SETTLEMENT ANALYSIS REPORT FOR BLUEWATER MILL TAILINGS GRANTS, NEW MEXICO

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ARCO-BLUEWATER MILL TAILINGS SETTLEMENT

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1.0 INTRODUCTION

The purpose of this report is to document that consolidation has occurred and placement of the radon barrier can proceed. The consolidation of concern is that caused by the placement of approximately 10-feet to 15-feet of fill over the northern portion of the tailings impoundment. At least 90% of this consolidation has occurred and the placement of the radon barrier can commence. This report also presents the results of programs that were performed at the Bluewater Mill Tailings Impoundment, Grants, New Mexico to determine the consolidation of the tailings and to mitigate any areas where the time for consolidation was too long relative to the construction schedule.

A comprehensive study of the slime tailings was implemented to:

1. characterize the depths to bedrock and slimes thickness within the tailings impoundment,

2. provide an understanding of consolidation of slimes tailings sufficient to determine the amount and time for consolidation in relation to slime thickness within the tailings,

3. identify areas within the tailings impoundment where settlement would be too long relative to the construction schedule and to design and implement a program to accelerate the rate of consolidation in these areas,

4. monitor settlement to determine when consolidation is complete so that construction of the cover can commence,

5 develop measures to provide for protection of ground water during tailings consolidation.

To achieve these objectives a series of field studies and analyses were conducted. These included:

1. Field Sampling Program

2. Laboratory Testing

3. Data Evaluation and Analysis

4. Accelerated Consolidation Design and Implementation

5. Settlement Monitoring

These programs are described in the subsequent sections.

2.0 BACKGROUND

The tailings impoundment covers an approximate area of 300-acres. Tailings were initially deposited by slurrying to a depression in the basalt in an area near the center of the existing impoundment. A series of earthen embankments were constructed over the years to provide the structure and increased capacity. During most of the tailings impoundment operation, tailings were discharged from several movable spigots along the southern and southwestern perimeter of the tailings area. This resulted in segregation of tailings with the coarser sands being deposited at the south end and the fine-grained tailings (slimes) being deposited at the north end. The general configuration of the tailings impoundment is shown on Figure 1.

The southern portion of the impoundment contains sand tailings and is unsaturated. The northern portion of the impoundment contains slimes tailings and these tailings are saturated. The saturated slimes tailings are the material that will experience consolidation as the 10-feet to 15-feet of fill is placed over them. Most areas were covered with a geofabric to facilitate placement of the fill.

Settlement of the unsaturated sands upon placement of the loading material will be minor and will occur immediately because unsaturated sands settle immediately upon loading. Therefore loading of tailings sands is not a concern in the consolidation assessment. The interbedded sand and slimes area will also experience rapid consolidation upon loading since the interbedded sand layers will allow the slimes layers to drain quickly. The program presented below determined the thickness of continuous slimes that would cause consolidation to occur too slowly. In addition, some settlement points as discussed in section 7 are in the interbedded slimes and sand area and show that consolidation is complete.

3.0 FIELD SAMPLING PROGRAM

The field sampling program was conducted during July and August 1992 within the northern section of the main tailings impoundment. The investigation was concentrated in the northern section because this is the area where saturated slimes exist. The tailings in the center portion of the impoundment consist of interbedded sands and slimes. The investigated area covered enough of this central region to determine the limit of the slimes that are thick enough to cause the time for consolidation to be of concern.

Eighty-one piezocone probes and three Shelby tube samples were taken in the northern portion of the impoundment The location of the piezocone probes and Shelby tube samples is shown in Figure 2.

3.1 Piezocone Probing

Piezocone probing involves the penetration of rods having a cone tip into the subsurface of tailings material. As the cone penetrates the tailings material, tip resistance and friction along the cone are measured. The piezocone probe also contains a porous stone element in the tip with built-in instrumentation to measure pore water pressures in the tailings. These measurements provide parameters which describe the stratigraphy of the tailings material subsurface. The report containing the logs for each of the piezocone probe locations are contained in the Fugro Geosciences, Inc. report provided as Appendix A to this report.

Dissipation tests, also conducted at select piezocone locations, provide a means of determining in-situ material properties. As the probe (cone) penetrates the tailings material, excess pore pressures within the tailings increase around the tip of the cone. If the probe is stopped and the excess pore pressures are allowed to dissipate, an in-situ horizontal coefficient of consolidation can be calculated. The horizontal coefficient of consolidation can then be used to characterize the slime layers and design vertical band drains (wicks) for accelerated consolidation. Vertical band drains are further described in Section 6.0.

3.2 Shelby Tube Samples

Shelby tube samples for laboratory analyses were taken of the slimes with an auger rig at three specific locations within the northern section of the tailings impoundment. The location of the samples, which are shown on Figure 2, were chosen based on the depth and location of the slimes found during the piezocone probing.

4.0 LABORATORY TESTING

Consolidation and index tests were performed on the three Shelby tube samples. Each of the samples were saturated during the consolidation tests. The index testing of the slime samples included initial and final density, water content, Atterberg limits, and 200 wash. The results of the index testing are presented in Table 1. The laboratory data and the curves derived from the consolidation and index testing are contained in Appendix B.

Table 1: Results of Index Testing

Sample Number	Dry Unit Weight (pcf)	Water Content (%)	Liquid Limit	Plasticity Index	% - #200 Sieve
1A	55.3	74.5	48	29	71.1
2A	46.3	96.8	83	53	97.4
3A	44.1	105.1	70	42	95.4

5.0 DATA EVALUATION AND ANALYSIS

The data obtained from the field sampling program and the laboratory testing were evaluated and analyzed in order to delineate the depth to bedrock, estimate the thickness of the slimes, and estimate the total amount of settlement and the time for 90 percent consolidation to occur.

5.1 Delineation of Bedrock and Tailings Distribution

The piezocone probe data were evaluated and analyzed using the simplified soil classification chart for piezocones provided in Robertson and Campanella (1983). The soil classification chart for piezocones is reprinted in Appendix A. According to the chart, sandy material has a high friction and resistance (friction ratio between 0-2%) and low pore pressure, whereas, clayey material has a low friction and resistance (friction ratio greater than 3-5%) and high pore pressures.

Relating the above information to the piezocone logs, the depth to bedrock and the thickness of the slimes at each of the piezocone probe locations were determined. Aerial photographs of the area, taken in 1952 (Earth Science Information Center), were also used to develop the depth to bedrock. The photograph for the area is reproduced as Figure 3. A contour map of the depth to bedrock and an isopach map depicting the thickness of the slimes within the area of concern were developed. The bedrock contour map and the slimes isopach map are presented in Figures 4 and 5, respectively.

5.2 Amount and Time Rate of Consolidation

The amount of settlement and time rate of consolidation were estimated after evaluation and analysis of the data from the laboratory testing. The time rate of consolidation and the amount of settlement were estimated from the coefficient of consolidation and the compression index, respectively. The result of this analysis were used to determine areas where consolidation would have to be accelerated.

5.2.1 Coefficient of Consolidation

The consolidation data obtained from the laboratory testing was analyzed in order to determine the coefficient of consolidation. The time for 90 percent consolidation to occur is estimated from the vertical coefficient of consolidation (c_v). The vertical coefficient of consolidation is calculated from the graph of the square root of time versus deformation (Lambe and Whitman, 1969) from the consolidation test. (See Appendix B.)

The equation used to calculate the time for 90 percent unaided consolidation to occur is:

$$t_{90} = \frac{0.848 (H_d)^2}{c_v}$$

where:
- H_d = average longest drainage path during consolidation, in this case, one half of the thickness of the slimes (for double drainage, free draining above and below the slimes layer),
- t_{90} = time for 90% consolidation to occur in cm²/sec, and
- c_v = vertical coefficient of consolidation.

A range of values, 0.0017 cm²/sec to 0.0043 cm²/sec, for the vertical coefficient of consolidation was calculated from the laboratory testing of the three slimes samples for the different loading increments. The average and most frequently occurring value which was used in the calculation of t_{90} was 0.002 cm²/sec.

Utilizing the above parameters and assuming the slimes can drain both vertically up and down, the time to achieve 90 percent consolidation for the 5-foot, 10-foot, 15-foot, 20-foot and 25-foot slimes thickness contour intervals were calculated. The time for 90 percent consolidation to occur at these thickness contour intervals after the placement of the fill material is presented in Table 2.

Table 2: Summary of Consolidation Analysis

Continuous Slimes Thickness (ft)	Predicted Surcharge Settlement (ft)	Time for Surcharge Caused Consolidation * (months)
5	1.7	1.0
10	2.6	4.0
15	3.3	8.5
17.5	3.6	12.0
20	3.9	15.2
25	4.4	23.7

*Time for settlement is for immediately after the placement of the fill which was essentially completed by July 1992. These times are for unaided consolidation (i.e. without wicks)

5.2.2 Compression Index

The consolidation data obtained from the laboratory testing were also analyzed in order to determine the compression index. The total amount of settlement that may occur is calculated from the compression index. The compression index (C_c) is calculated from the curve of the void ratio (e) versus the log of the vertical stress (see Appendix A).

The equation used to calculate the total amount of settlement that may occur is:

$$\Delta H = \frac{C_c H}{1+e_o} \log \frac{\Delta\sigma + \sigma_o'}{\sigma_o'}$$

where:
H = thickness of the slimes,
e_o = initial void ratio,
$\Delta\sigma$ = increase in vertical stress in the slimes layer in psf,
σ_o' = initial effective stress in the slimes layer in psf, and
C_c = compression index.

The value determined for the compression index from the laboratory consolidation testing was 0.90. Based on the above parameters and equation, the total amount of settlement for the slime intervals was calculated. The predicted amount of settlement due to the placement of the approximately 15 feet of fill material prior to the placement of the radon barrier is presented in Table 2. A contour map of the predicted amount of settlement for 5 foot intervals of slimes thickness is presented in Figure 8.

At the time of the analysis, the last of the fill had been in place for approximately 6 months. Fill placement began in 1990 which was approximately 2 years prior to the analysis. Therefore all of the settlement for the areas with 10-feet or less of continuous slimes thickness and many areas where the slimes thickness is greater than 10-feet has already experienced at least 90% of the total consolidation due to the cover. At the time of analysis (6 months after the placement of the last fill), additional settlement was possible for areas that have 15-feet or more continuous slimes.

The time for the remainder of the consolidation to occur after the time of analysis is shown on Figure 6. These estimates are for unaided settlement. Due to the fact that much of the fill was placed before the consolidation analysis, much of the consolidation occurred prior to the analysis, therefore the actual time for the remainder to the consolidation to occur will be less than the estimates shown on Figure 6.

Areas which have continuous slimes thickness greater than 15-feet possibly had additional settlement which had not occurred at the time of the analysis. Much of this area would have experienced total settlement by the time of radon barrier installation without accelerated consolidation. However, to insure that all areas would be ready for radon barrier placement as soon as possible, it was decided that all areas within the 15-foot slimes thickness contour and the area north of the 15-foot slimes contour thickness along the northern embankment would require settlement to be accelerated. The area is designated as the "area of concern" and covers approximately 74-acres of the tailings impoundment and is shown on Figure 7.

6.0 ACCELERATED CONSOLIDATION DESIGN AND GROUND WATER PROTECTION

Because the amount of predicted settlement and the time predicted for consolidation are large for the area of concern, a method for accelerating the consolidation process was designed. The method chosen to accelerate consolidation process was vertical band drains or wicks. Vertical band drains are used to accelerate consolidation of relatively thick deposits of fine-grained soils. The function of the band drains is to shorten the length of the flow paths of pore water by allowing pore water to dissipate along a horizontal flow path toward the drains. The design assumed that 90 percent of the consolidation caused by the surcharge would need to be completed within about 6 months after the installation of the wicks.

6.1 Design

The vertical band drains consist of a central core which acts as a free-draining water channel. Surrounding the central core is a thin filter jacket which prevents soil from entering the central core while allowing free entry of the excess pore water to the central core.

In order to optimize consolidation the vertical band drain spacing can be determined using the values of the horizontal coefficient of consolidation, c_h, obtained from the piezocone testing and the equation presented below (Hansbo, 1979):

$$t = \frac{\alpha}{c_h} D^2 \left(\frac{D\gamma_w}{\Delta u_o'}\right)^{1/2} \left(\frac{1}{(1-U_h)^{1/2}} - 1\right)$$

where:
- t = time of consolidation,
- $\alpha = f(D/d)$,
- d = diameter of drain = 50 mm,
- D = diameter of dewatered soil cylinder,
- c_h = horizontal coefficient of consolidation = .0092 cm^2/sec.
- γ_w = unit weight of water = 62.4 lbs/ft^3
- $\Delta u_o'$ = initial excess pore water pressure = surcharge = 12' of fill @ 110 pcf
- U_h = degree of consolidation required = 90%

The horizontal coefficient of consolidation, c_h, was determined from the piezocone dissipation tests. Time versus pore pressure curves were subsequently developed from the dissipation tests. The dissipation curves were analyzed and interpreted according to guidelines provided in Baligh and Levadoux (1986). The range of c_h values calculated was 0.0092 cm^2/sec to 0.1963 cm^2/sec. To be conservative, the lower end of the range, 0.0092 cm^2/sec, was chosen for the wick design. The dissipation curves are presented in the Fugro Geosciences, Inc. report provided in Appendix A.

Using the above equation and parameters, the spacing necessary to provide 90 percent consolidation within the specified period of time of 6 months was calculated. The drain spacing was calculated to be 11 feet for a triangular spacing. Triangular spacing was chosen as opposed to square spacing as it is more cost efficient. The total surface area over which the vertical band drains were installed is 74 acres. The location and spacing of the wicks are presented on Figure 9.

Ground water protection will be provided by maximizing the amount of tailings fluid that moves upward where it is removed by evaporation or adsorbed by the loading material. The vertical band drains were placed to within 3 to 5 feet of the bottom of the slimes. The band drains did not fully penetrate the slimes layer. This was done to maximize the amount of water that would

be brought to the surface and minimize the flow into the foundation in order to protect groundwater and while still maintaining the efficiency of the band drain. The depth of wick penetration, measured from the existing ground surface is given on Figure 10.

6.2 Vertical Drain Installation

Vertical band drains were installed at the locations and to the depths shown on Figure 10. The drains were installed from November 1, 1992 to March 12, 1993. A summary of the wick installation is presented in Table 3.

Table 3: Summary of Wick Installation

Period of Time (months)	Wick Spacing (ft)	Number of Wicks	Total Lineal Footage
6	11	27,456	754,996

7.0 SETTLEMENT MONITORING

Settlement monitoring has been conducted at the Bluewater Mill to observe and document the consolidation of the slimes portion of the Main Tailings Impoundment following the placement of fill from cleanup activities around the site.

7.1 Settlement Monuments and Surveys

A total of 27 settlement monuments were placed and have been monitored since the completion of the vertical band drain installation. These settlement monuments are located as shown on Figure 11. The settlement data from these monuments is presented on Table 4. The settlement versus time and the settlement versus the square root of time are plotted and presented Appendix C.

The settlement monuments consist of a stable point so that repeated surveying does not disturb the point. The monuments are constructed of a one foot square steel plate with a steel bar welded to the plate and the base embedded in several inches of concrete. The plates were buried approximately 10-feet to 15-feet below the surface, immediately above the geofabric material and slimes. Elevation readings were taken for the settlement monuments using differential level surveys. These level surveys were tied to a stable survey reference monument located off the tailings. The uniformity of survey data indicates good survey precision.

7.2 Settlement Results

The settlement data were plotted against the square root of time so that a graphical analysis could be conducted to determine when 90% of the primary consolidation was complete. This is a common technique used to interpret settlement data (Lambe and Whitman, 1969).

Settlement point 20 shown on Figure 12, is typical of the settlement points. A total of approximately 0.2 to 1.0-feet of settlement has been observed in all areas. The most recent readings indicate that very little, if any, additional settlement is continuing.

The total amount of expected settlement, as discussed in Section 5, was between 3.3 and 4.4 feet for areas that received wicks (areas with more than 15-feet of continuous slimes). It is apparent from the monitoring results that settlement of this magnitude was not observed. This leads to two possible conclusions. The settlement was essentially complete before the settlement monitoring began, or excessive settlement is yet to occur. The data as discussed below indicate that settlement is complete.

There are three arguments that lead to the conclusion that at least 90% of the primary settlement due to the placement of 10 to 15 feet of fill has occurred. First, the calculation for both unaided and consolidation after wicks were placed would indicate that settlement should be finished. Second, the shape of the settlement versus square root of time curves indicate that 90% consolidation has occurred. Third, the differences between most recent settlement readings are very small and are a result of random survey errors and not additional settlement. Each of these three arguments are developed below.

Recall that the wicks were designed so that 90% consolidation would occur within six months after wick installation which should have been between April and September, 1993. Settlement monitoring did not begin until February 22. Therefore much of the settlement caused by the vertical band drains likely occurred before the monitoring began. In addition, it is likely that significant settlement occurred in many areas before the wicks were placed. It was assumed, in the analysis to determine the time for unaided consolidation, that all of the fill was placed in July, 1992. In reality, the majority of the fill and therefore the majority of the settlement occurred well before the wicks were installed. Therefore, given that much of the settlement occurred before the drains were placed and settlement monitoring did not begin until well after the installation of the wicks, it is not surprising that the settlement that was measured is much less than the total expected.

The plots of the settlement data versus the square root of time also indicates that the settlement is complete for all areas. A complete settlement curve plotted against the square root of time is shown in Figure 13 (Lambe and Whitman, 1969). As can be seen, the shape of the Bluewater settlement data is characteristic of the tail of the Lambe and Whitman settlement versus square root of time curve (i.e. the portion of the settlement curve after t90). The graphical technique

suggested by Lambe and Whitman (1969) can not be totally applied to the Bluewater data since the initial steep portion of the curve is not available. However, based on the characteristic shape of the all of the settlement curves, it can be concluded that all of the areas have experienced at least 90% of the primary consolidation.

Recent readings clearly show that no additional settlement is occurring. The most recent readings are different by less than approximately 0.05-feet with some monuments showing lower elevations and some showing higher elevations with the most recent readings. This small difference between the most recent readings is well within the range that can be attributed to random survey errors. ARCO's 1990 approved Reclamation Plan states that the settlement will be deemed complete when the most recent readings are different by less than random survey errors. The typical error in the survey closure of the settlement survey loop is 0.05-feet.

8.0 CONCLUSION

A comprehensive program was conducted which demonstrates that consolidation of the tailings has been achieved and placement of the radon barrier can commence. The program identified areas where consolidation was complete and no action was necessary. It also identified areas where an accelerated consolidation program was necessary. Wicks were installed in these areas and consolidation has now occurred. Monitoring data taken since the wicks were installed indicated that settlement due to the placement of the fill over the tailings is complete and, therefore, placement of the radon barrier can commence immediately.

9.0 REFERENCES

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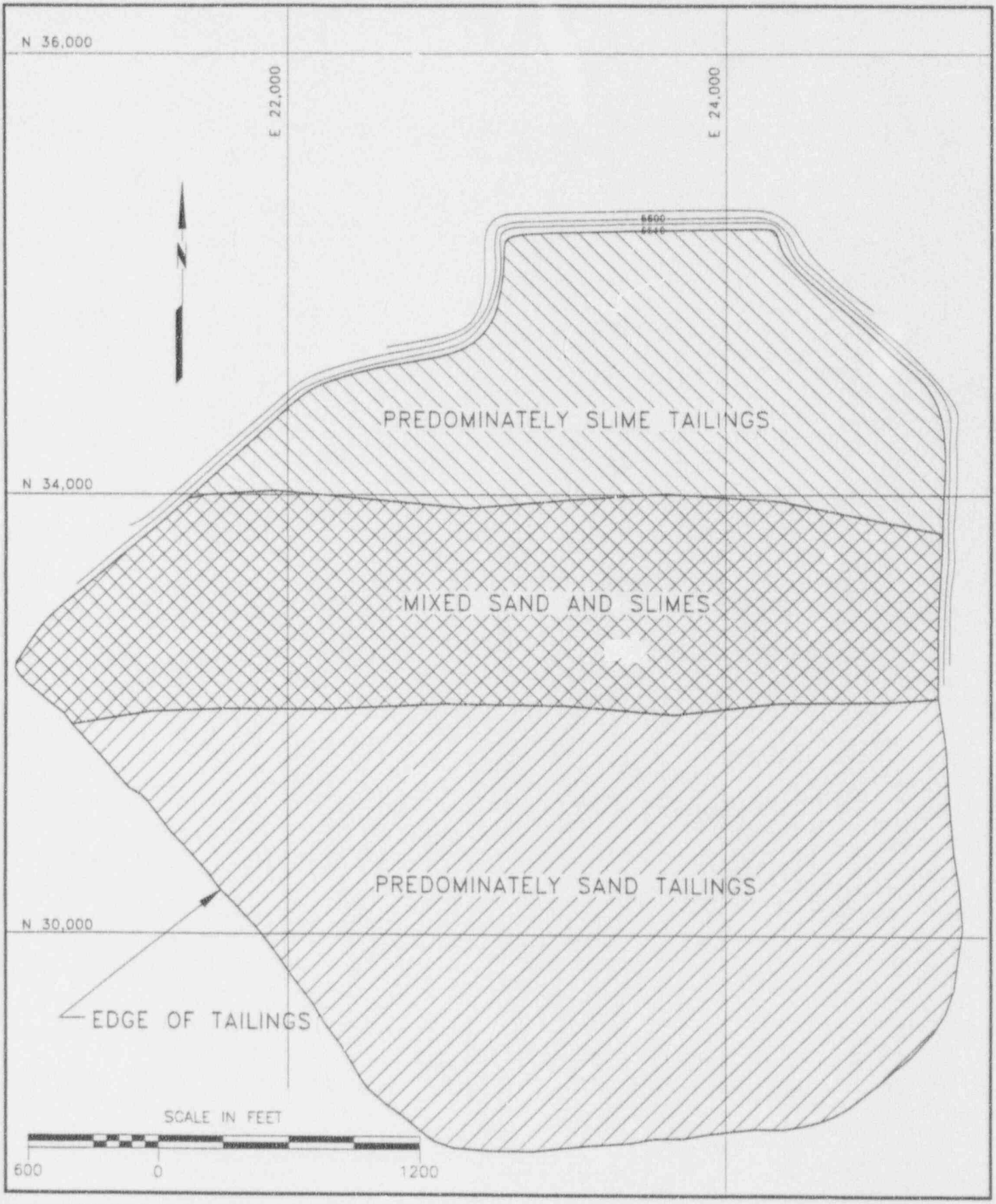
Table 4 Settlement Data

Date	S1	S2	S3	S4	S5	S6	S7	S8	SN8	S9	S10	S11	S12	S13	S14	S15
22-FEB-93	6817.58	6813.41	6809.08	6807.38	6805.74	6806.19	6807.73	6809.99	6803.9	6815.48	destroyed	6811.21	not set by evaluation period			
11-MAR-93	6817.55	6813.42	6808.98	6807.31	6805.7	6806.18	6807.89	6809.82	6803.86	6815.42	by TMC	6811.21				
22-MAR-93	6817.65	6813.47	6809.04	6807.35	6805.79	6806.21	6807.78	6809.78	6803.91	6815.5		6811.24				
07-APR-93	6817.6	6813.41	6808.94	6807.25	6805.7	6806.14	6807.7	6809.68	6803.84	6815.48		6811.25				
15-APR-93	6817.62	6813.41	6808.92	6807.24	6805.69	6806.13	6807.69	6809.66	6803.83	6815.47		6811.25				
21-APR-93	6817.6	6813.4	6808.9	6807.2	6805.67	6806.11	6807.67	6809.61	6803.81	6815.45		6811.23				
29-APR-93	6817.6	6813.41	6808.87	6807.19	6805.66	6806.11	6807.66	6809.8	6803.8	6815.47		6811.23				
11-MAY-93	6817.57	6813.35	6808.8	6807.12	6805.58	6806.03	6807.59	6809.51	6803.73	6815.4		6811.18				
29-MAY-93	6817.55	6813.33	6808.74	6807.08	6805.54	6806.01	6807.57	6809.44	6803.7	6815.39		6811.15				
10-JUN-93	6817.57	6813.37	6808.75	6807.08	6805.54	6806.02	6807.58	6809.48	6803.71	6815.43		6811.18				
24-JUN-93	6817.59	6813.37	6808.74	6807.08	6805.55	6806.02	6807.56	6809.42	6803.72	6815.42		6811.19				
13-JUL-93	6817.55	6813.31	6808.64	6806.95	6805.45	6805.95	6807.48	6809.34	6803.62	6815.36		6811.11				
27-JUL-93	6817.58	6813.34	6808.62	6806.93	6805.45	6805.95	6807.49	6809.33	6803.61	6815.39		6811.14				
12-AUG-93	6817.59	6813.35	6808.62	6806.93	6805.44	6805.95	6807.5	6809.33	6803.62	6815.38		6811.16				
25-AUG-93	6817.59	6813.34	6808.59	6806.87	6805.41	6805.94	6807.47	6809.3	6803.6	6815.39		6811.15				
8-SEP-93	6817.55	6813.29	6808.51	6806.8	6805.33	6805.88	6807.41	6809.24	6803.52	6815.35		6811.11				
25-SEP-93	6817.56	6813.28	6808.52	6806.81	6805.35	6805.9	6807.43	6809.24	6803.53	6815.36		6811.12				
06-OCT-93	6817.53		6808.48	6806.75	6805.27	6805.83	6807.38	6809.2	6803.5	6815.32		6811.07				
18-OCT-93	6817.54	6813.27	6808.45	6806.71	6805.24	6805.81	6807.34	6809.16	6803.45	6815.32		6811.07				

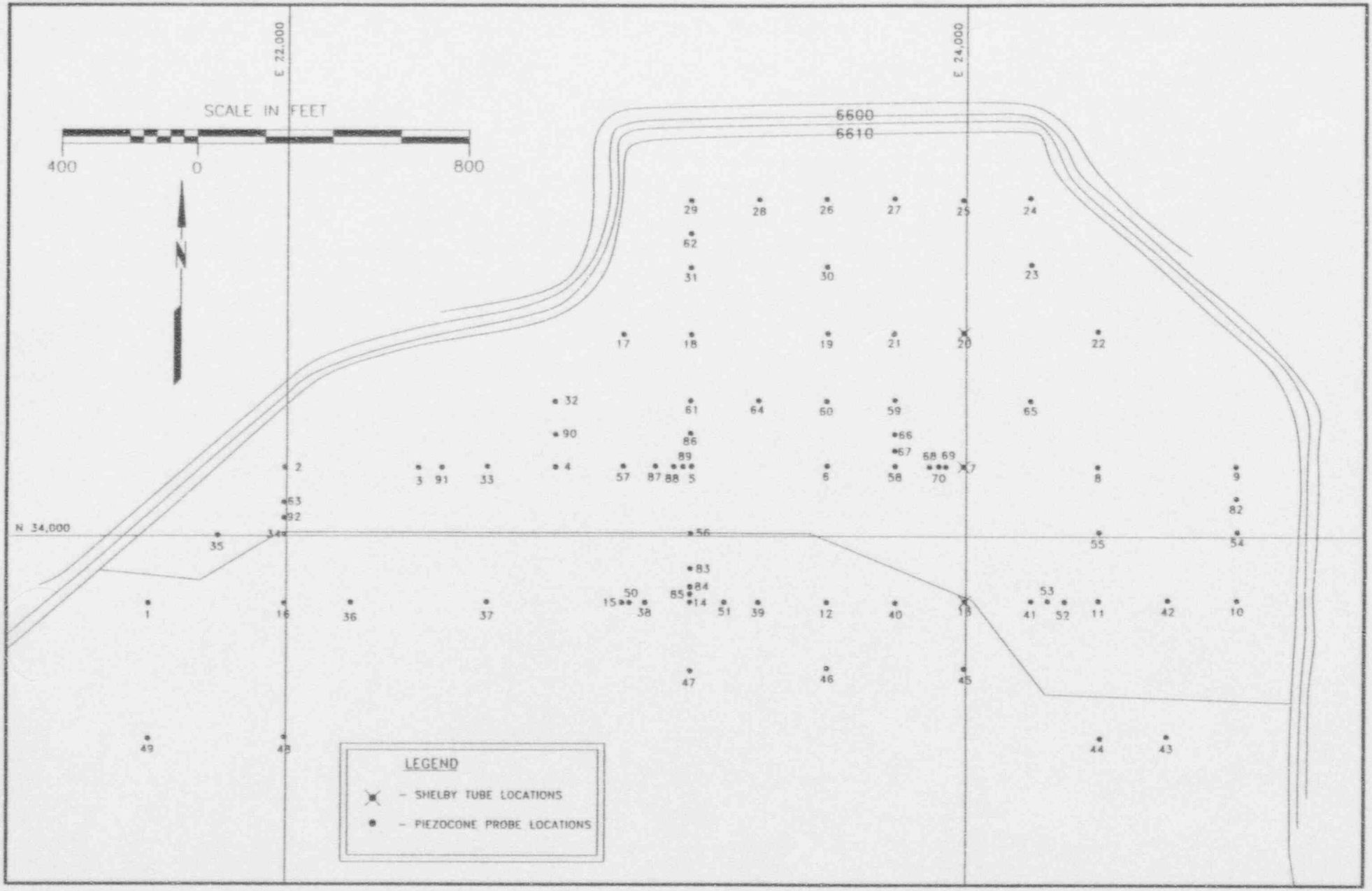
Date	S16	S17	S18	S19	S20	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30	S31	S32
22-FEB-93	6814.47	6810.15	not set	6807.76	6810.74	6807.08	6810.93	6808.94	6809.59	6809.94	6814.95	6813.13	6811.11	6810.29	6811.94	6813.93	6809.48
11-MAR-93	6814.37	6810.08		6807.72	6810.67	6807.09		6808.84	6809.5	-16.87	6814.92	6813	6811.01		6811.8	6813.78	6809.37
22-MAR-93	6814.34	6810.12		6807.78	6810.73	6807.13	6810.95	6808.85	6809.56	6809.95	6815.05	6813.03	6811.02	6810.25	6811.85	6813.77	6809.34
07-APR-93	6814.26	6810.01		6807.7	6810.62	6807.05	6810.88	6808.74	6809.45	6809.89	6815	6812.91	6810.87	6810.2	6811.75	6813.71	6809.24
15-APR-93	6814.24	6809.99		6807.69	6810.63	6807.04	6810.84	6808.73	6809.48	6809.88	6815.02	6812.88	6810.85	6810.18	6811.72	6813.7	6809.2
21-APR-93	6814.18	6809.96		6807.68	6810.6	6807.02	6810.83	6808.69	6809.43	6809.86	6815.01	6812.84	6810.81	6810.14	6811.67	6813.65	6809.11
29-APR-93	6814.15	6809.94		6807.68	6810.59	6807.01	6810.81	6808.68	6809.41	6809.85	6815.01	6812.81	6810.79	6810.13	6811.66	6813.65	6809.12
11-MAY-93	6814.04	6809.86		6807.6	6810.52	6806.92	6810.74	6808.58	6809.33	6809.78	6814.97	6812.72	6810.67	6810.03	6811.55	6813.56	6809
29-MAY-93	6813.97	6809.8		6807.58	6810.47	6806.91	6810.66	6808.51	6809.28	6809.76	6814.96	6812.64	6810.62	6809.99	6811.48	6813.52	6809.12
10-JUN-93	6813.95	6809.81		6807.58	6810.48		6810.67	6808.52	6809.29	6809.78	6814.96	6812.64	6810.63	6809.99	6811.48	6813.54	6808.91
24-JUN-93	6813.92	6809.78		6807.6	6810.48	6806.92	6810.64	6808.5	6809.29	6809.75	6815	6812.6	6810.6	6809.97	6811.43	6813.53	6808.85
13-JUL-93	6813.8	6809.68		6807.5	6810.4	6806.83	6810.56	6808.39	6809.19	6809.66	6814.95	6812.49	6810.5	6809.86	6811.32	6813.44	6808.72
27-JUL-93	6813.79	6809.68		6807.51	6810.39	6806.83	6810.56	6808.38	6809.17	6809.67	6814.96	6812.46	6810.48	6809.85	6811.3	6813.45	6808.69
12-AUG-93	6813.77	6809.65		6807.51	6810.39	6806.83	6810.54	6808.35	6809.17	6809.66	6815	6812.43	6810.46	6809.84	6811.27	6813.46	6808.67
25-AUG-93	6813.72	6809.62		6807.5	6810.36	6806.81	6810.52	6808.31	6809.13	6809.65	6814.99	6812.38	6810.42	6809.8	6811.23	6813.43	6808.6
8-SEP-93	6813.64	6809.54		6807.42	6810.28	6806.75	6810.44	6808.22	6809.05	6809.6	6814.93	6812.3	6810.35	6809.72	6811.13	6813.38	6808.52
25-SEP-93	6813.64	6809.53		6807.45	6810.29	6806.78	6810.45	6808.22	6809.06	6809.61	6814.95	6812.29	6810.34	6809.72	6811.11	6813.4	6808.49
06-OCT-93	6813.59	6809.5		6807.4	6810.23	6806.7	6810.43	6808.17	6809.02	6809.58	6814.95	6812.24	6810.3	6809.67	6811.03	6813.37	6808.42
18-OCT-93	6813.53	6809.47		6807.38	6810.21	6806.68	6810.4	6808.13	6808.96	6809.52	6814.95	6812.2	6810.28	6809.61	6810.98	6813.33	6808.37



SMI
SHEPHERD MILLER, INC.

FIGURE 1
BLUEWATER TAILINGS IMPOUNDMENT

Date:	OCT. 1993
Project:	312
File:	TAIL-1



SMI
SHEPHERD MILLER, INC.

FIGURE 2
LOCATION OF PIEZOCONE PROBES AND SHELBY TUBE SAMPLES

Date:	OCT. 1993
Project:	312
File:	PROBES

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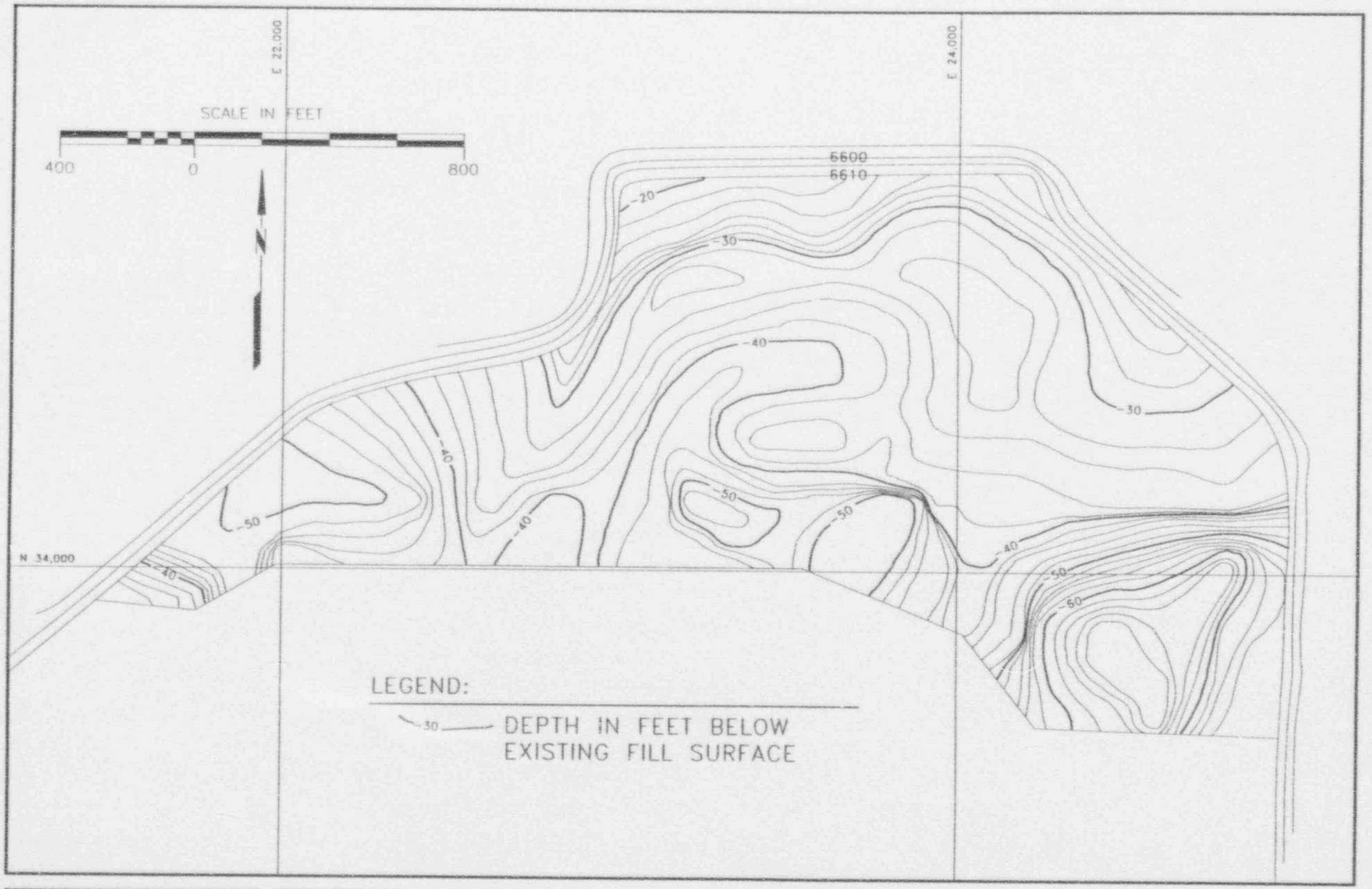
SHEPHERD MILLER, INC.

FIGURE 3
1952 AERIAL PHOTOGRAPH

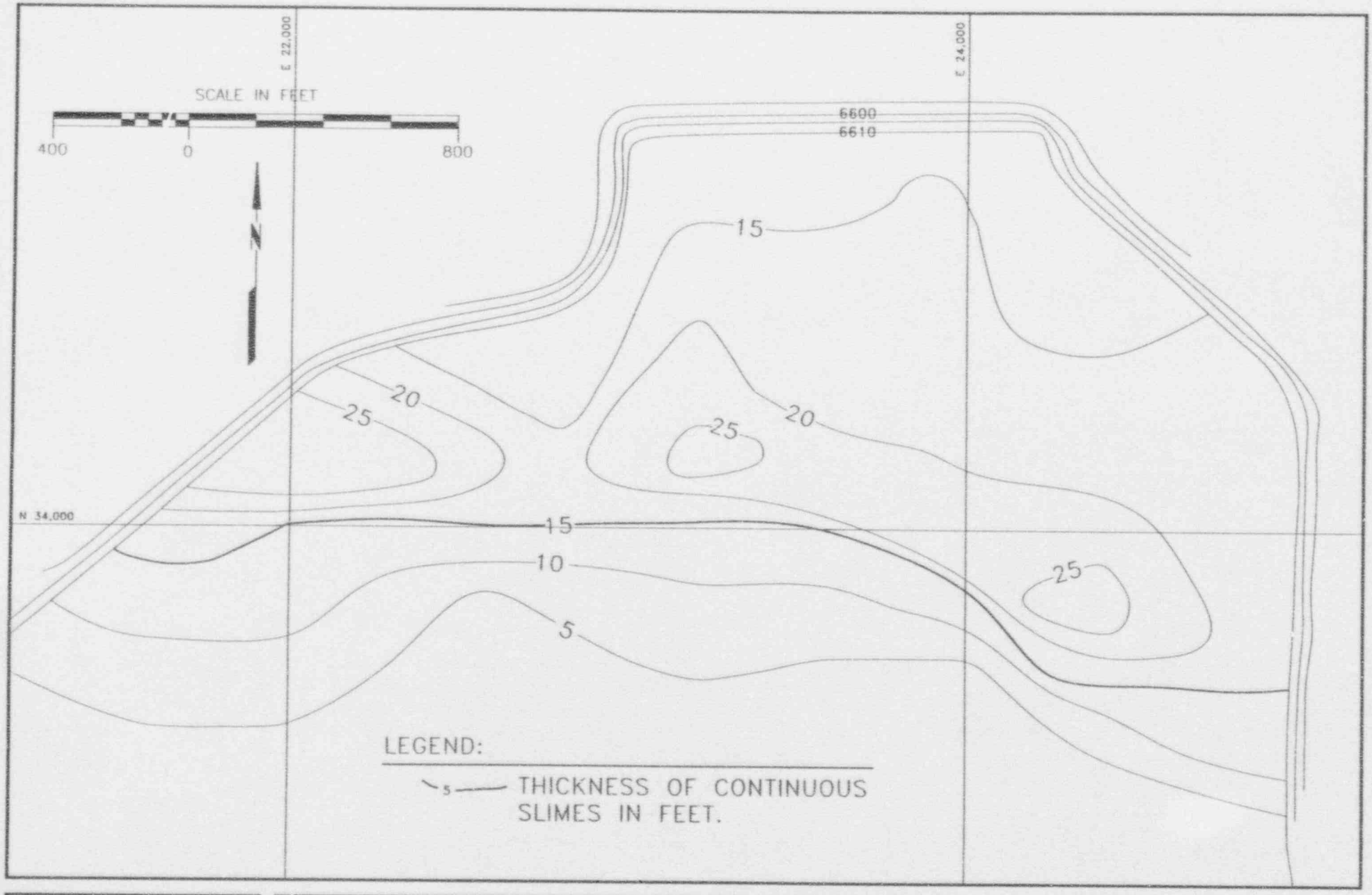
Date: OCT., 1993
Project: 360
File:



SMI
SHEPHERD MILLER, INC.

FIGURE 4
BEDROCK CONTOUR MAP

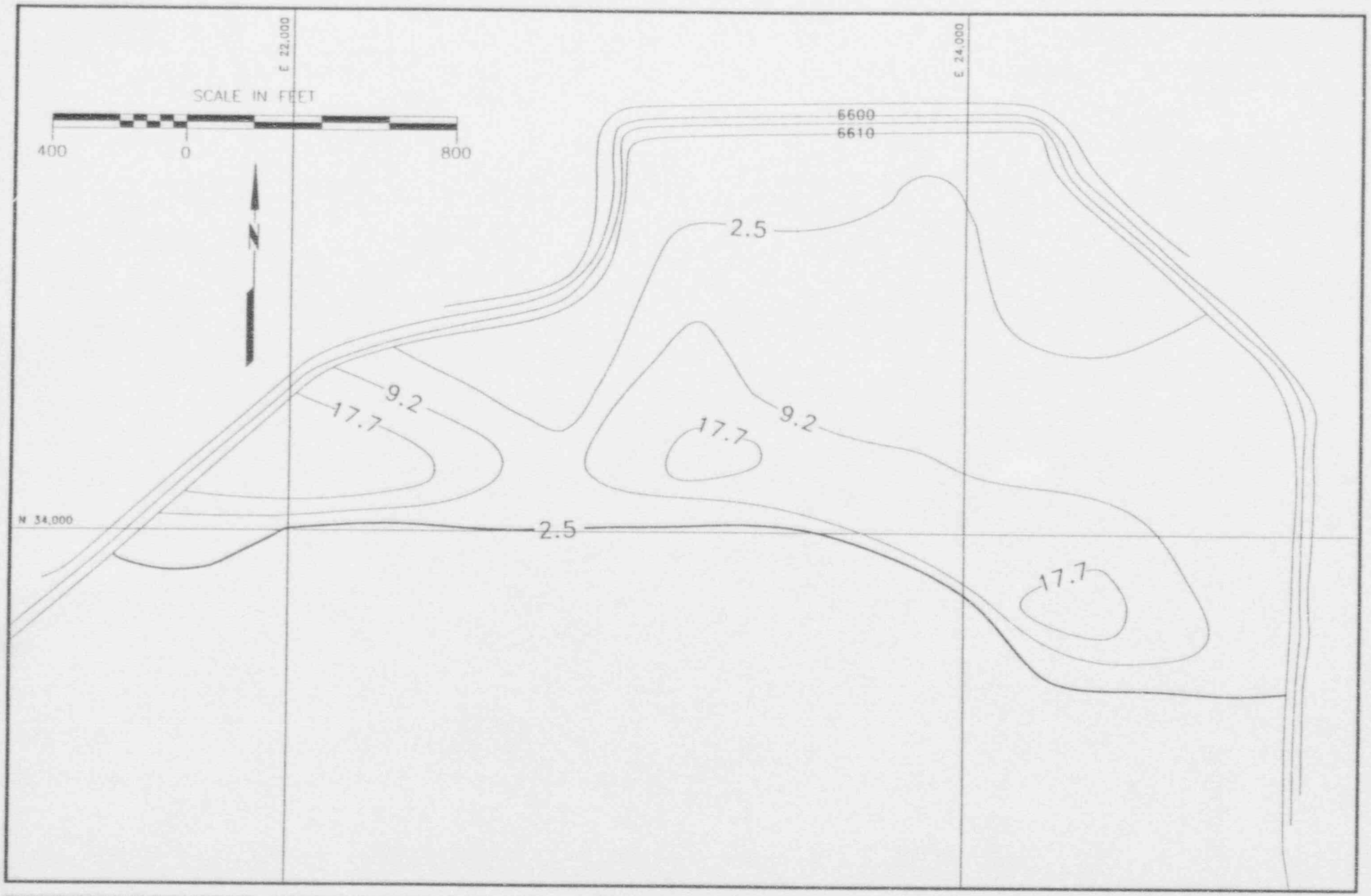
Date:	OCT., 1993
Project:	312
File:	TOPO1



SMI
SHEPHERD MILLER, INC.

FIGURE 5
SLIMES ISOPACH MAP

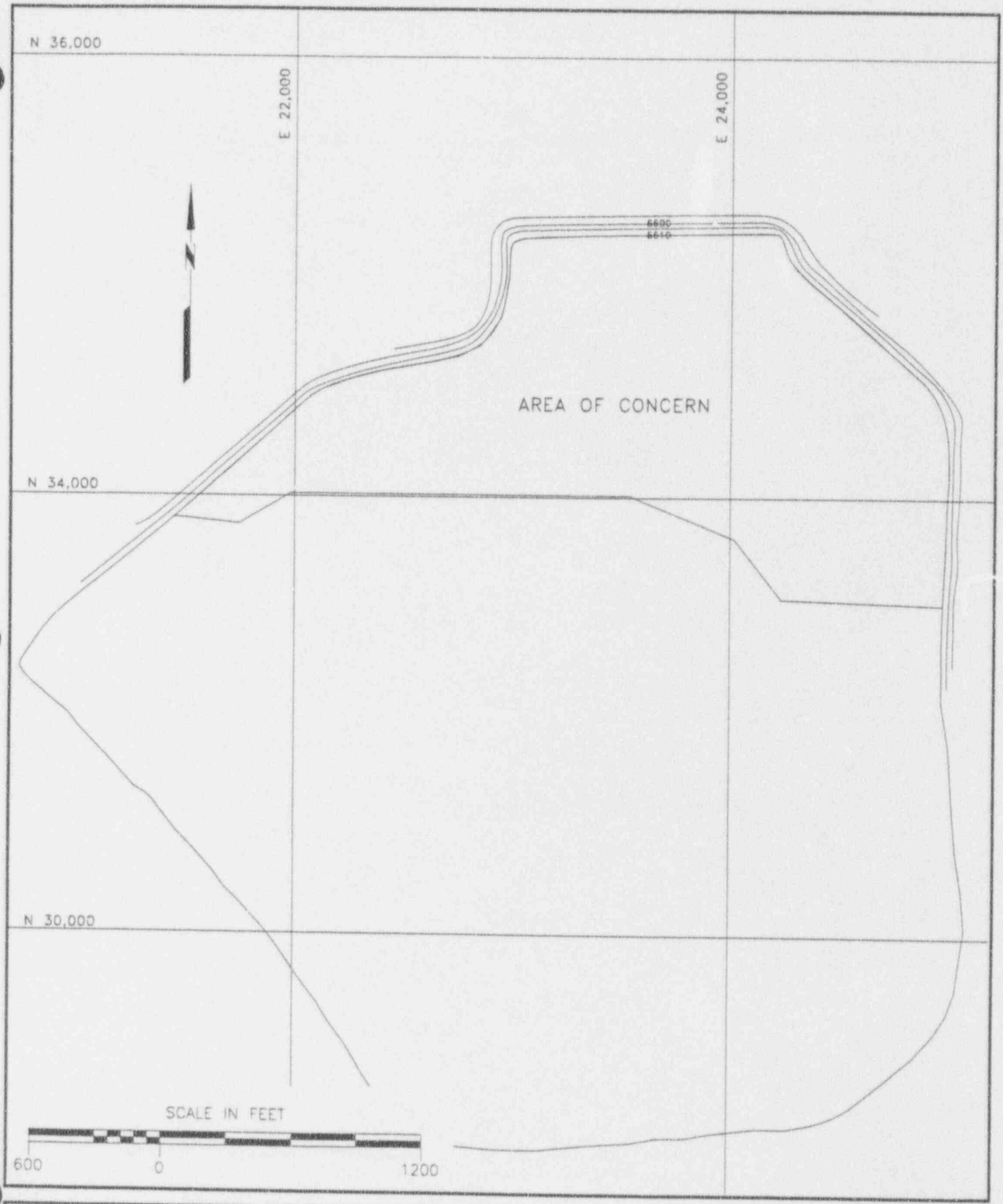
Date:	OCT., 1993
Project:	312
File:	ISOPACH2



SMI
SHEPHERD MILLER, INC.

FIGURE 6
CONTOURS FOR ADDITIONAL TIME IN MONTHS FOR
90% UNAIDED CONSOLIDATION TO OCCUR

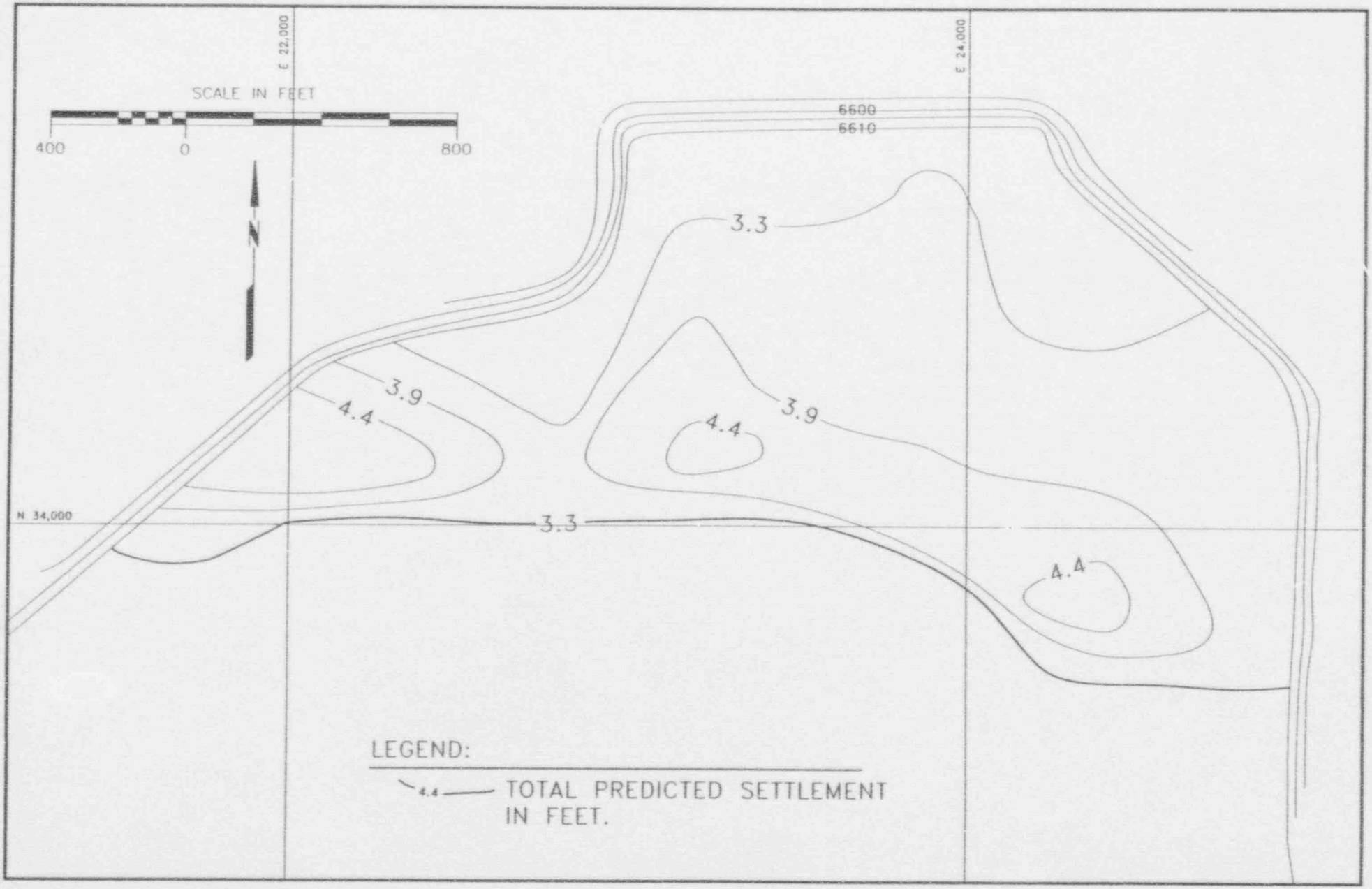
Date: OCT., 1993
Project: 312
File: DRAINSET



SMI
SHEPHERD MILLER, INC.

FIGURE 7
AREA OF CONCERN

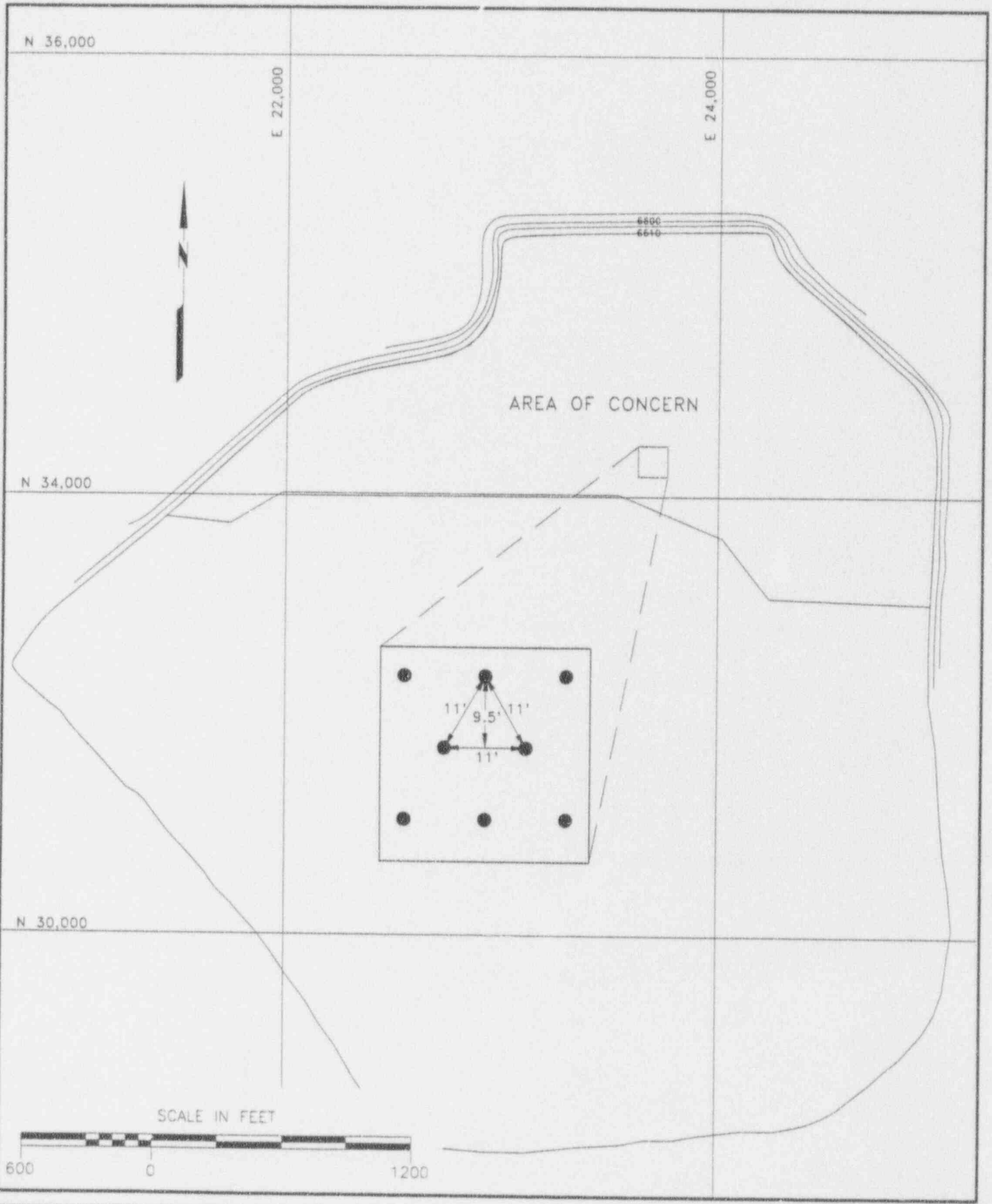
Date:	OCT. 1993
Project:	312
File:	WICKS



SMI
SHEPHERD MILLER, INC.

FIGURE 8
PREDICTED AMOUNT OF SETTLEMENT

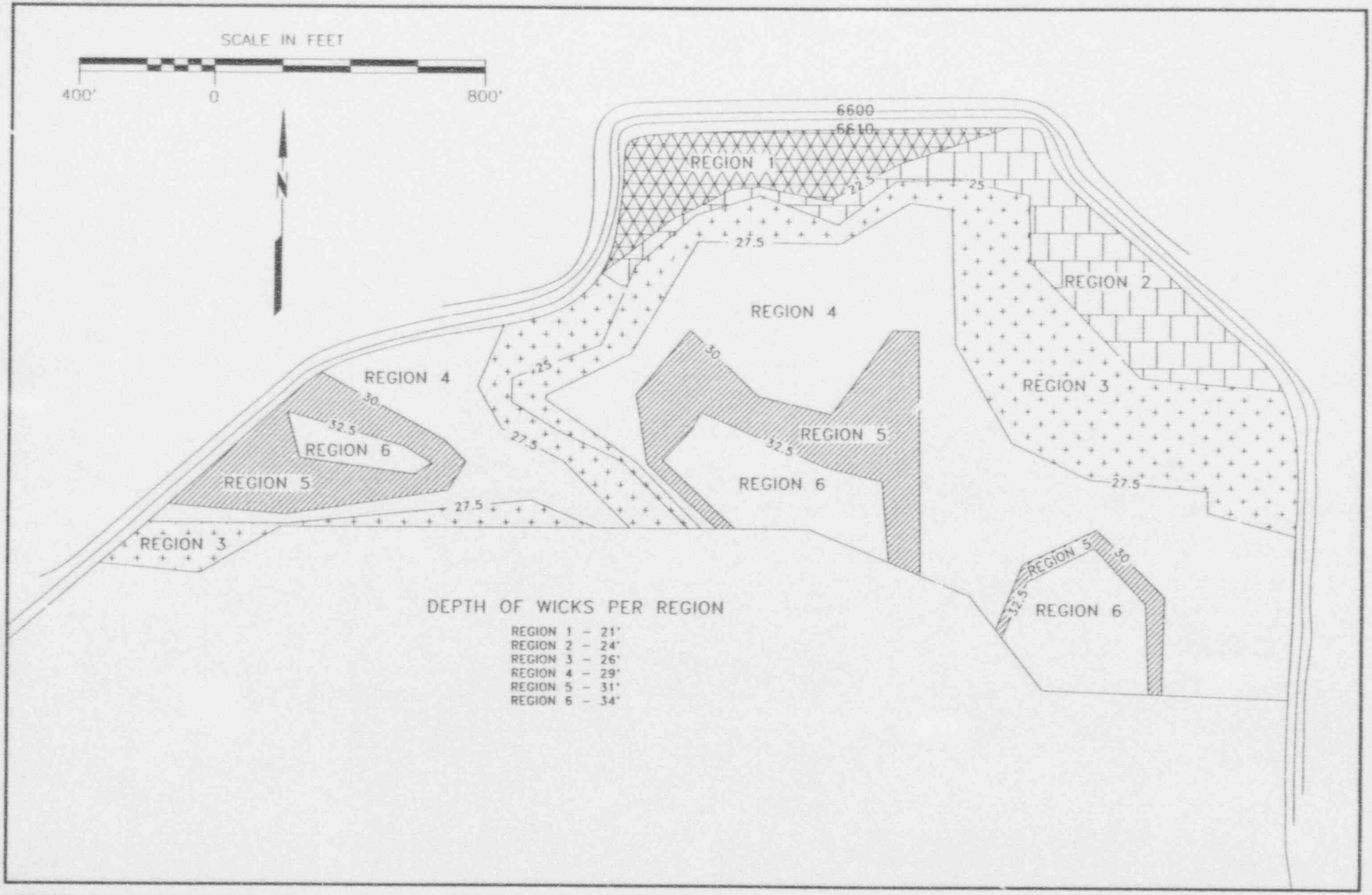
Date:	OCT., 1993
Project:	312
File:	PREDICT



SMI
SHEPHERD MILLER, INC.

FIGURE 9
LOCATION AND SPACING OF WICKS
IN AREA OF CONCERN

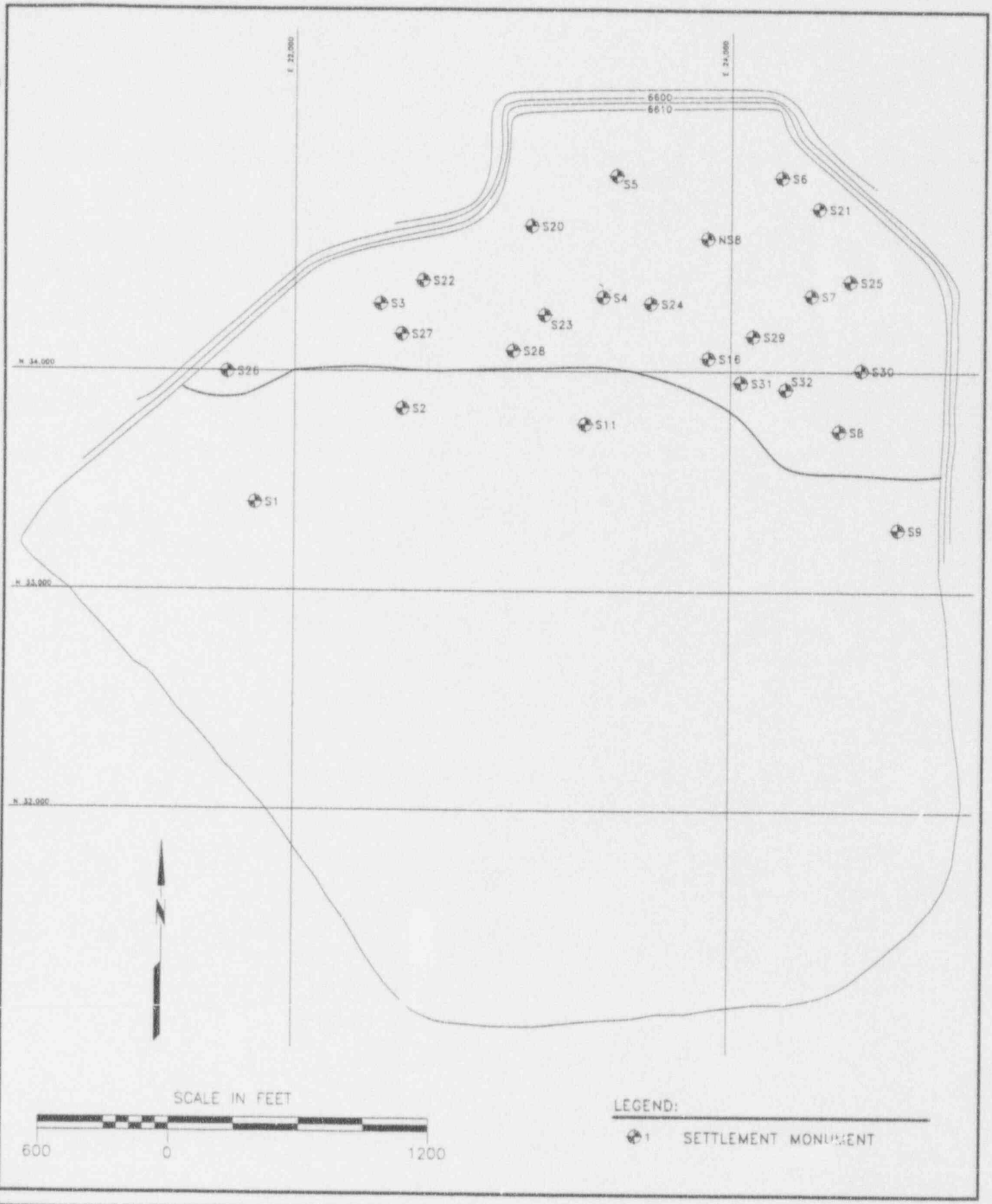
Date:	SEPT. 1992
Project:	312
File:	WICKS



SMI
SHEPHERD MILLER, INC.

FIGURE 10
INSTALLATION DEPTH OF WICKS

Date:	OCT., 1993
Project:	312
File:	75PERCNT



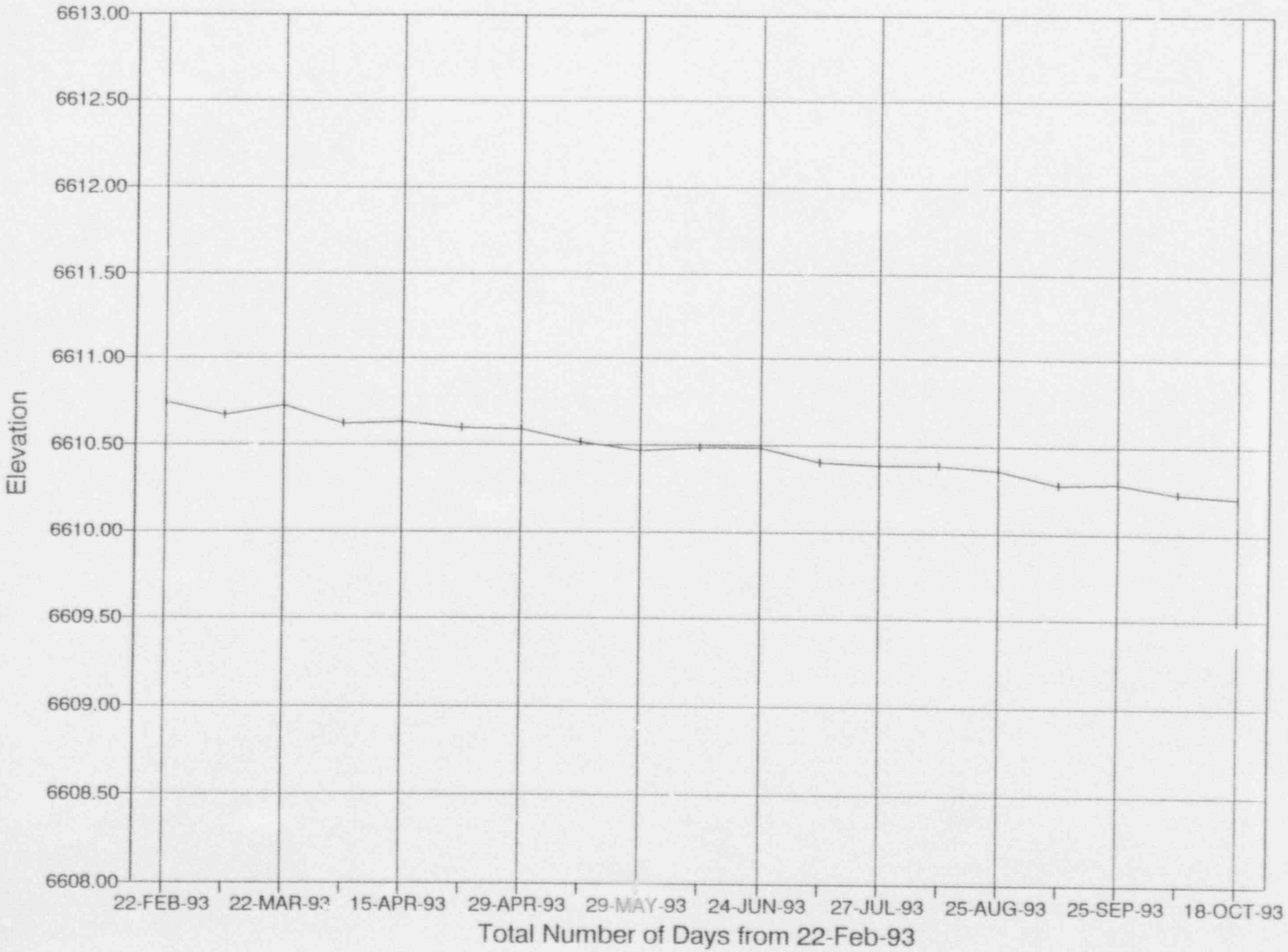
SMI
SHEPHERD MILLER, INC.

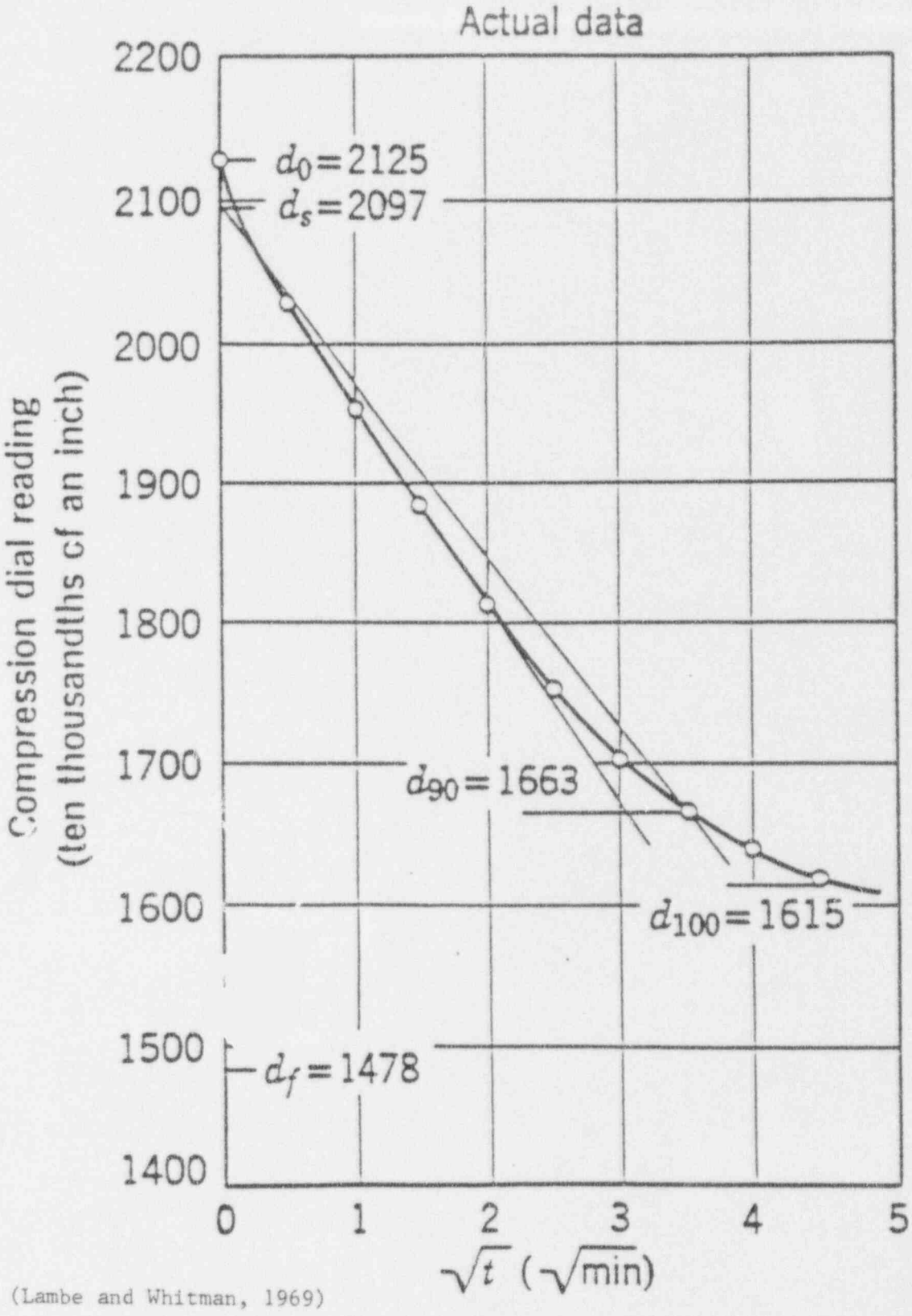
FIGURE 11
SETTLEMENT MONUMENT LOCATIONS

Date:	OCT., 1993
Project:	360
File:	SETLOC

Figure 12

Settlement Point 20





(Lambe and Whitman, 1969)

SMI
SHEPHERD MILLER, INC.

FIGURE 13
TYPICAL SETTLEMENT-SQUARE ROOT OF TIME PLOT

Date:	OCT., 1993
Project:	360
File:	

APPENDIX A

FUGRO PIEZOCONE REPORT

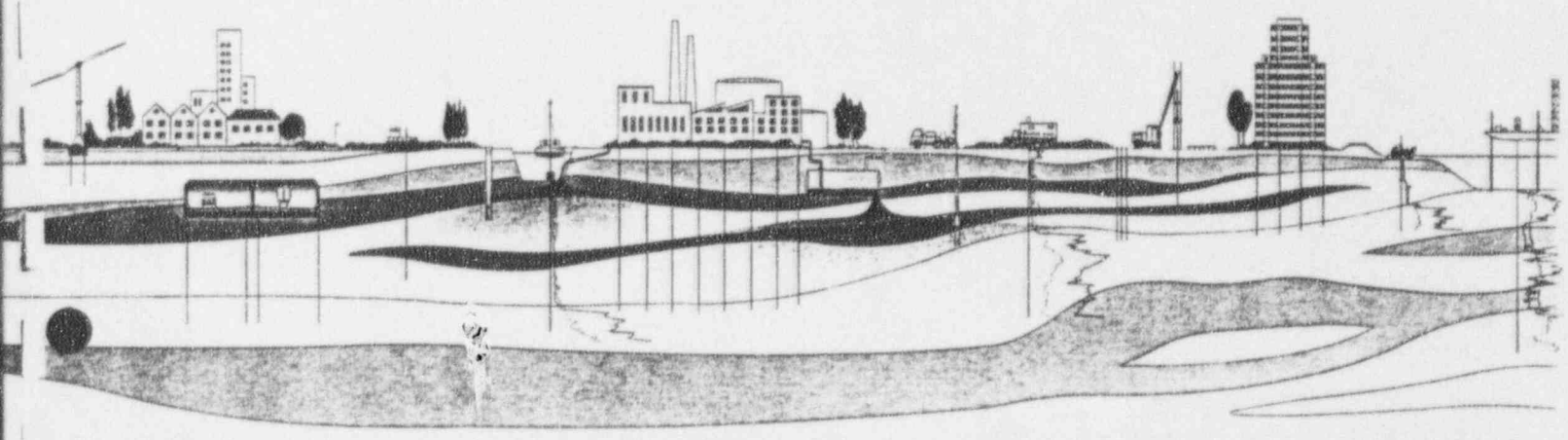
FUGRO GEOSCIENCES, INC.

CONE PENETROMETER TESTING

AND RELATED SERVICES

BLUE WATER MILL

GRANTS, NEW MEXICO



CONE PENETROMETER TESTING
AND RELATED SERVICES
BLUE WATER MILL
GRANTS, NEW MEXICO
REPORT NO. 0301-2236

* * * * *

Report To:

SHEPHERD MILLER, INC.

Fort Collins, Colorado

* * * * *

Submitted By:

FUGRO GEOSCIENCES, INC.

Houston, Texas

* * * * *

August 1992

FUGRO GEOSCIENCES, INC.

6105 Rookin
Houston, Texas 77074
Tel: (713) 778-5580
Fax: (713) 778-5501

August 31, 1992
Report Number 0301-2236

Shepherd Miller, Inc.
1600 Specht Point Drive, Suite F
Fort Collins, Colorado 80525

Attention: Mr. Lou Miller

**CONE PENETROMETER TESTING
AND RELATED SERVICES
BLUE WATER MILL
GRANTS, NEW MEXICO**

Dear Mr. Miller

Please find enclosed herewith the final results of the cone penetrometer tests conducted at the above referenced location.

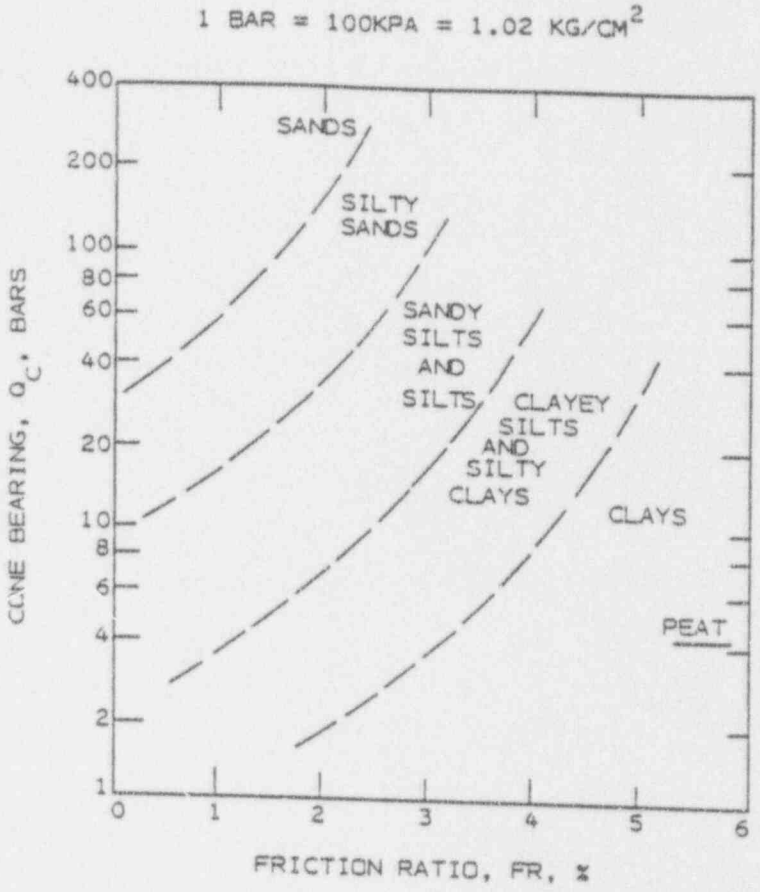
For your information, the soil stratigraphy was identified using Campanella and Robertson's Simplified Soil Behavior Chart. Please note that because of the empirical nature of the soil behavior chart, the soil identification should be verified locally.

Fugro Geosciences appreciates the opportunity to be of service to your organization. If you should have any questions, or if we can be of further assistance, please do not hesitate to contact us. We look forward to working with you in the future.

Very truly yours,
FUGRO GEOSCIENCES, INC.

Recep Yilmaz
President

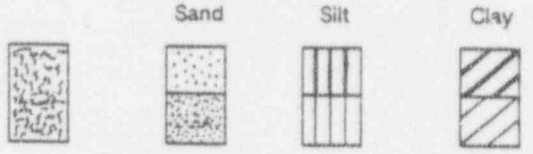
RY/kjp



CAMPANELLA AND ROBERTSON CLASSIFICATION CHART

Key To Soil Classification and Symbols

SOIL TYPE
(Shown in Symbol Column)



Predominant Type Shown Heavy

SAMPLE TYPE
(Shown in Samples Column)

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (Major portion Retained on No. 200 Sieve)
Includes (1) clean gravels and sand described as fine, medium or course, depending on distribution of grain sizes (2) silty or clayey gravels and sands and (3) fine grained low plasticity soils (PI < 10) such as sandy silts. Condition is rated according to relative density, as determined by lab tests or estimated from resistance to sampler penetration.

Descriptive Term	Penetration Resistance*	Relative Density
Loose	0 - 10	0 to 40%
Medium Dense	10 - 30	40 to 70%
Dense	30 - 50	70 to 90%
Very Dense	Over 50	90 to 100%

* Blows/Foot, 140# Hammer, 30" Drop

FINE GRAINED SOILS (Major Portion Passing No. 200 Sieve)
Includes (1) inorganic and organic silts and clays, (2) sandy, gravelly or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings or by unconfined compression tests for soils with PI $\geq$ 10.

Descriptive Term	Cohesive Shear Strength Tons/Square Foot
Very Soft	Less Than 0.125
Soft	0.125 to 0.25
Firm	0.25 to 0.50
Stiff	0.50 to 1.00
Very Stiff	1.00 to 2.00
Hard	2.00 and Higher

Note: Slickensided and fissured clay may have lower unconfined compressive strengths than shown above because of planes of weakness or shrinkage cracks; consistency ratings of such soils are based on hand penetrometer readings.

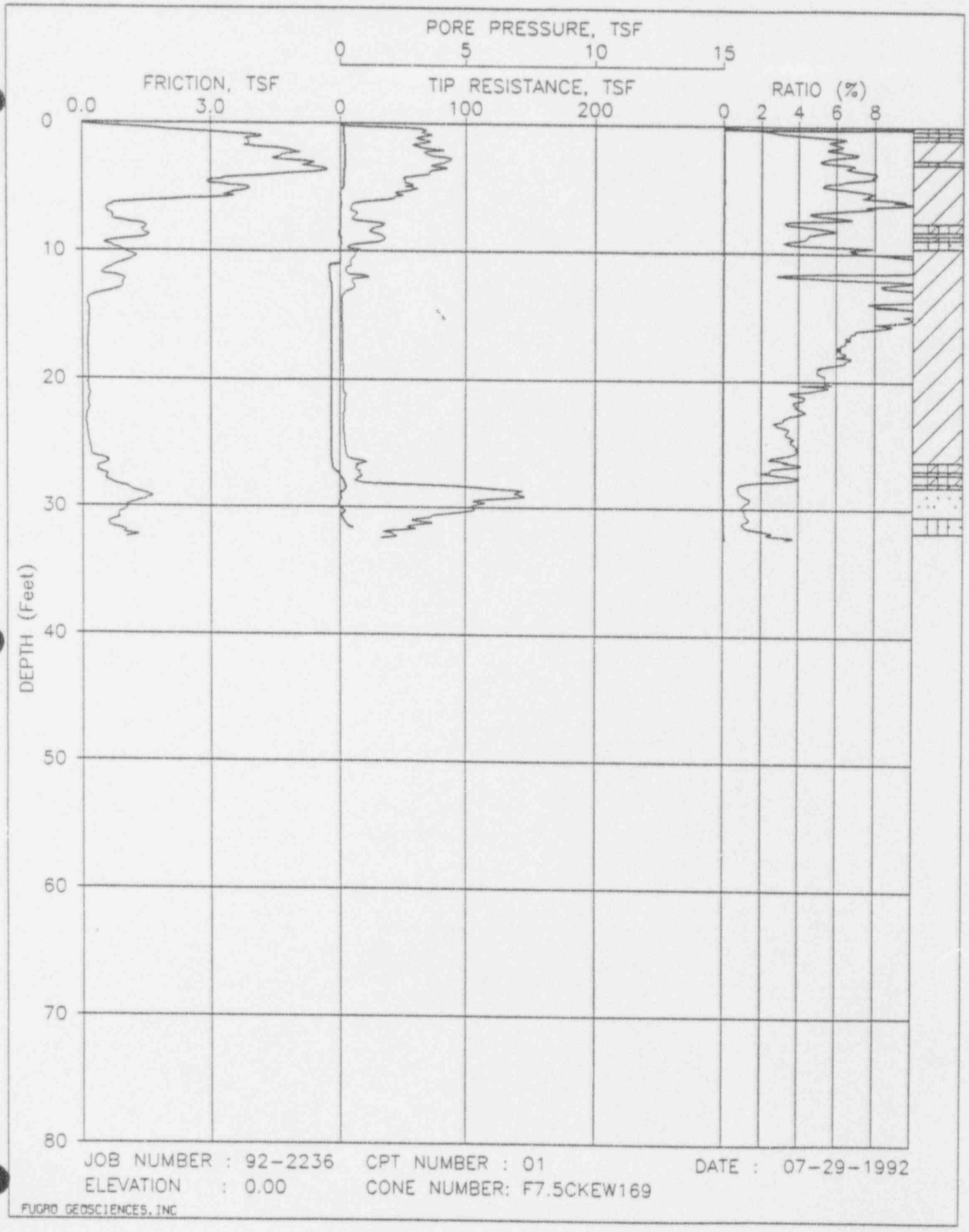
TERMS CHARACTERIZING SOIL STRUCTURE

Parting: paper thin in size
Seam: 1/8" to 3" thick
Layer: greater than 3"
Fissured: containing shrinkage cracks, frequently filled with fine sand or silt, usually more or less vertical
Sensitive: pertaining to cohesive soils that are subject to appreciable loss of strength when remolded
Interbedded: composed of alternate layers of different soil types
Laminated: composed of thin layers of varying color and texture
Calcareous: containing appreciable quantities of calcium carbonate
Well Graded: having wide range in grain sizes and substantial amounts of all intermediate particle sizes
Poorly Graded: predominantly of one grain size, or having a range of sizes with some intermediate size missing

Flocculated: pertaining to cohesive soils that exhibit a loose knit or flakey structure
Slickensided: having inclined planes of weakness that are slick and glossy in appearance.

