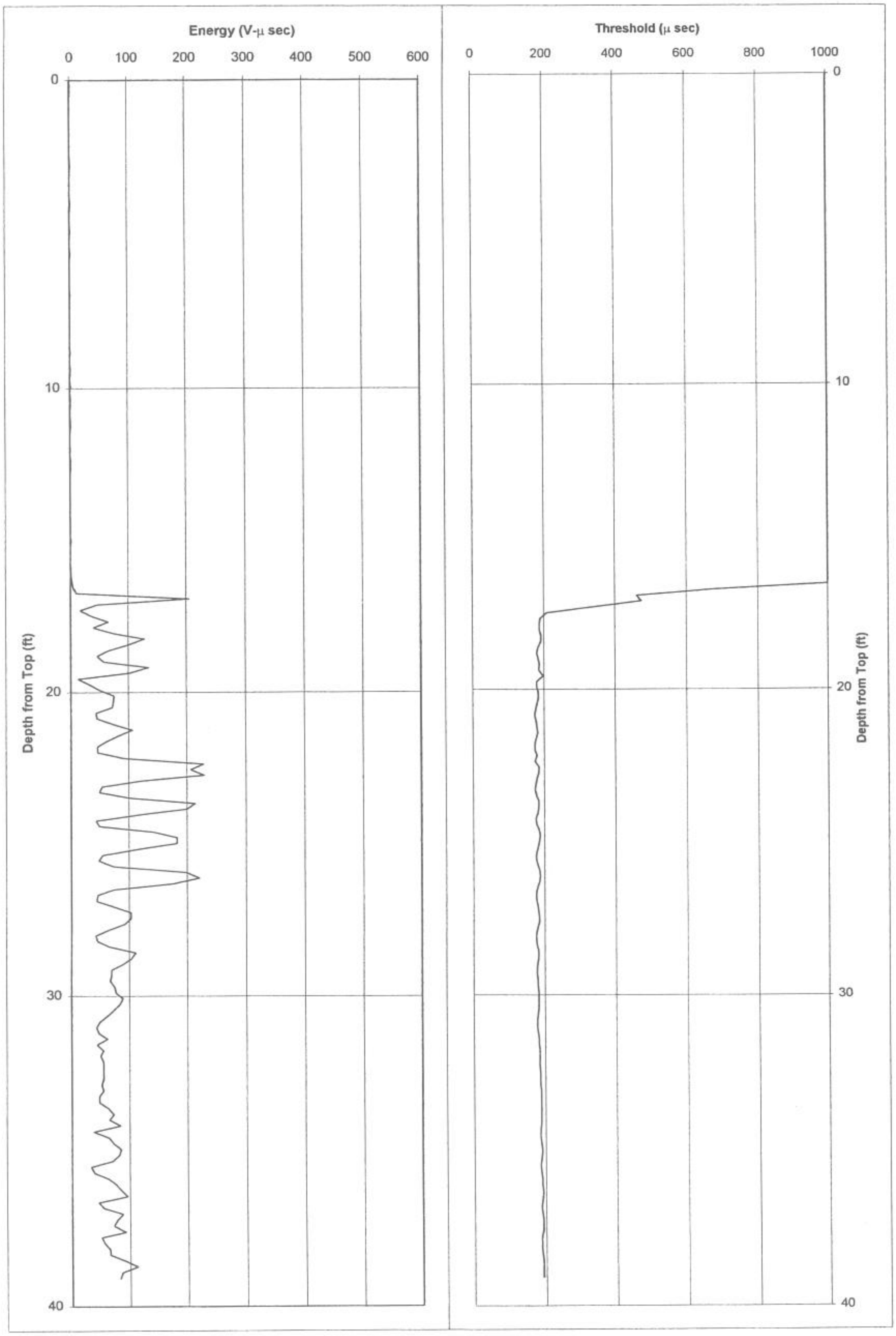

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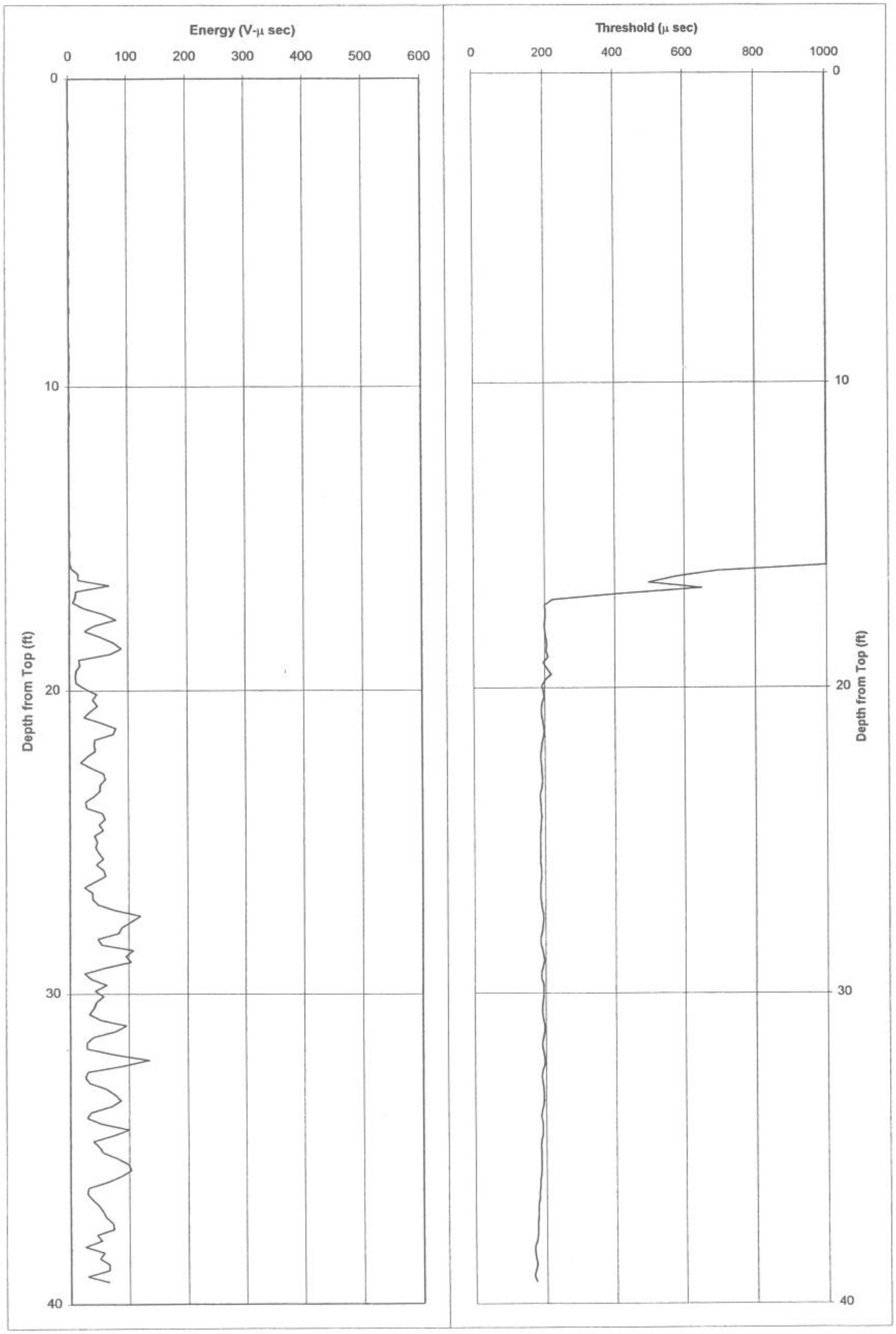