Degree of Slickensided Development

Slightly Slickensided: slickensides present at intervals of 1' to 2', soil does not easily break along these plates
Moderately Slickensided: slickensides spaced at intervals of 1' to 2', soil breaks easily along these planes
Extremely Slickensided: continuous and interconnected slickensides spaced at intervals of 4" to 12", soil breaks along the slickensides into pieces 3" to 6" in size
Intensely Slickensided: slickensides spaced at intervals of less than 4", continuous in all directions; soil breaks down along planes into nodules 1/4" to 2" in size.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FRICTION, TSF
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TIP RESISTANCE, TSF
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RATIO (%)
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4
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8
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70
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DEPTH (Feet)
JOB NUMBER : 92-2236
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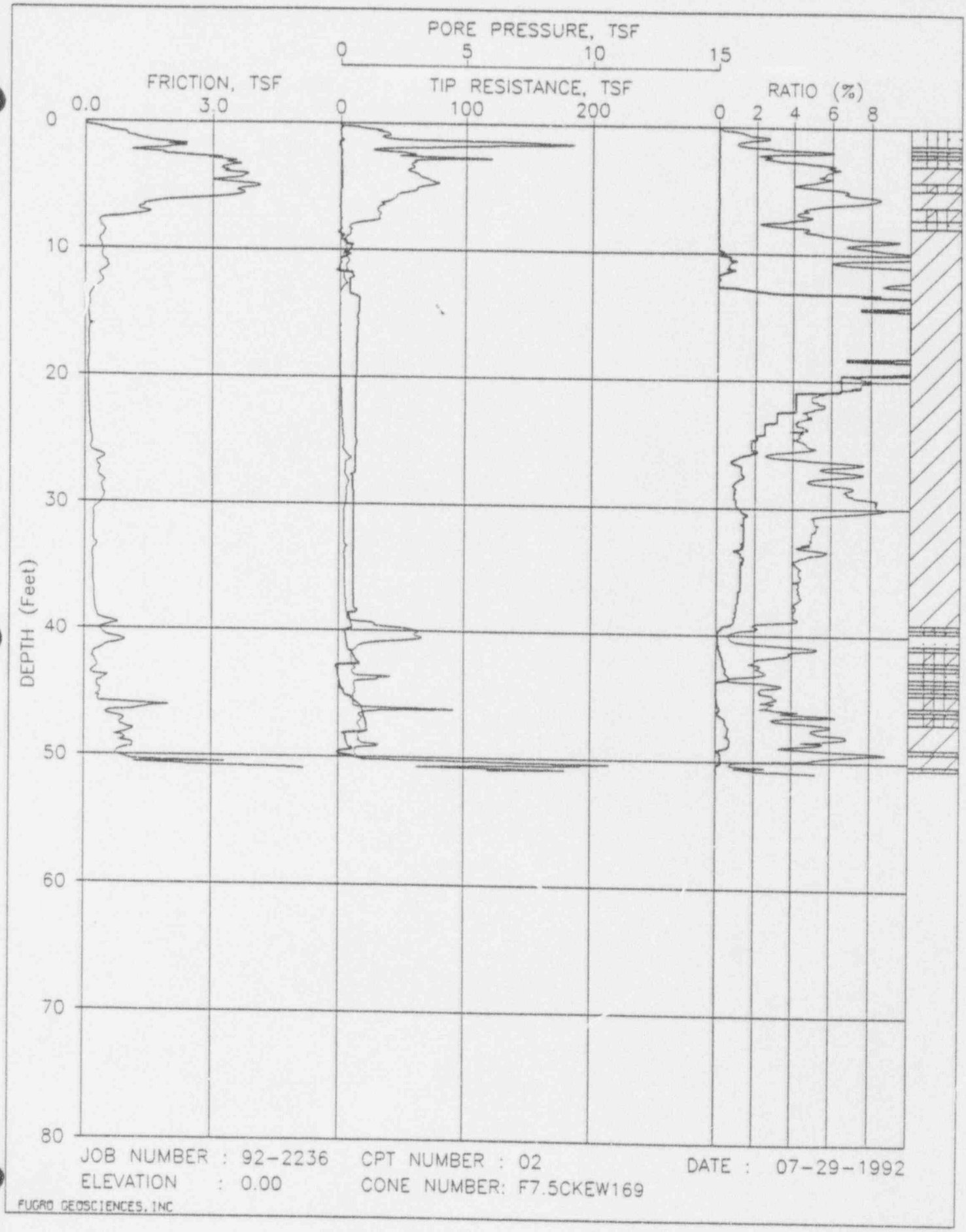
FUGRO GEOSCIENCES, INC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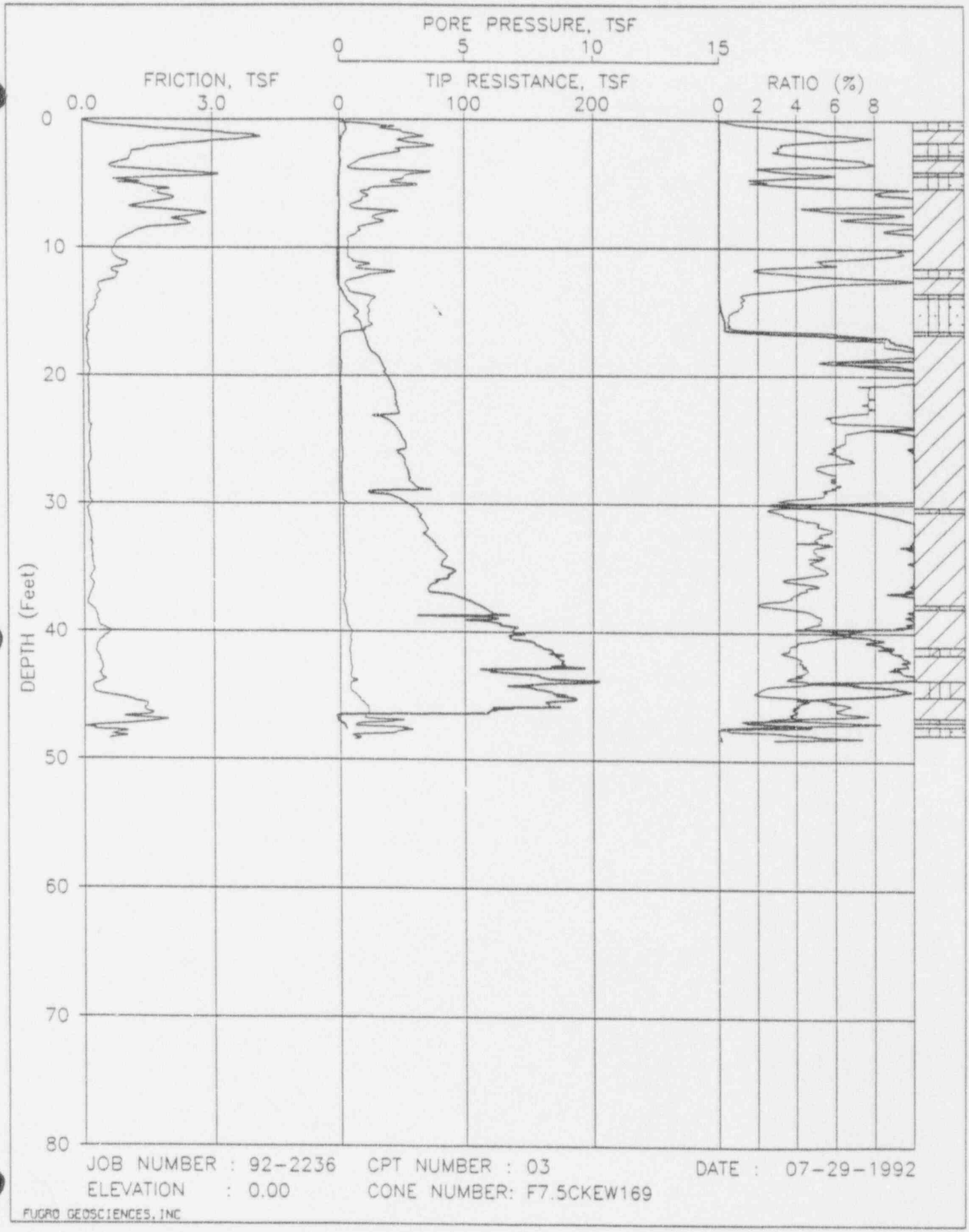
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DEPTH (Feet)
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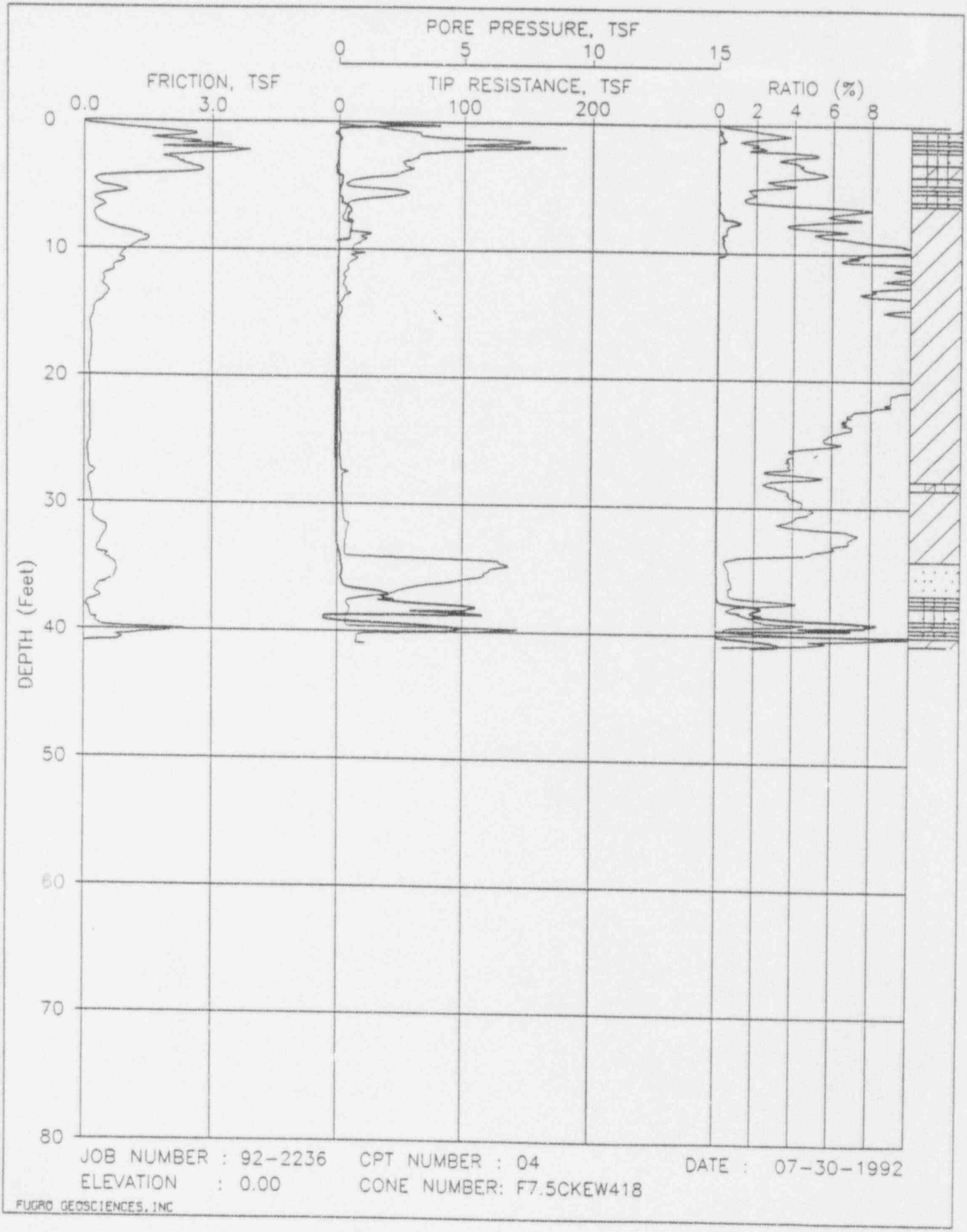
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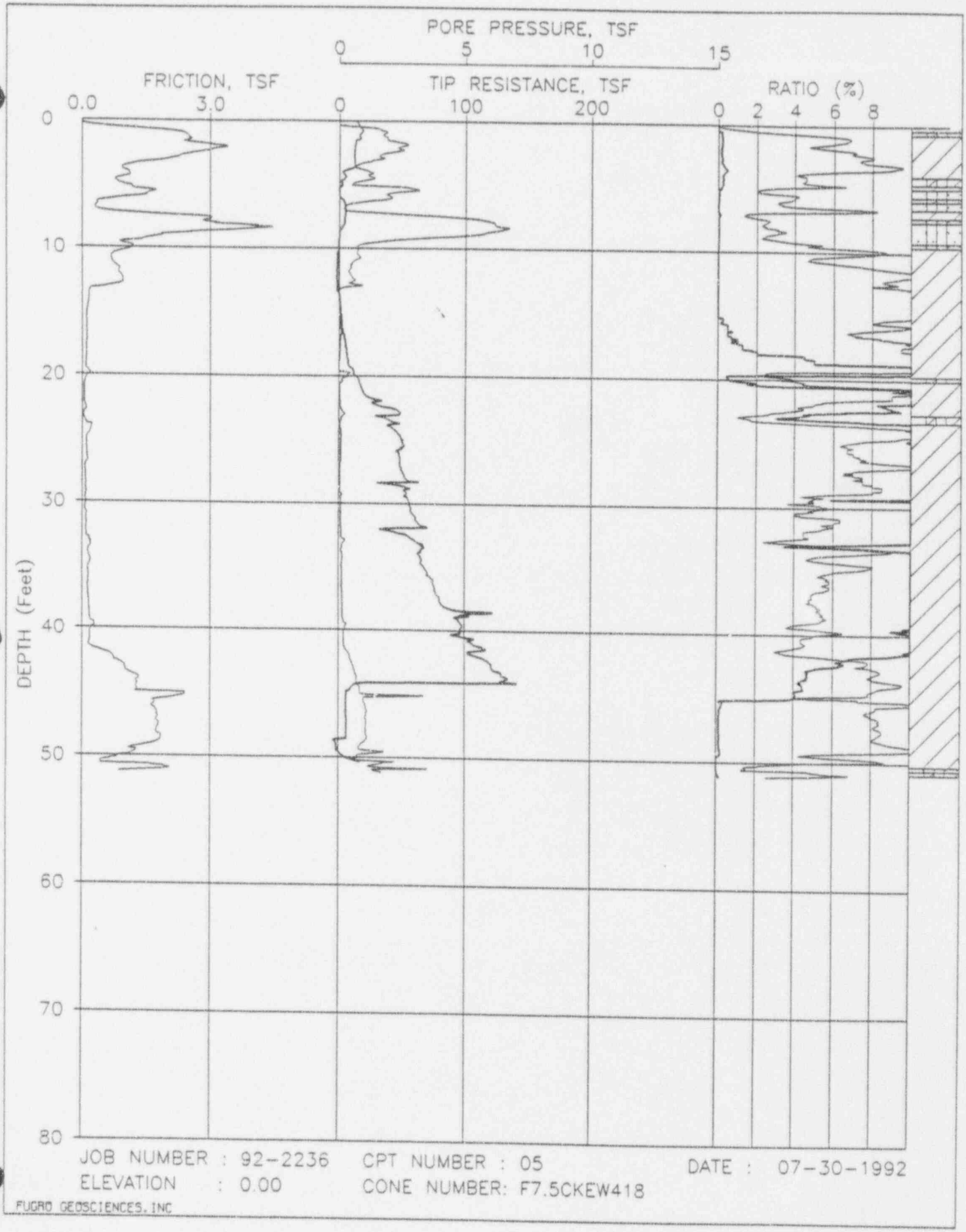
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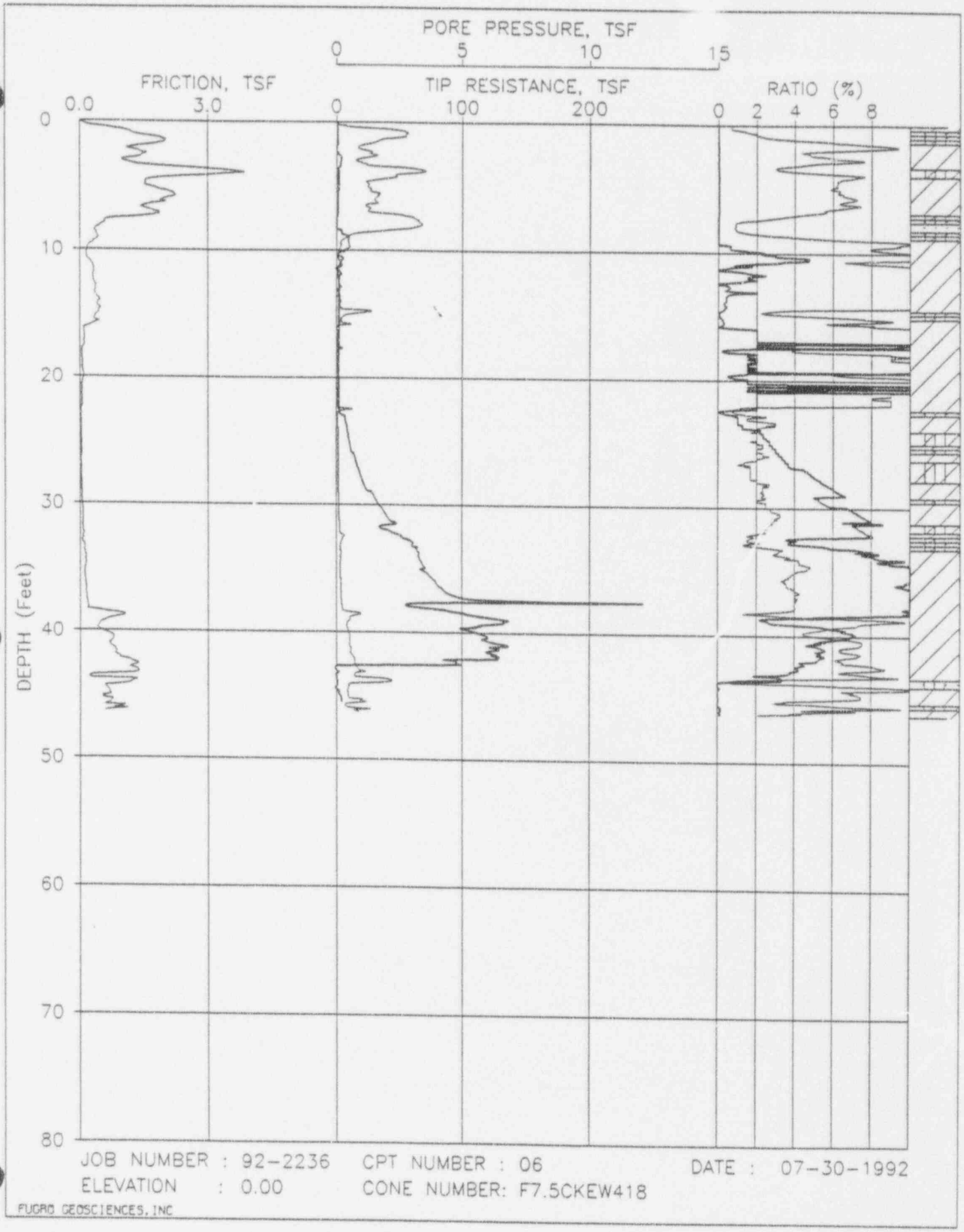
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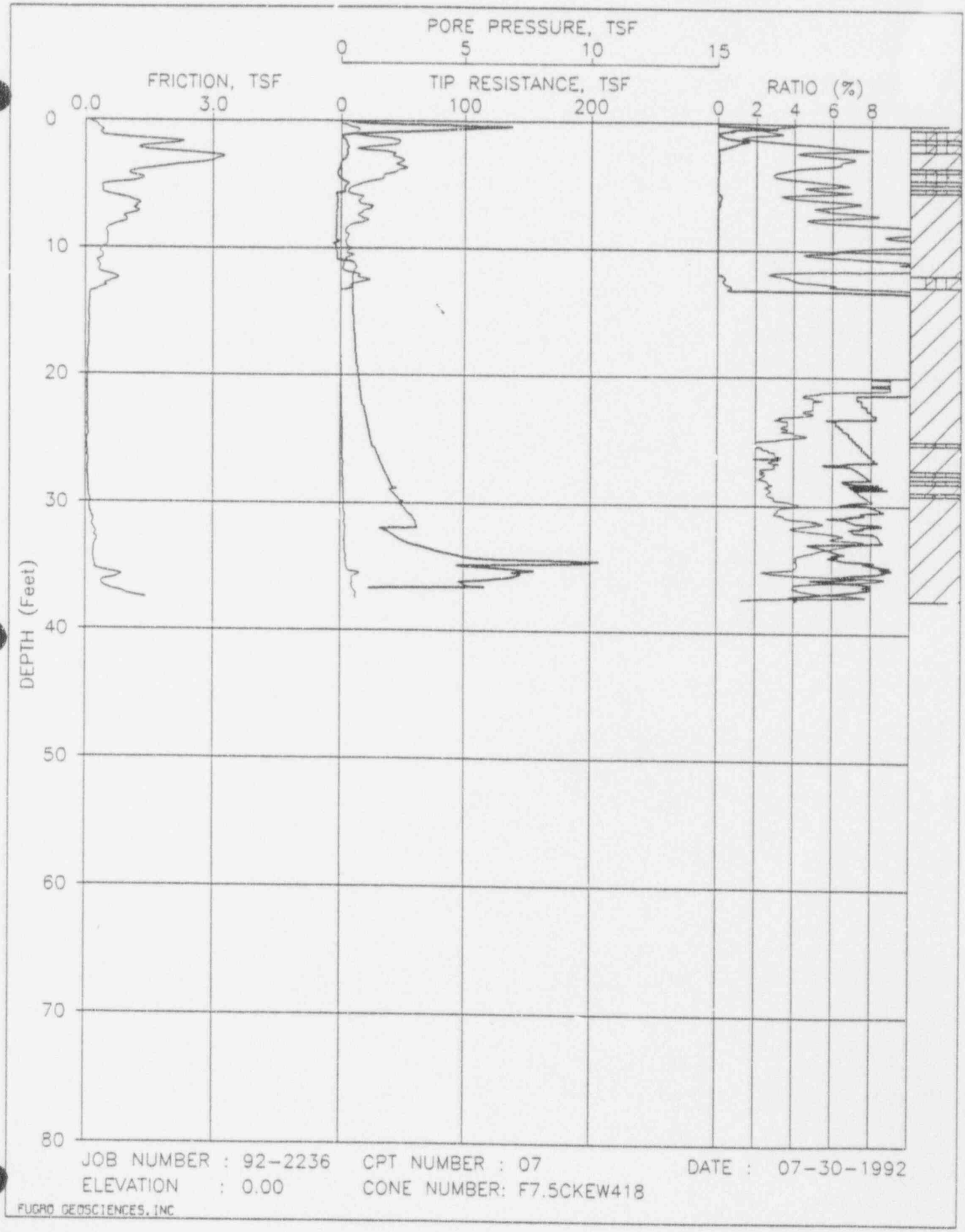

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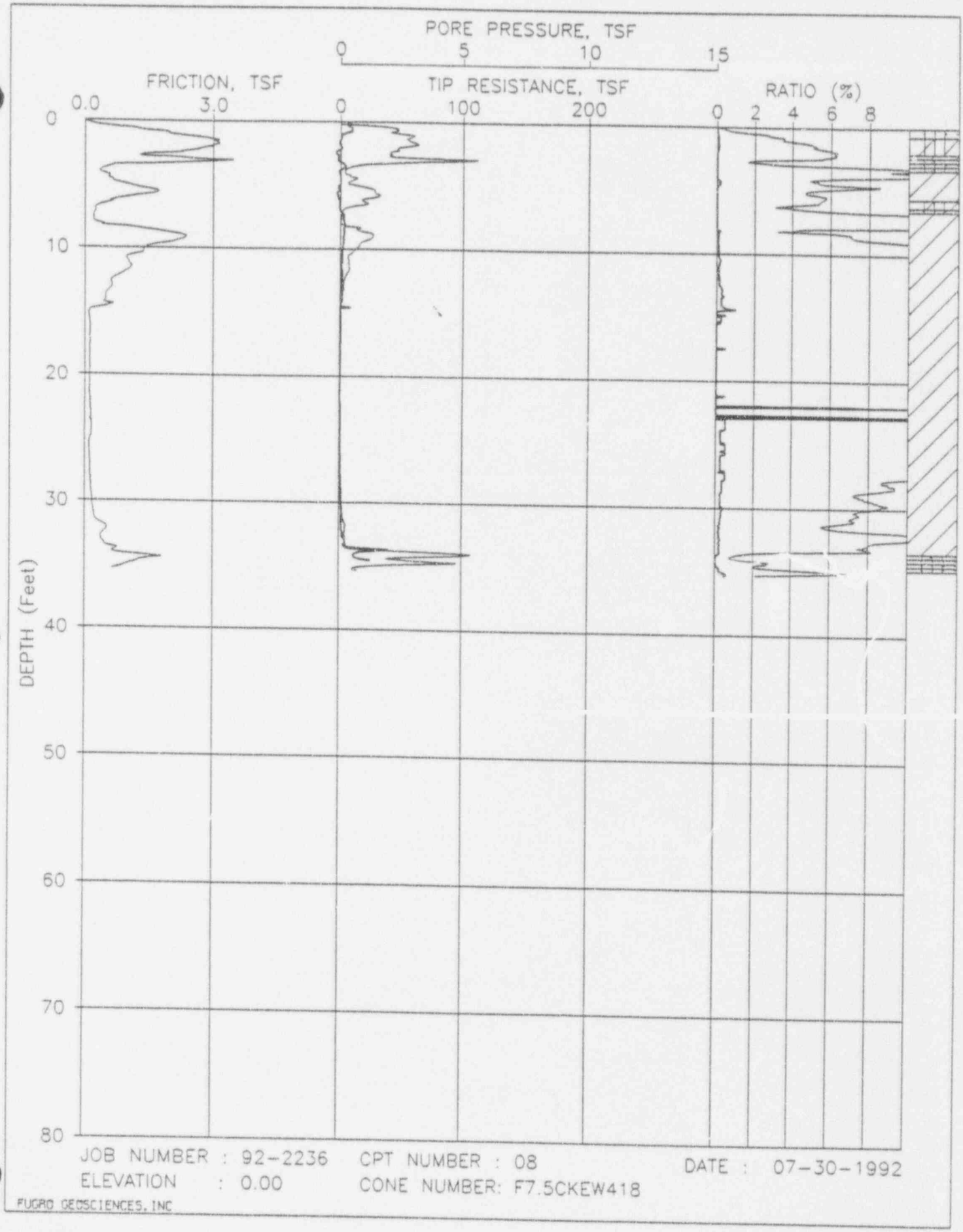
FUGRO GEOSCIENCES, INC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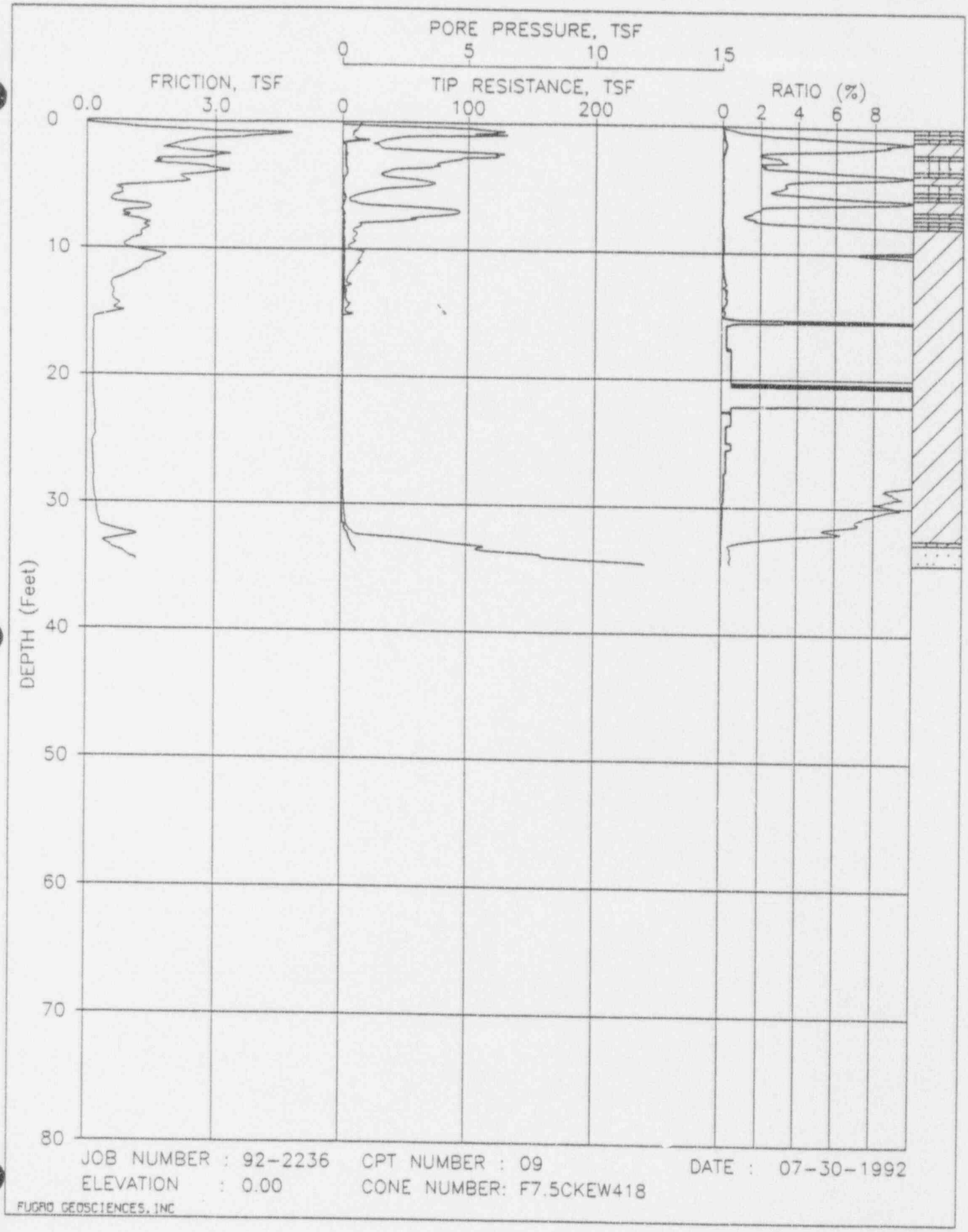
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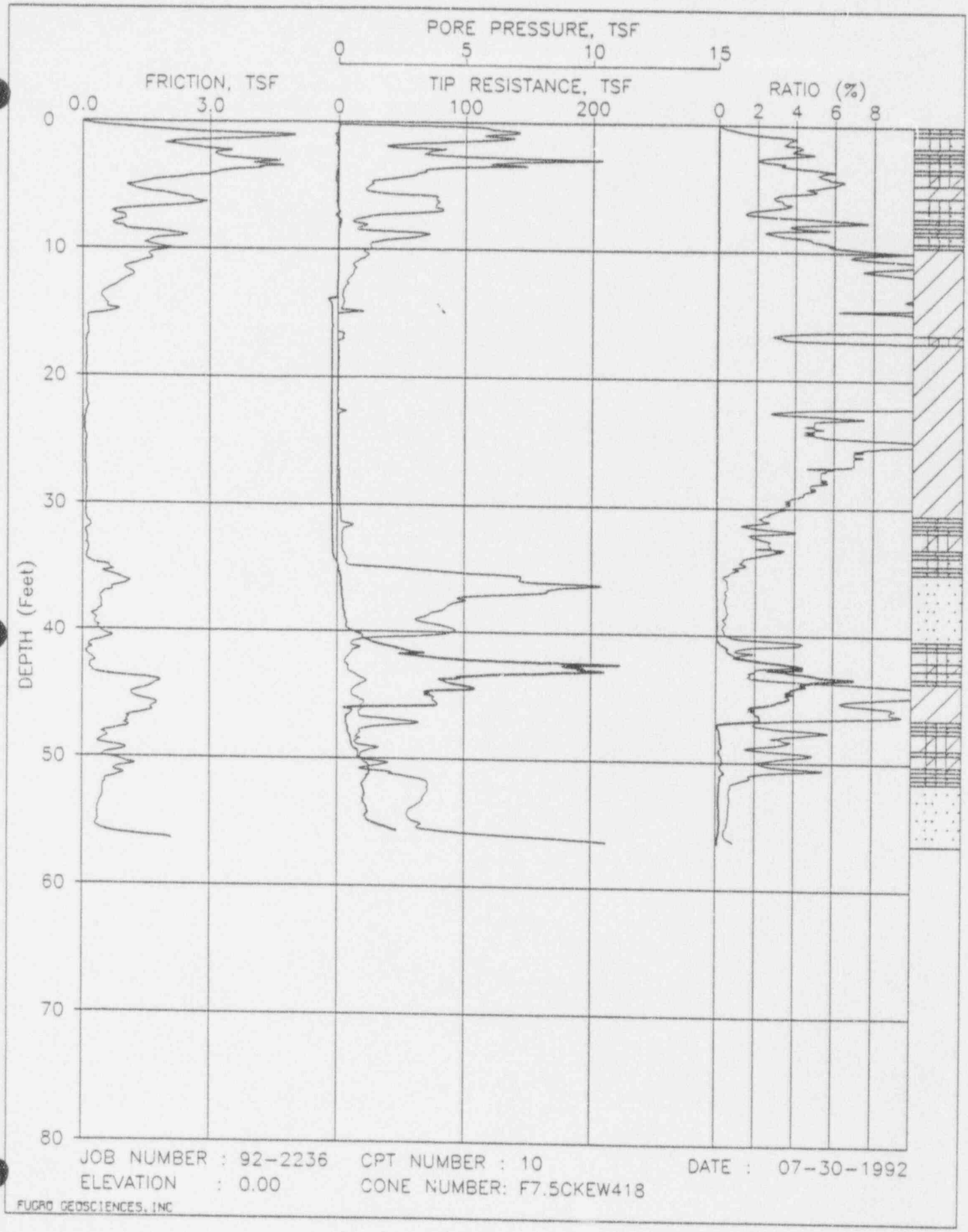
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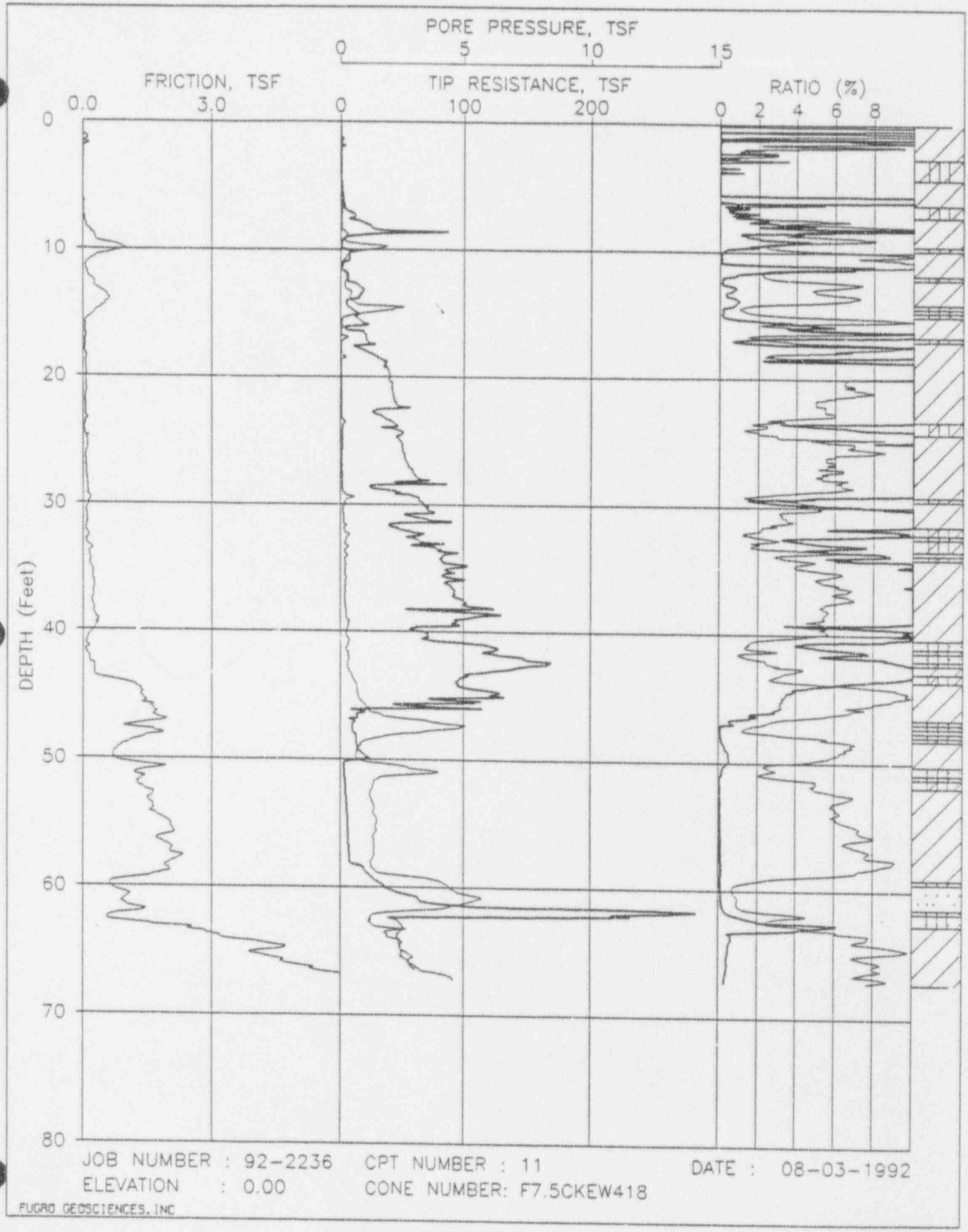
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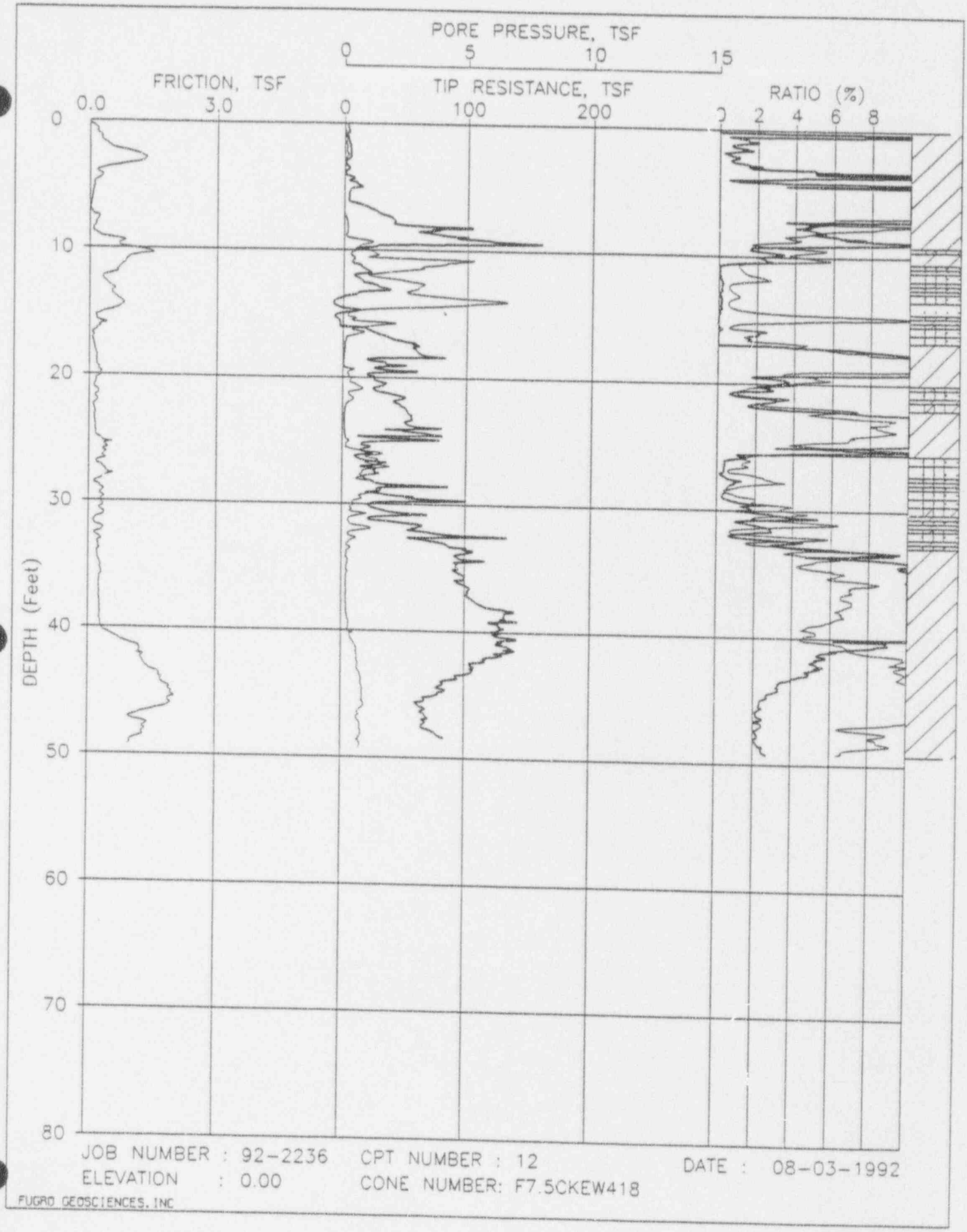
FUGRO GEOSCIENCES, INC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DEPTH (Feet)
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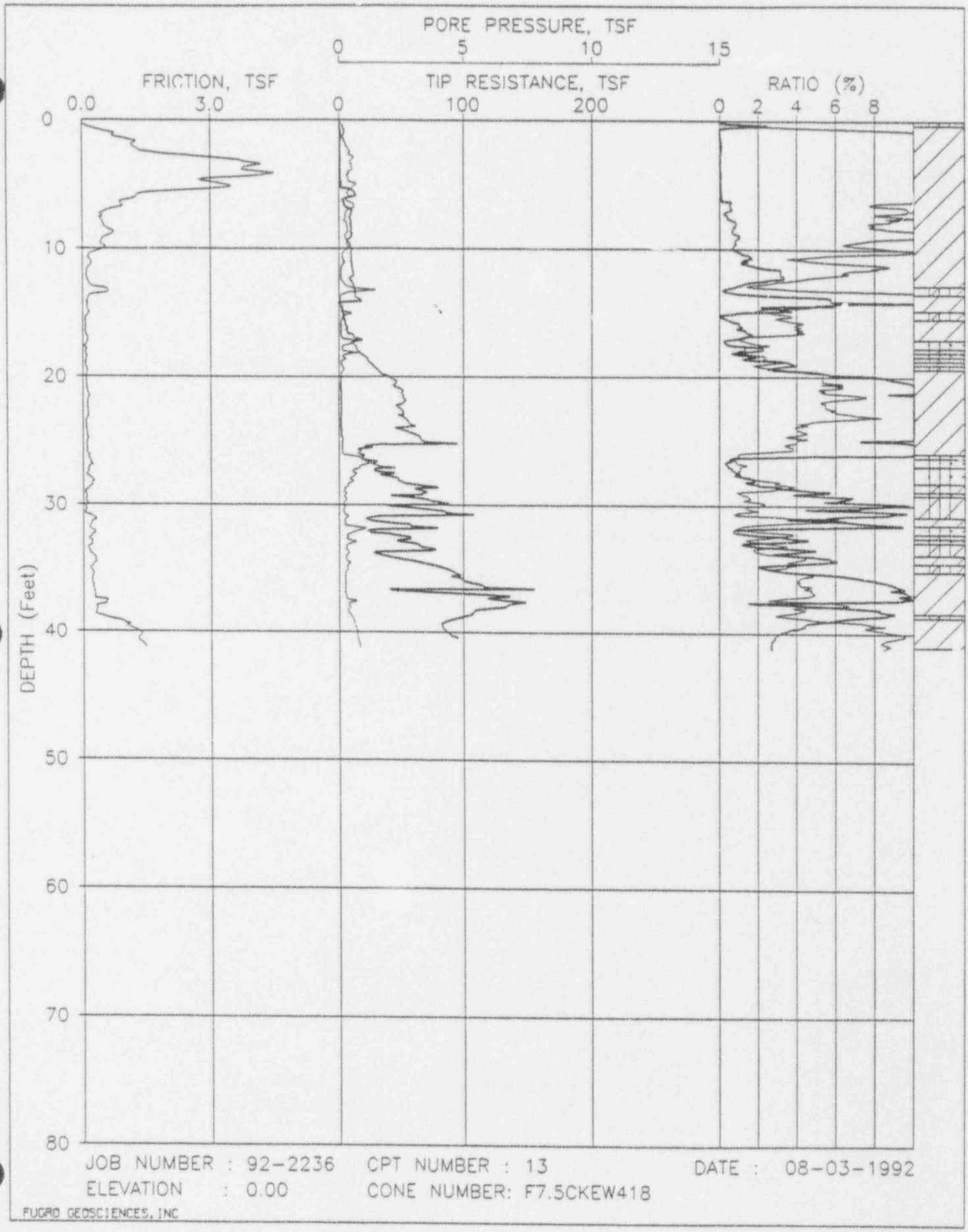
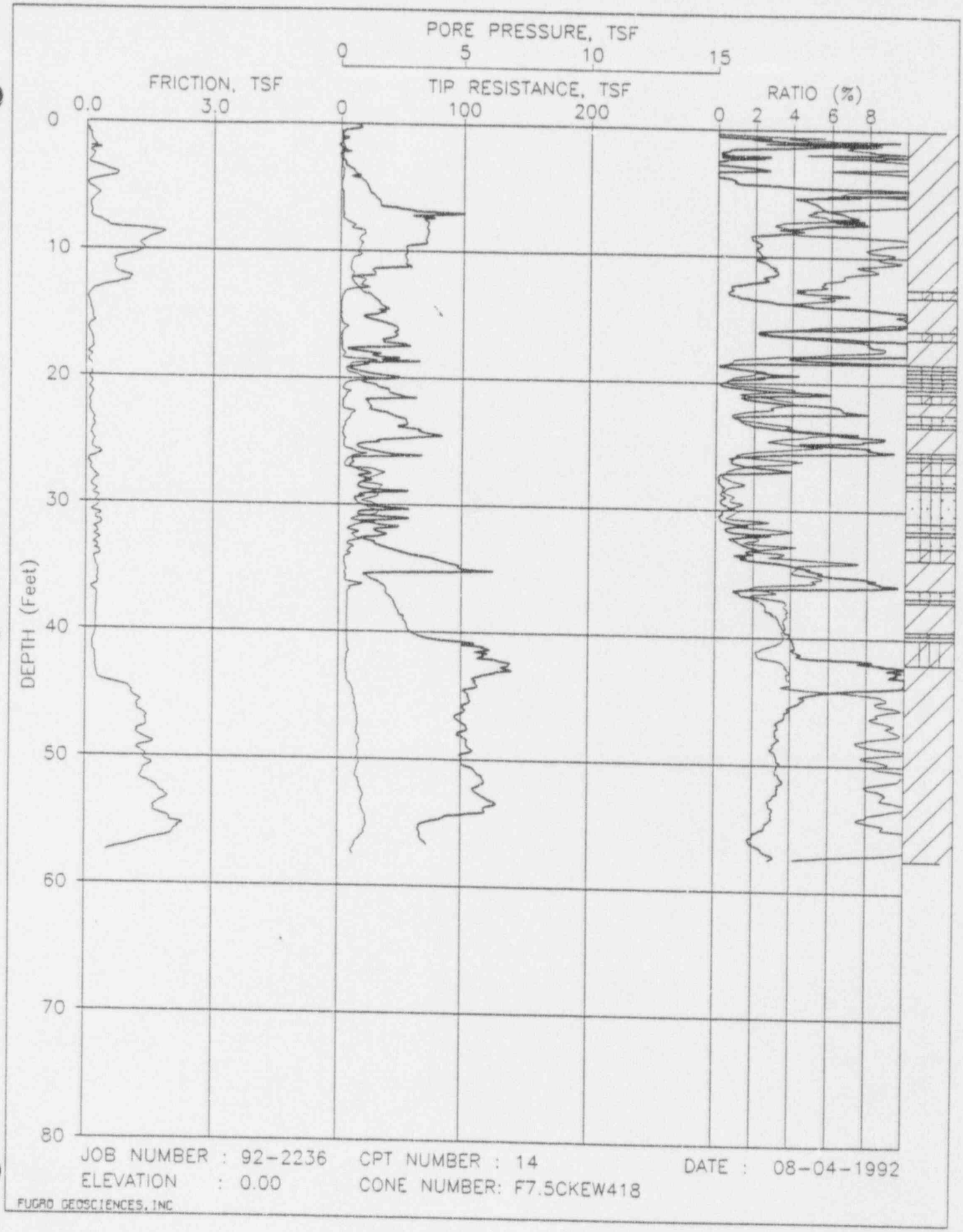
ELEVATION : 0.00
CPT NUMBER : 12
CONE NUMBER: F7.5CKEW418
DATE : 08-03-1992
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 13 DATE : 08-03-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEW418

FUGRO GEOSCIENCES, INC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FRICTION, TSF
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3.0
TIP RESISTANCE, TSF
0
100
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RATIO (%)
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DEPTH (Feet)
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10
20
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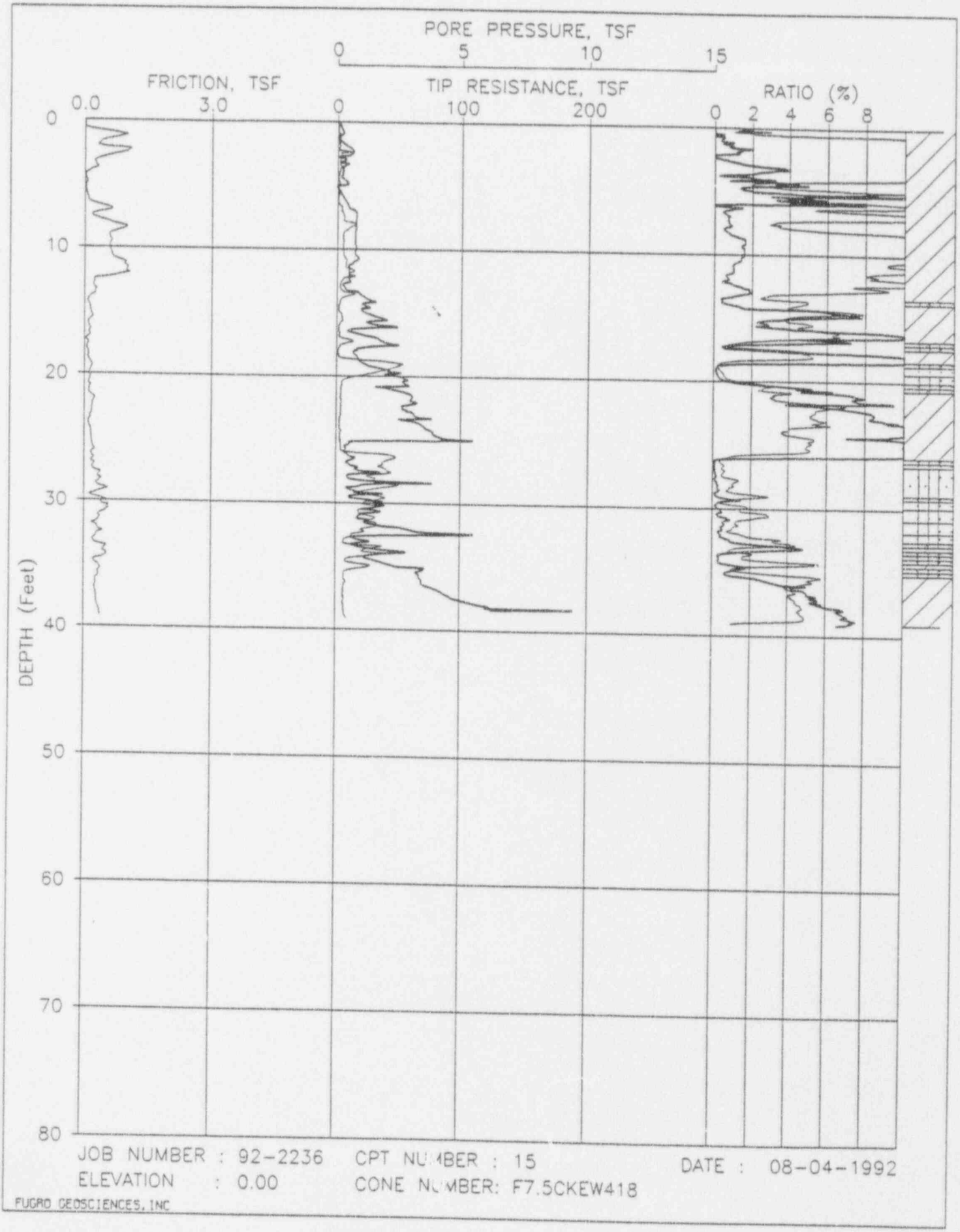
JOB NUMBER : 92-2236
CPT NUMBER : 14
DATE : 08-04-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC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FRICTION, TSF
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3.0
TIP RESISTANCE, TSF
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100
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RATIO (%)
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DEPTH (Feet)
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10
20
30
40
50
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70
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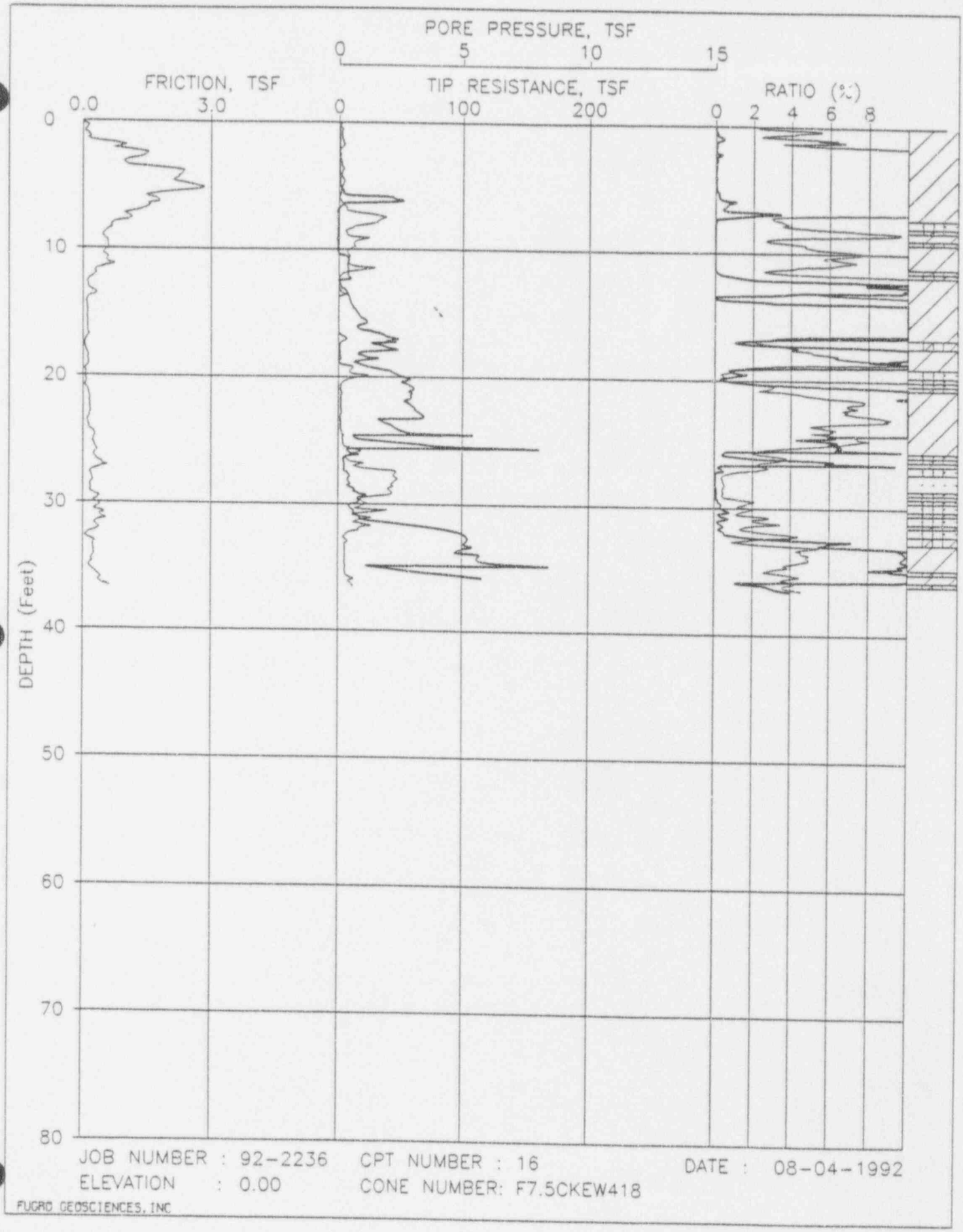
JOB NUMBER : 92-2236
CPT NUMBER : 15
DATE : 08-04-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC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FRICTION, TSF
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3.0
TIP RESISTANCE, TSF
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100
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RATIO (%)
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6
8
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10
20
30
40
50
60
70
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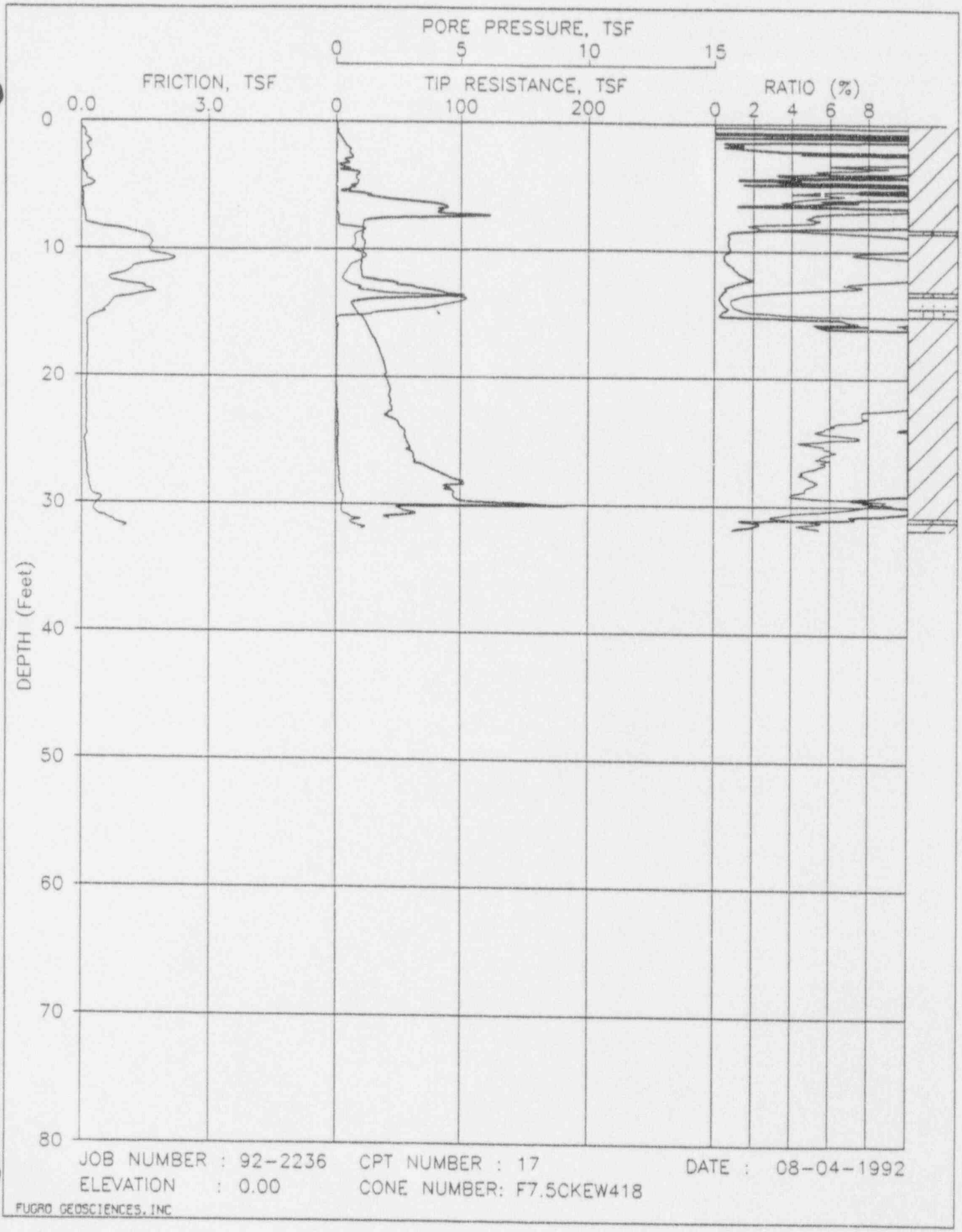
DEPTH (Feet)
JOB NUMBER : 92-2236
CPT NUMBER : 16
DATE : 08-04-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC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FRICTION, TSF
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3.0
TIP RESISTANCE, TSF
0
100
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RATIO (%)
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DEPTH (Feet)
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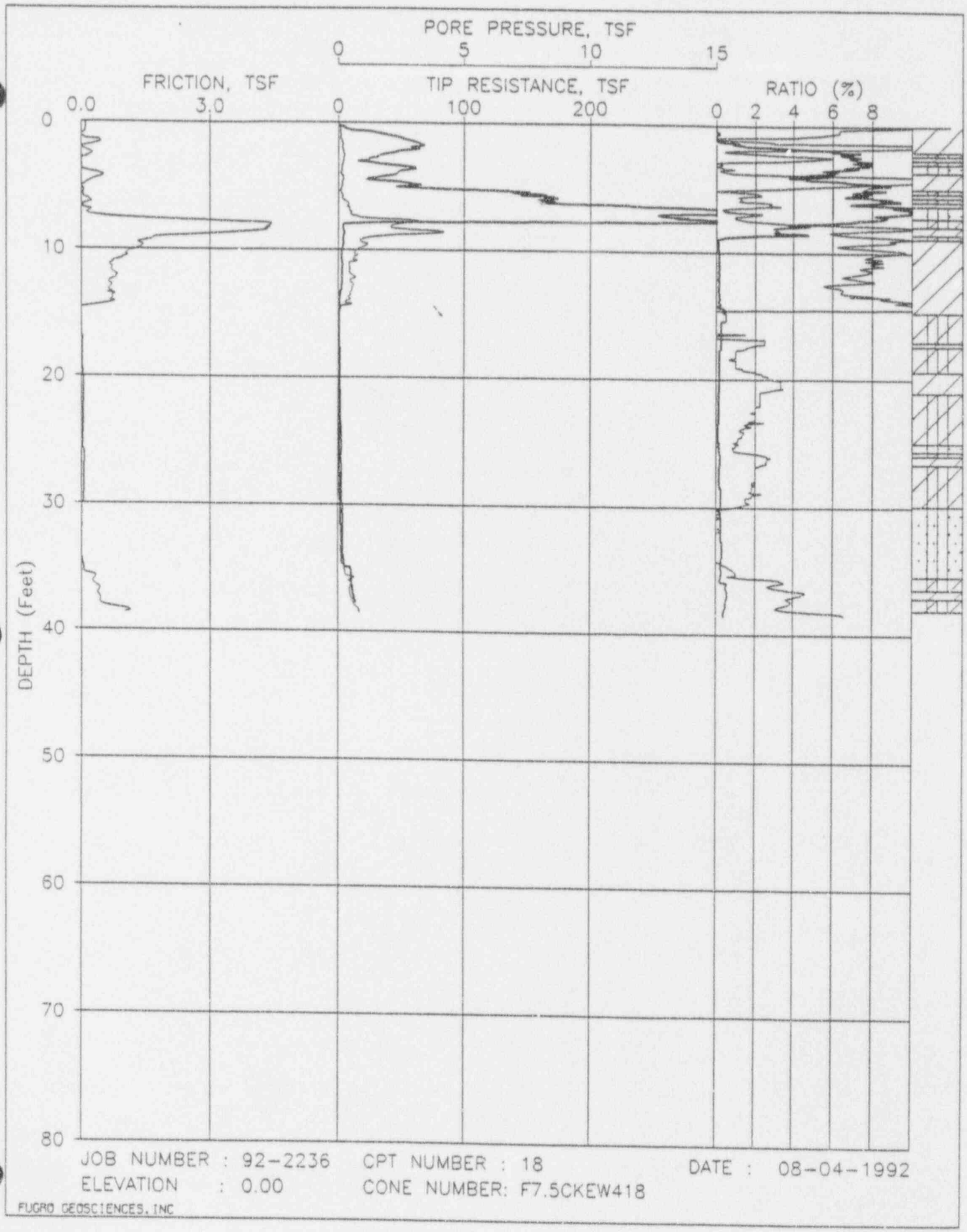
10
20
30
40
50
60
70
80
JOB NUMBER : 92-2236
CPT NUMBER : 17
DATE : 08-04-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC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FRICTION, TSF
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3.0
TIP RESISTANCE, TSF
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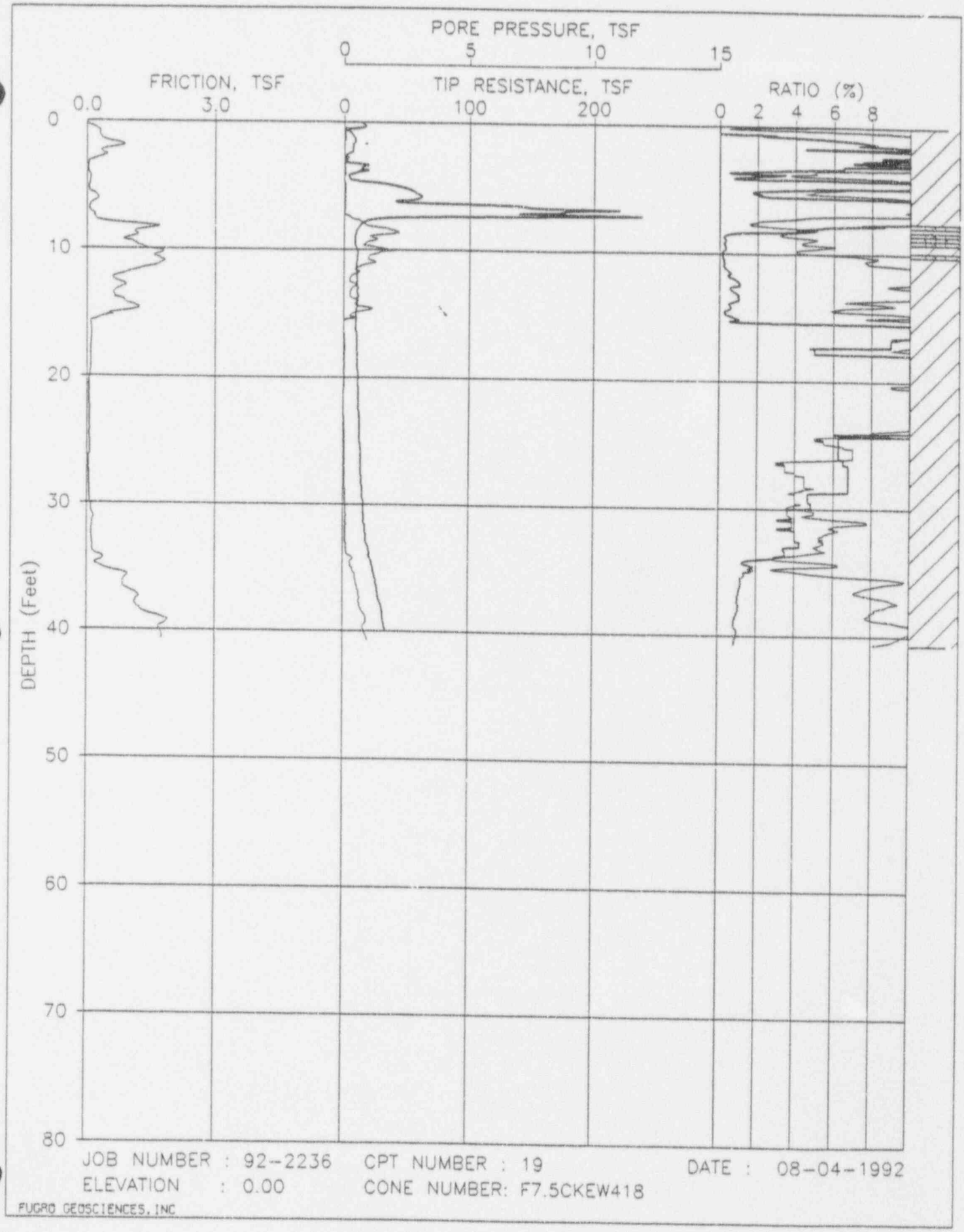
100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
0
10
20
30
40
50
60
70
80
JOB NUMBER : 92-2236
CPT NUMBER : 18
DATE : 08-04-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC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FRICTION, TSF
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3.0
TIP RESISTANCE, TSF
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RATIO (%)
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DEPTH (Feet)
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20
30
40
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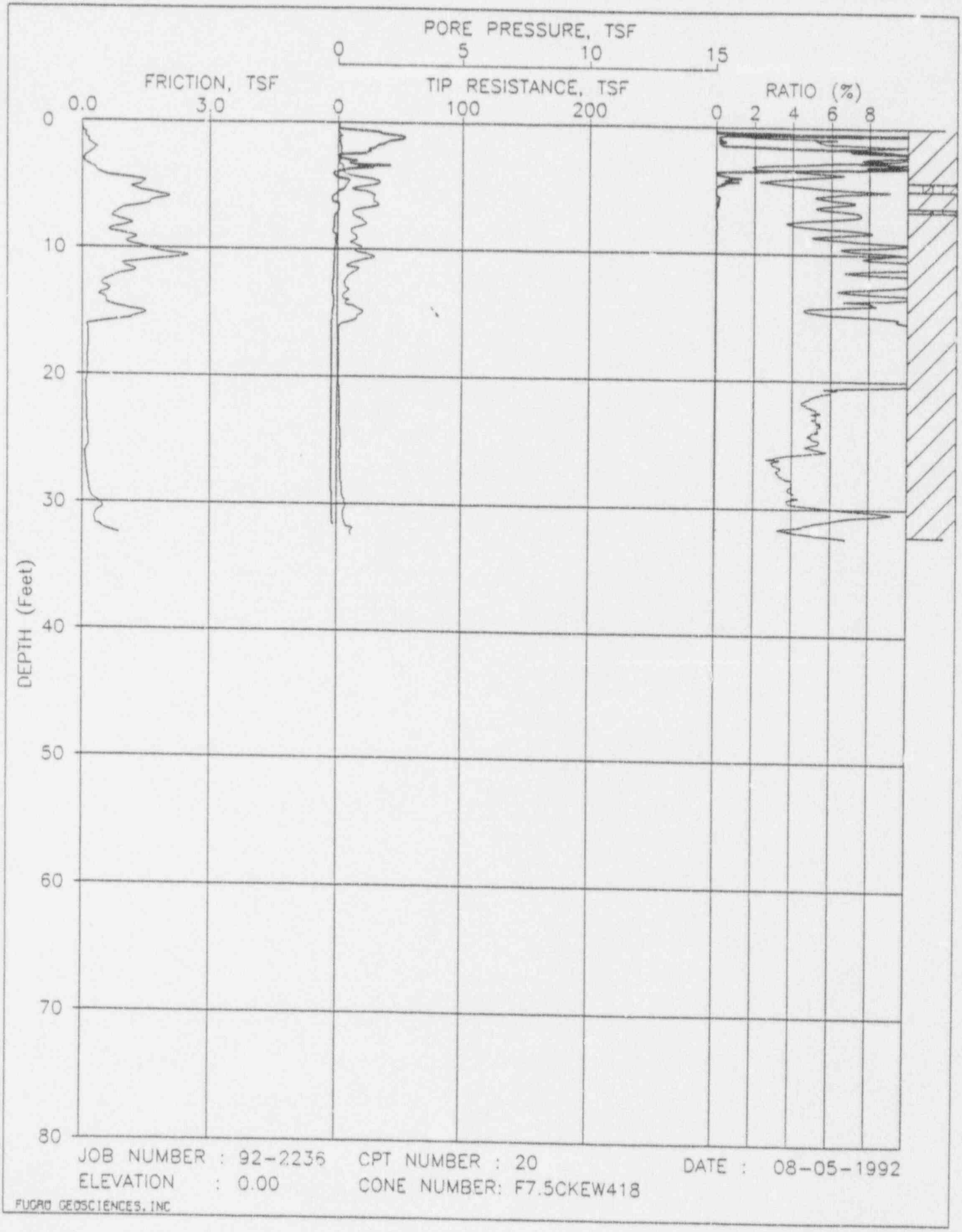
60
70
80
JOB NUMBER : 92-2236
CPT NUMBER : 19
DATE : 08-04-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC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FRICTION, TSF
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3.0
TIP RESISTANCE, TSF
0
100
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RATIO (%)
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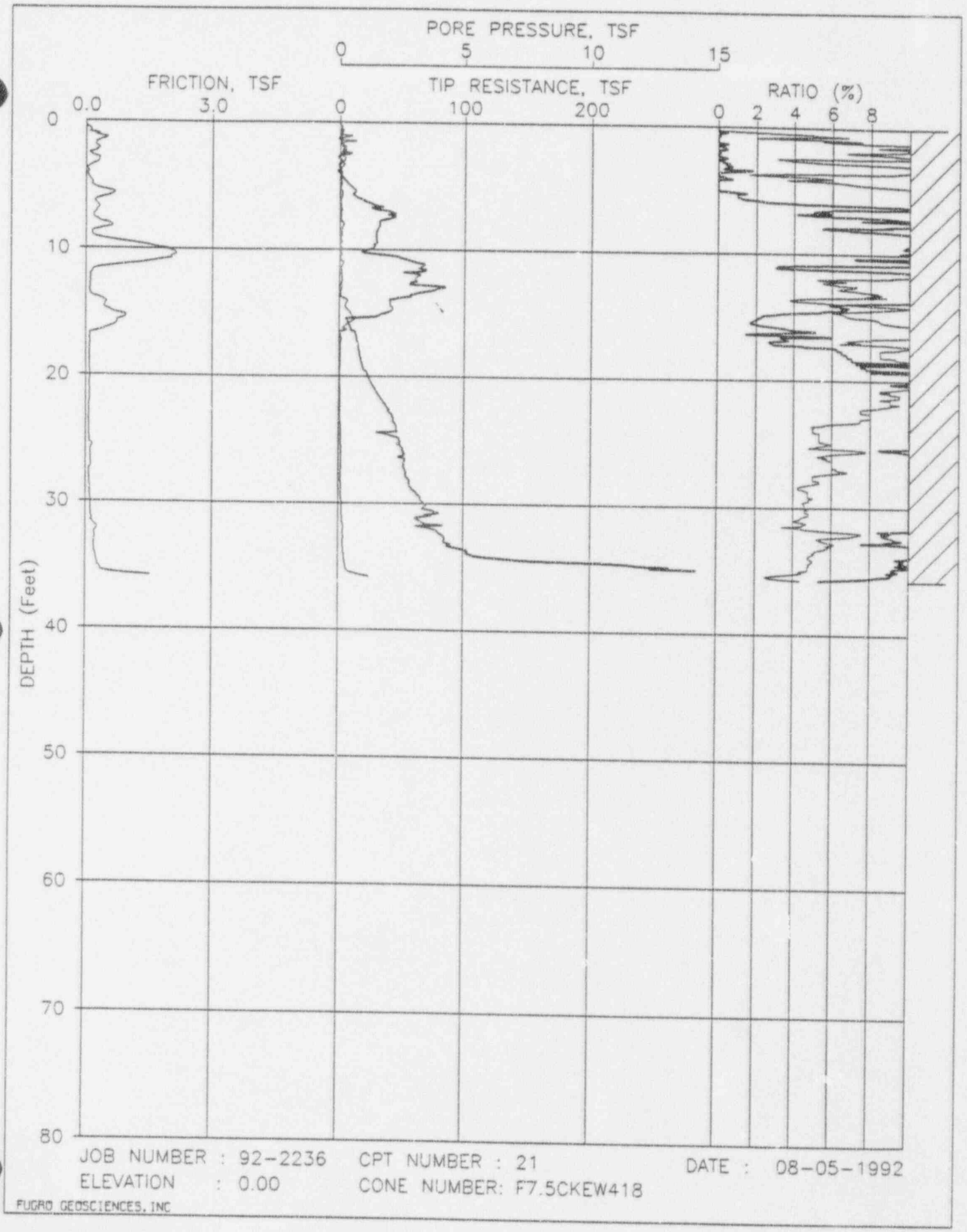
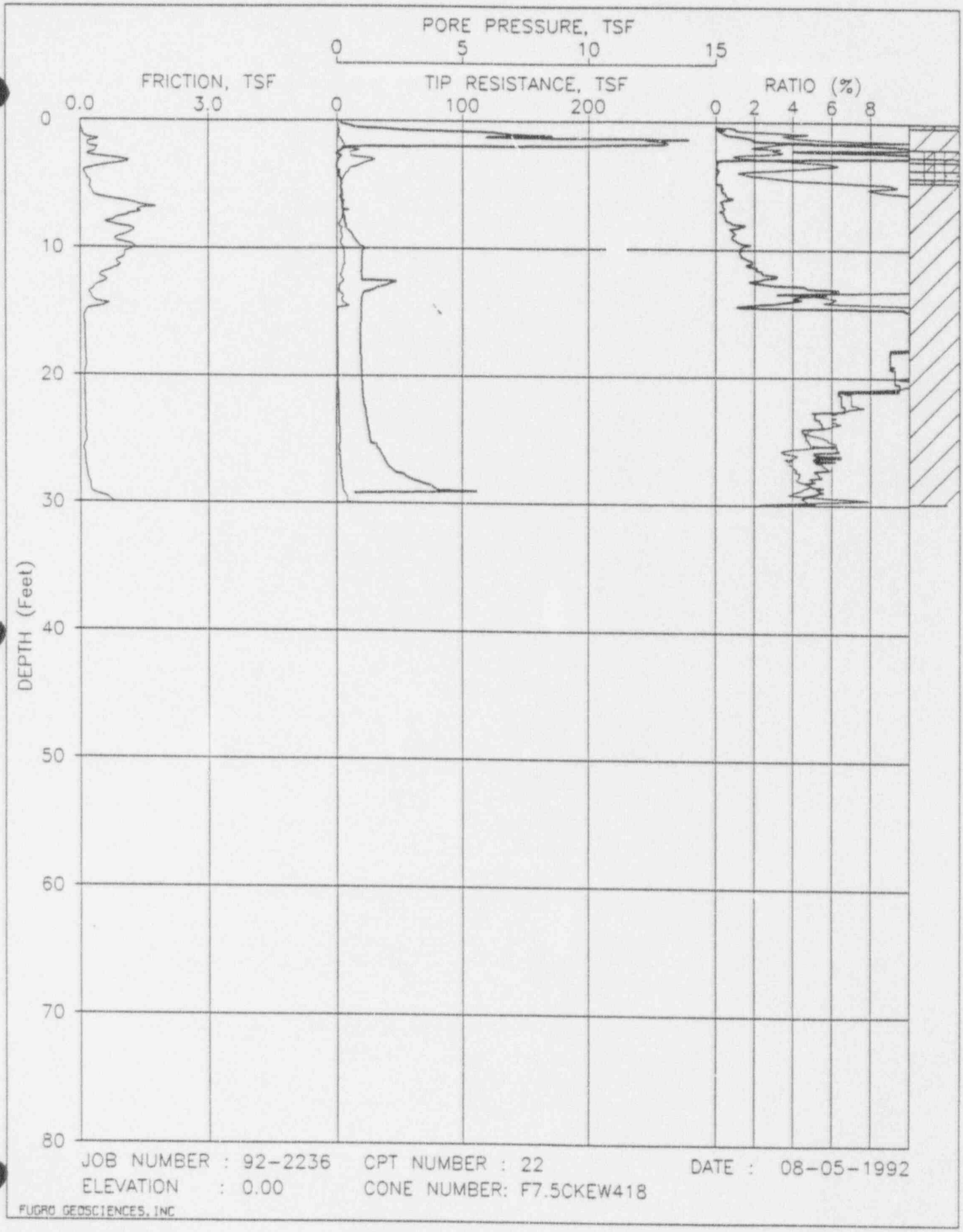
4
6
8
DEPTH (Feet)
0
10
20
30
40
50
60
70
80
JOB NUMBER : 92-2236
CPT NUMBER : 20
DATE : 08-05-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 21 DATE : 08-05-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEW418

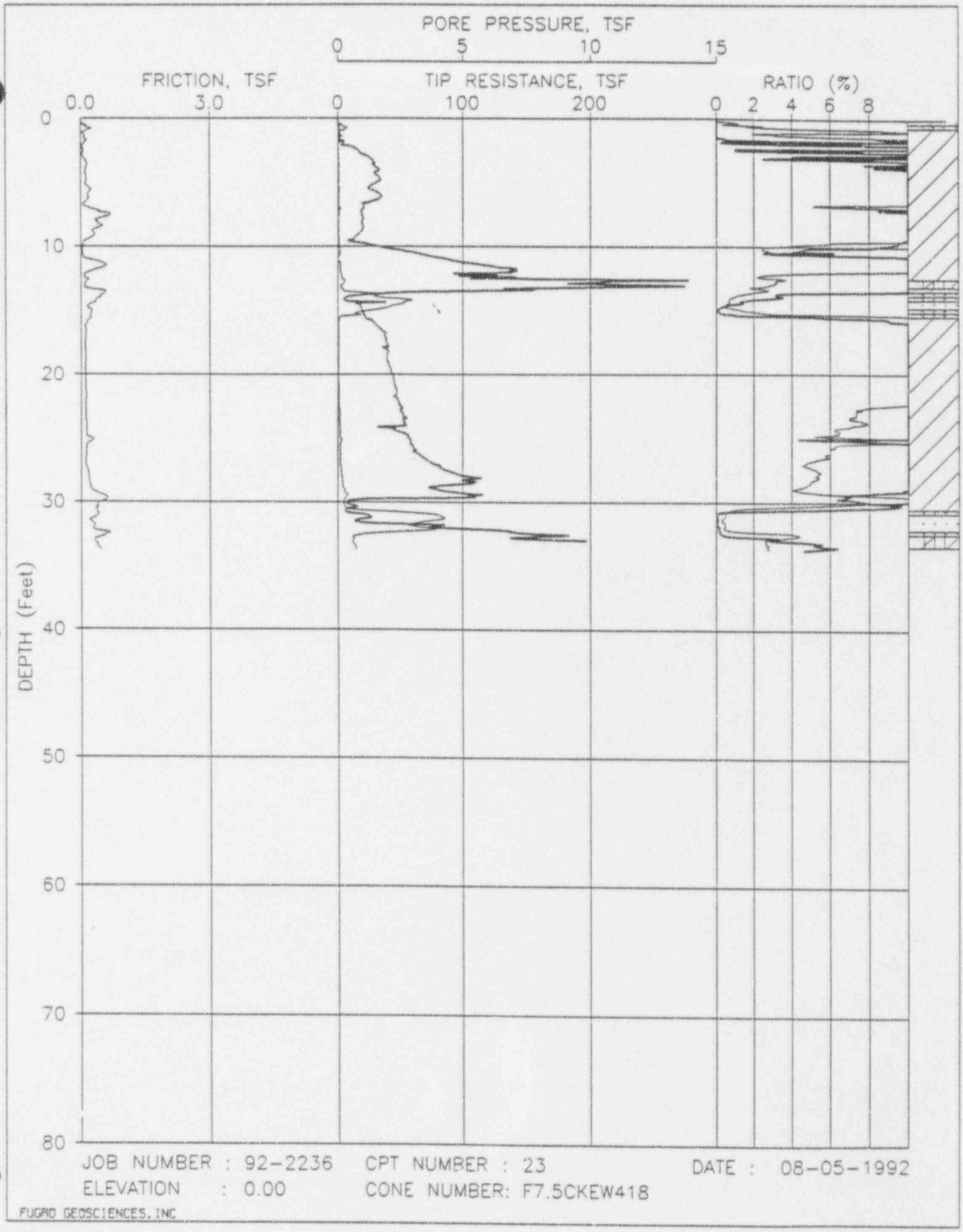
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 22 DATE : 08-05-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEW418

FUGRO GEOSCIENCES, INC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FRICTION, TSF
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3.0
TIP RESISTANCE, TSF
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100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
0
10
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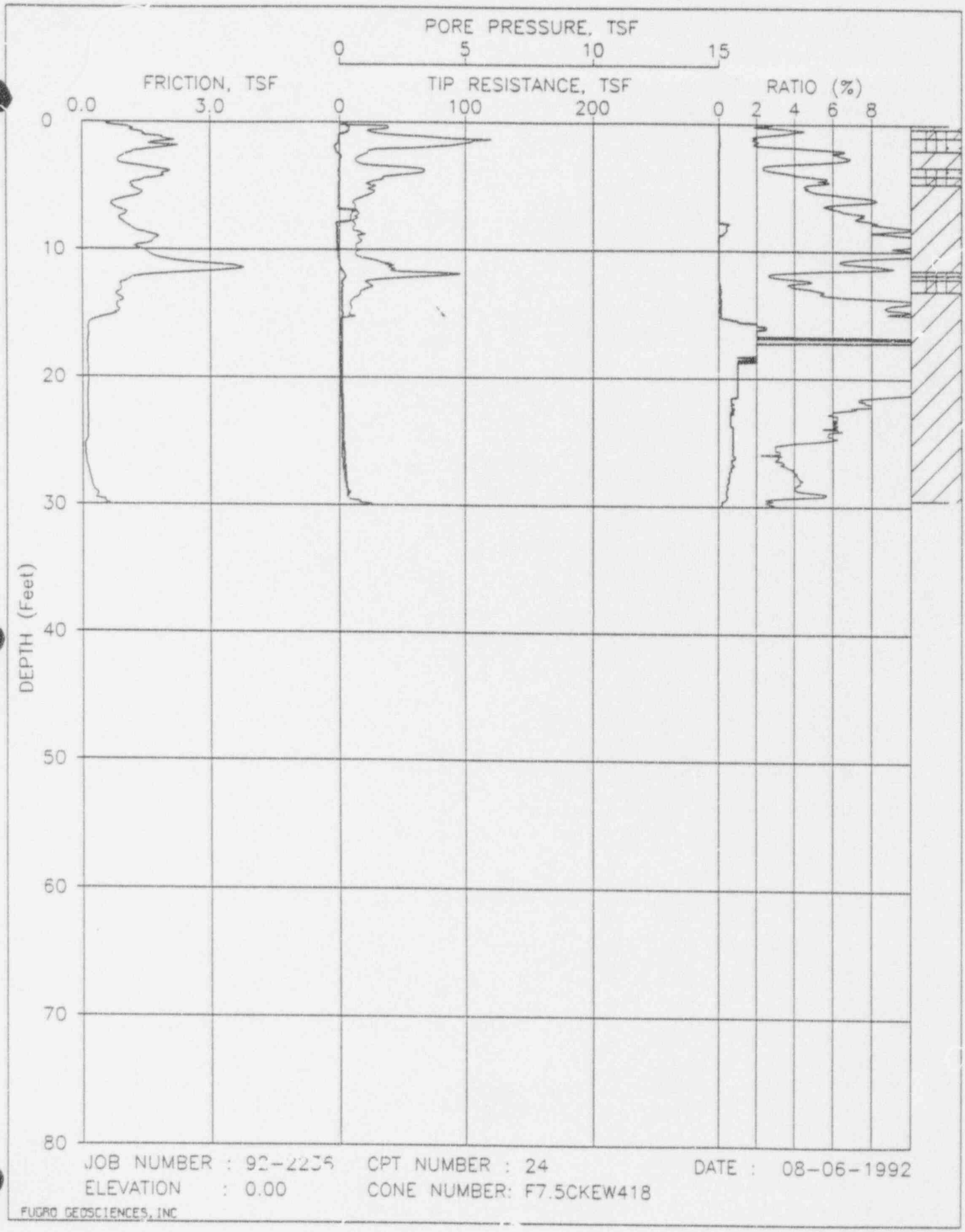
30
40
50
60
70
80
JOB NUMBER : 92-2236
CPT NUMBER : 23
DATE : 08-05-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC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FRICTION, TSF
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3.0
TIP RESISTANCE, TSF
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100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
0
10
20
30
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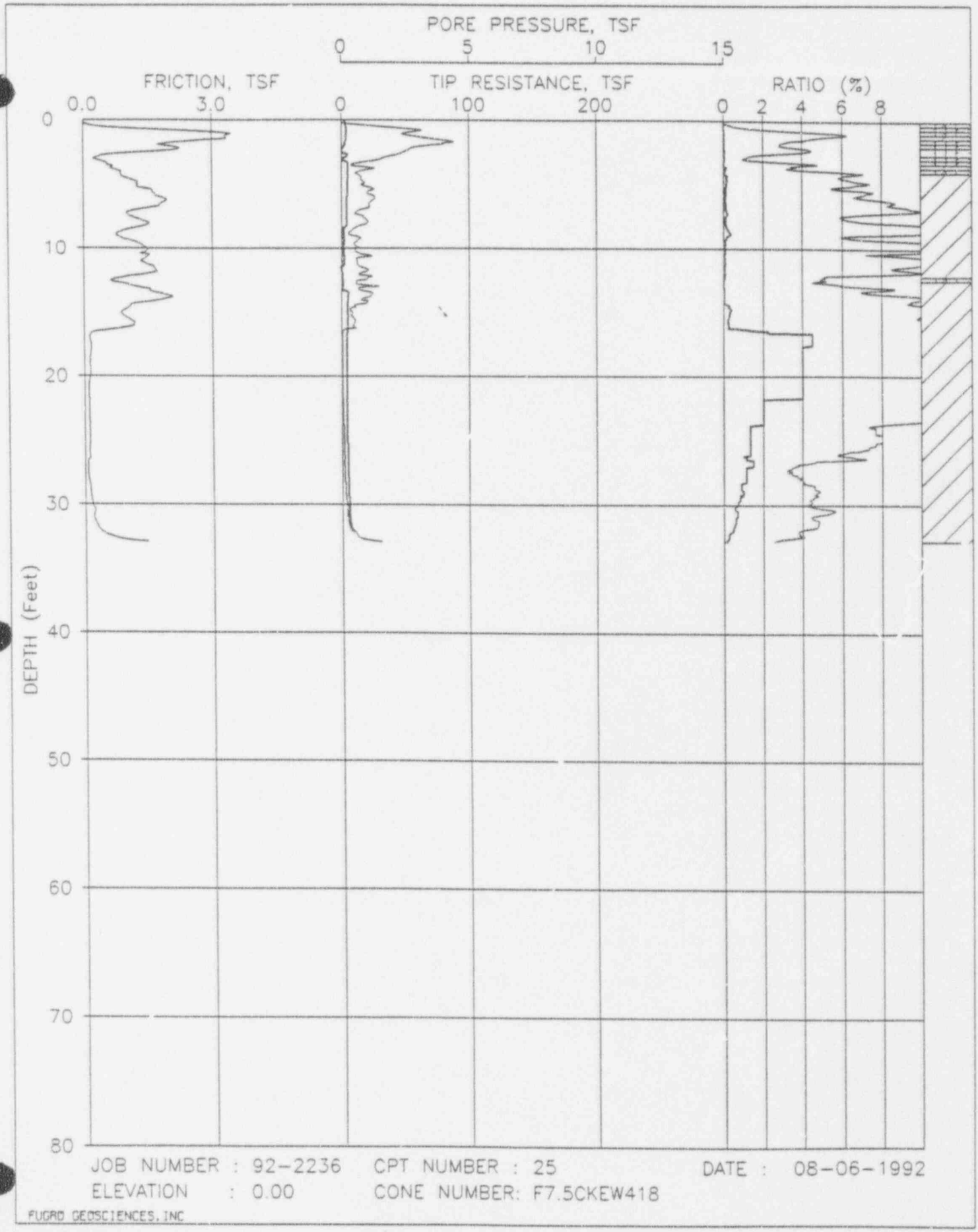
60
70
80
JOB NUMBER : 92-2236
CPT NUMBER : 24
DATE : 08-06-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC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FRICTION, TSF
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TIP RESISTANCE, TSF
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RATIO (%)
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DEPTH (Feet)
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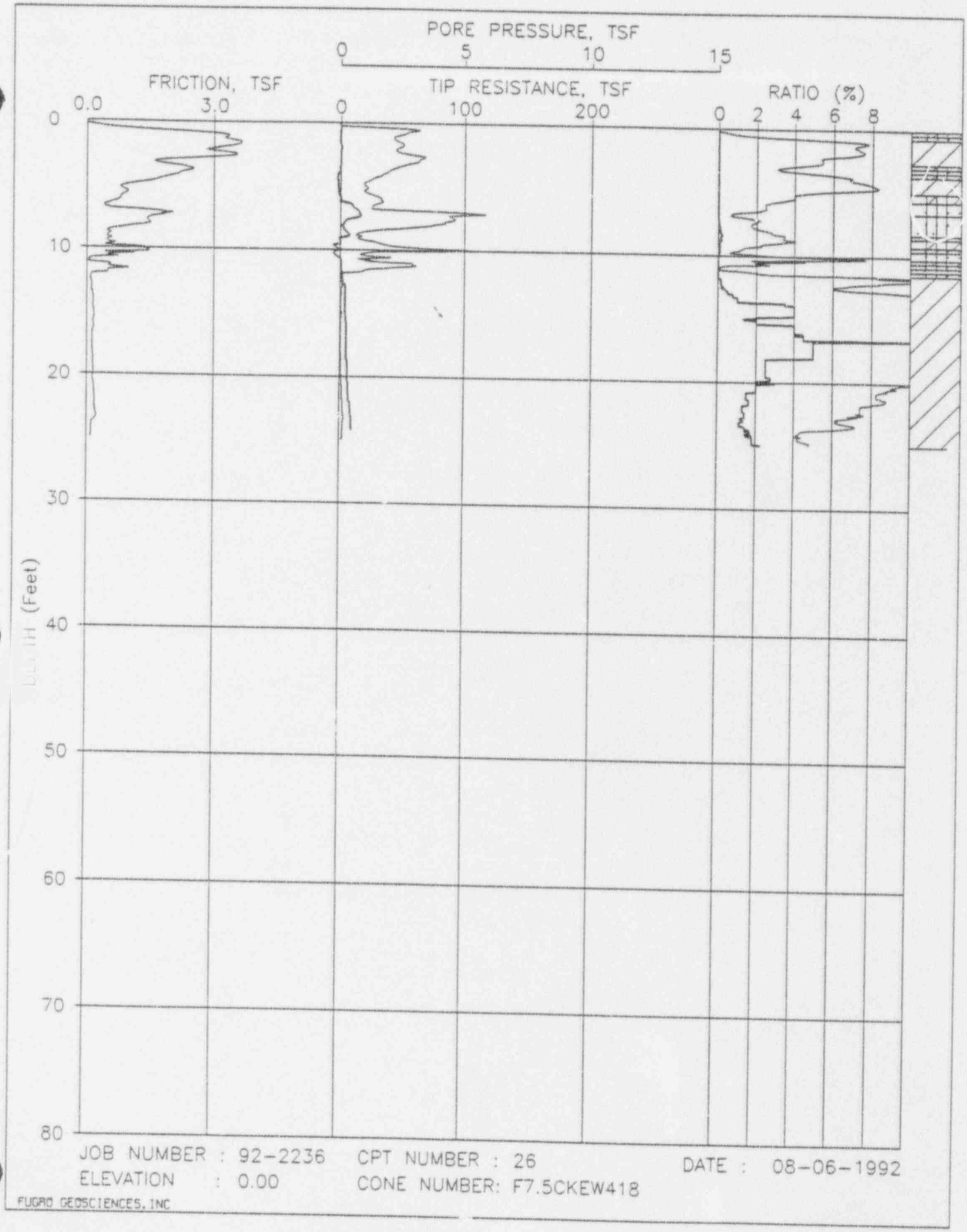
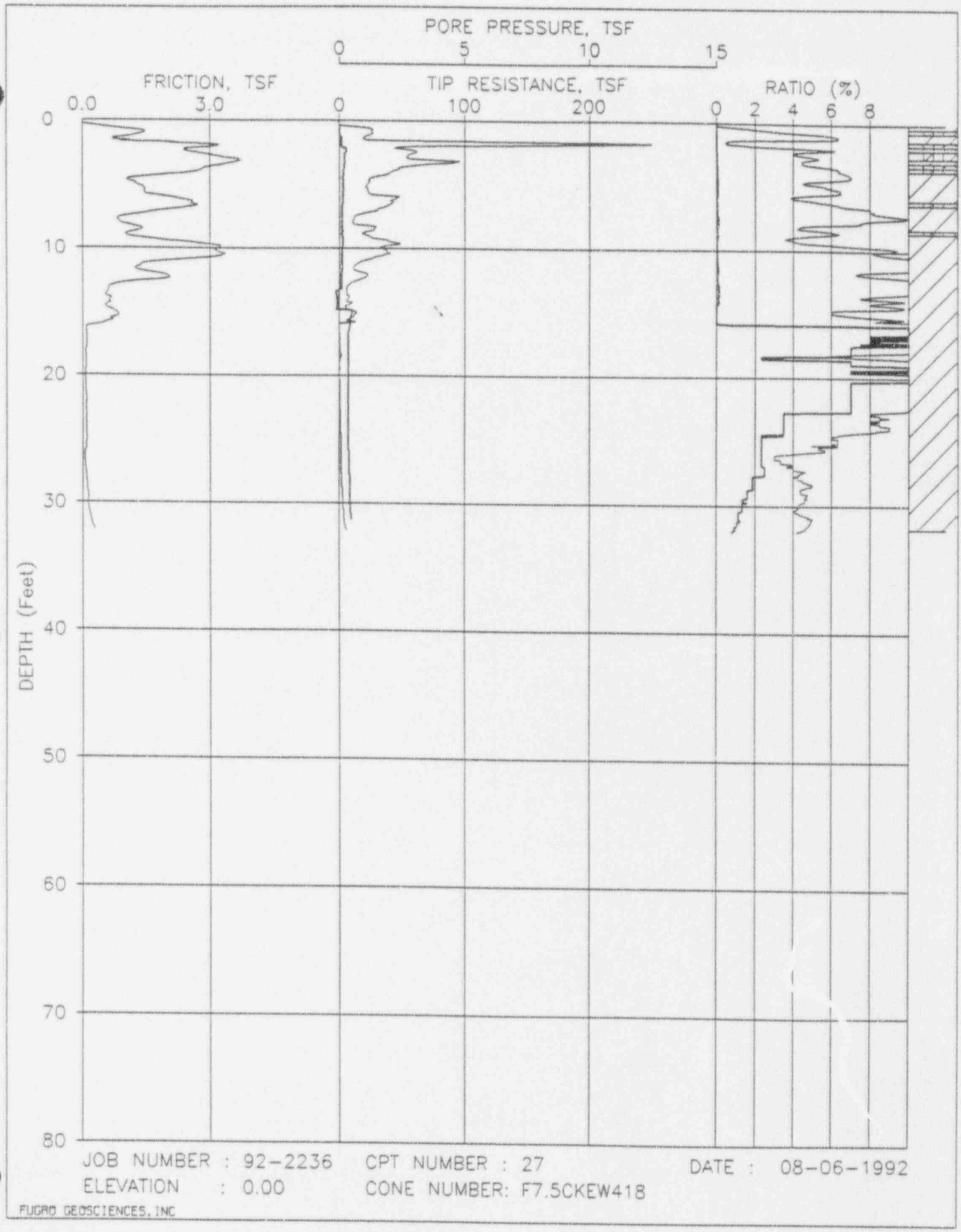
JOB NUMBER : 92-2236
CPT NUMBER : 25
DATE : 08-06-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 26 DATE : 08-06-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEW418

FUGRO GEOSCIENCES, INC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TIP RESISTANCE, TSF
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100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
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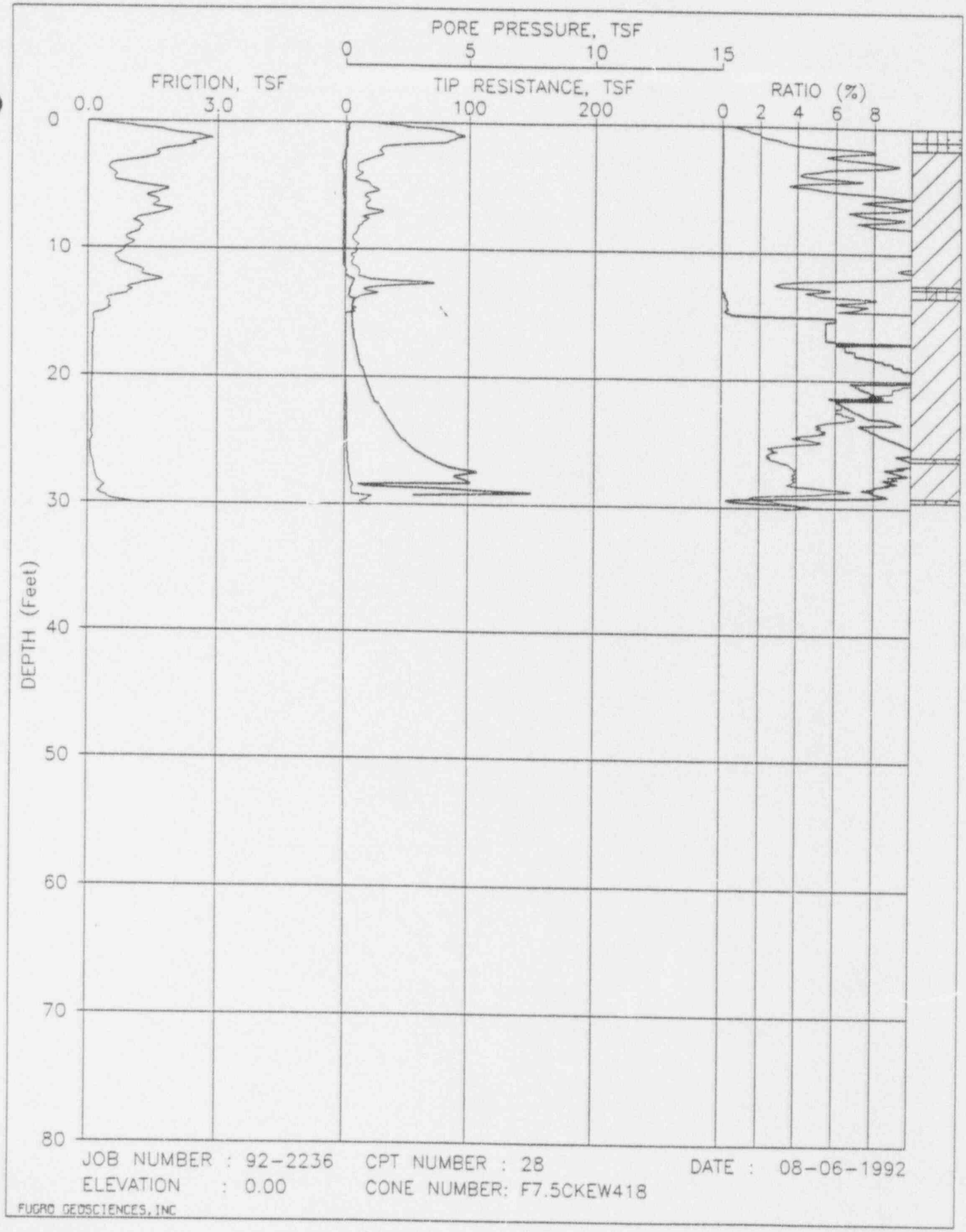
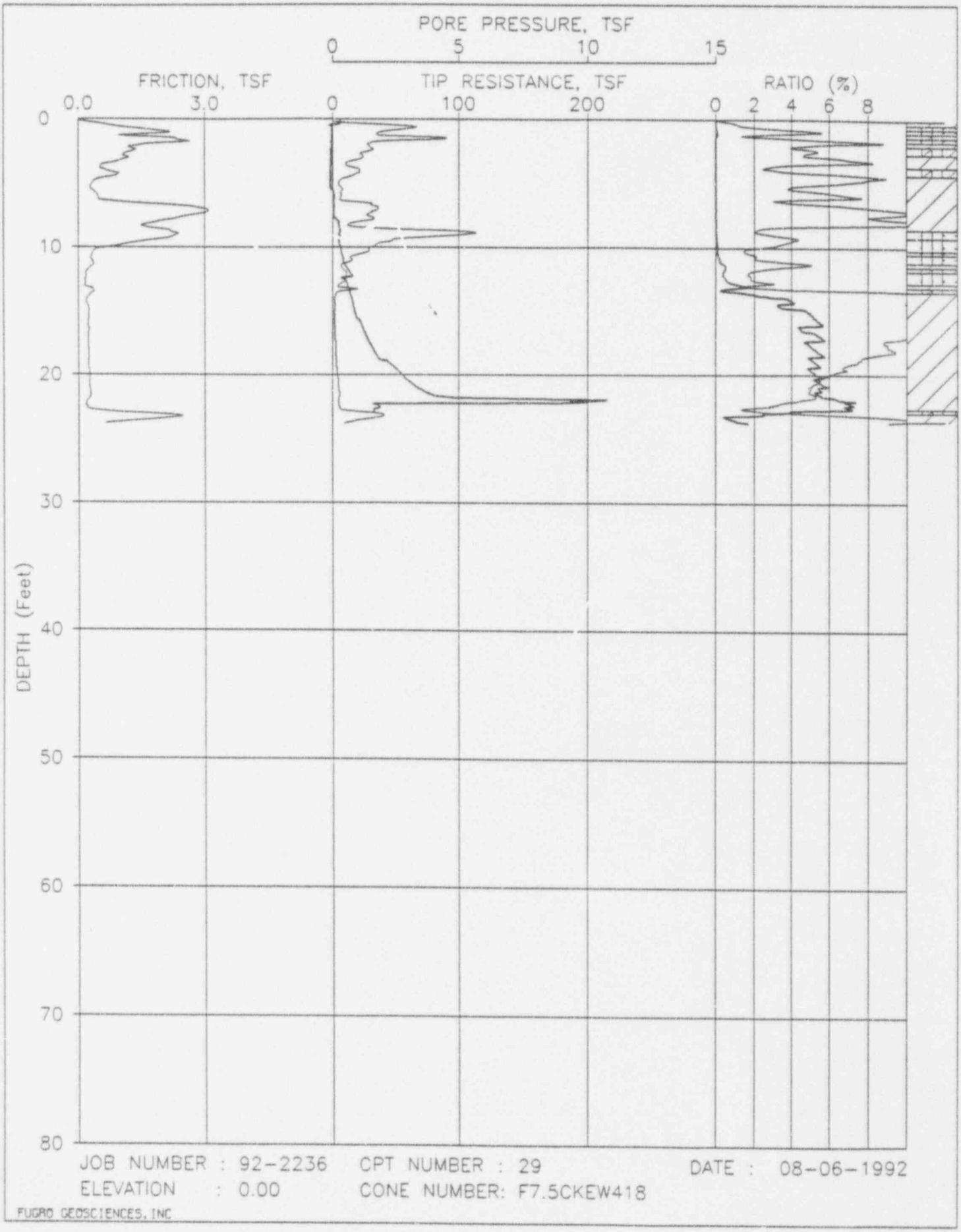
80
JOB NUMBER : 92-2236
CPT NUMBER : 27
DATE : 08-06-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 28 DATE : 08-06-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEW418

FUGRO GEOSCIENCES, INC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TIP RESISTANCE, TSF
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100
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RATIO (%)
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DEPTH (Feet)
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20
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40
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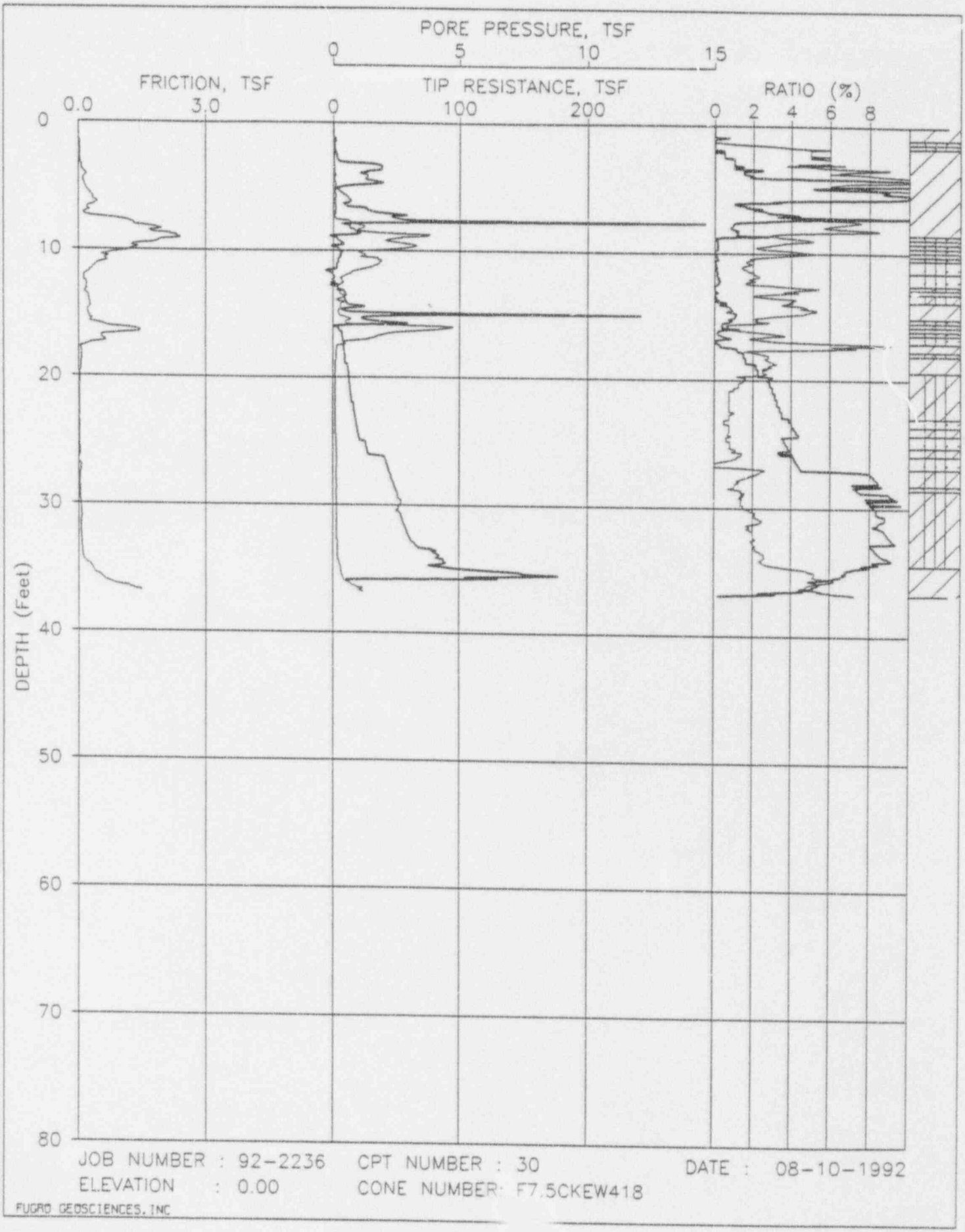
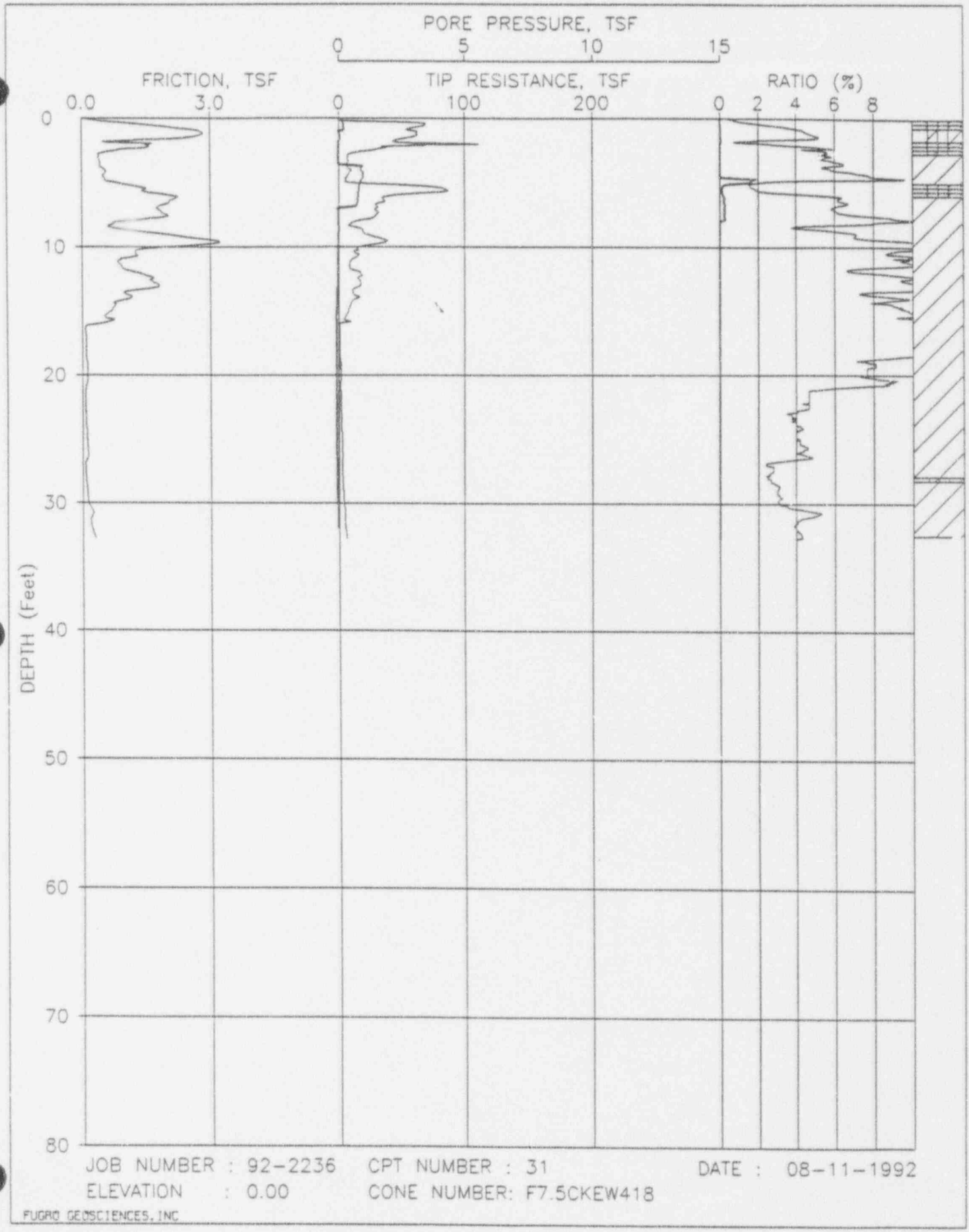
80
JOB NUMBER : 92-2236
CPT NUMBER : 29
DATE : 08-06-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 30 DATE : 08-10-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEW418

FUGRO GEOSCIENCES, INC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FRICTION, TSF
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3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
0
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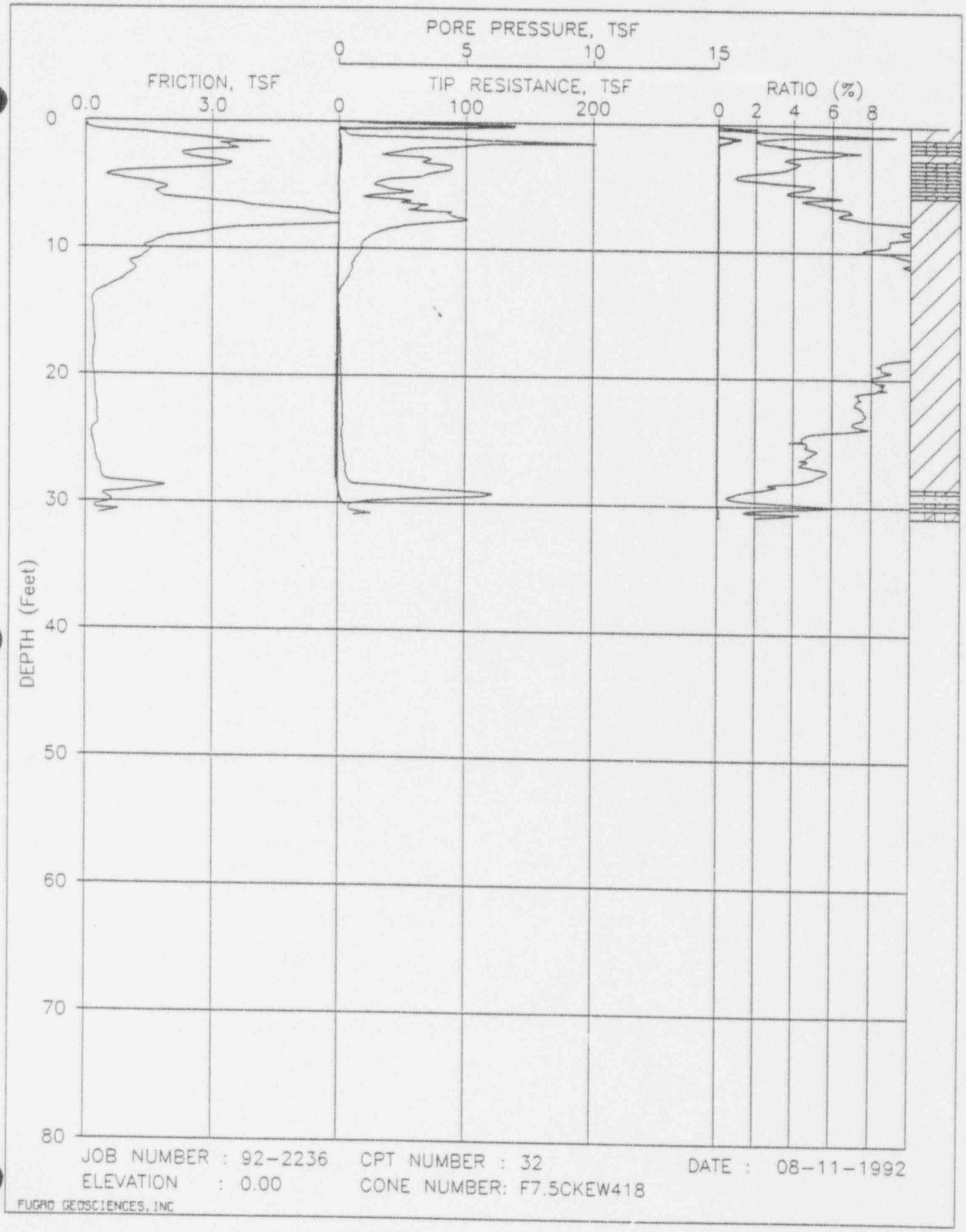
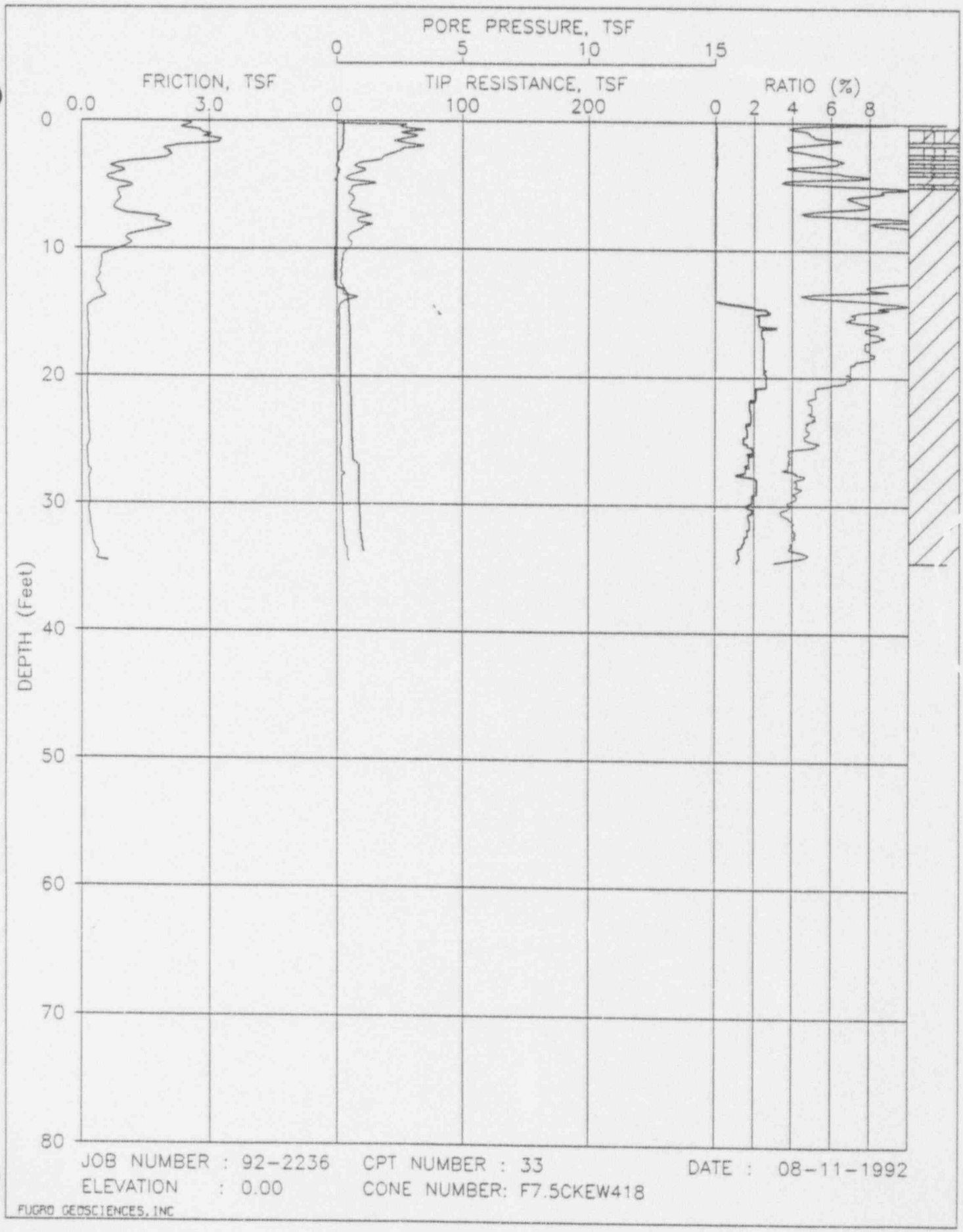
20
30
40
50
60
70
80
DEPTH (Feet)
JOB NUMBER : 92-2236
CPT NUMBER : 31
DATE : 08-11-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 32 DATE : 08-11-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEW418

FUGRO GEOSCIENCES, INC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200
RATIO (%)
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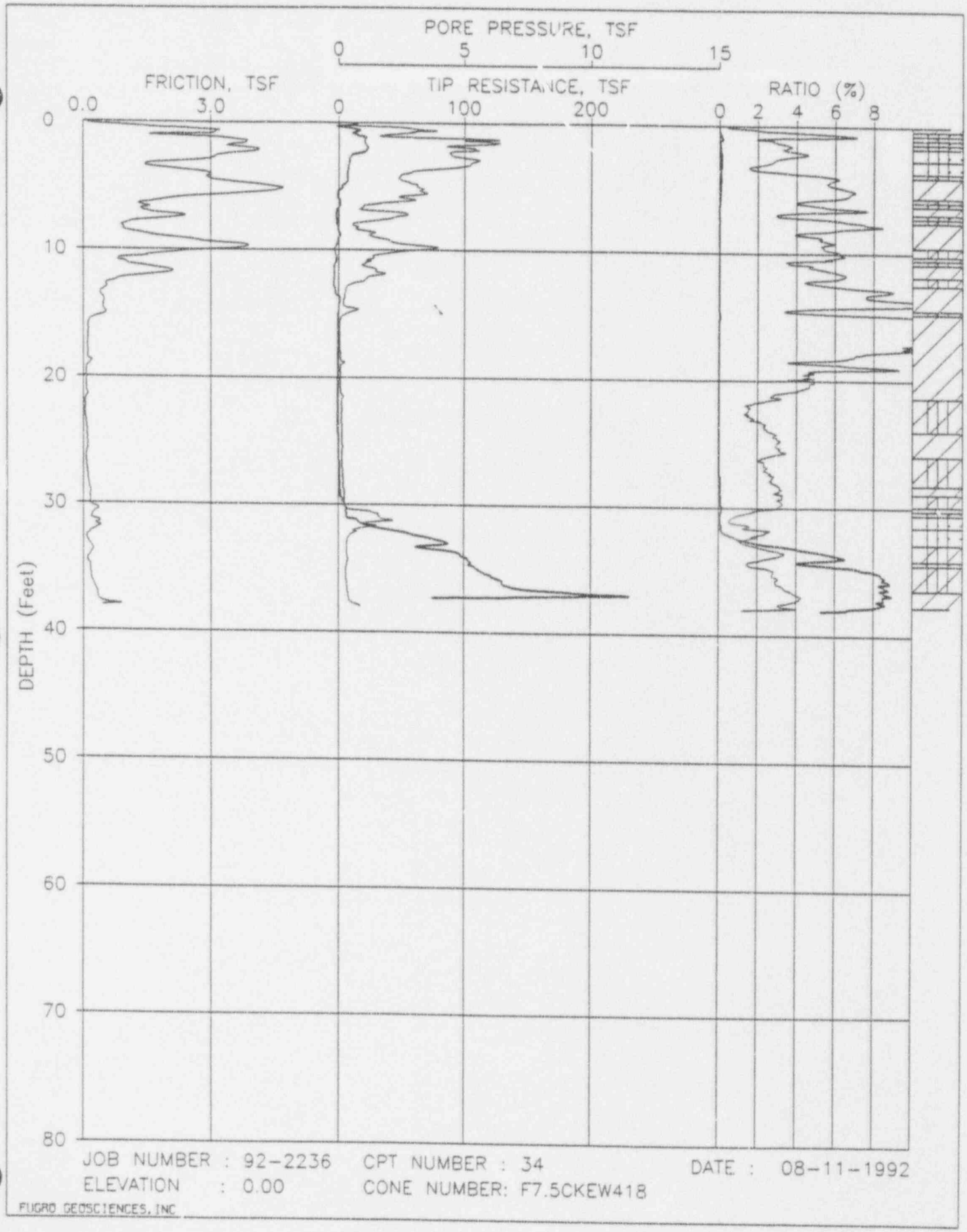
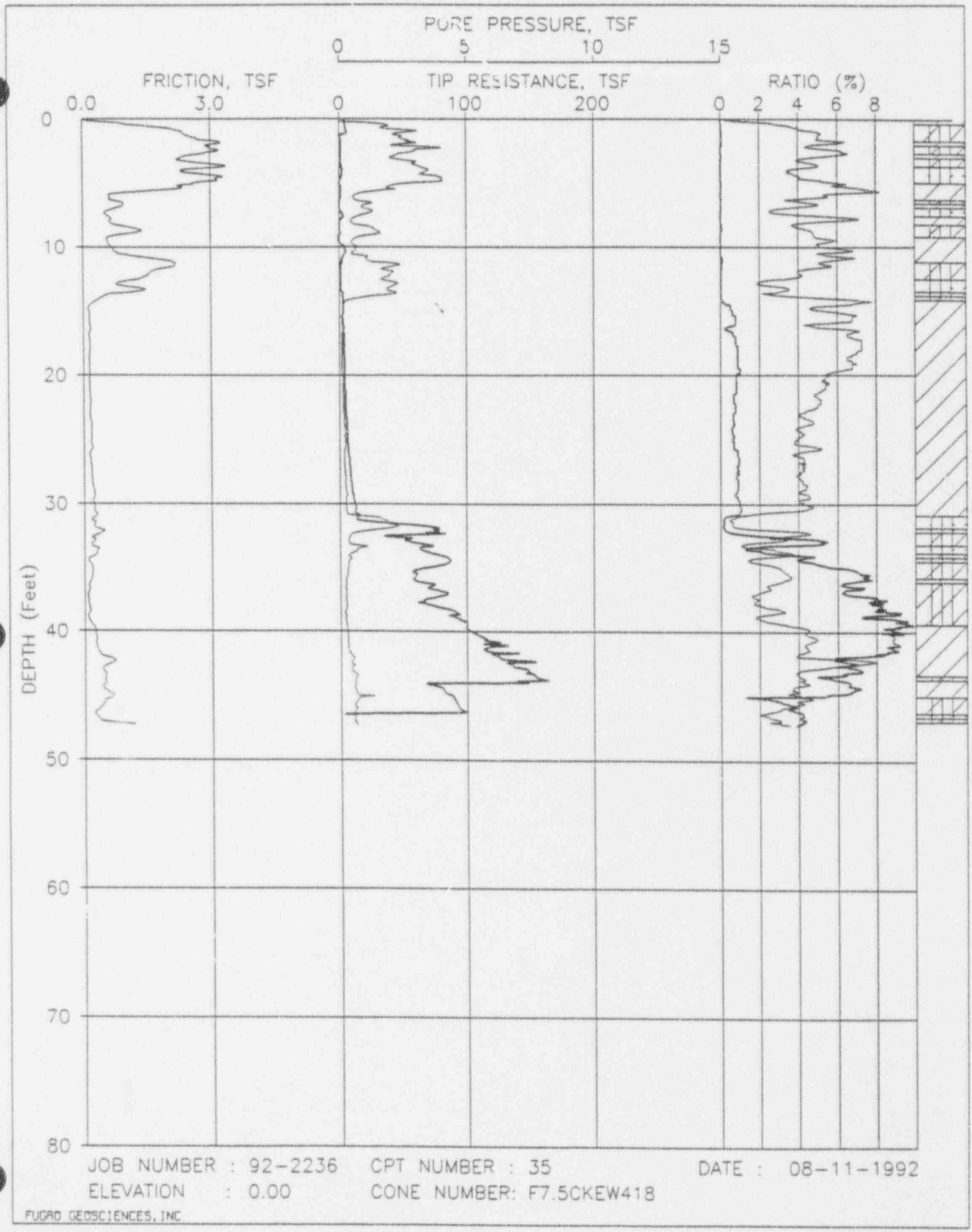
4
6
8
0
10
20
30
40
50
60
70
80
DEPTH (Feet)
JOB NUMBER : 92-2236
CPT NUMBER : 33
DATE : 08-11-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 34 DATE : 08-11-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEW418

FUGRO GEOSCIENCES, INC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100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
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10
20
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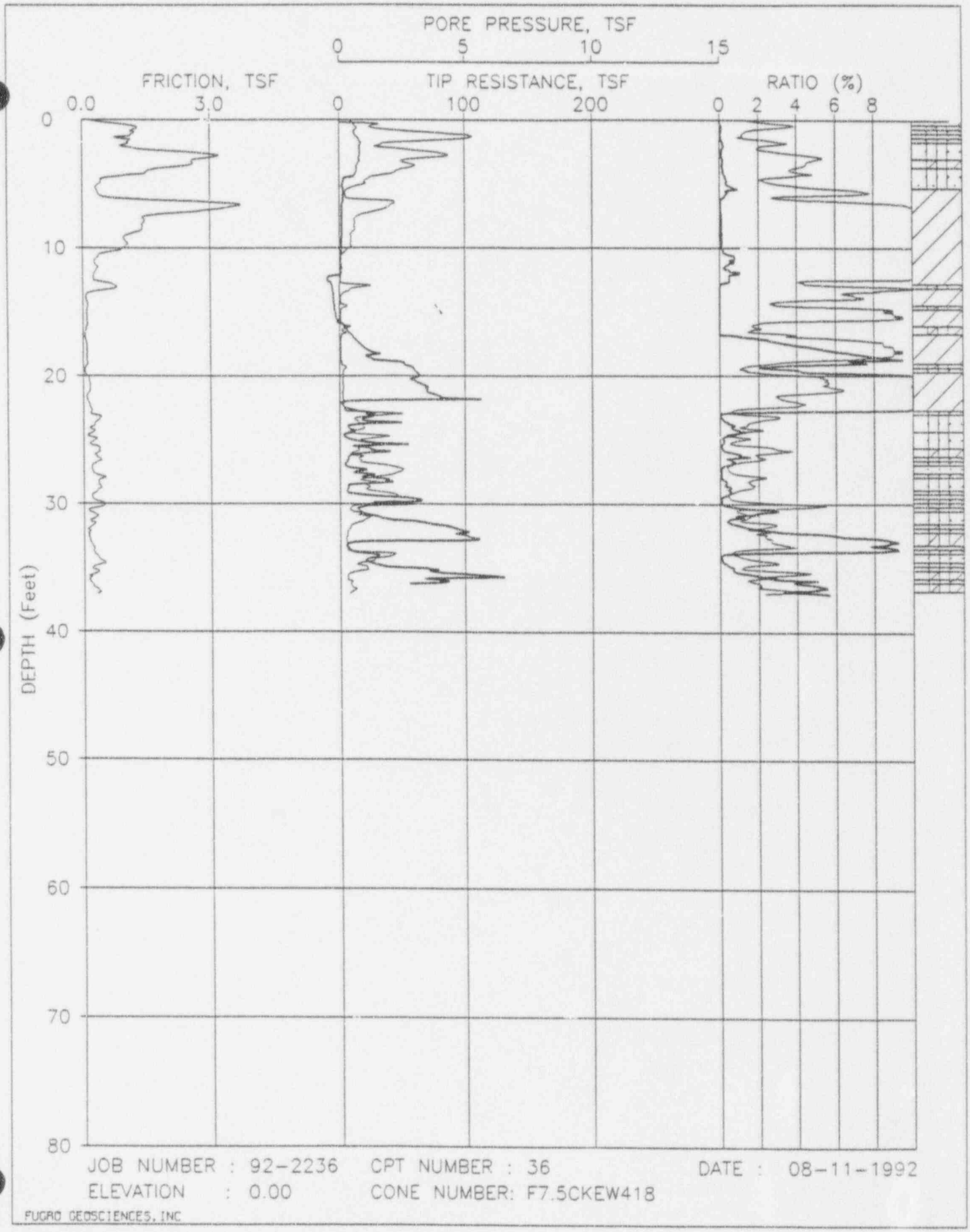
JOB NUMBER : 92-2236
CPT NUMBER : 35
DATE : 08-11-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC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DEPTH (Feet)
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10
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40
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60
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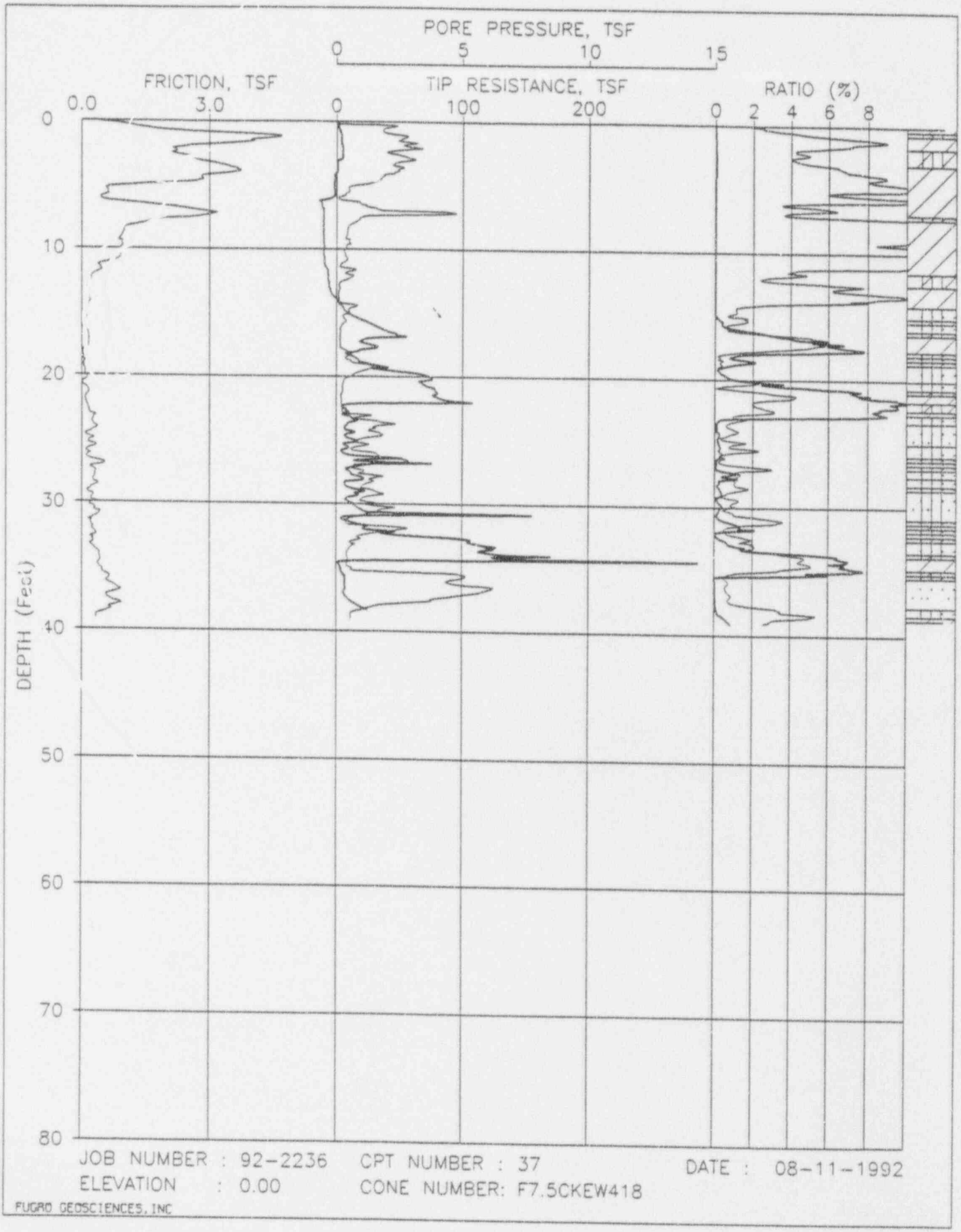
80
JOB NUMBER : 92-2236
CPT NUMBER : 36
DATE : 08-11-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC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RATIO (%)
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40
50
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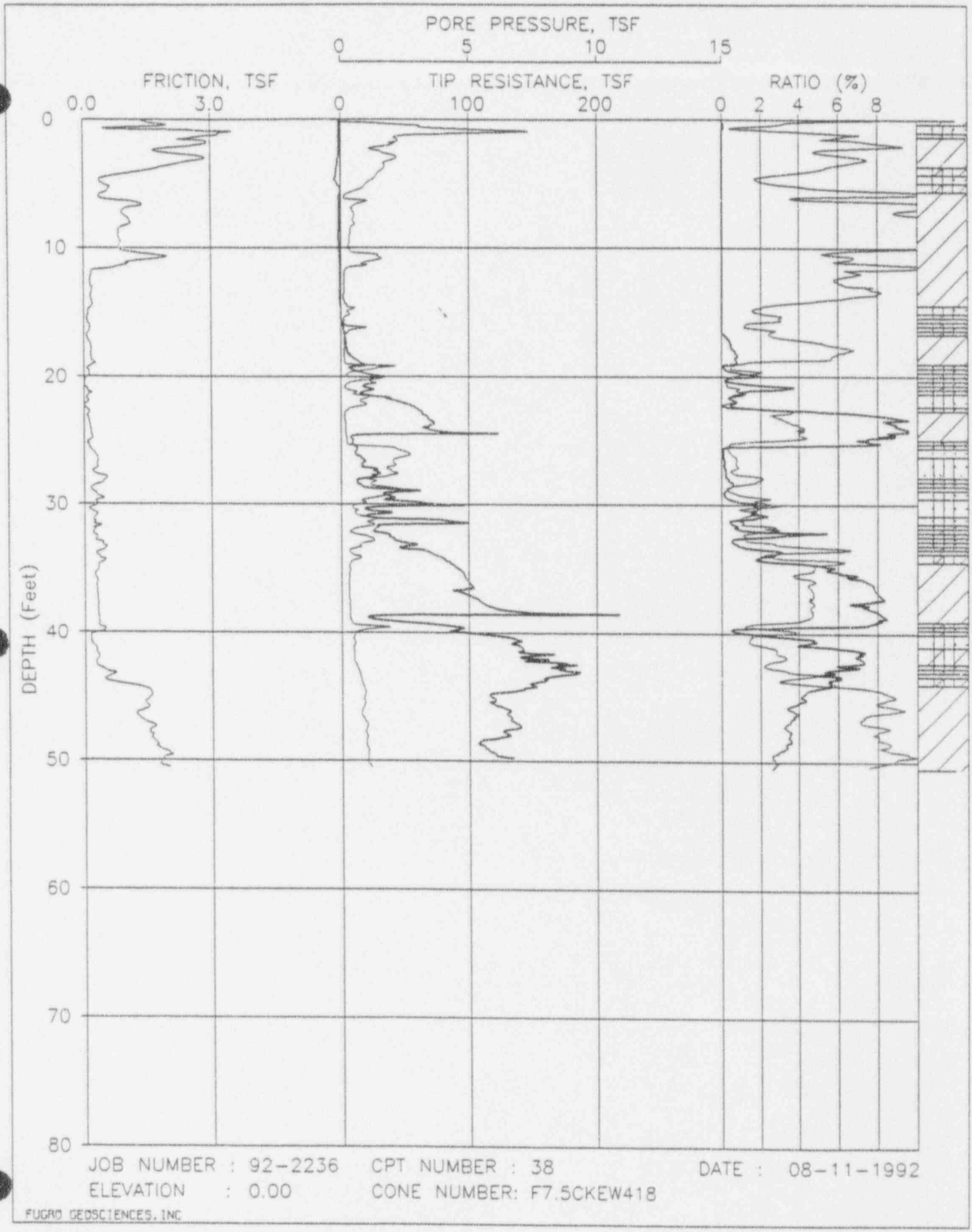
DEPTH (Feet)
JOB NUMBER : 92-2236
CPT NUMBER : 37
DATE : 08-11-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC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100
200
RATIO (%)
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50
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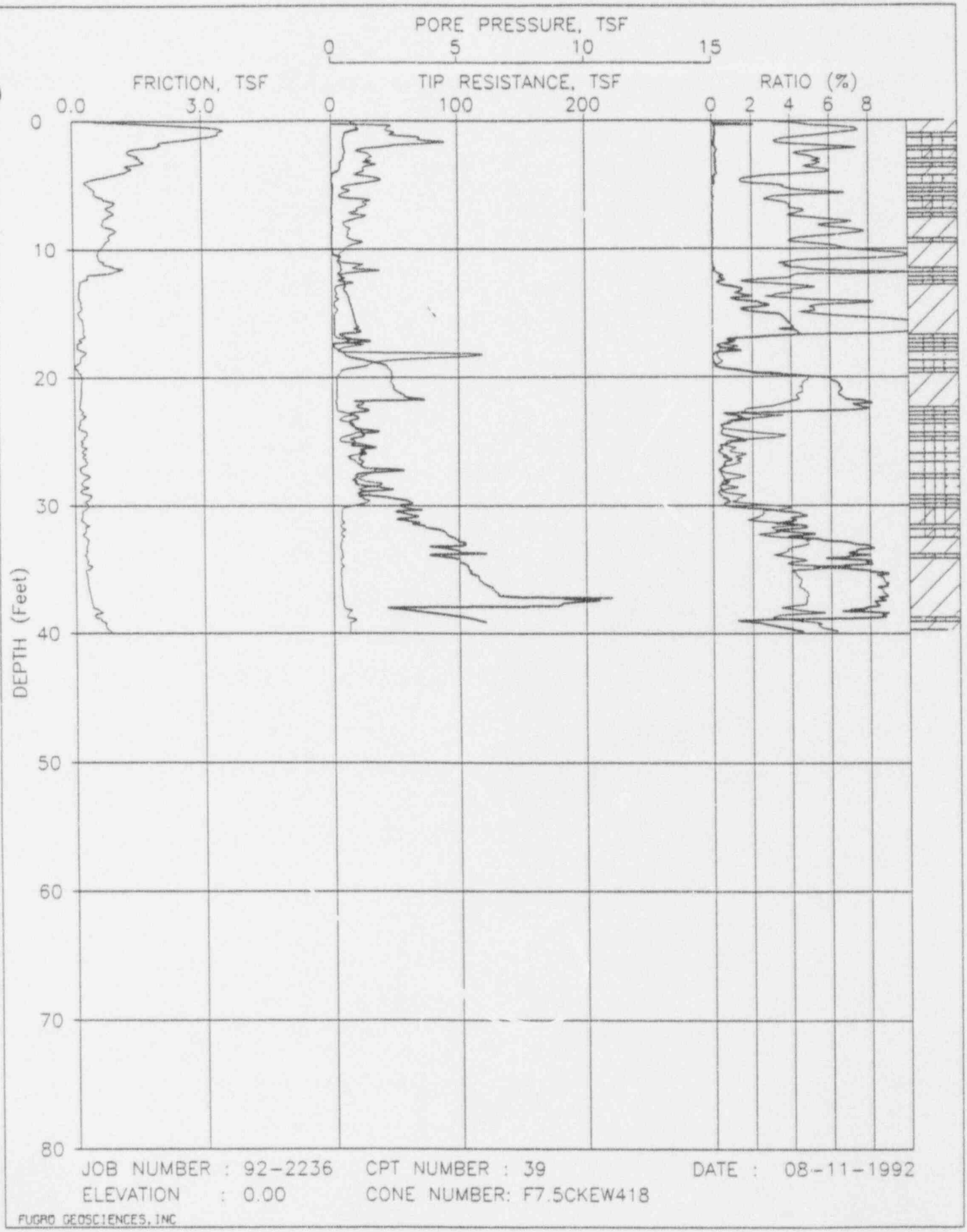
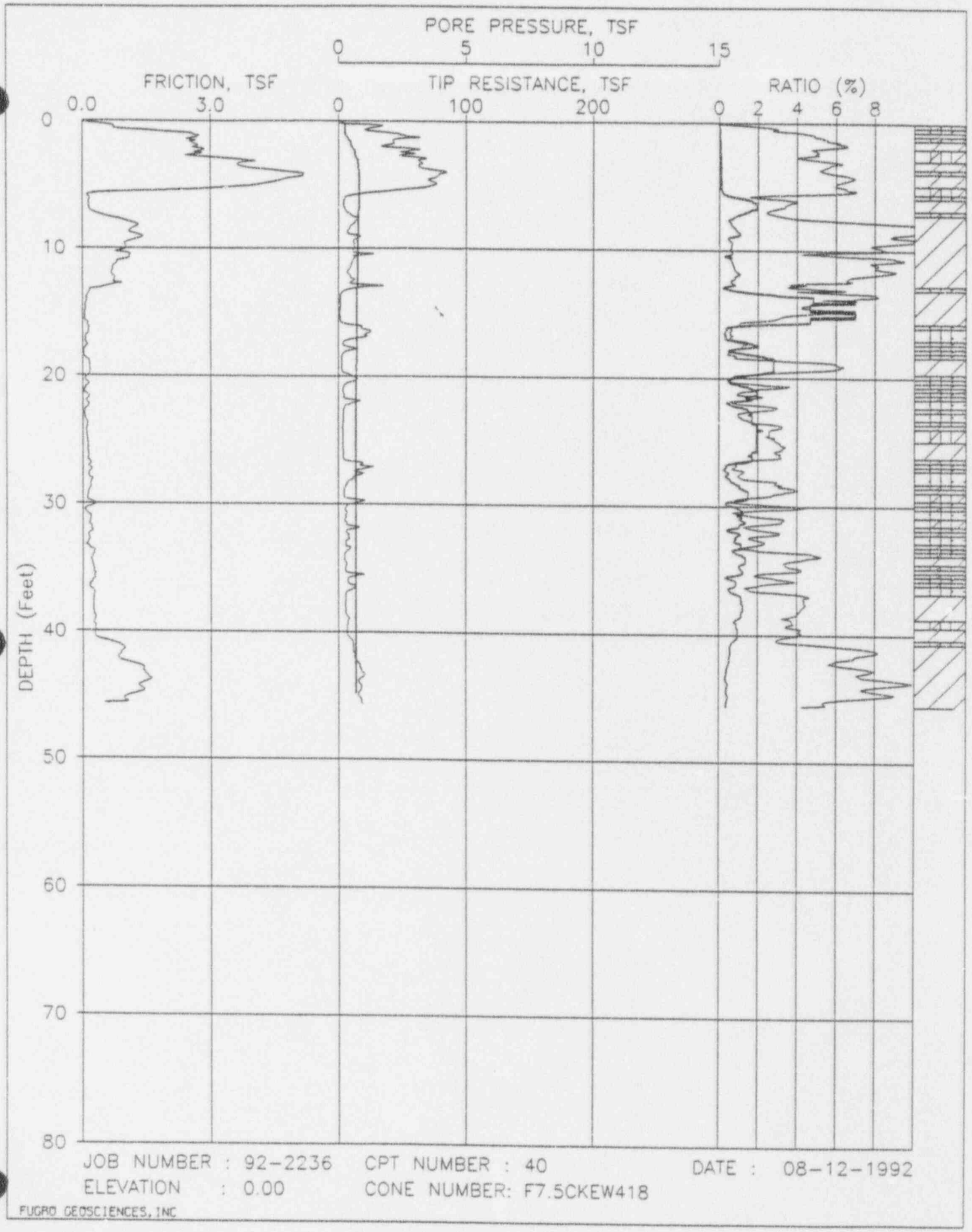
DEPTH (Feet)
JOB NUMBER : 92-2236
CPT NUMBER : 38
DATE : 08-11-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 39 DATE : 08-11-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEW418

FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 40 DATE : 08-12-1992

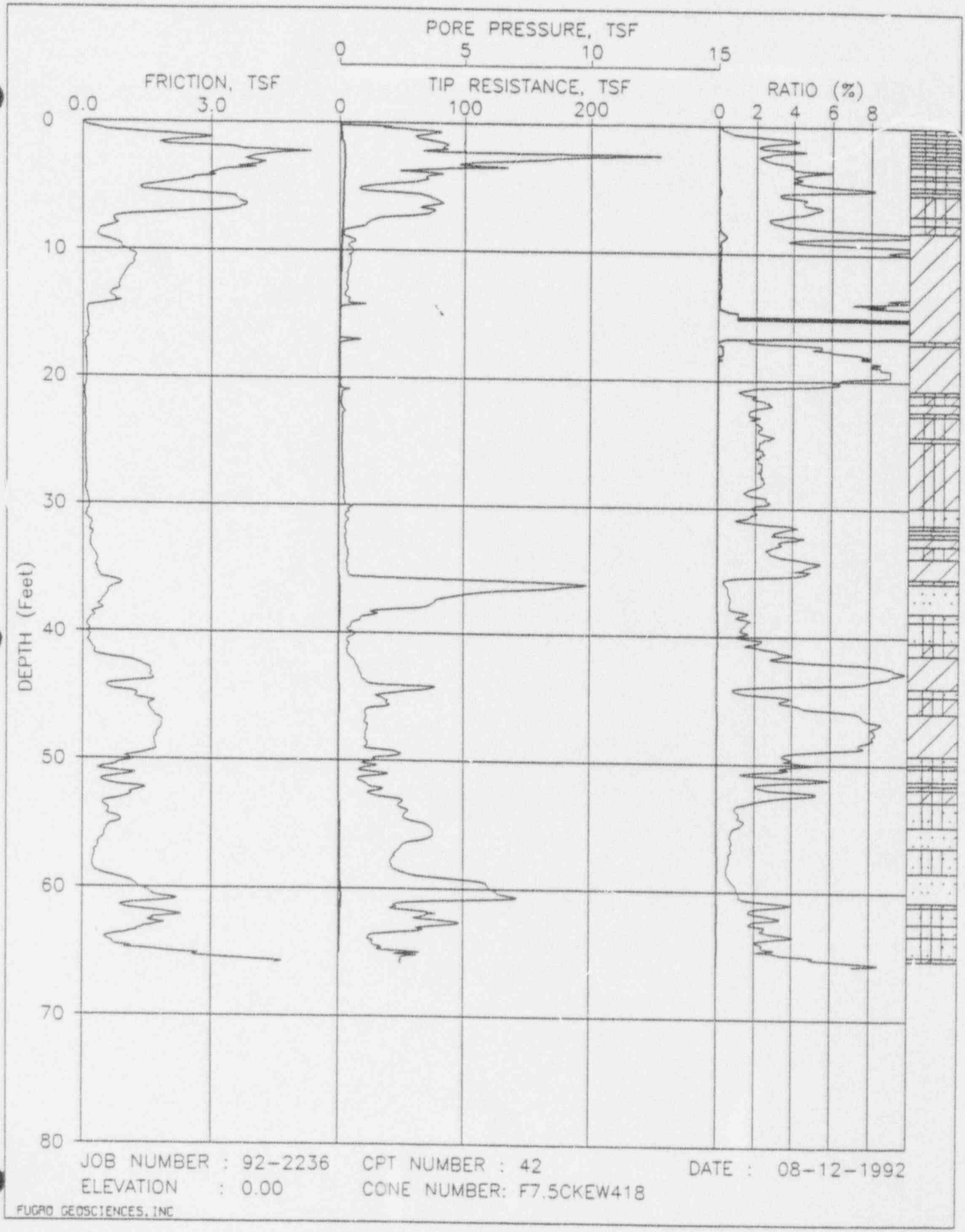
ELEVATION : 0.00 CONE NUMBER: F7.5CKEW418

FUGRO GEOSCIENCES, INC

JOB NUMBER : 92-2236 CPT NUMBER : 41 DATE : 08-12-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEW418

FUGRO GEOSCIENCES, INC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200
RATIO (%)
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DEPTH (Feet)
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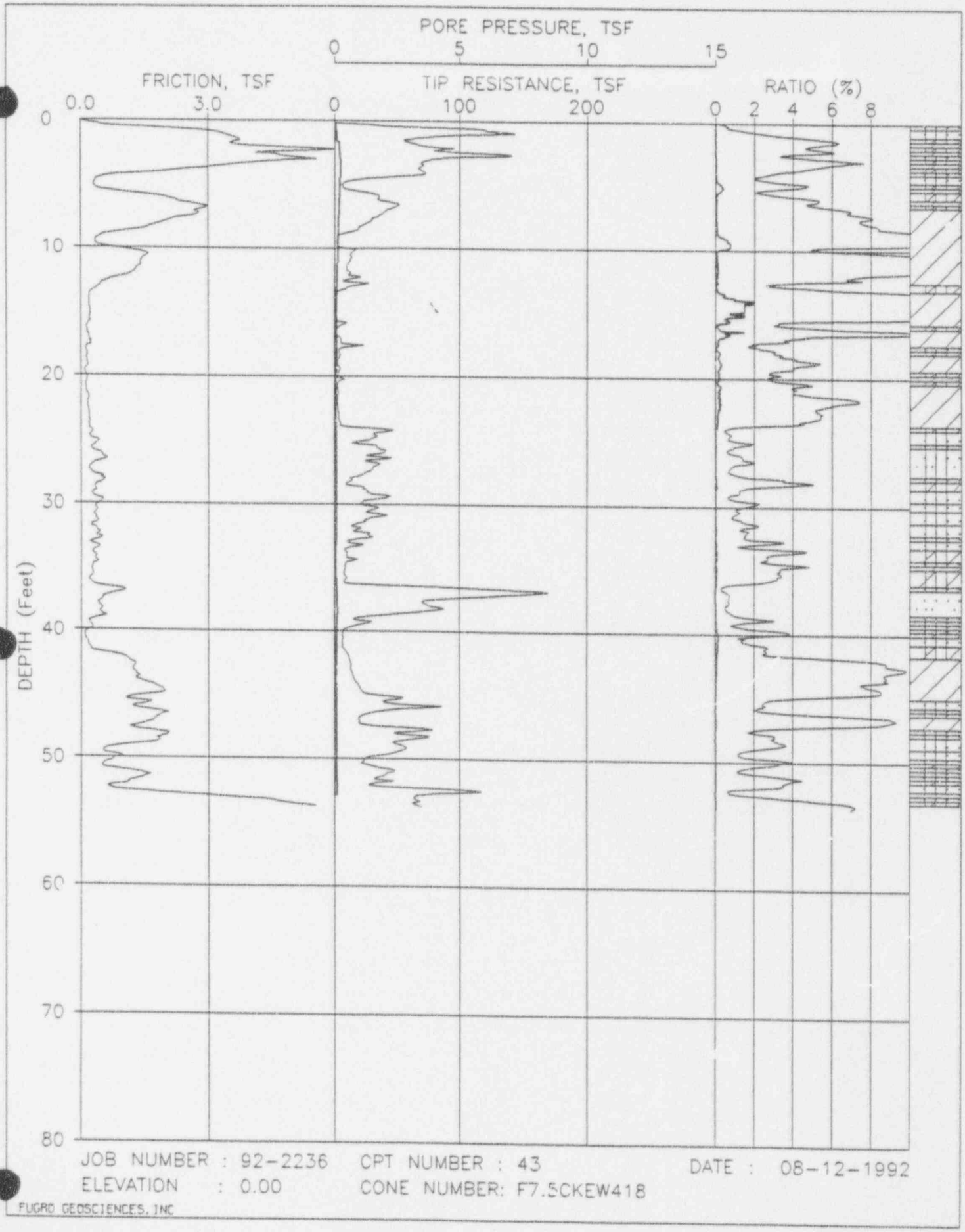
JOB NUMBER : 92-2236
CPT NUMBER : 42
DATE : 08-12-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC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TIP RESISTANCE, TSF
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200
RATIO (%)
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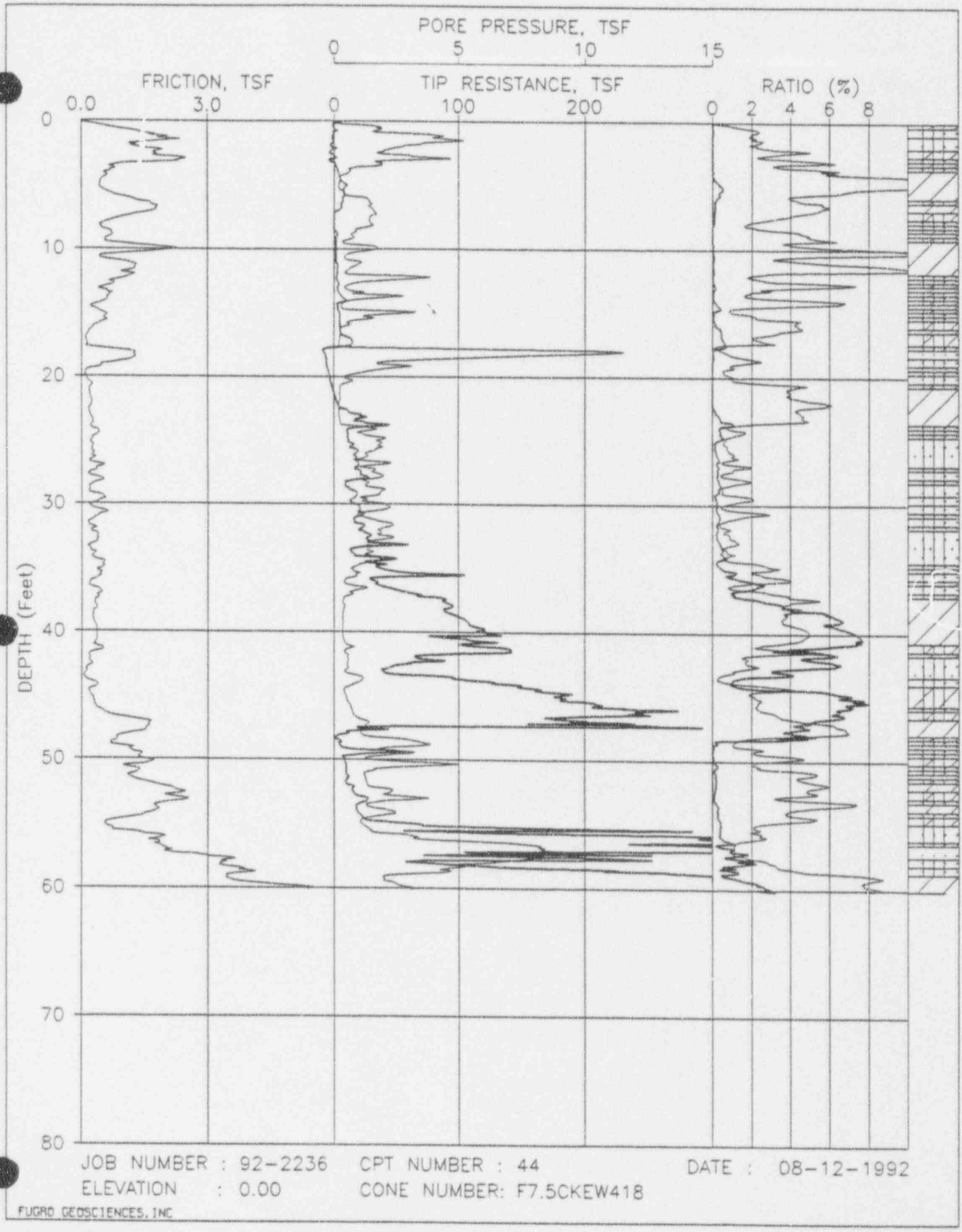
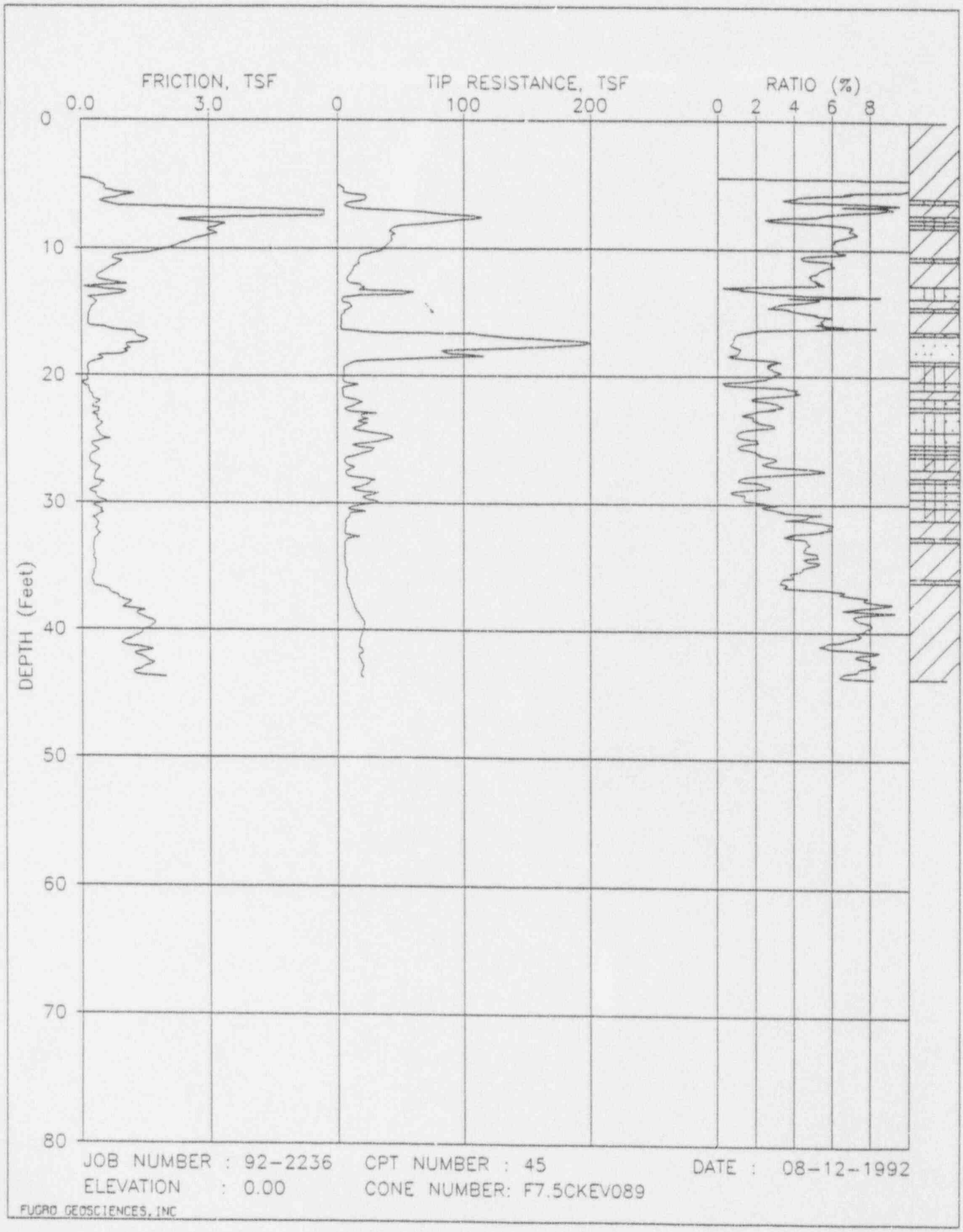
DEPTH (Feet)
JOB NUMBER : 92-2236
CPT NUMBER : 43
DATE : 08-12-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC

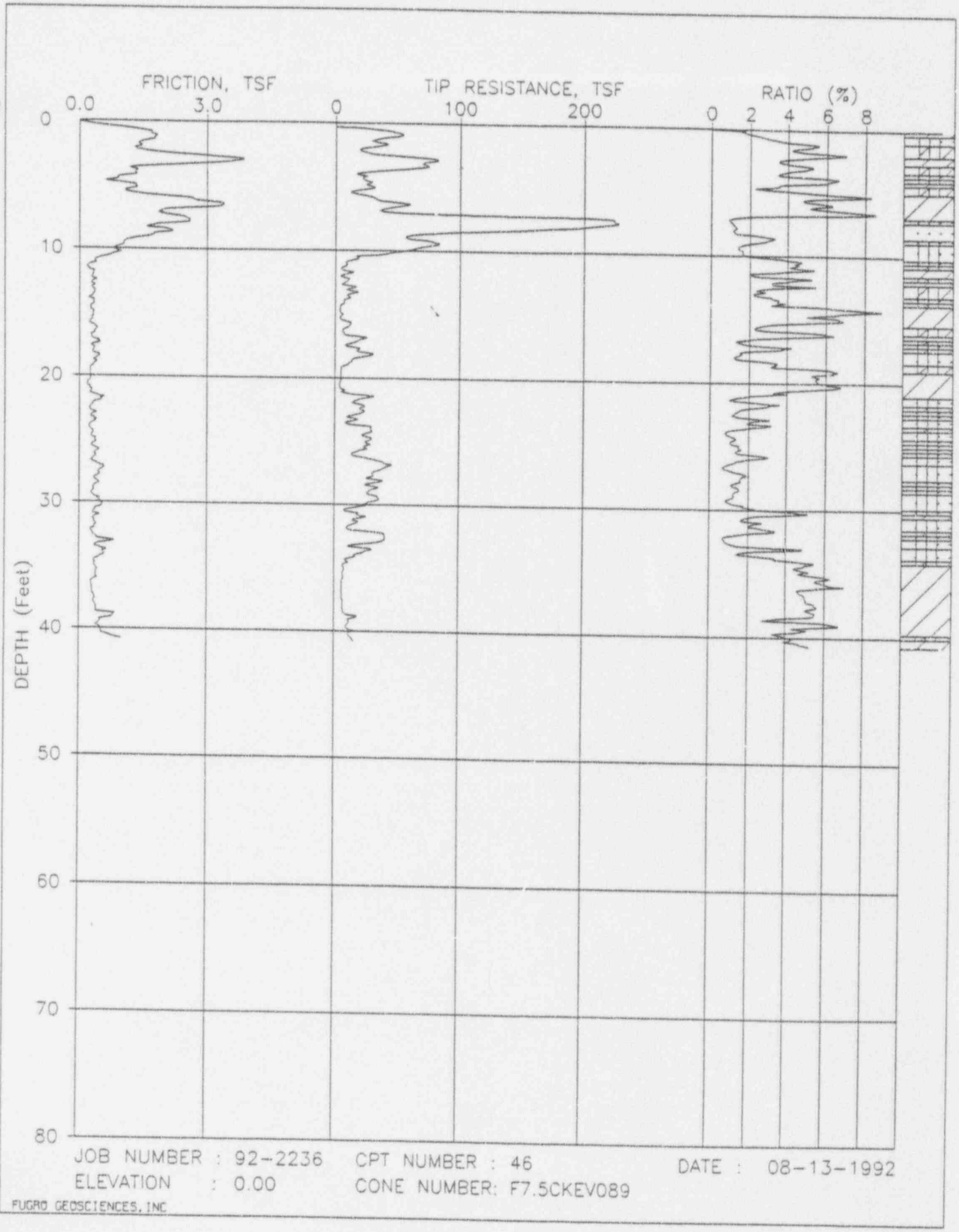

PORE PRESSURE, TSF
0
5
10
15
FRICTION, TSF
0.0
3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
0
10
20
30
40
50
60
70
80
JOB NUMBER : 92-2236
CPT NUMBER : 44
DATE : 08-12-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW418
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 45 DATE : 08-12-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV089

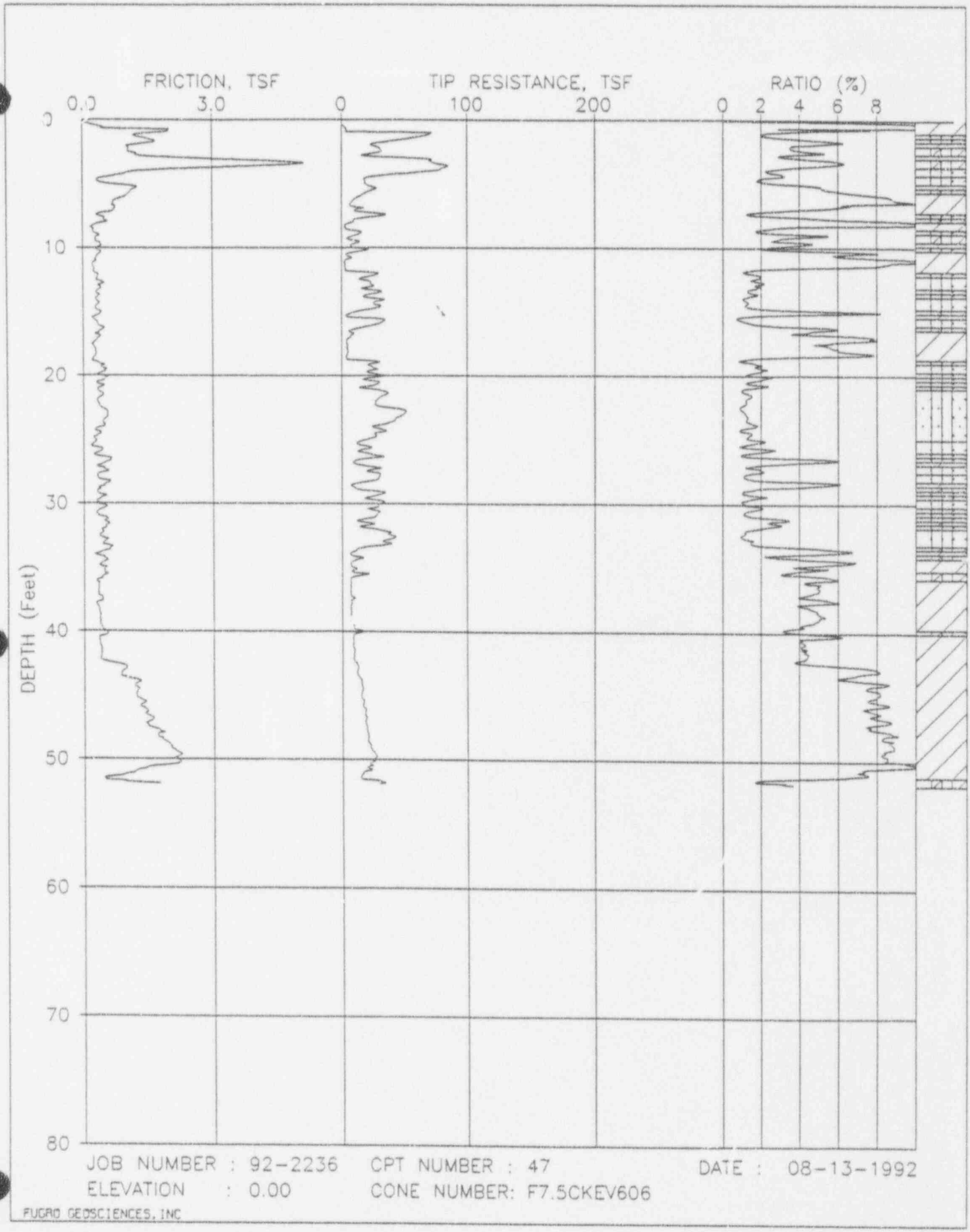
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 46 DATE : 08-13-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV089

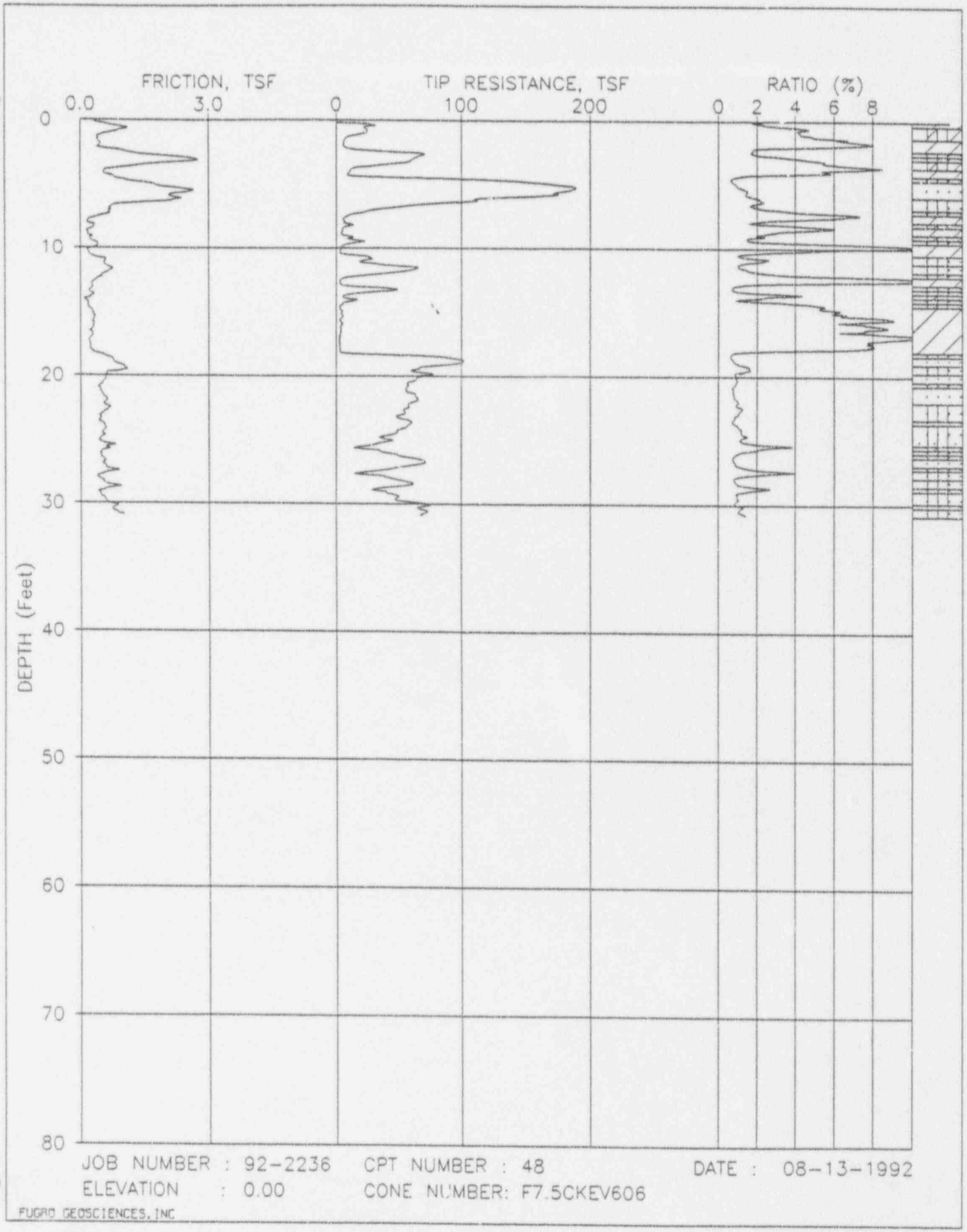
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 47 DATE : 08-13-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

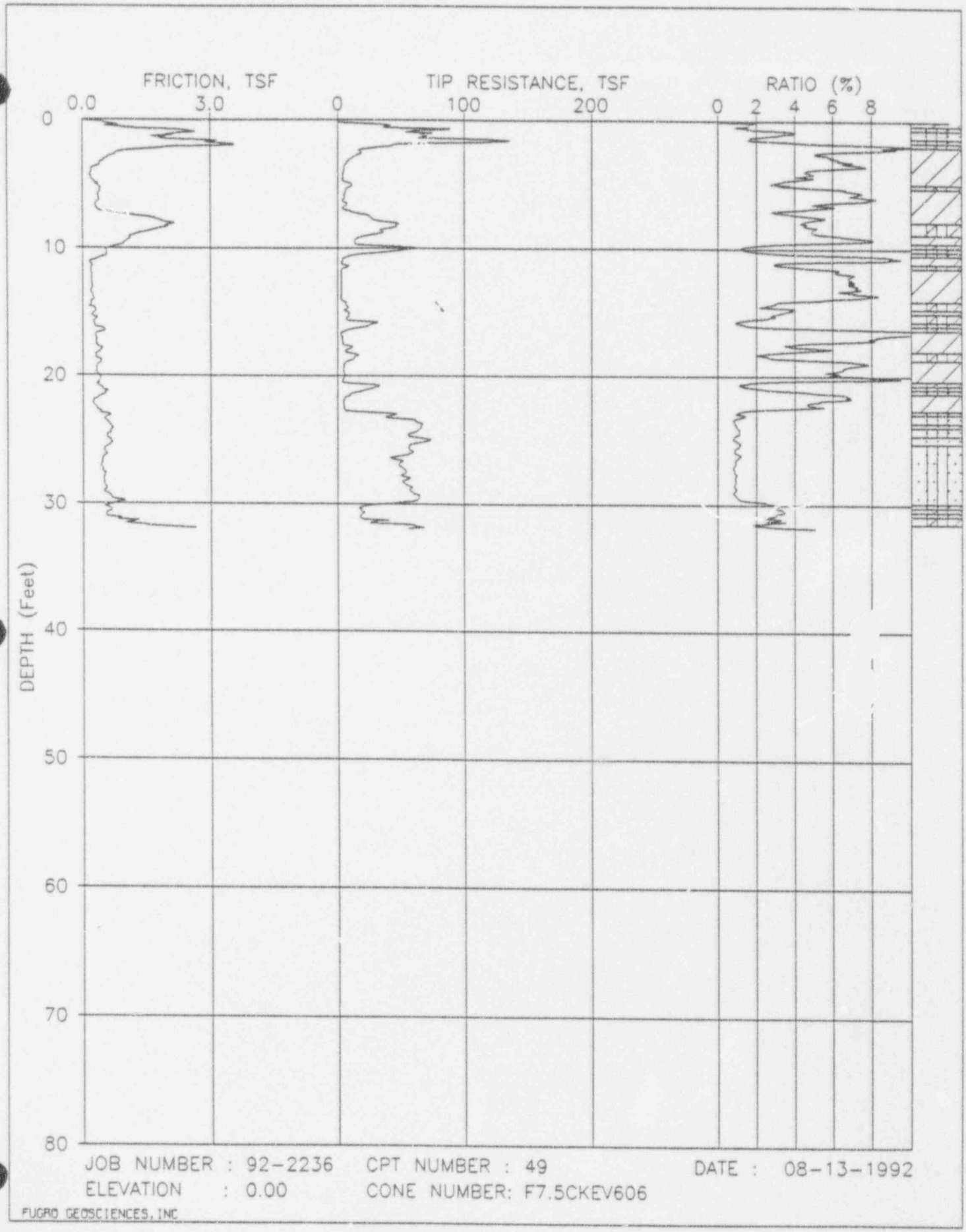
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 48 DATE : 08-13-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

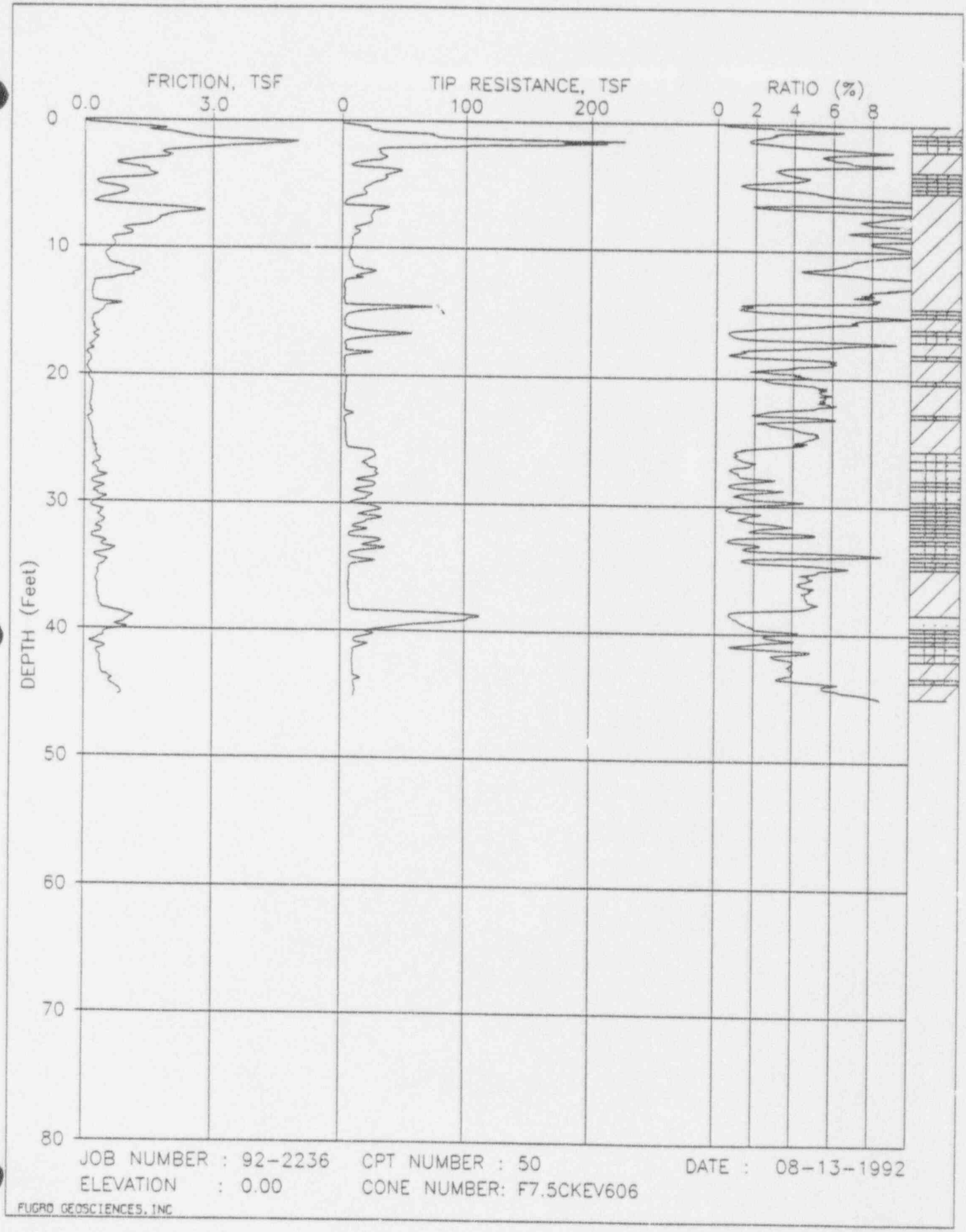
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 49 DATE : 08-13-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

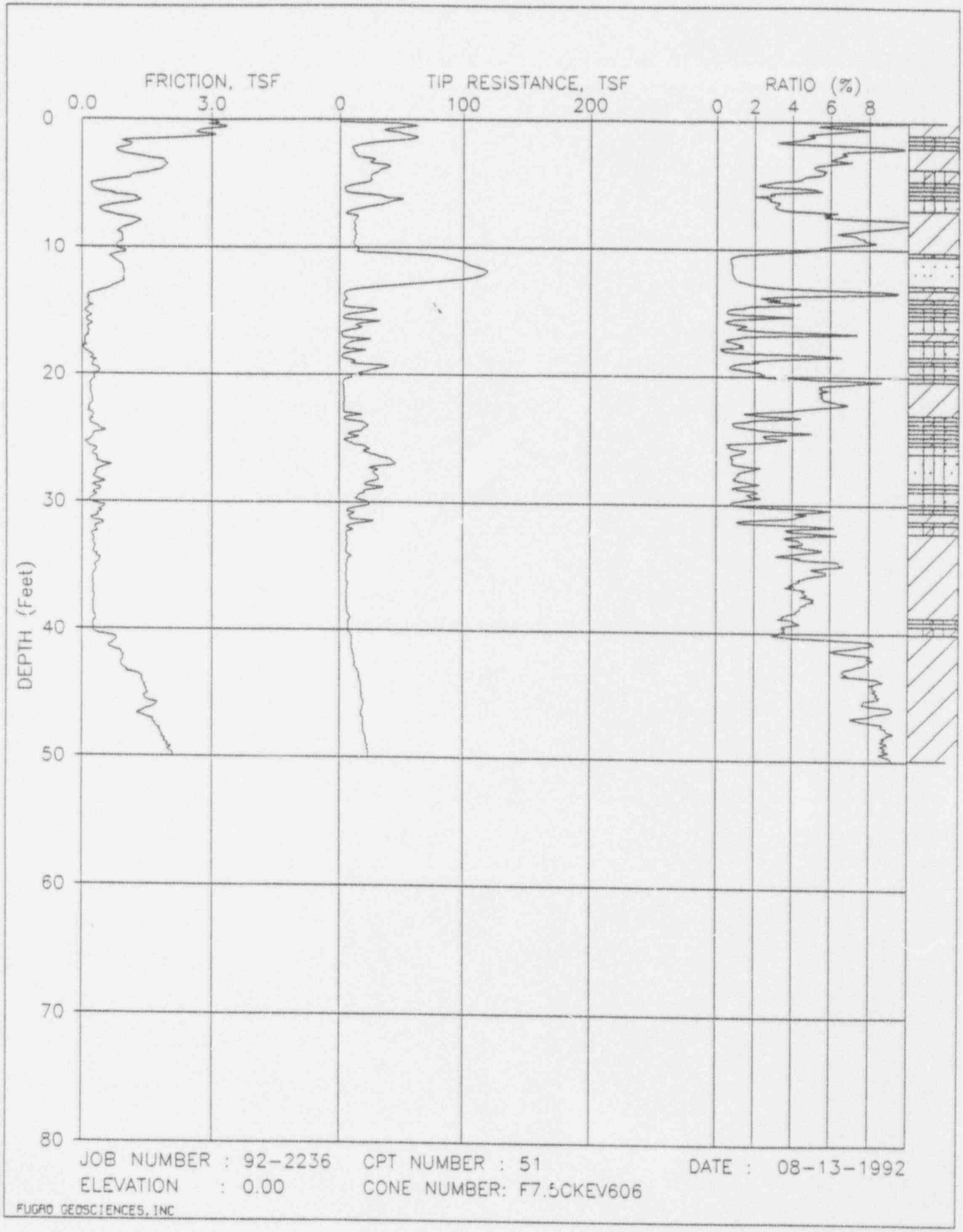
FUGRO GEOSCIENCES, INC

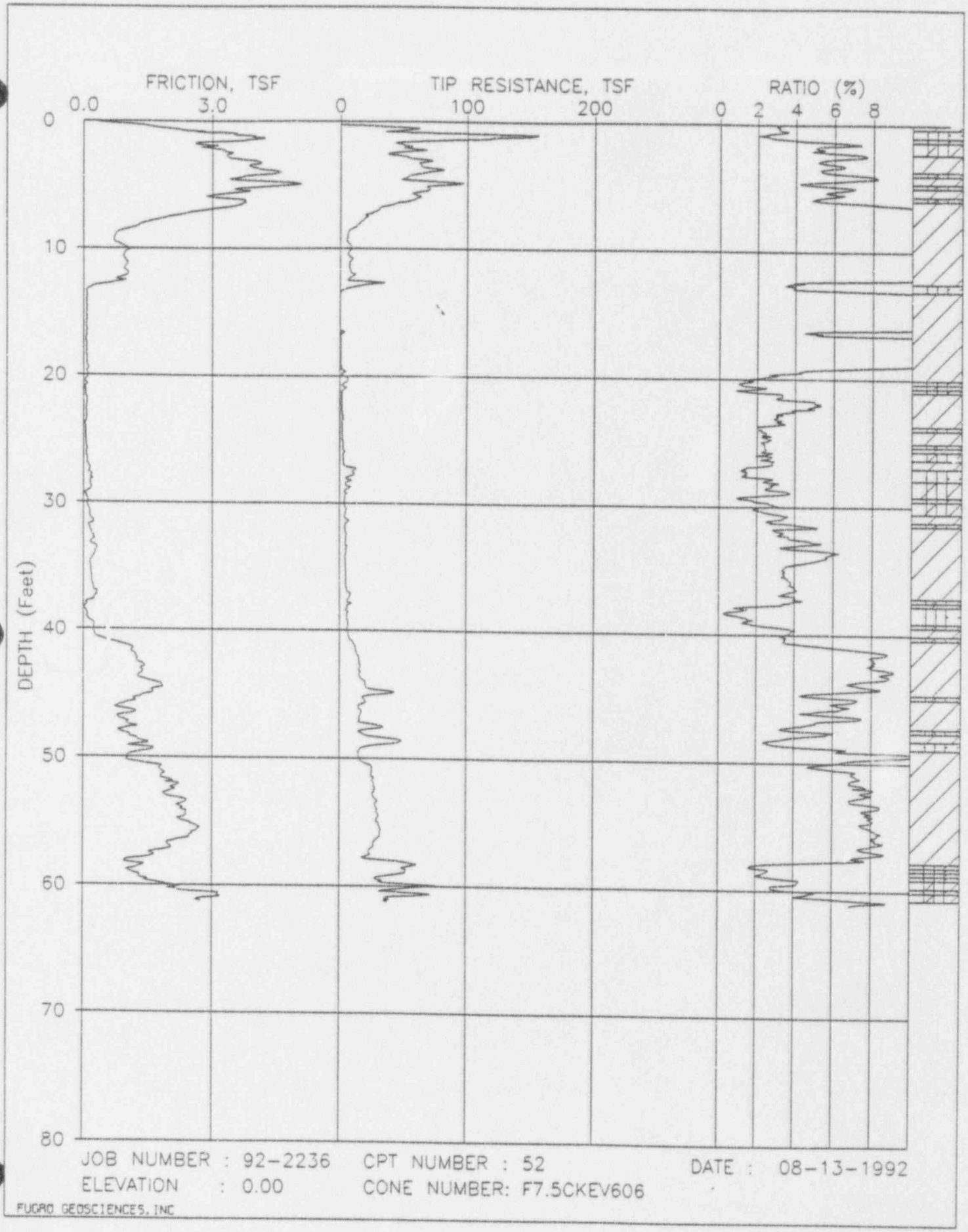


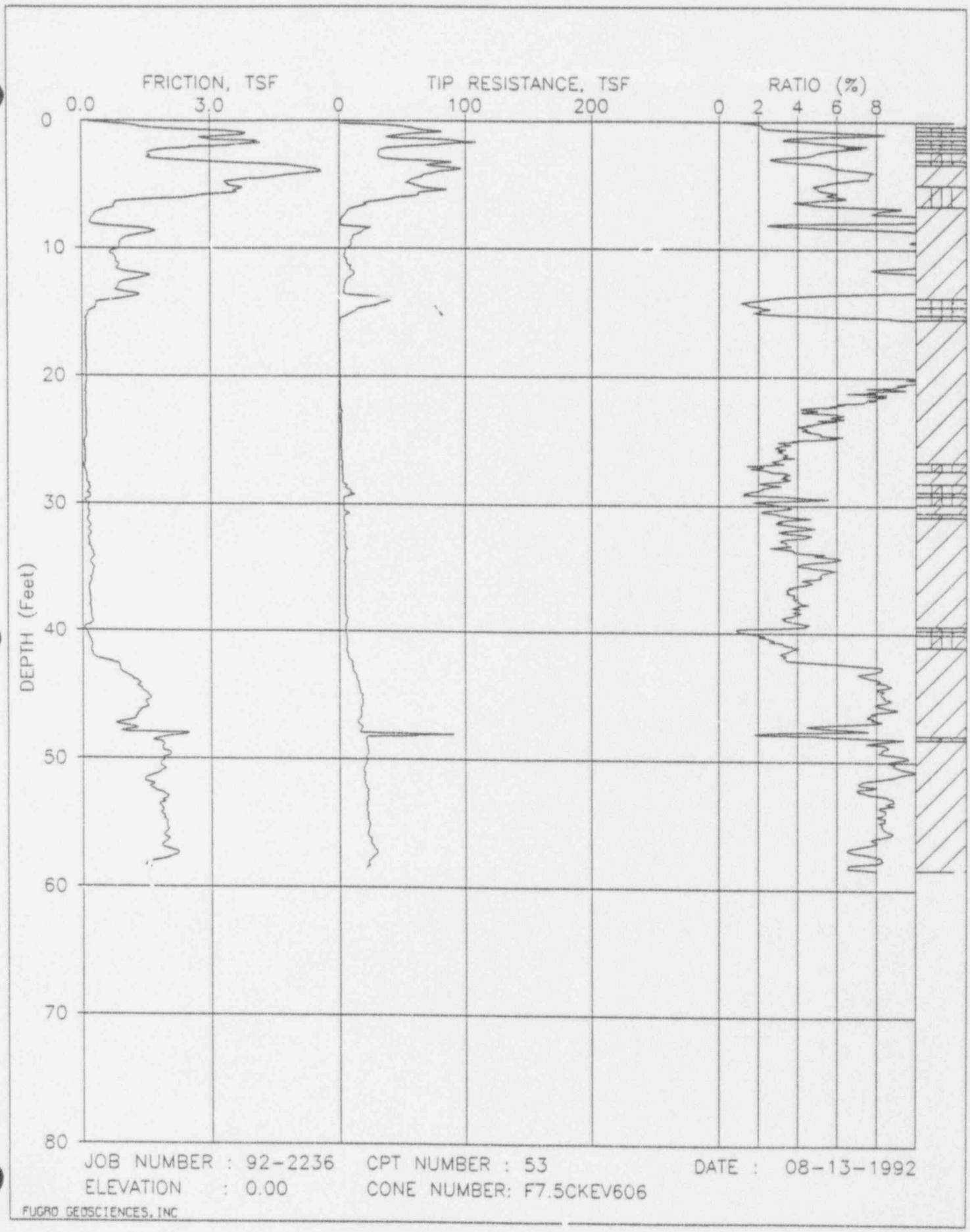
JOB NUMBER : 92-2236 CPT NUMBER : 50 DATE : 08-13-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

FUGRO GEOSCIENCES, INC


FRICTION, TSF
0.0
3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
0
10
20
30
40
50
60
70
80
JOB NUMBER : 92-2236
CPT NUMBER : 51
DATE : 08-13-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEV606
FUGRO GEOSCIENCES, INC

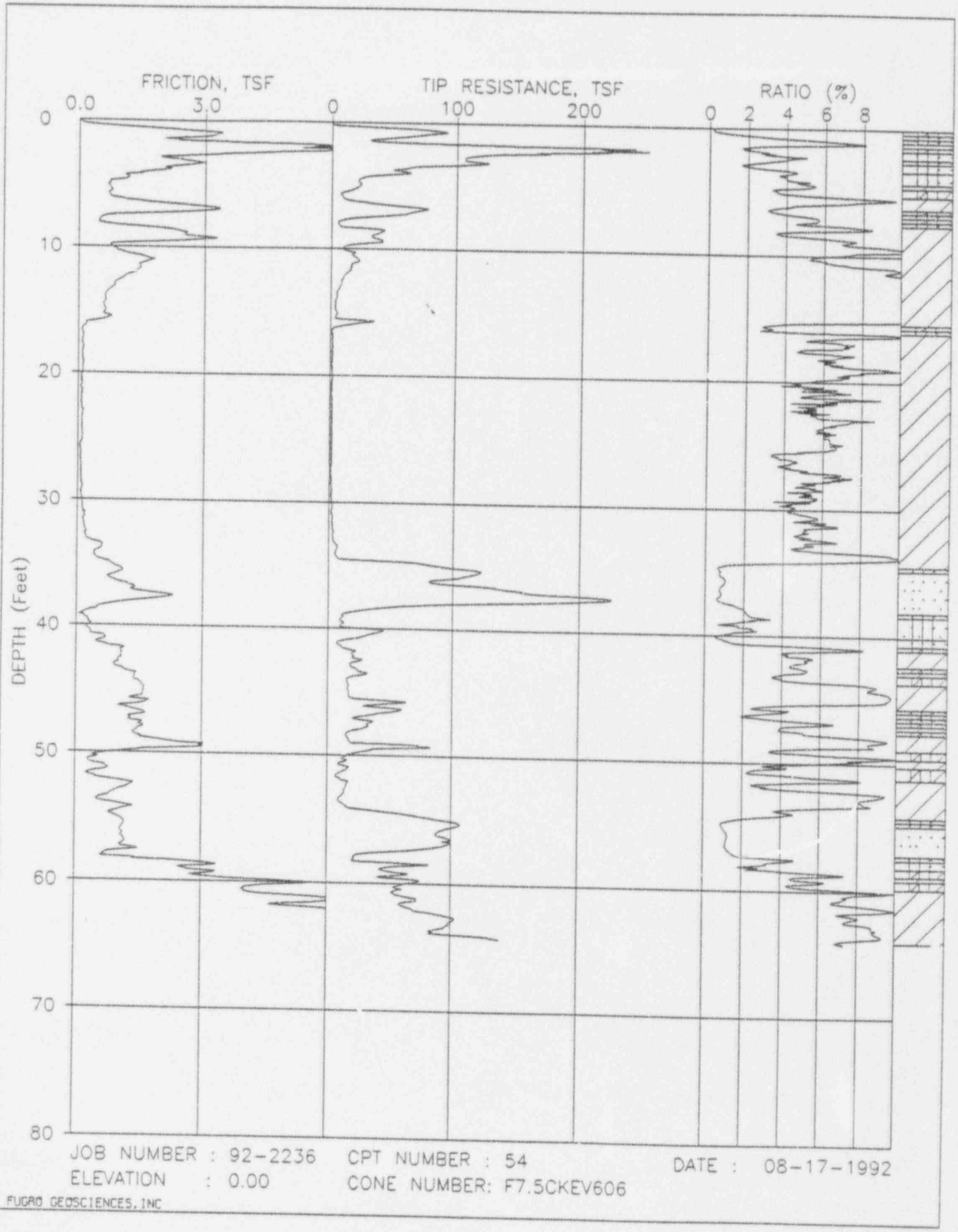

FRICTION, TSF
0.0
3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
0
10
20
30
40
50
60
70
80
JOB NUMBER : 92-2236
CPT NUMBER : 52
DATE : 08-13-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEV606
FUGRO GEOSCIENCES, INC

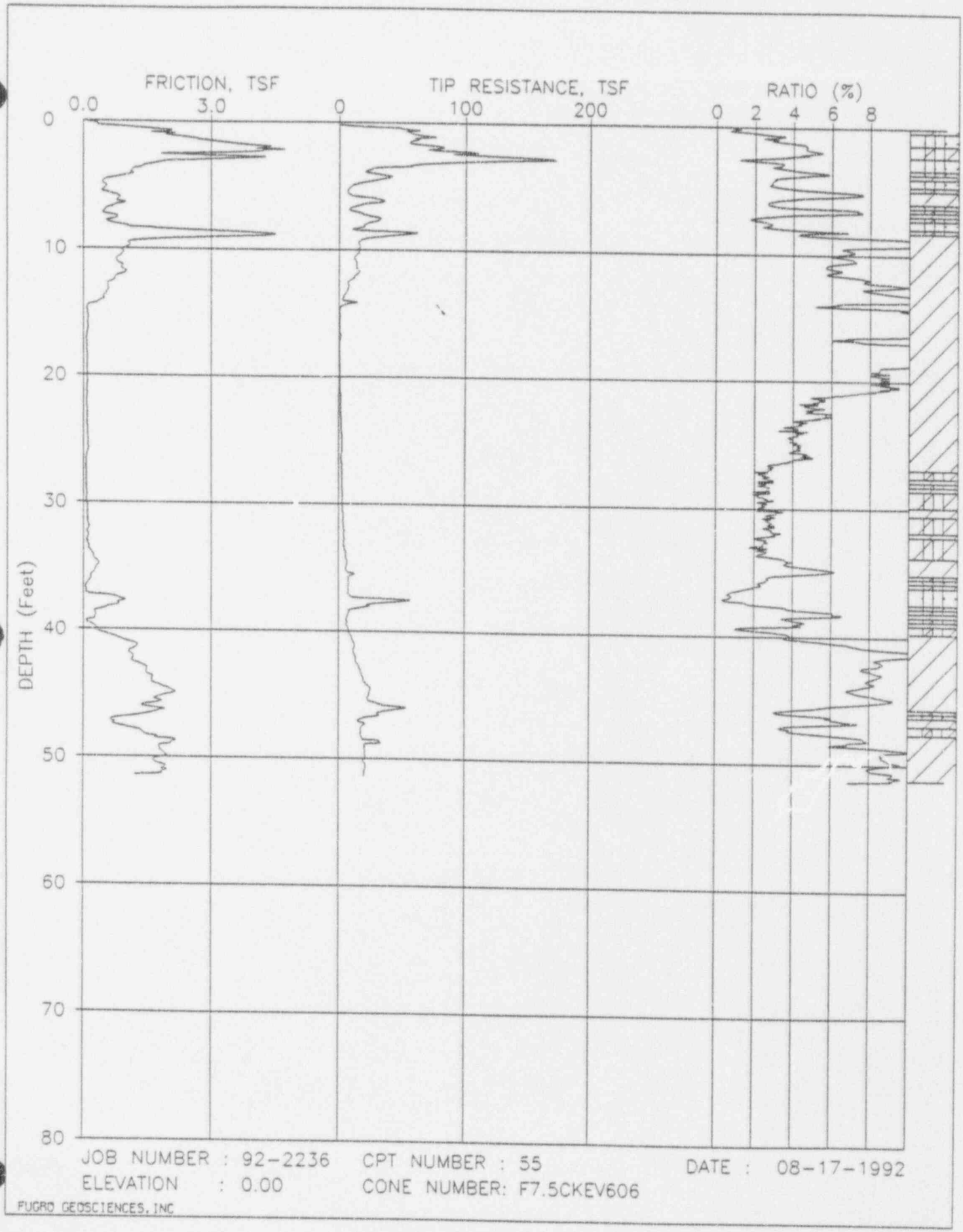


JOB NUMBER : 92-2236 CPT NUMBER : 53 DATE : 08-13-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

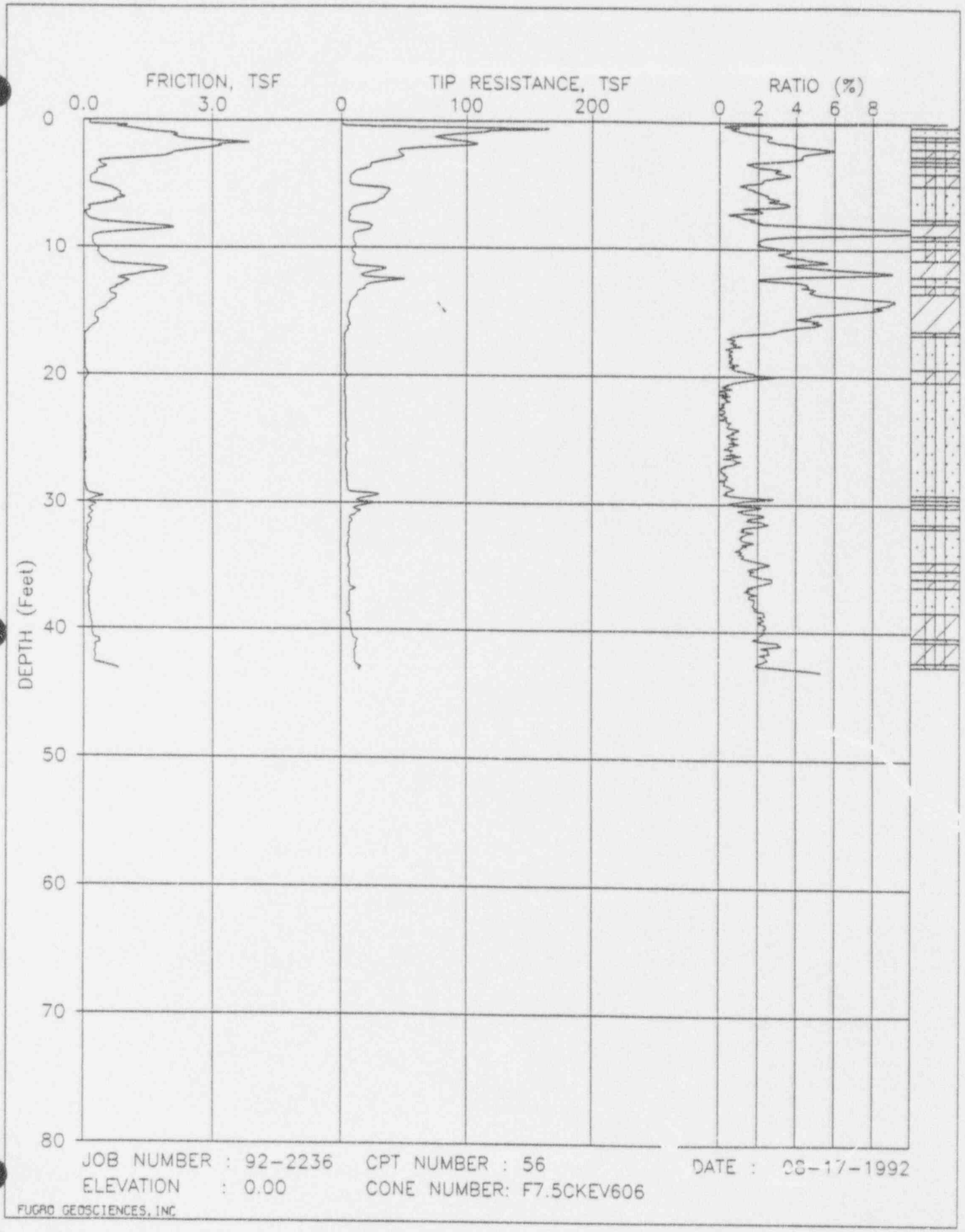
FUGRO GEOSCIENCES, INC


FRICTION, TSF
0.0
3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
0
10
20
30
40
50
60
70
80
JOB NUMBER : 92-2236
CPT NUMBER : 54
DATE : 08-17-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEV606
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 55 DATE : 08-17-1992
ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