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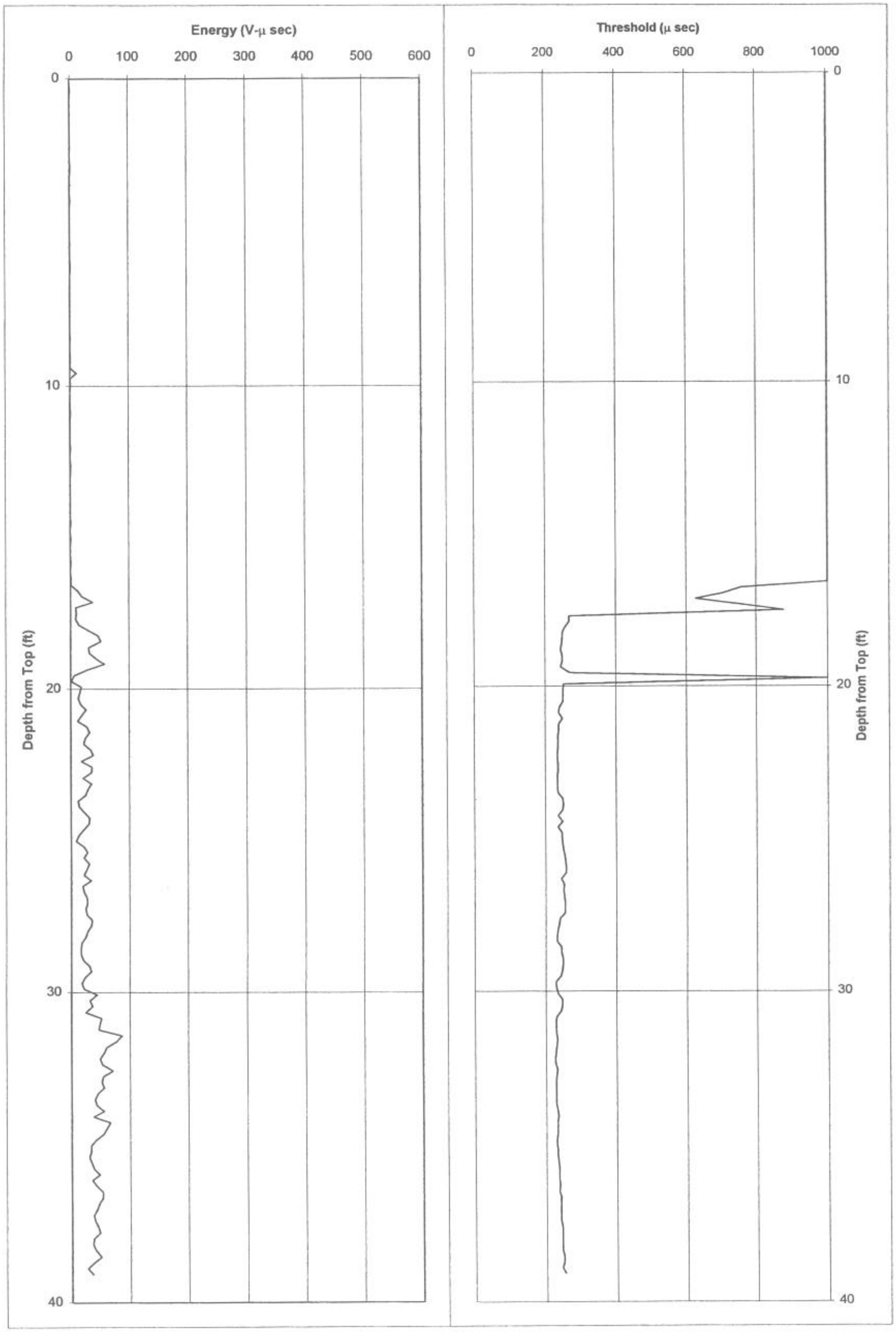

West Test Shaft Tube pair 6 - 1
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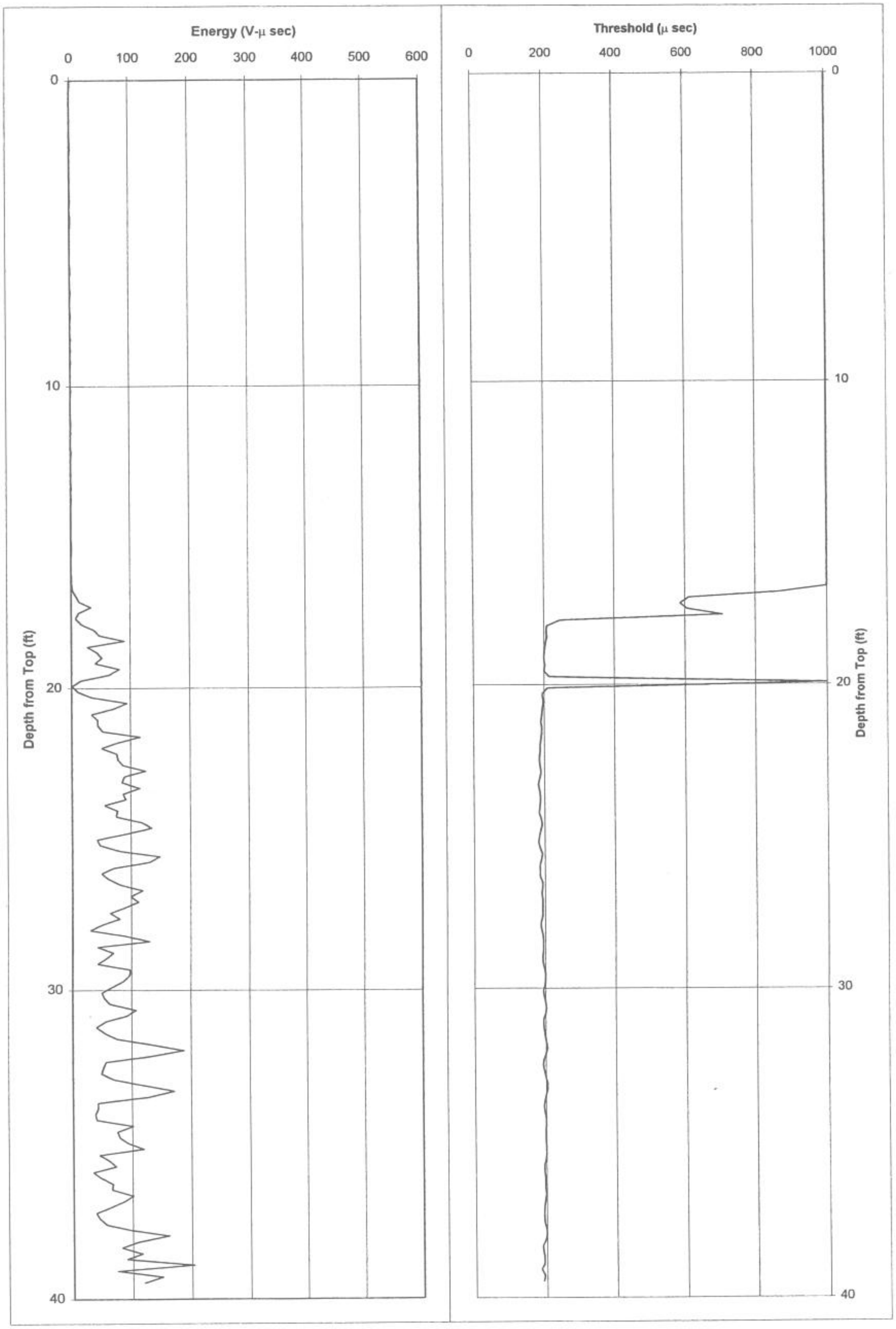