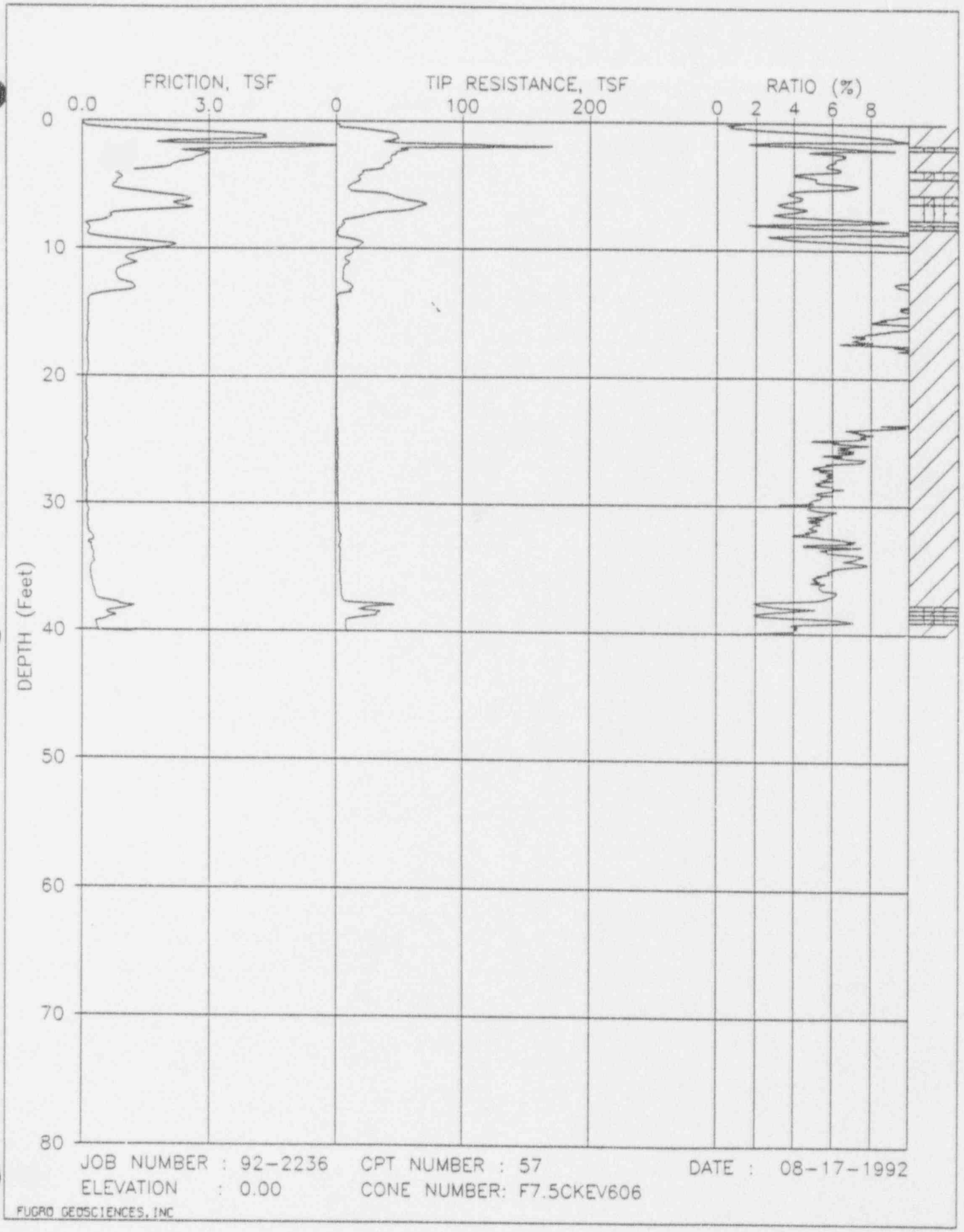
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 56 DATE : 08-17-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

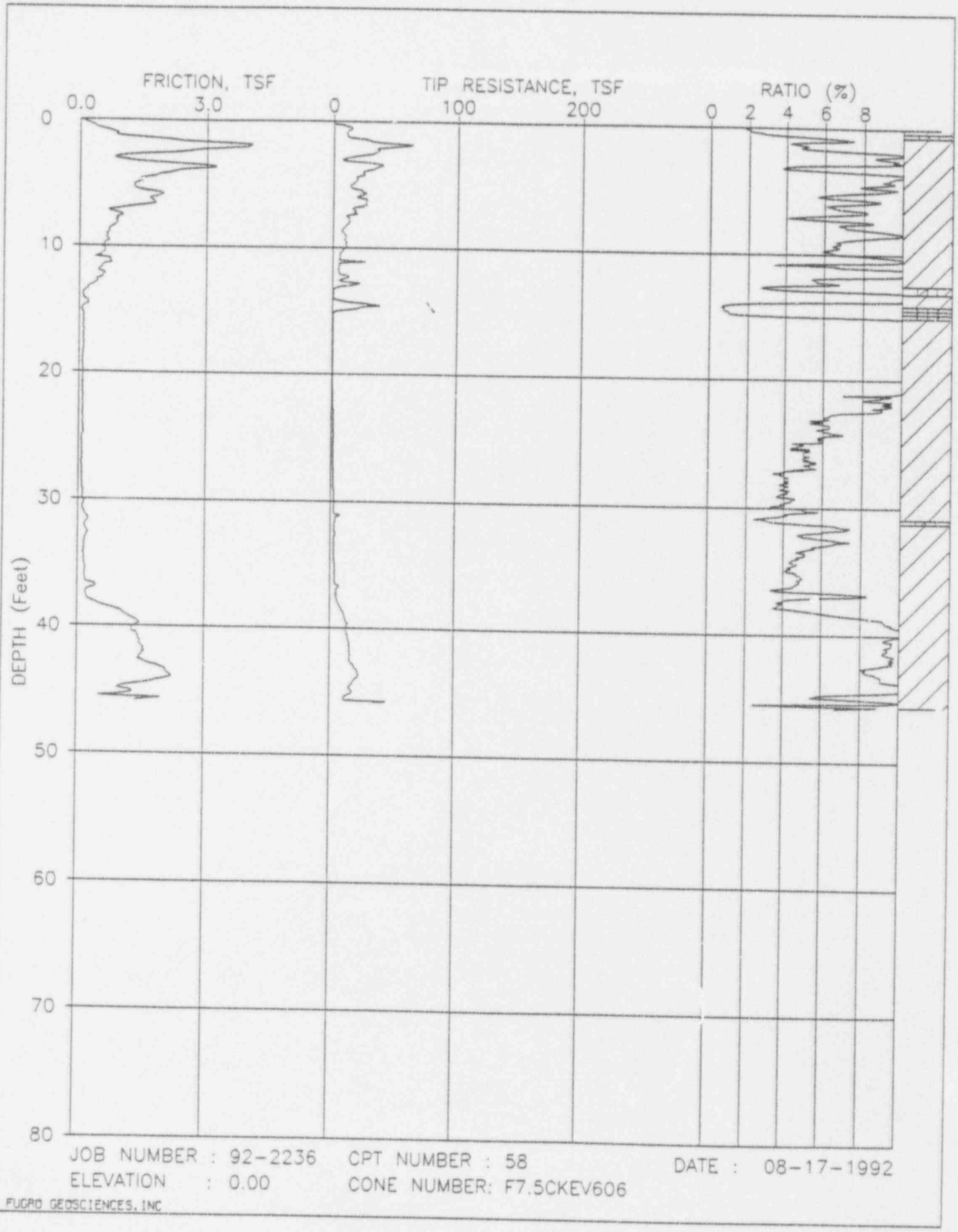
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 57 DATE : 08-17-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 58 DATE : 08-17-1992

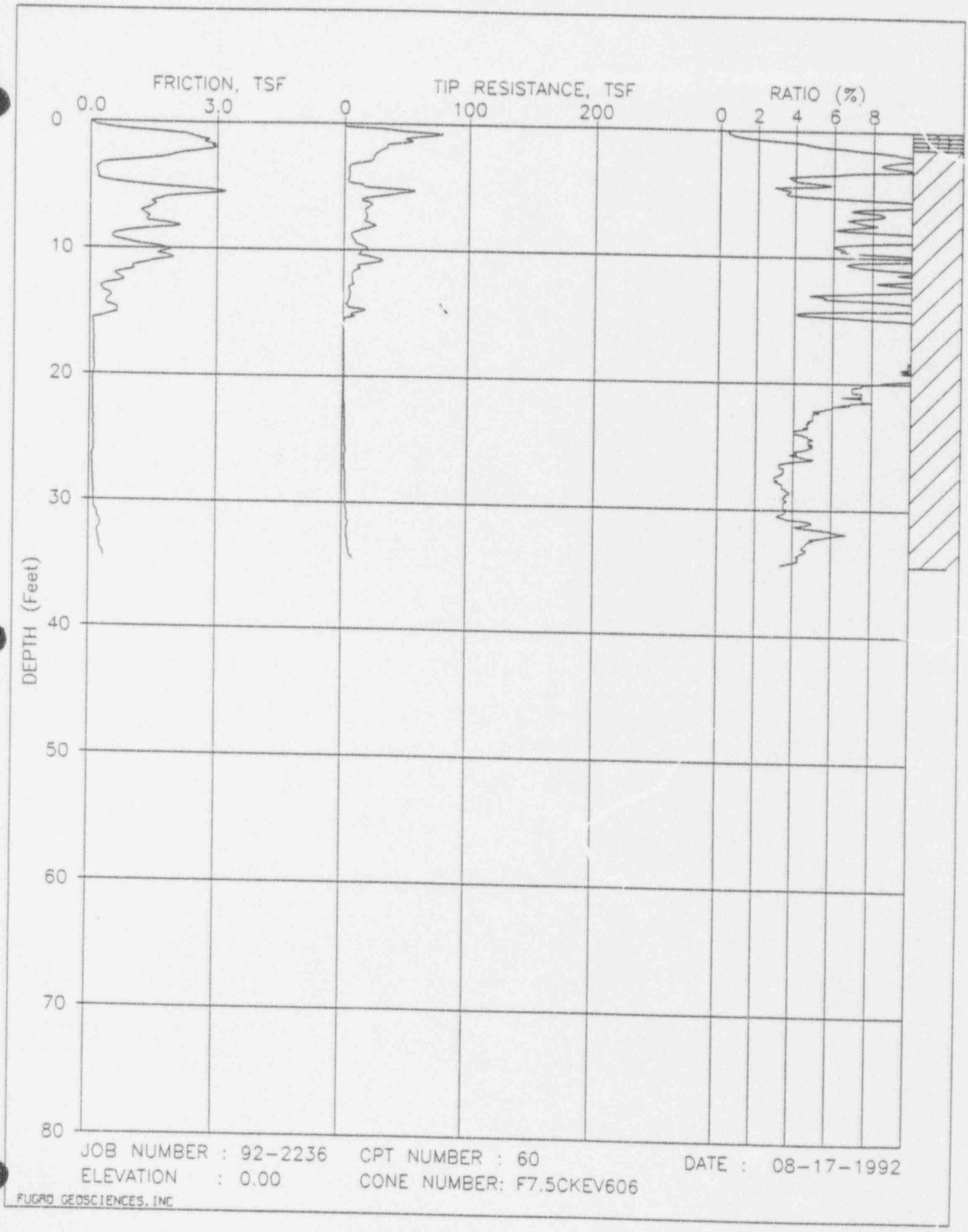
ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

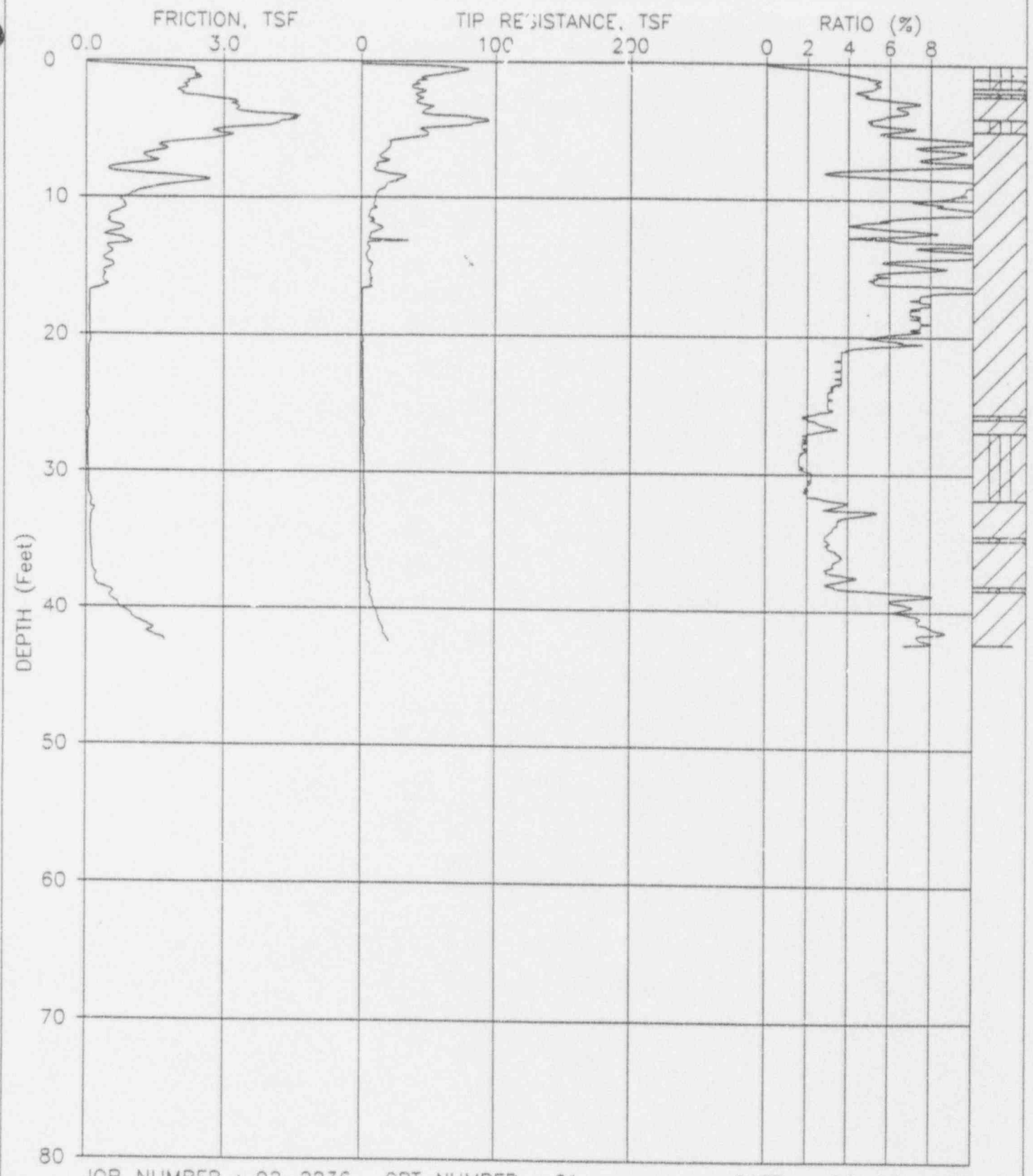
FUGRO GEOSCIENCES, INC

JOB NUMBER : 92-2236 CPT NUMBER : 59 DATE : 08-17-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

FUGRO GEOSCIENCES, INC

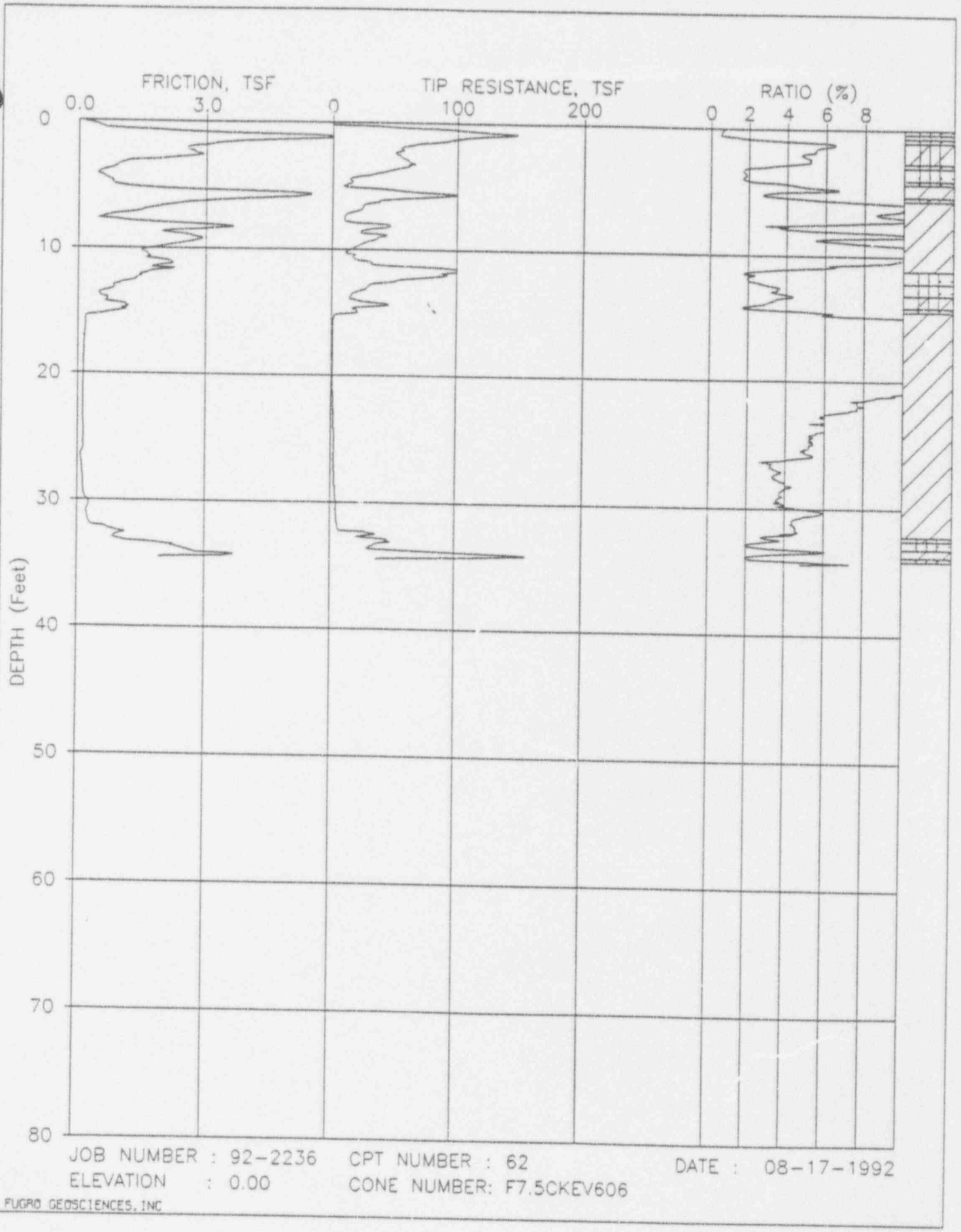

FRICTION, TSF
0.0
3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
0
10
20
30
40
50
60
70
80
DEPTH (Feet)
JOB NUMBER : 92-2236
CPT NUMBER : 60
DATE : 08-17-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEV606
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 61 DATE : 08-17-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

FUGRO GEOSCIENCES, INC

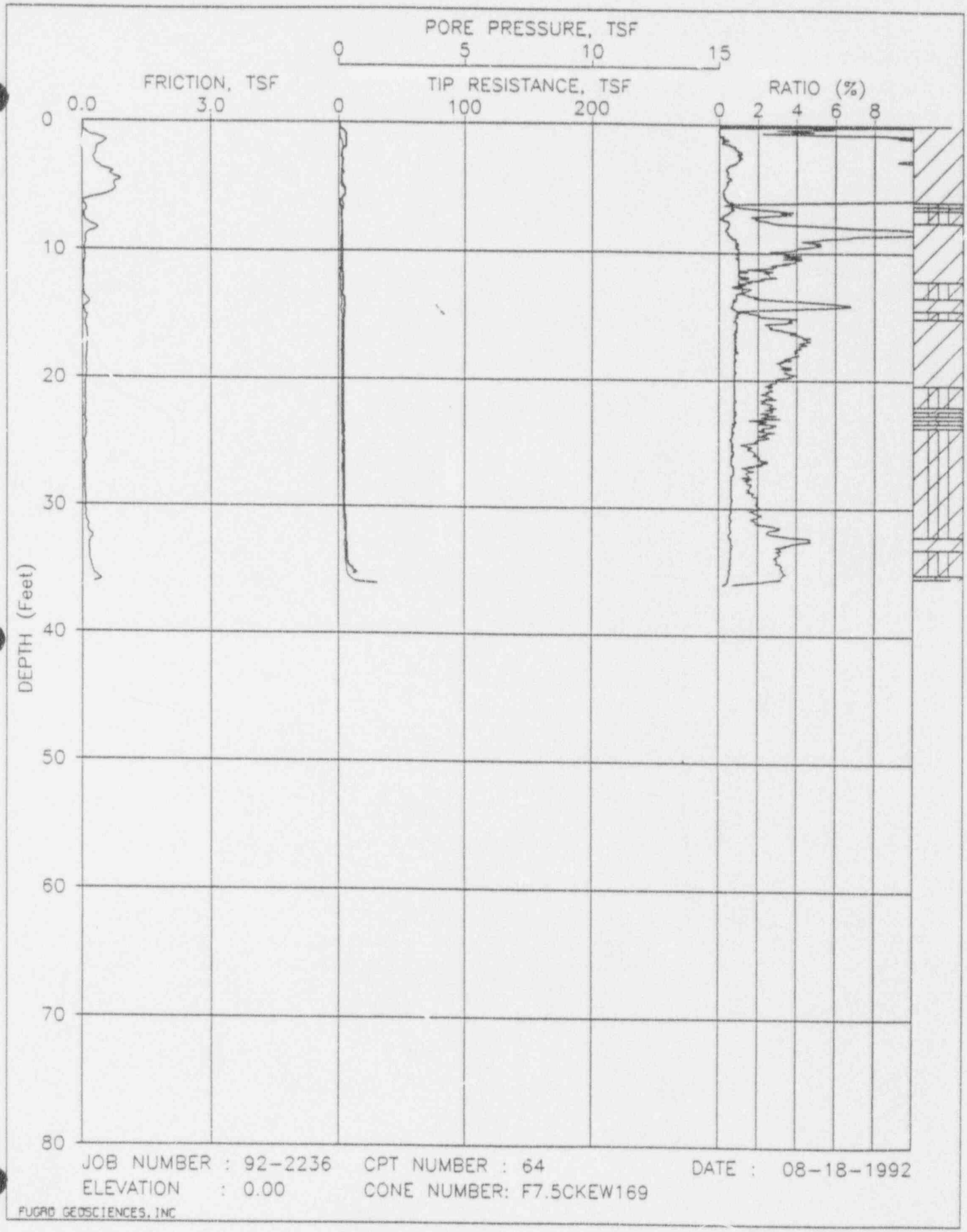


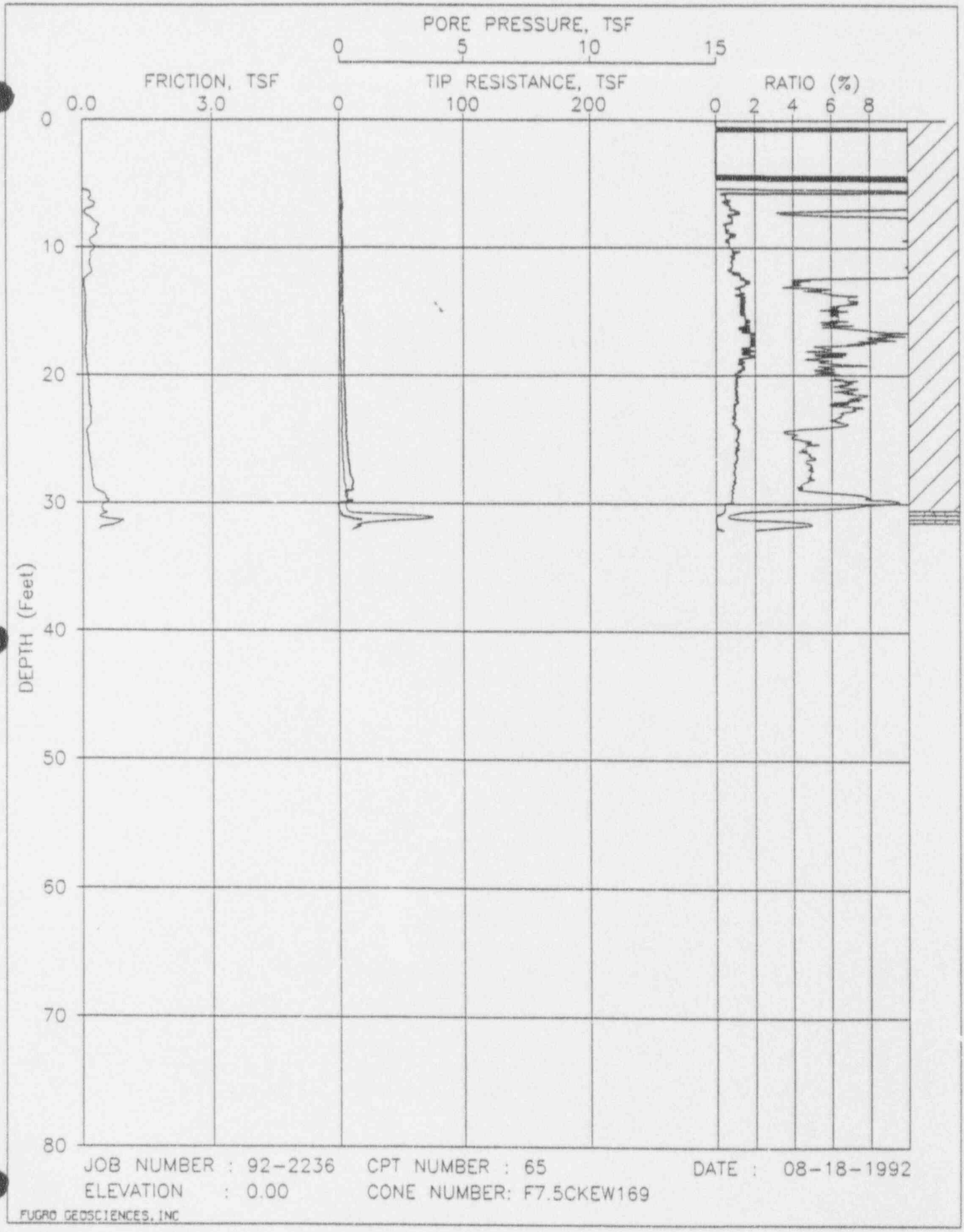
JOB NUMBER : 92-2236 CPT NUMBER : 62 DATE : 08-17-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

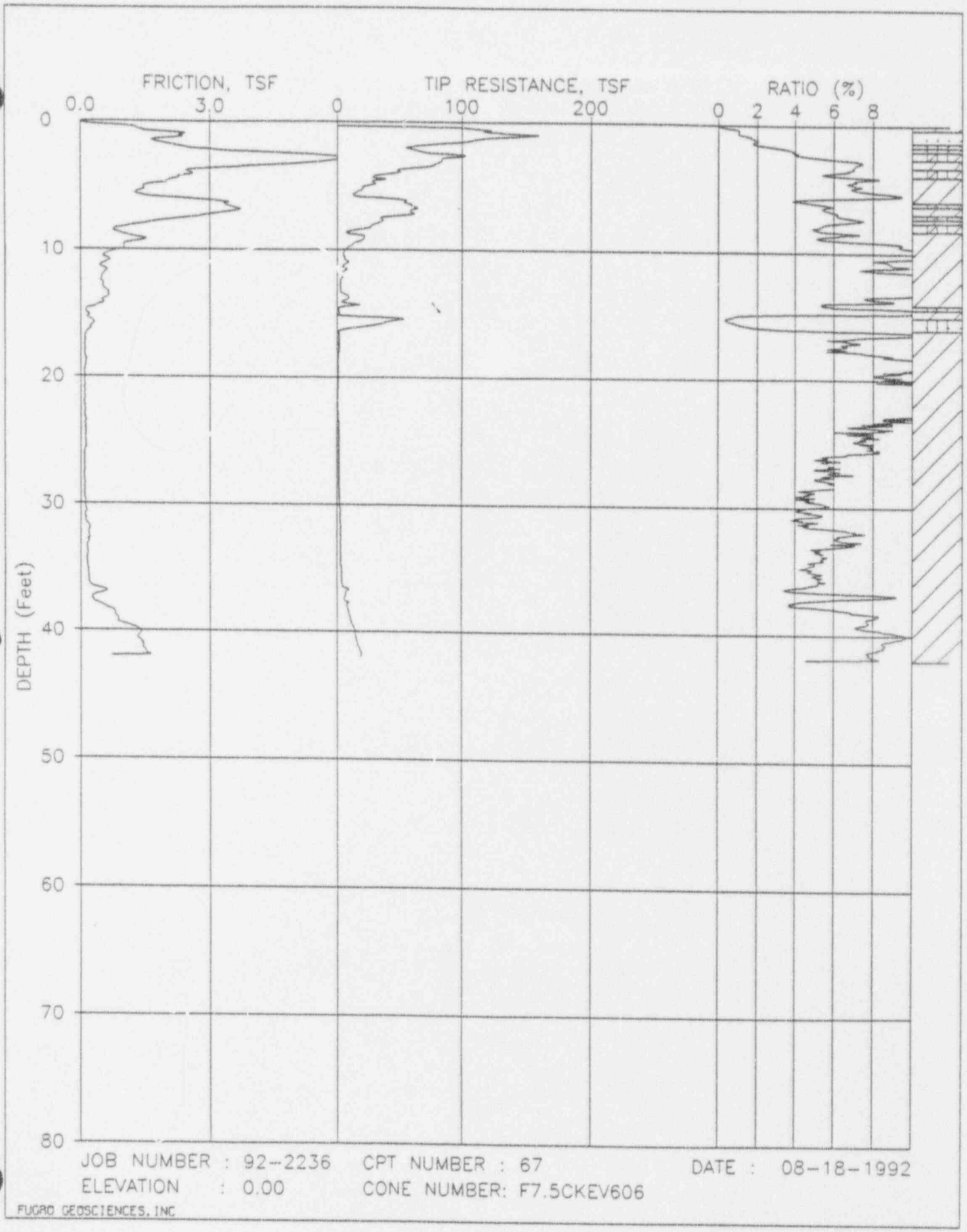
FUGRO GEOSCIENCES, INC


FRICTION, TSF
0.0
3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
0
10
20
30
40
50
60
70
80
DEPTH (Feet)
JOB NUMBER : 92-2236
CPT NUMBER : 63
DATE : 08-18-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEV606
FUGRO GEOSCIENCES, INC


PORE PRESSURE, TSF
0
5
10
15
FRICTION, TSF
0.0
3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
0
10
20
30
40
50
60
70
80
JOB NUMBER : 92-2236
CPT NUMBER : 64
DATE : 08-18-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW169
FUGRO GEOSCIENCES, INC


PORE PRESSURE, TSF
0
5
10
15
FRICTION, TSF
0.0
3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
0
10
20
30
40
50
60
70
80
DEPTH (Feet)
JOB NUMBER : 92-2236
CPT NUMBER : 65
DATE : 08-18-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW169
FUGRO GEOSCIENCES, INC

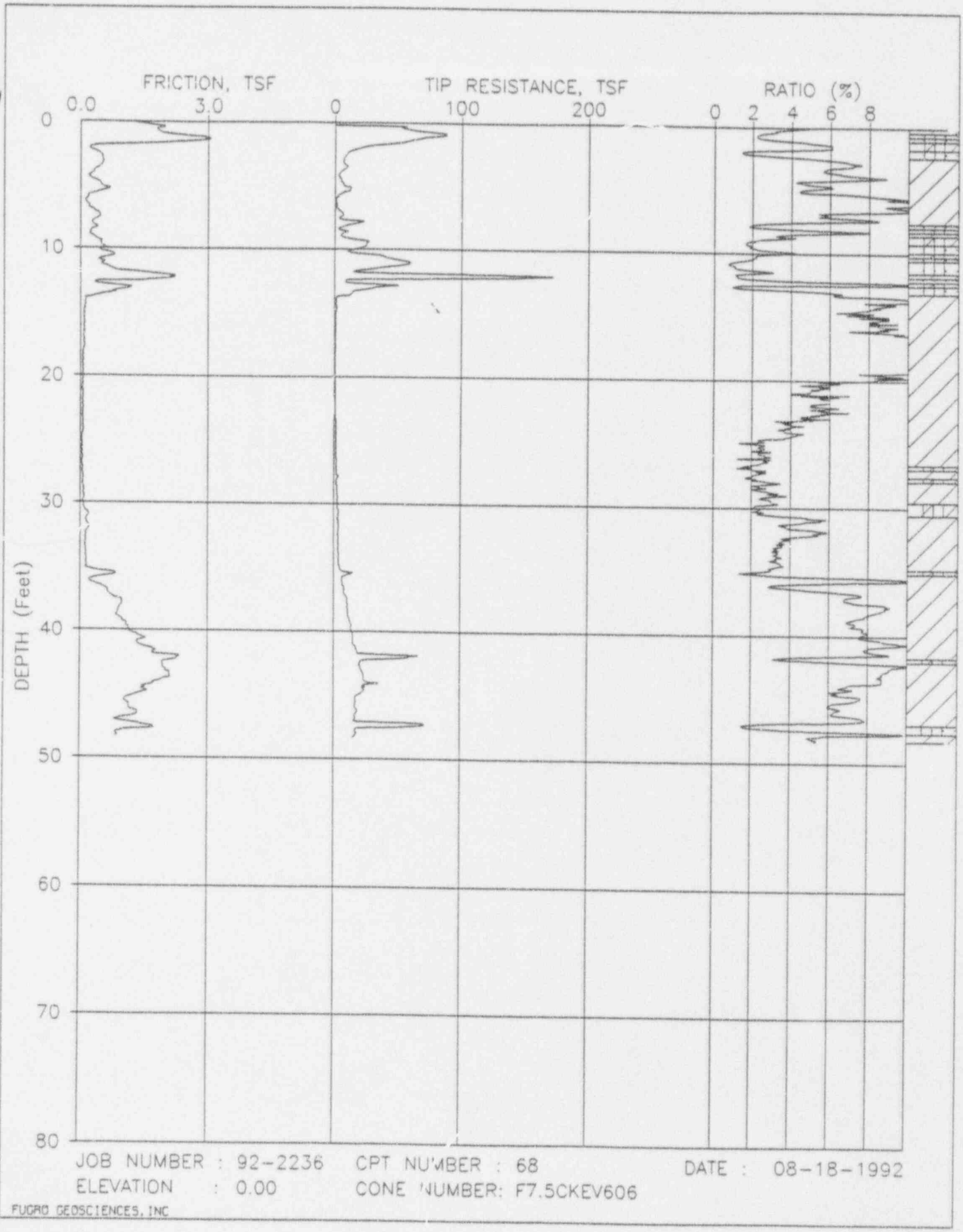

PORE PRESSURE, TSF
0
5
10
15
FRICTION, TSF
0.0
3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
0
10
20
30
40
50
60
70
80
JOB NUMBER : 92-2236
CPT NUMBER : 66
DATE : 08-18-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW169
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 67 DATE : 08-18-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

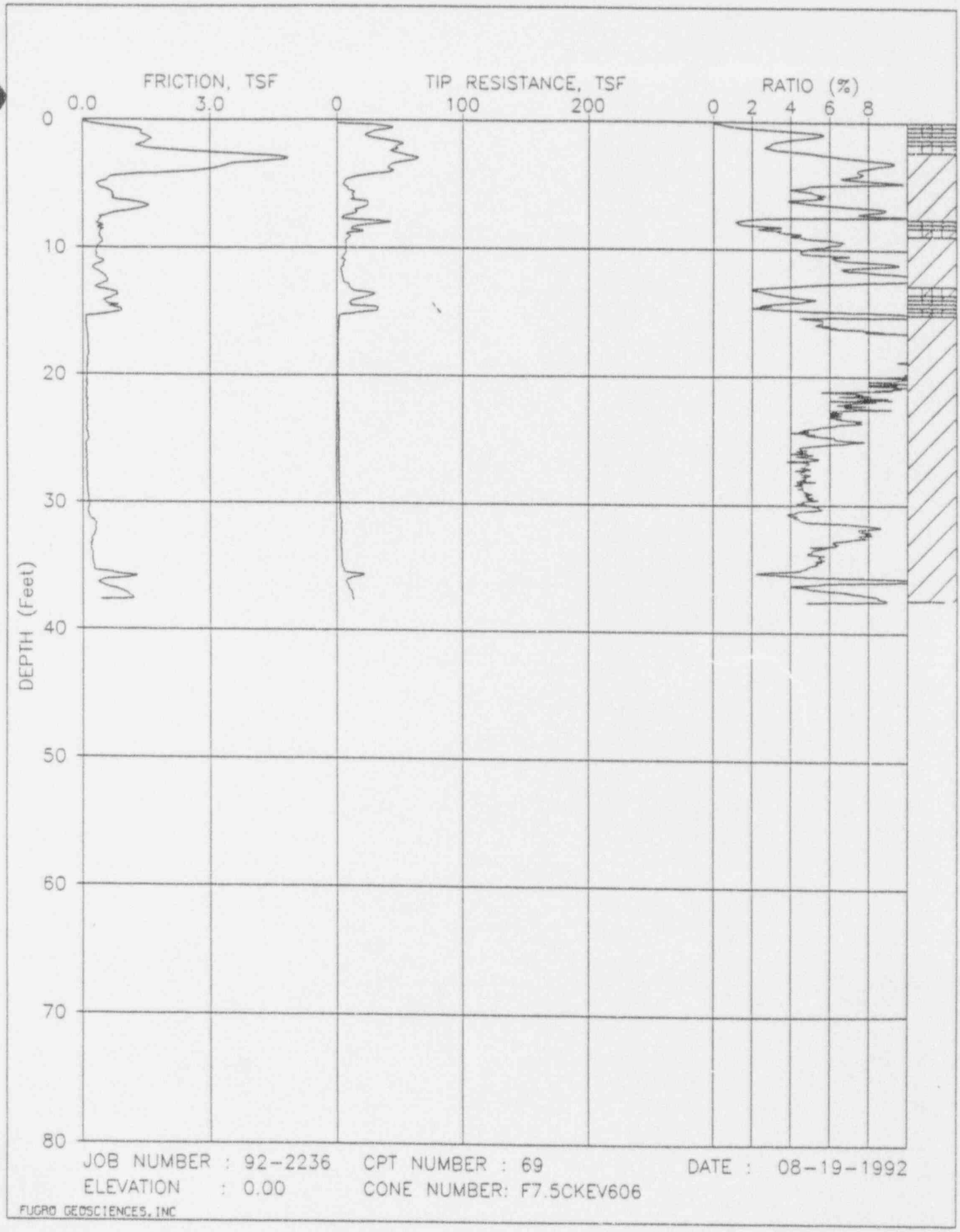
FUGRO GEOSCIENCES, INC

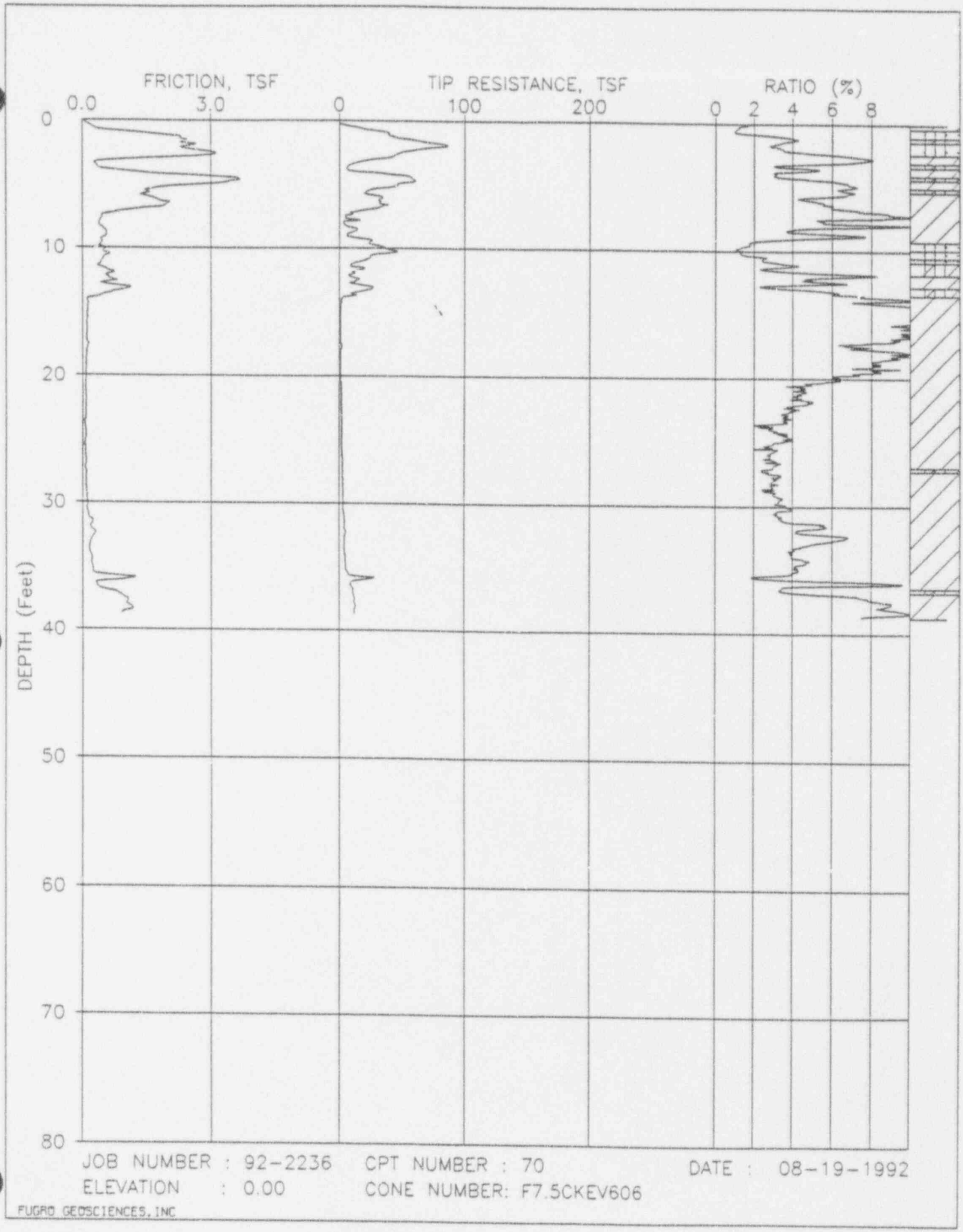


JOB NUMBER : 92-2236 CPT NUMBER : 68 DATE : 08-18-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

FUGRO GEOSCIENCES, INC

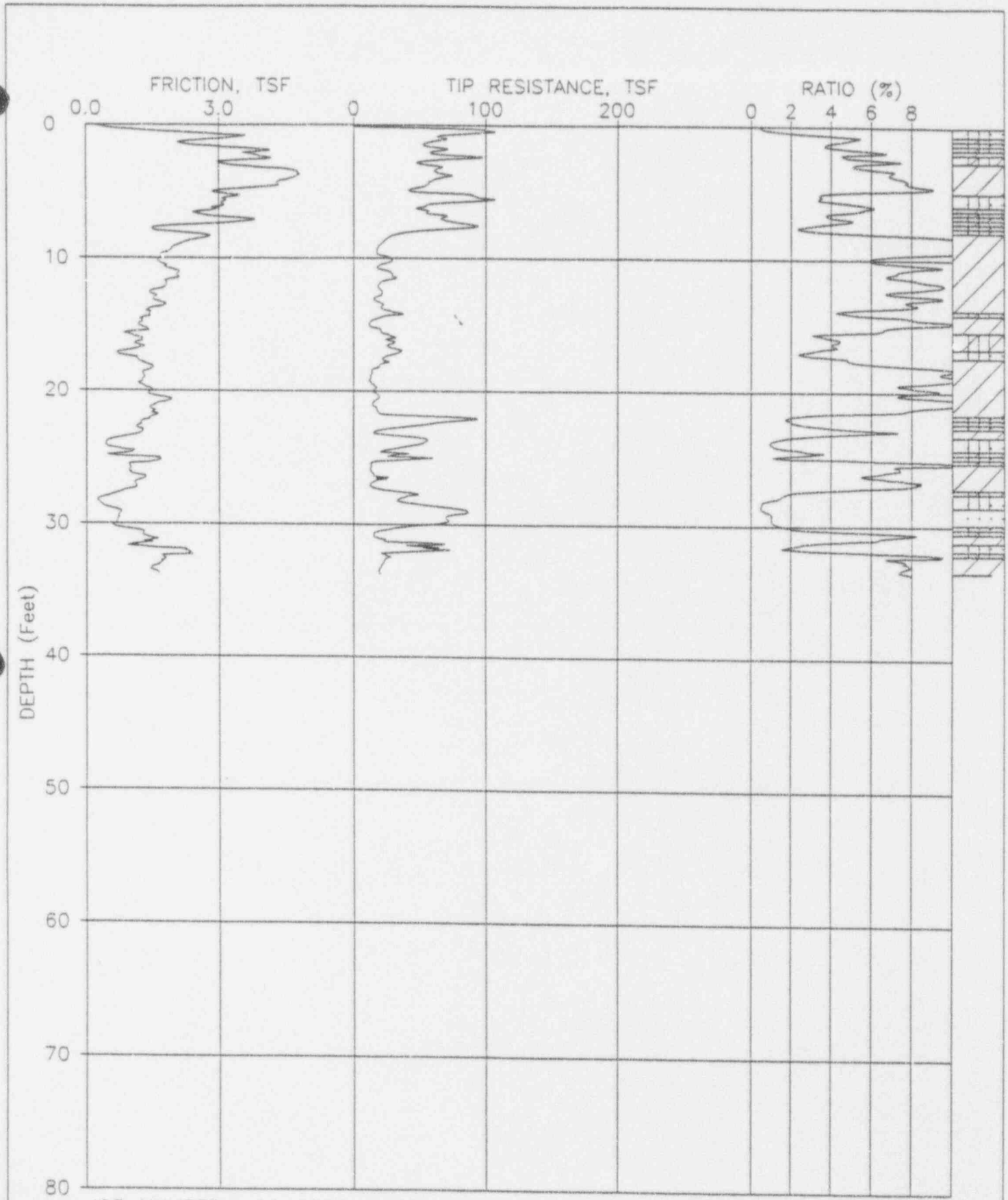

FRICTION, TSF
0.0
3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
0
10
20
30
40
50
60
70
80
JOB NUMBER : 92-2236
CPT NUMBER : 69
DATE : 08-19-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEV606
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 70 DATE : 08-19-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

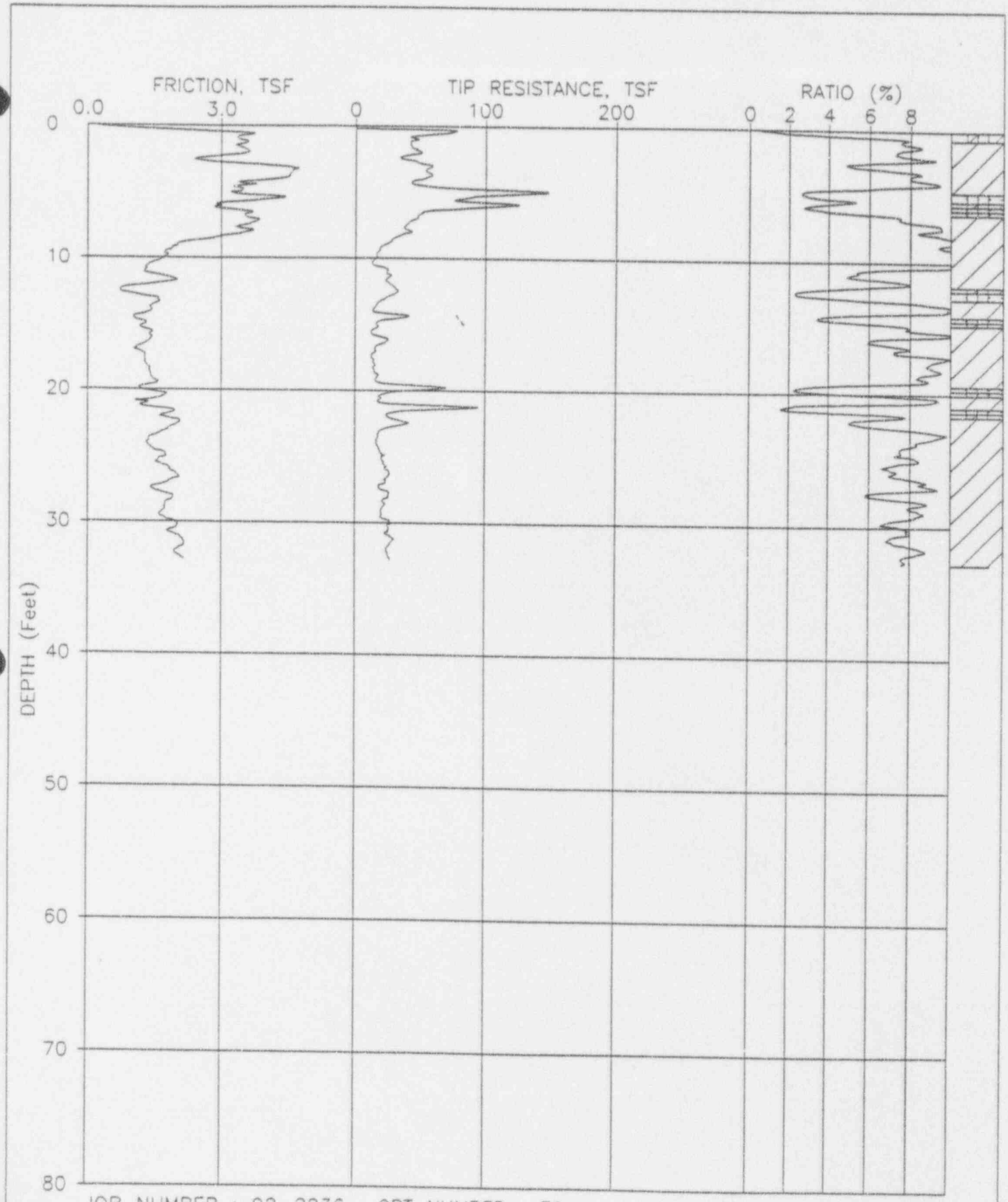
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 71 DATE : 08-19-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

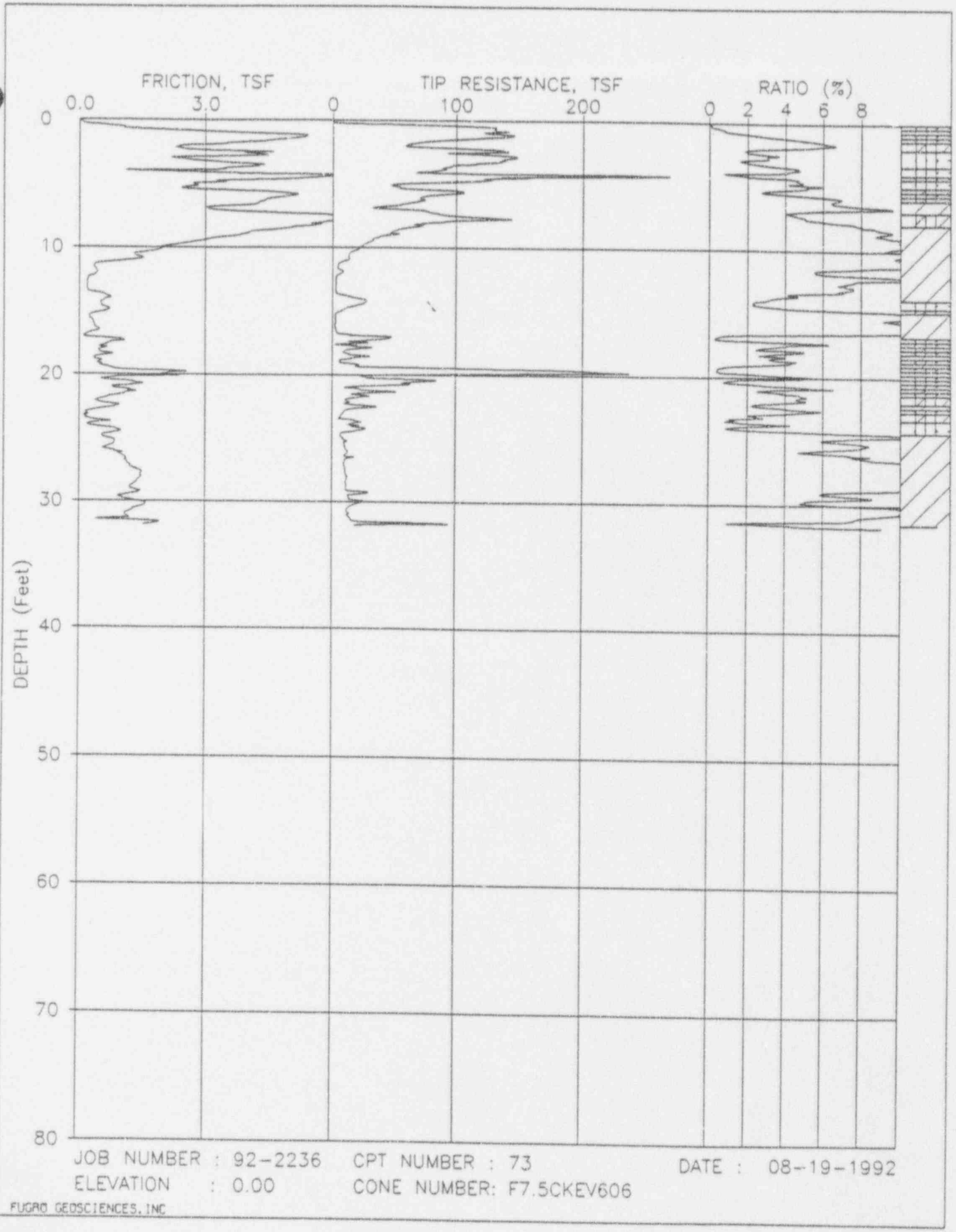
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 72 DATE : 08-19-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

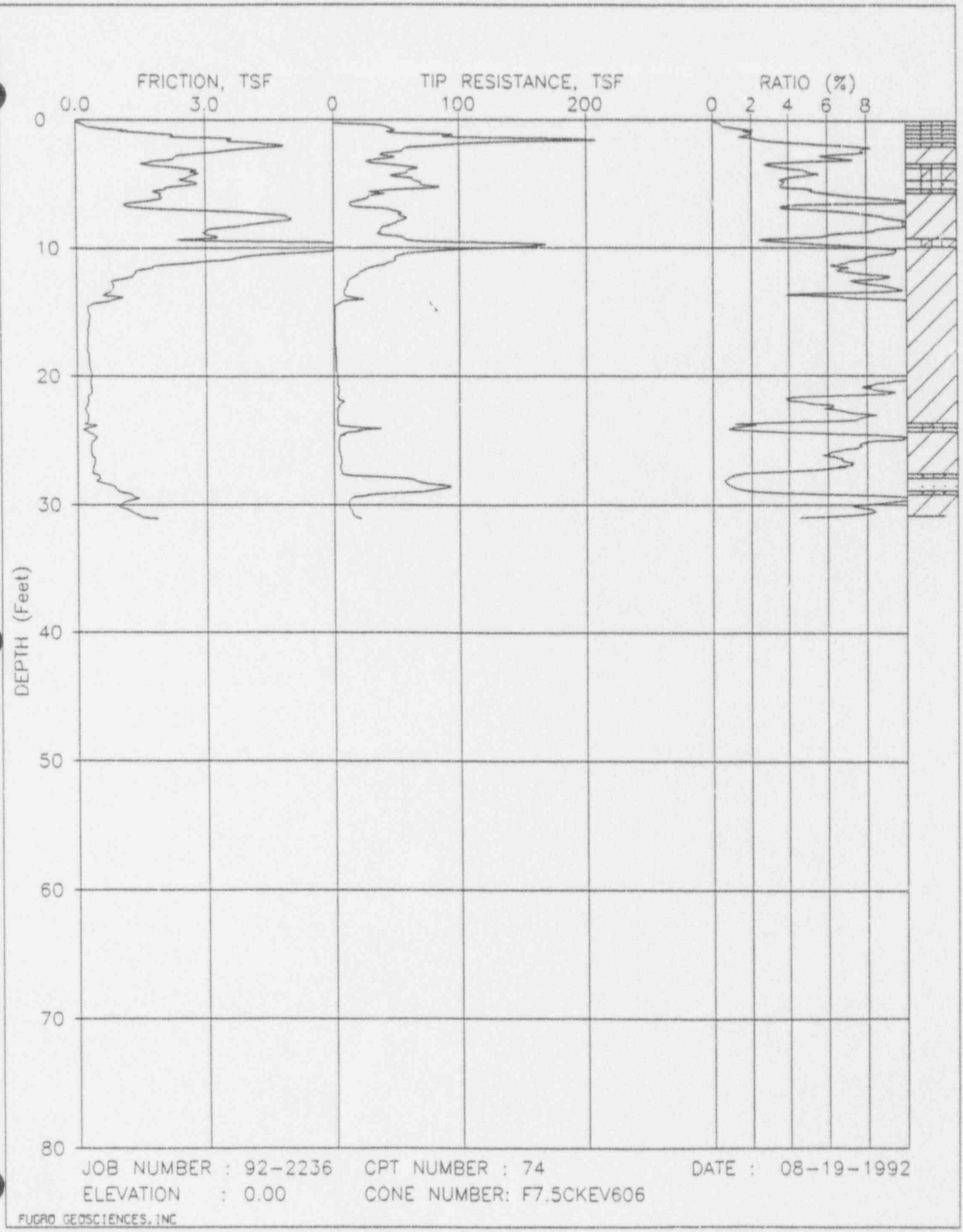
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 73 DATE : 08-19-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

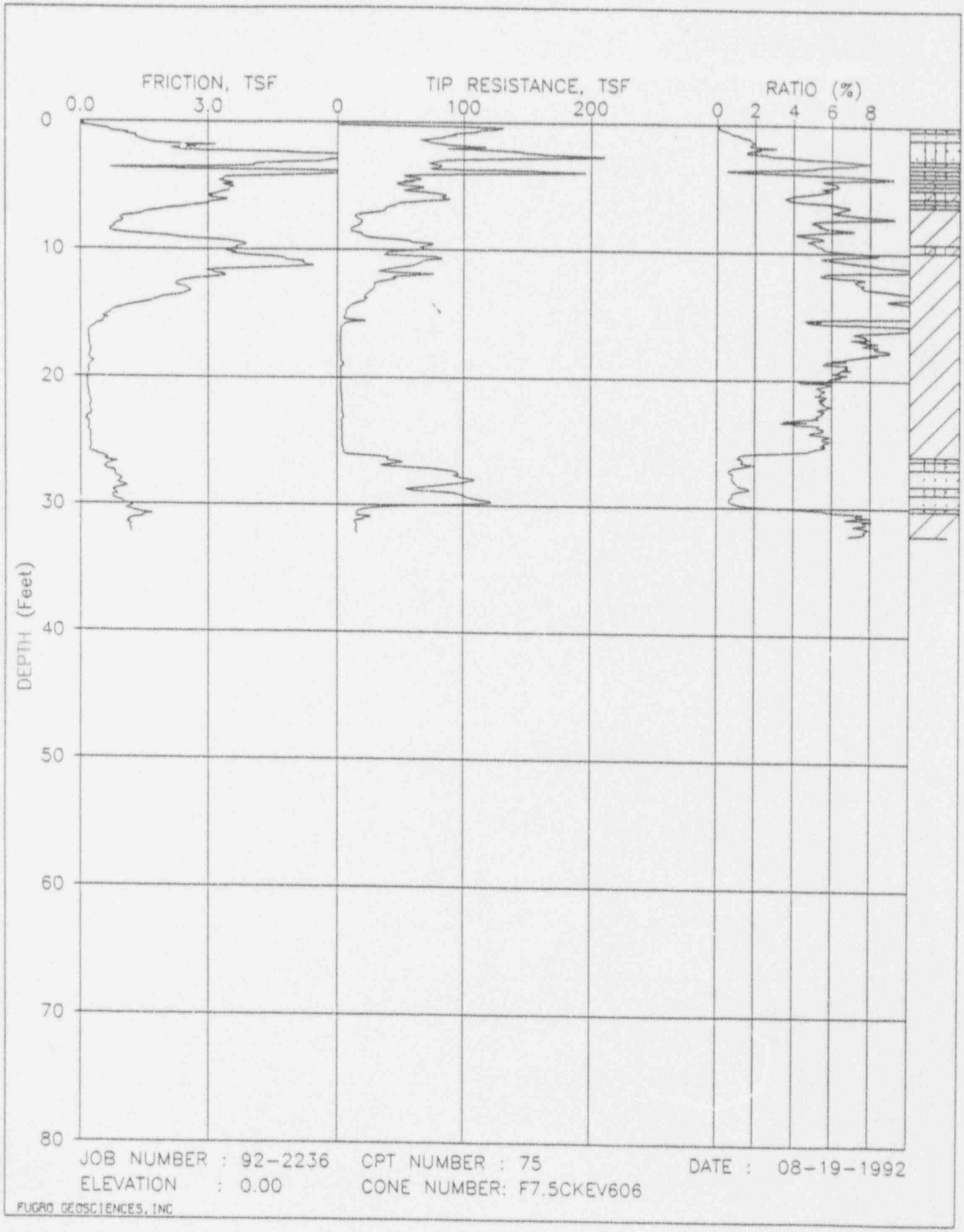
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 74 DATE : 08-19-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

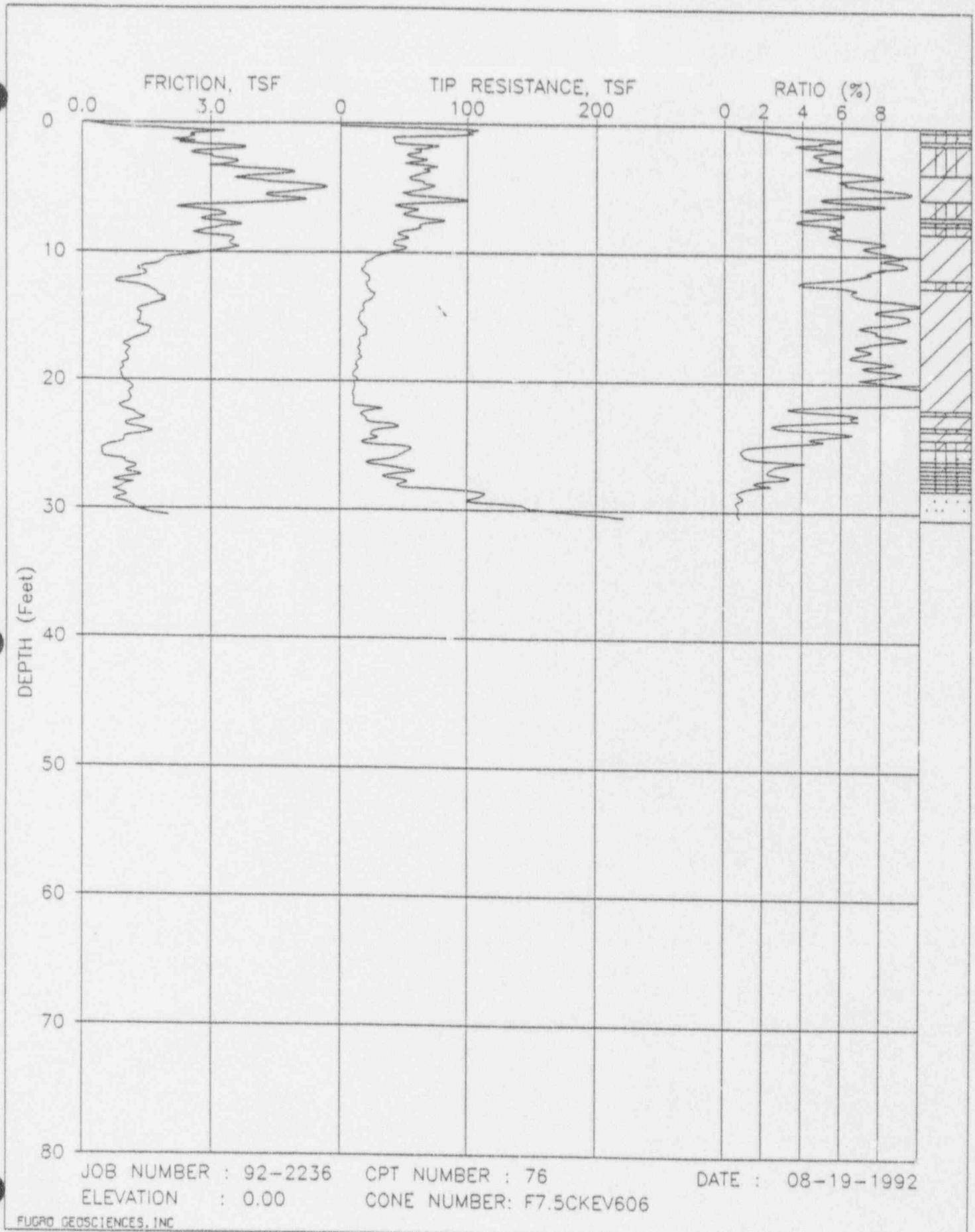
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 75 DATE : 08-19-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

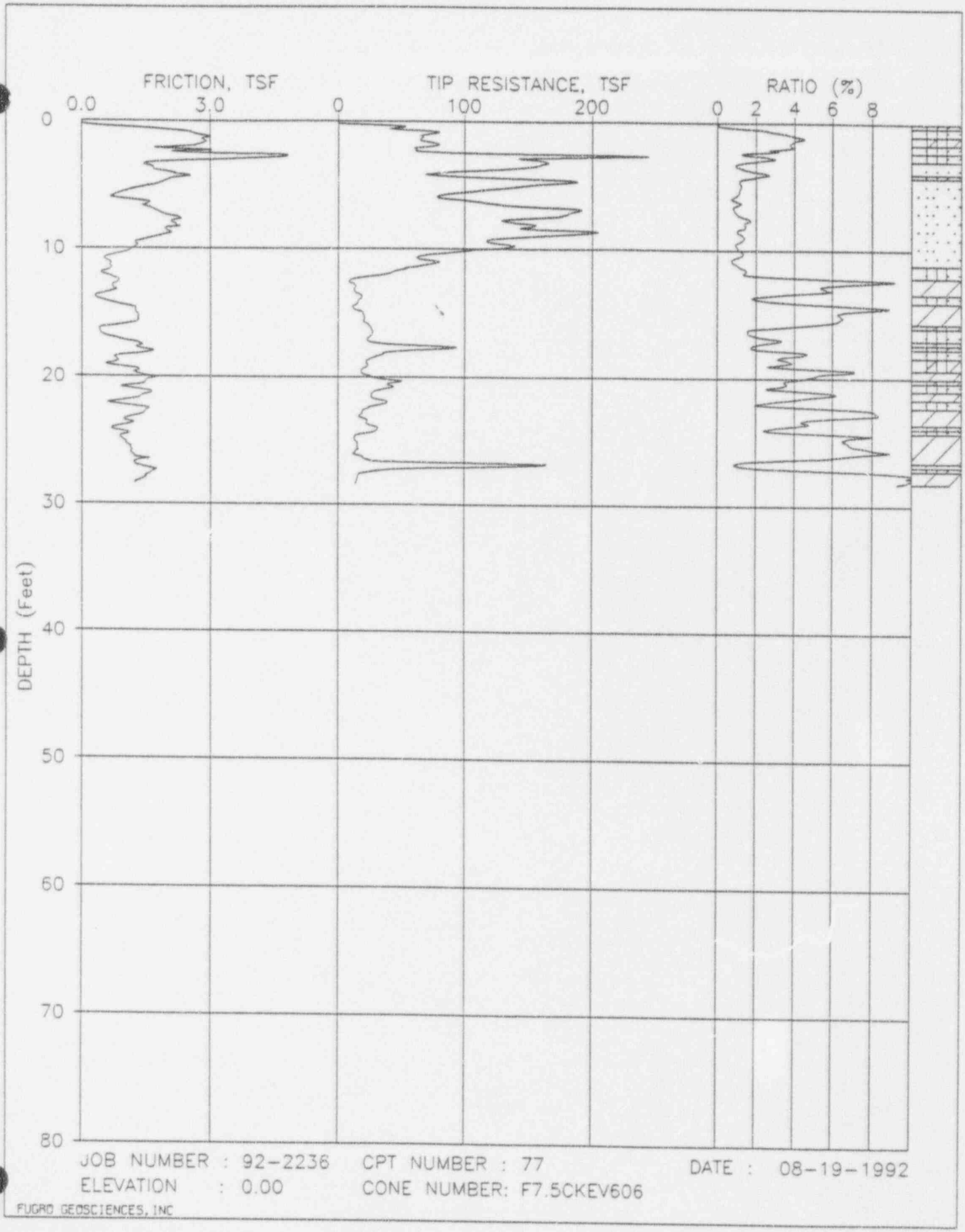
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 76 DATE : 08-19-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

FUGRO GEOSCIENCES, INC

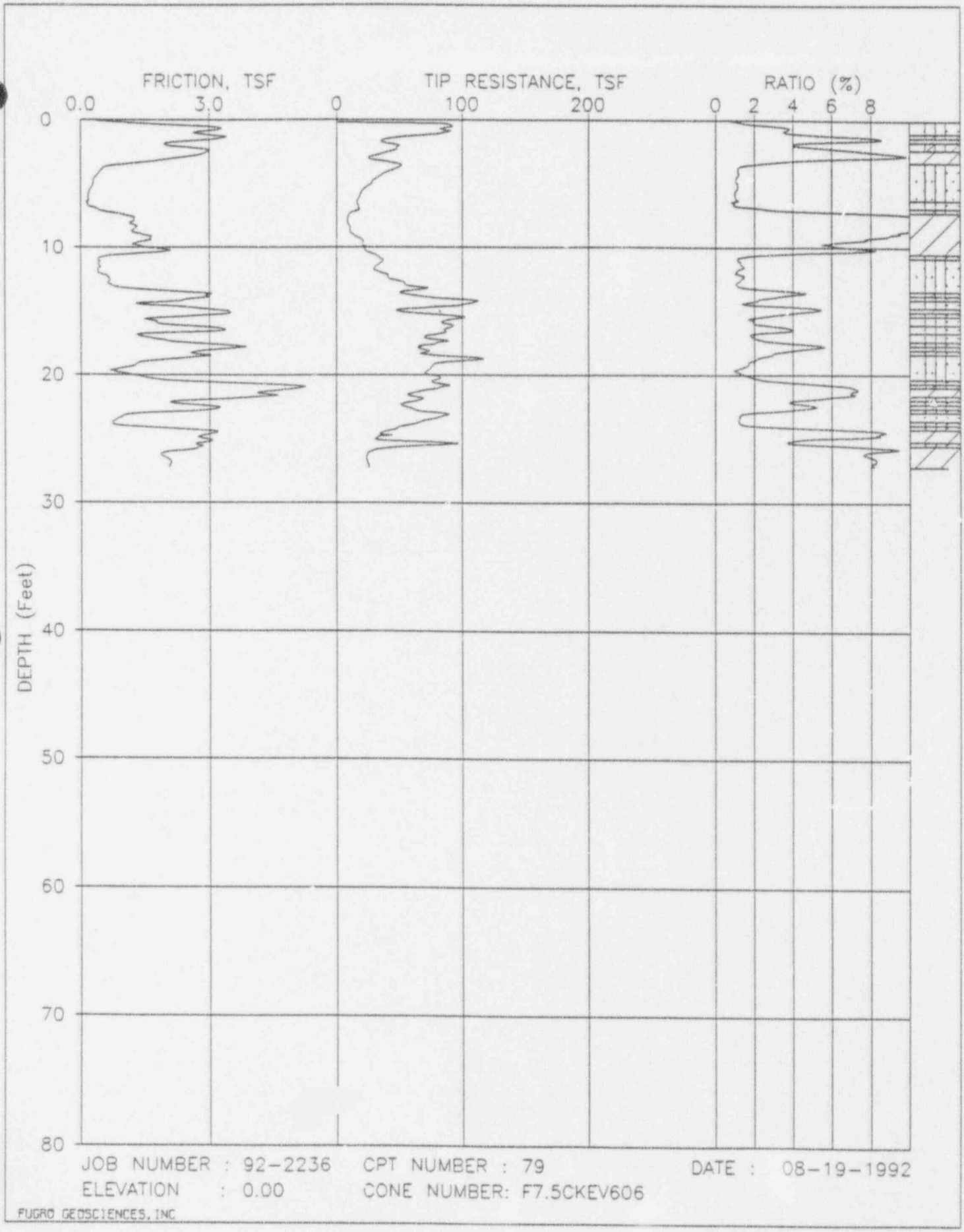


JOB NUMBER : 92-2236 CPT NUMBER : 77 DATE : 08-19-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

FUGRO GEOSCIENCES, INC

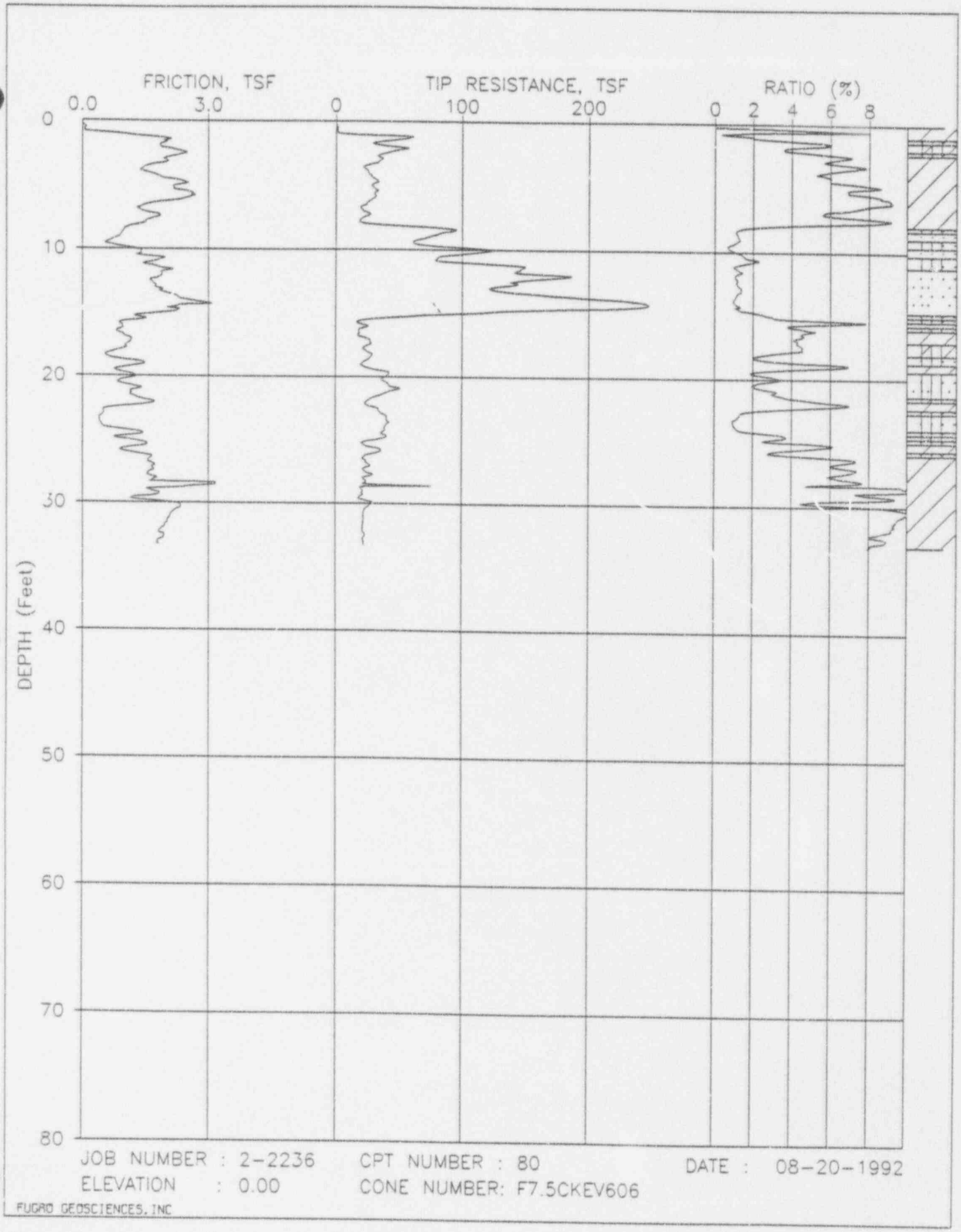

FRICTION, TSF
0.0
3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
0
10
20
30
40
50
60
70
80
DEPTH (Feet)
JOB NUMBER : 92-2236
ELEVATION : 0.00
CPT NUMBER : 78
CONE NUMBER: F7.5CKEV606
DATE : 08-19-1992
FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 79 DATE : 08-19-1992

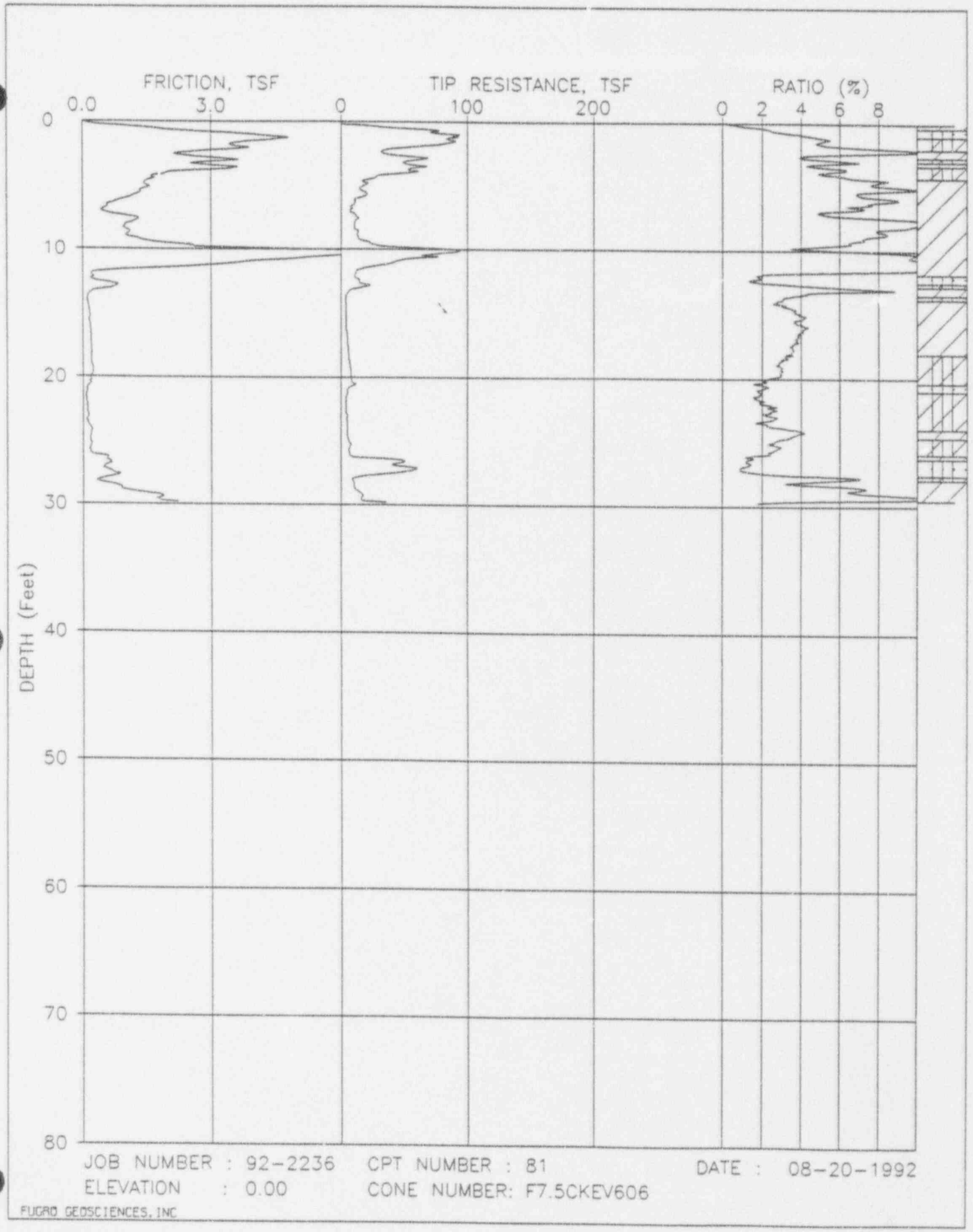
ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

FUGRO GEOSCIENCES, INC



JOB NUMBER : 2-2236
ELEVATION : 0.00
CPT NUMBER : 80
CONE NUMBER: F7.5CKEV606
DATE : 08-20-1992

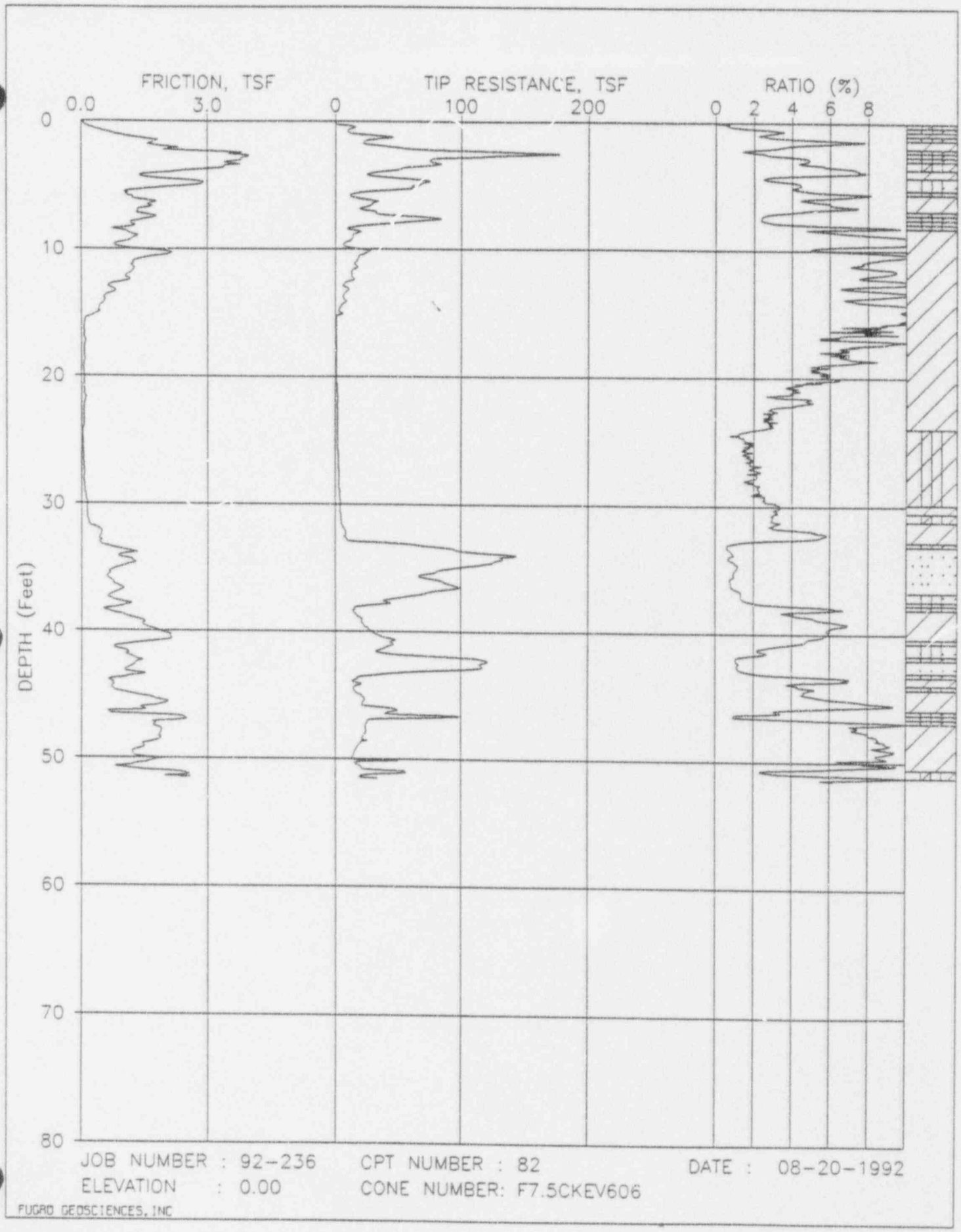
FUGRO GEOSCIENCES, INC

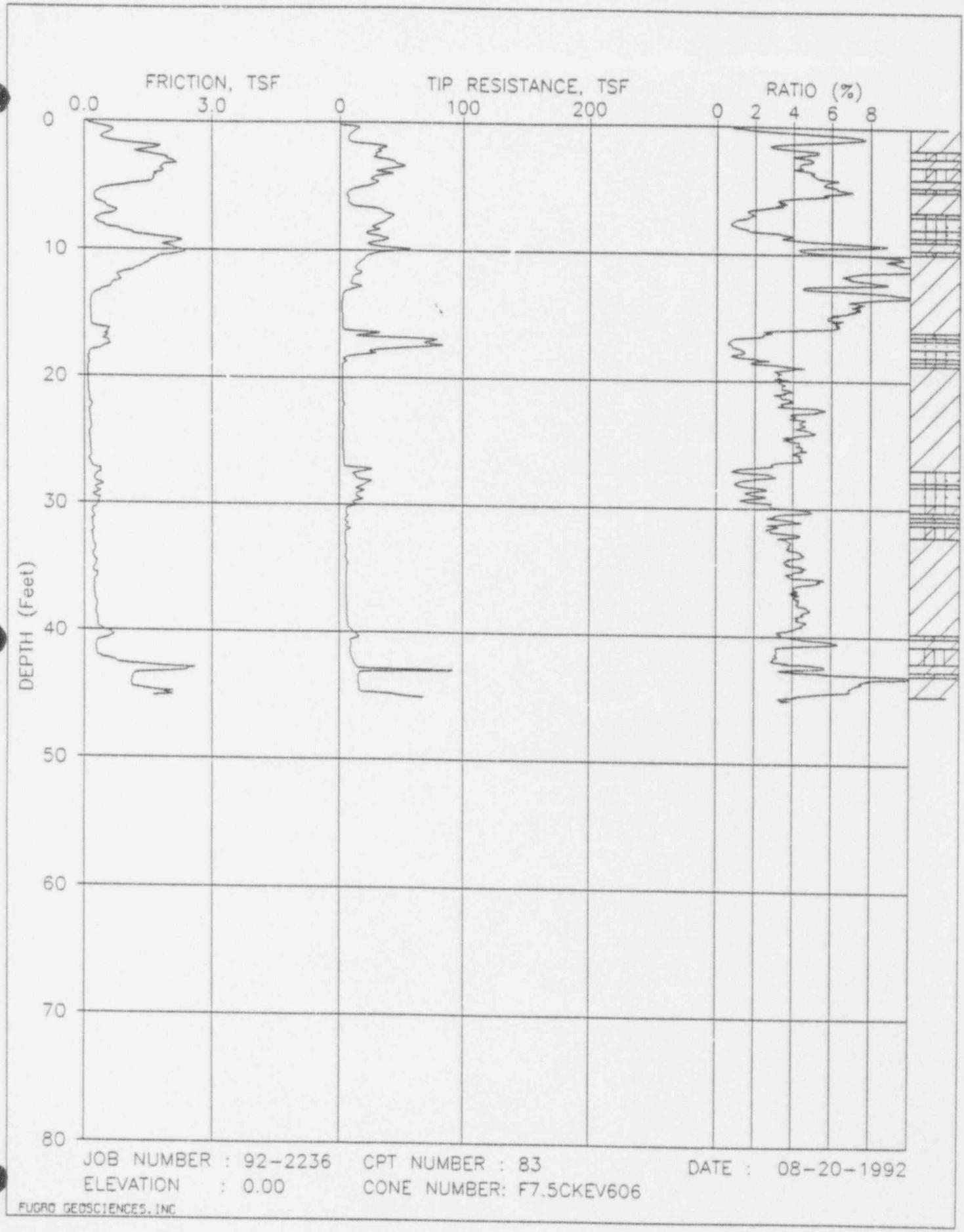


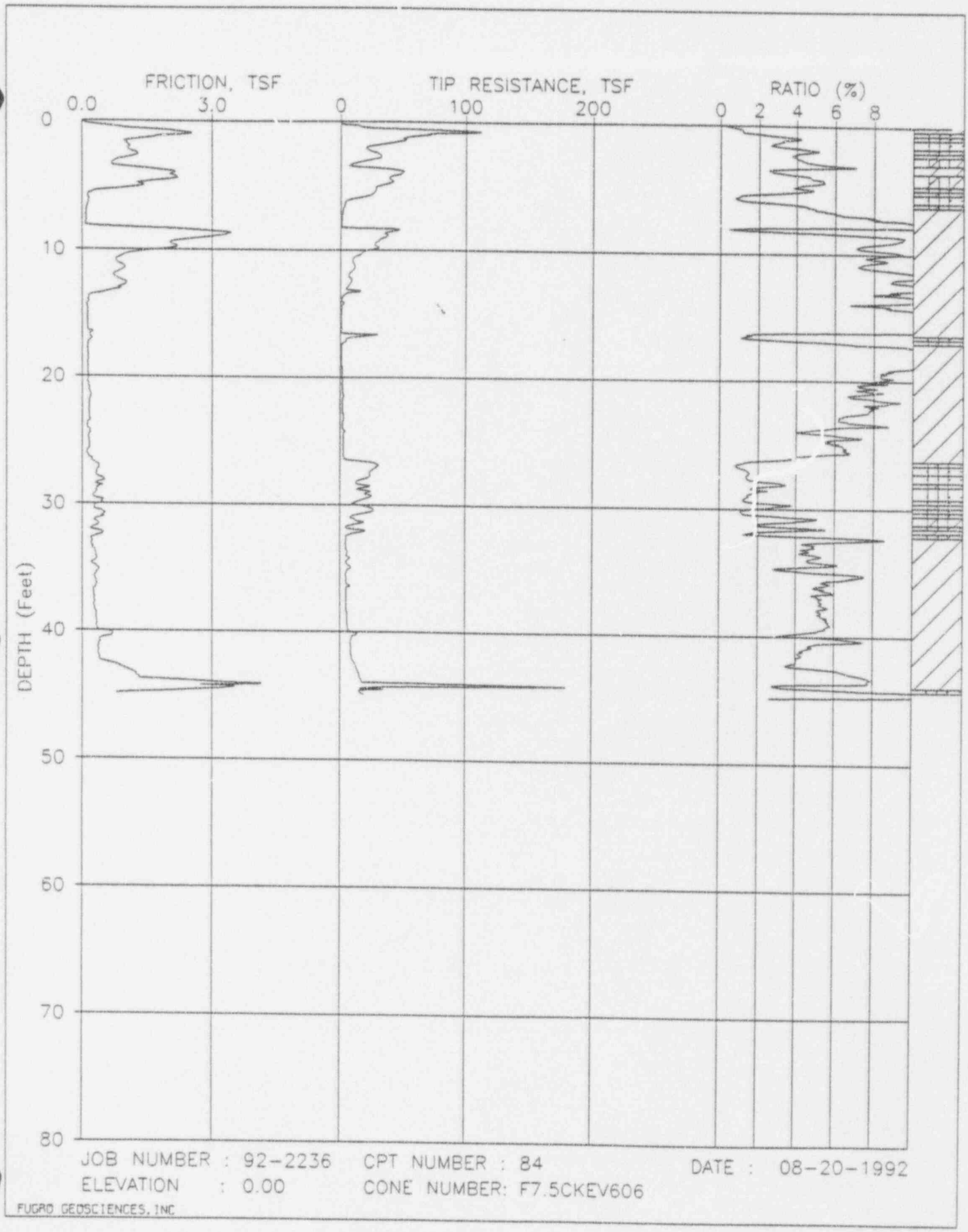
JOB NUMBER : 92-2236 CPT NUMBER : 81 DATE : 08-20-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

FUGRO GEOSCIENCES, INC


FRICTION, TSF
0.0
3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
0
10
20
30
40
50
60
70
80
DEPTH (Feet)
JOB NUMBER : 92-236
ELEVATION : 0.00
CPT NUMBER : 82
CONE NUMBER: F7.5CKEV606
DATE : 08-20-1992
FUGRO GEOSCIENCES, INC

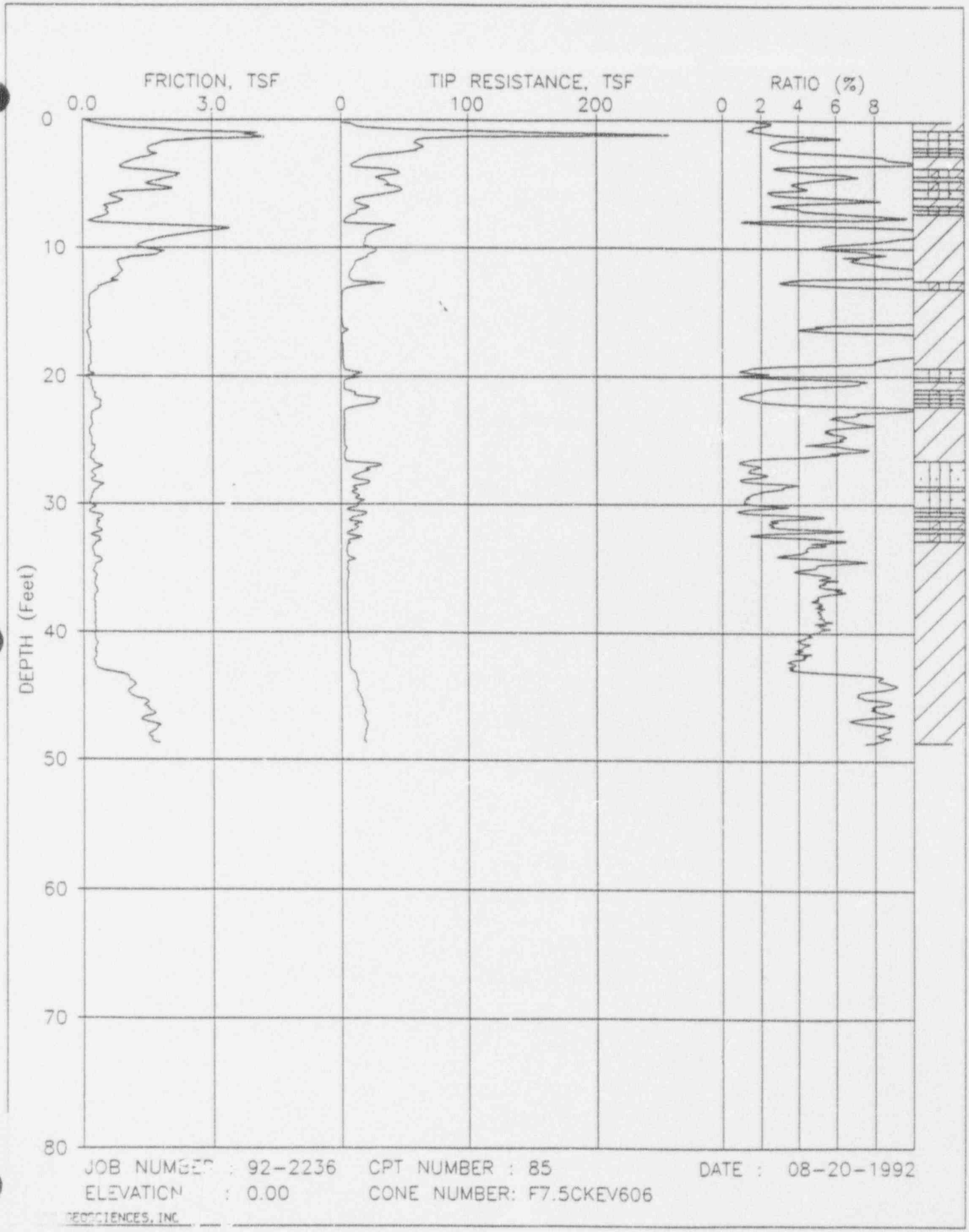

FRICTION, TSF
0.0
3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
0
10
20
30
40
50
60
70
80
JOB NUMBER : 92-2236
ELEVATION : 0.00
CPT NUMBER : 83
CONE NUMBER: F7.5CKEV606
DATE : 08-20-1992
FUGRO GEOSCIENCES, INC

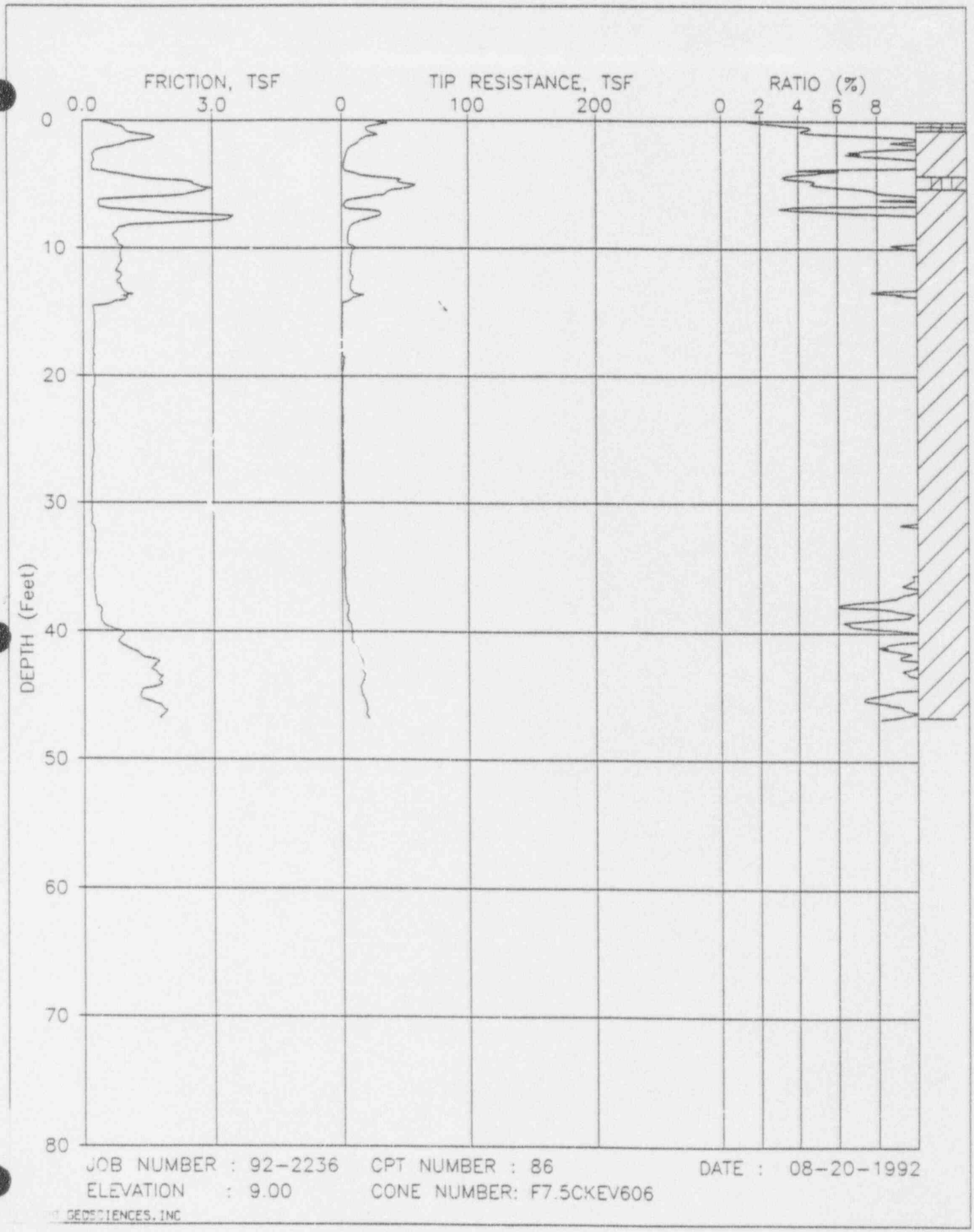


JOB NUMBER : 92-2236 CPT NUMBER : 84 DATE : 08-20-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

FUGRO GEOSCIENCES, INC

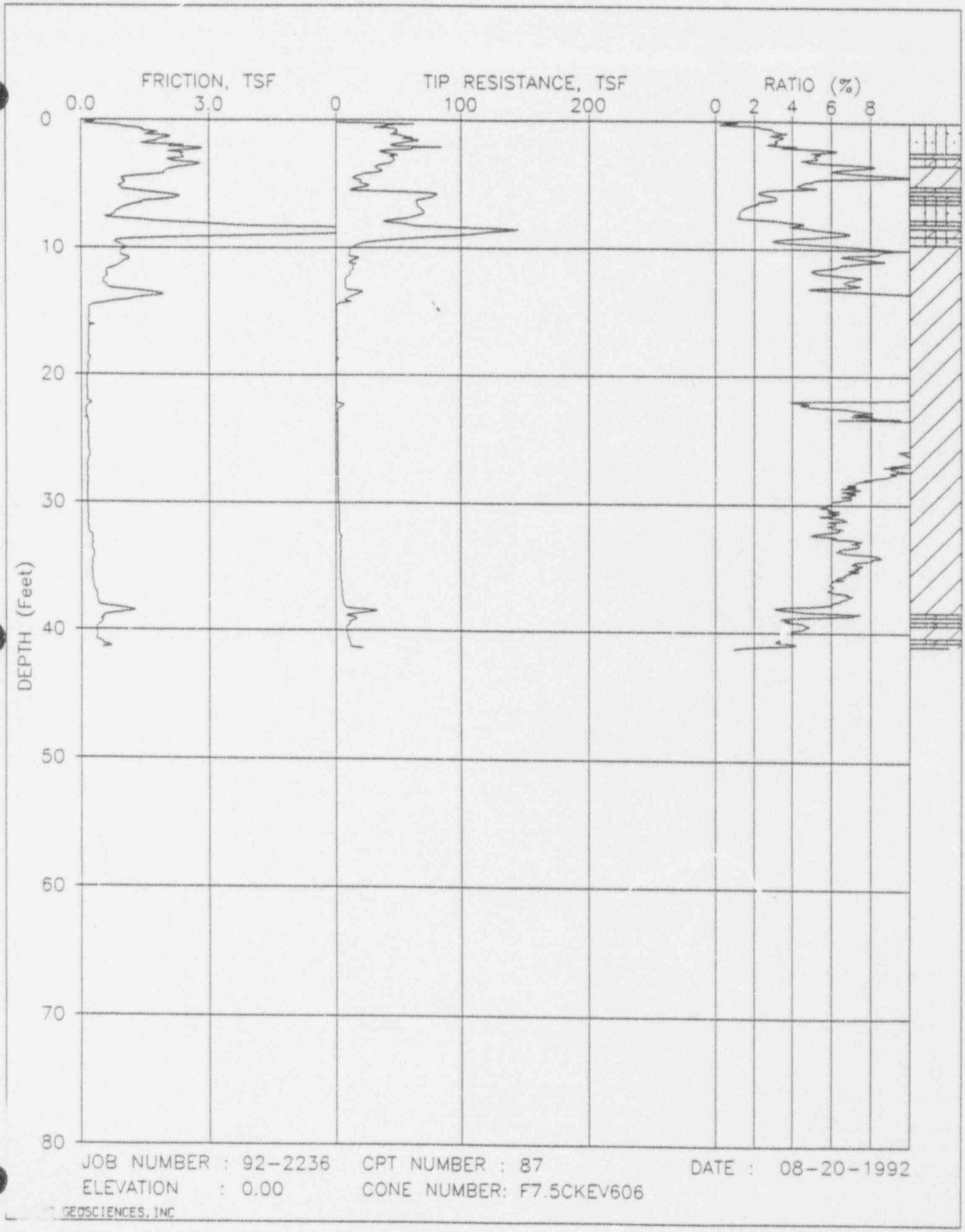

FRICTION, TSF
0.0
3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
0
10
20
30
40
50
60
70
80
JOB NUMBER : 92-2236
CPT NUMBER : 85
DATE : 08-20-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEV606
GEOSCIENCES, INC.



JOB NUMBER : 92-2236 CPT NUMBER : 86 DATE : 08-20-1992

ELEVATION : 9.00 CONE NUMBER: F7.5CKEV606

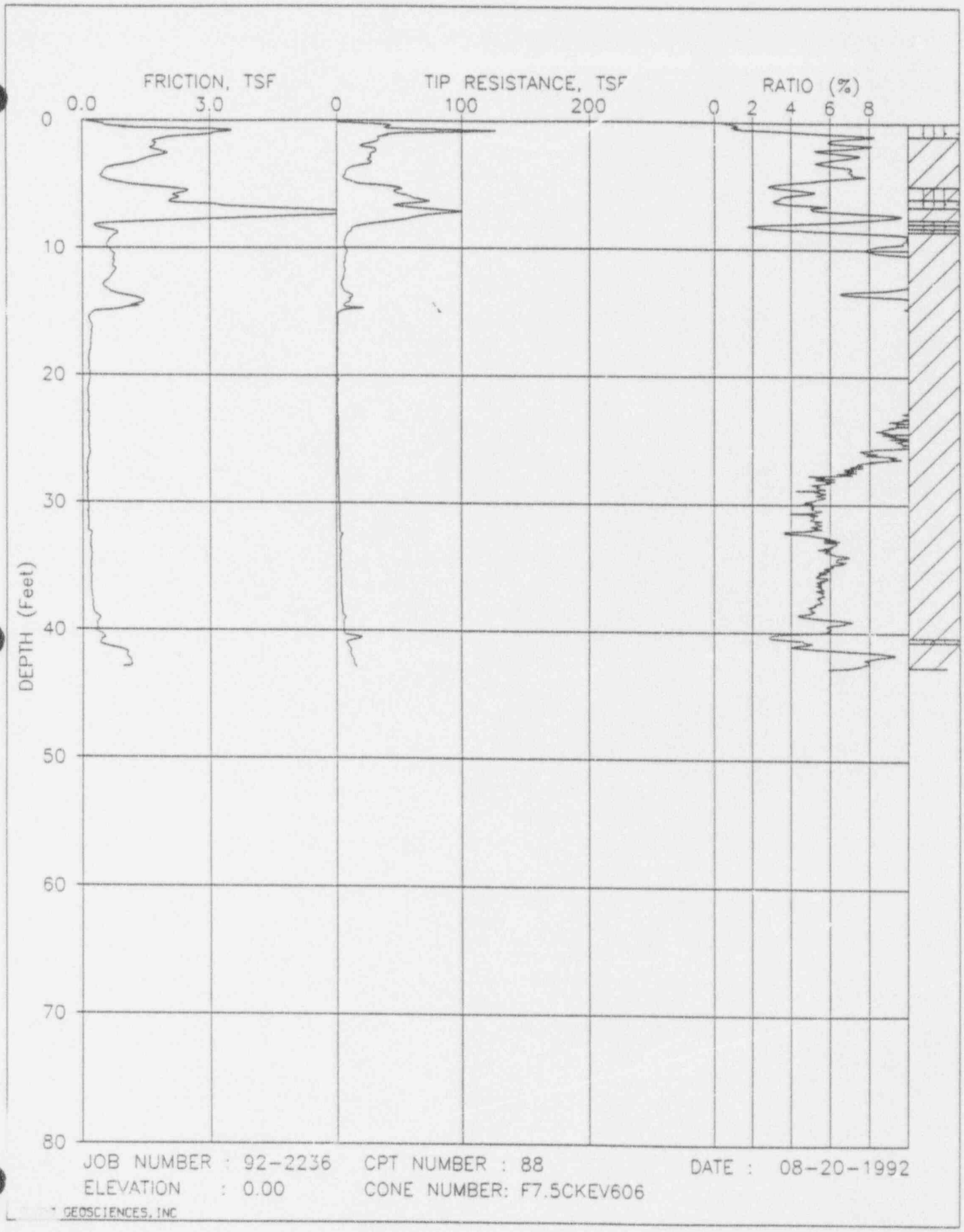
GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 87 DATE : 08-20-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

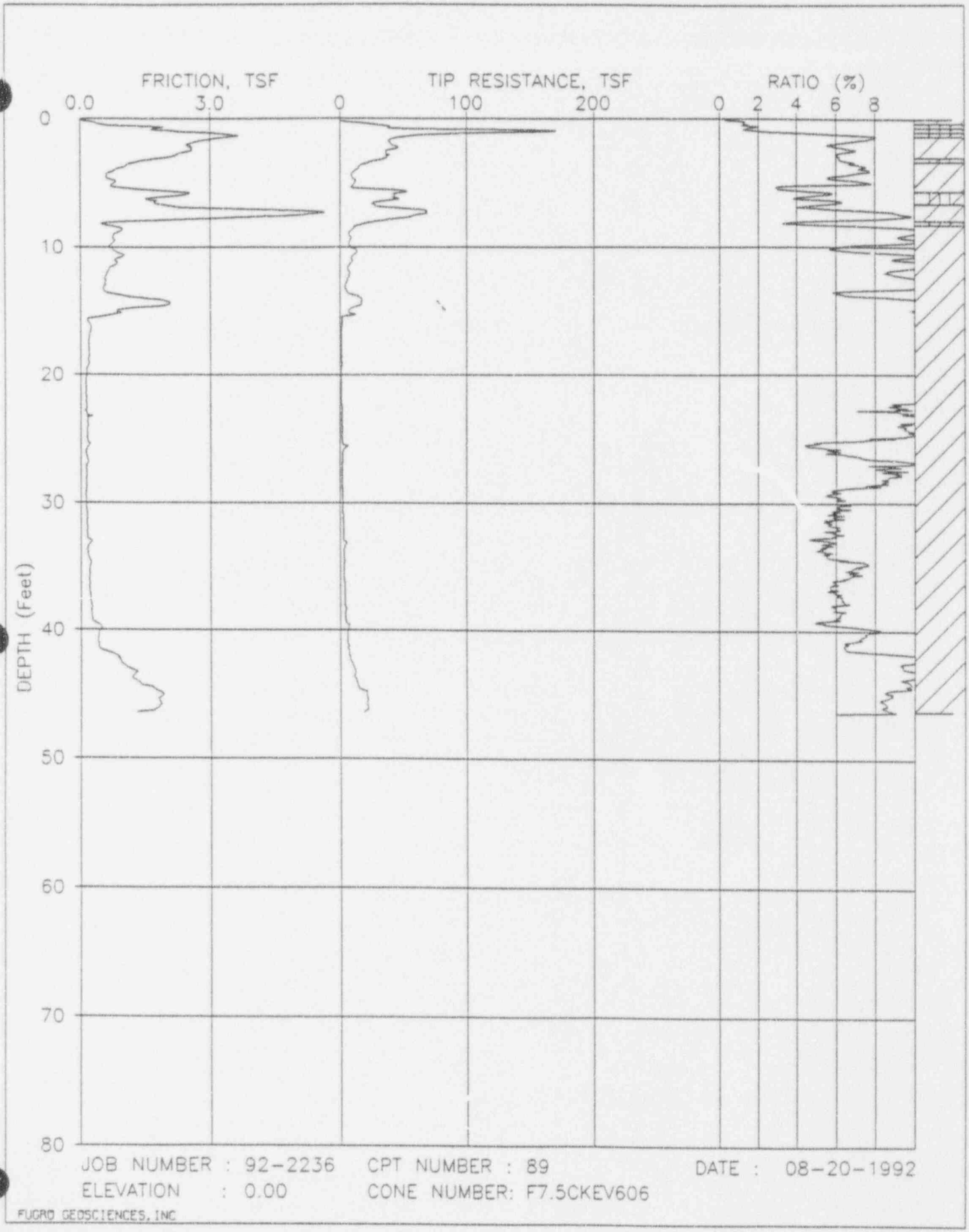
GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 88 DATE : 08-20-1992

ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

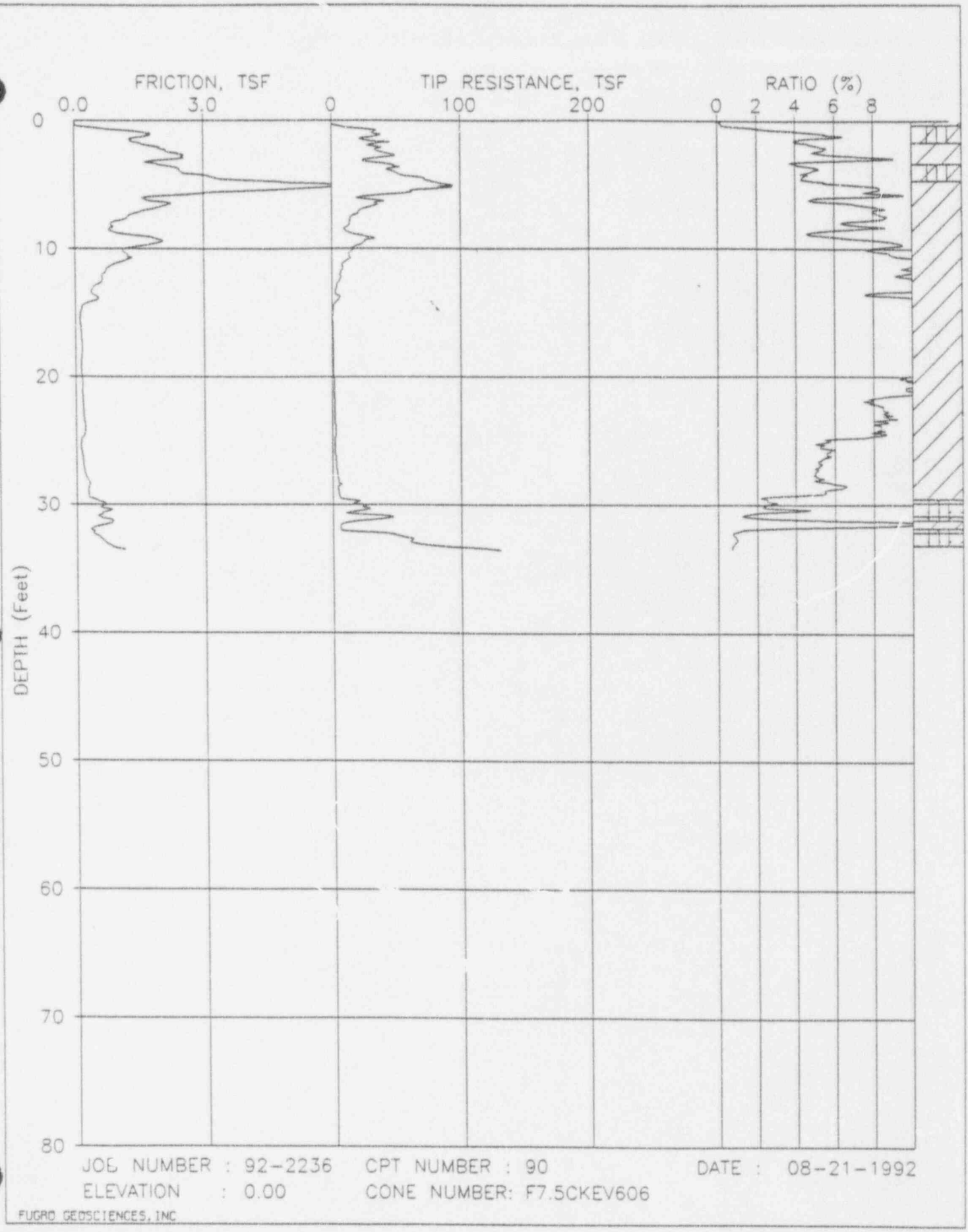
GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 89 DATE : 08-20-1992

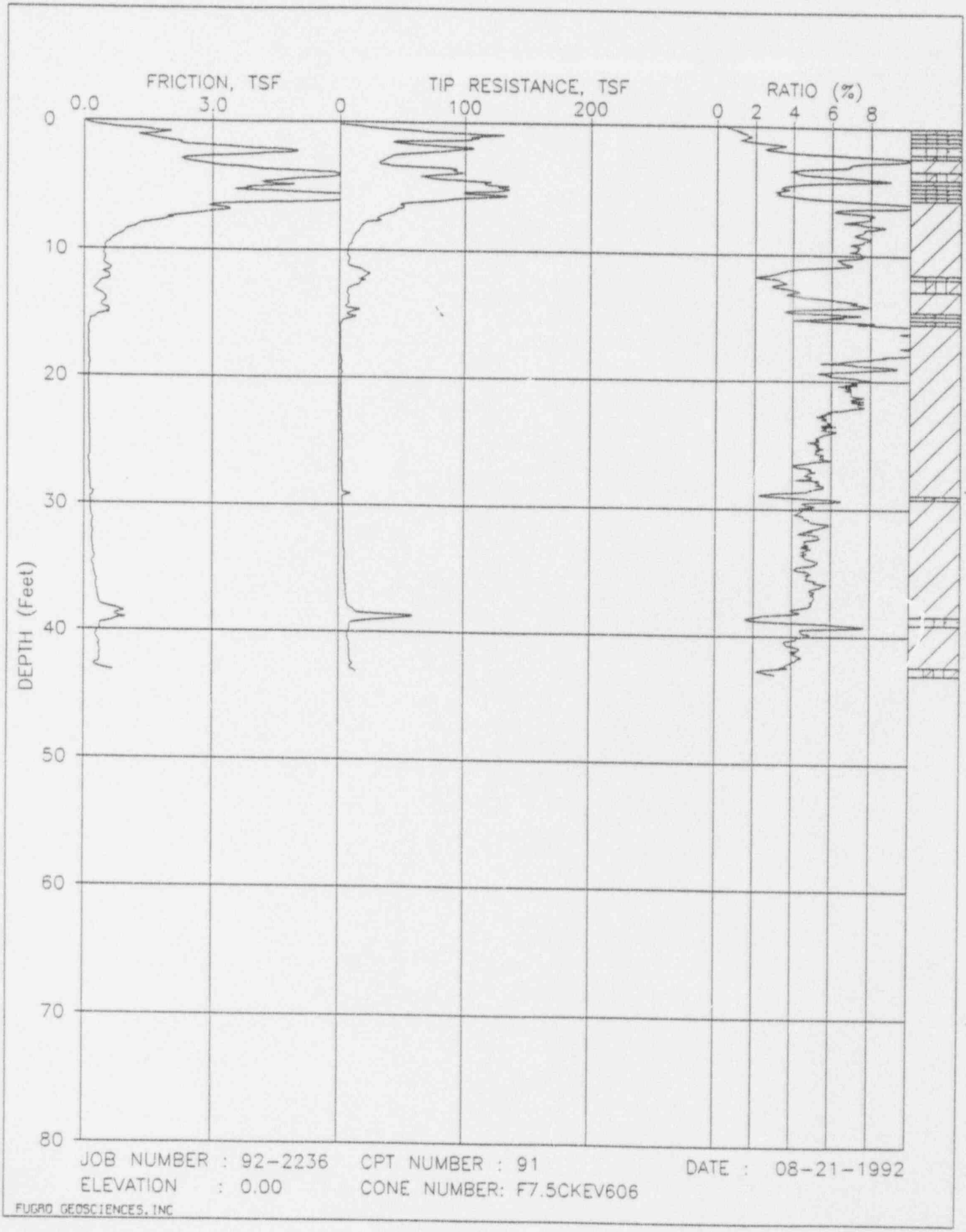
ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

FUGRO GEOSCIENCES, INC



JOB NUMBER : 92-2236 CPT NUMBER : 90 DATE : 08-21-1992
ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

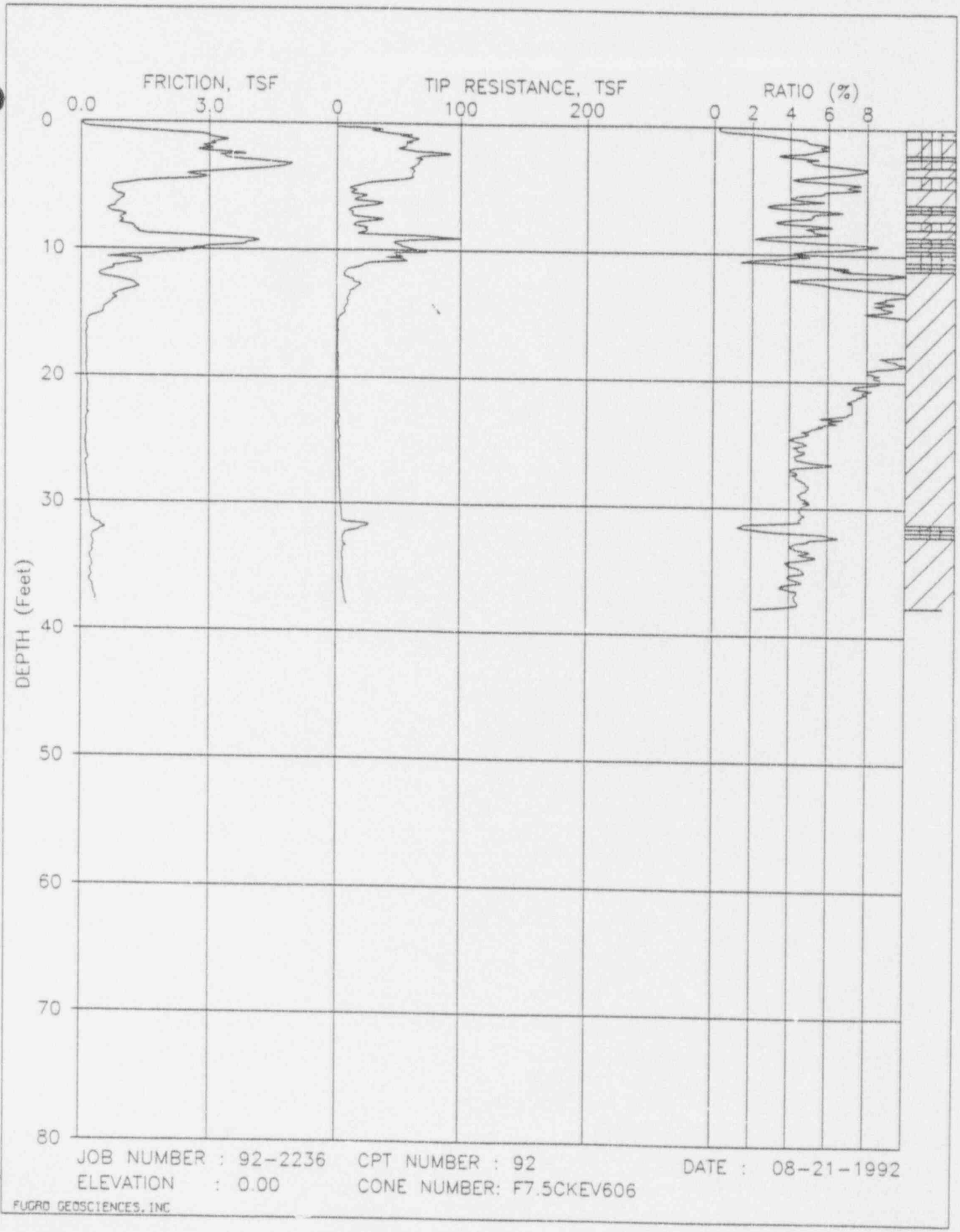
FUGRO GEOSCIENCES, INC

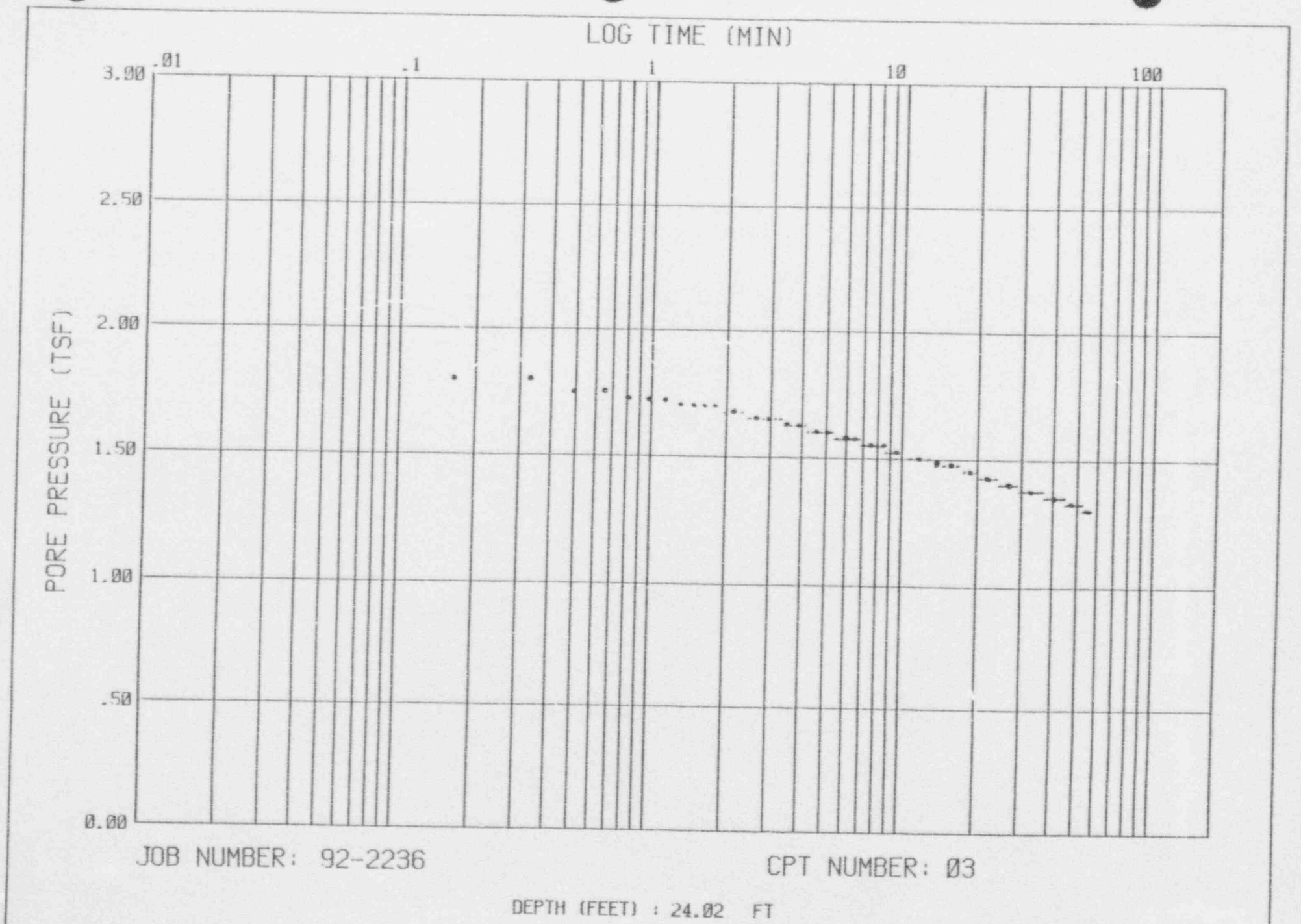


JOB NUMBER : 92-2236 CPT NUMBER : 91 DATE : 08-21-1992

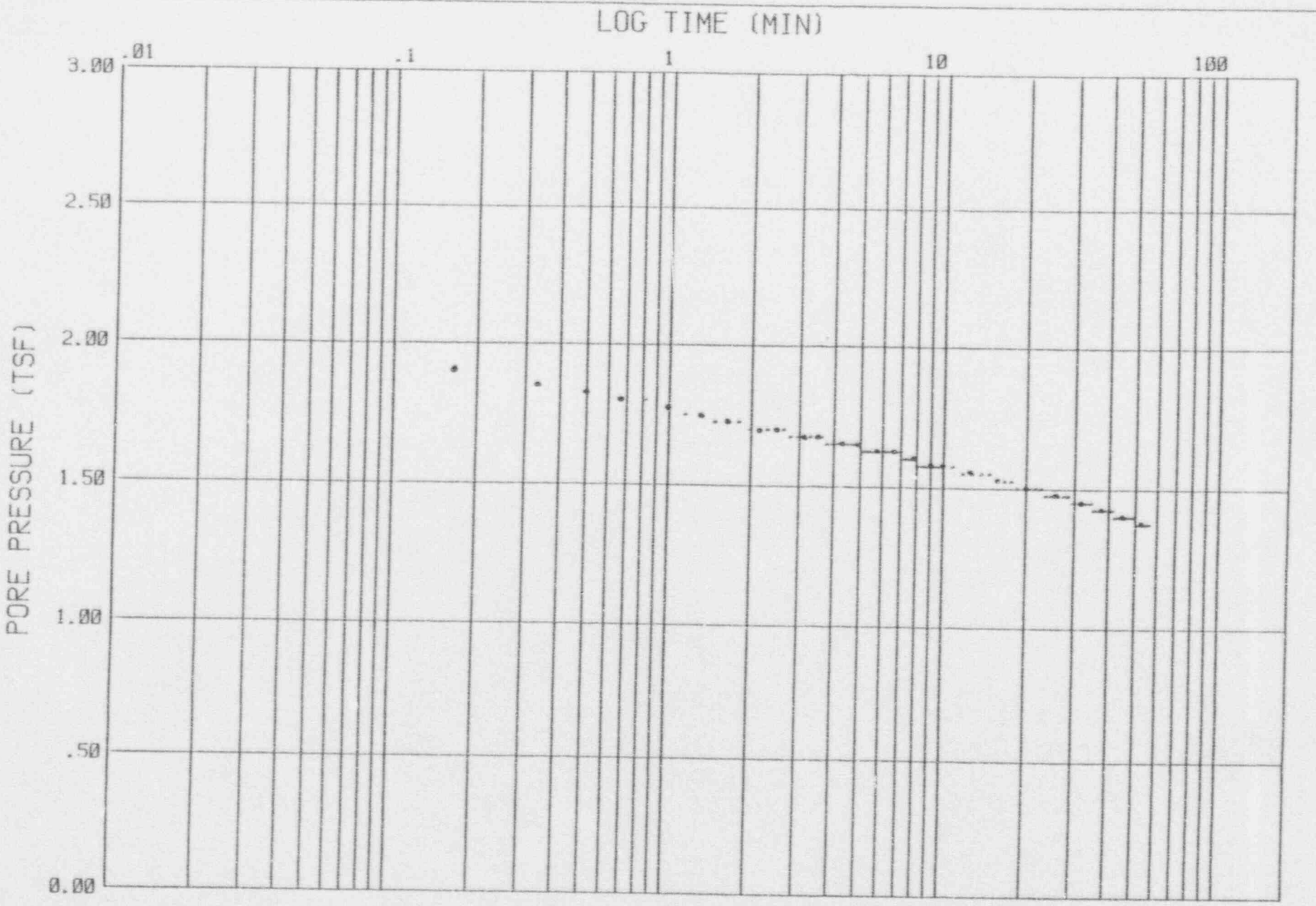
ELEVATION : 0.00 CONE NUMBER: F7.5CKEV606

FUGRO GEOSCIENCES, INC

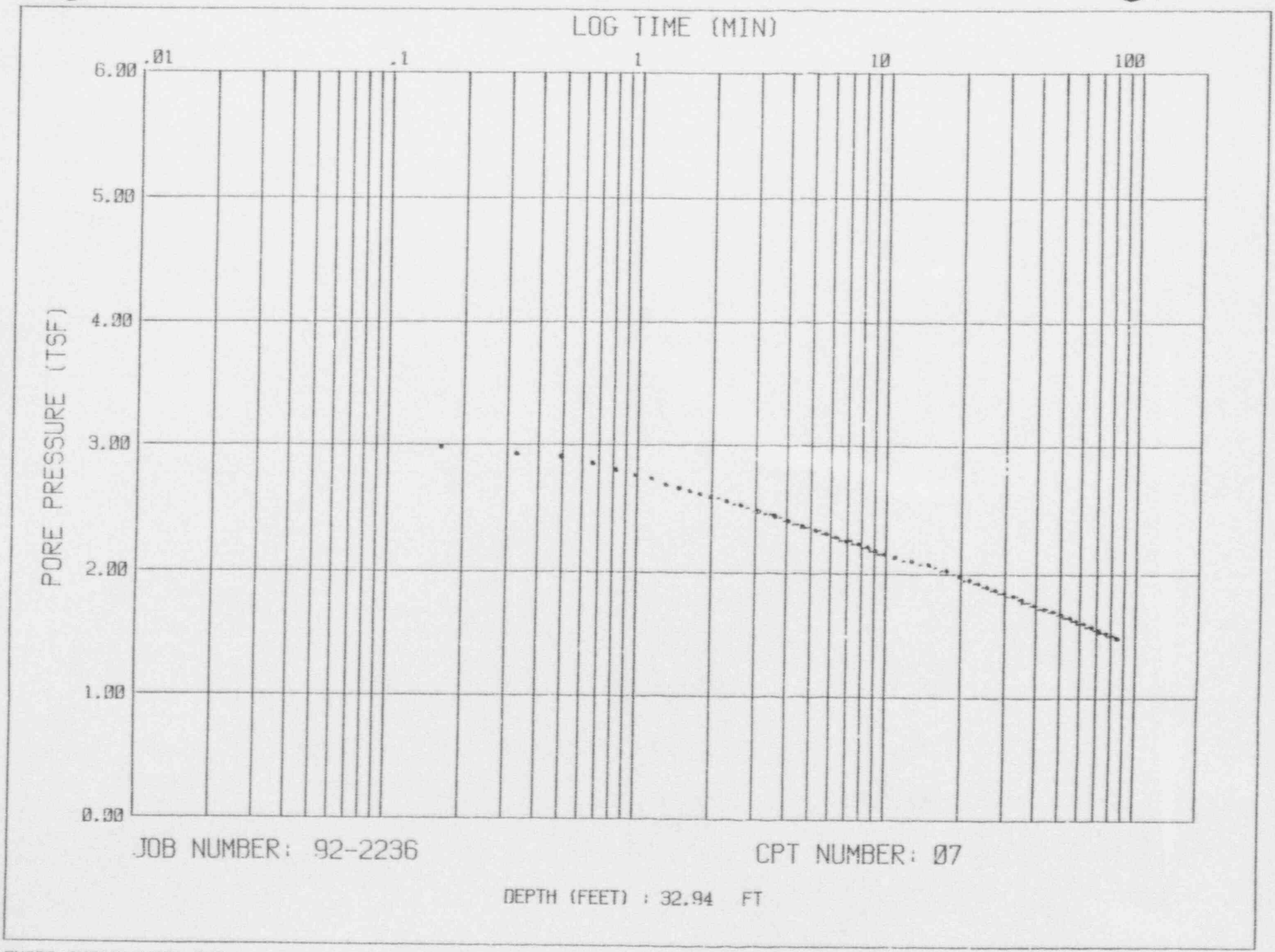

FRICTION, TSF
0.0
3.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
0
10
20
30
40
50
60
70
80
JOB NUMBER : 92-2236
CPT NUMBER : 92
DATE : 08-21-1992
ELEVATION : 0.00
CONE NUMBER: F7.5CKEV606
FUGRO GEOSCIENCES, INC



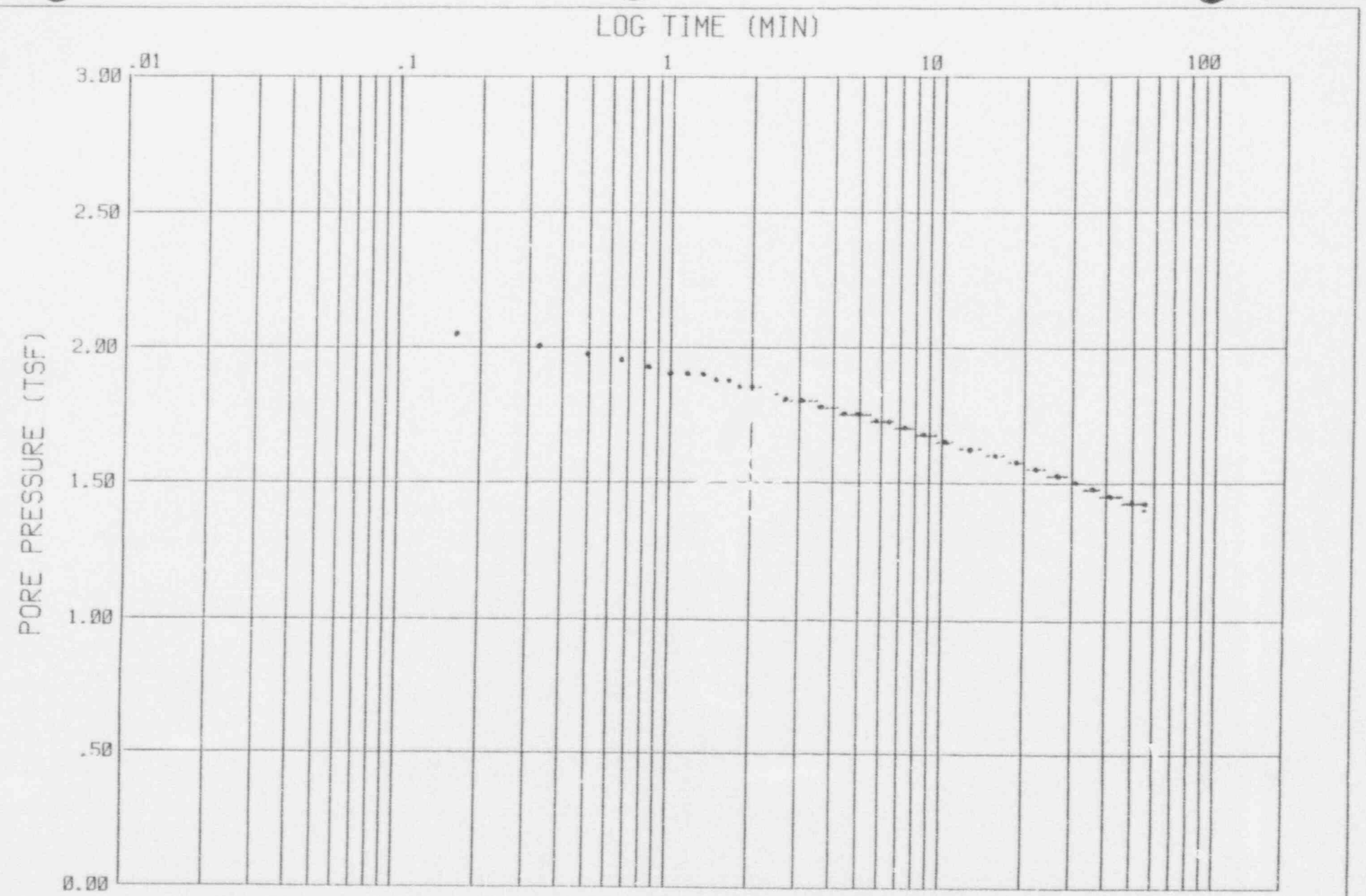
FUGRO GEOSCIENCES, INC



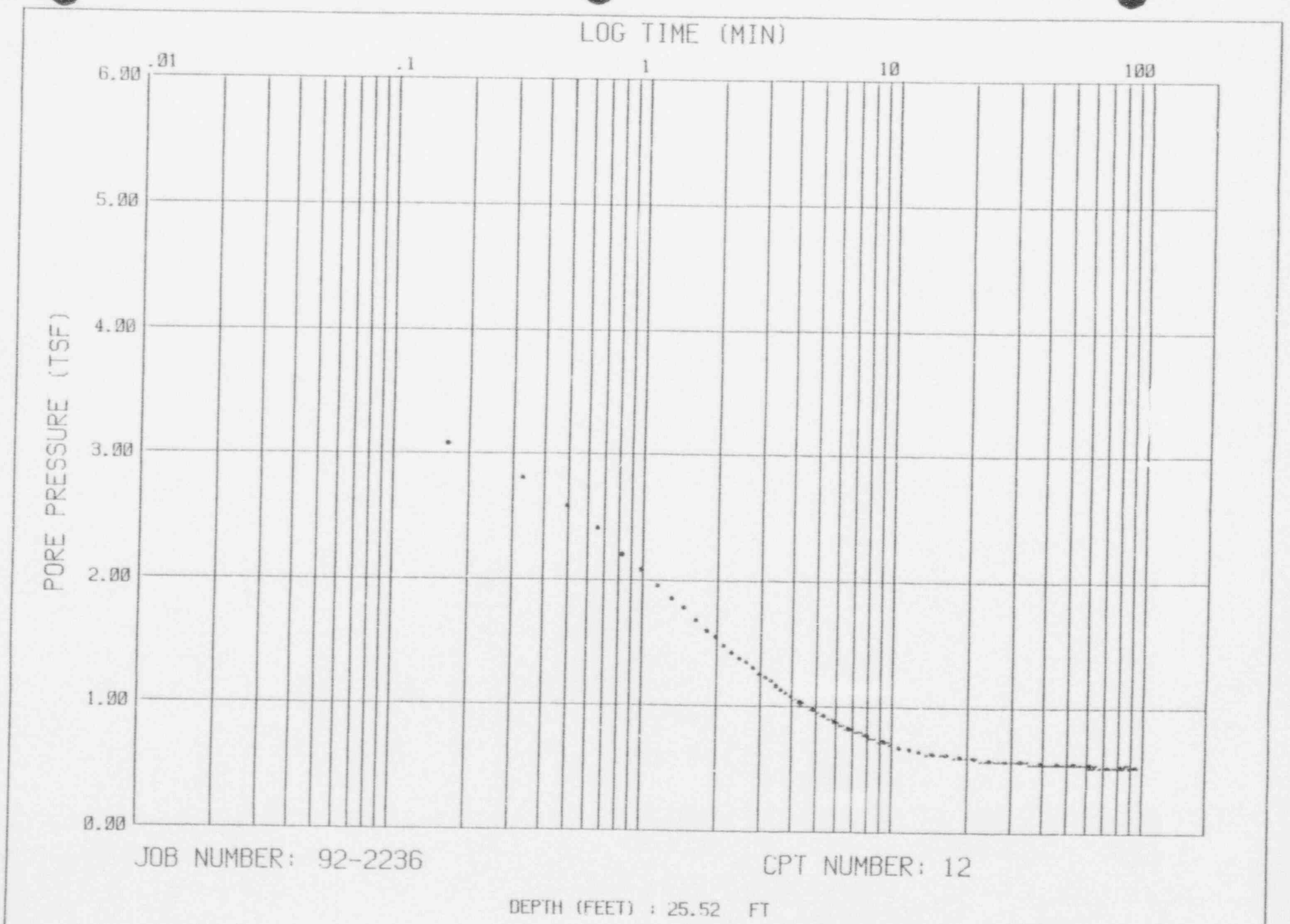
FUGRO GEOSCIENCES, INC



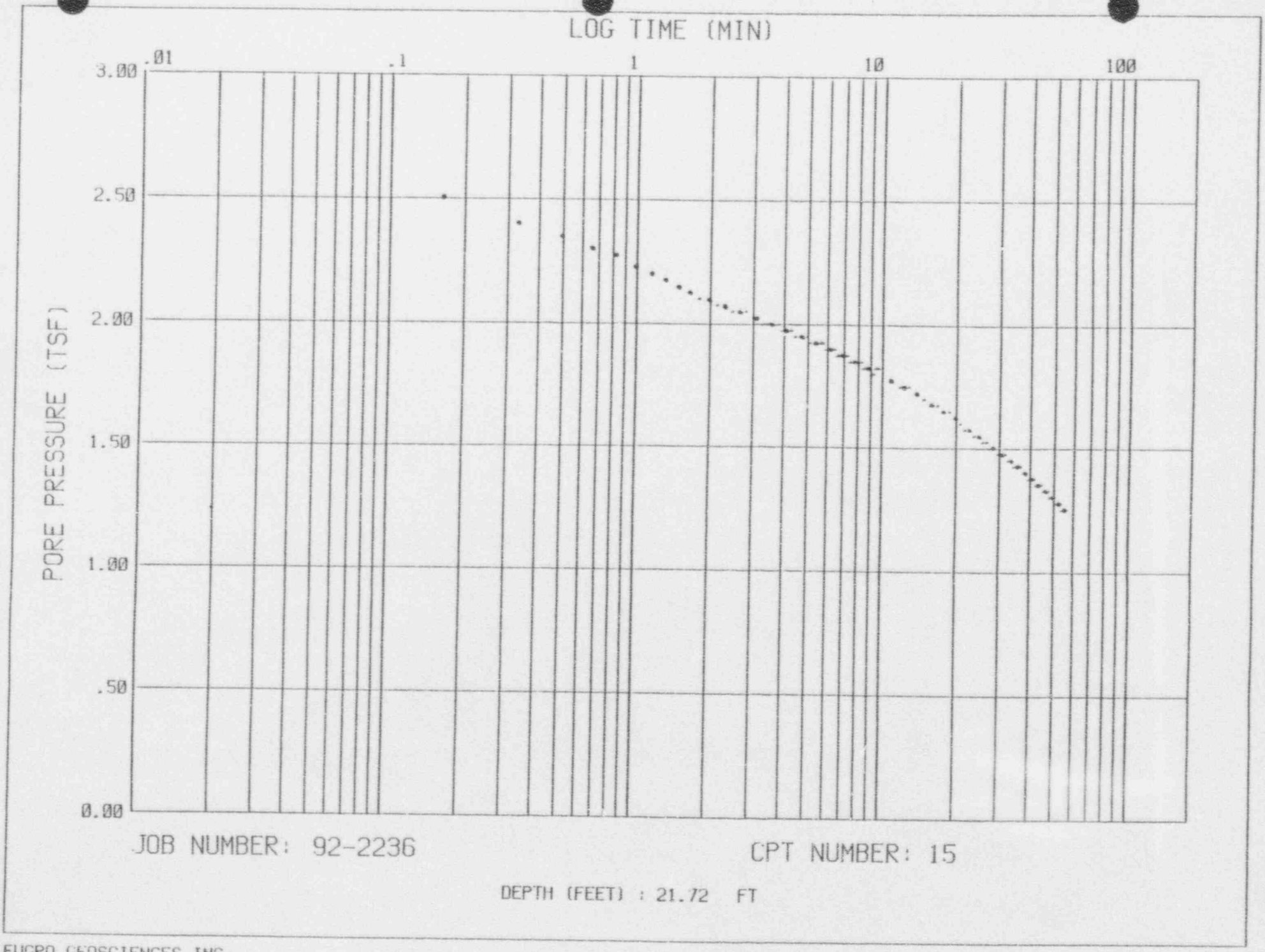
FUGRO GEOSCIENCES, INC



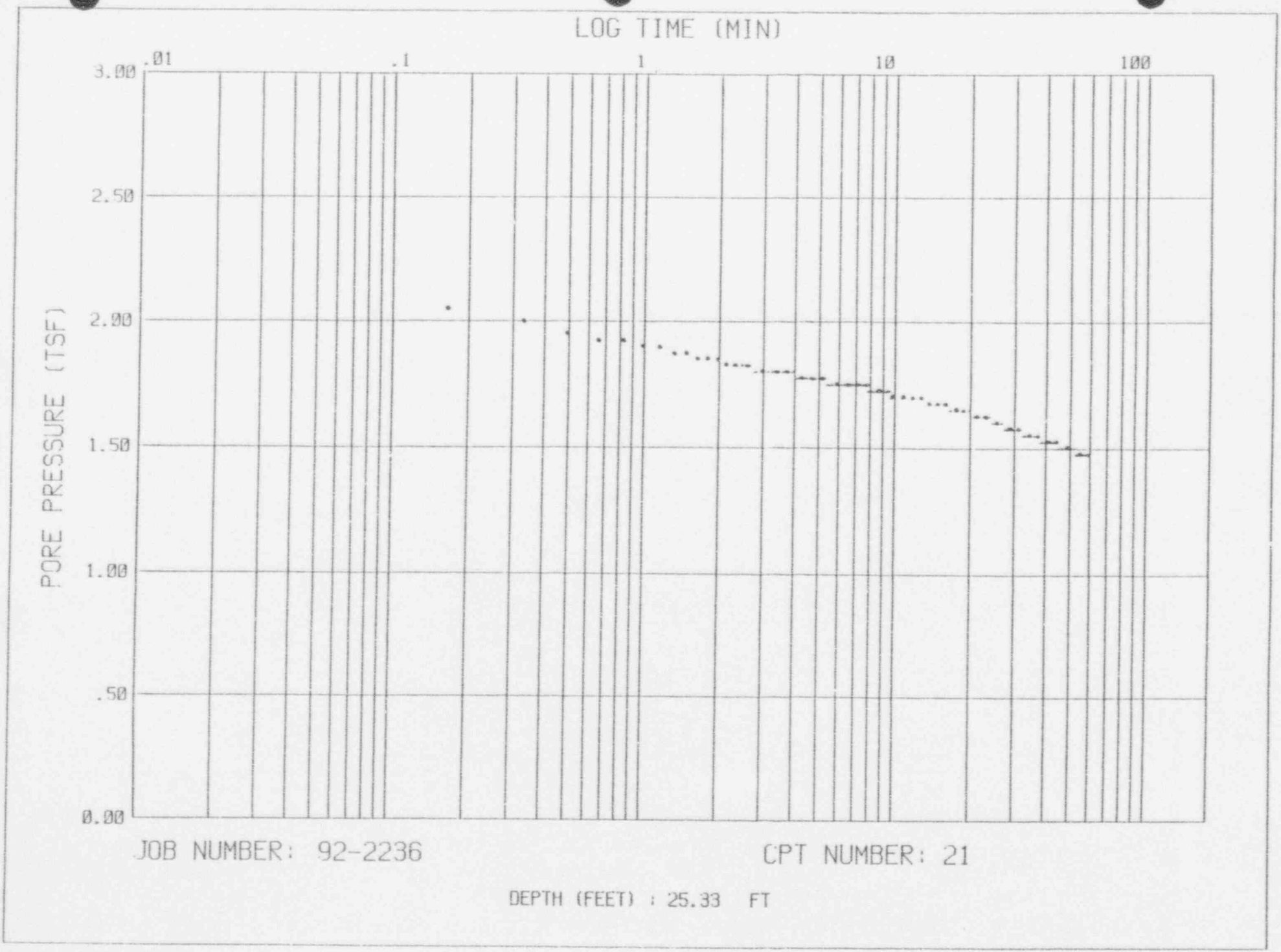
FUGRO GEOSCIENCES, INC



FUGRO GEOSCIENCES, INC

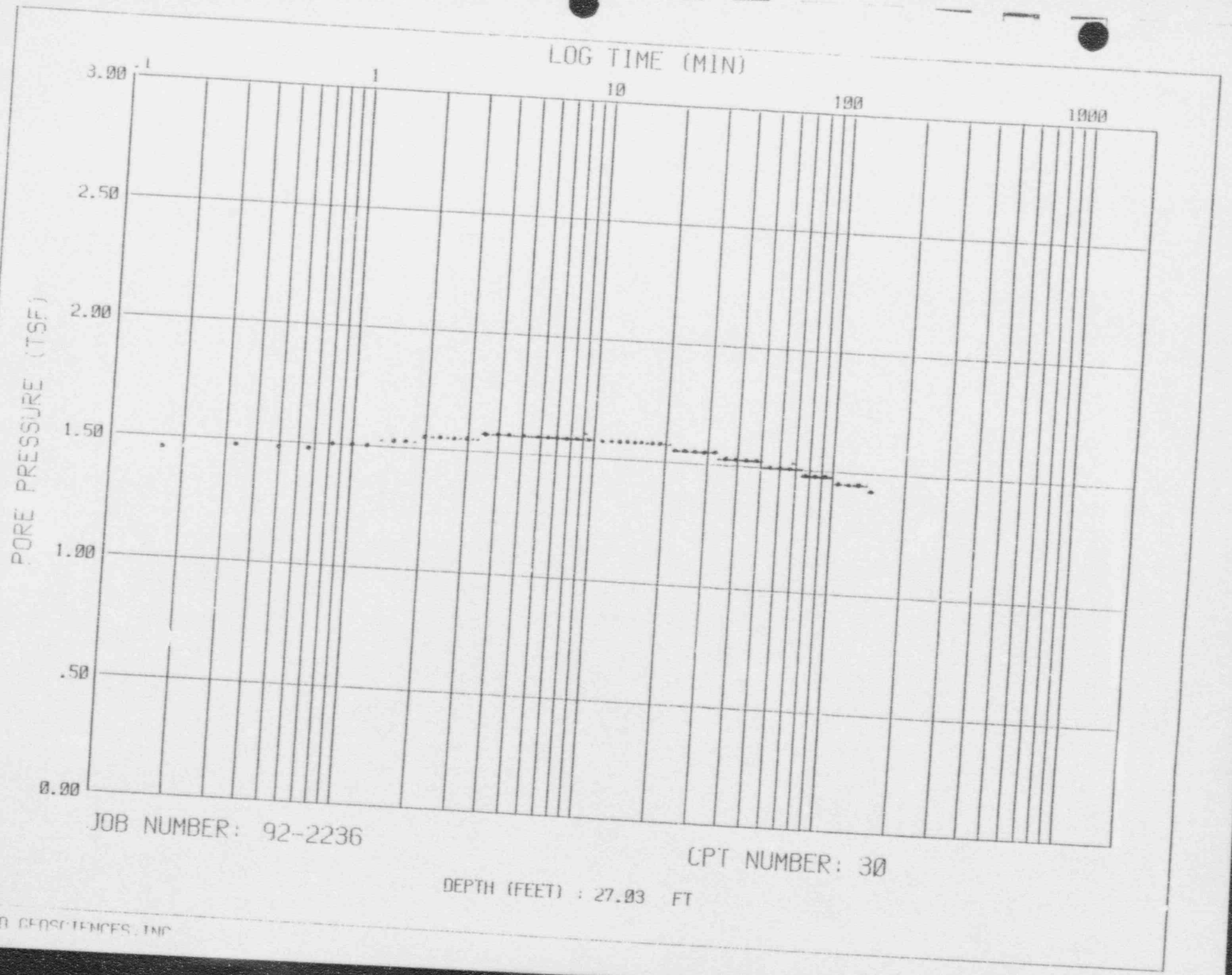


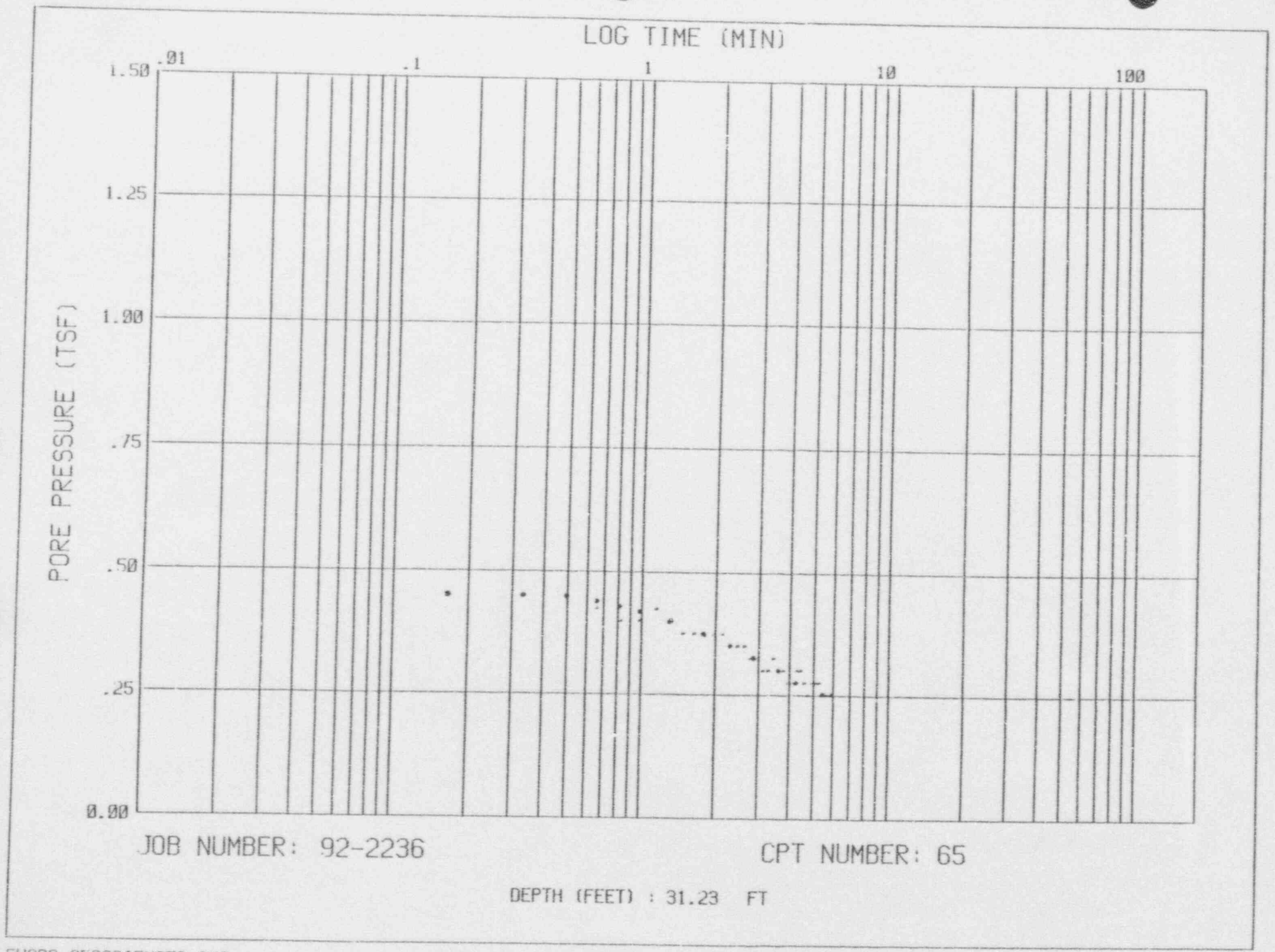
FUGRO GEOSCIENCES, INC



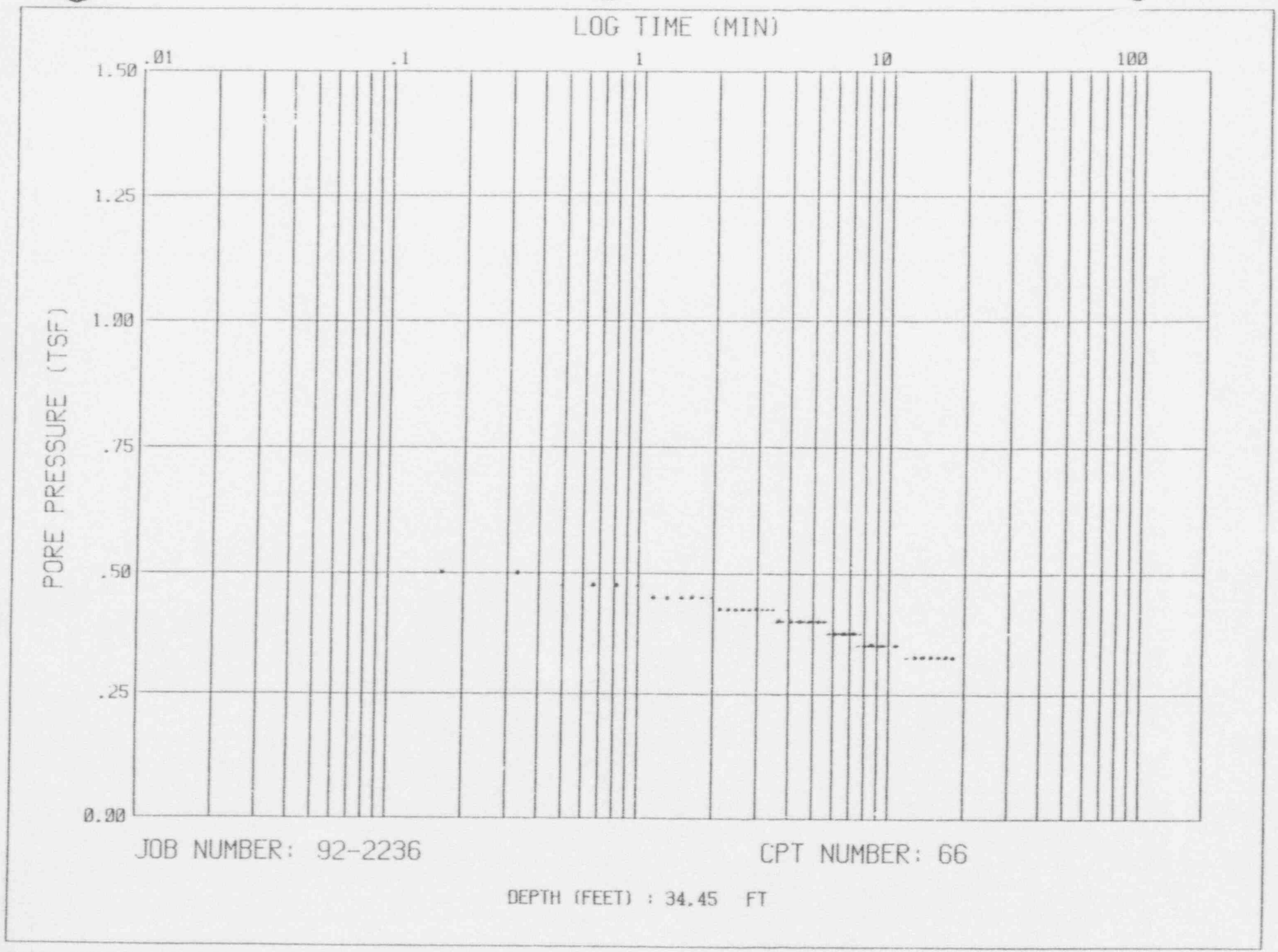
FUGRO GEOSCIENCES, INC

FUGRO GEOSCIENCES, INC


LOG TIME (MIN)
.1
1
10
100
1000
3.00
2.50
2.00
1.50
1.00
.50
0.00
PORE PRESSURE (TSF)
JOB NUMBER: 92-2236
CPT NUMBER: 30
DEPTH (FEET) : 27.03 FT
FUGRO GEOSCIENCES, INC



FUGRO GEOSCIENCES, INC



FUGRO GEOSCIENCES, INC

APPENDIX B

LABORATORY DATA

B.1 Introduction

The laboratory data obtained from the consolidation and index testing are presented in this appendix. The consolidation and e-log p curves generated for each of the samples tested are provided as well as the time-compression data. The dissipation tests from the piezocone testing are also included.

Ring height 1"
Diameter 2 1/2"

$55.3 \frac{lb}{Ft^3} \times \frac{453.592\,g}{lb} \times \frac{1\,Ft^3}{(12in)^3} \times \frac{1\,in^3}{16.387\,cm^3} = .8858\,gm/cm^3$

$W_s = .8858\,gm/cm^3 \times 2.54cm \times 31.7cm^2 = 71.3\,gm$

CONSOLIDATION TEST (Time–compression data) Data Sheet 15

Project S.M.I Job No.

Location of Project GRANTS, N.M Boring No. 13 Sample No. 1A

Description of Soil TAILINGS Depth of Sample

Tested By Date of Testing

Dry Density = 55.3 #/Ft³, Moisture = 74.5 %
-#200 = 71.1 LL = 48 P.I. = 29

Loading Test Data

Load 250 P.S.F. Load 500 P.S.F

Date applied Date applied

Applied by LH Applied by LH

Clock time and date	Elapsed time, min	*Dial readings x ____ Original	%
9:10:00	0	.700	0.0
	0.1 (6")	.6860	1.4
	0.25 (15")	.6850	1.5
	0.5 (30")	.6841	1.6
9:11	1	.6825	1.8
9:12	2	.6805	2.0
9:14	4	.6780	2.2
9:18	8	.6751	2.5
9:25	15	.6729	2.7
9:40	30	.6713	2.9
10:10	60	.6706	2.9
11:10	2 hrs	.6699	3.0
1:10	4	.6695	3.1
6:10	9	.6681	3.1
7:40	24 32½	.6682	3.2

Clock time and date	Elapsed time, min	Dial readings x ____ Original	%
7:40	0	.6682	3.2
	0.1	.6667	3.4
	0.25	.6651	3.5
	0.5	.6638	3.6
7:41	1	.6623	3.8
7:42	2	.6602	4.0
7:44	4	.6575	4.3
7:48	8	.6547	4.5
7:55	15	.6524	4.8
8:10	30	.6507	4.9
8:40	60	.6495	5.1
9:40	2 hrs	.6483	5.2
11:40	4	.6472	5.3
4:40	9	.6456	5.4
7:40	24	.6442	5.6

*Insert gage subdivisions 0.01" /div, etc.

CONSOLIDATION TEST (Time–compression data) Data Sheet 15

Project S.M.I Job No. SHEMI 920781 04702

Location of Project GRANTS, N.M. Boring No. 13 Sample No. 1A

Description of Soil TAILINGS Depth of Sample

Tested By LHM/JAL Date of Testing

Loading Test Data

Load 1000 P.S.F Load 2000 P.S.F

Date applied Date applied

Applied by LHM Applied by LHM

Clock time and date	Elapsed time, min	*Dial readings x ____ Original	%
8/27 7:40	0	.6442	5.6
	0.1 (6 sec)	.6403	6.0 ✓
	0.25 (15 sec)	.6383	6.2
	0.5 (30 sec)	.6363	6.4
7:41	1	.6334	6.7
7:42	2	.6298	7.0 ✓
7:44	4	.6254	7.5
7:48	8	.6209	7.9
7:55	15	.6175	8.3
8:10	30	.6147	8.5
8:40	60	.6128	8.7
9:40	2 hrs	.6112	8.9
11:40	4	.6095	9.1
4:40	9	.6071	9.3
8/28 7:40	24	.6041	9.6

Clock time and date	Elapsed time, min	Dial readings x ____ Original	%
8/28 7:40	0	.6041	9.6
	0.1	.5980	10.2
	0.25	.5952	10.5 ✓
	0.5	.5923	10.8
7:41	1	.5883	11.2
7:42	2	.5833	11.7 ✓
7:44	4	.5775	12.3
7:48	8	.5715	12.9
7:55	15	.5671	13.3
8:10	30	.5638	13.6
8:40	60	.5612	13.9
9:40		.5588	14.1
11:40		0.5568	14.3
4:40		.5542	14.6
8/29 7:40		.5517	14.8

*Insert gage subdivisions 0.01" /div, etc.

CONSOLIDATION TEST (Time–compression data) Data Sheet 15

Project S. MI Job No. SHEMI 920781 04702

Location of Project GRANTS, N. M. Boring No. 13 Sample No. 1A

Description of Soil TAILINGS Depth of Sample

Tested By LitM / JAL Date of Testing

Loading Test Data

Load 4000 P.S.F Load P.S.F

Date applied Date applied

Applied by LAM Applied by

Clock time and date	Elapsed time, min	*Dial readings x ____ Original	%	Clock time and date	Elapsed time, min	Dial readings x ____ Original	%
7:40	0	.5517	14.8		0		
	0.1 (6 sec)	.5462	15.4		0.1		
	0.25 (15)	.5430	15.7 ✓		0.25		
	0.5 (30)	.5397	16.0		0.5		
7:41	1	.5355	16.5 ✓		1		
7:42	2	.5305	17.0		2		
7:44	4	.5252	17.5		4		
7:48	8	.5189	18.1		8		
7:55	15	.5148	18.5		15		
8:10	30	.5117	18.8		30		
8:40	60	.5092	19.1		30		
9:40	2 hrs	.5067	19.3				
11:40	4	.5048	19.5				
4:40	9	.5023	19.8				
7:40	24	.4993	20.1				

*Insert gage subdivisions 0.01" /div, etc.

LANDMARK LABORATORIES LTD.

CLIENT Shepherd Miller, Inc. SAMPLE IDENT. #13

PROJECT Grants N.M. - Tailings - SHEMI-92089F-05-702 DATE 8-25-92

MOISTURE PERCENT

271.2	Wet Wt. & Pan	MATERIAL Lean Clay With Sand	TEST NO.
204.5	Dry Wt. & Pan	CLASSIFICATION (CL)	
96.1	Tare Pan	PIT NAME	
66.7	Loss	AREA REP.	TEST BY LAM
108.4	Dry Weight	SAMPLED BY Client	
61.5	% Moisture		

GRADATION DATA

Sieve Size	Grs.	Retained %	Passing %	Specs.
#200	31.3	28.9	71.1	

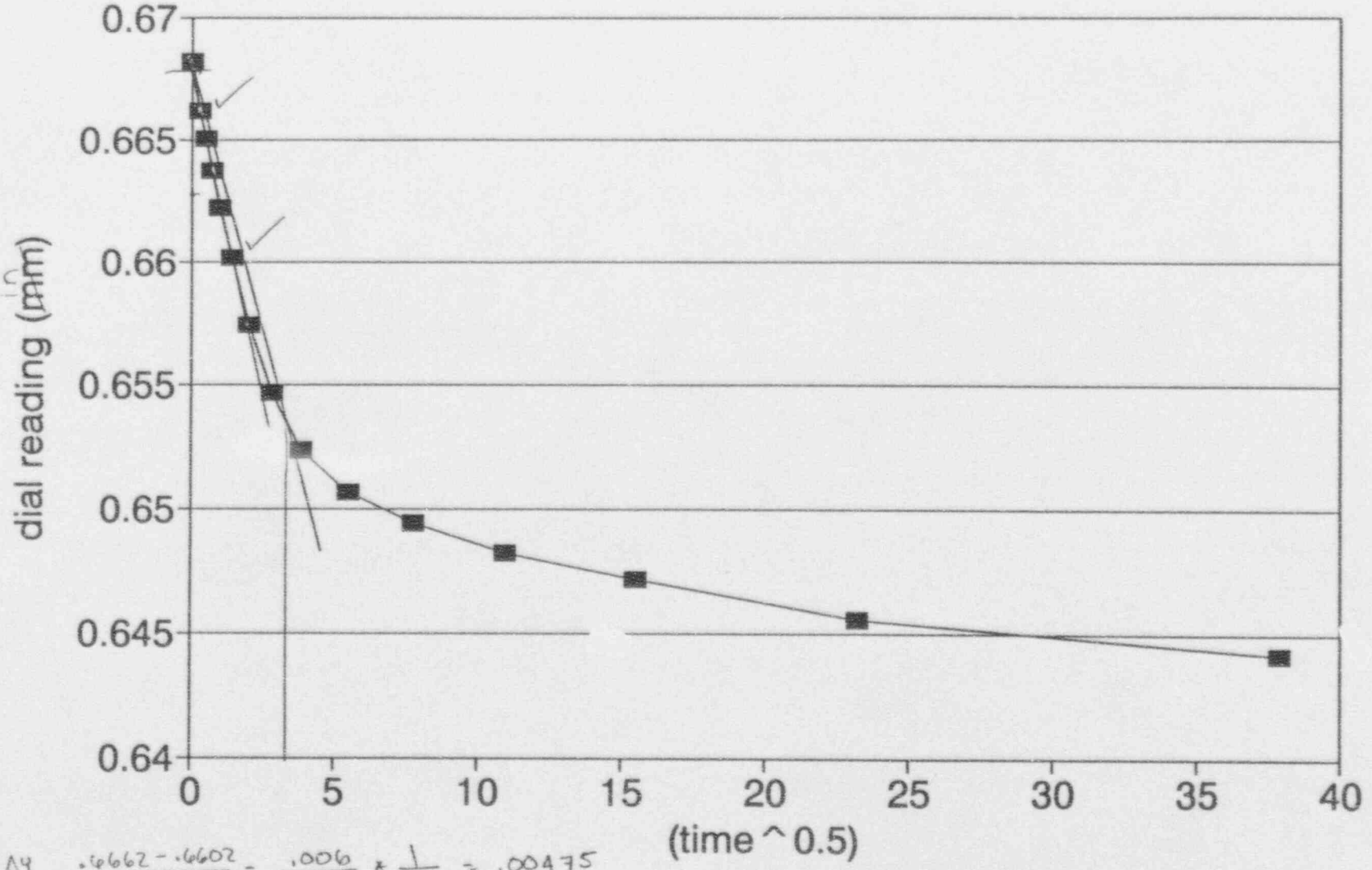
PLASTICITY INDEX

LIQUID LIMIT (LL) = 48

PLASTIC LIMIT (PL) = 19

Sample 1A

Load = 500 psf



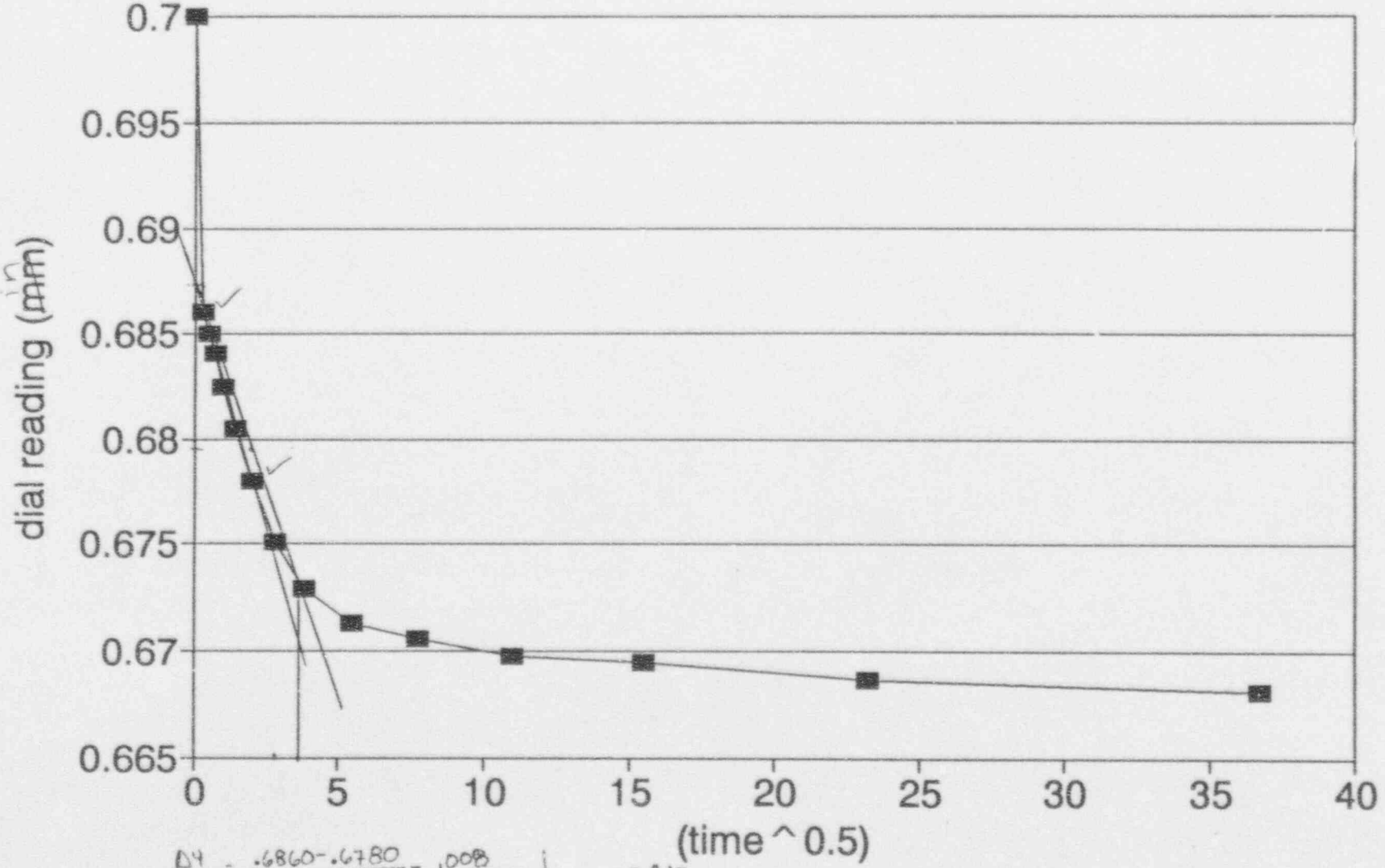
$\frac{\Delta y}{\Delta x} = \frac{.6662 - .6602}{\sqrt{.1} - \sqrt{2}} = \frac{.006}{1.098} \times \frac{1}{1.15} = .00475$

$T_{90} = (3.5)^2 = 12.25 \text{ min}$

$C_v = \frac{.848 (.5 \text{ in})^2}{12.25 \text{ min}} \times \frac{\text{min}}{60 \text{ sec}} \times \frac{2.54^2 \text{ cm}^2}{\text{in}^2} = .00186 \text{ cm}^2/\text{sec}$

Sample 1A

Load = 250 psf



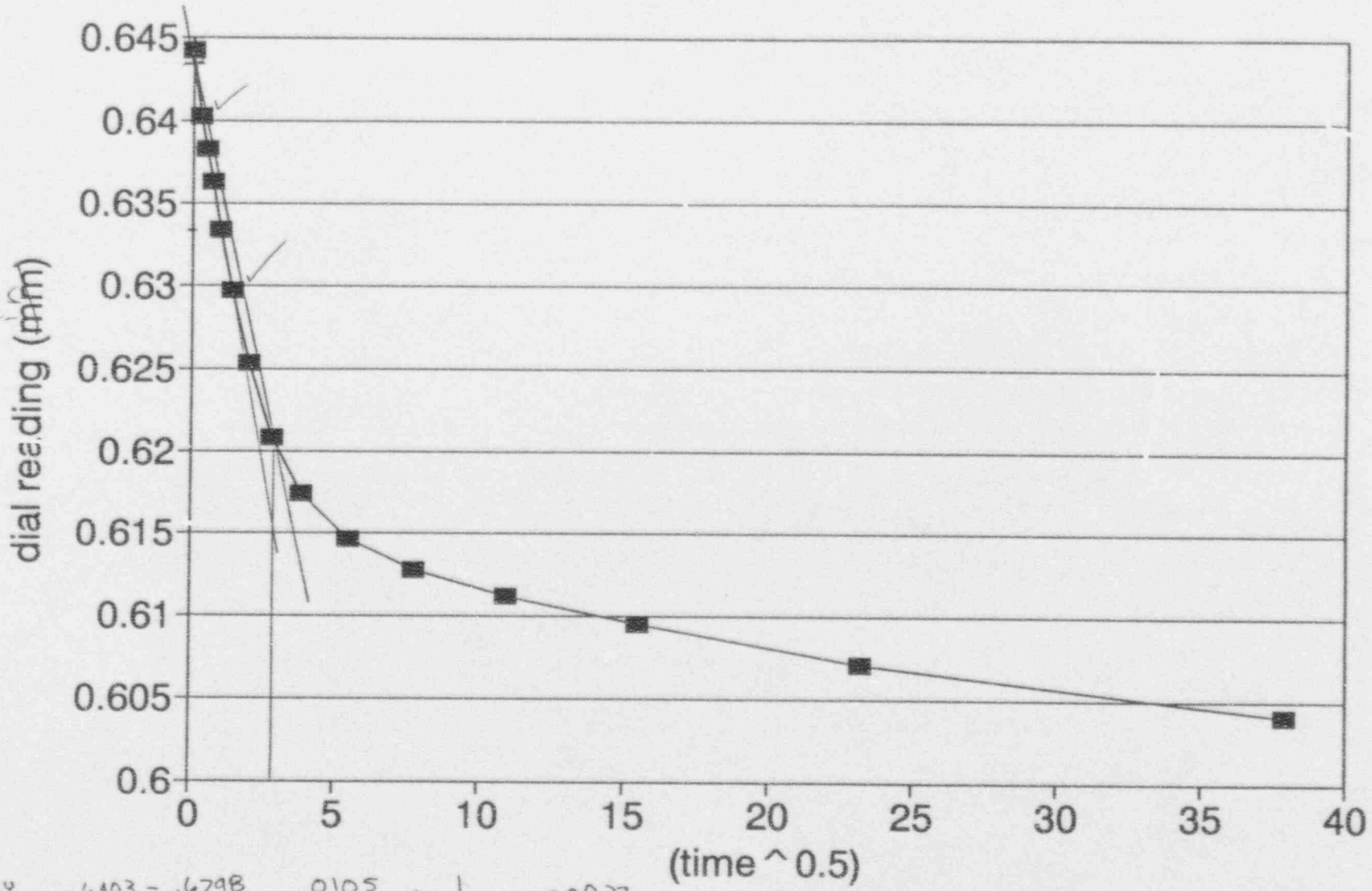
$\frac{\Delta y}{\Delta x} = \frac{.6860 - .6780}{\sqrt{1.1} - \sqrt{1.4}} = \frac{.008}{1.684} * \frac{1}{1.15} = .00413$

$T_{90} = (3.6)^2 = 13 \text{ min}$

$C_v = \frac{.848(.5\text{in})^2}{(13\text{min})} = .01631 \frac{\text{in}^2}{\text{min}} \left| \frac{\text{min}}{60\text{sec}} \right| \frac{(2.54\text{cm})^2}{\text{in}^2} = .00175 \text{ cm}^2/\text{sec}$

Sample 1A

Load = 1000 psf



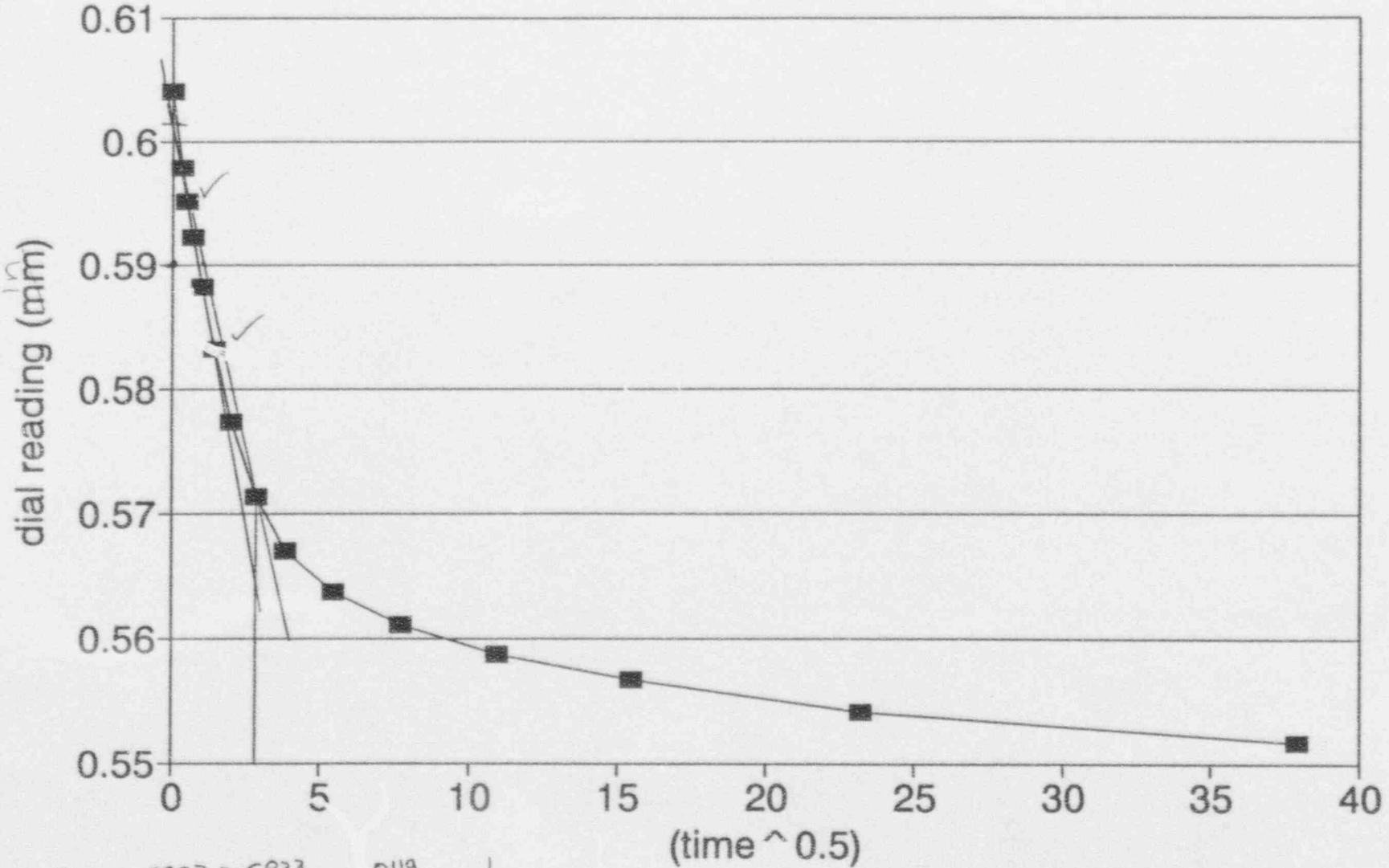
$\frac{\Delta y}{\Delta x} = \frac{.6403 - .6298}{\sqrt{.1} - \sqrt{.2}} = \frac{.0105}{1.098} * \frac{1}{1.15} = .00832$

$T_{cm} = (.28)^2 = 8.0 \text{ min}$

$C_y = \frac{.848(.5\text{in})^2}{60\text{sec}} \Big| \frac{\min}{(2.54\text{cm})^2} \Big| \frac{}{\text{in}^2} = .00285 \text{ cm}^2/\text{sec}$

Sample 1A

Load = 2000 psf



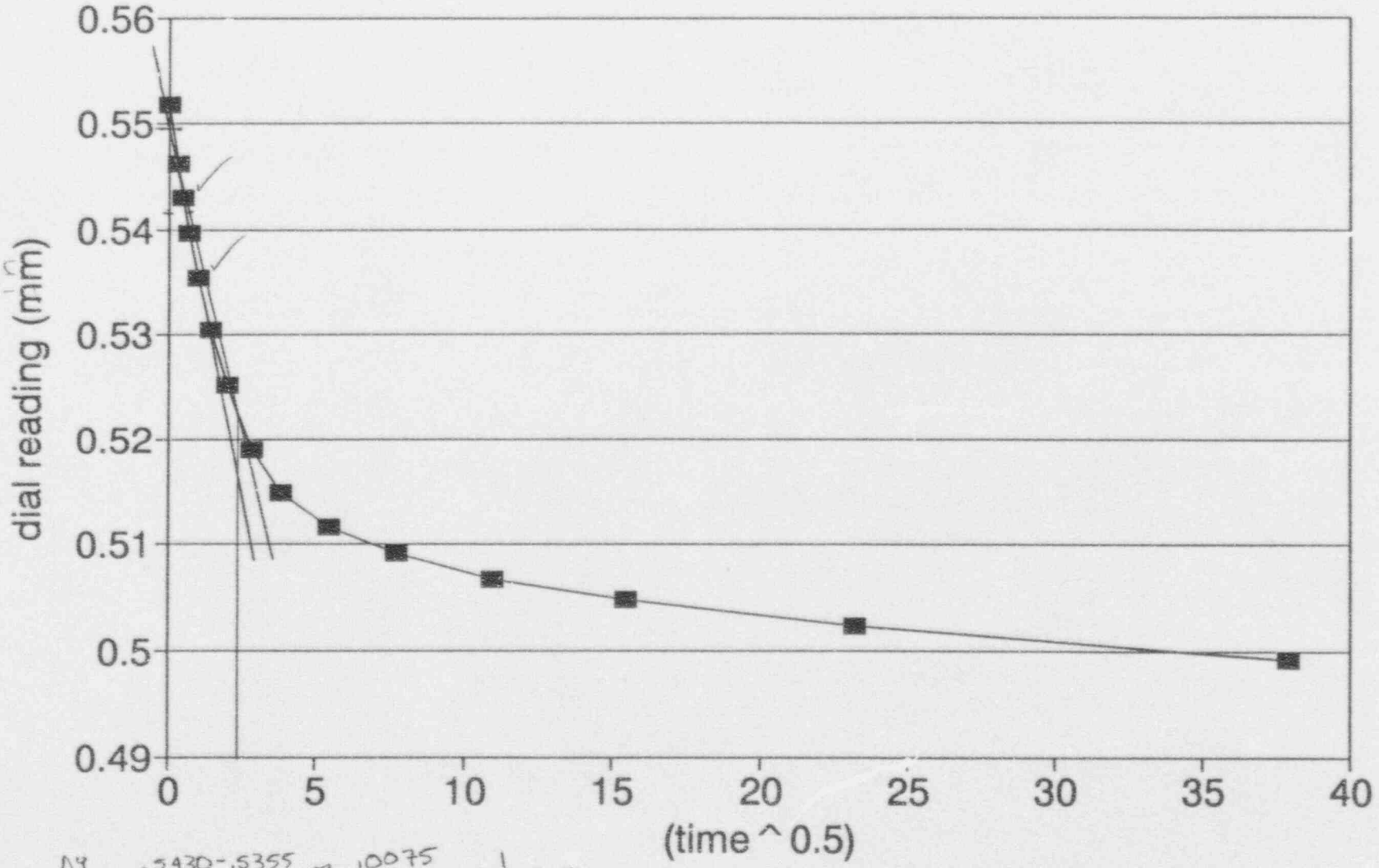
$\frac{\Delta y}{\Delta x} = \frac{.5952 - .5833}{\sqrt{1.25} - \sqrt{2}} \neq \frac{.0119}{.91} * \frac{1}{1.15} = .01137$

$T_{90} \neq (2.7)^2 = 7.3 \text{ min}$

$C_v = \frac{.848(.5\text{in})^2}{7.3\text{min}} \left| \frac{\text{min}}{60\text{sec}} \right| \frac{(2.54\text{cm})^2}{\text{in}^2} = .00312 \text{ cm}^2/\text{sec}$

Sample 1A

Load = 4000 psf



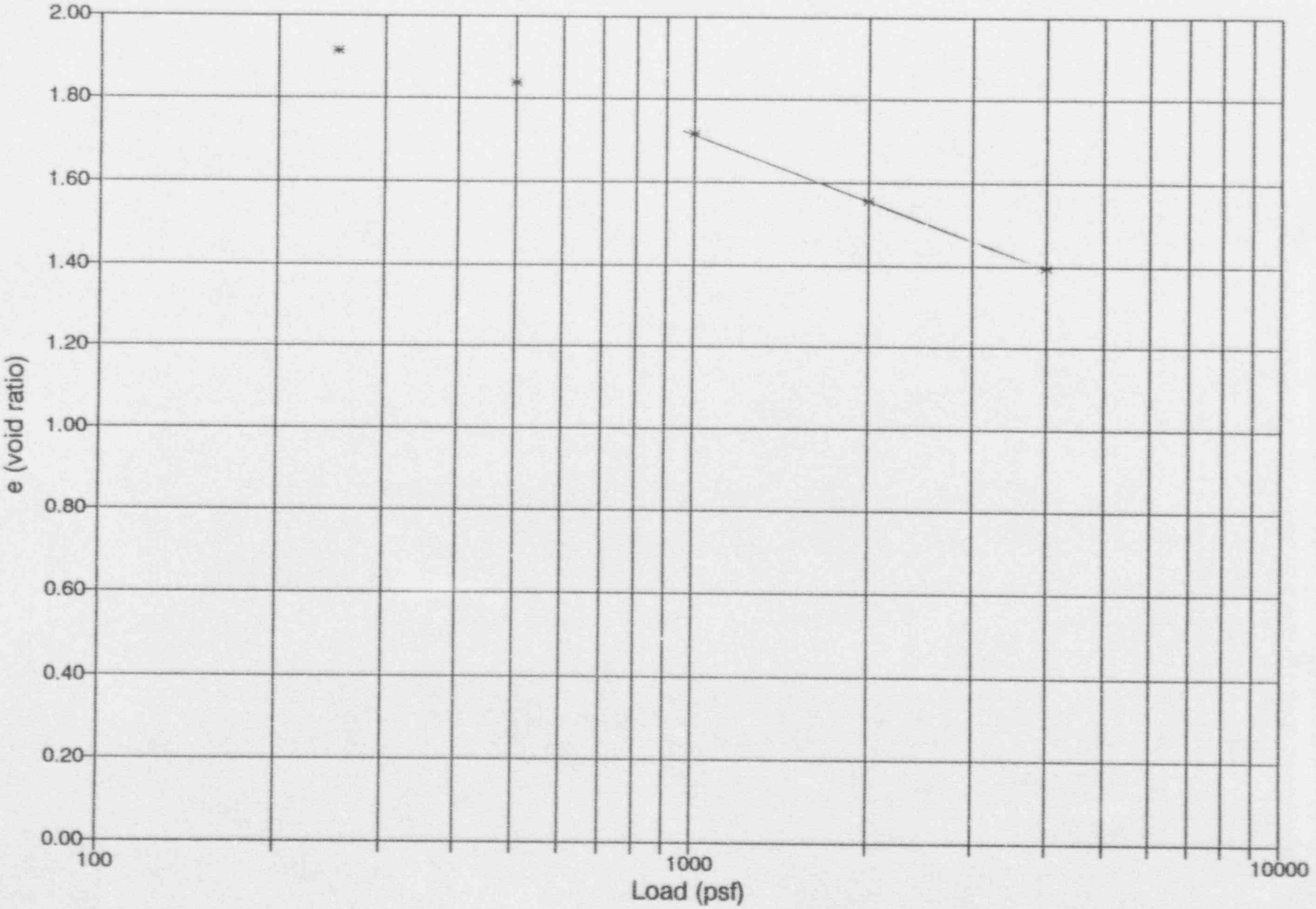
$\frac{\Delta y}{\Delta x} = \frac{.5430 - .5355}{\sqrt{1.25} - \sqrt{1}} = \frac{.0075}{.5} \times \frac{1}{1.15} =$

$T_{90} = (2.4)^2 = 5.8 \text{ min}$

$C_v = \frac{.848(.5\text{in})^2}{5.8\text{ min}} \left| \frac{\text{min}}{60\text{ sec}} \right| \frac{}{(2.54\text{cm})^2} = .00393 \text{ cm}^2/\text{sec}$

Sample 1A

e vs log P



$C_c = \frac{\Delta e}{\Delta \log P} = \frac{1.558 - 1.398}{\log 2000 - \log 4000} = .53$

$46.3 \frac{lb}{ft^3} \times \frac{453.592 gm}{1 lb} \times \frac{1 ft^3}{(12 in)^3} \times \frac{1 in^3}{16.387 cm^3} = .74166 \frac{gm}{cm^3}$

$W_s = .74166 \times 2.54 \times 31.7$

$= 59.7 gm$

CONSOLIDATION TEST (Time–compression data) **Data Sheet 15**

Project S. M. I Job No.

Location of Project GRANTS N.M. Boring No. 20 Sample No. 2A

Description of Soil TAILINGS Depth of Sample

Tested By Date of Testing

Dry Density = 46.3 #/ft3, moisture = 96.8 %

-#200 = 97.4 LL = 83 P.I = 53

Loading Test Data

Load 250 Load 500

Date applied Date applied

Applied by Author Applied by Author

Clock time and date	Elapsed time, min	*Dial readings x ____ Original	%	Clock time and date	Elapsed time min	Dial readings x ____ Original	%
8-25 9:15:00	0	.700	0.0	8/26 7:45	0	.6626	3.7
	0.1 (6s)	.6926	0.7 ✓		0.1 (6s)	.6595	4.1 ✓
	0.25 (15)	.6907	0.9		0.25 (15)	.6584	4.2
	0.5 (30)	.6890	1.1		0.5 (30)	.6570	4.3
9:16	1	.6865	1.4	7:46	1	.6552	4.5
9:17	2	.6833	1.7 ✓	7:47	2	.6526	4.7 ✓
9:19	4	.6798	2.0	7:49	4	.6494	5.1
9:23	8	.6759	2.4	7:53	8	.6455	5.4
9:30	15	.6725	2.7	8:00	15	.6421	5.8
9:45	30	.6700	3.0	8:15	30	.6389	6.1
10:15	60	.6681	3.2	8:45	60	.6363	6.4
11:15	2 hrs	.6663	3.4	9:45	2 hrs	.6337	6.6
1:15	4	.6653	3.5	11:45	4	.6310	6.9
6:15	9	.6638	3.6	4:15	9	.6282	7.2
8/26 7:45	~~24~~ 22½	.6626	3.7 8/22	7:45	24	.6253	7.5

*Insert gage subdivisions 0.01 " /div, etc.