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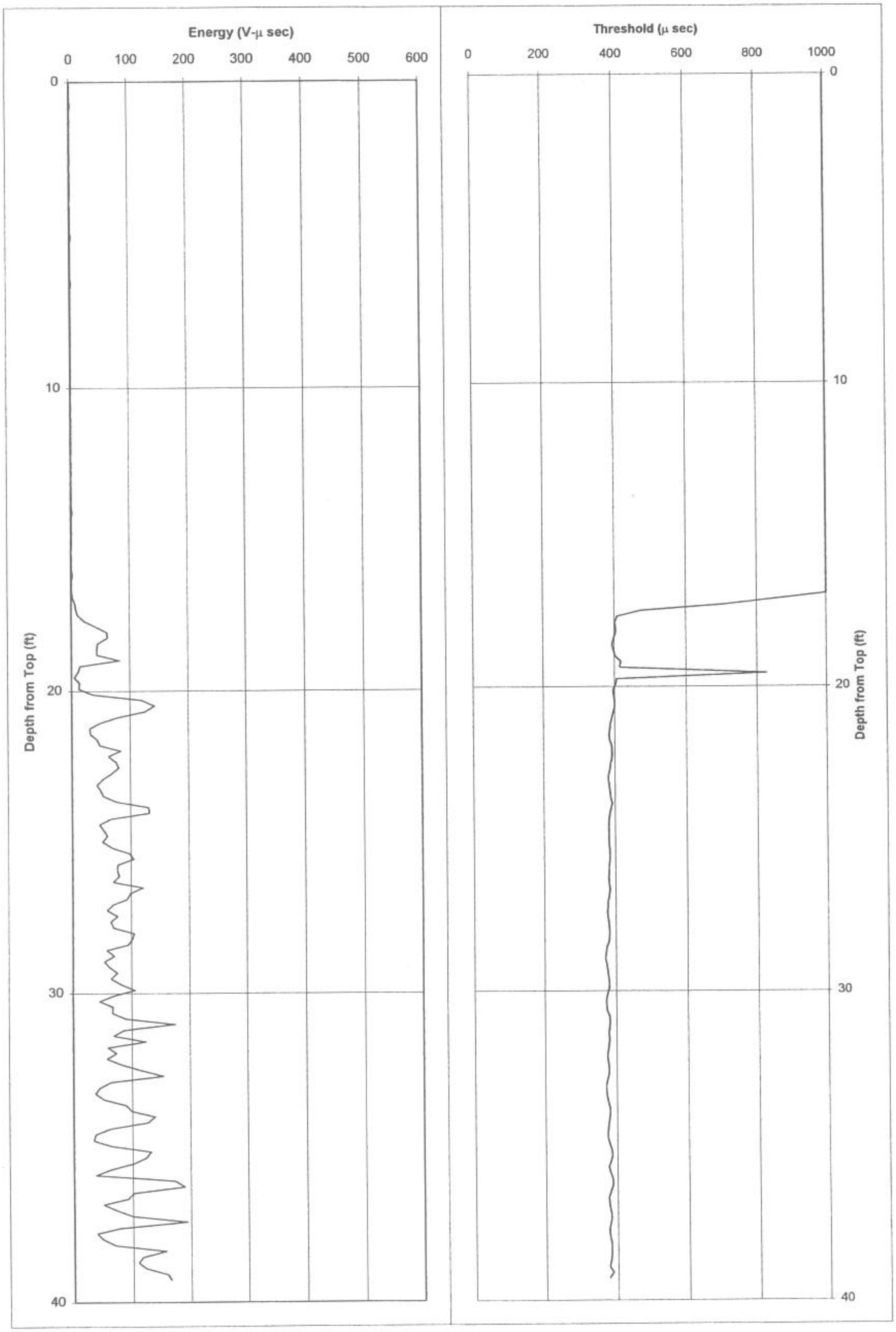

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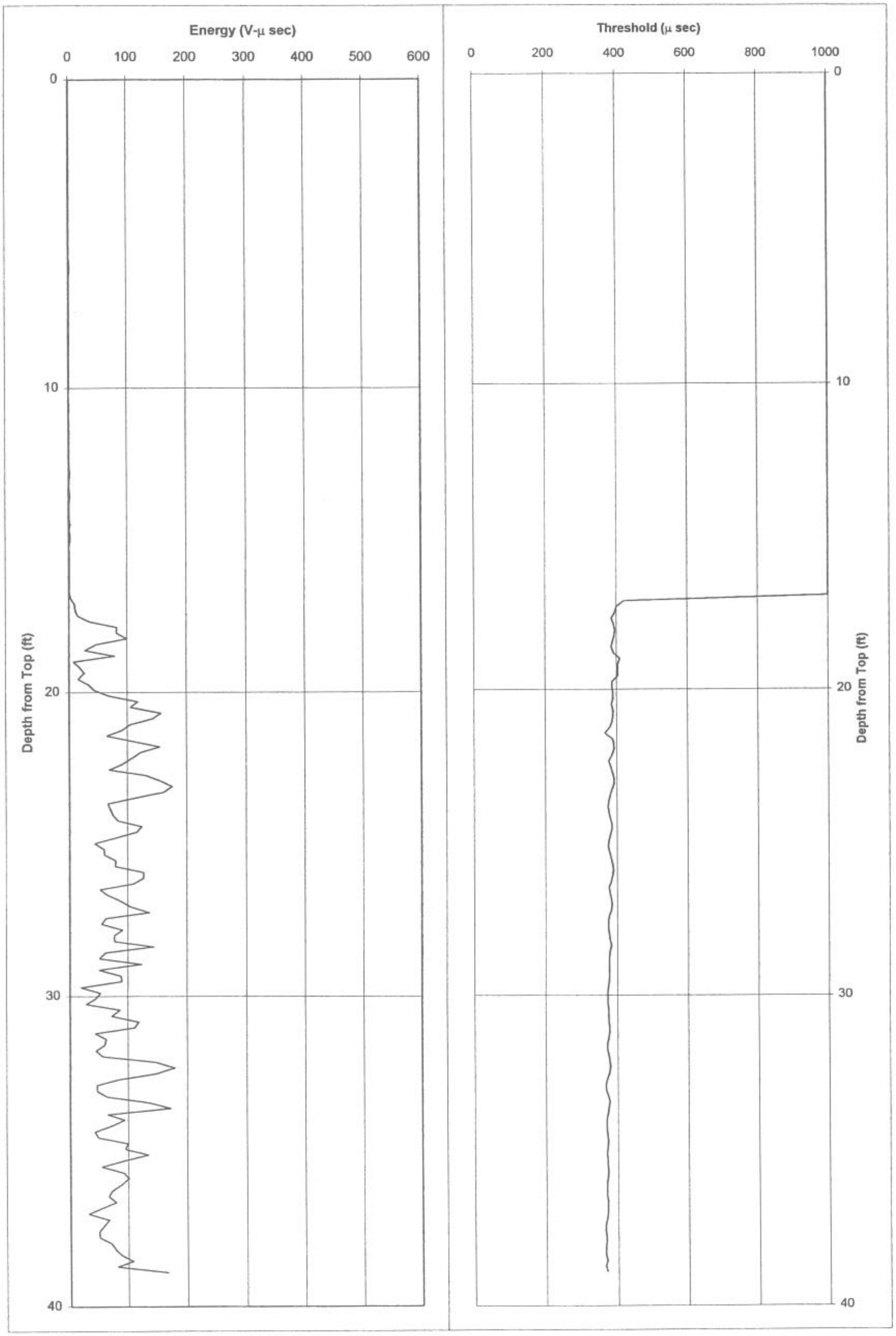