CONSOLIDATION TEST (Time–compression data) Data Sheet 15

Project S. MI Job No. SHEMI 92078I 04702

Location of Project GRANTS, N.M. Boring No. 20 Sample No. 2A

Description of Soil TAILINGS Depth of Sample

Tested By LHM/JAL Date of Testing

Loading Test Data

Load 1000 P.S.F Load 2000 P.S.F

Date applied Date applied

Applied by LHM Applied by LHM

Clock time and date	Elapsed time, min	*Dial readings x ____ Original	%	Clock time and date	Elapsed time, min	Dial readings x ____ Original	%
8/27 7:45	0	.6253	7.5	8/28 7:45	0	.5658	13.4
	0.1 (6 sec)	.6217	7.8 ✓		0.1	.5615	13.9 ✓
	0.25 (15 sec)	.6200	8.0		0.25	.5593	14.1
	0.5 (30)	.6180	8.2		0.5	.5567	14.3
7:46	1	.6151	8.5	7:46	1	.5529	14.7
7:47	2	.6110	8.9	7:47	2	.5467	15.3
7:49	4	.6053	9.5 ✓	7:49	4	.5402	16.0 ✓
7:53	8	.5984	10.2	7:53	8	.5314	16.9
8:00	15	.5922	10.8	8:00	15	.5232	17.7
8:15	30	.5861	11.4	8:15	30	5158	18.4
8:45	60	.5813	11.9	8:45	60	5100	19.0
9:45	2 hrs	.5778	12.2	9:45	2hrs	.5051	19.5
11:45	4	.5739	12.6	11:45	4	0.5010	19.9
4:45	9	.5697	13.0	4:45	9	.4963	20.4
8/28 7:45	24	.5658	13.4	8/29 7:45	24	.4917	20.8

*Insert gage subdivisions 0.01" /div, etc.

CONSOLIDATION TEST (Time–compression data) Data Sheet 15

Project S.M.I. Job No. SHEMI 92078I 04702

Location of Project GRANTS, N.M. Boring No. 20 Sample No. 2A

Description of Soil TAILINGS Depth of Sample

Tested By LH/JAL Date of Testing

Loading Test Data

Load 4000 P.S.F Load P.S.F

Date applied Date applied

Applied by LH Applied by

Clock time and date	Elapsed time, min	*Dial readings x	
		Original	%
7:45	0	.4917	20.3
	0.1 (6 sec)	.4880	21.2
	0.25 (15 sec)	.4858	21.4
	0.5 (30 sec)	.4829	21.7
7:46	1	.4790	22.1
7:47	2	.4739	22.6
7:49	4	.4671	23.3
7:53	8	.4600	24.0
8:00	15	.4517	24.8
8:15	30	.4442	25.6
8:45	60	.4380	26.2
9:45	2 hrs	.4326	26.7
11:45	4	.4288	27.1
4:45	9	.4238	27.6
7:45	24	.4193	28.1

Clock time and date	Elapsed time, min	Dial readings x	
		Original	%
	0		
	0.1		
	0.25		
	0.5		
	1		
	2		
	4		
	8		
	15		
	30		
	60		

*Insert gage subdivisions 0.01" /div, etc.

LANDMARK LABORATORIES LTD.

CLIENT Shepherd Miller, Inc. SAMPLE IDENT. #20

PROJECT Grants N.M. - Tailings - SHEMI-92089F-05-702 DATE 8-25-92

MOISTURE PERCENT

220.9	Wet Wt. & Pan	MATERIAL Fat Clay	TEST NO.
158.5	Dry Wt. & Pan	CLASSIFICATION (CH)	
95.8	Tare Pan C4	PIT NAME	
62.4	Loss	AREA REP.	TEST BY LAM
62.7	Dry Weight	SAMPLED BY Client	
99.5	% Moisture		

GRADATION DATA

Sieve Size	Grs.	Retained %	Passing %	Specs.
#200	1.6	2.6	97.4	

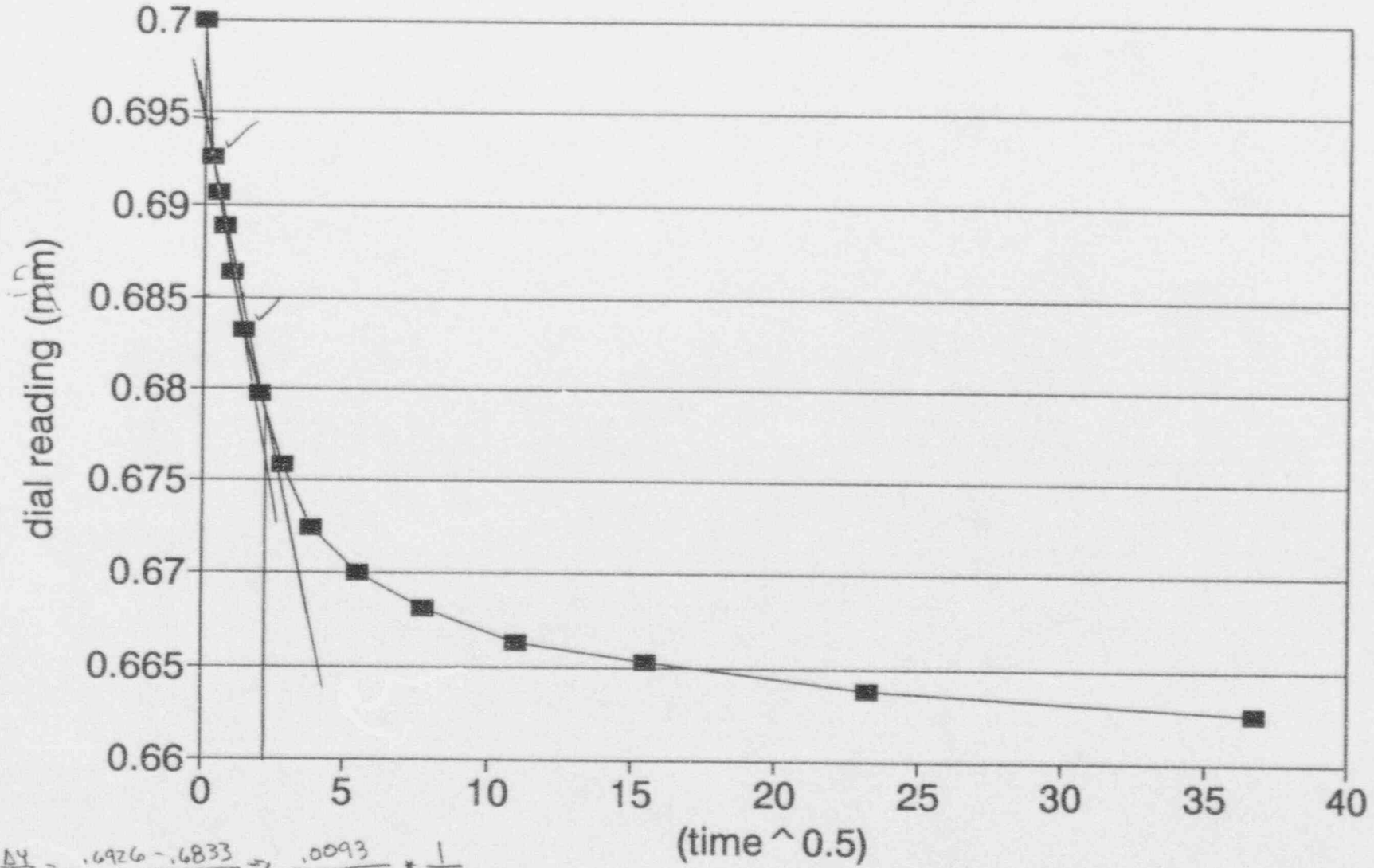
PLASTICITY INDEX

LIQUID LIMIT (LL) = 83

PLASTIC LIMIT (PL) = 30

Sample 2A

Load = 250 psf



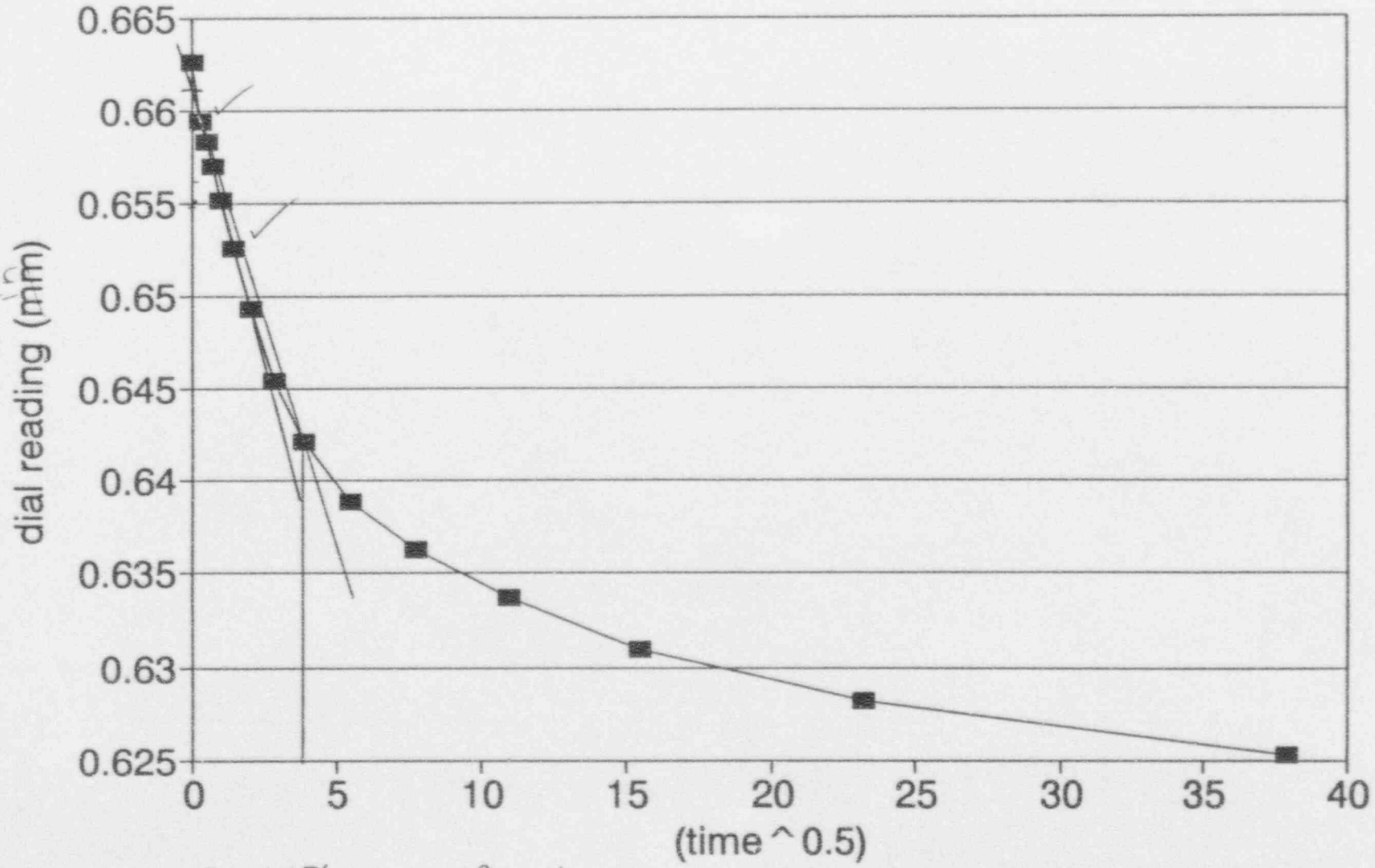
$\frac{\Delta y}{\Delta x} = \frac{.6926 - .6833}{\sqrt{.1} - \sqrt{2}} \Rightarrow \frac{.0093}{1.097} * \frac{1}{1.15}$

$T_{90} = (2.3^2) = 5.3\text{min}$

$C_y = \frac{.848(.5\text{in})^2}{5.3\text{min}} \left| \frac{\text{min}}{60\text{sec}} \right| \frac{(2.54\text{cm})^2}{\text{in}^2} = .00430\,\text{cm}^2/\text{sec}$

Sample 2A

Load = 500 psf



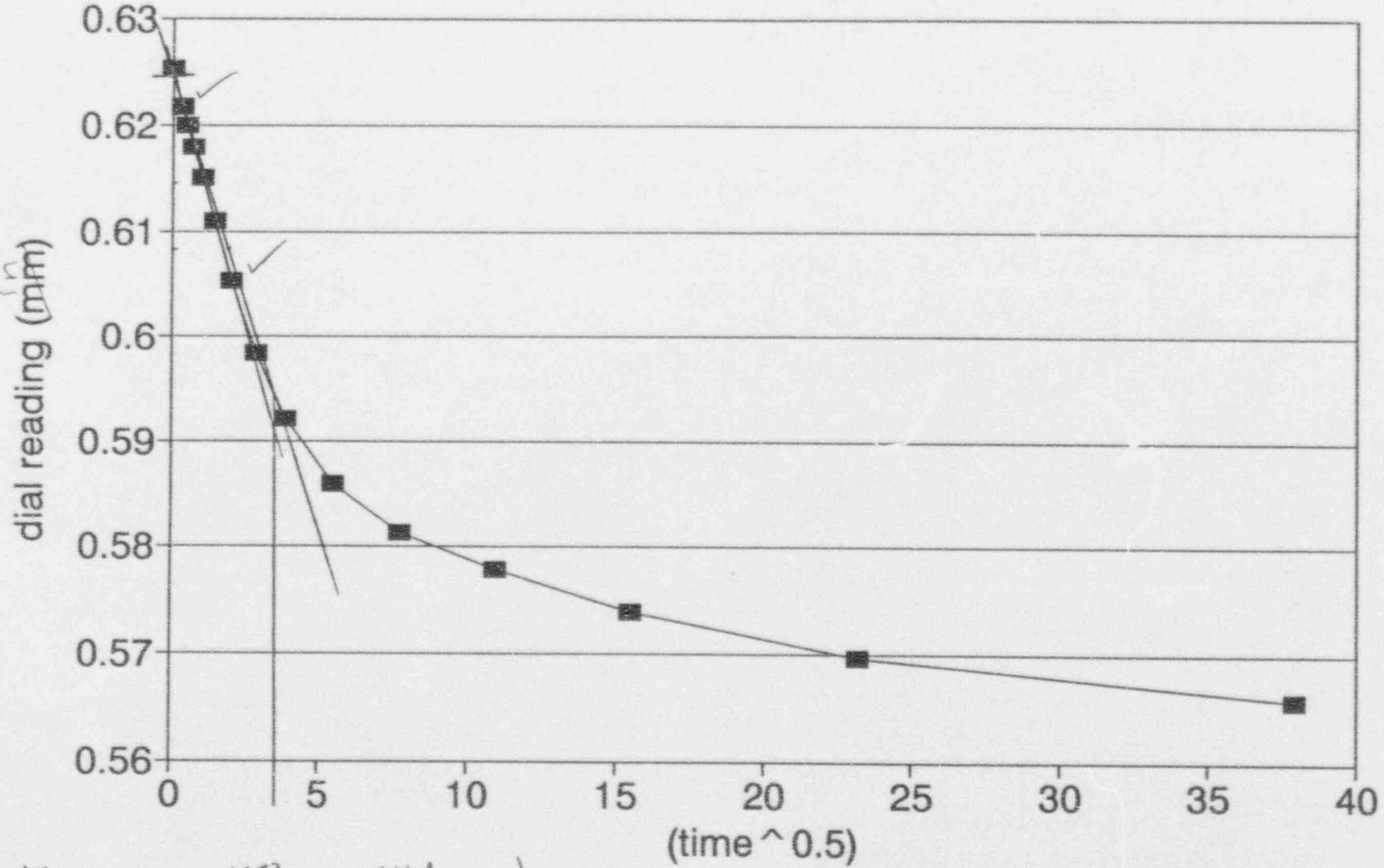
$\frac{\Delta y}{\Delta x} = \frac{.6595 - .6526}{\sqrt{01} - \sqrt{2}} \Rightarrow \frac{.0069}{1.097} \times \frac{1}{1.15}$

$T_{90} = (3.3)^2 = 10.9 \text{ min}$

$C_v = \frac{.848(.5\text{in})^2}{10.9\text{ min}} \left| \frac{\text{min}}{60\text{sec}} \right| \frac{(2.54\text{cm})^2}{\text{in}^2} = .00209 \text{ cm}^2/\text{sec}$

Sample 2A

Load = 1000 psf



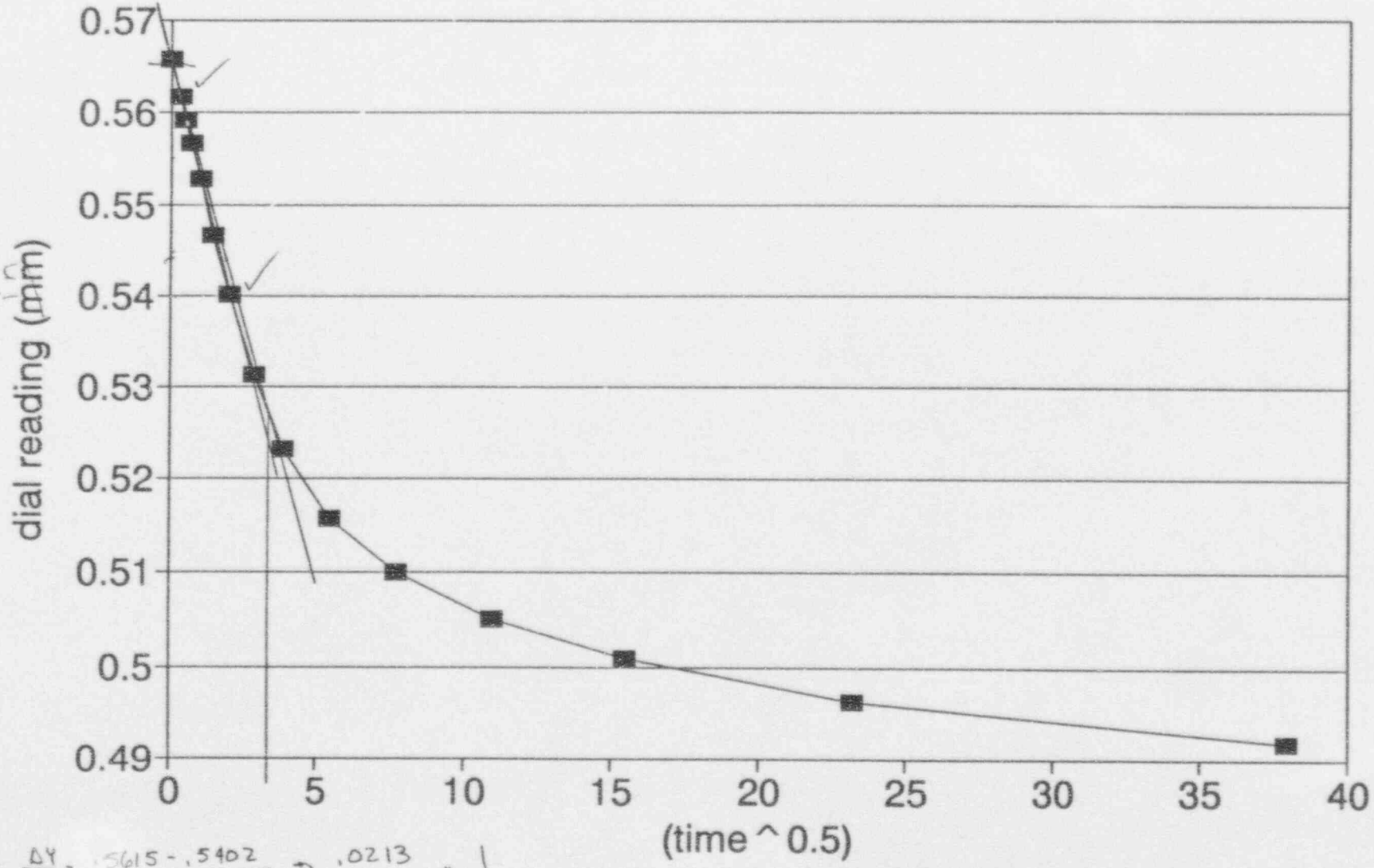
$\frac{\Delta y}{\Delta x} = \frac{.6217 - .6053}{\sqrt{.1} - \sqrt{4}} \Rightarrow \frac{.0164}{1.684} \times \frac{1}{1.15}$

$C_v = \frac{.848(.5in)^2}{13.7min} \left| \frac{min}{60sec} \right| \frac{(2.54cm)^2}{in^2} = .00166\ cm^2/sec$

$T_{50} = (.71)^2 = 13.7\ min$

Sample 2A

Load = 2000 psf



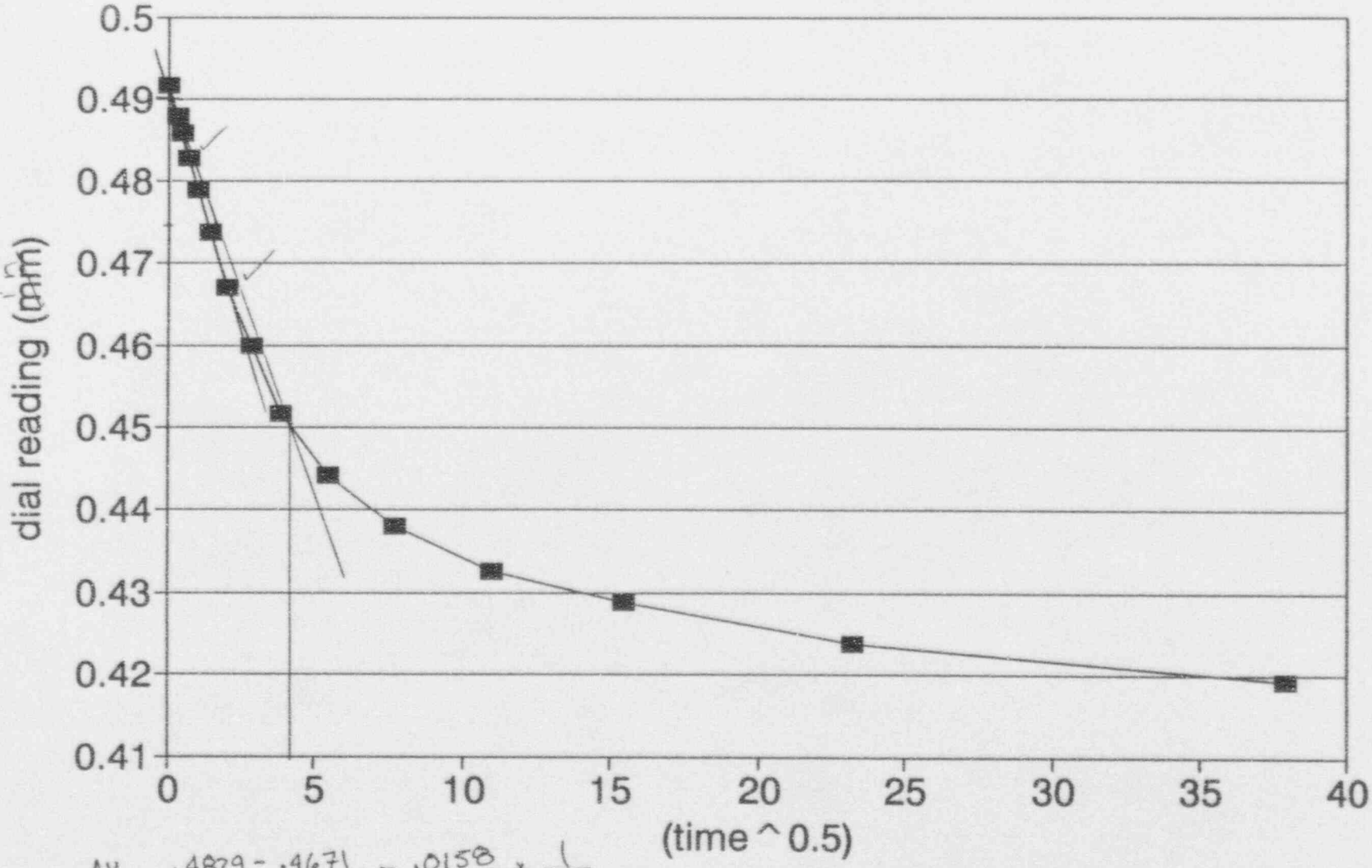
$\frac{\Delta Y}{\Delta X} = \frac{.5615 - .5402}{\sqrt{.1} - \sqrt{4}} \Rightarrow \frac{.0213}{1.684} * \frac{1}{1.15}$

$T_{90} = (3.3)^2 = 10.9 \text{ min}$

$C_V = \frac{.848 (1.5 \text{ in})^2}{10.9} \left| \frac{\text{min}}{60 \text{ sec}} \right| \frac{(2.54 \text{ cm})^2}{1 \text{ in}^2} = .00209 \text{ cm}^2/\text{sec}$

Sample 2A

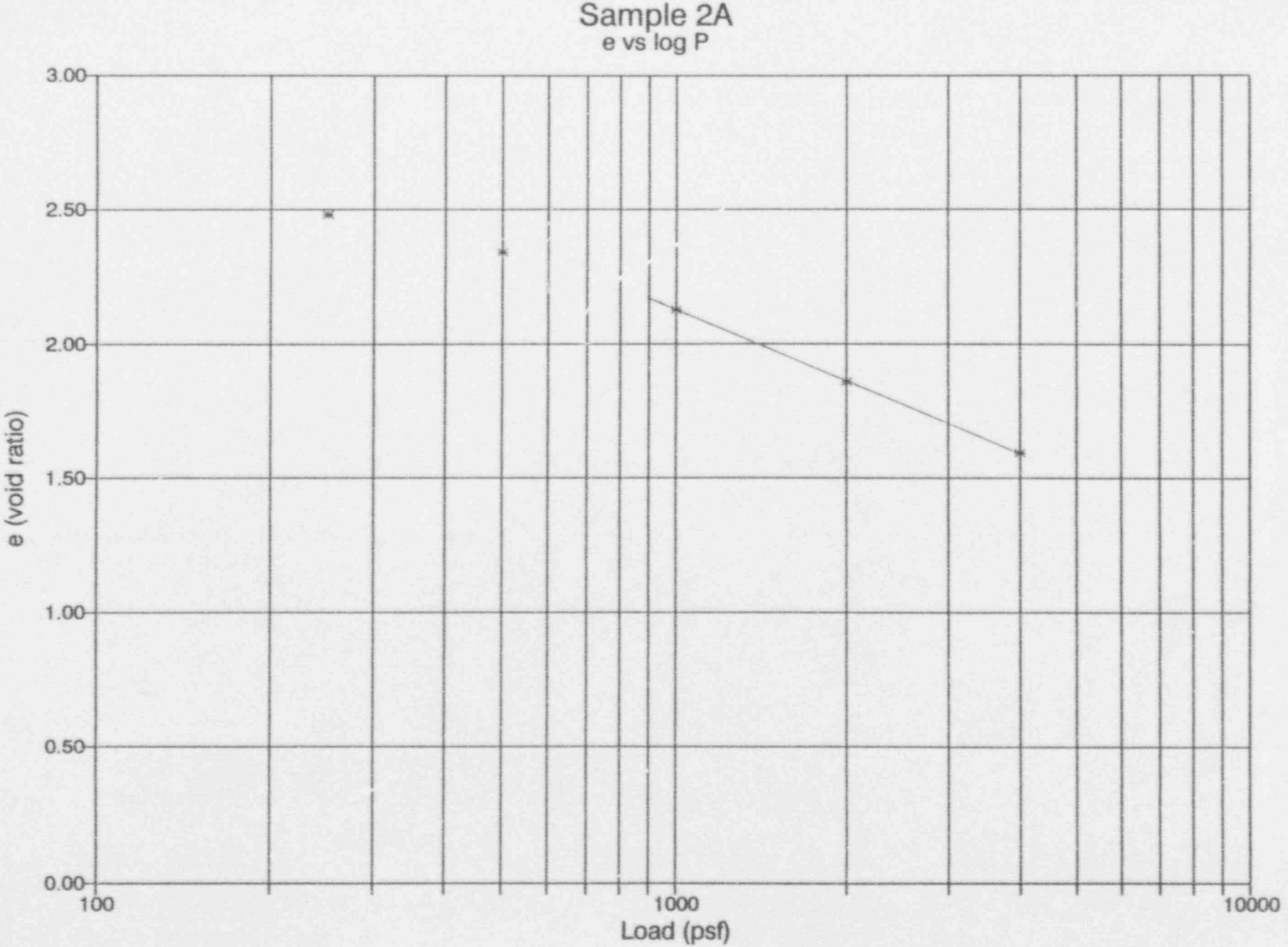
Load = 4000 psf



$\frac{\Delta Y}{\Delta X} = \frac{.4829 - .4671}{\sqrt{.5} - \sqrt{4}} = \frac{.0158}{1.293} \times \frac{1}{1.15}$

$T_{90} = (3.7)^2 = 13.7 \text{ min}$

$C_v = \frac{.848(.5\text{in})^2}{13.7 \text{ min}} \left| \frac{\text{min}}{60 \text{ sec}} \right| \frac{(2.54 \text{ cm})^2}{\text{in}^2} = .00166 \text{ cm}^2/\text{sec}$



$C_c = \frac{-\Delta e}{\Delta \log P} = \frac{1.854 - 1.59}{\log 2000 - \log 1000} = .877$

$44.1 \frac{lb}{ft^3} * \frac{453.592\ g}{lb} * \frac{1\ ft^3}{(12\ in)^3} * \frac{1\ in^3}{16.387\ cm^3} = .7064 \frac{gm}{cm^3}$

CONSOLIDATION TEST (Time–compression data) $W_g = .7064 * 2.54 * 31.7 = 56.87\ gm$ **Data Sheet 15**

Project S.M.I. Job No.

Location of Project GRANTS, N.M. Boring No. 7 Sample No. 3A

Description of Soil TAILINGS Depth of Sample

Tested By Lthm Date of Testing

Dry Density = 44.1 #/ft3, Moisture = 105.1 %
-#200 = 95.4 LL = 70 PI = 42

Loading Test Data

Load 250 P.S.F. Load 500 P.S.F

Date applied Date applied

Applied by Lthm Applied by Lthm

Clock time and date	Elapsed time, min	*Dial readings x ____ Original	%	Clock time and date	Elapsed time, min	Dial readings x ____ Original	%
8-25 9:05:00	0	.700	0.0	8/26 7:35	0	.6431	5.7
	0.1 (6 sec)	.692	0.8 ✓		0.1 6	.6398	6.0 ✓
	0.25 (15)	.690	1.0		0.25 15	.6378	6.2
	0.5 (30)	.6876	1.2		0.5 30	6358	6.4
9:06	1	.6842	1.6	7:36	1	.6341	6.6
9:07	2	.6796	2.0	7:37	2	.6270	7.3 ✓
9:09	4	.6738	2.7 ✓	7:39	4	.6222	7.8
9:13	8	.6656	3.4	7:43	8	.6162	8.4
9:20	15	.6588	4.1	7:50	15	.6108	8.9
9:35	30	.6532	4.7	8:05	30	.6051	9.4
10:05	60	.6497	5.0	8:35	60	.6017	9.8
11:05	2 hrs	.6472	5.3	9:35	2 hrs	.5981	10.2
1:05	4	.6456	5.4	11:35	4	.5933	10.7
6.05	9	.6443	5.6	4:35	9	.5894	11.1
8/26 7:35	~~24~~ 22 1/2	.6431	5.7	8/27 7:35	24	.5867	11.3

*Insert gage subdivisions ~~0.01~~ ", .1 div. etc.

CONSOLIDATION TEST (Time–compression data) Data Sheet 15

Project S.M.I Job No. SHEMI 92078I 04702

Location of Project GRANTS, N.M. Boring No. 7 Sample No. 3A

Description of Soil TAILINGS Depth of Sample

Tested By LHM/JAL Date of Testing

Loading Test Data

Load 1000 P.S.F Load 2000 P.S.F

Date applied Date applied

Applied by LHM Applied by LHM

Clock time and date	Elapsed time, min	*Dial readings x ____ Original	%	Clock time and date	Elapsed time, min	Dial readings x ____ Original	%
8/27 7:35	0	.5867	11.3	8/28 7:35	0	.5280	17.2
	0.1 (6s)	5832	11.7 ✓		0.1	.5220	17.8 ✓
	0.25 (15)	5810	11.9		0.25	.5191	18.1
	0.5 (30)	.5784	12.2		0.5	.5158	18.4
7:36	1	.5748	12.5	7:36	1	.5100	19.0
7:37	2	.5692	13.1	7:37	2	.5025	19.8 ✓
7:39	4	.5629	13.7 ✓	7:39	4	.4947	20.5
7:43	8	.5555	14.5	7:43	8	.4857	21.4
7:50	15	.5505	15.0	7:50	15	4773	223
8:05	30	.5458	15.4	8:05	30	.4686	23.1
8:35	60	.5421	15.8	8:35	60	.4638	23.6
9:35	2 hrs	.5387	16.1	9:35	2 hrs	.4585	24.2
11:35	4	.5348	16.5	11:35	4	0.4539	24.6
4:35	9	.5313	16.9	4:35	9	.4496	25.0
8/28 7:35	24	.5280	17.2	8/29 7:35	24	.4457	25.4

*Insert gage subdivisions 0.01" /div. etc.

CONSOLIDATION TEST (Time–compression data) Data Sheet 15

Project S.M.I. Job No. SHEMI 9207 8I 0470 2

Location of Project GRANTS, N.M. Boring No. 7 Sample No. 3A

Description of Soil TAILINGS Depth of Sample

Tested By LHM/JAL Date of Testing

Loading Test Data

Load 4000 P.S.F Load P.S.F

Date applied Date applied

Applied by Applied by

Clock time and date	Elapsed time, min	*Dial readings × ____ Original	*Dial readings × ____ o/o	Clock time and date	Elapsed time, min	Dial readings × ____ Original	Dial readings × ____ o/o
7:35	0	.4457	25.4		0		
	0.1 (6s)	.4420	25.8 ✓		0.1		
	0.25 (15)	.4379	26.2		0.25		
	0.5 (30)	.4330	26.7		0.5		
7:36	1	.4273	27.3		1		
7:37	2	.4188	28.1 ✓		2		
7:39	4	.4087	29.1		4		
7:43	8	.3973	30.3		8		
7:50	15	.3881	31.2		15		
8:05	30	.3807	31.9		30		
8:35	60	.3760	32.4		60		
9:35	2 hrs	.3732	32.7				
11:35	4	.3707	32.9				
4:35	9	.3676	33.2				
7:35	24	.3649	33.5				

*Insert gage subdivisions 0.01" /div. etc.

LANDMARK LABORATORIES LTD.

CLIENT Shepherd Miller, Inc. SAMPLE IDENT. #7

PROJECT Grants N.M. - Tailings - SHEMI-92089F-05-702 DATE 8-25-92

MOISTURE PERCENT

227.5	Wet Wt. & Pan	MATERIAL	Fat Clay	TEST NO.
161.8	Dry Wt. & Pan	CLASSIFICATION	(CH)	
96.2	Tare Pan B-10	PIT NAME		
65.7	Loss	AREA REP.		TEST BY LAM
65.6	Dry Weight	SAMPLED BY	Client	
100.2	% Moisture			

GRADATION DATA

Sieve Size	Grs.	Retained %	Passing %	Specs.
#200	3.0	4.6	95.4	

PLASTICITY INDEX

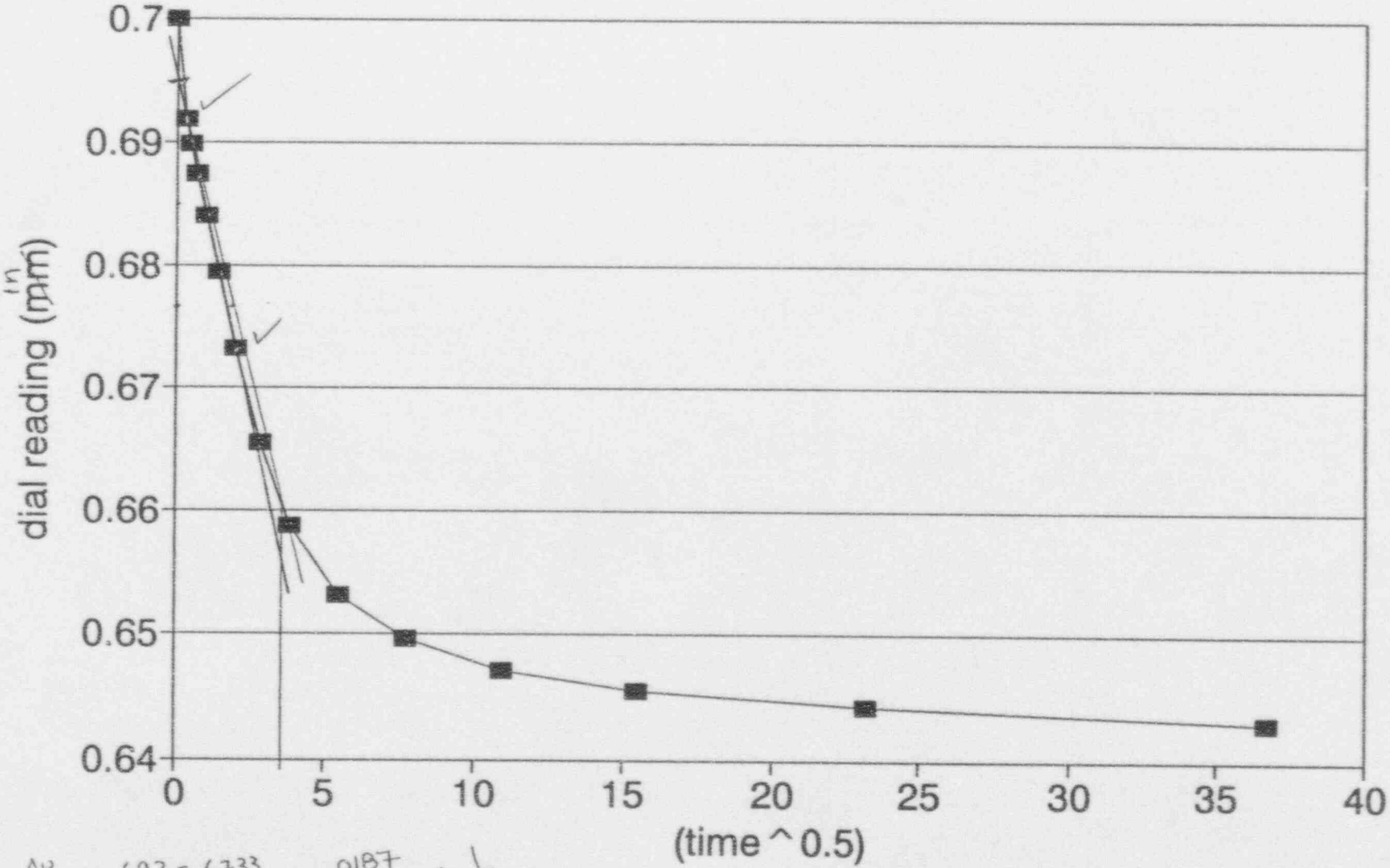
LIQUID LIMIT (LL) = 70

PLASTIC LIMIT (PL) = 28

PLASTICITY INDEX (PI) = 42

Sample 3A

Load = 250 psf



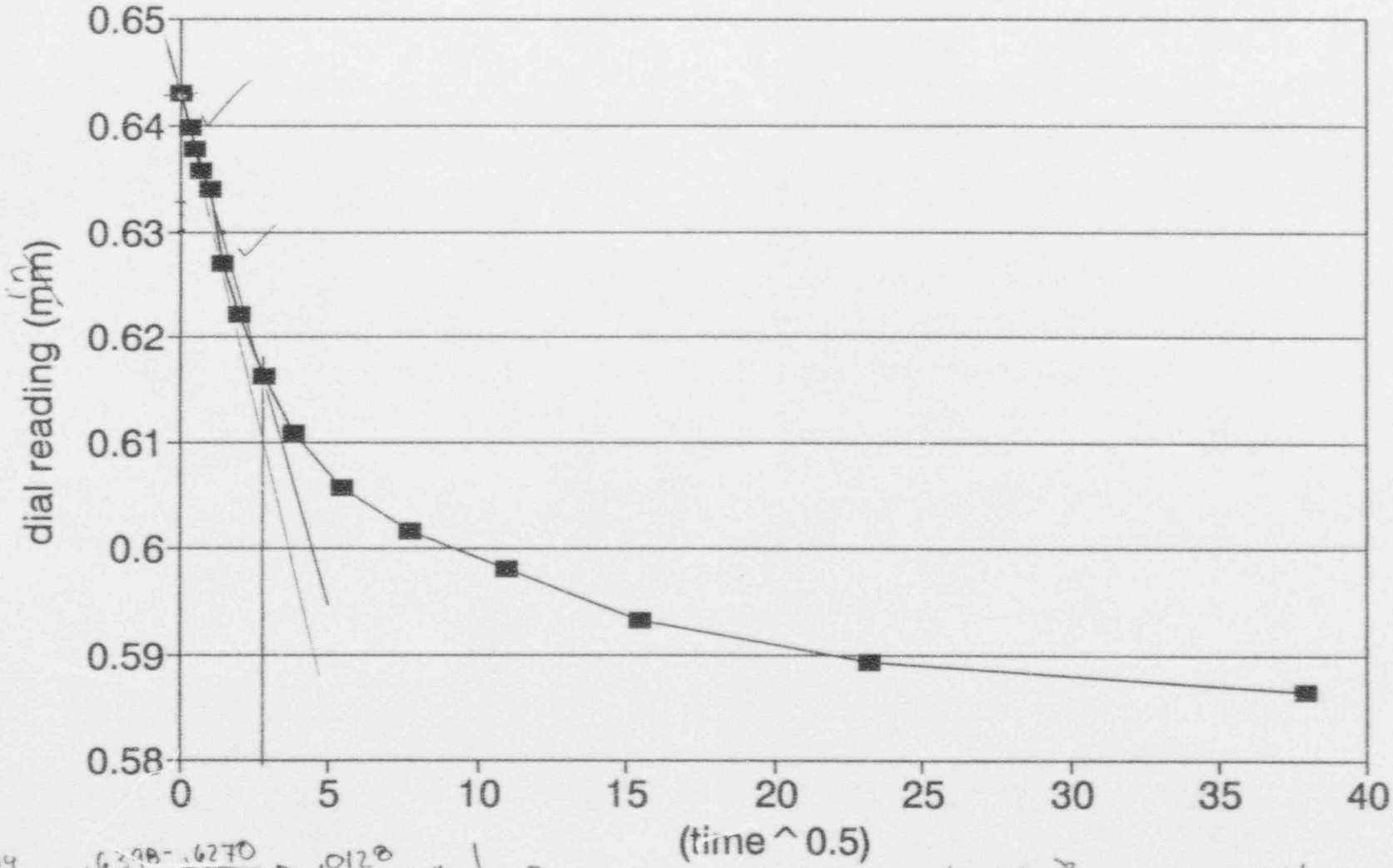
$\frac{\Delta y}{\Delta x} = \frac{.692 - .6733}{\sqrt{.1} - \sqrt{4}} \Rightarrow \frac{.0187}{1.684} * \frac{1}{1.15} =$

$T_{90} = (3.7)^2 = 13.7 \text{ min}$

$C_y = \frac{.848(.5\text{in})^2}{13.7\text{ min}} \left| \frac{\text{min}}{60\text{sec}} \right| \frac{(2.54\text{cm})^2}{\text{in}^2} = .00166 \text{ cm}^2/\text{sec}$

Sample 3A

Load = 500 psf



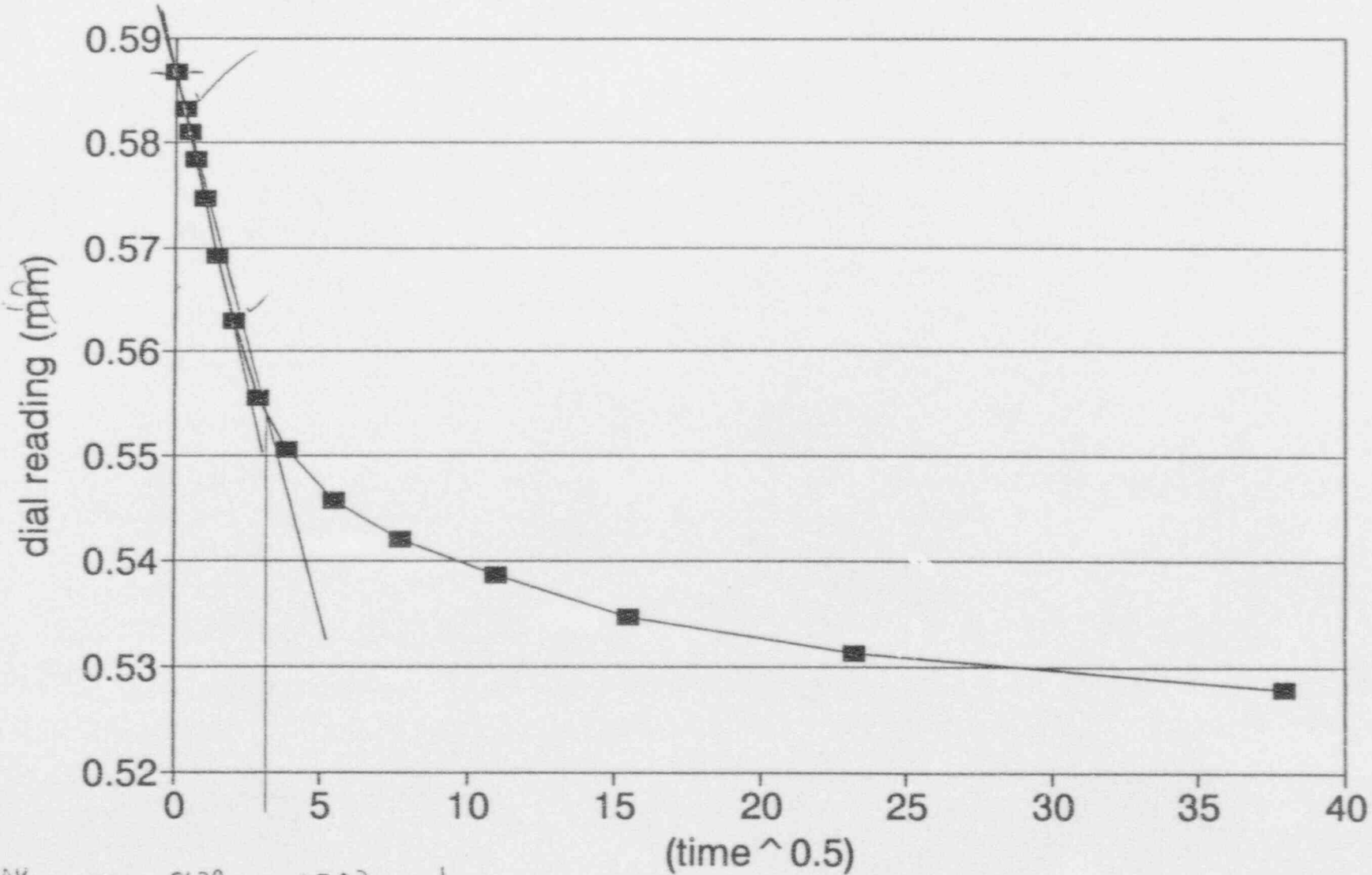
$\frac{\Delta y}{\Delta x} = \frac{.6398 - .6270}{\sqrt{.1} - \sqrt{2}} \Rightarrow \frac{.0128}{1.098} * \frac{1}{1.15} =$

$C_v = \frac{.848(.5)^2}{8} \left| \frac{\text{min}}{60\text{sec}} \right| \frac{(2.54\text{cm})^2}{1\text{in}^2} = .00285\ \text{cm}^2/\text{sec}$

$T_{90} = 8\text{min}$

Sample 3A

Load = 1000 psf



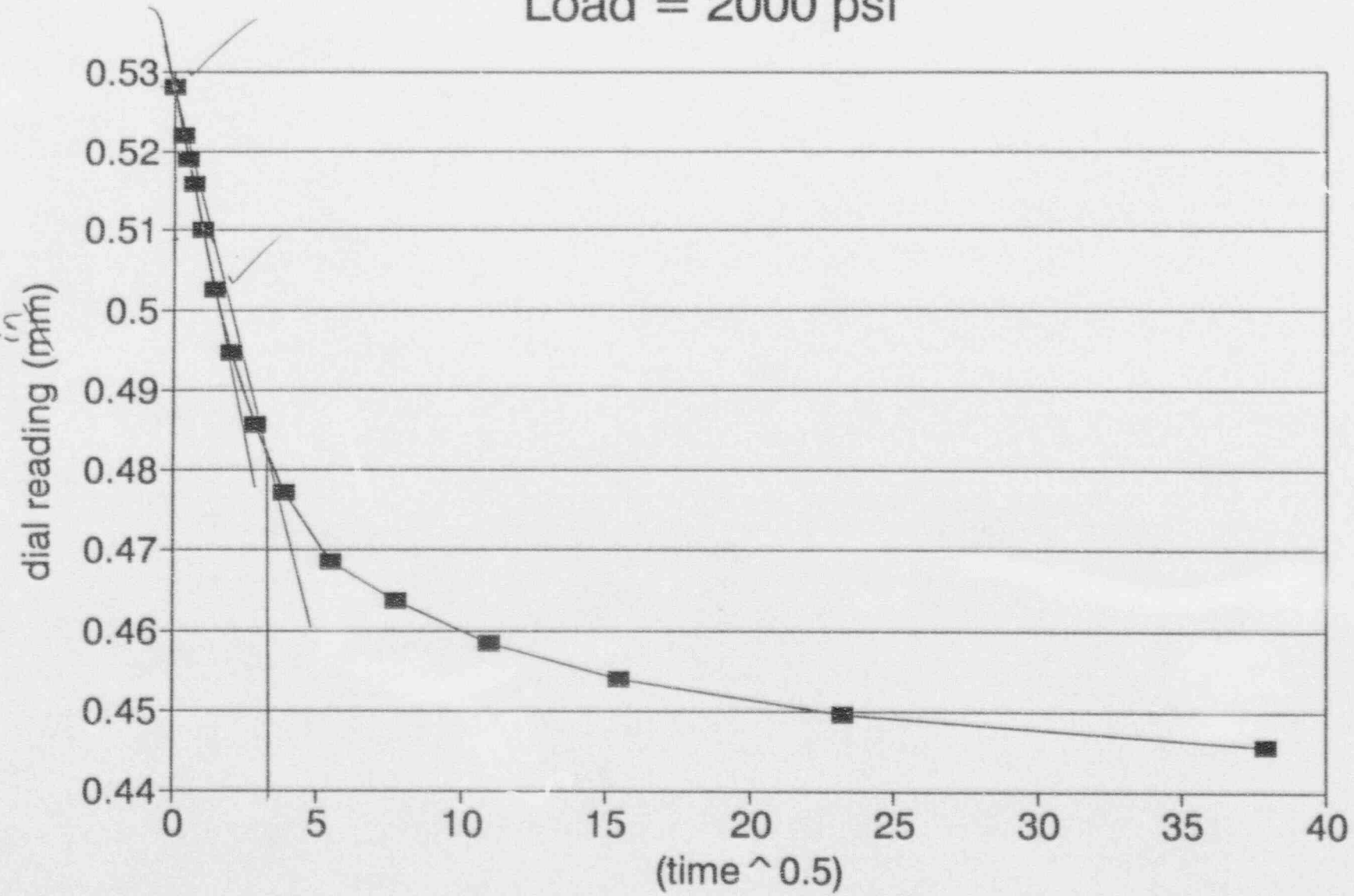
$\frac{\Delta y}{\Delta x} = \frac{.5832 - .5629}{\sqrt{.1} - \sqrt{4}} \Rightarrow \frac{.0203}{1.684} * \frac{1}{1.15} =$

$T_{90} = (3.2)^2 = 10.2\,min$

$C_y = \frac{.848(1.5)^2}{10.2} \left| \frac{min}{60sec} \right| \frac{(7.54cm)^2}{in^2} = .00223\,cm^2/sec$

Sample 3A

Load = 2000 psf



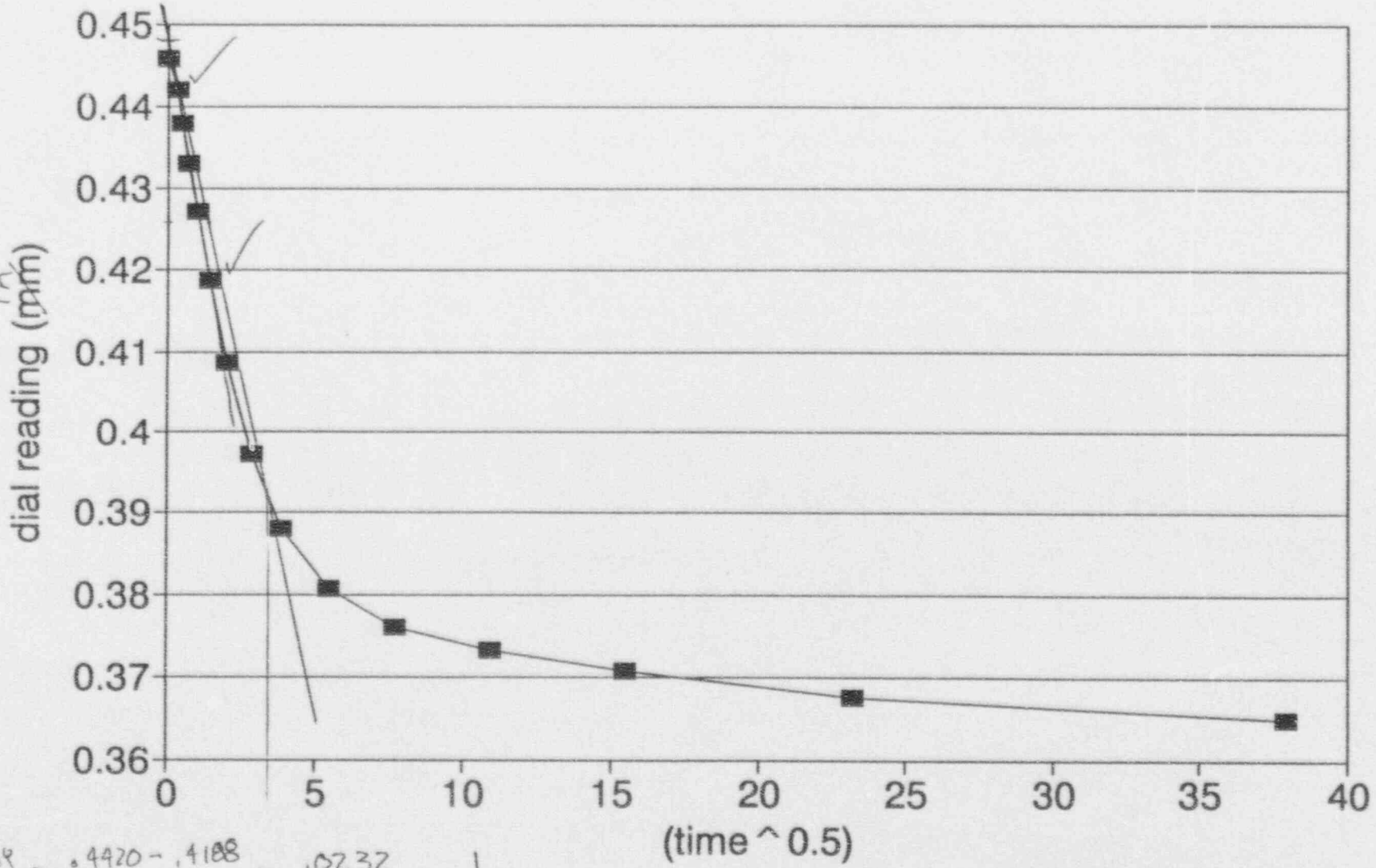
$\frac{\Delta Y}{\Delta X} = \frac{.5280 - .3025}{\sqrt{.1} - \sqrt{2}} \rightarrow \frac{.0195}{1.098} * \frac{1}{1.15}$

$T = (1.2)^2 = 10.9$

$C_y = \frac{.848(.5)^2}{10.9\,min} \left| \frac{min}{60sec} \right| \frac{(2.54cm)^2}{in^2} = .00209\,cm^2/sec$

Sample 3A

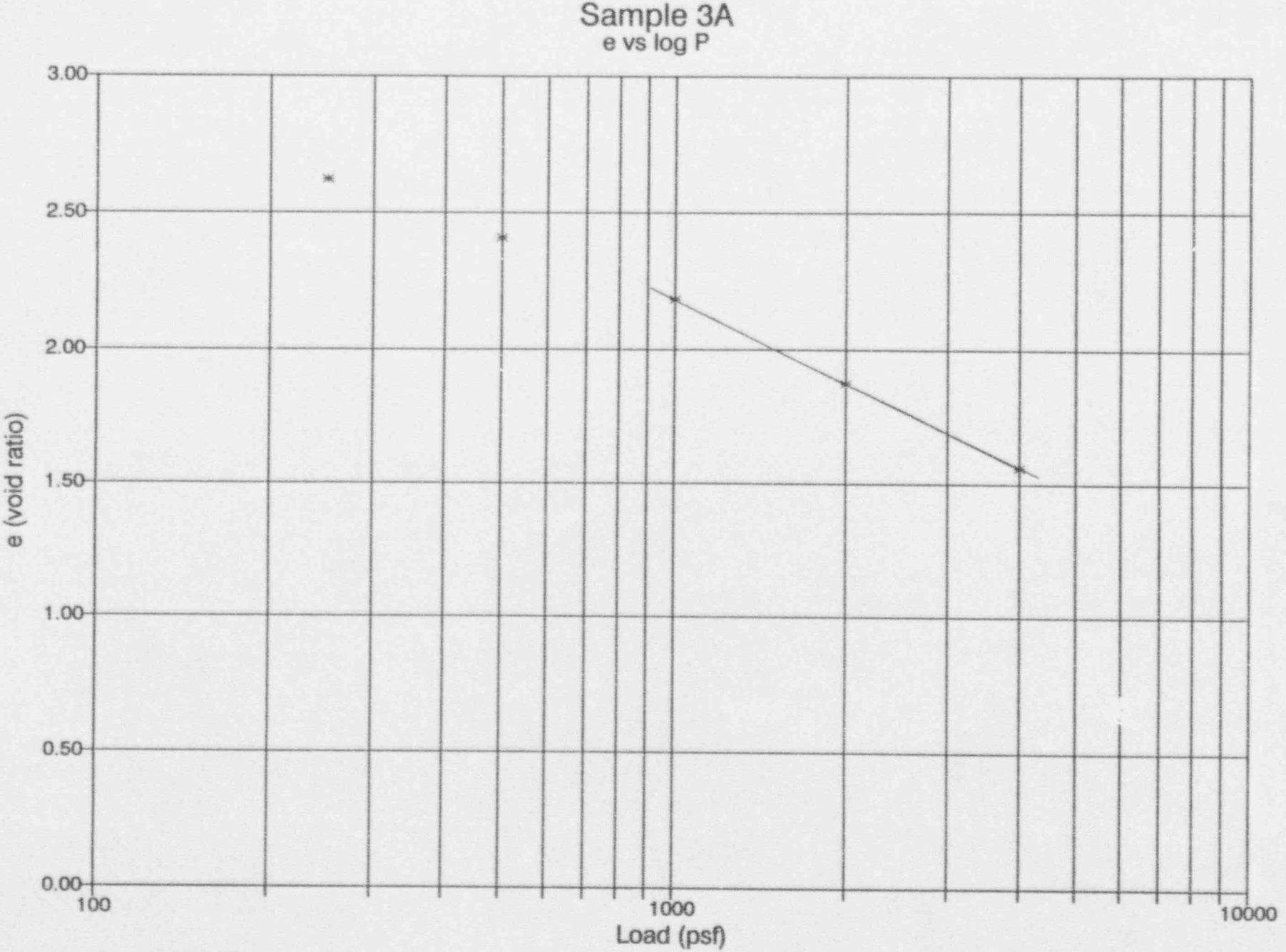
Load = 4000 psf



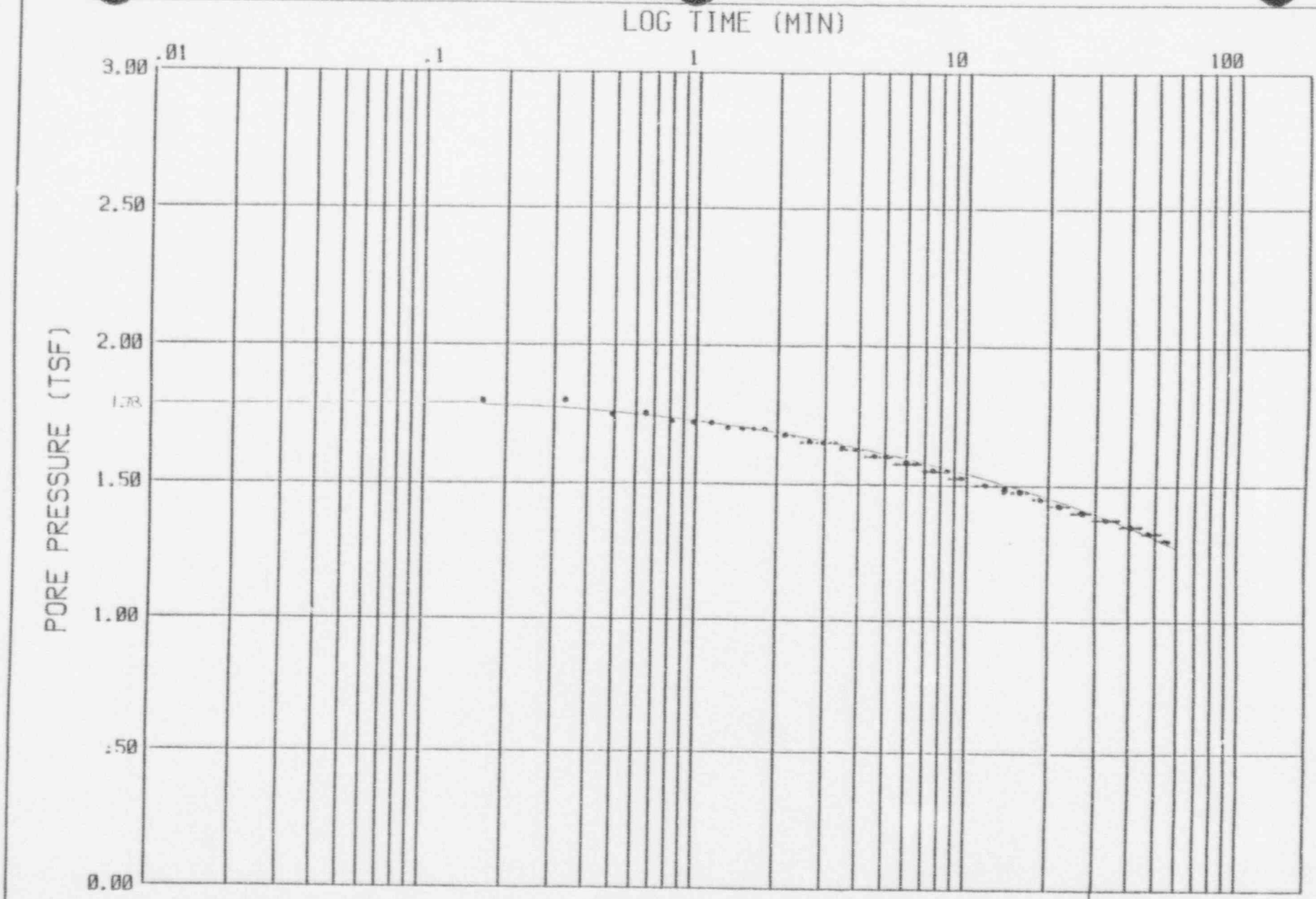
$\frac{\Delta r}{\Delta x} = \frac{.4420 - .4188}{\sqrt{.1} - \sqrt{.2}} \Rightarrow \frac{.0232}{1.098} * \frac{1}{1.15}$

$T_{90} = (2.4)^2 = 11.6 \text{ min}$

$C_v = \frac{.848\,(.5)^2}{11.6 \text{ min}} \left| \frac{\text{min}}{60 \text{ sec}} \right| \frac{(2.54 \text{ cm})^2}{\text{in}^2} = .00197 \text{ cm}^2/\text{sec}$



$C_c = \frac{-\Delta e}{\Delta \log P} = \frac{1.87 - 1.562}{\log 2000 - \log 4000} = 1.02$



JOB NUMBER: 92-2236

CPT NUMBER: Ø3

t_{50} = 30min = 1800sec

T = 3.7

r = 2.185 cm

$c_h = \frac{Tr^2}{t_{50}} = \frac{3.7(2.185\,cm)^2}{1800\,sec} = 0.0098\,cm^2/sec$

DEPTH (FEET) : 24.02 FT (slimes)

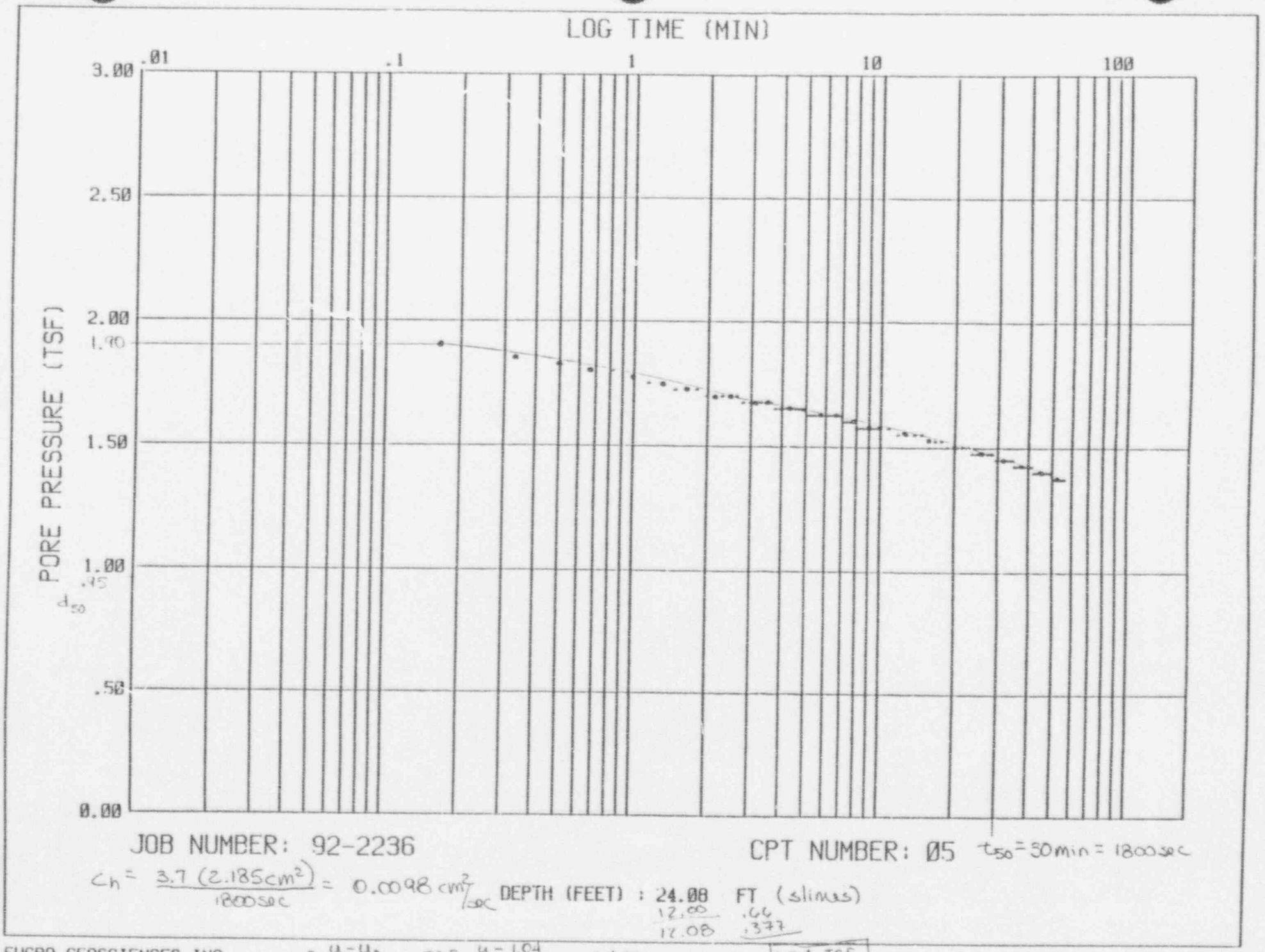
12.00 .06

12.02 .375

1.035 TSF

$\bar{u} = \frac{u-u_0}{\quad} = .50 = \frac{u-1.035}{\quad}$ $u_i = 1.41$

FUGRO GEOSCIENCES, INC



JOB NUMBER: 92-2236

CPT NUMBER: Ø5 t_{50} = 30 min = 1800 sec

$c_h = \frac{3.7\,(2.185\,cm^2)}{1800\,sec} = 0.0098\ cm^2/sec$

DEPTH (FEET) : 24.08 FT (slimes)

12.00 .66

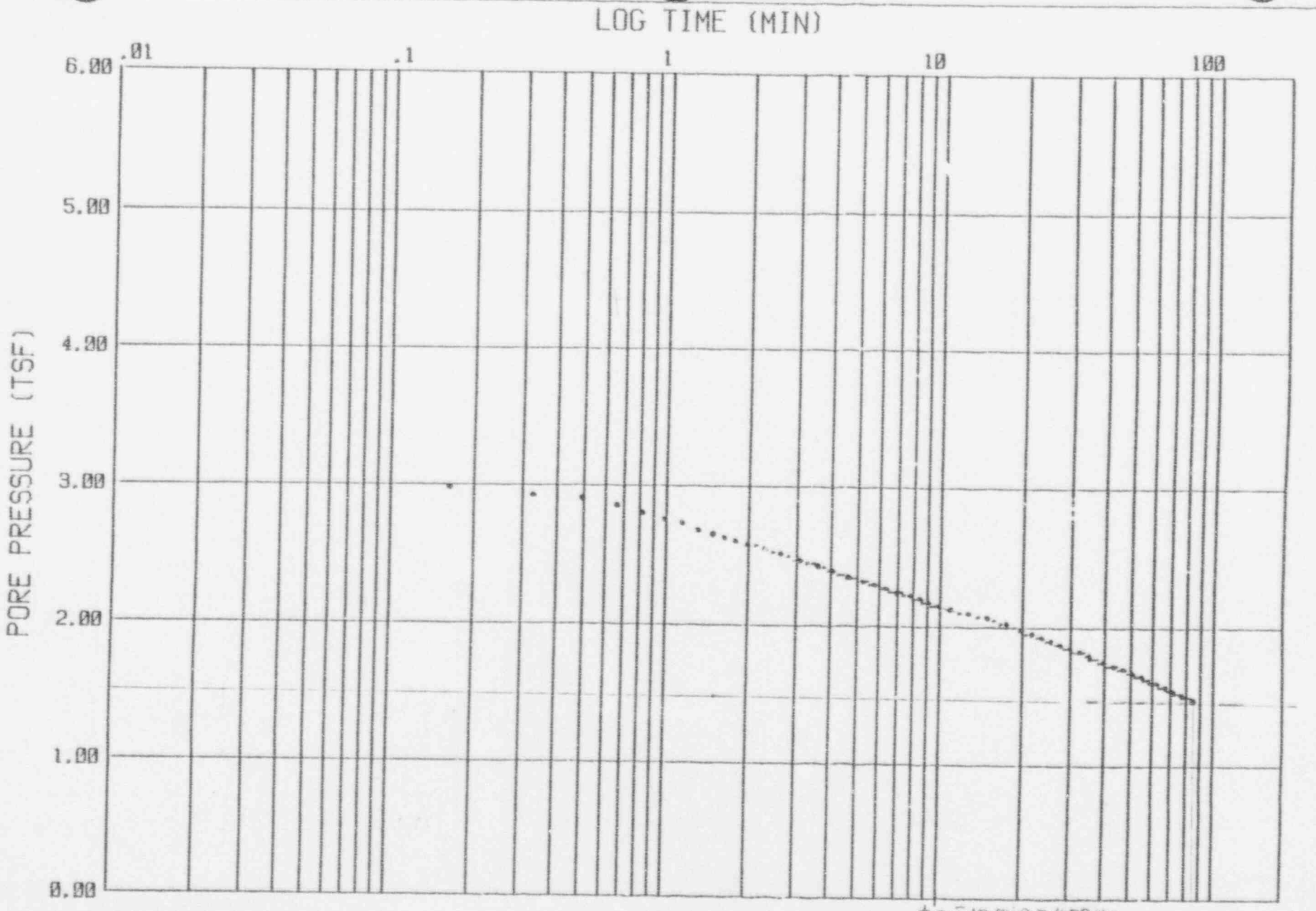
12.08 .377

1.04 TSF

$u_1 = u - u_0$ $\quad u_{50} = u - 1.04$ $\quad u_1 = 1.47$

FUGRO GEOSCIENCES, INC

Arco #212 Blueprint scp



JOB NUMBER: 92-2236

CPT NUMBER: 07

T = 3.7

r = 2.185 cm

$C_h = \frac{Tr^2}{t_{50}} = \frac{3.7(2.185\text{cm})^2}{600\text{sec}}$

$C_h = 0.029\ \text{cm}^2/\text{sec}$

DEPTH (FEET) : 32.94 FT (strikes)

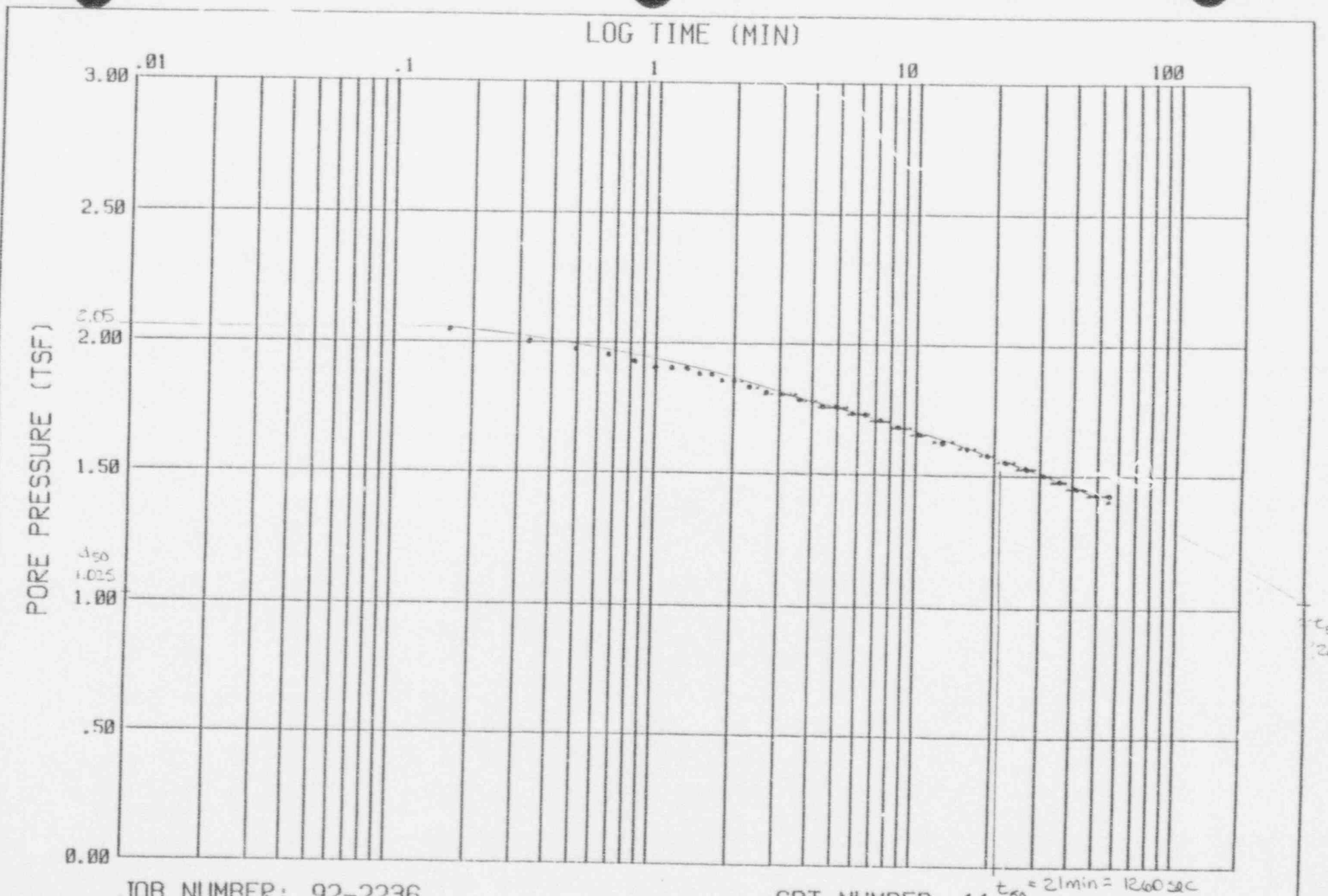
$\frac{12.00}{20.94}$ ft H_2O = .653 TSF

.66 TSF

$\bar{U} = \frac{u - u_o}{\quad} = .50 = \frac{u - 1.313}{1.213}$ $u = 2.16$ $u_o = 1.313$

FUGRO GEOSCIENCES, INC

Arco Bluff #31C SCP



JOB NUMBER: 92-2236

CPT NUMBER: 11

$C_h = \frac{3.7\,(2.185\,cm)^2}{1260\,sec} = 0.014\ cm^2/sec$

DEPTH (FEET) : 25.00 FT (silty slime?)

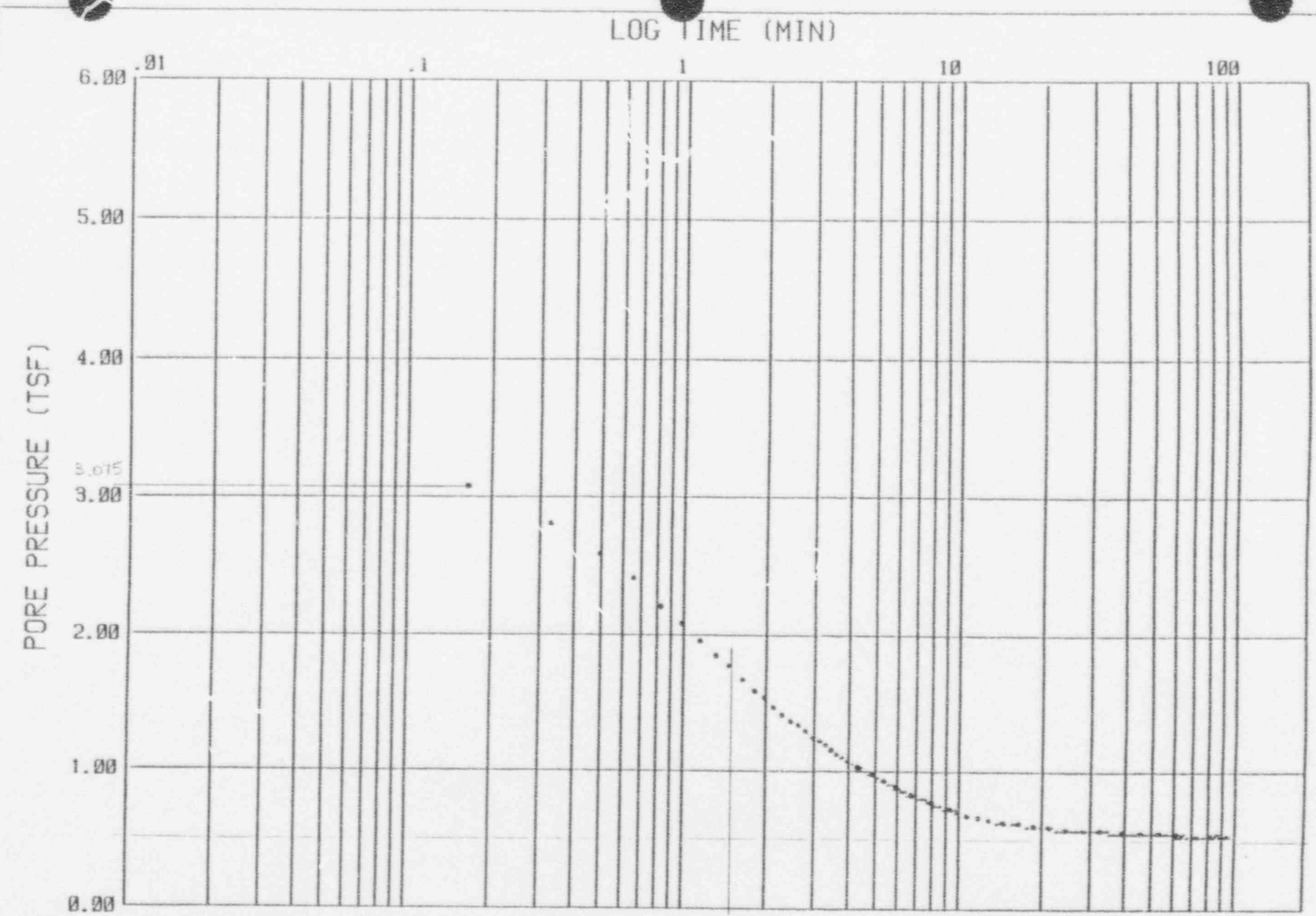
12.00 .66

13.00 .4056

FUGRO GEOSCIENCES, INC

$\bar{u} = \frac{u - u_e}{} = \frac{u - 1.07}{}$ = 1.56 1.07 TSF

Area #12 Elevator sp



JOB NUMBER: 92-2236

t_{50} = 1.5 min = 90 sec CPT NUMBER: 12

T = 3.7

r = 2.185 cm

$c_h = \frac{T r^2}{t_{50}} = \frac{3.7 (2.185\,cm)^2}{90\,sec}$

$c_h = 0.1803\ cm^2/sec$

DEPTH (FEET) : 25.52 FT (right at contact w/ sandy silt)

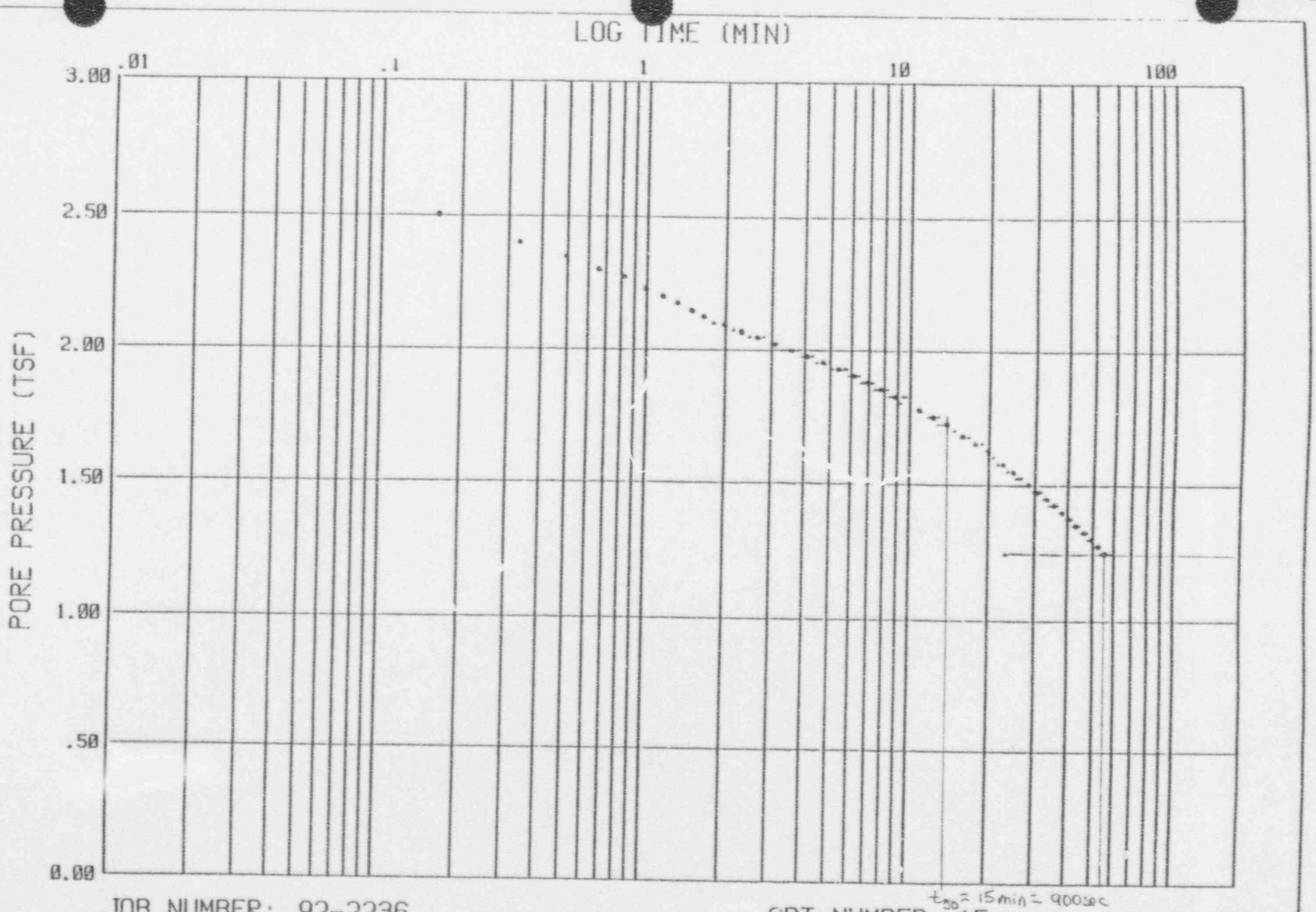
$\frac{12.0}{13.52}$ .422 ⇒ .422 TSF ⇐

FUGRO GEOSCIENCES, INC

u_o = 0.50 tsf

$\bar{u} = \frac{u - u_o}{\quad} = .50 = \frac{u - .50}{\quad}$ u = 1.7875 tsf

Arco #32 Sounder SCP



JOB NUMBER: 92-2236

CPT NUMBER: 15

t_{50} = 15 min = 900 sec

T = 3.7

r = 2.185 cm

$c_h = \frac{Tr^2}{t_{50}} = \frac{3.7(2.185\text{cm})^2}{900\text{ sec}}$

c_h = 0.020 cm²/sec

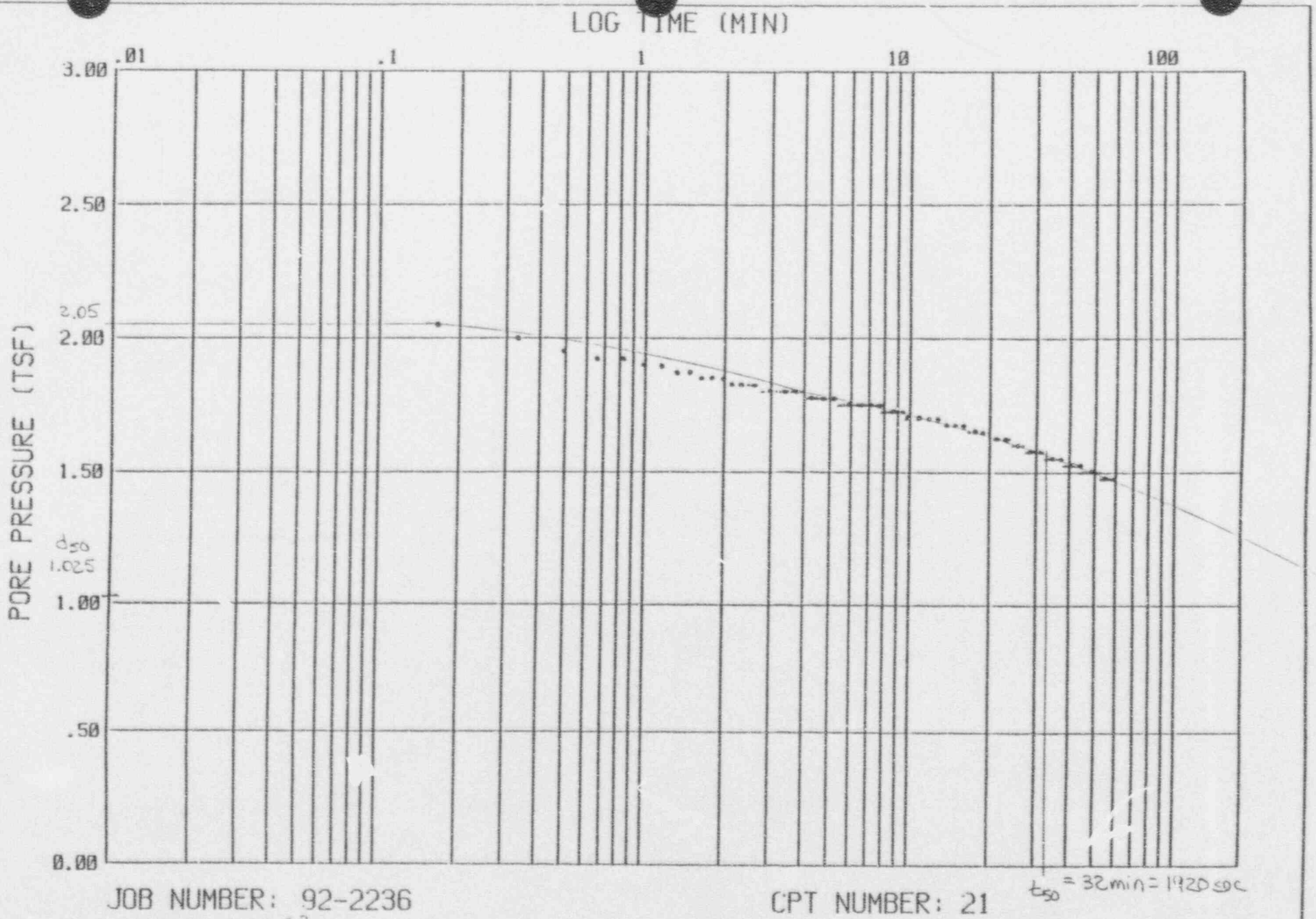
DEPTH (FEET) : 21.72 FT (slides)

$\frac{12.0}{9.72} \Rightarrow \frac{166}{1303}$ = .963 TSF

FUGRO GEOSCIENCES, INC

$\bar{u} = \frac{u-u_0}{u_i-u_0} = .50 = \frac{u-.963}{2.5-.963}$ u = 1.73

Arco #312 Elevator Crp



JOB NUMBER: 92-2236

CPT NUMBER: 21

$c_h = \frac{3.7\,(2.185\text{cm})^2}{1920\text{ sec}}$

$c_h = 0.0092\ \text{cm}^2/\text{sec}$

DEPTH (FEET) : 25.33 FT (slimes)

$\frac{12.0}{13.33}$ .66

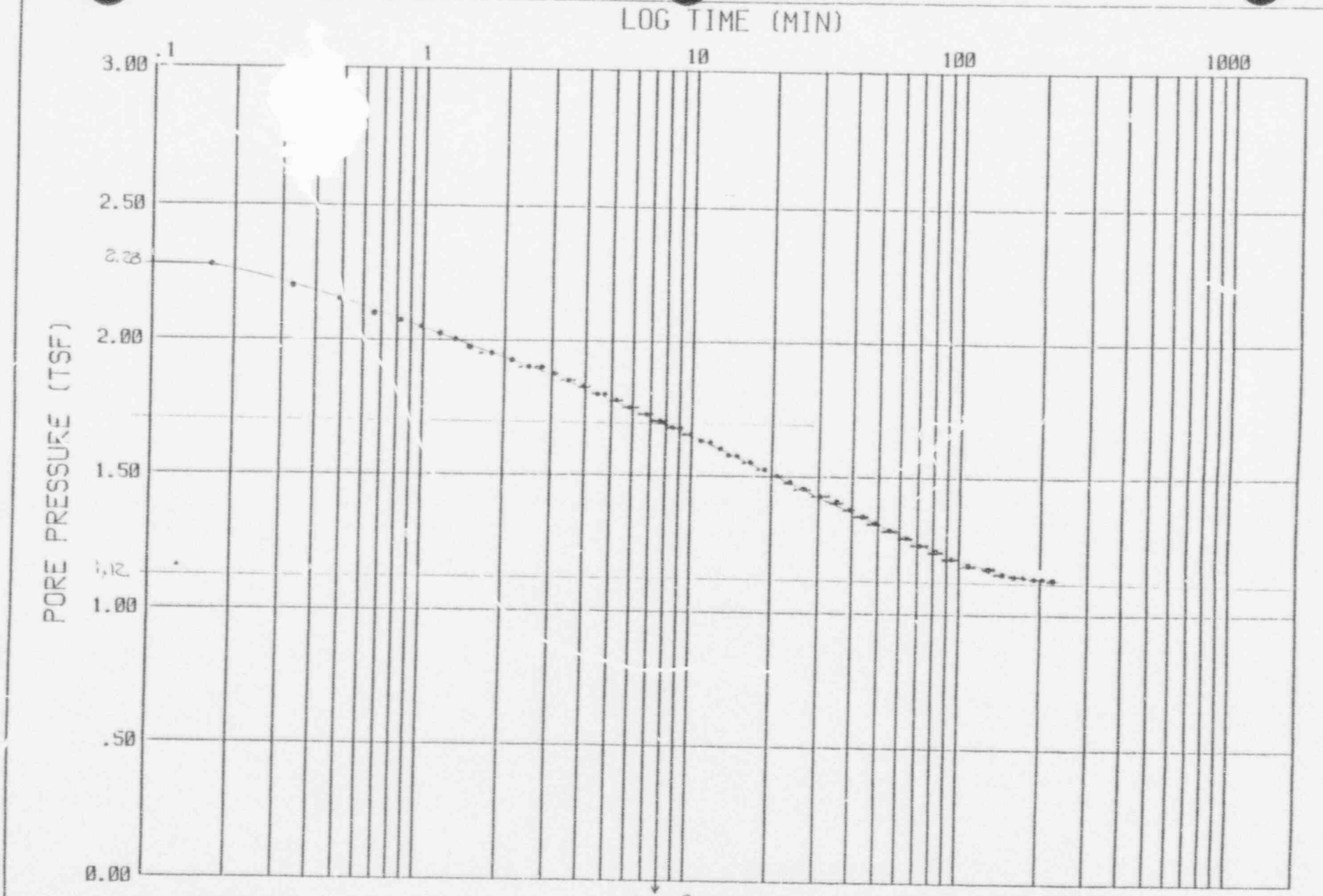
.416

$\bar{u} = \frac{u - u_o}{u_i - u_o} = .50 = \frac{u - 1.08}{2.05 - 1.08}$ $u = 1.565$

1.08 TSF

FUGRO GEOSCIENCES, INC

Arco #31C Elevator Cap



JOB NUMBER: 92-2236

t_{50} = 8 min = 480 sec

CPT NUMBER: 23

T = 3.7

r = 2.185 cm

$C_h = \frac{Tr^2}{t_{50}} = \frac{3.7(2.185\,cm)^2}{480\,sec}$

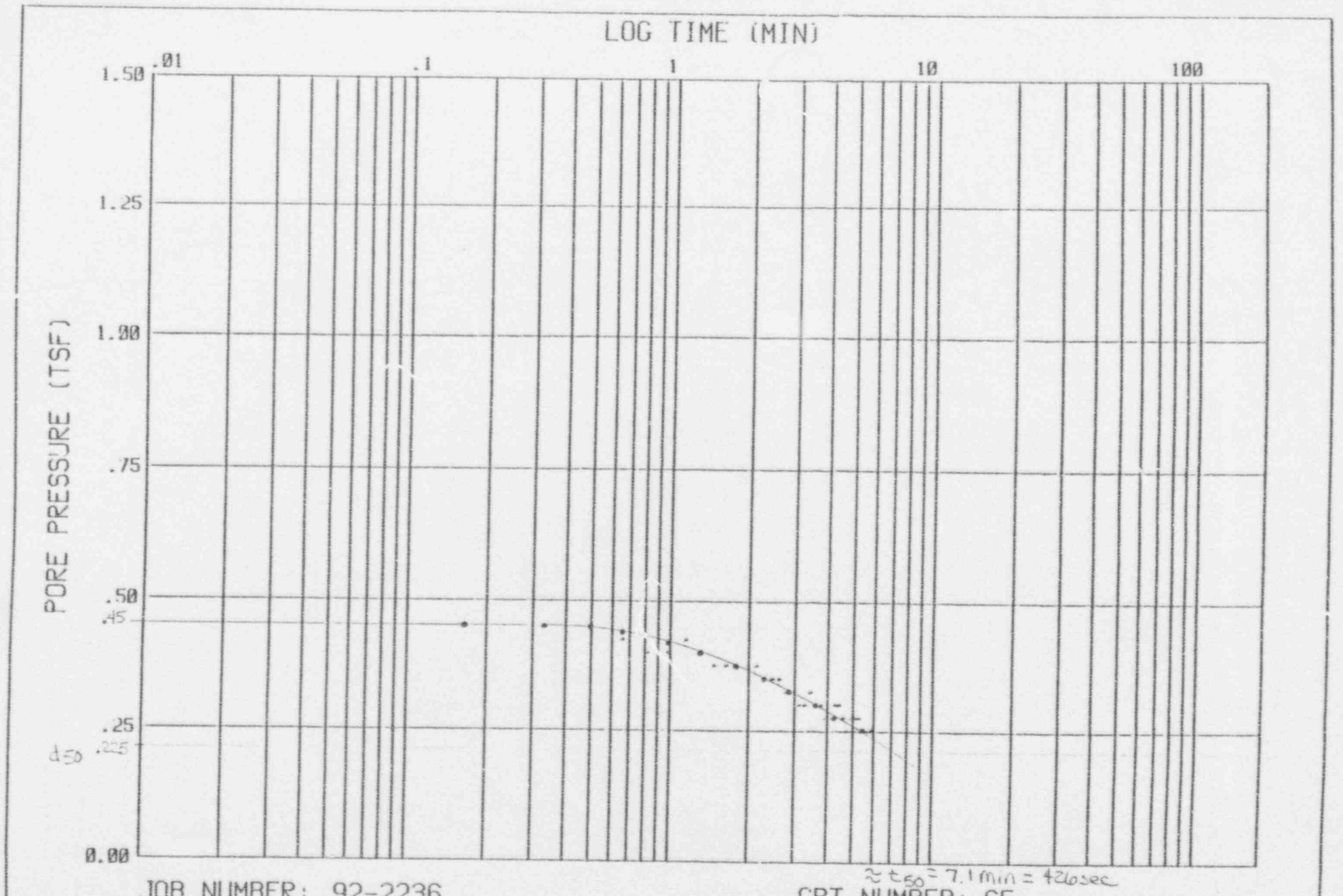
$C_h = 0.0368\ cm^2/sec$

DEPTH (FEET) : 25.00 FT (slime?)