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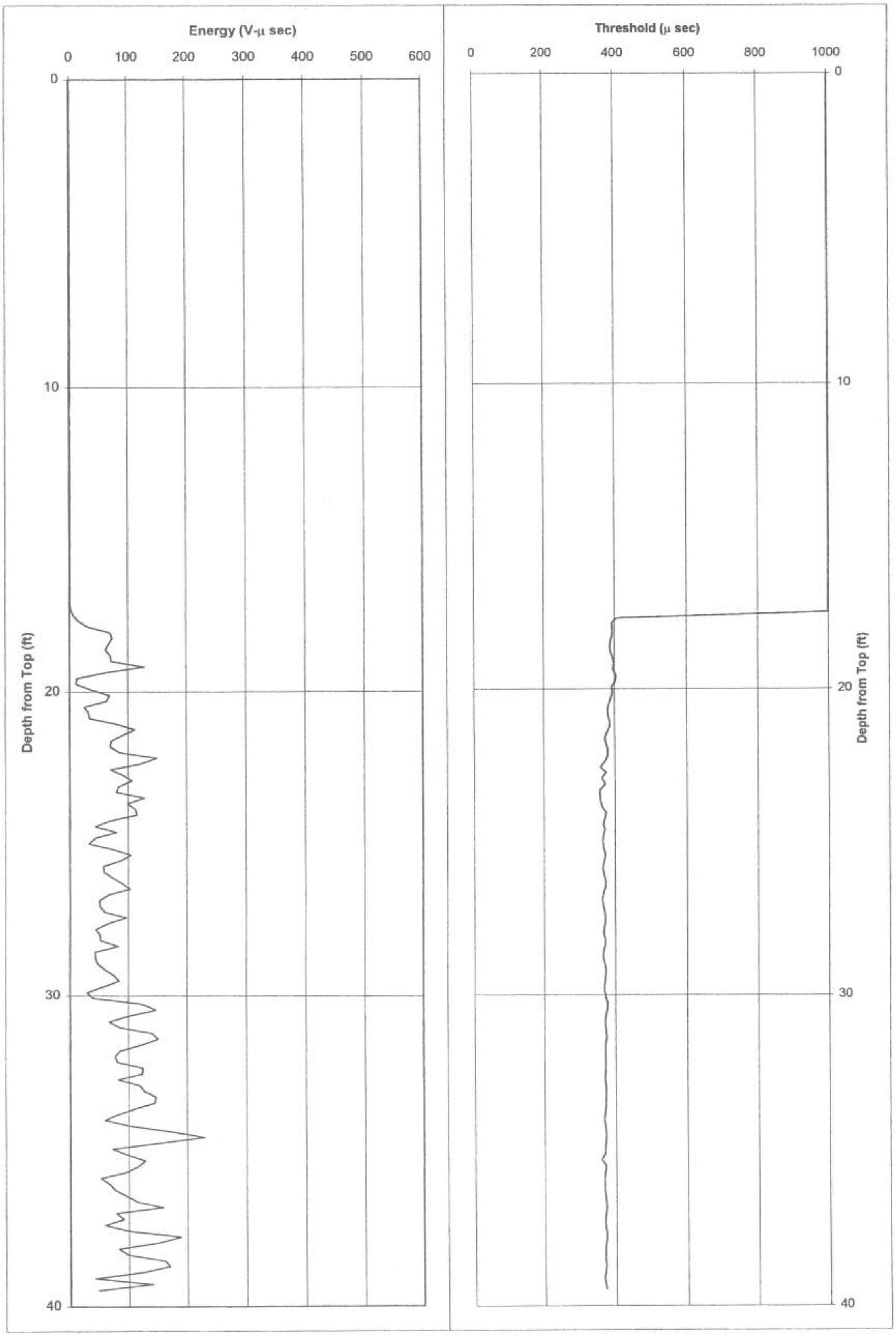

East Test Shaft Tube pair 1 - 2
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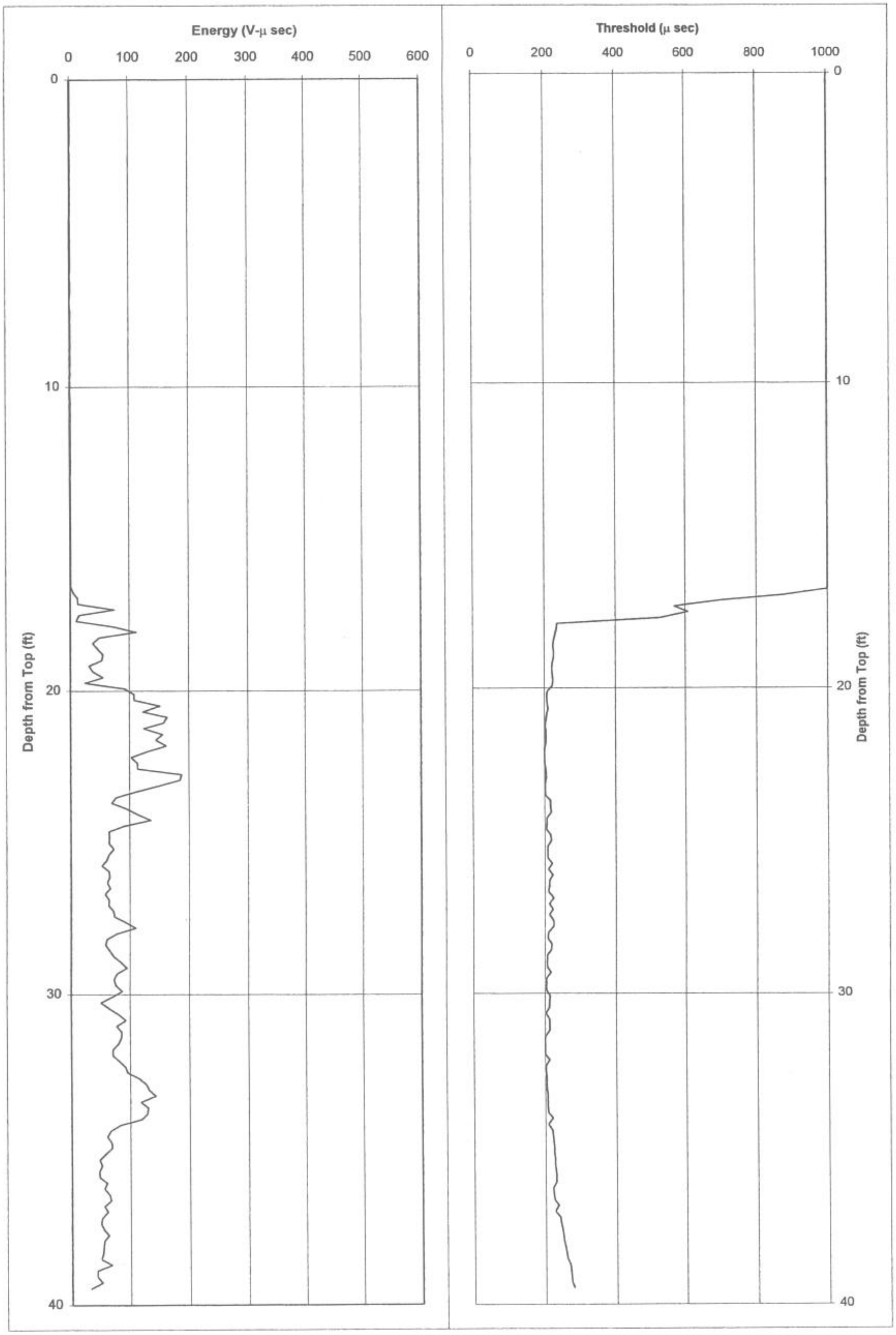

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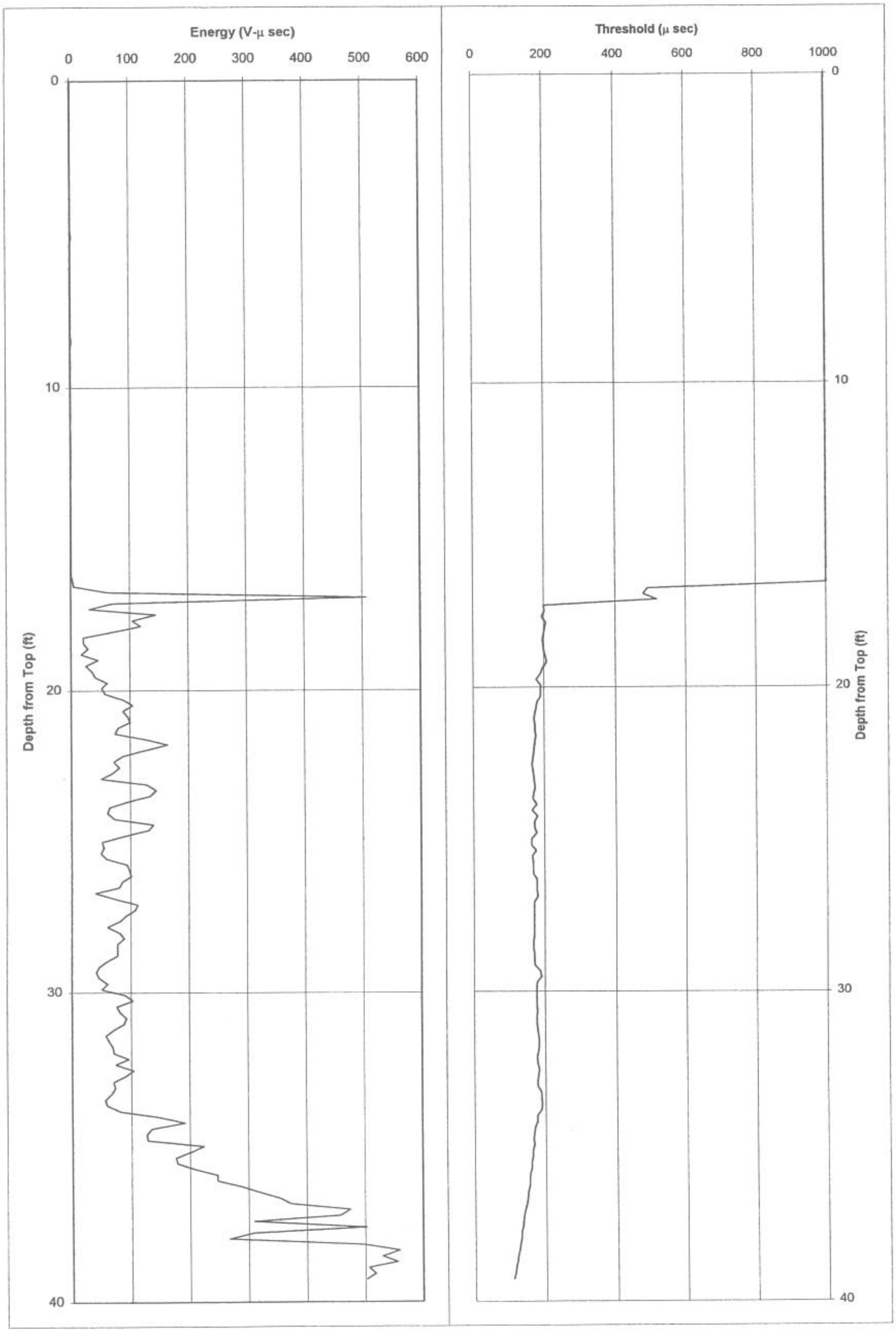

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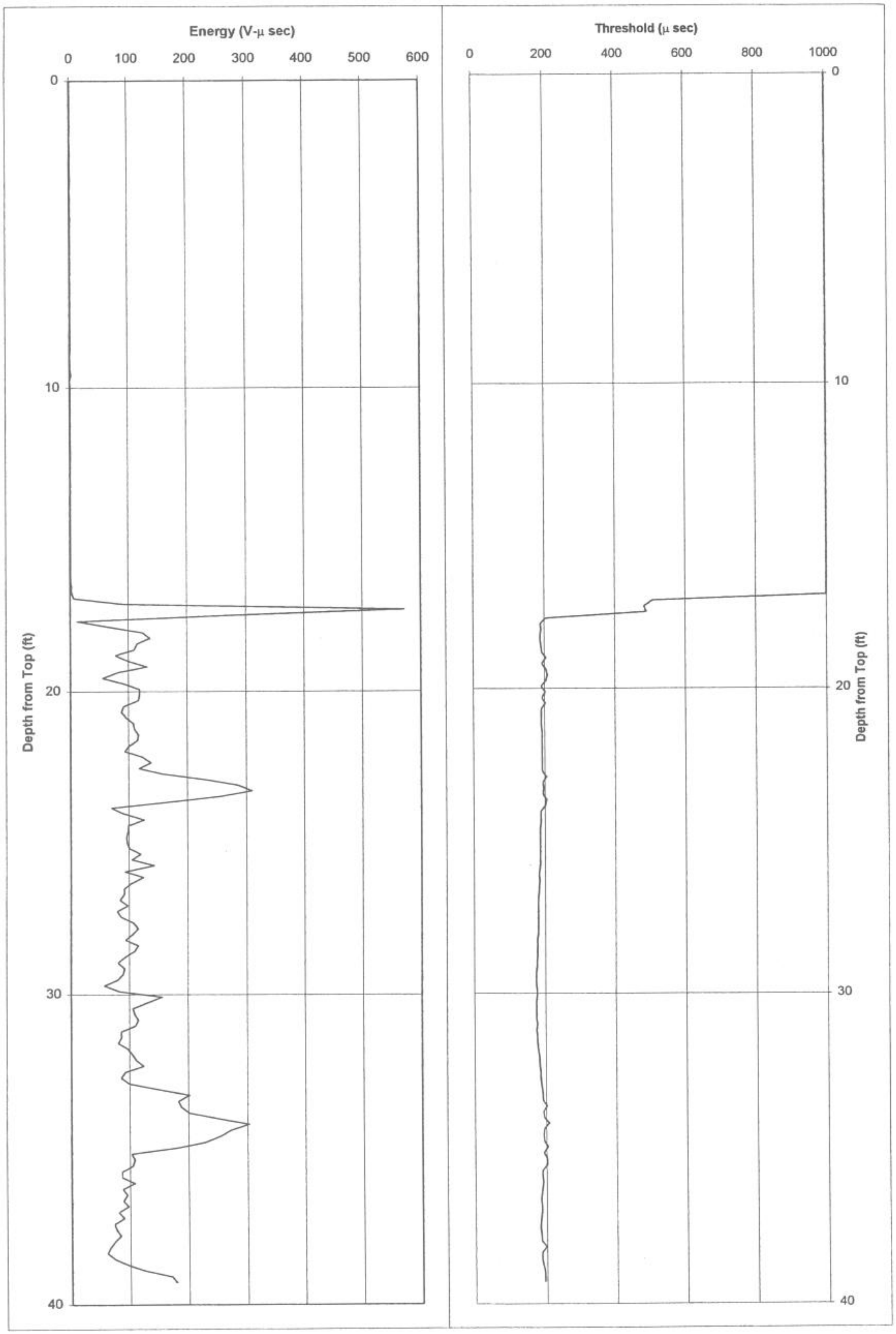

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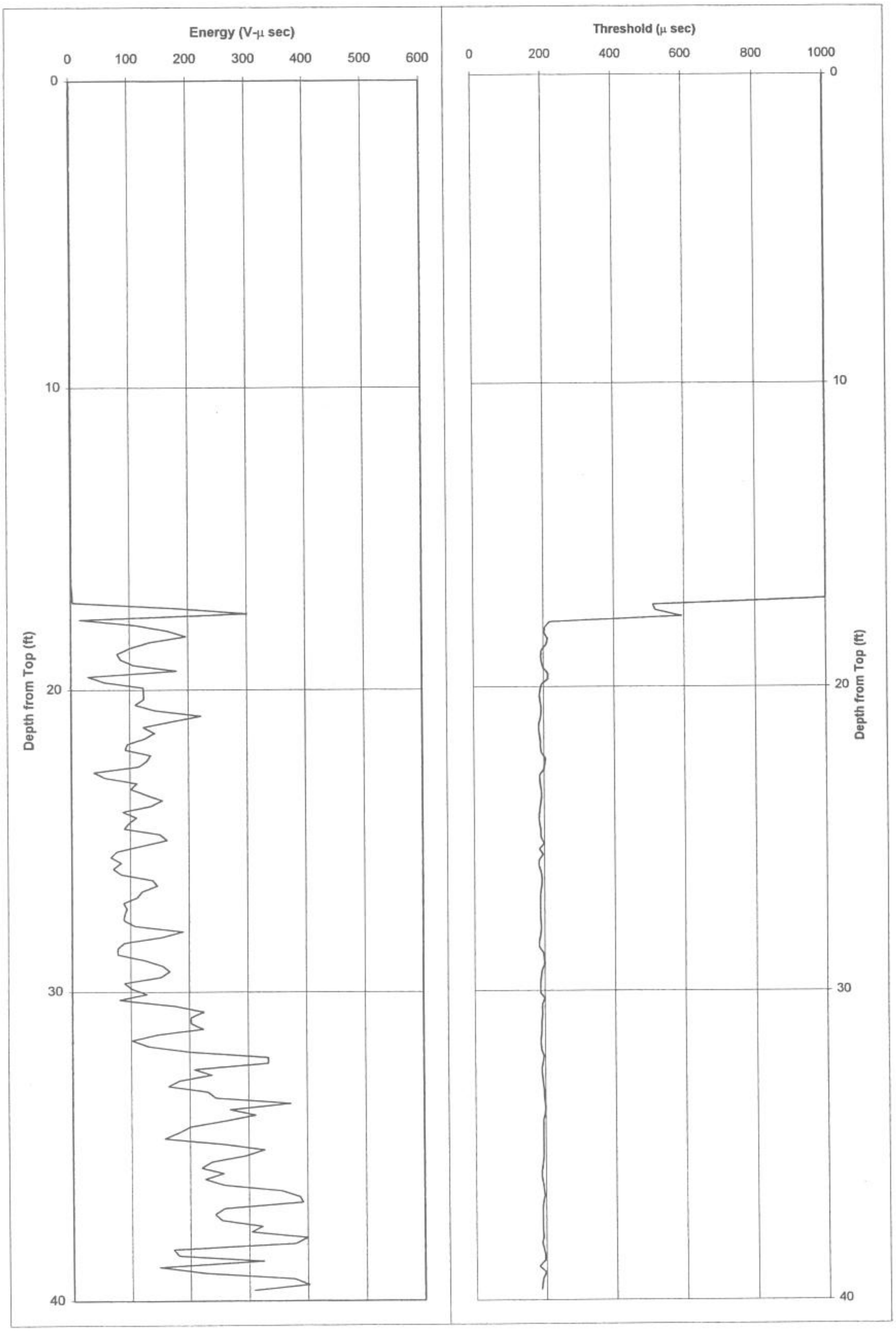