12.00 / 13.00 .66 .405 → .405 TSF

u_o = 1.12 tsf $\bar{u} = \frac{u - u_o}{\quad} = .50 = \frac{u - 1.12}{\quad}$ u = 1.70 tsf

FUGRO GEOSCIENCES, INC



JOB NUMBER: 92-2236

CPT NUMBER: 65

$C_h = \frac{Tr^2}{t_{50}} = \frac{3.7(2.185cm)^2}{426sec}$

$C_h = 0.0415\ cm^2/sec$

DEPTH (FEET) : 31.23 FT (sandy silt?)

12.00

19.23

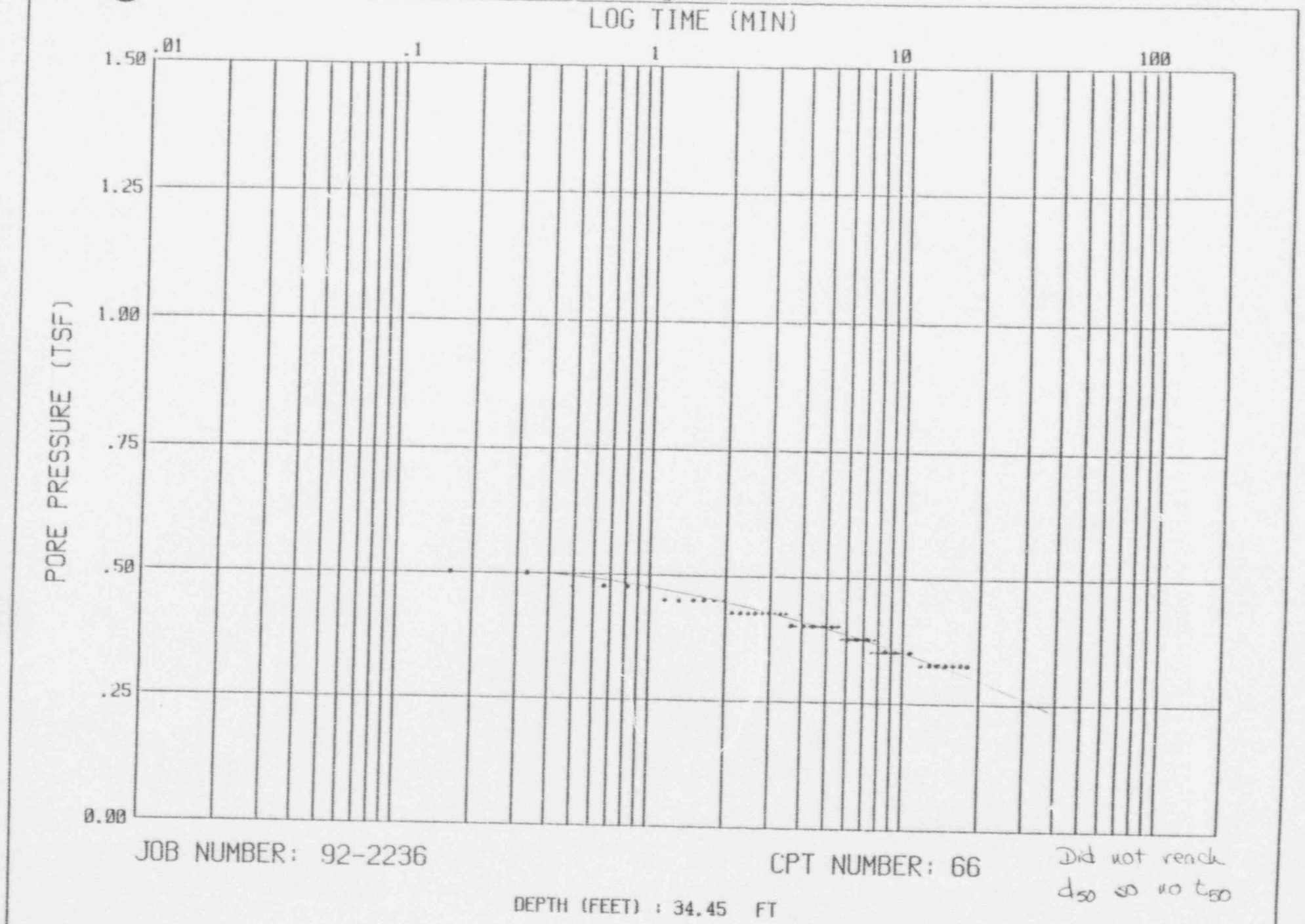
.166

.549

1.21 TSF

Area #312 Excavator cut

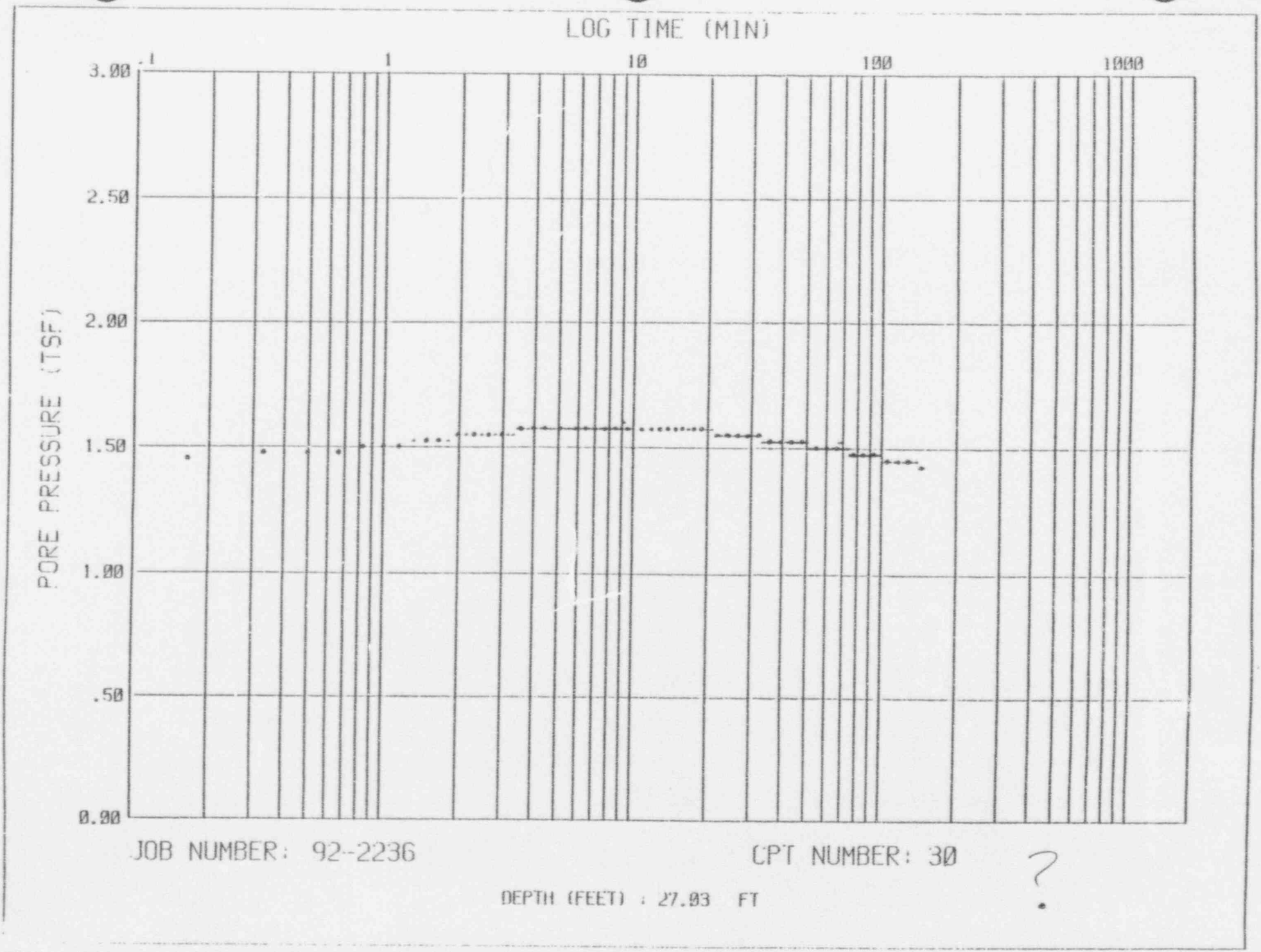
FUGRO GEOSCIENCES, INC



Did not reach d_{50} so no t_{50}

Arco #312 Edwards SCP

FUGRO GEOSCIENCES, INC



Arco #32 Equator SCP

?

APPENDIX C

SETTLEMENT MONITORING

C.1 Introduction

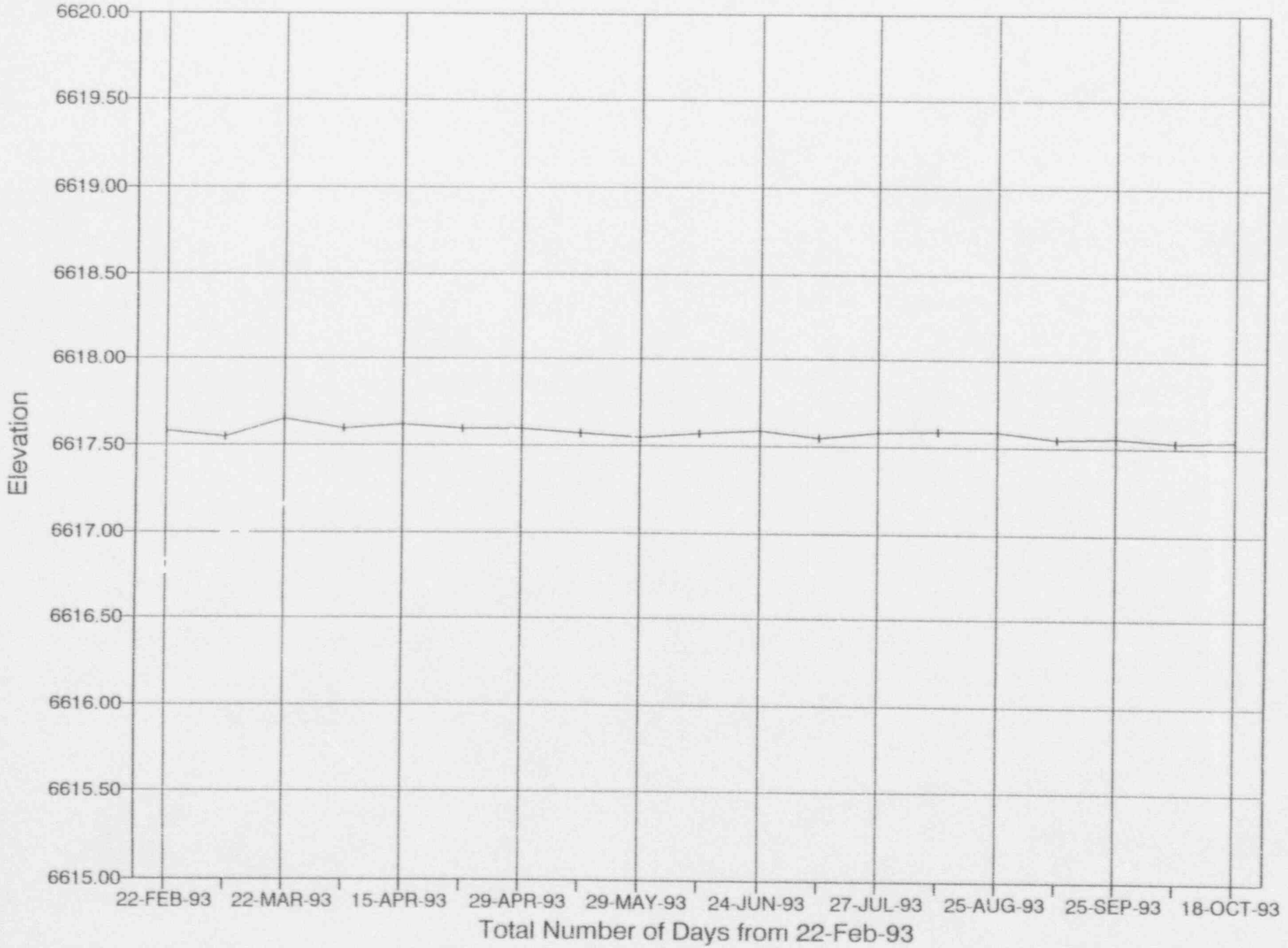
The settlement monitoring data are presented in this Appendix. The information includes a table presenting all of the data, The settlement data plotted against time and the settlement data plotted against the square root of time for each of the settlement points. Table C-1 shows the status of the settlement monuments.

Table C-1 ARCO Settlement Monuments Status

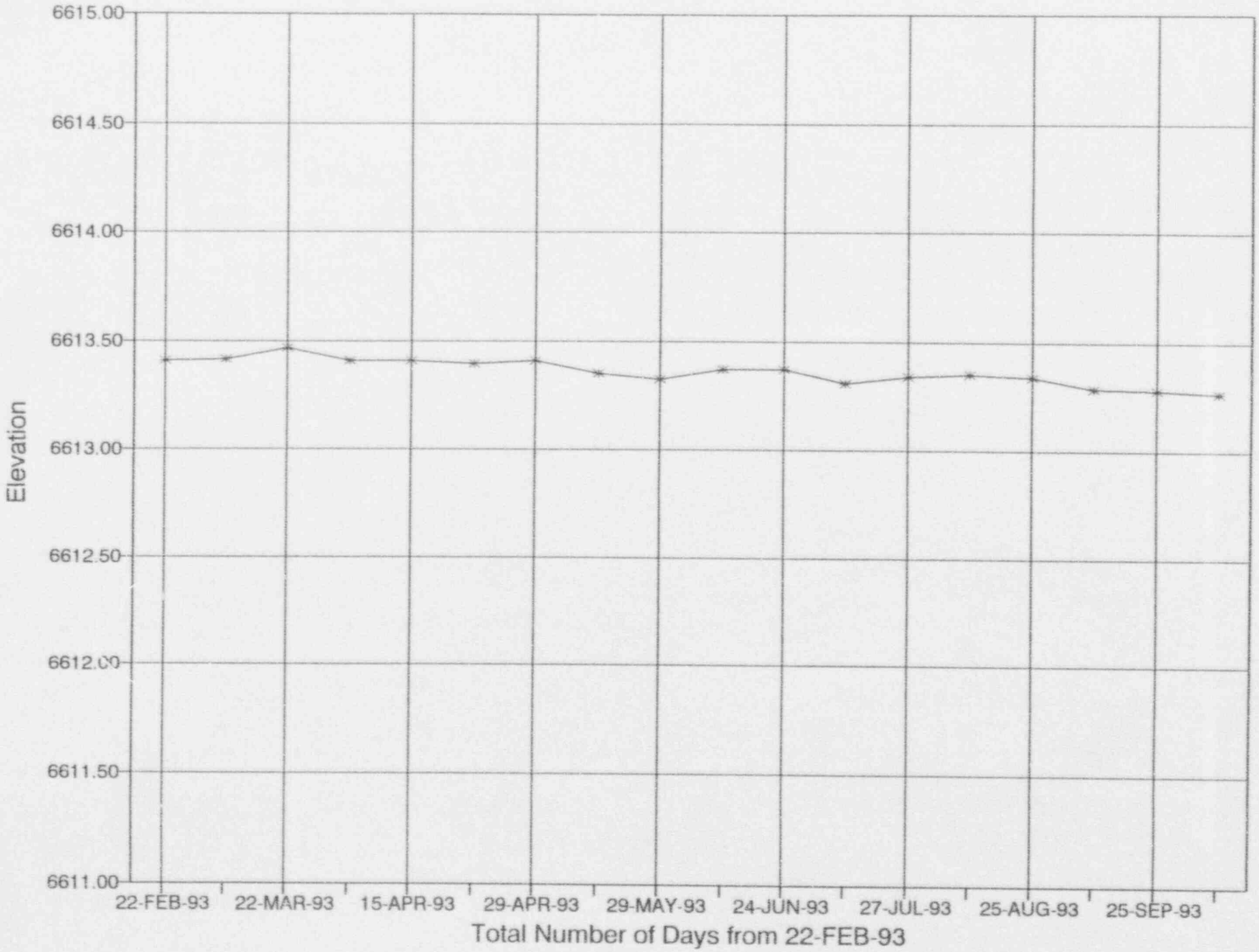
Monument	Current Status
1-9	in-place
10	destroyed by TMC
11	in-place
12-15	not set by evaluation period
16-17	in-place
18	not set
19-32	in-place

TOTAL NUMBER OF DAYS

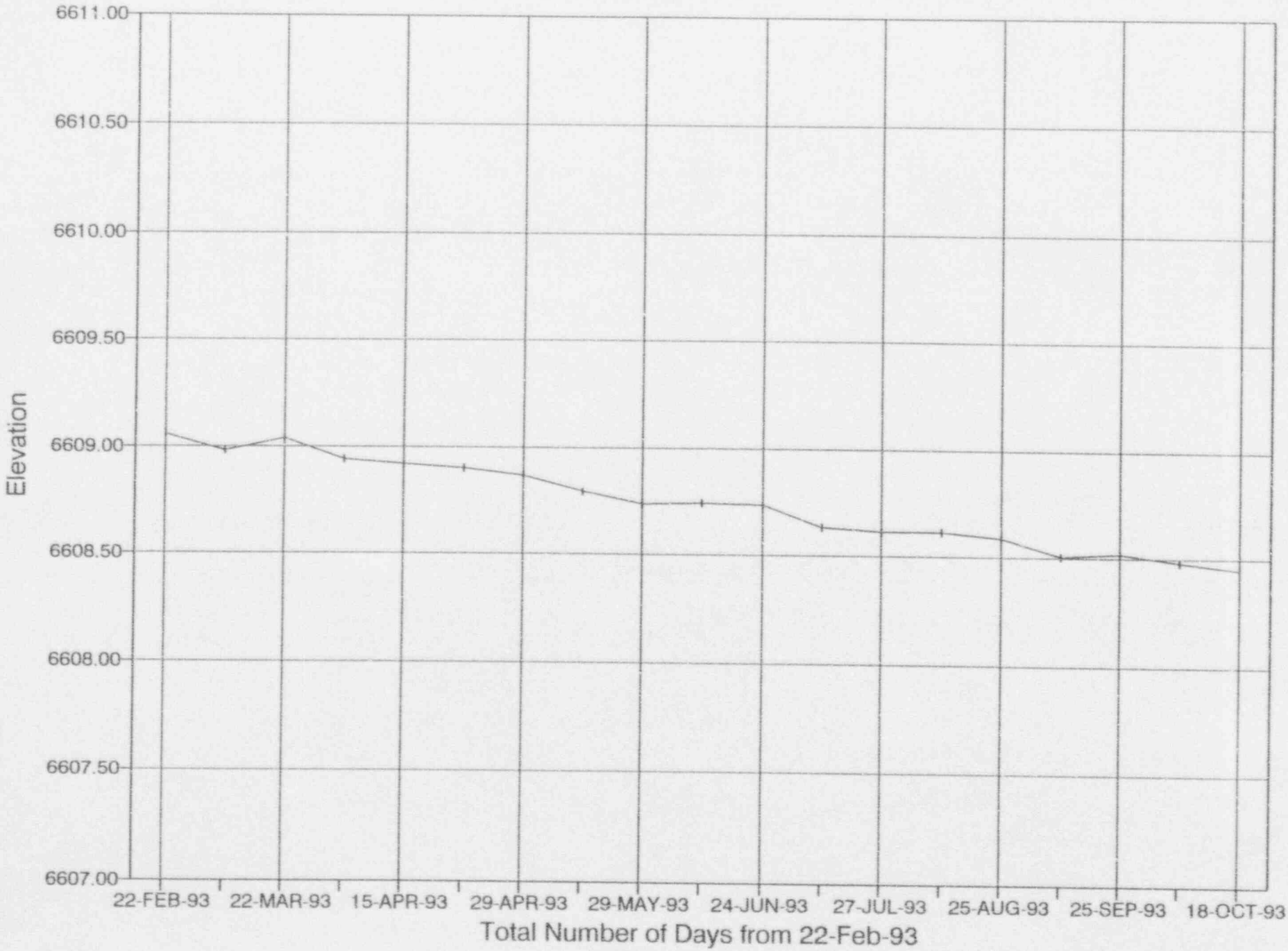
Settlement Point 1



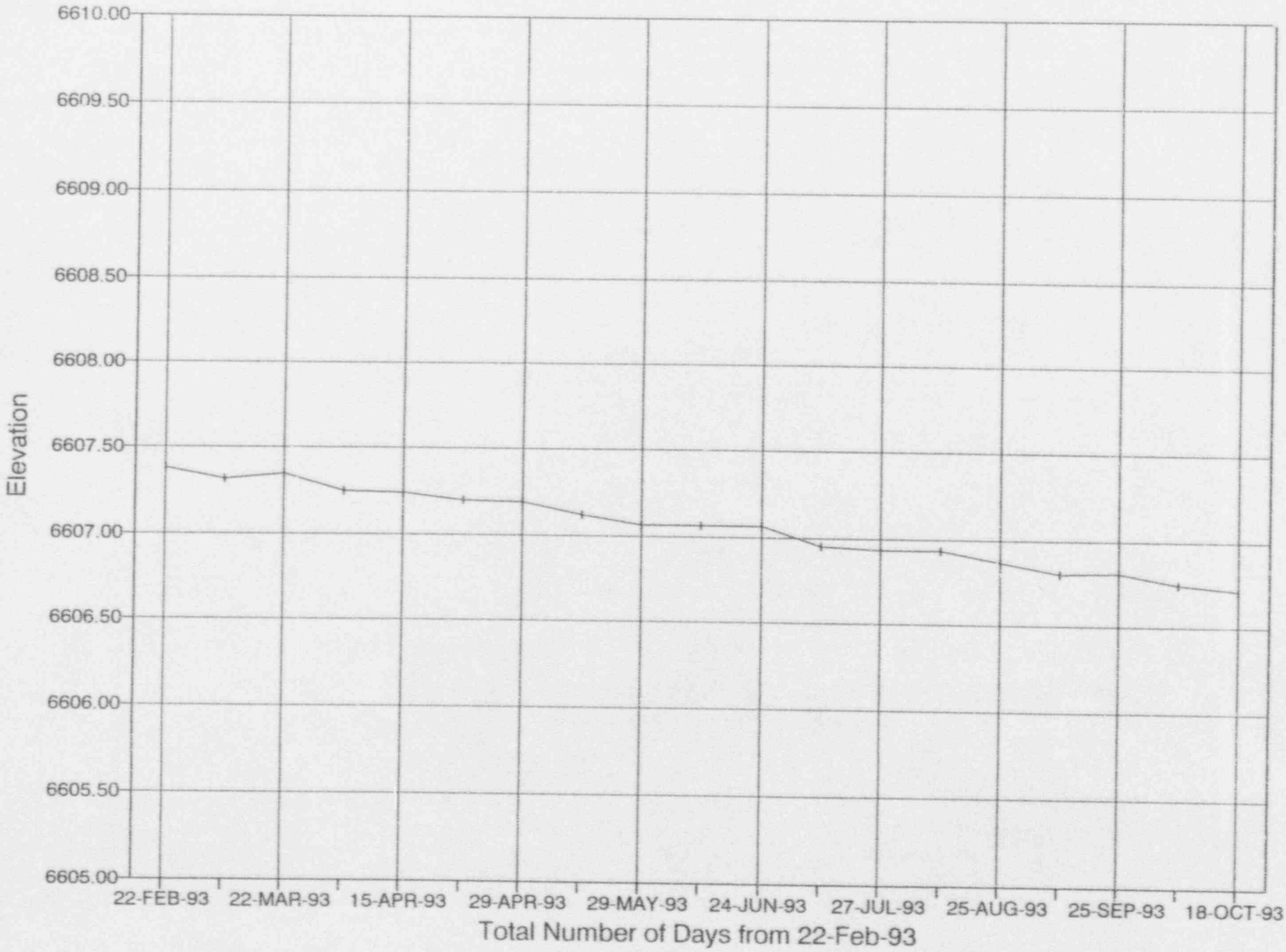
Settlement Point 2



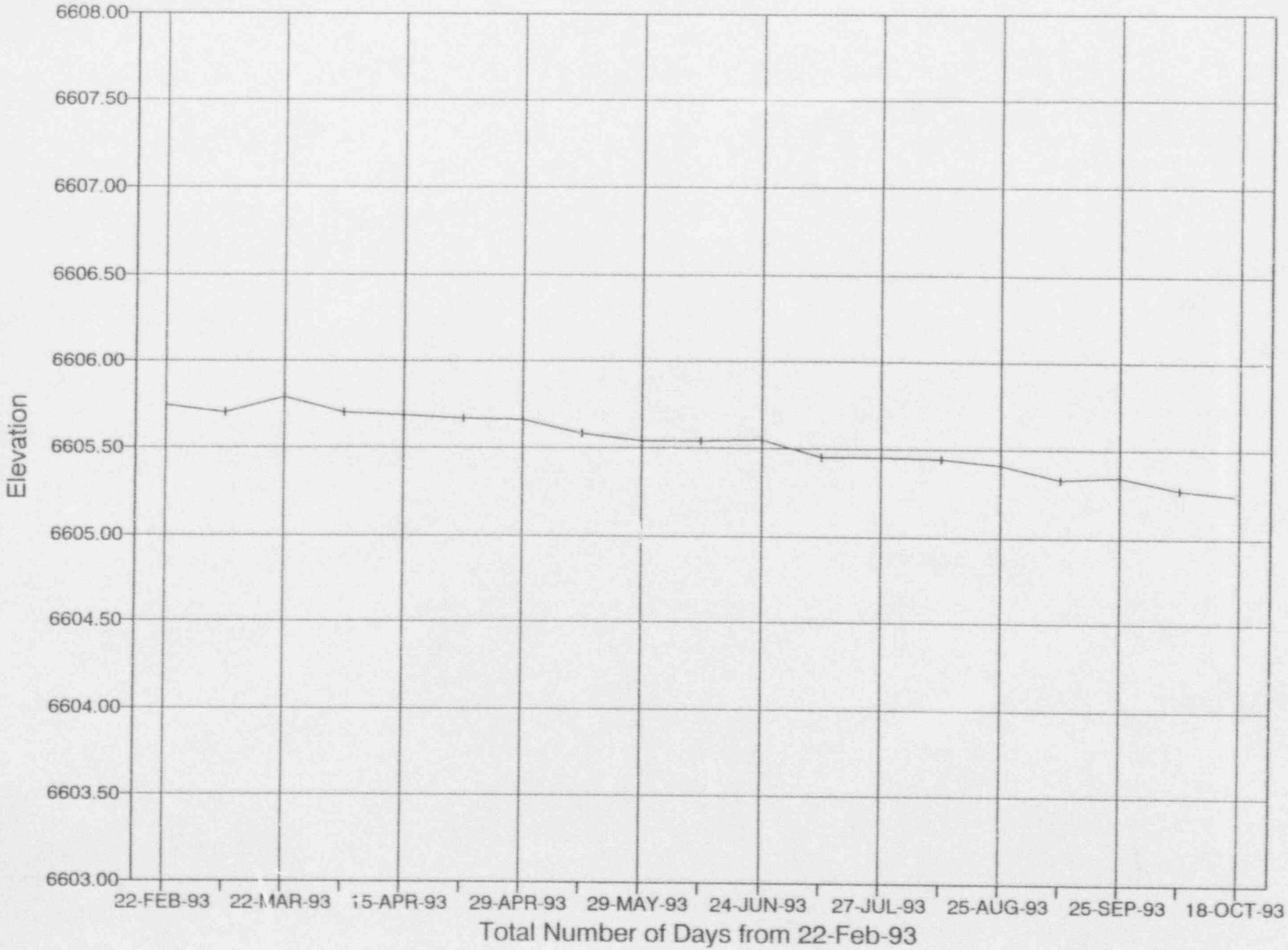
Settlement Point 3



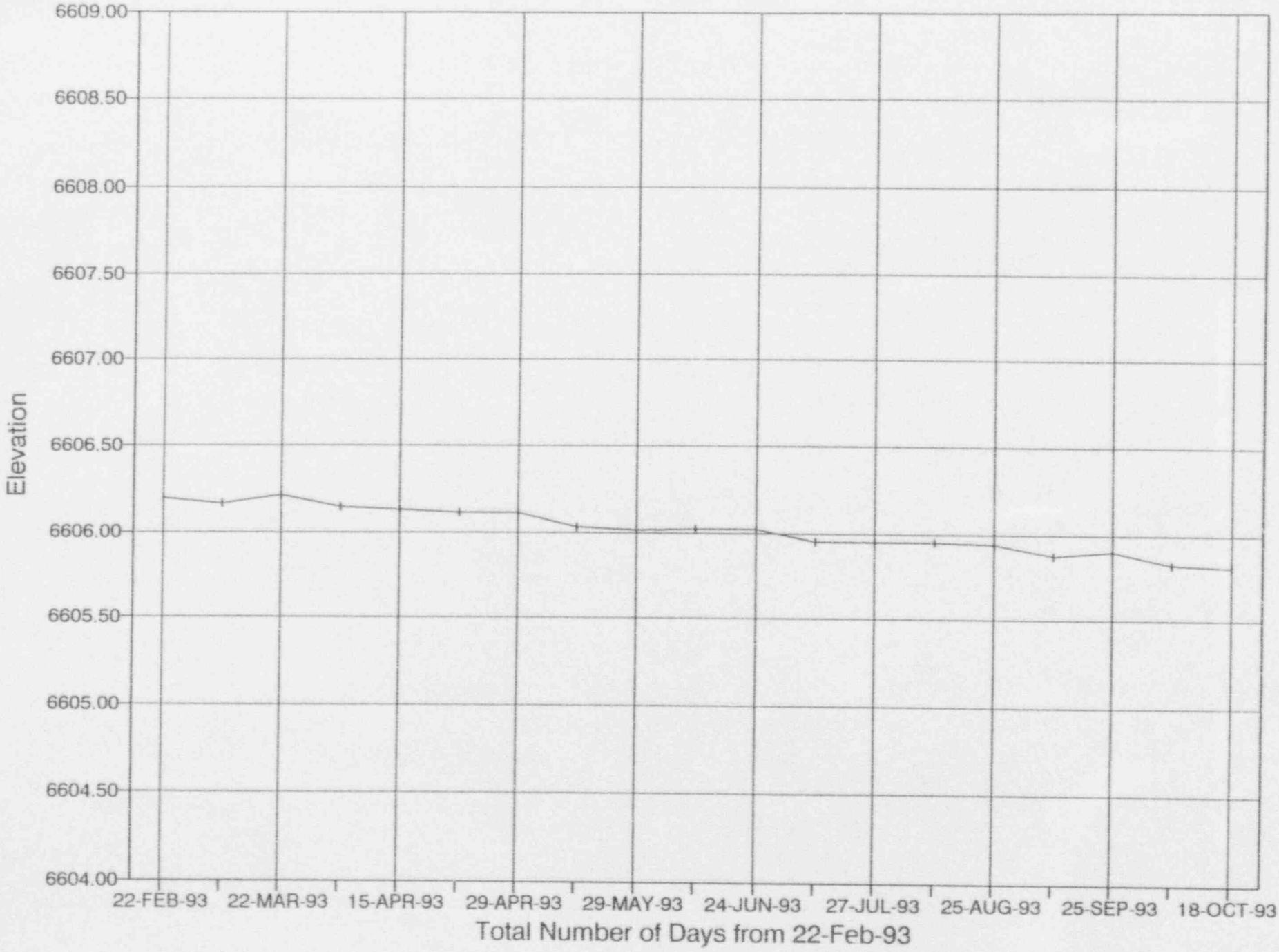
Settlement Point 4



Settlement Point 5



Settlement Point 6



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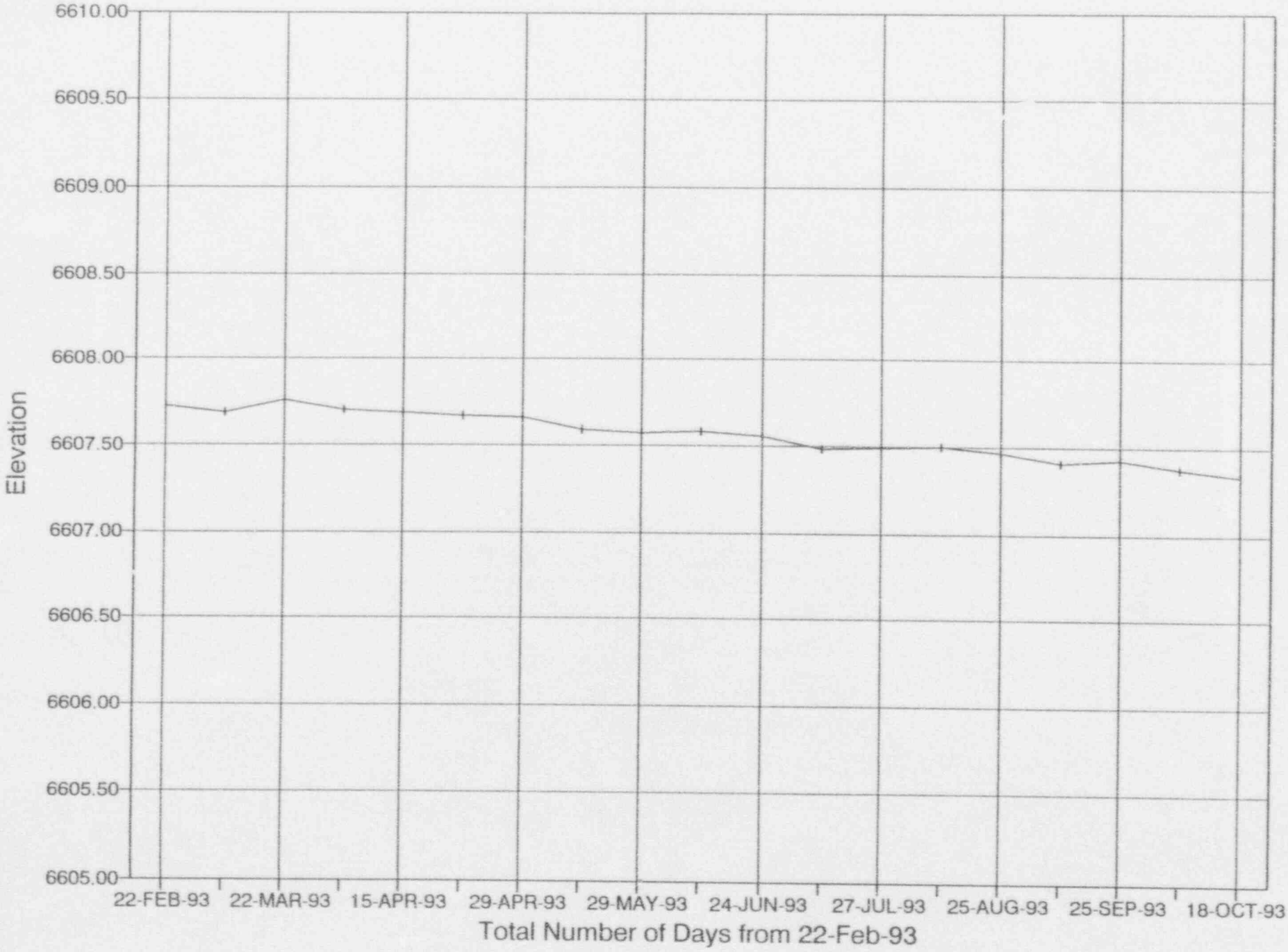
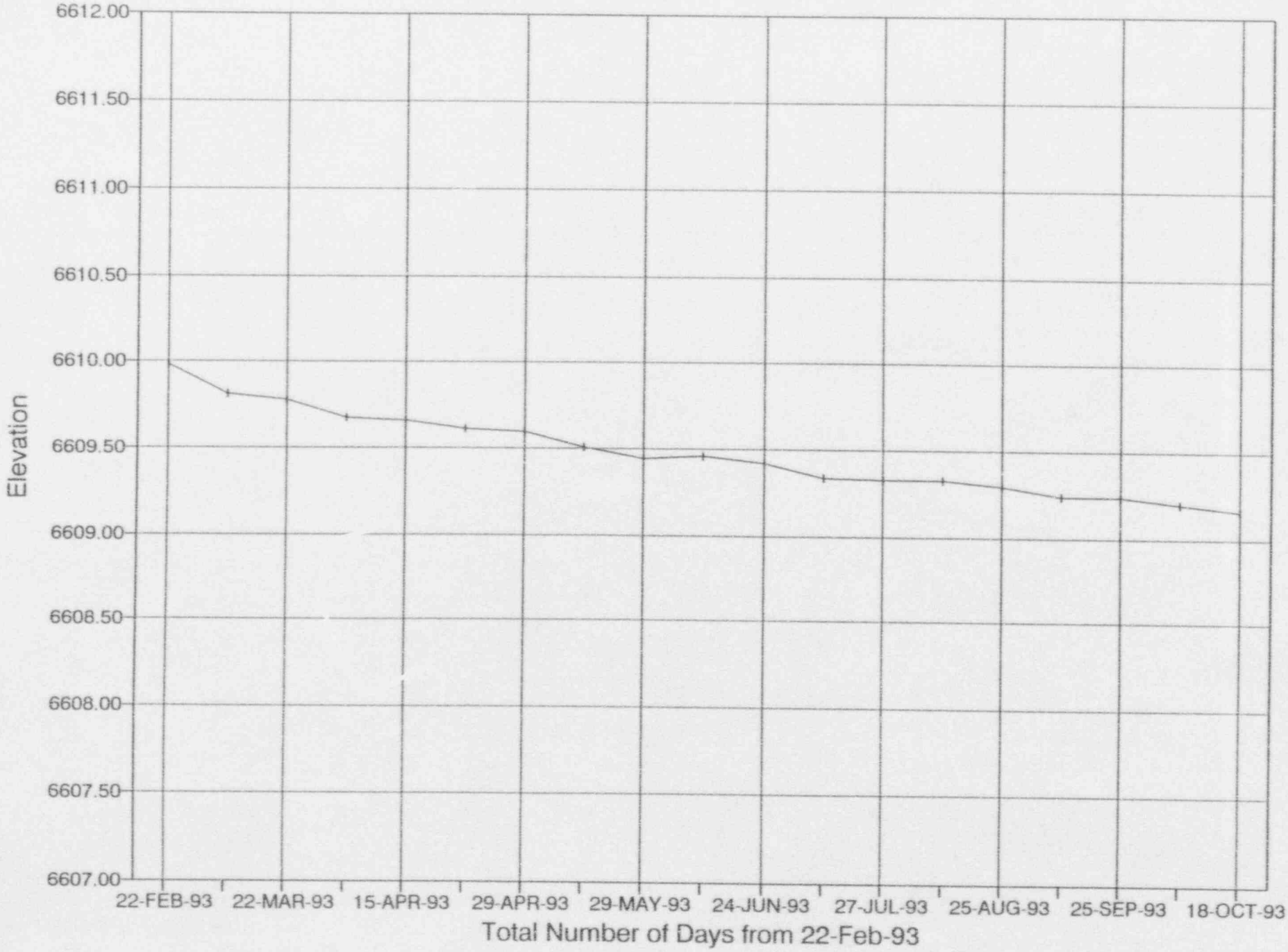
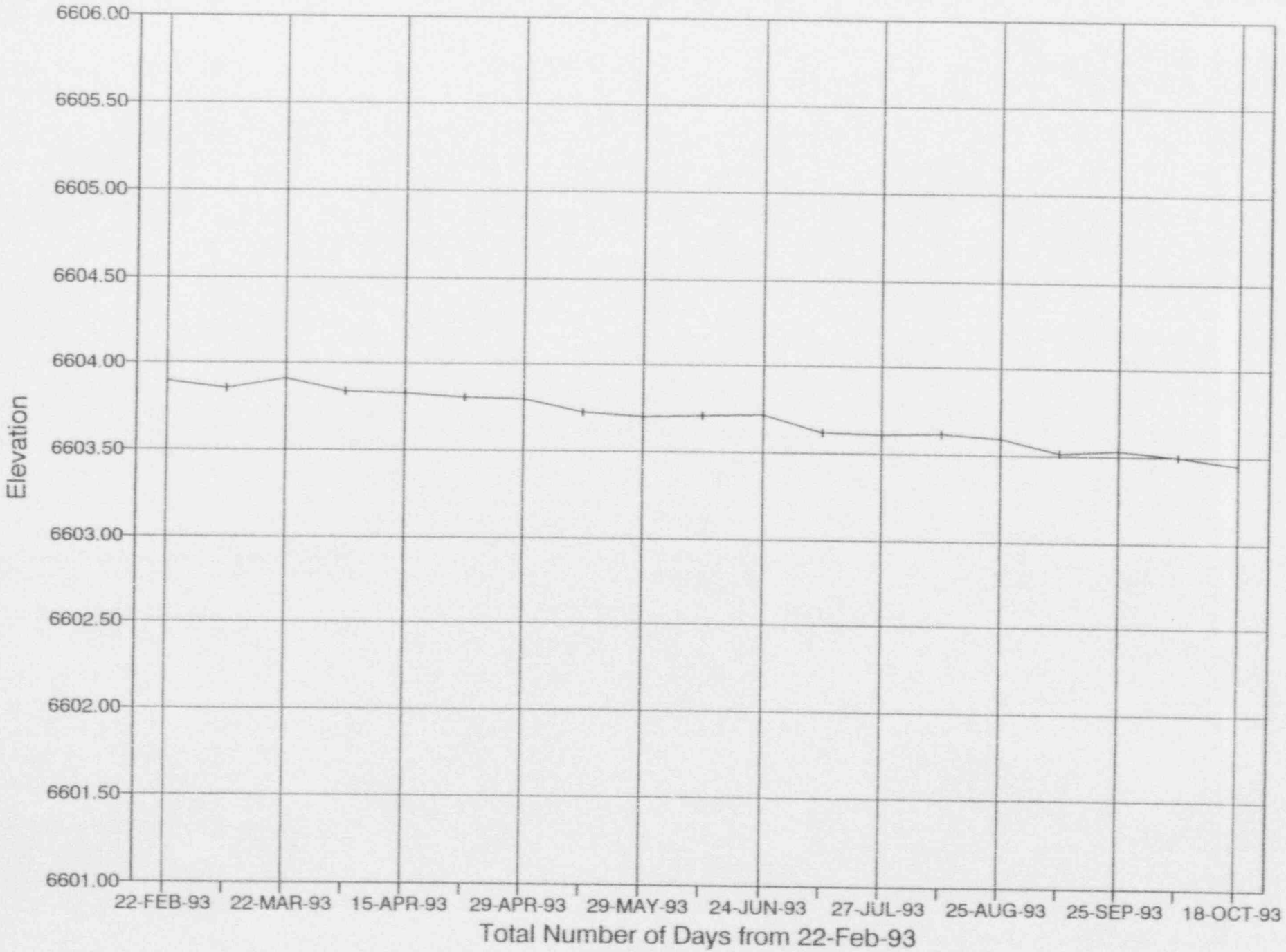


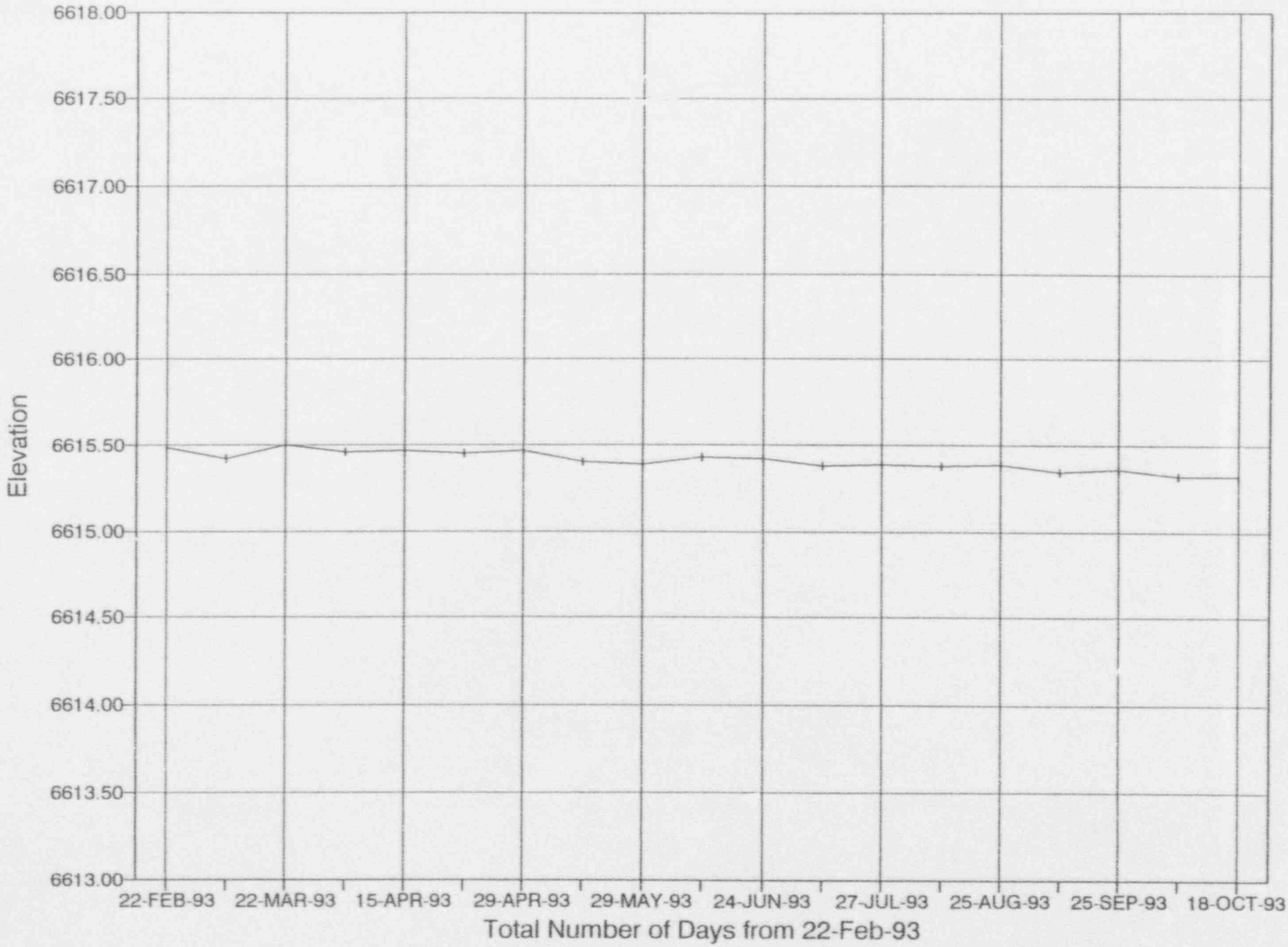
Settlement Point 8



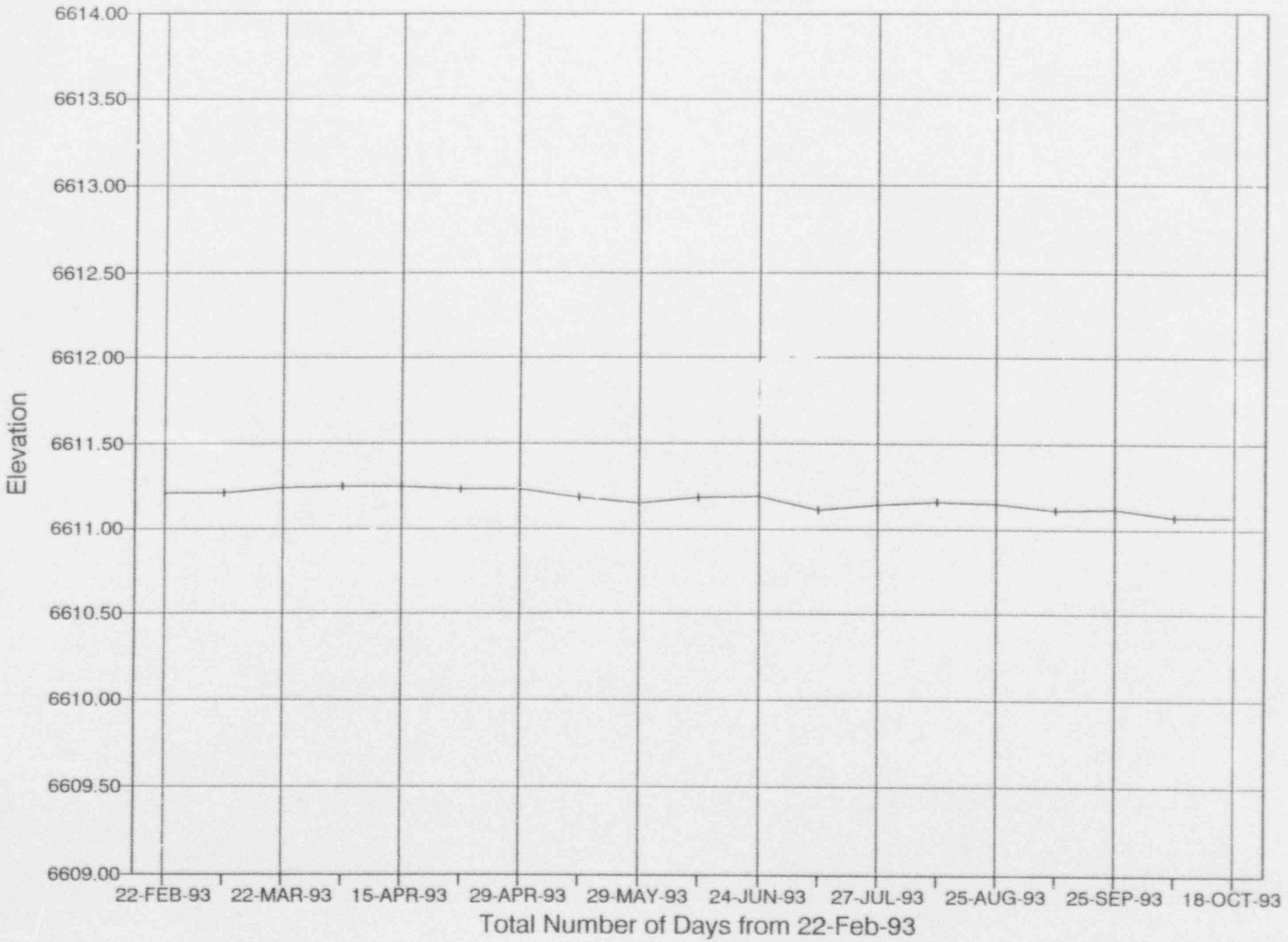
Settlement Point N8



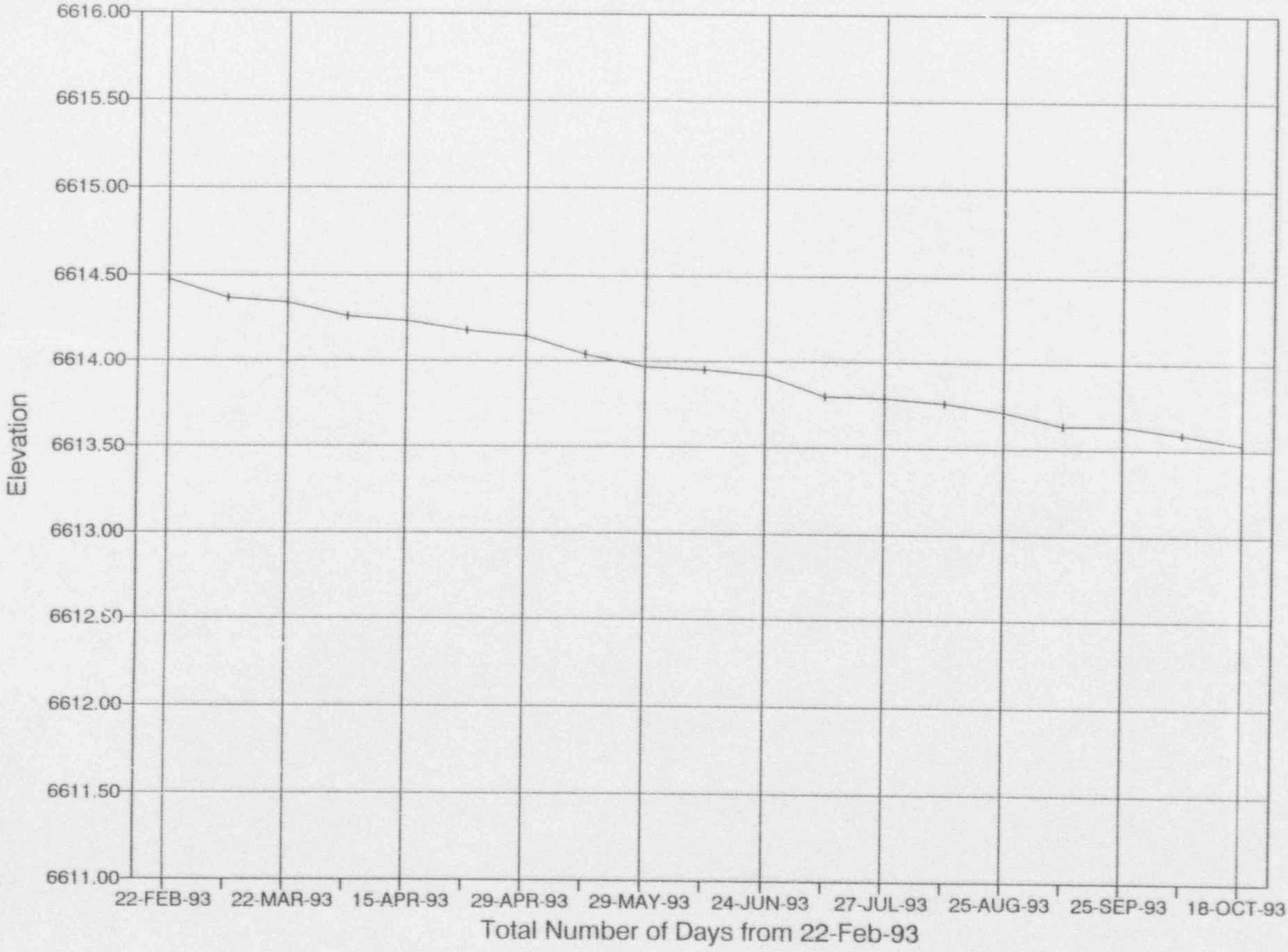
Settlement Point 9



Settlement Point 11



Settlement Point 16



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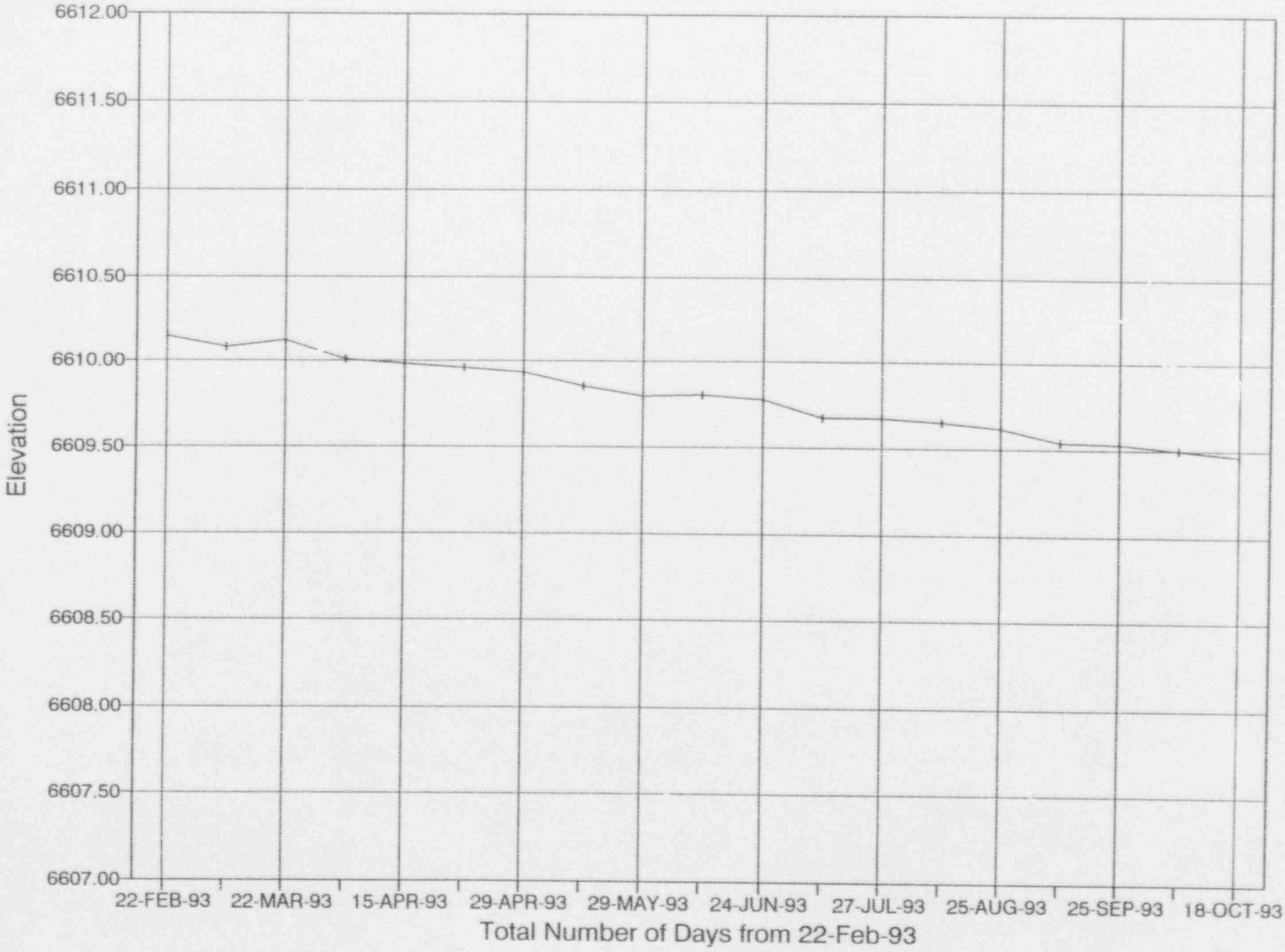
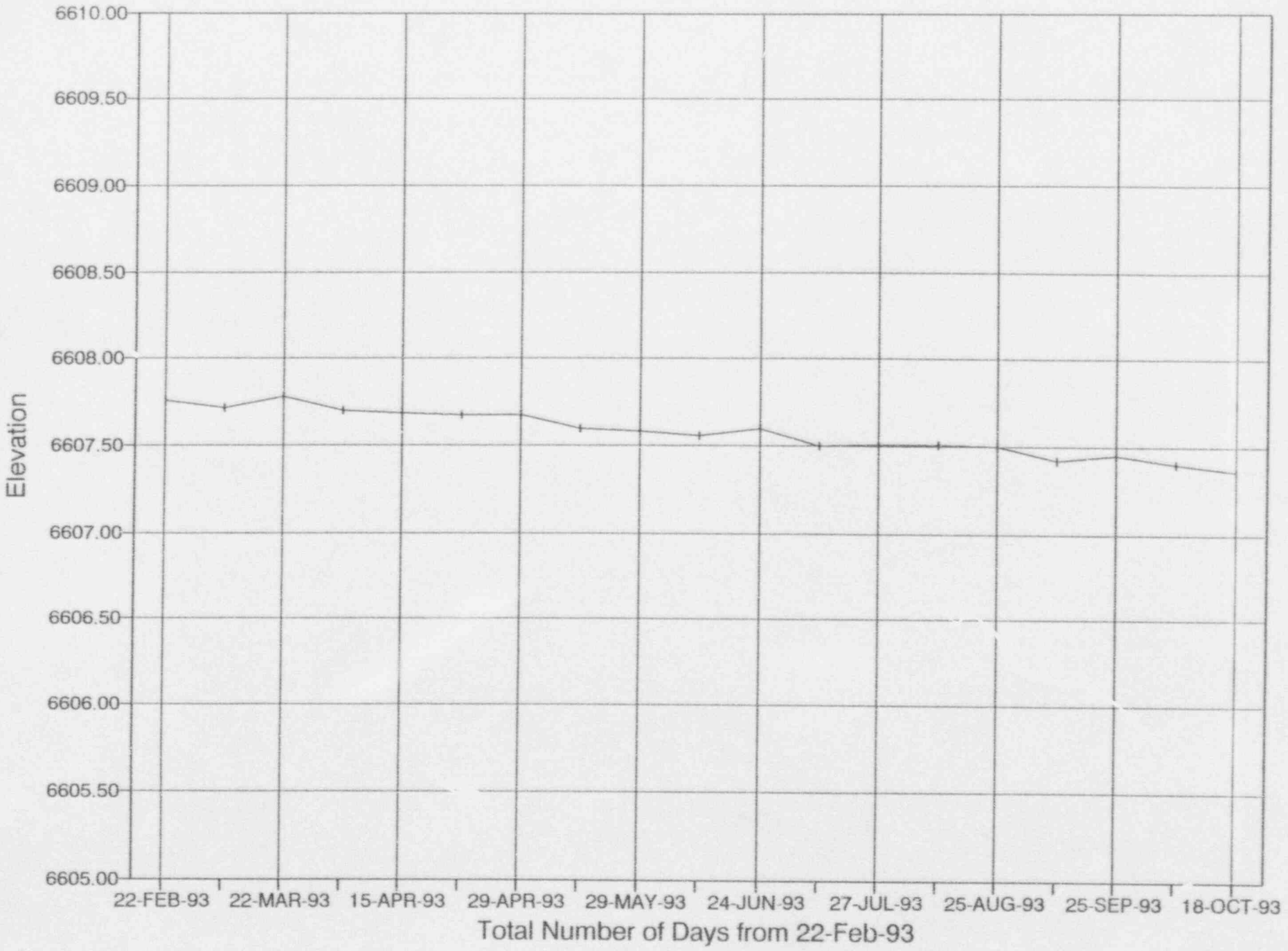
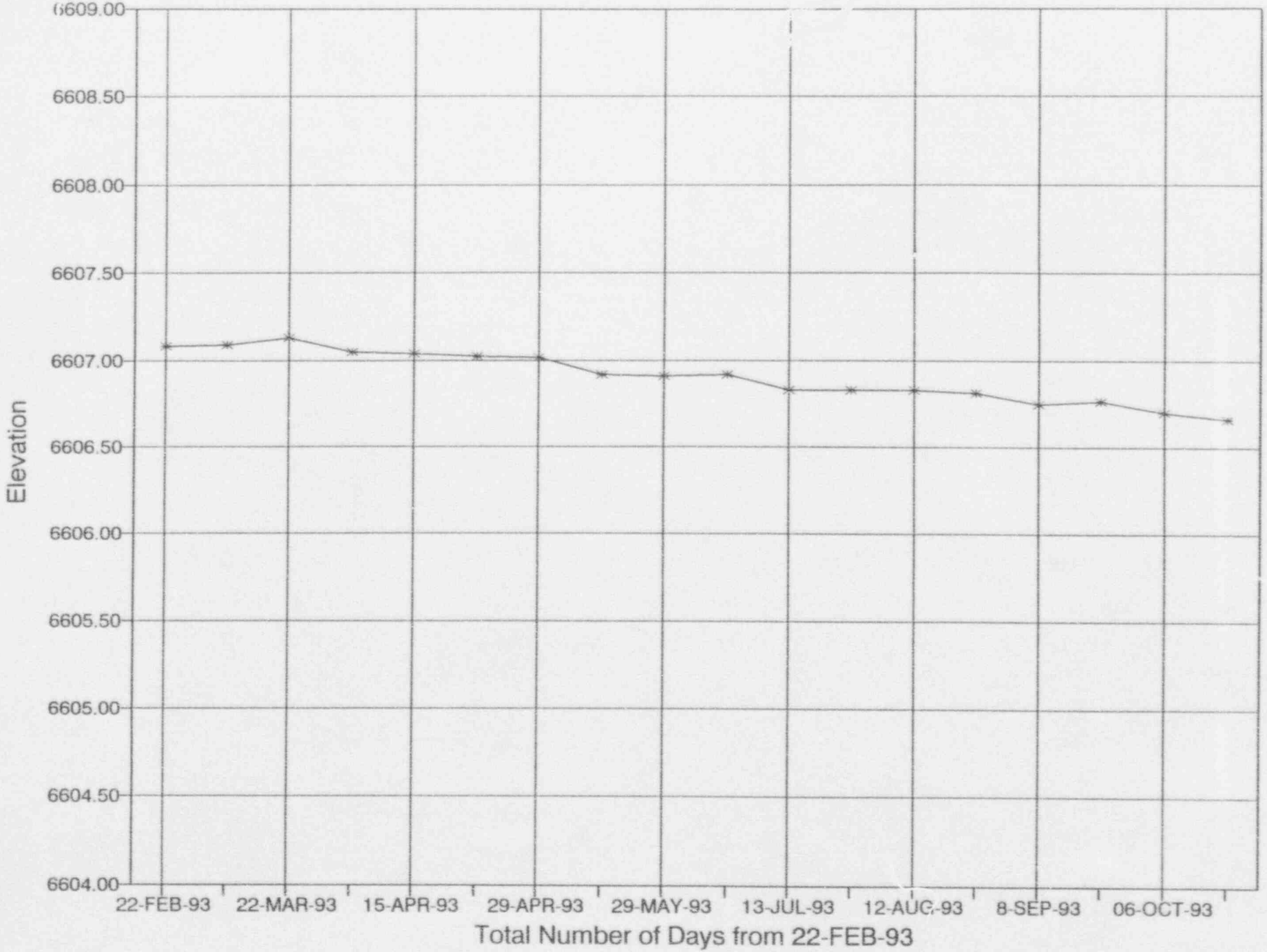


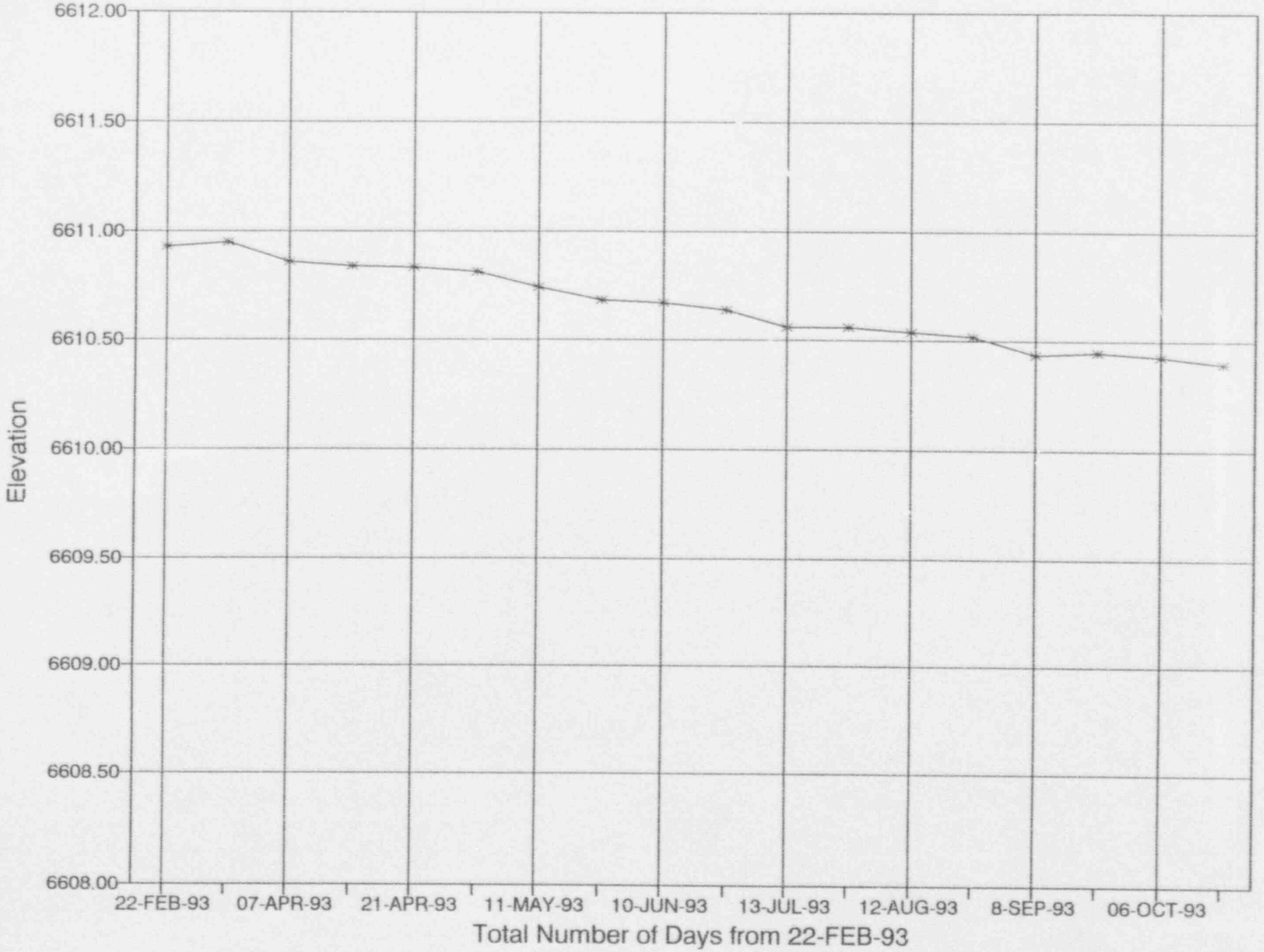
Settlement Point 19



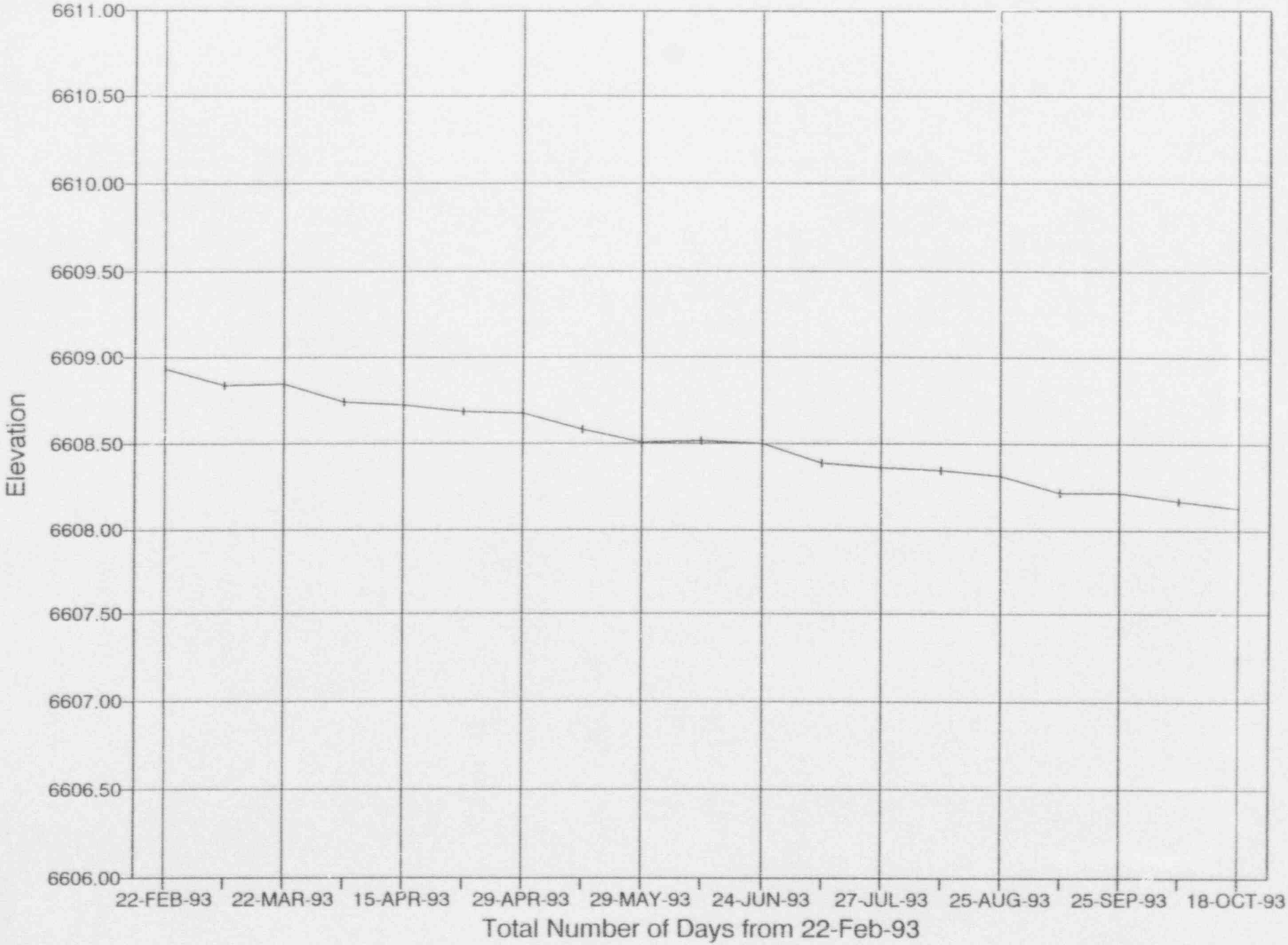
Settlement Point 21



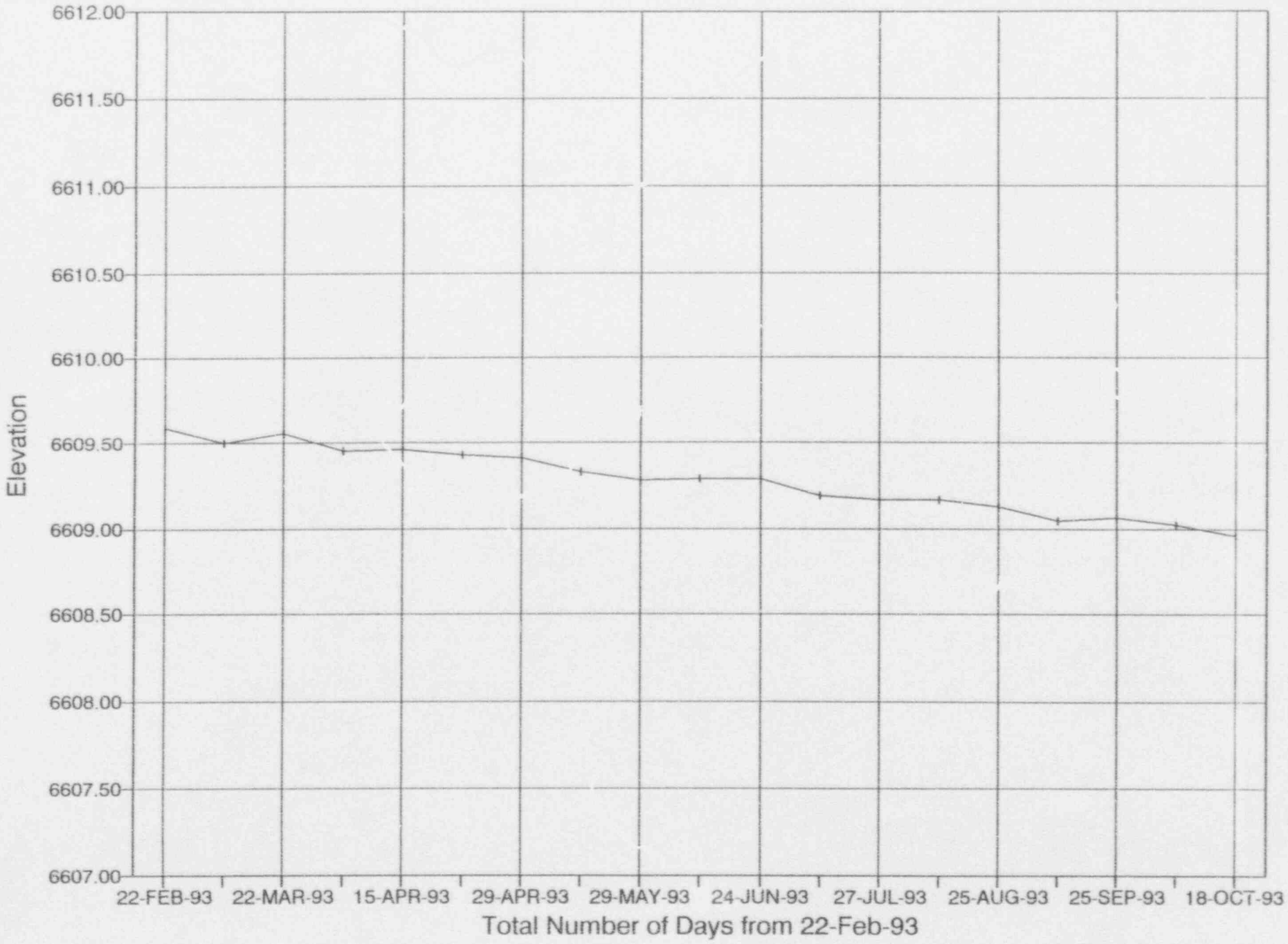
Settlement Point 22



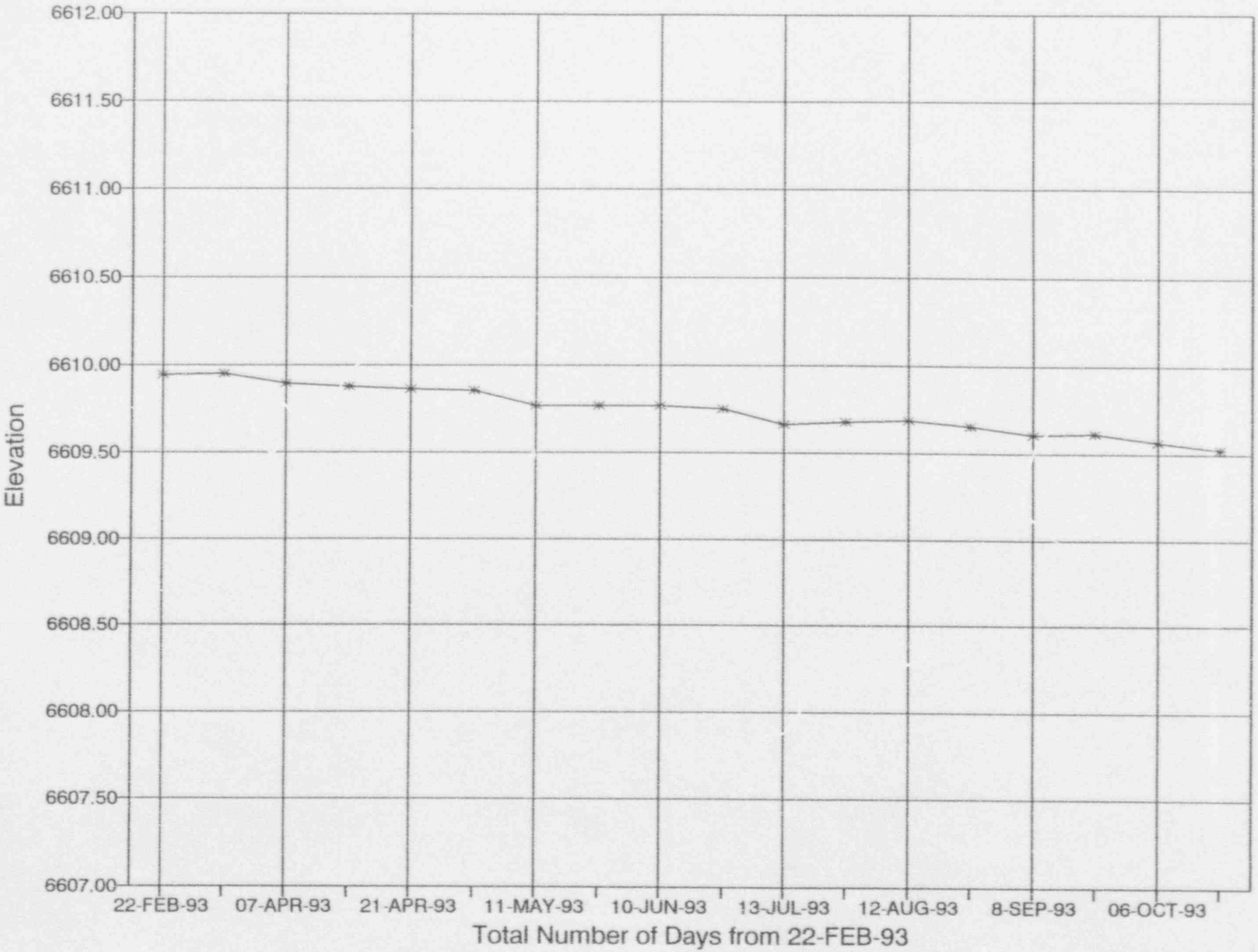
Settlement Point 23



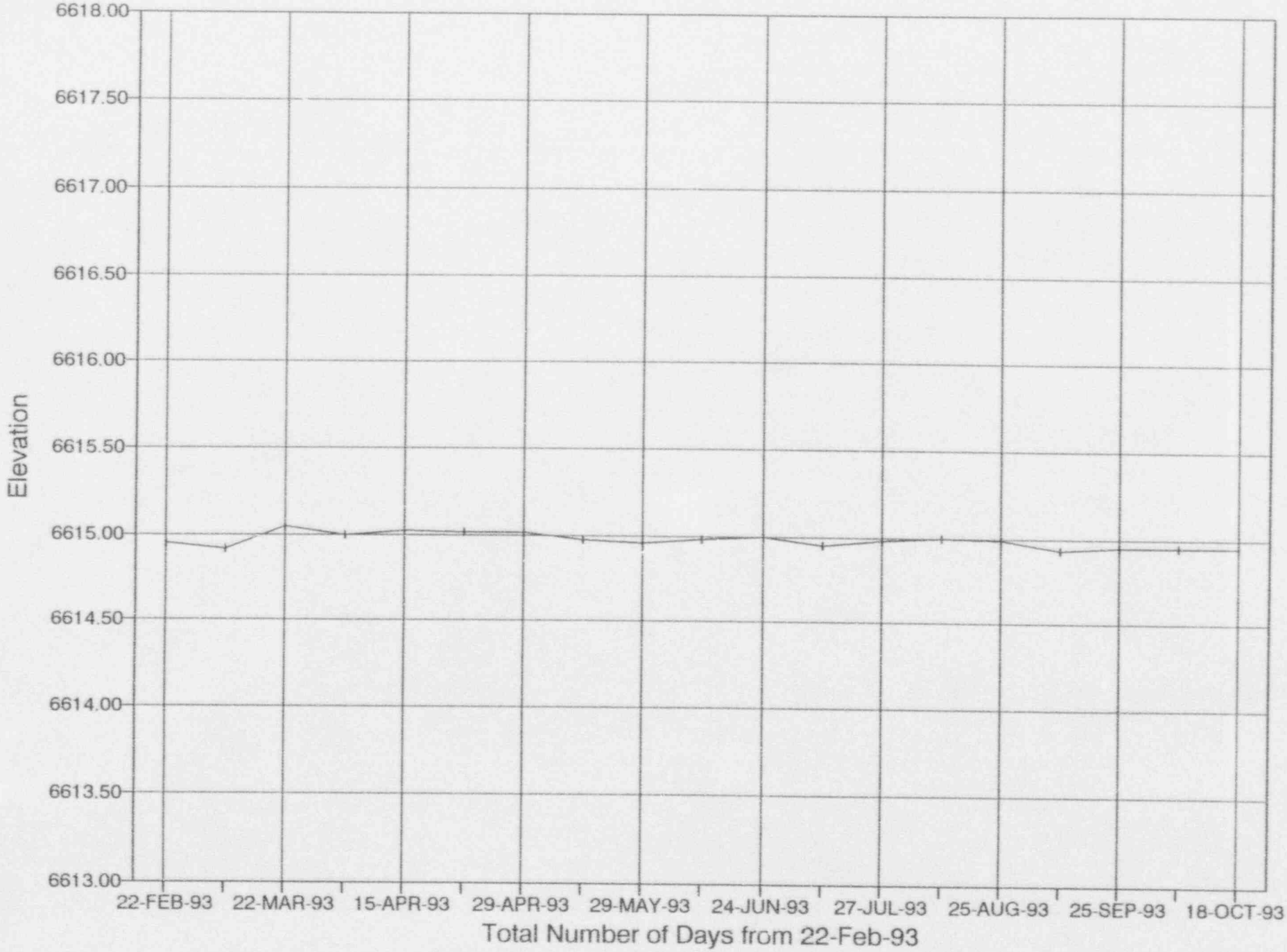
Settlement Point 24



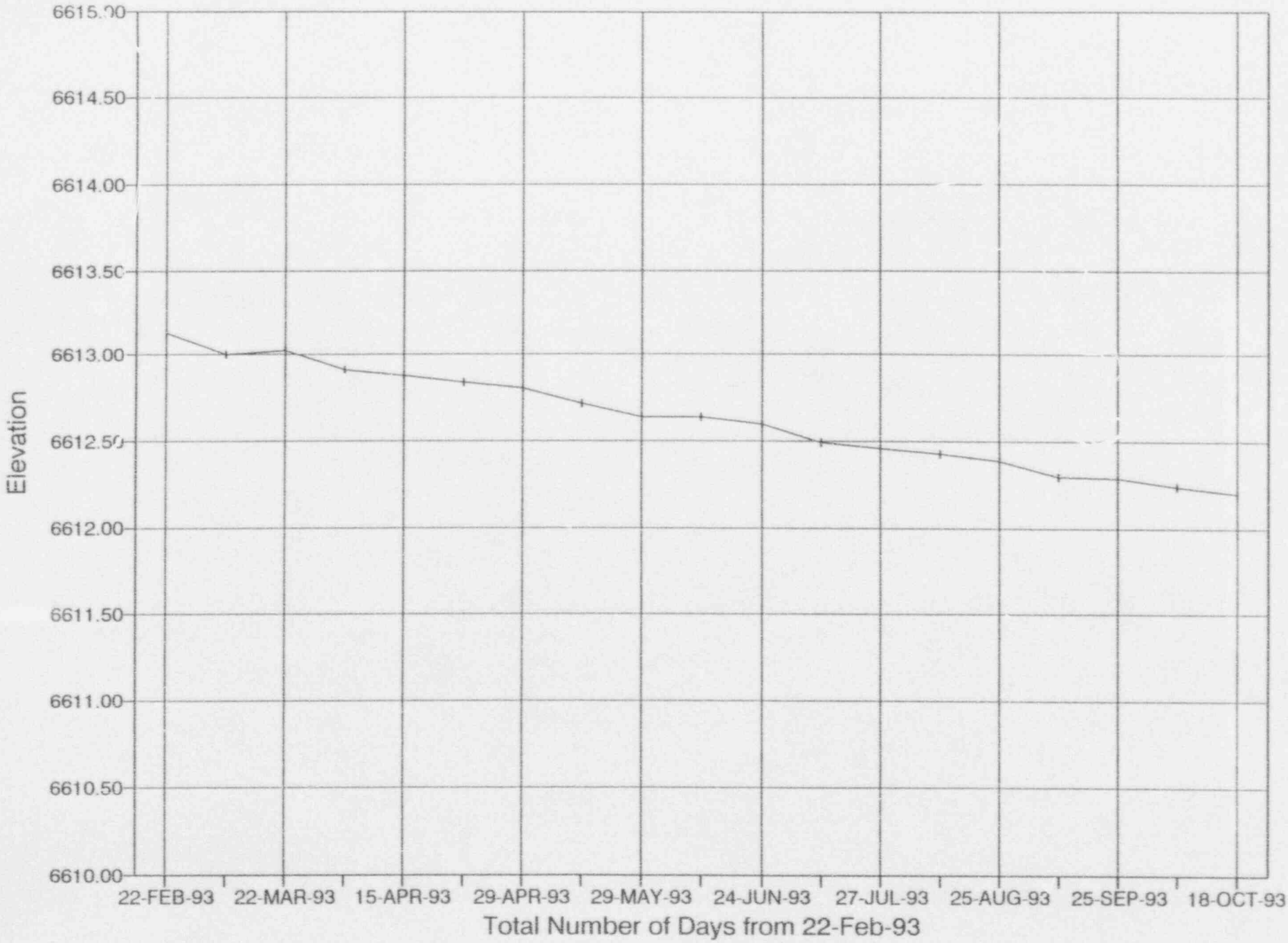
Settlement Point 25



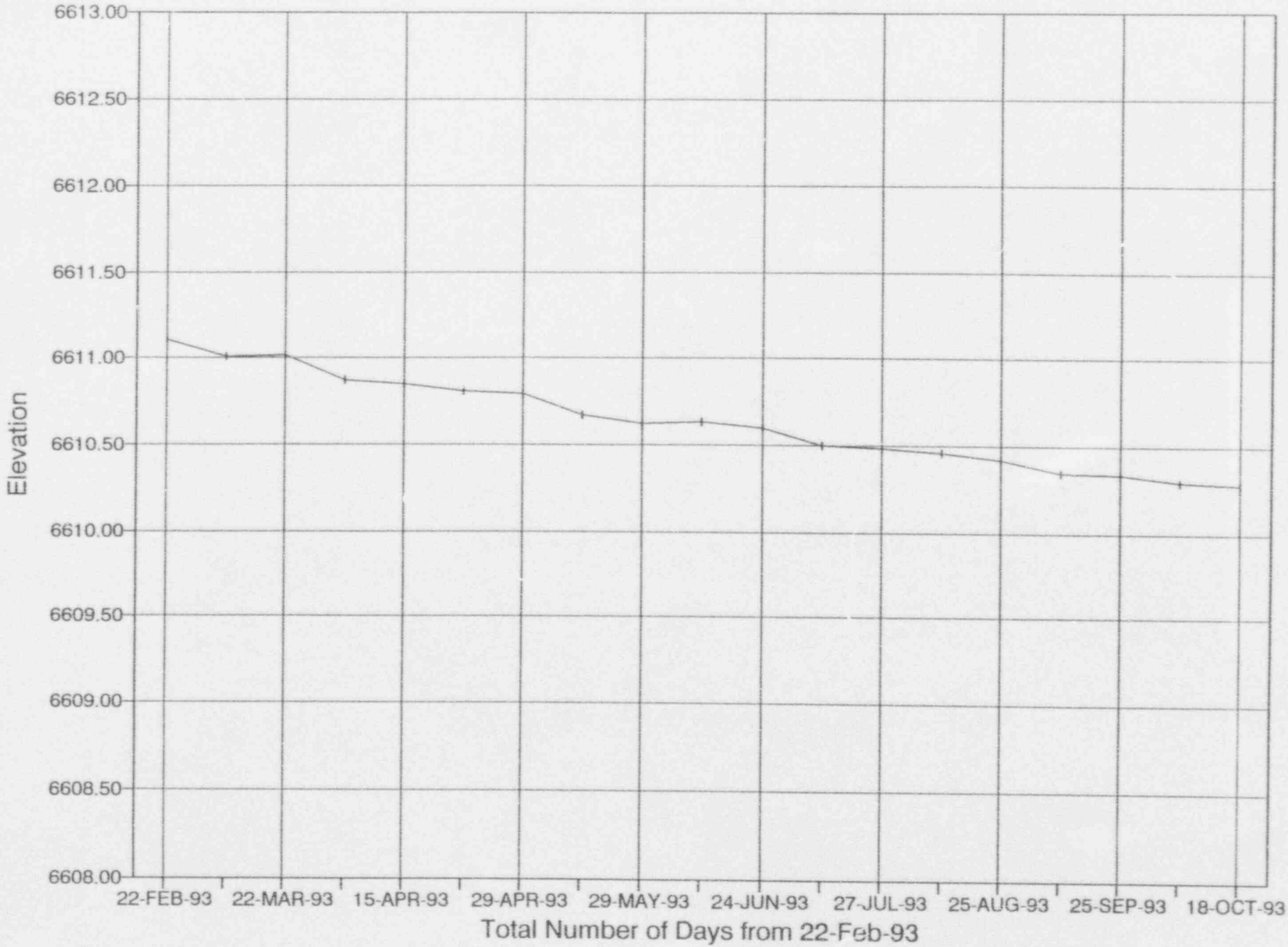
Settlement Point 26



Settlement Point 27



Settlement Point 28



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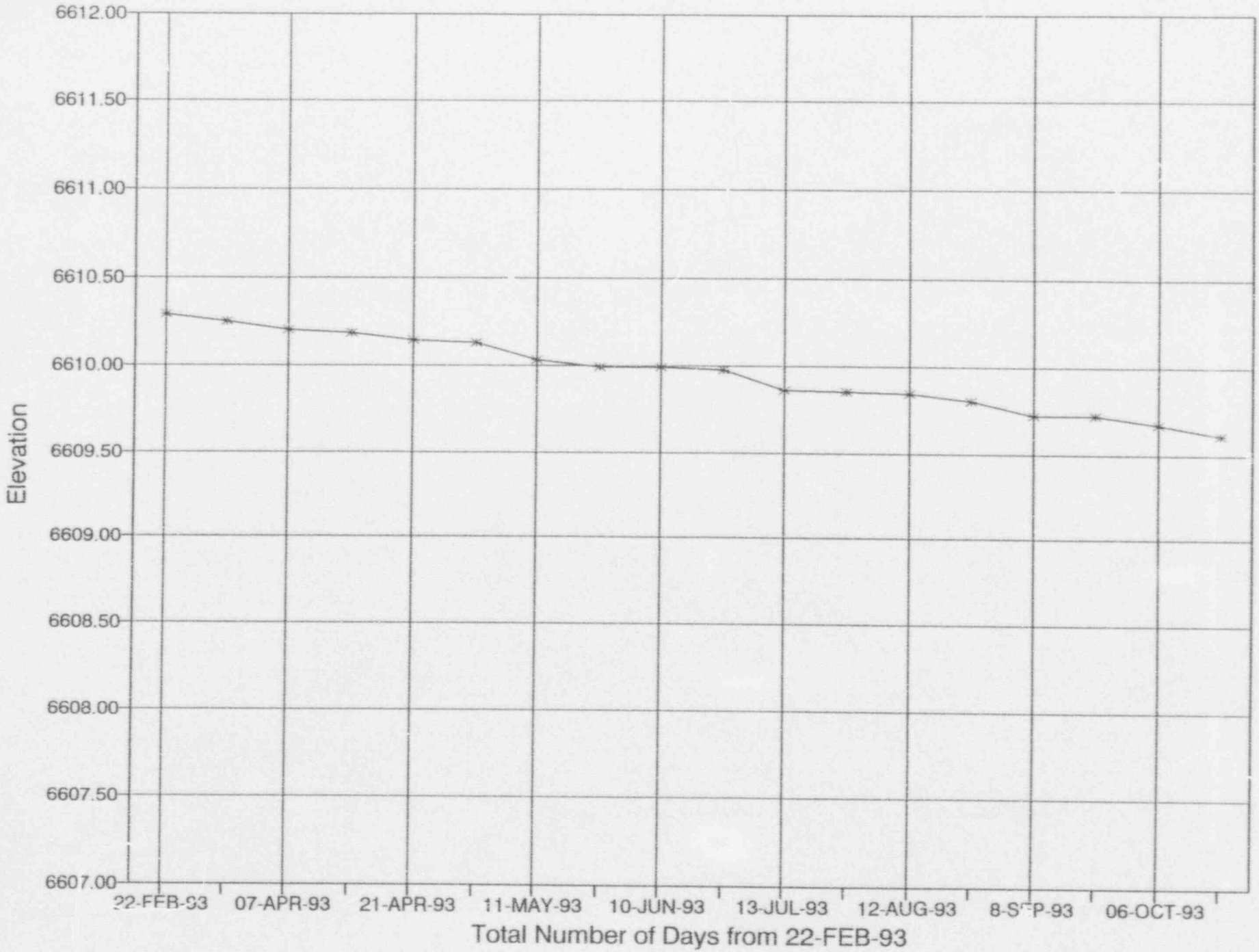