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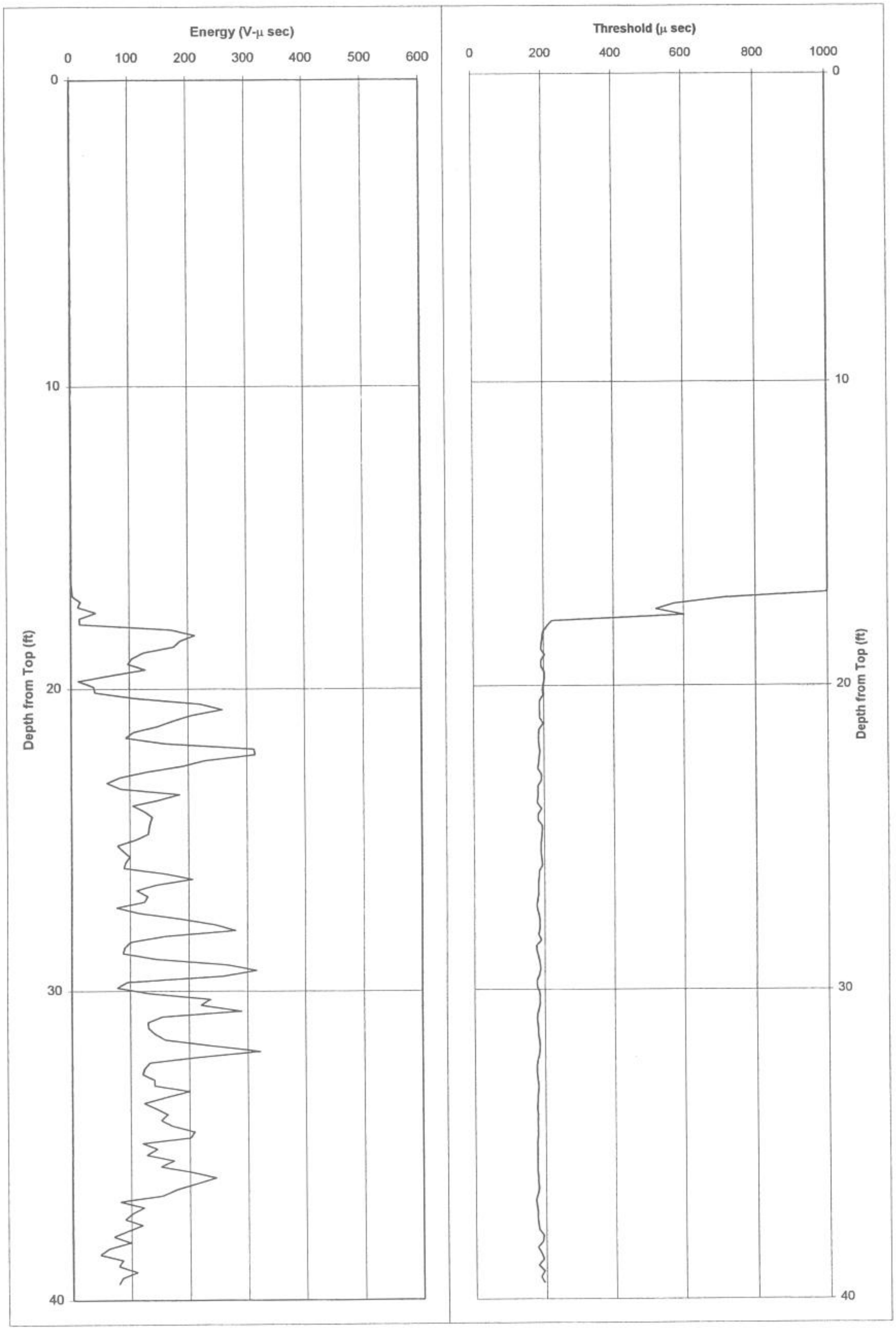

East Test Shaft Tube pair 6 - 1
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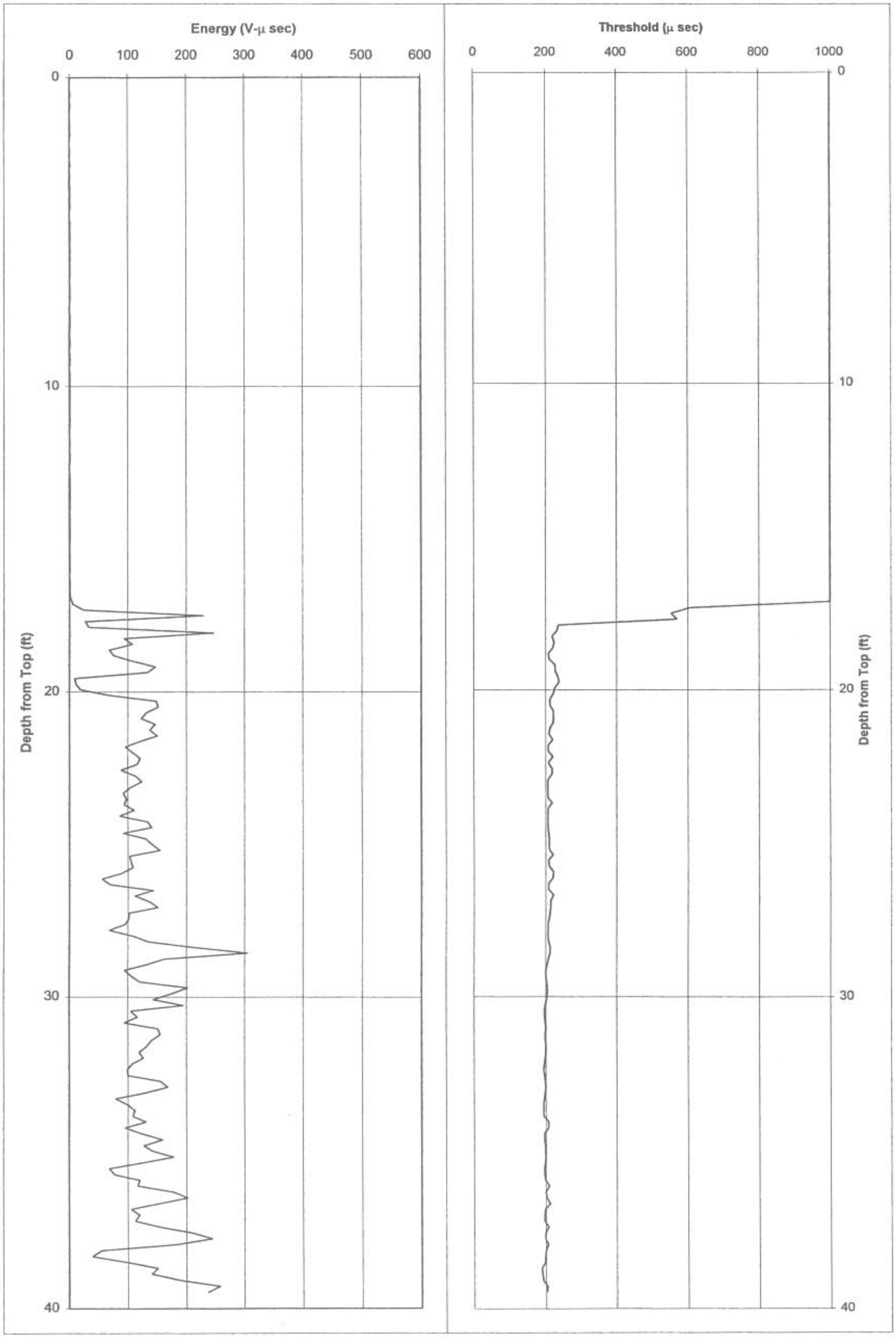
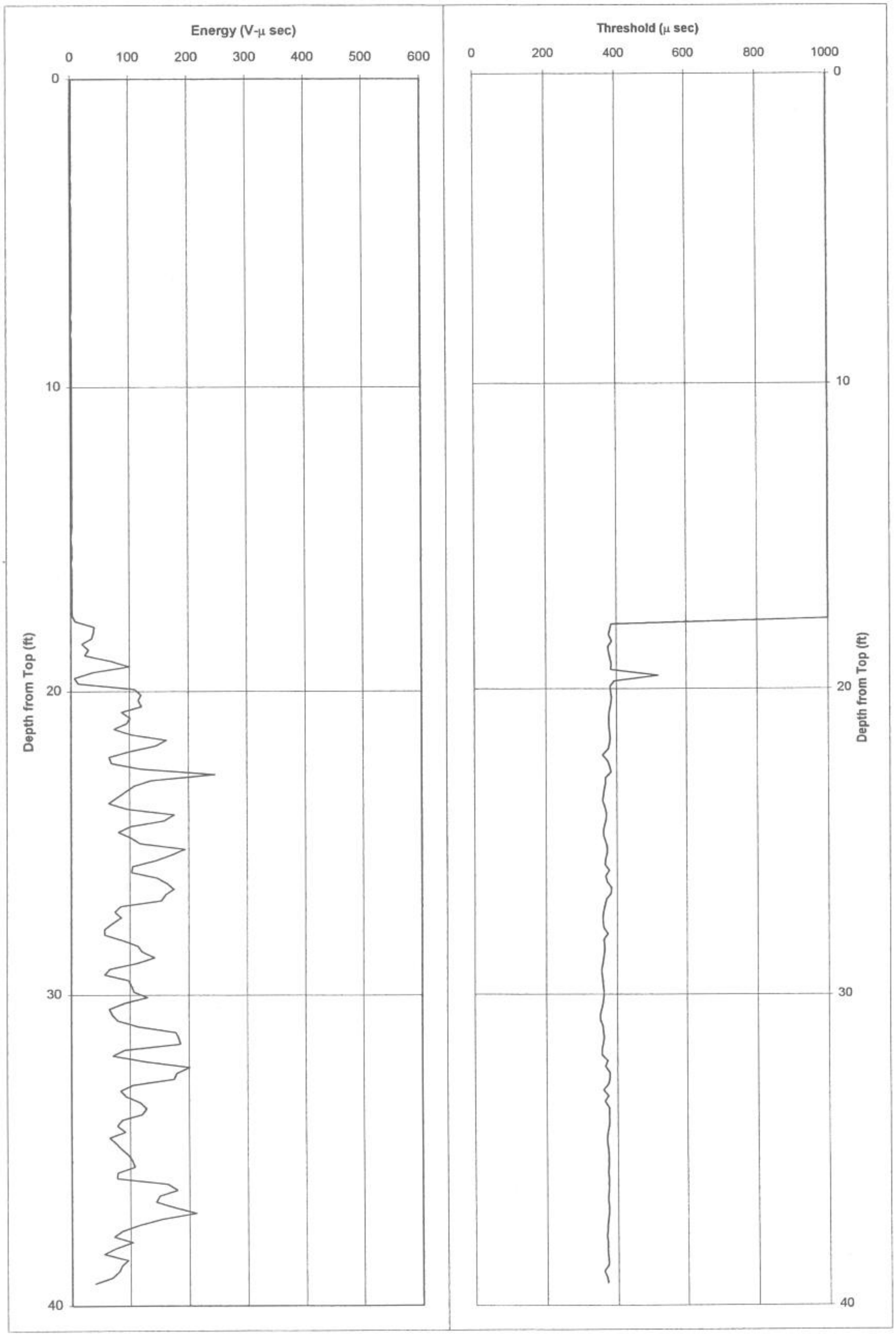
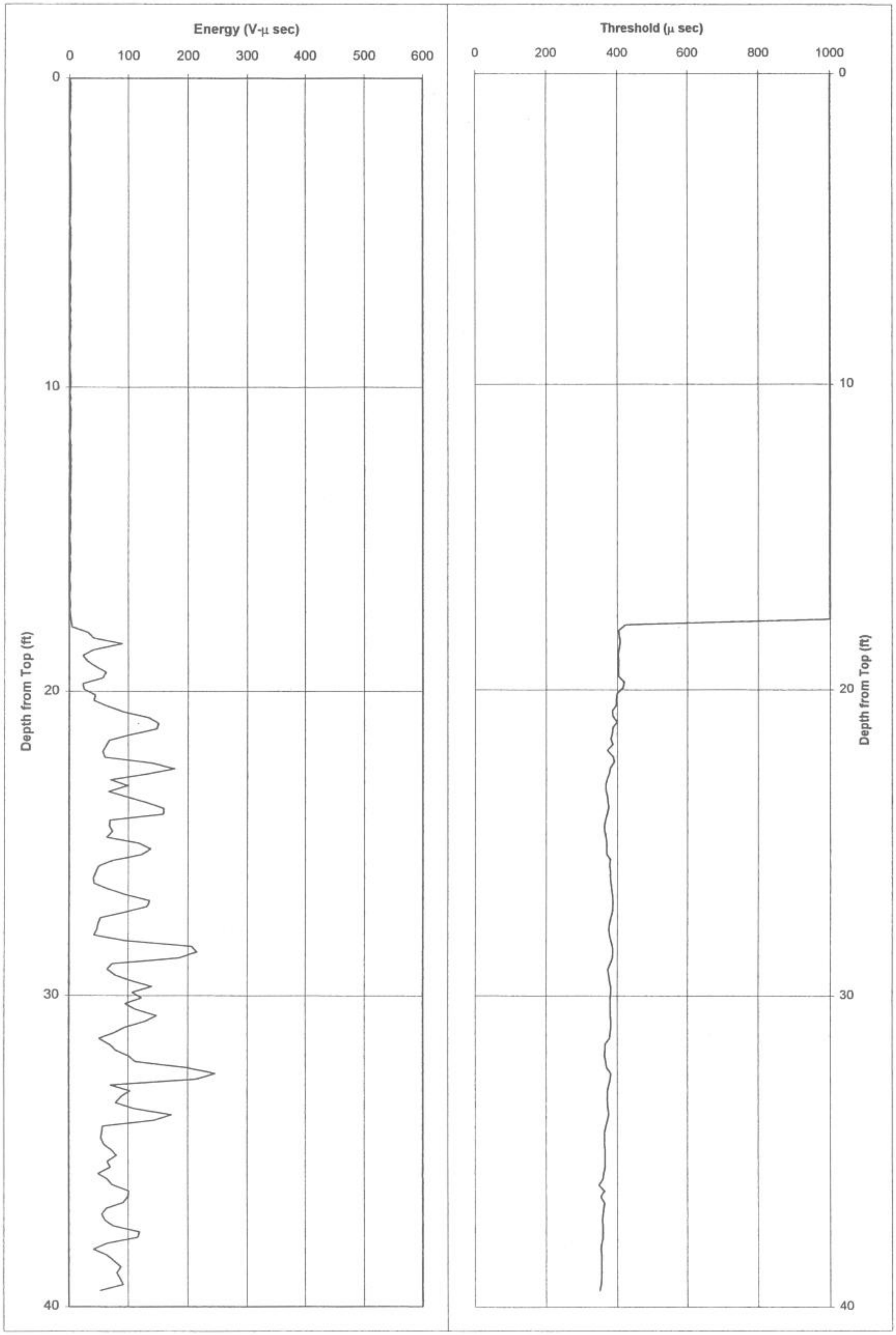


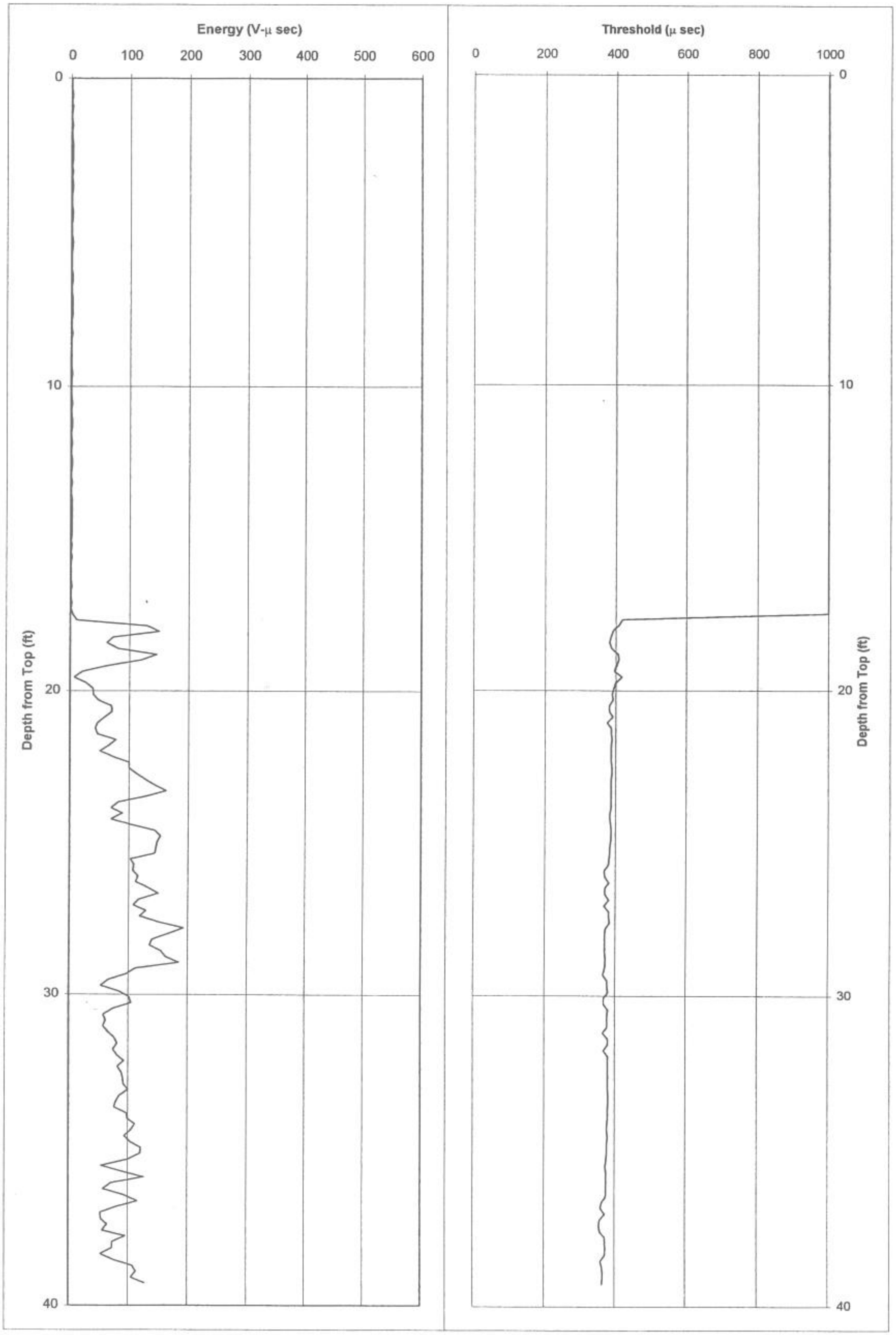
East Test Shaft Tube pair 1 - 4 Spacing = 60.0 in.



East Test Shaft Tube pair 2 - 5 Spacing = 60.5 in.



East Test Shaft Tube pair 3 - 6 Spacing = 60.5 in.



LOADTEST, Inc. Project No. 8718-CSL US 36 over Republican River Scandia, Kansas Figure 9

APPENDIX B

PRINCIPLES OF THE CSL AND SSL METHODS

The Nondestructive Testing (NDT) method used in this work is to provide quality assurance of the integrity of the concrete drilled shaft foundations. Crosshole Sonic Logging (CSL) was used to evaluate the integrity of the 2 shafts tested. Since only the CSL method was used in this investigation, only the principle of this method will be presented herein. The CSL method discussion includes the principles of the Singlehole Sonic Logging (SSL) because both methods are closely related.

2.1 Crosshole and Singlehole Sonic Logging (CSL and SSL) Methods

The CSL and SSL tests are downhole methods for quality assurance testing of drilled shaft foundations and concrete slurry walls. Access tubes, typically PVC or steel, must be cast-in-place in the concrete during construction to permit logging as illustrated in Fig. A. For a CSL test, logging involves passing an ultrasonic pulse through the concrete between source and receiver probes in a water-filled tube pair as the probe cables are pulled back to the surface over a depth measurement wheel. The CSL method thus tests the quality of the concrete lying between a tested pair of tubes. The SSL test is similar to the CSL test, but the source and receiver are in the same tube and separated by a fixed distance (typically three feet). The SSL method thus tests the quality of concrete in the first few inches immediately surrounding a tube. The CSL test provides the most information on the shaft integrity while the SSL test is used to confirm defects and/or investigate tube-concrete bonding conditions. In both tests, the source is excited by a high voltage pulse for every 0.1-0.2 feet of transducer travel, while the receiver response and measurement depth are simultaneously recorded for each measurement. To minimize noise, the receiver response is electronically bandpass filtered around the receiver's resonant frequency. Data from the receiver probe is then recorded and processed by a PC-based sonic logging system.

Analyses to evaluate the integrity of the concrete include measurement of wave travel times between the source and receiver, calculation of corresponding wave velocity, and receiver response energy. Longer travel times and corresponding slower velocities are indicative of irregularities in the concrete between the tubes, provided good bonding is present between the tubes and concrete. The complete loss of signal is indicative of a significant defect in the concrete between one or more tube pair combinations. Desirable results show consistent pulse arrival times with corresponding good compression wave velocities reasonable for concrete. Defects such as contaminated, weak concrete and soil intrusions will result in delayed arrivals (slower velocity) or no arrivals, respectively, in the defect zone. The signal energy level is a secondary indicator of concrete quality with low energy indicating poorer quality concrete. The wave velocity increases with time in concrete as it matures, particularly in the first few days of curing.

Angled source and receiver CSL logs (source and receiver offset vertically) can help to better define the nature and locations of defects indicated by initial same elevation source and receiver logs. In addition, Singlehole Sonic Logs (SSL) can provide information on the vertical extent of a defect zone for a given tube and also verify the tube to concrete coupling, or "bonding", in the event an anomaly occurs in a CSL log.

The sonic logs reported herein were performed with our 35 kilohertz (1 kHz = 1000 Hz), 1.35 inch O.D. transducers. Note that the 2-inch PVC access tubes extended to the top of the Osterberg cell, but not below. The CSL tests provide no information about the condition of the shaft below the bottom of the tubes. The CSL method cannot locate bulbs (diameter increases) because of the geometry of the test. The CSL method is, however, effective in locating significant necks or caves as these generally intrude into the signal paths. Diameter changes can generally be located with the SE/IR methods, if access is available to the shaft top concrete.