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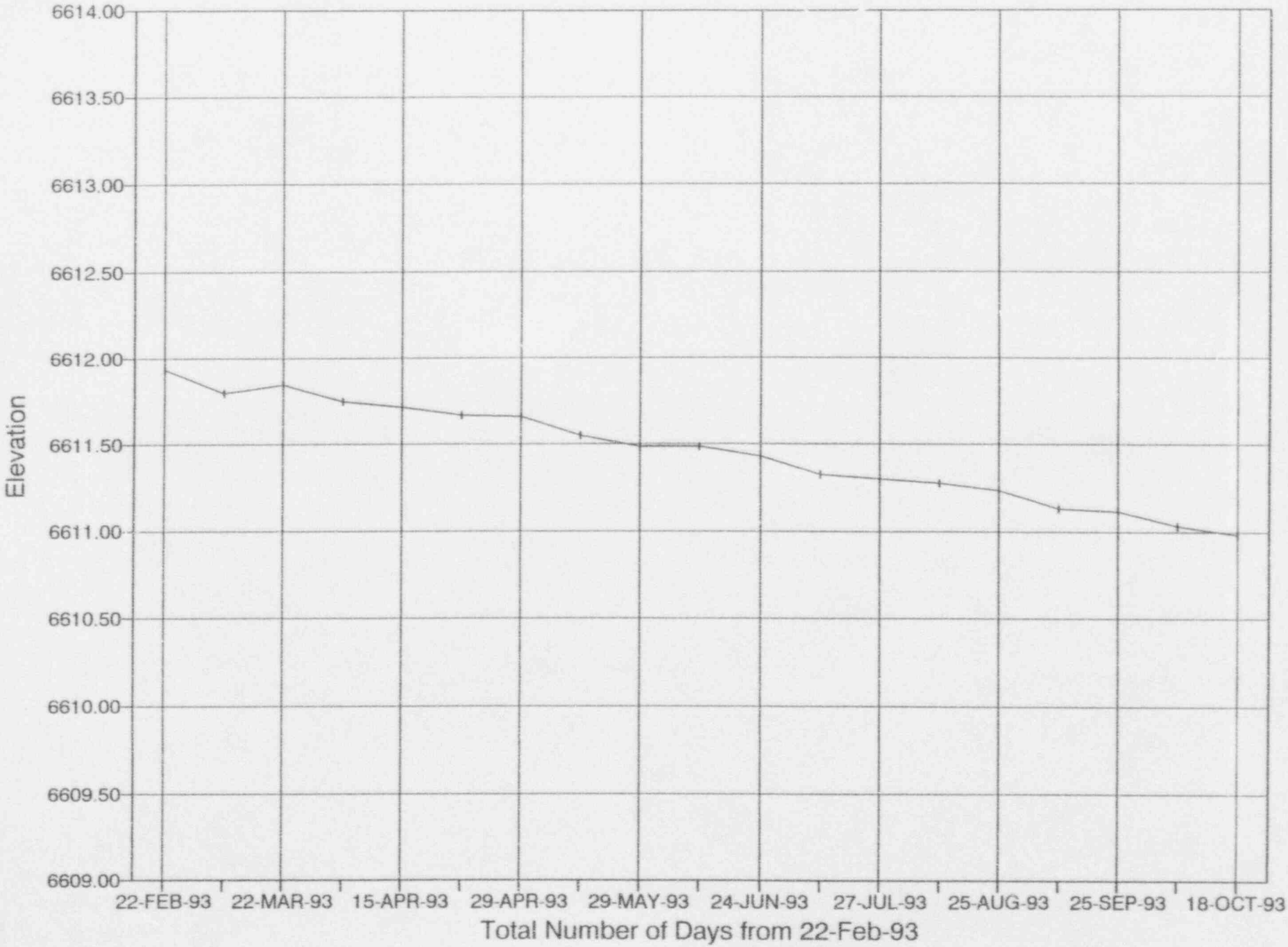
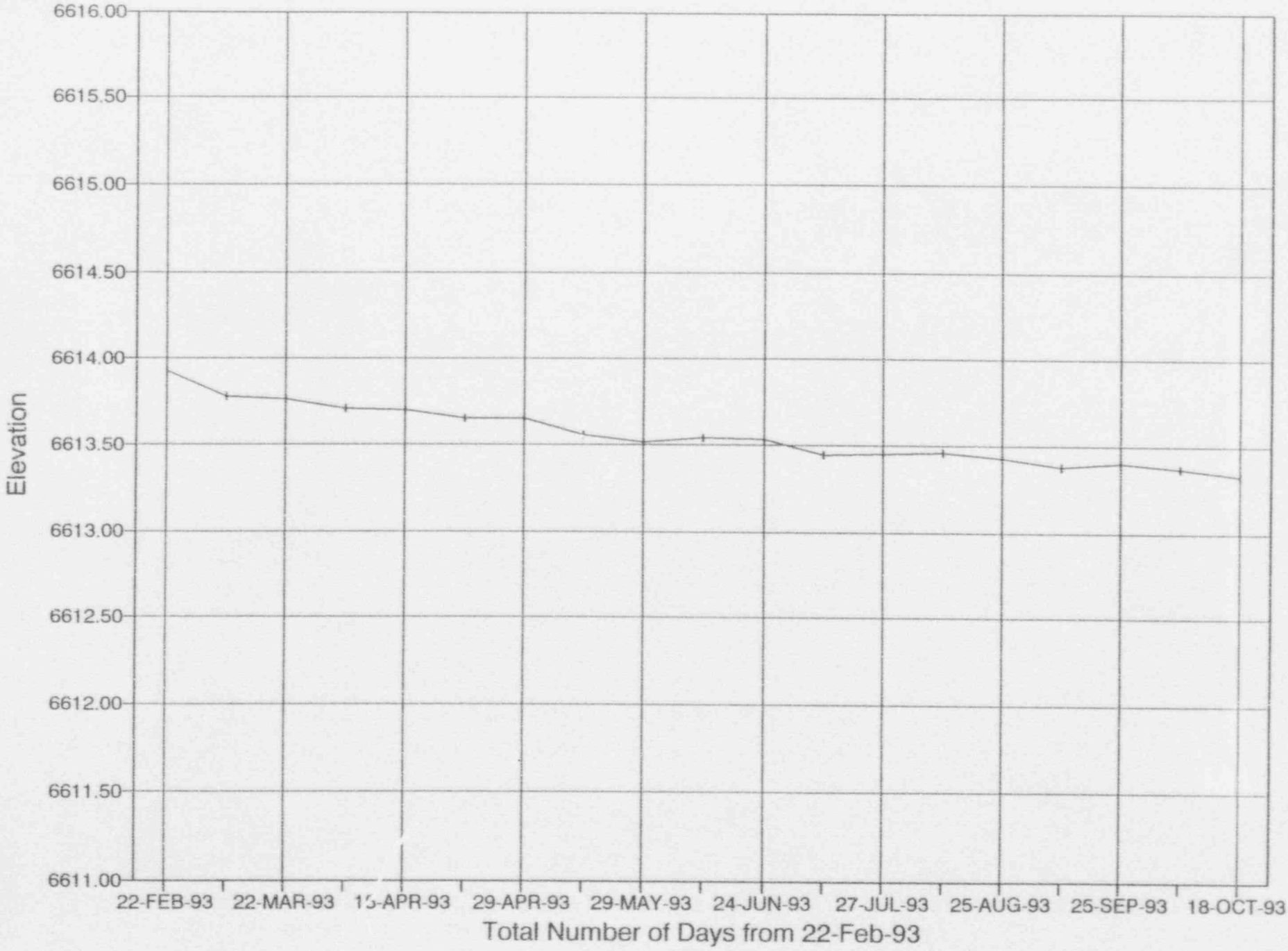


Settlement Point 31



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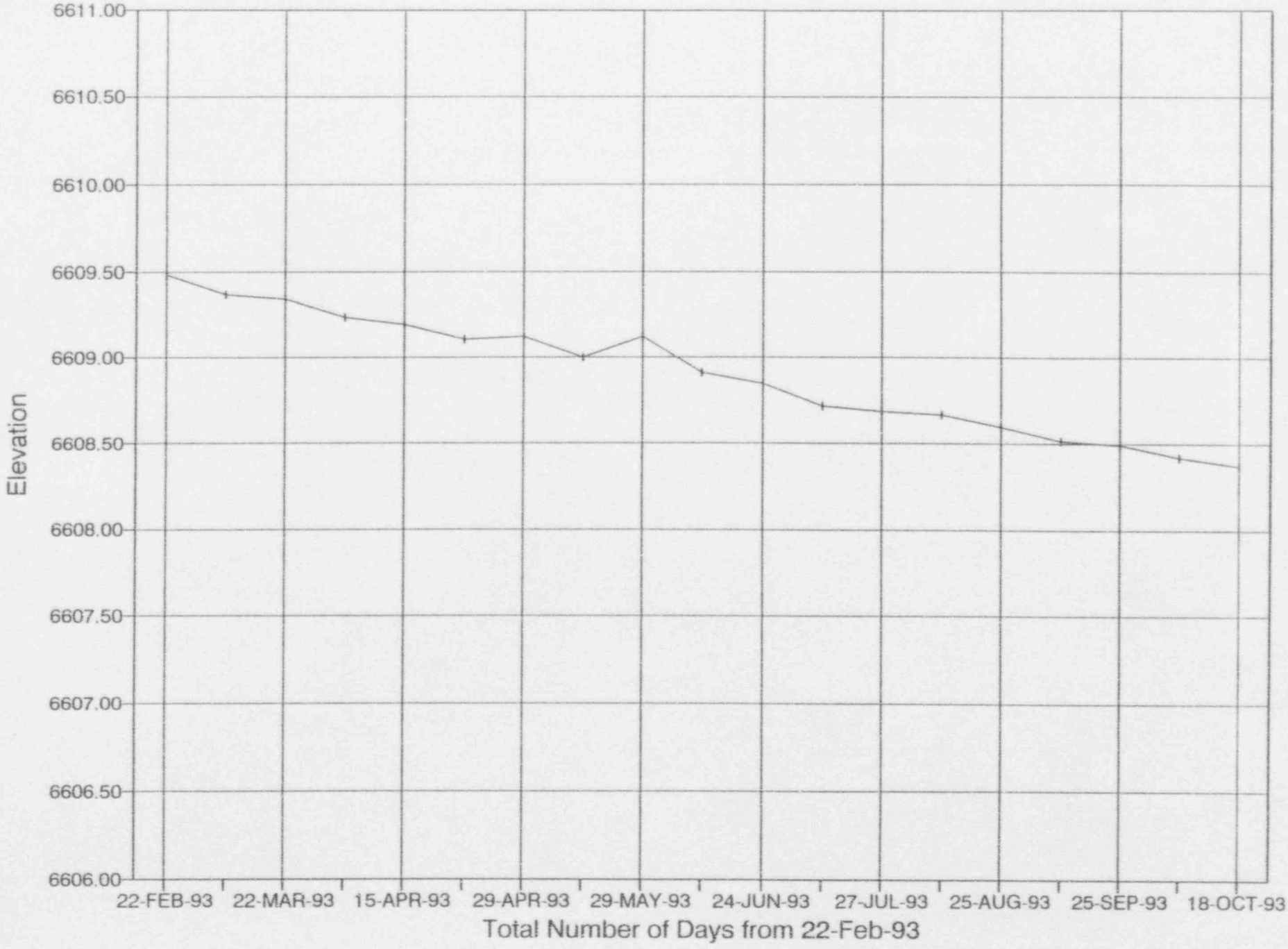
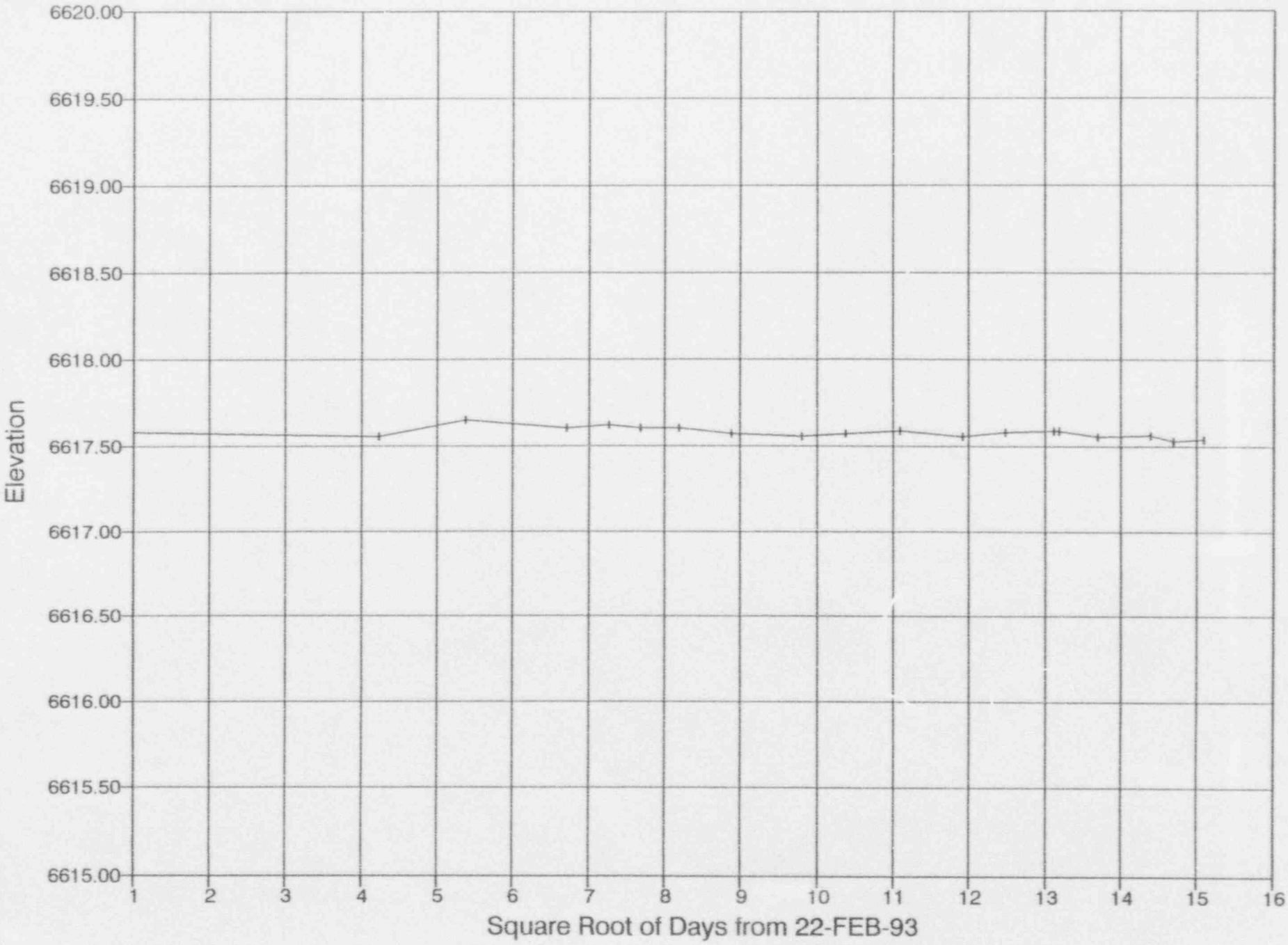


SQUARE ROOT OF DAYS

Settlement Point 1



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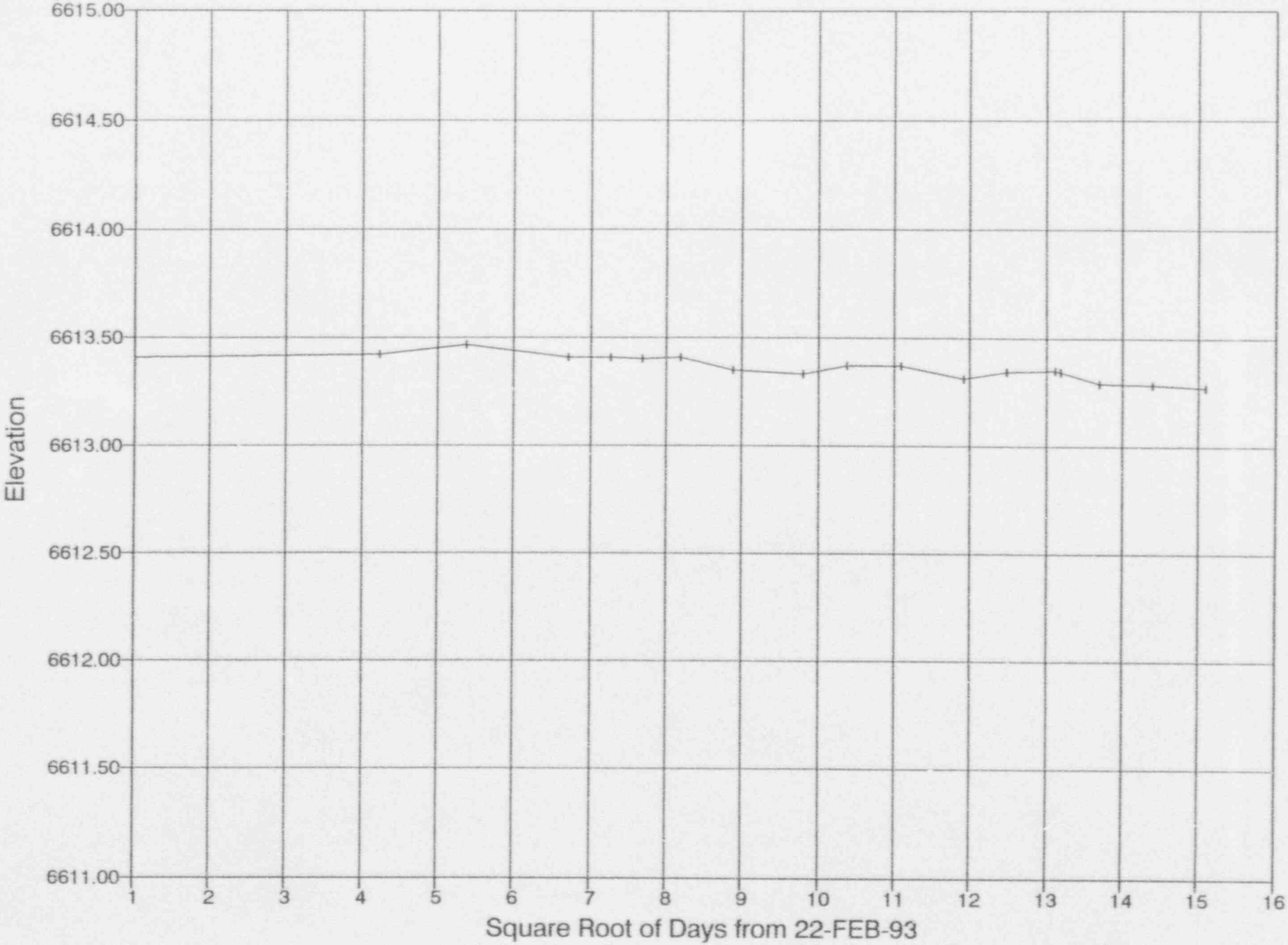
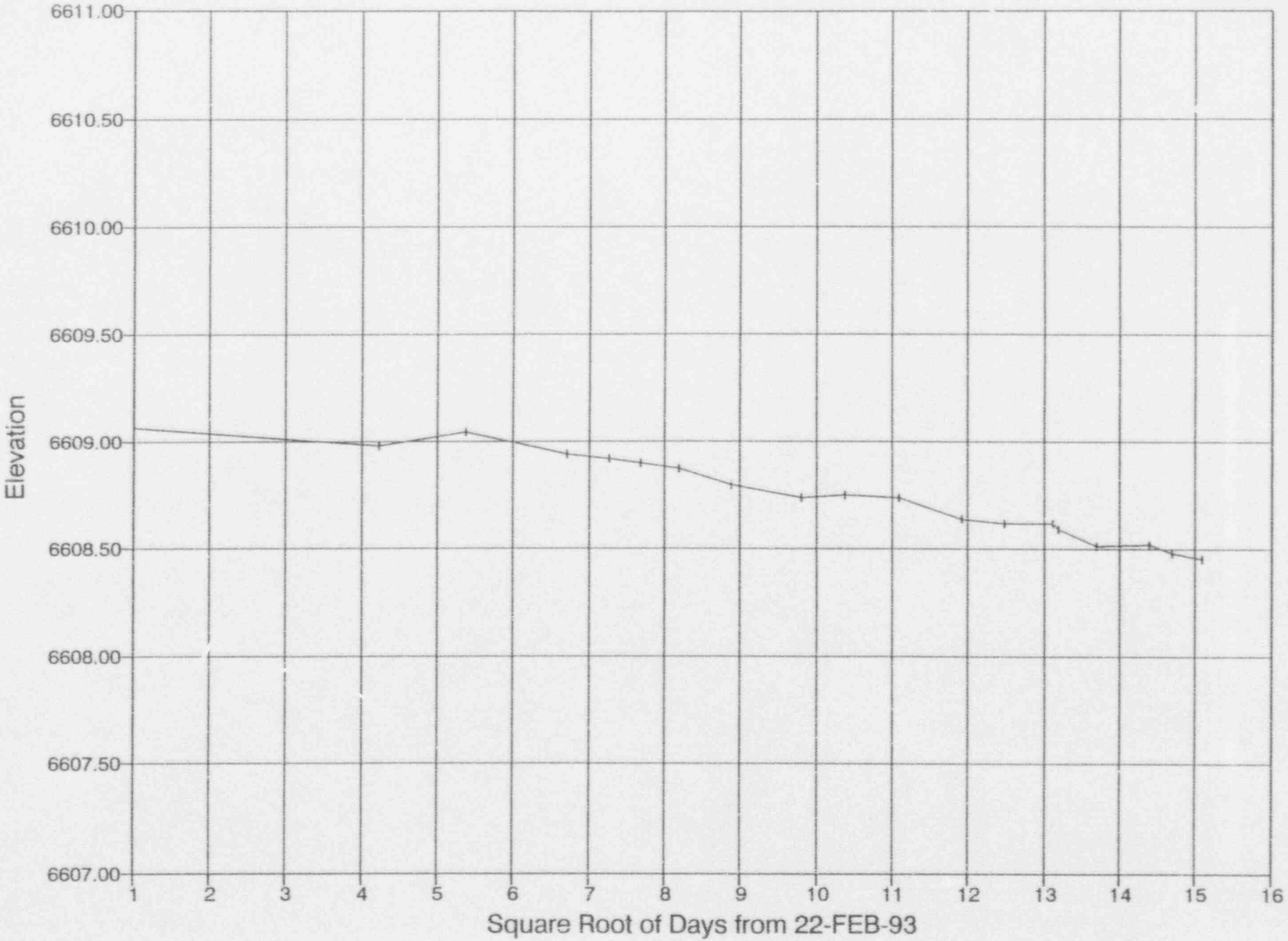


Settlement Point 3



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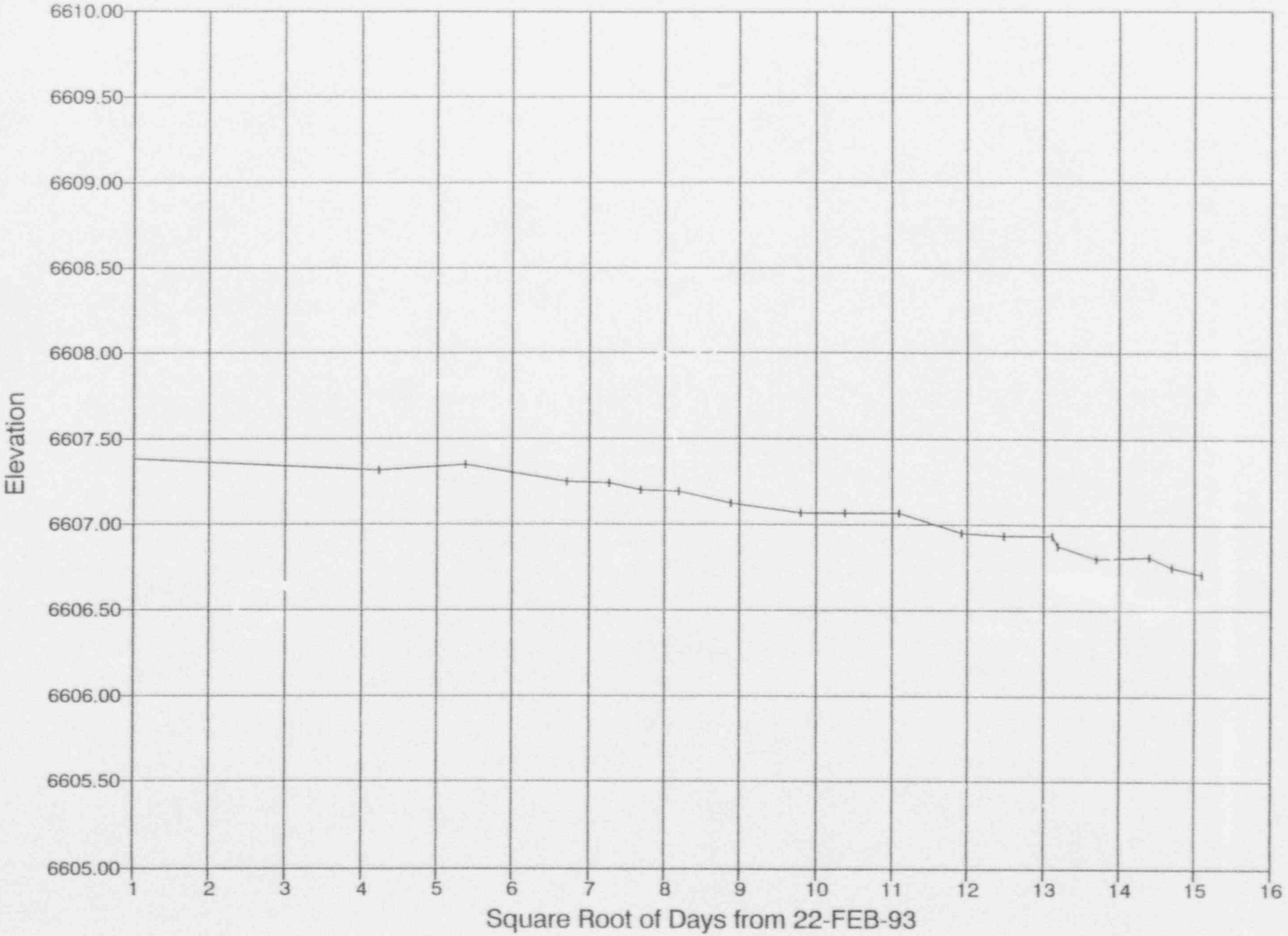

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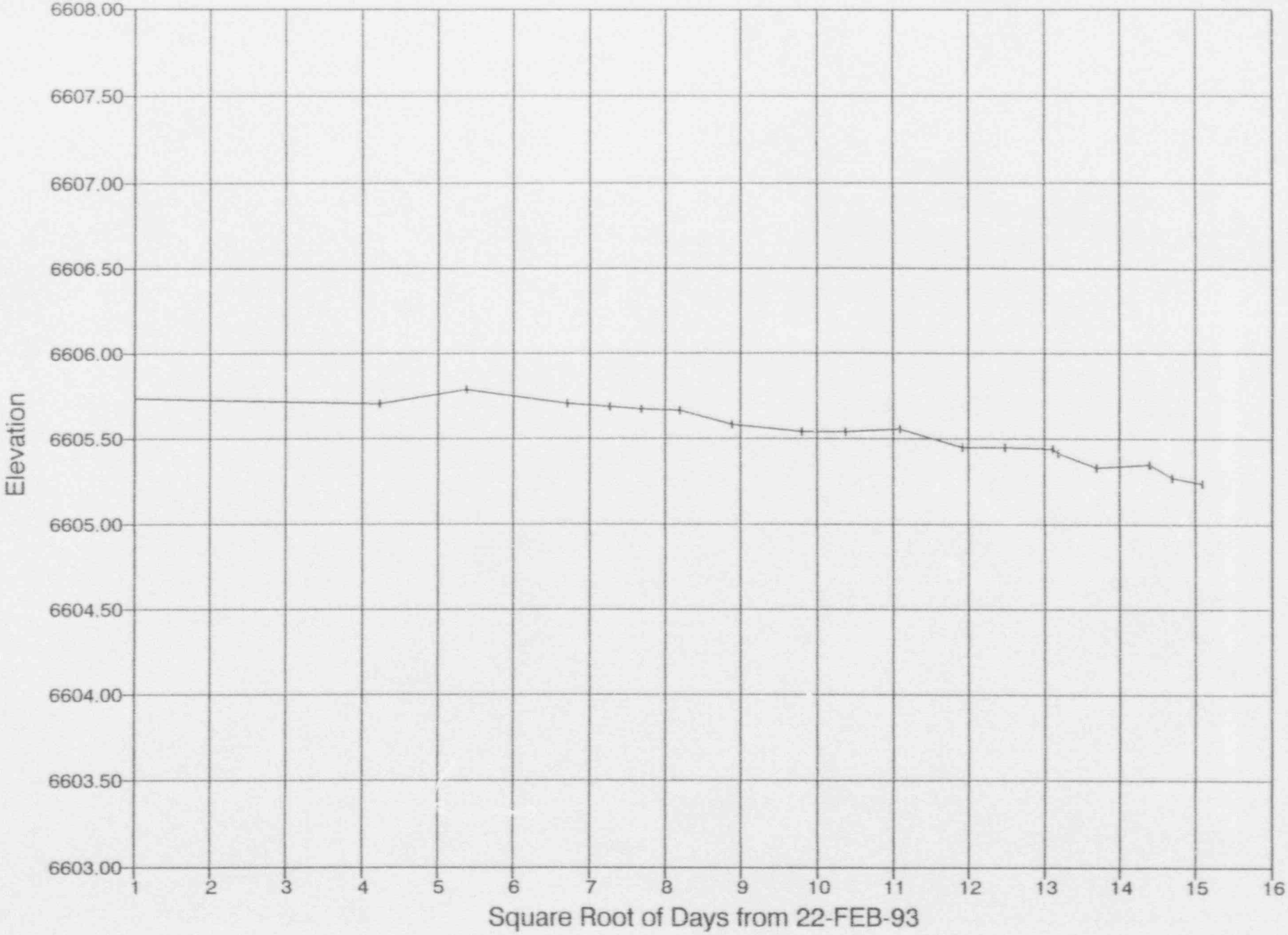

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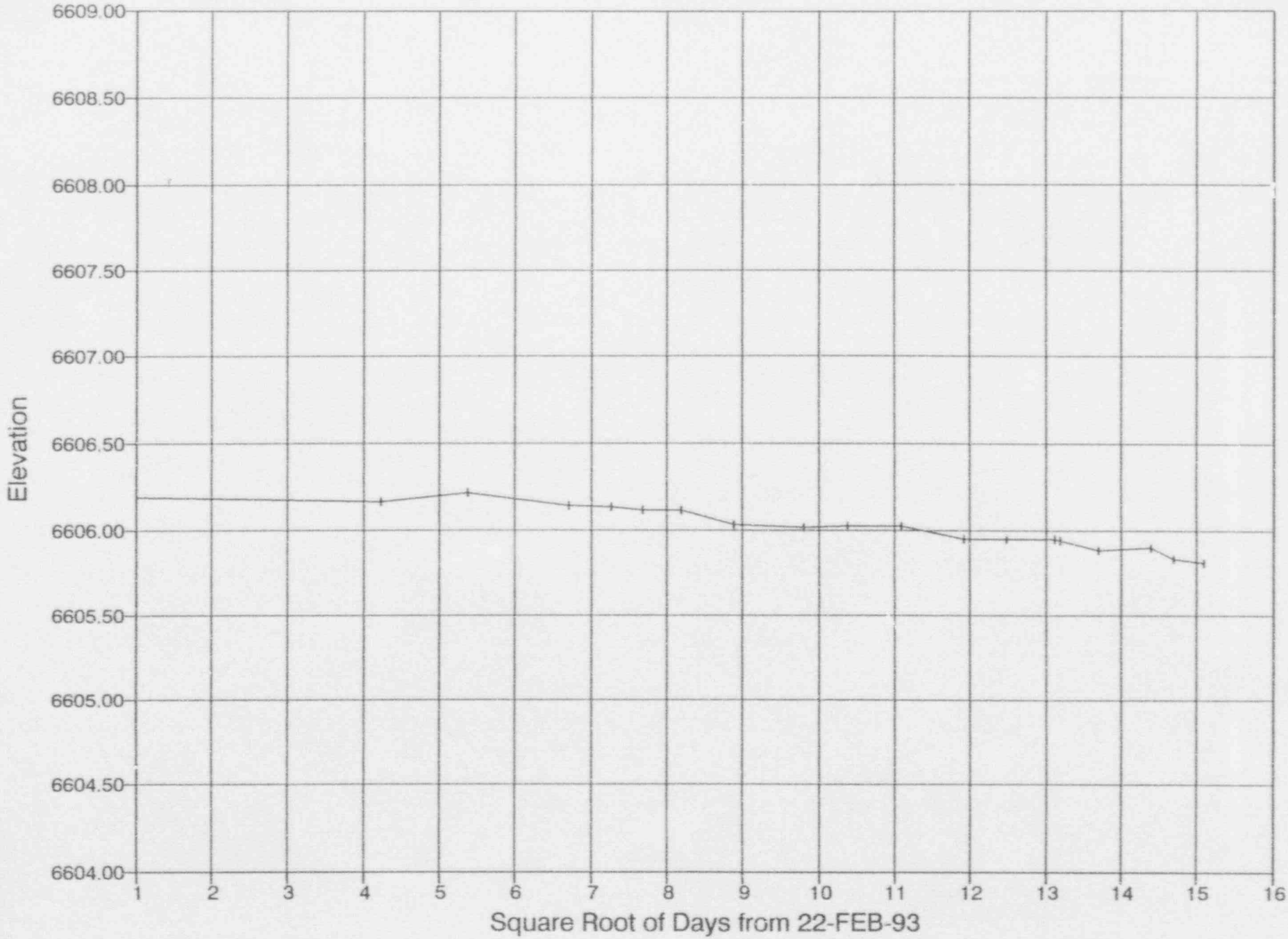
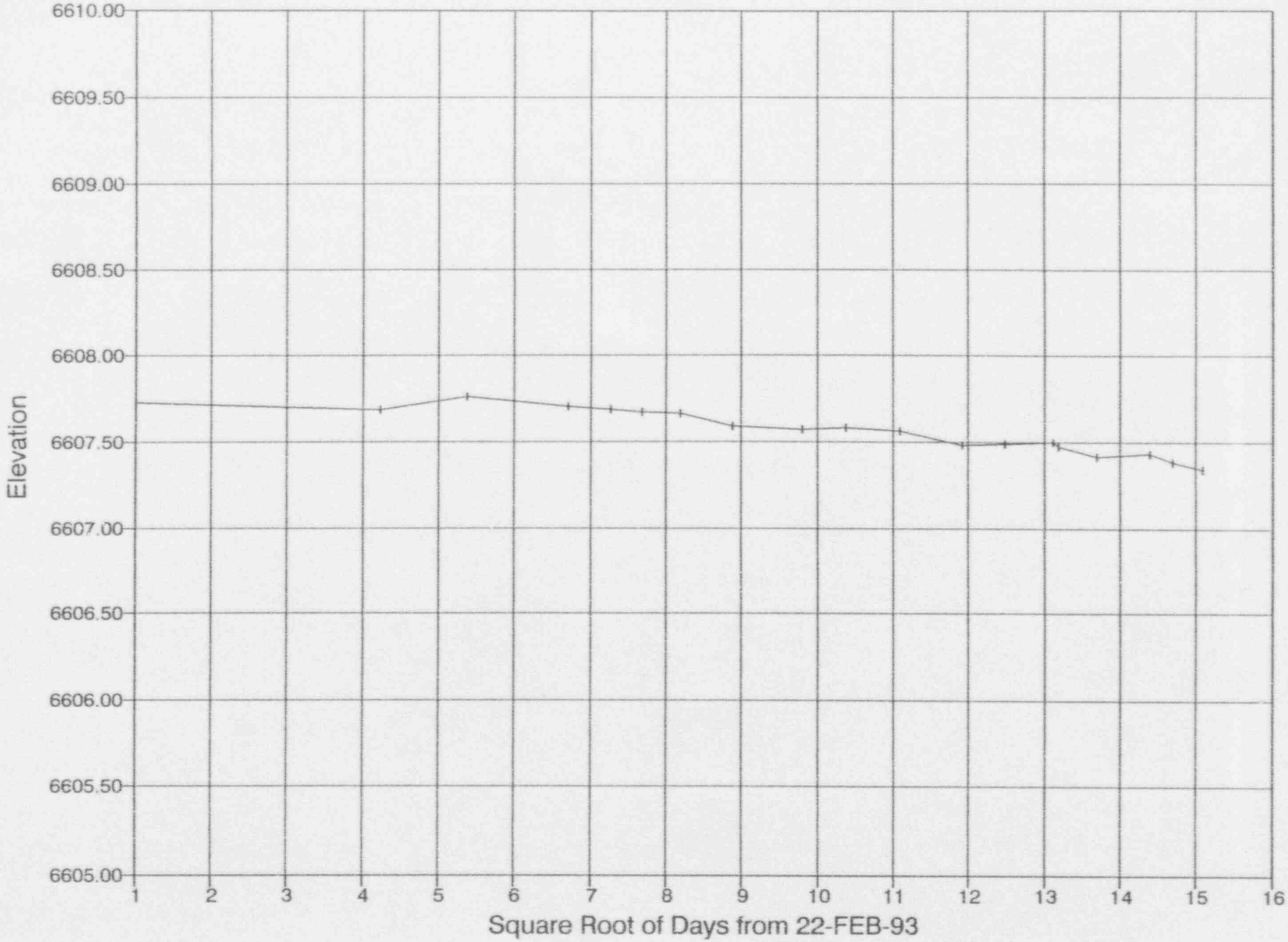
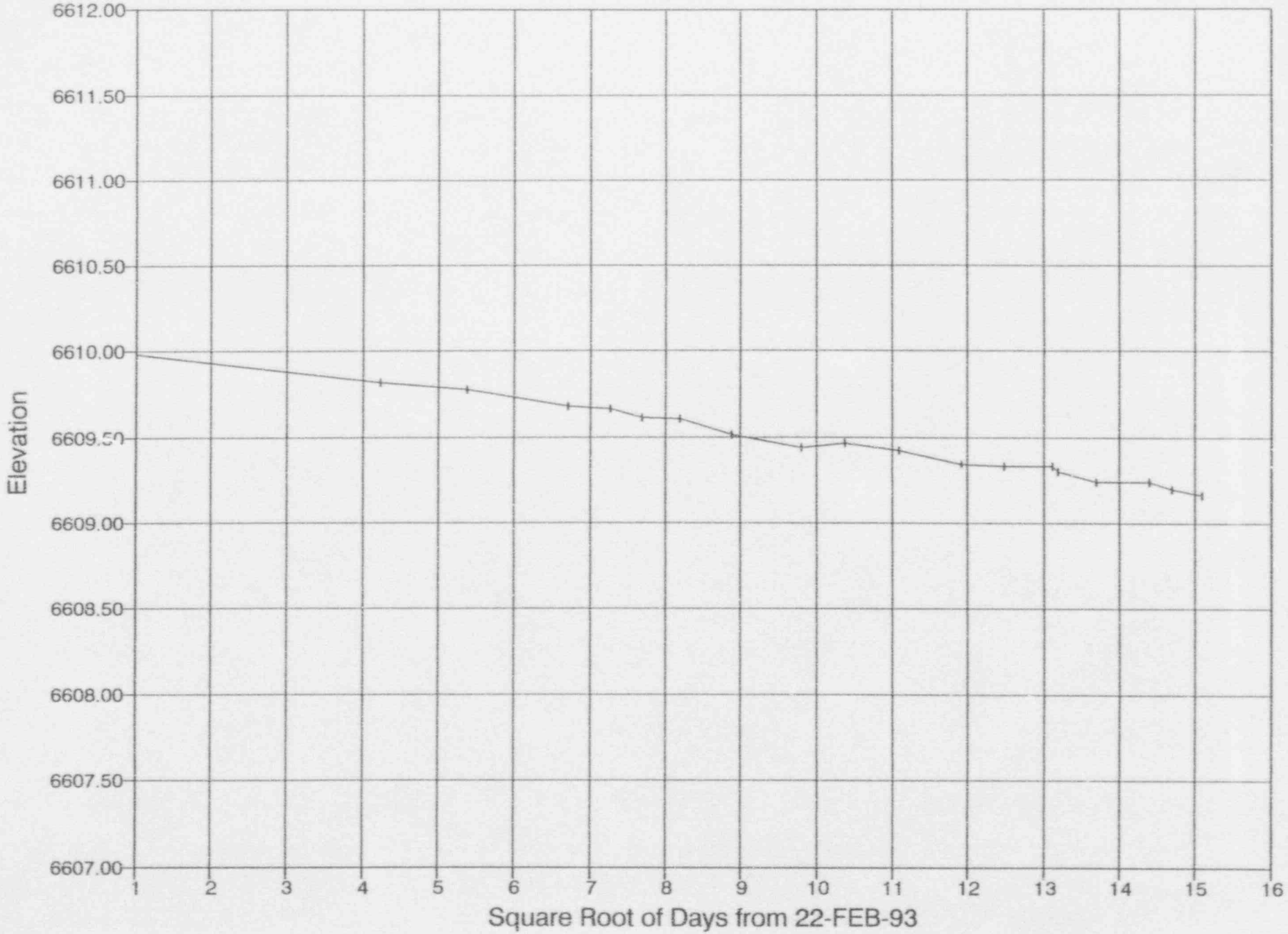


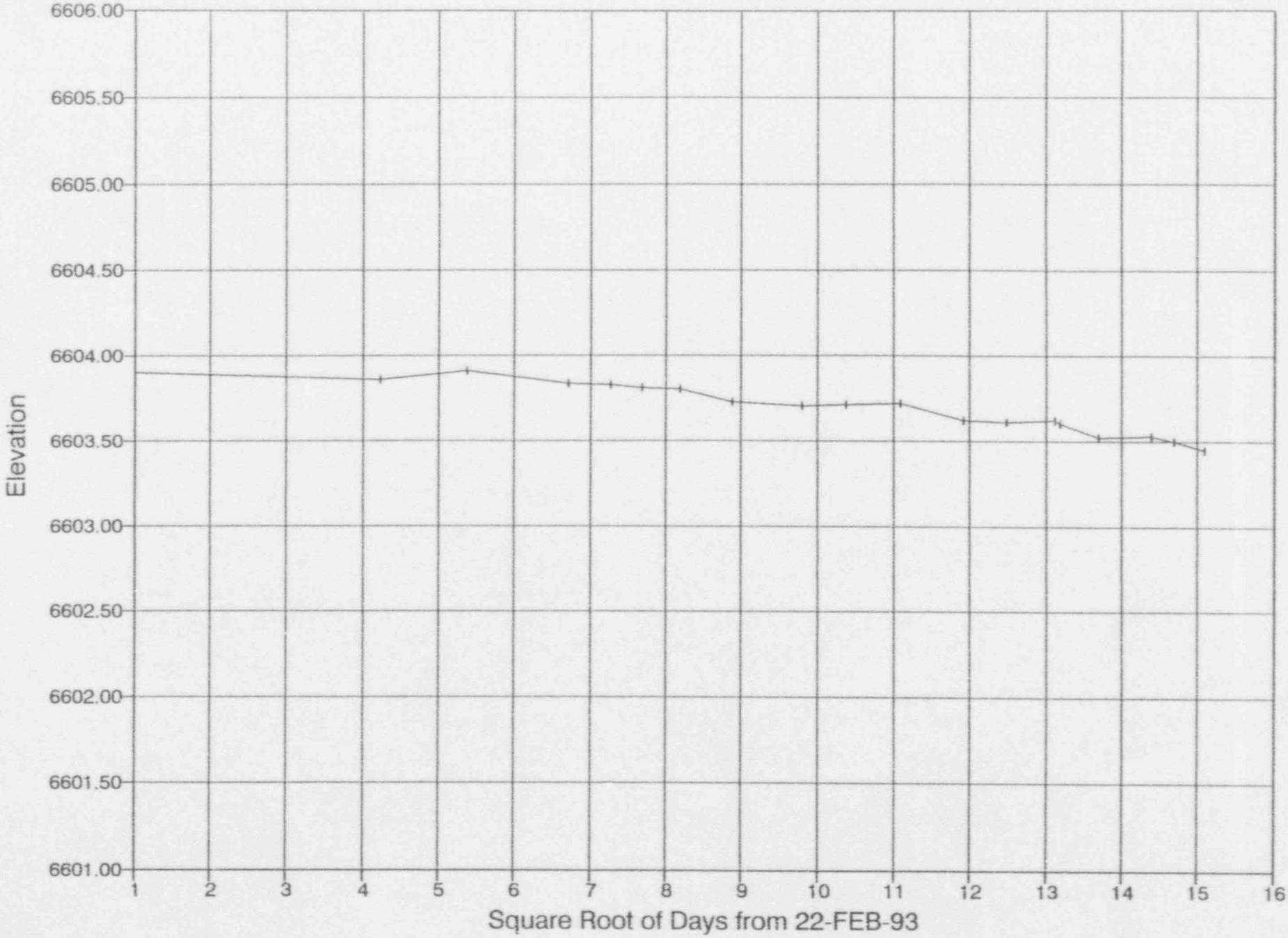
Settlement Point 7



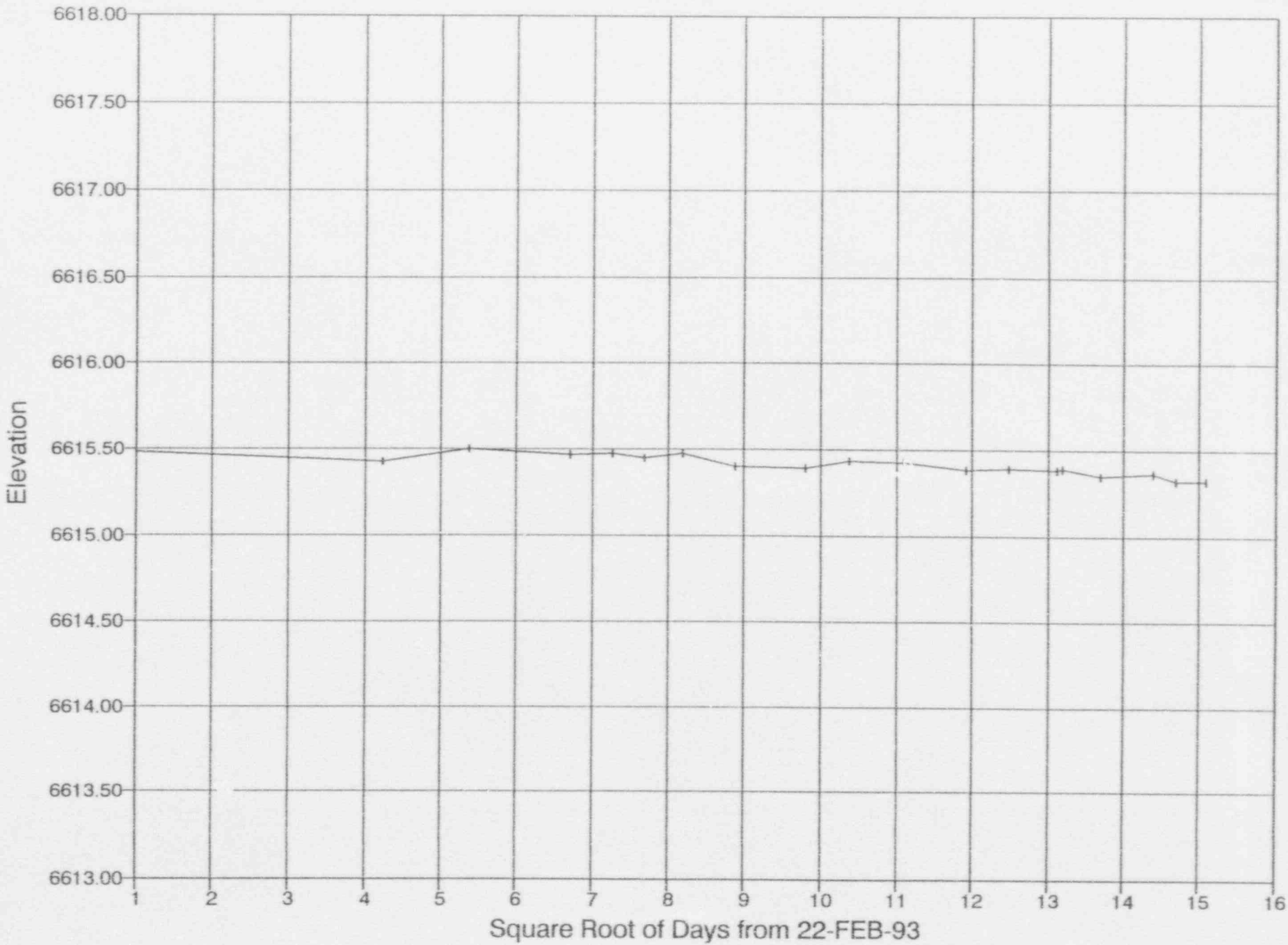
Settlement Point 8



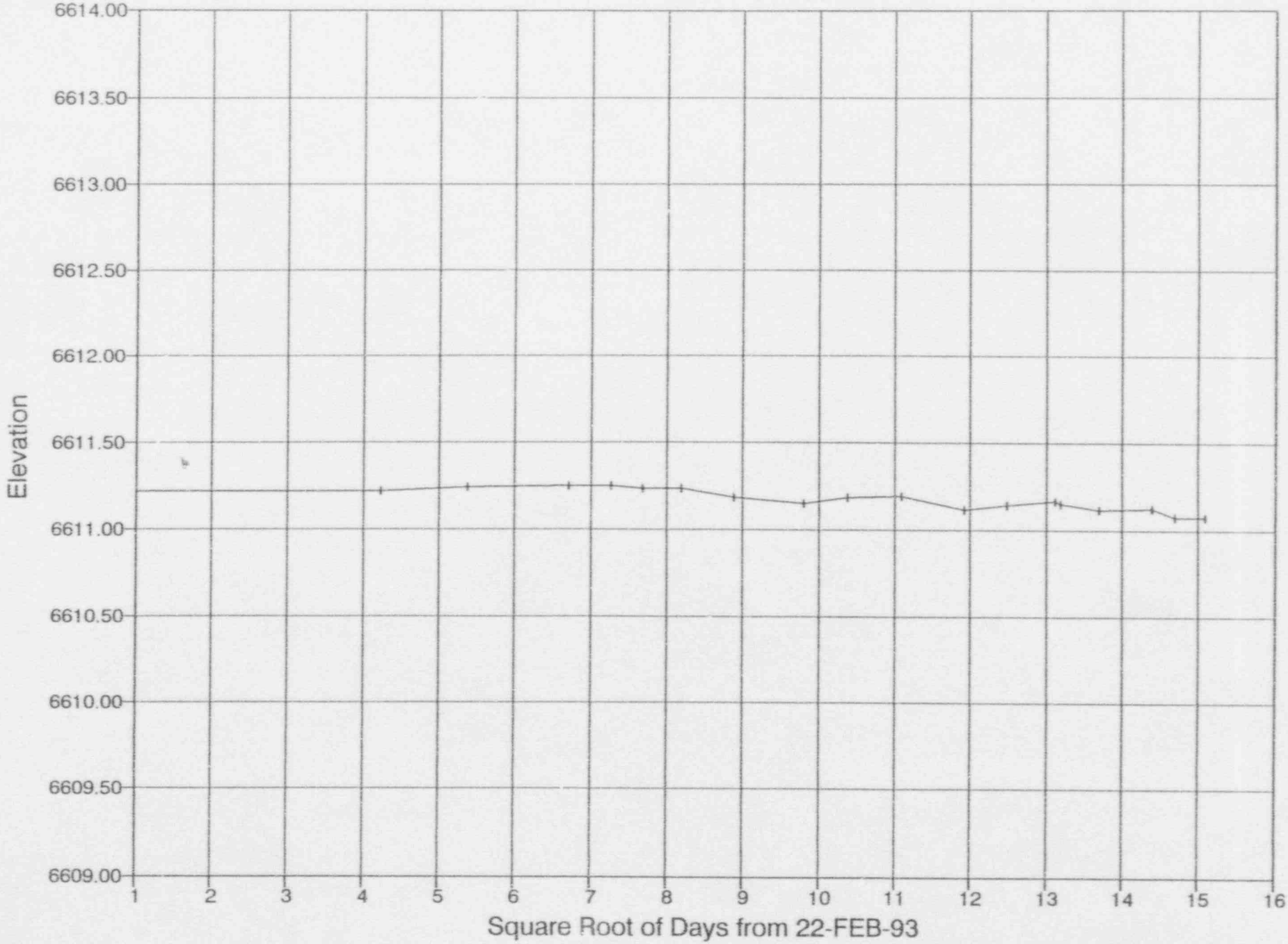
Settlement Point N8



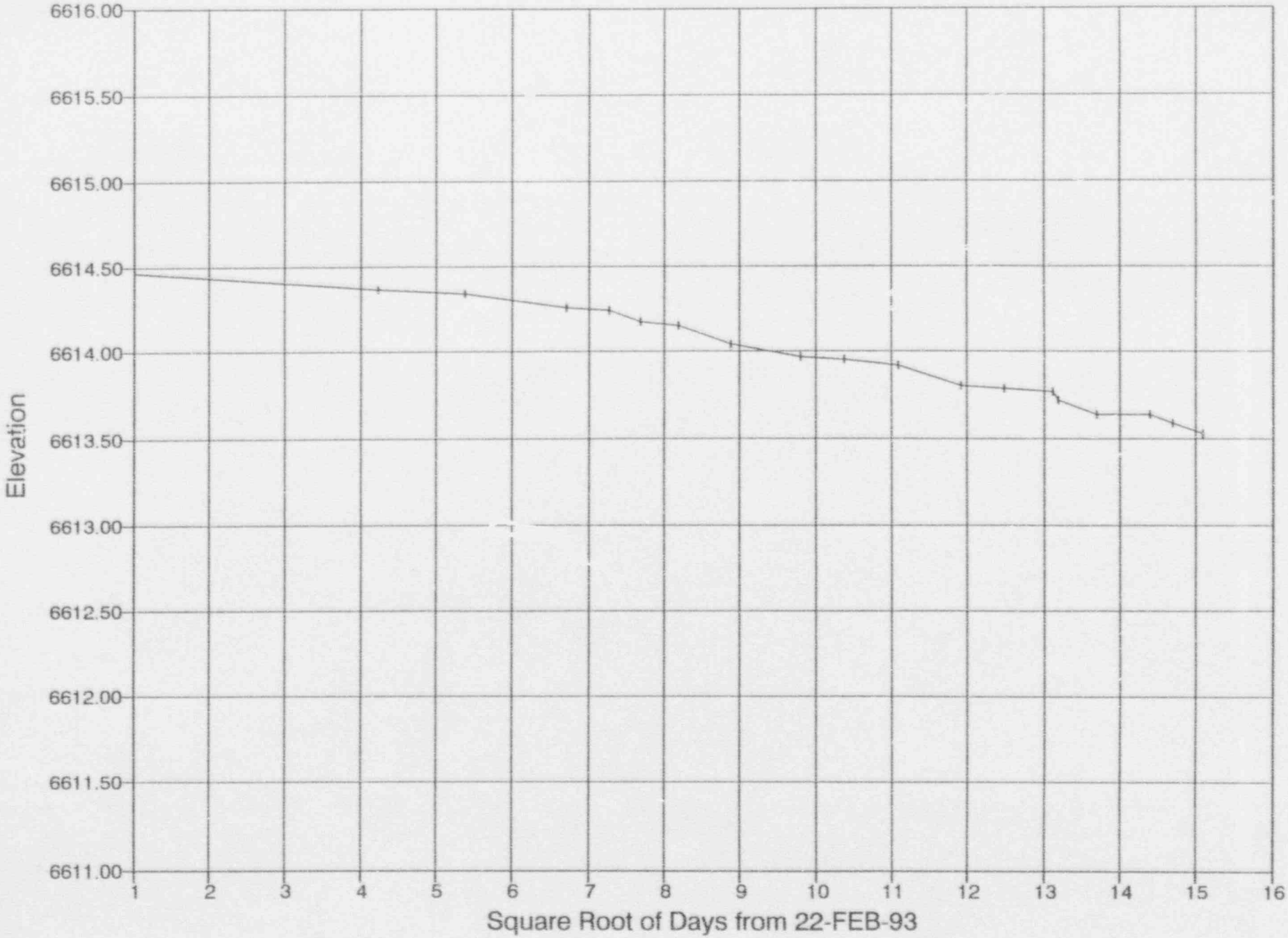
Settlement Point 9



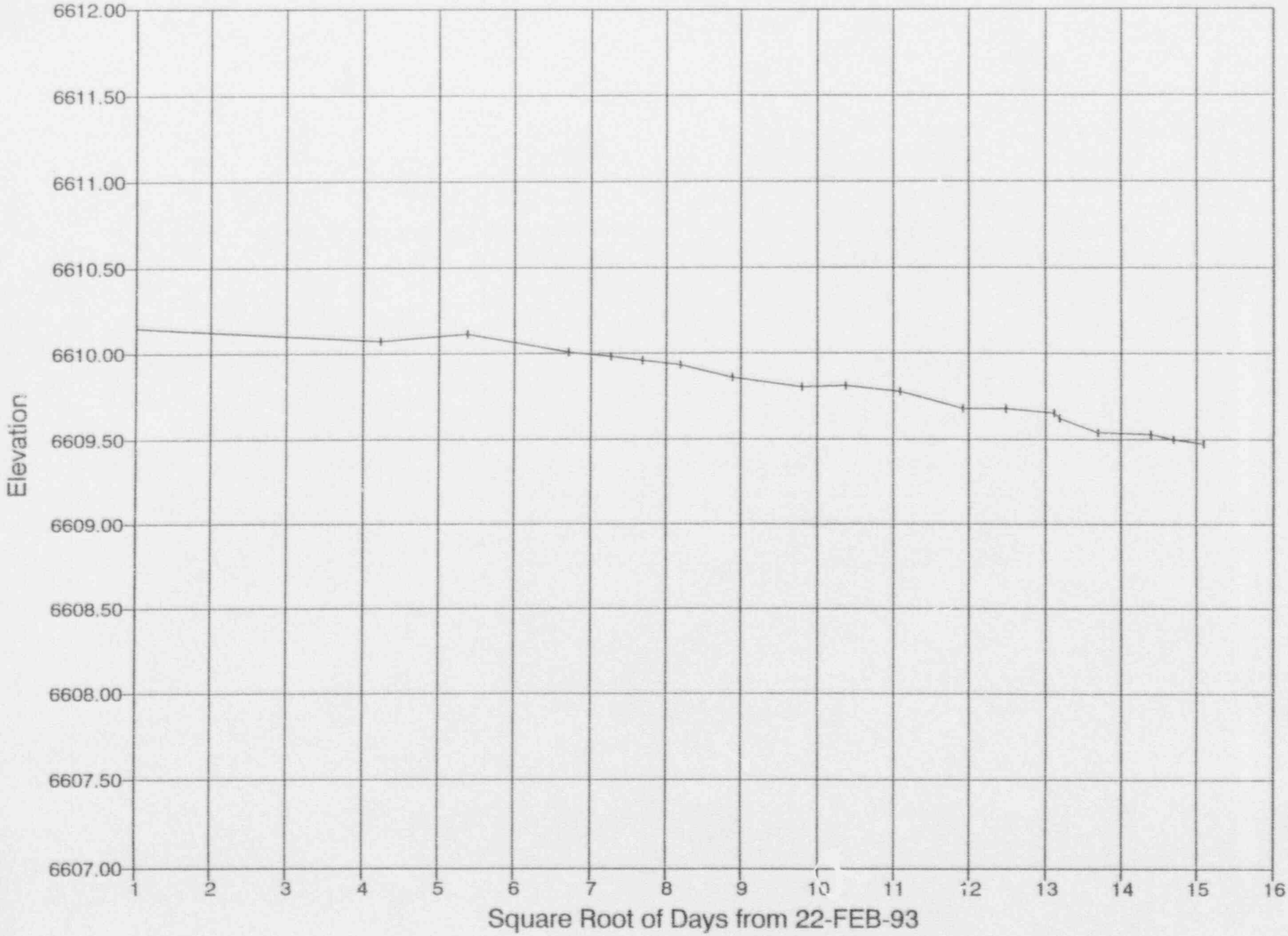
Settlement Point 11



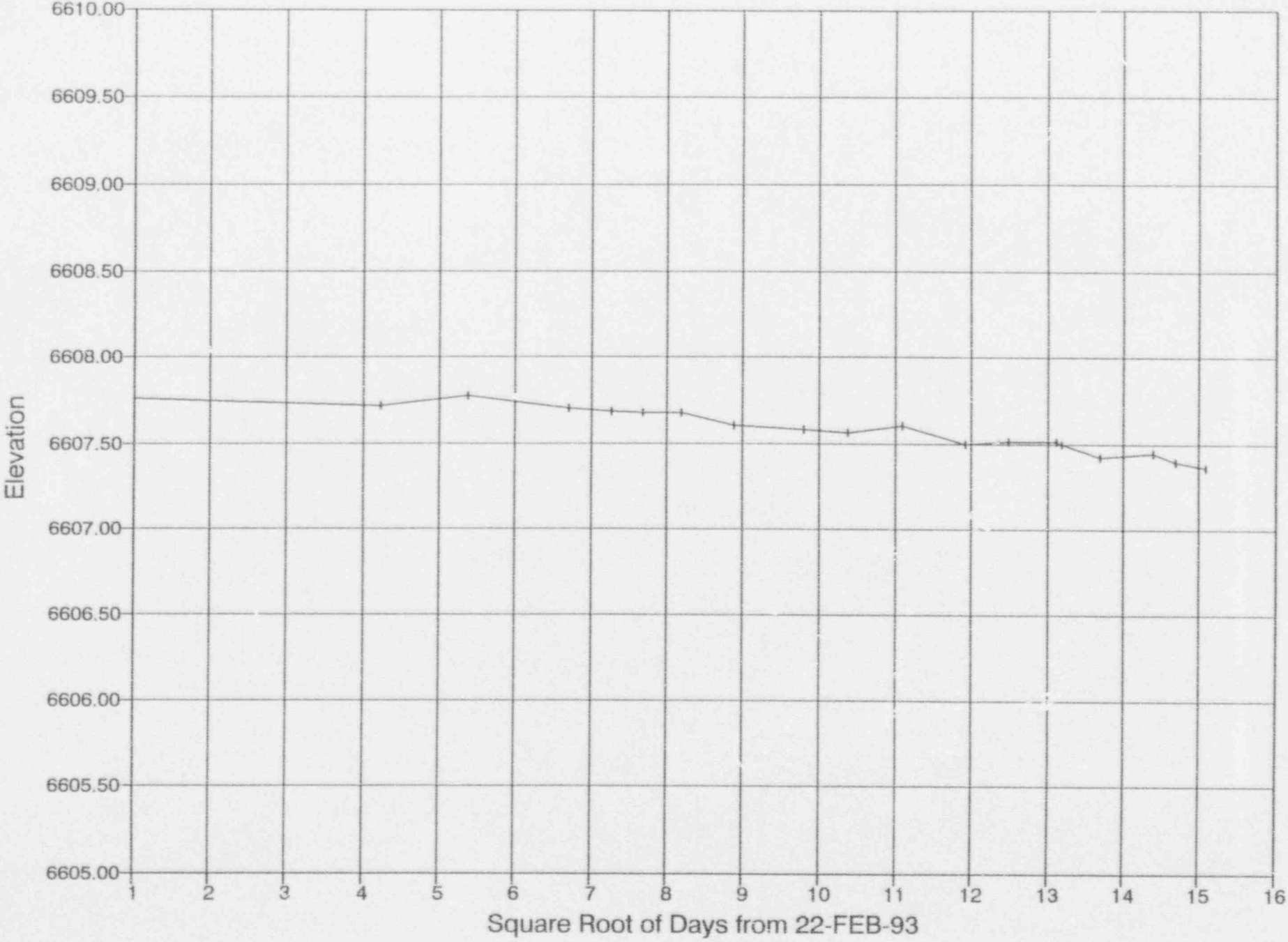
Settlement Point 16



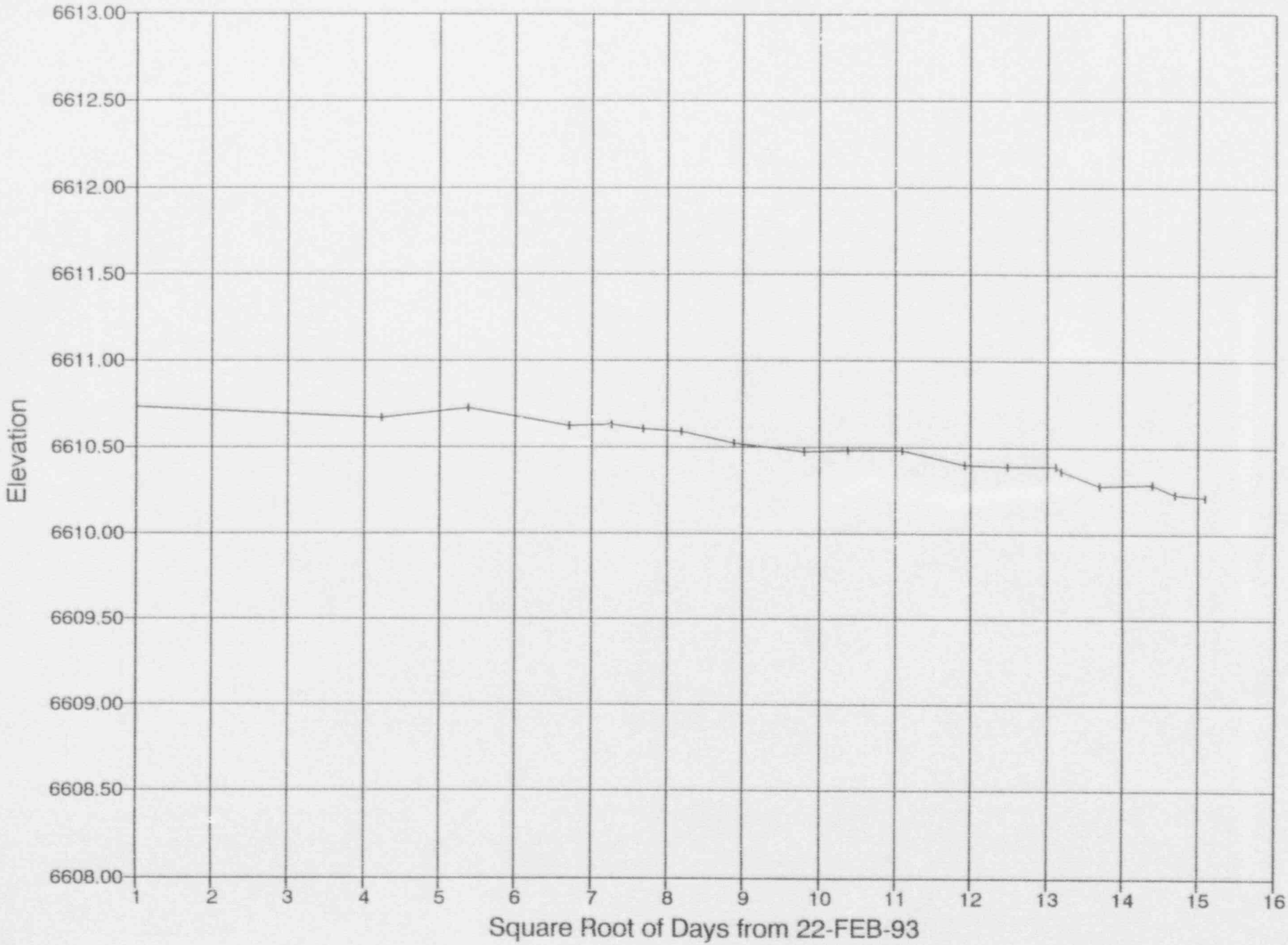
Settlement Point 17



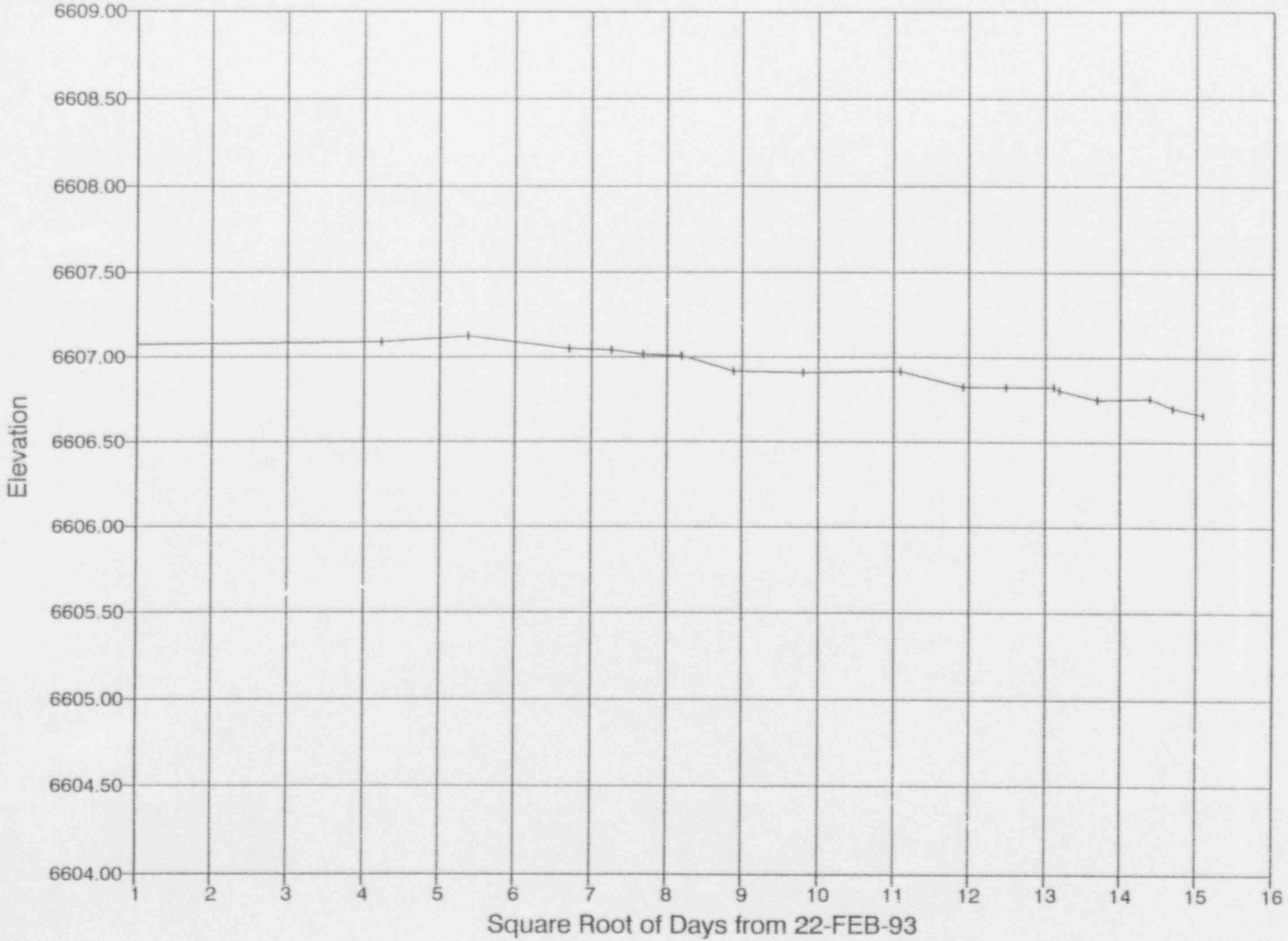
Settlement Point 19



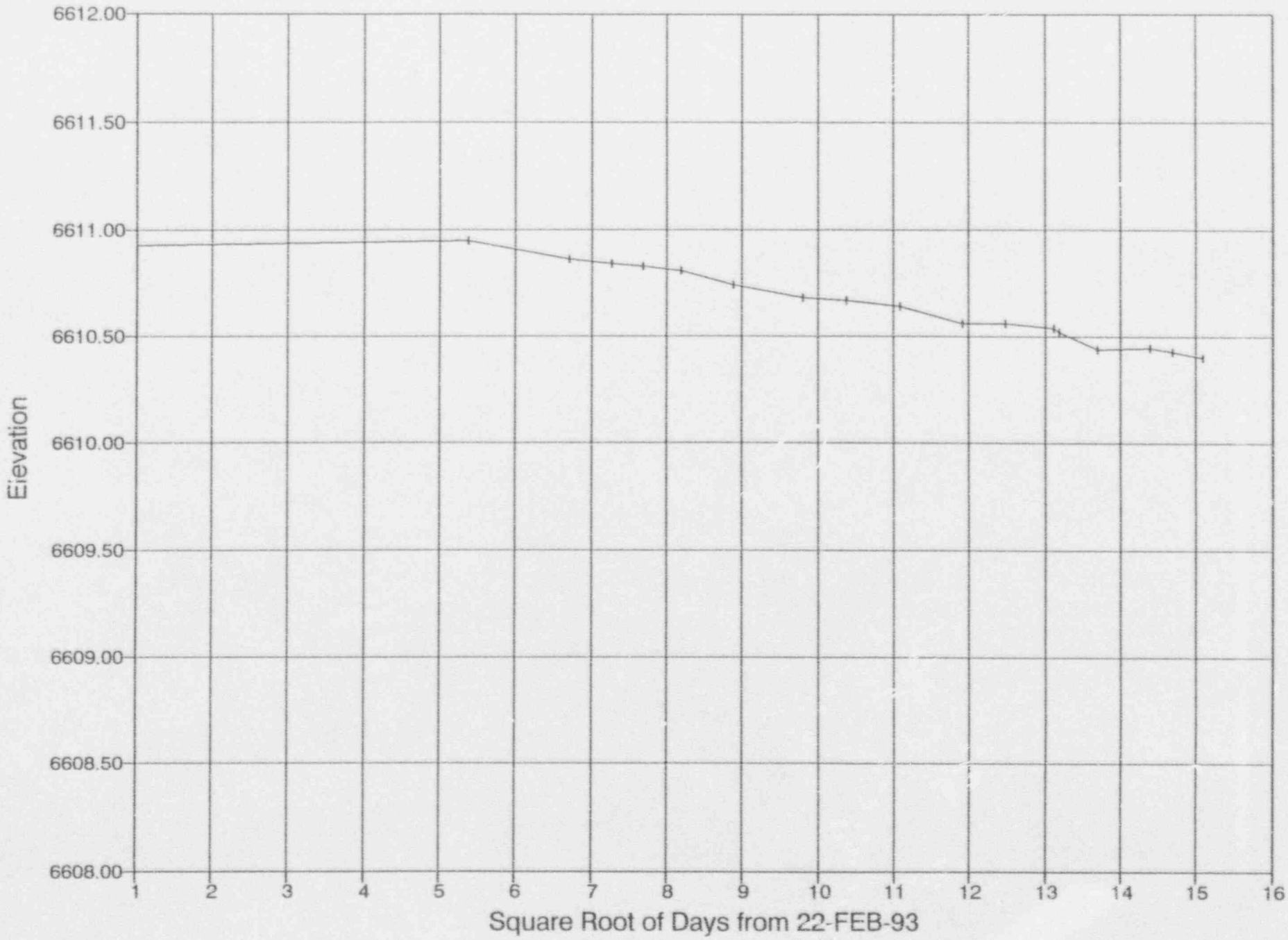
Settlement Point 20



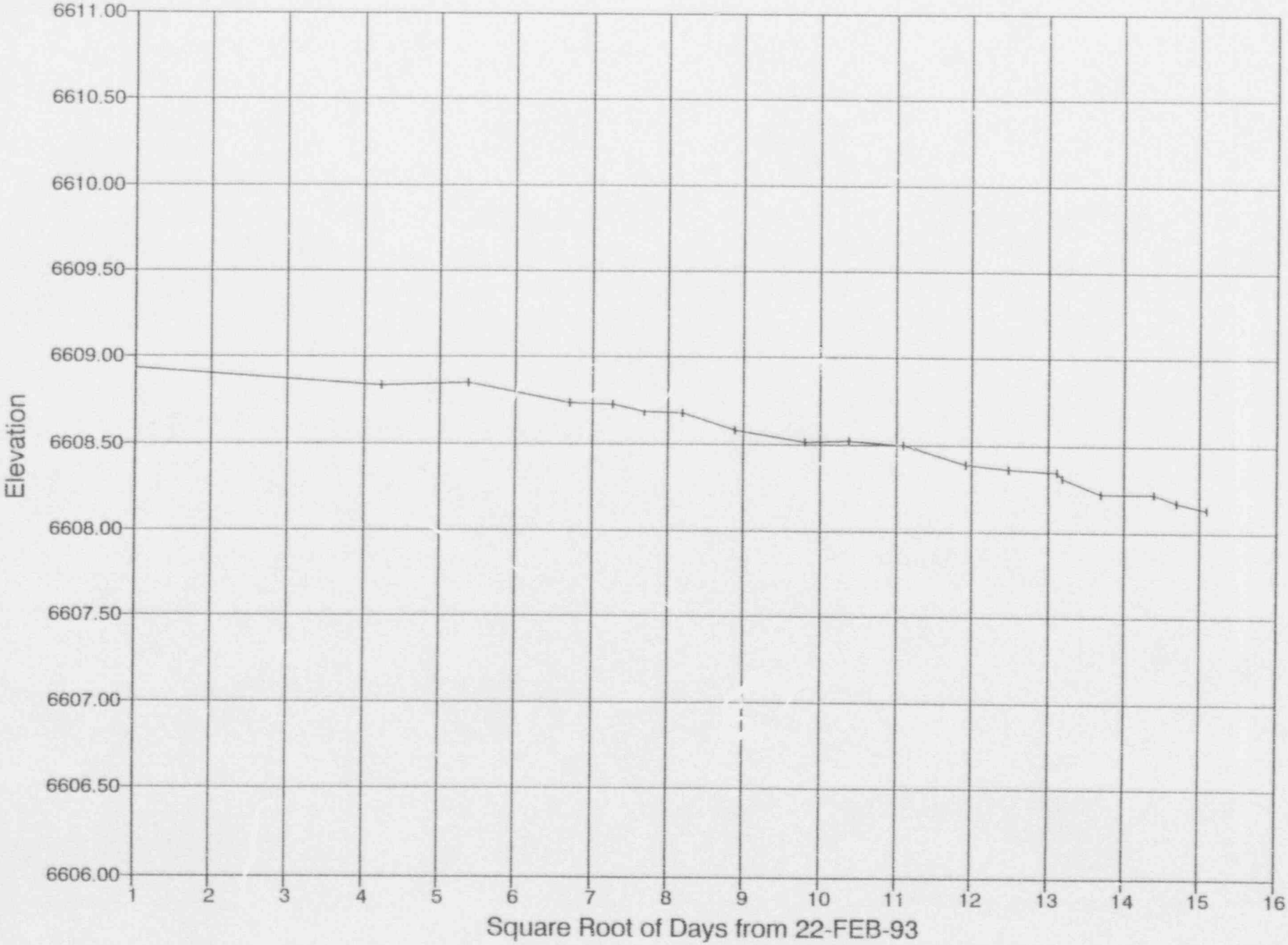
Settlement Point 21



Settlement Point 22



Settlement Point 23



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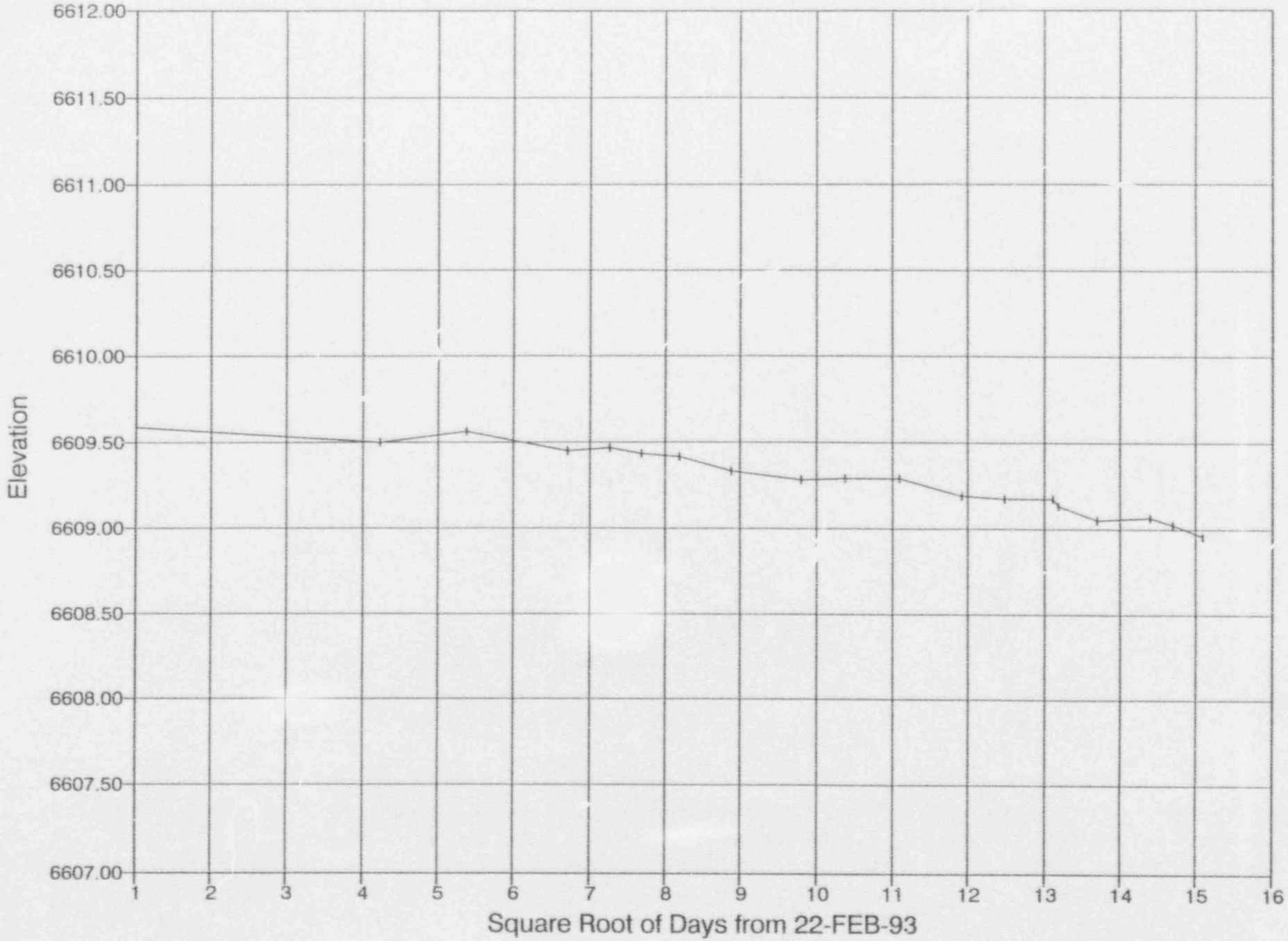
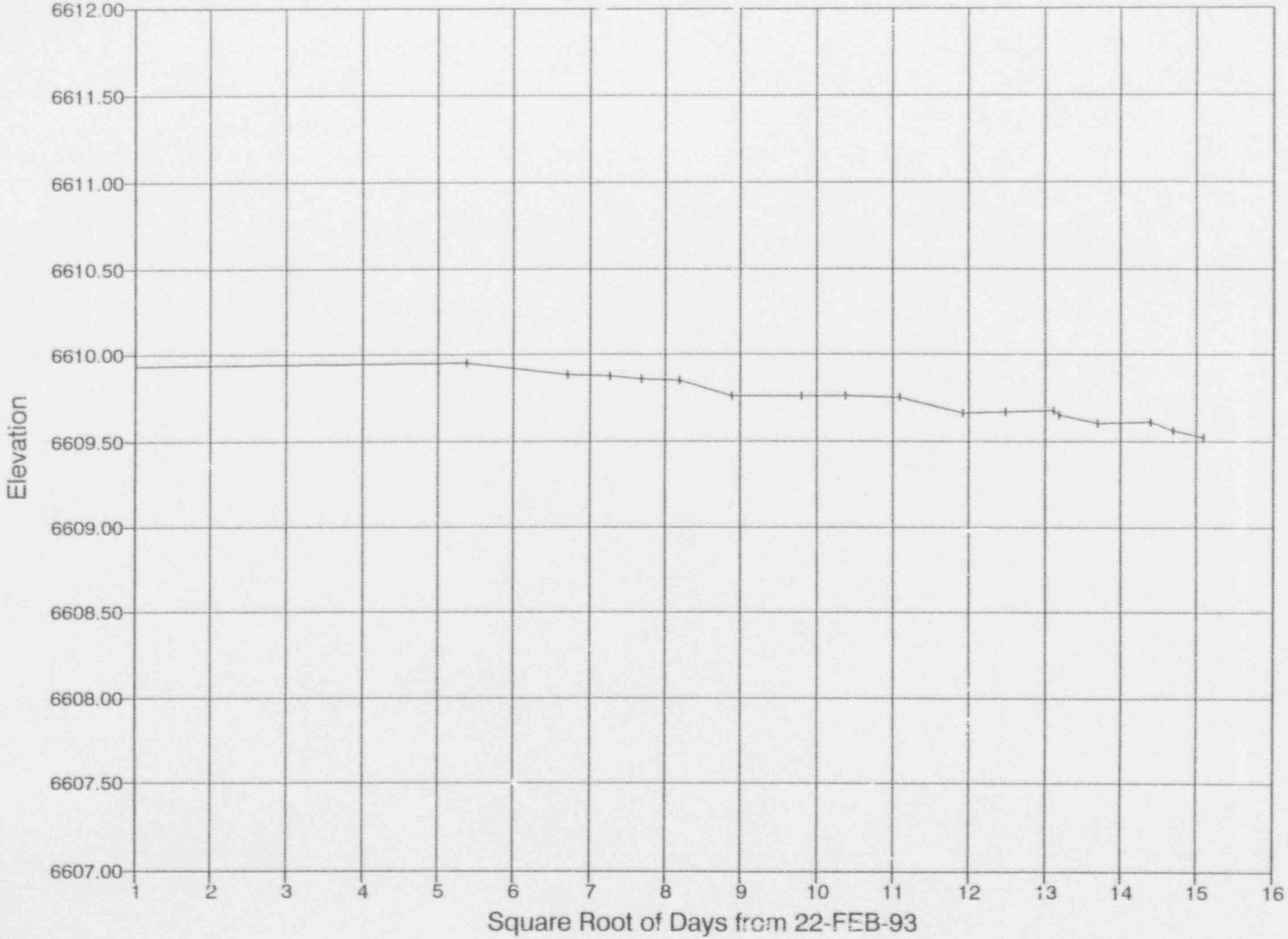
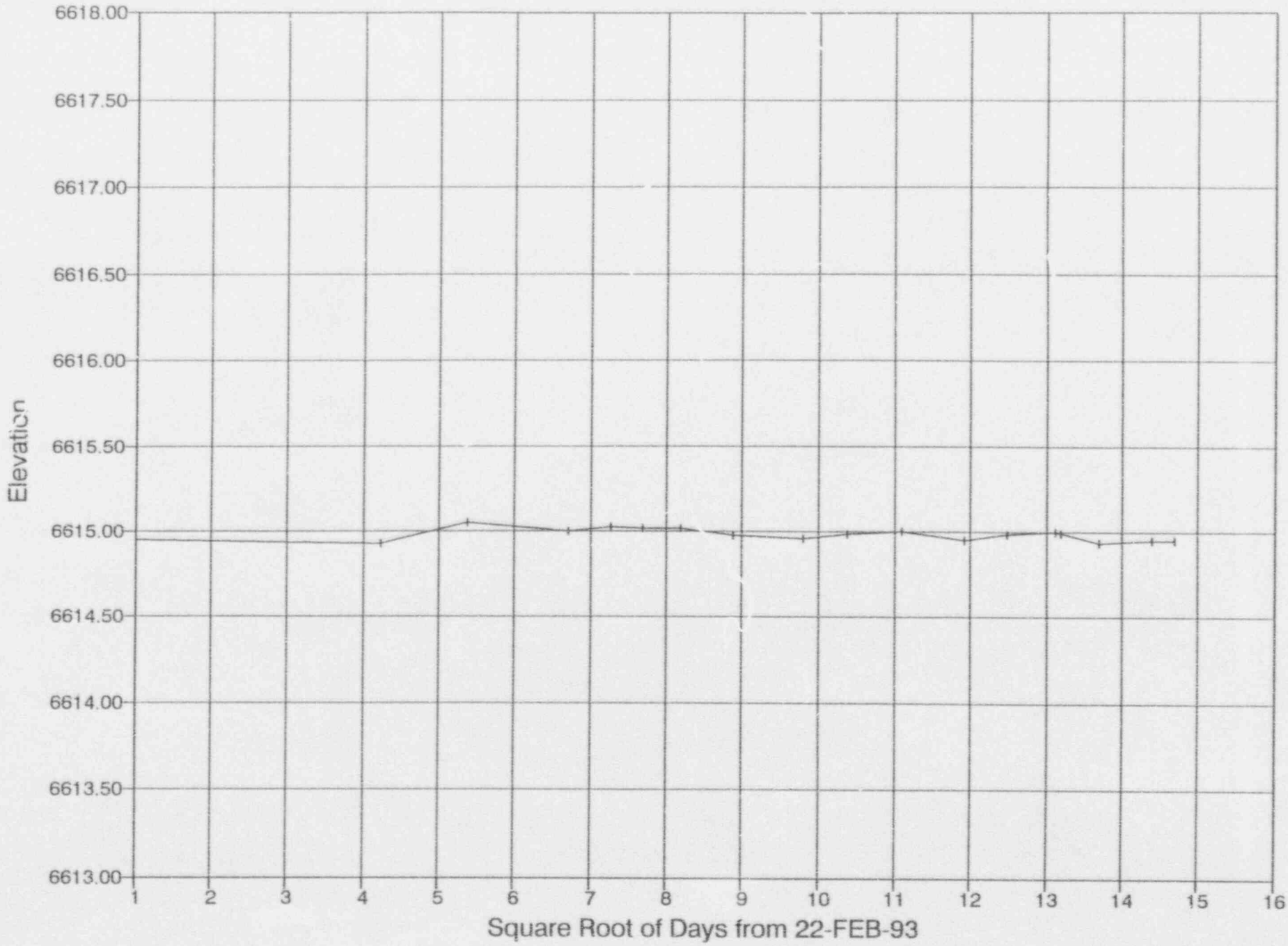


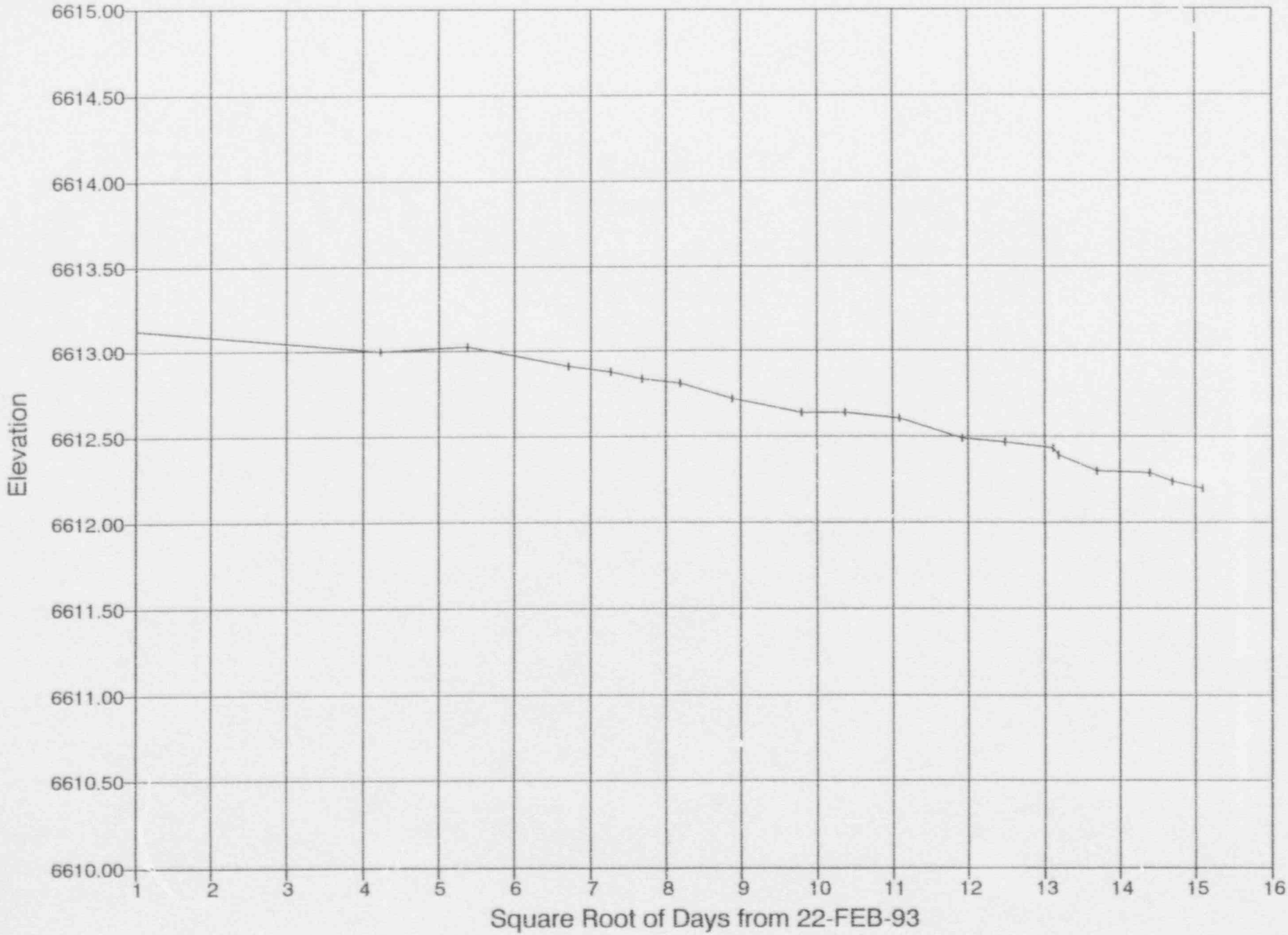
Settlement Point 25



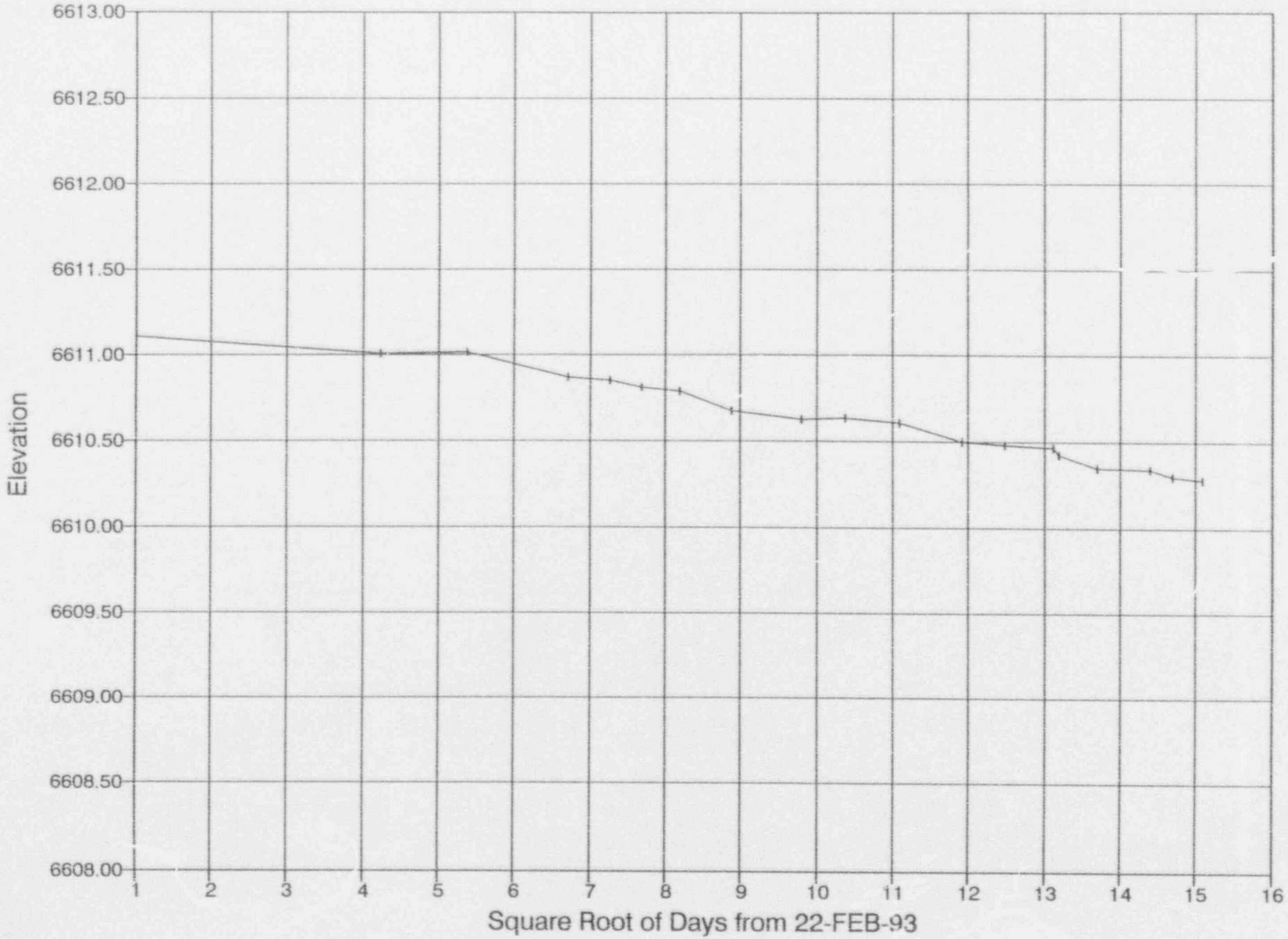
Settlement Point 26



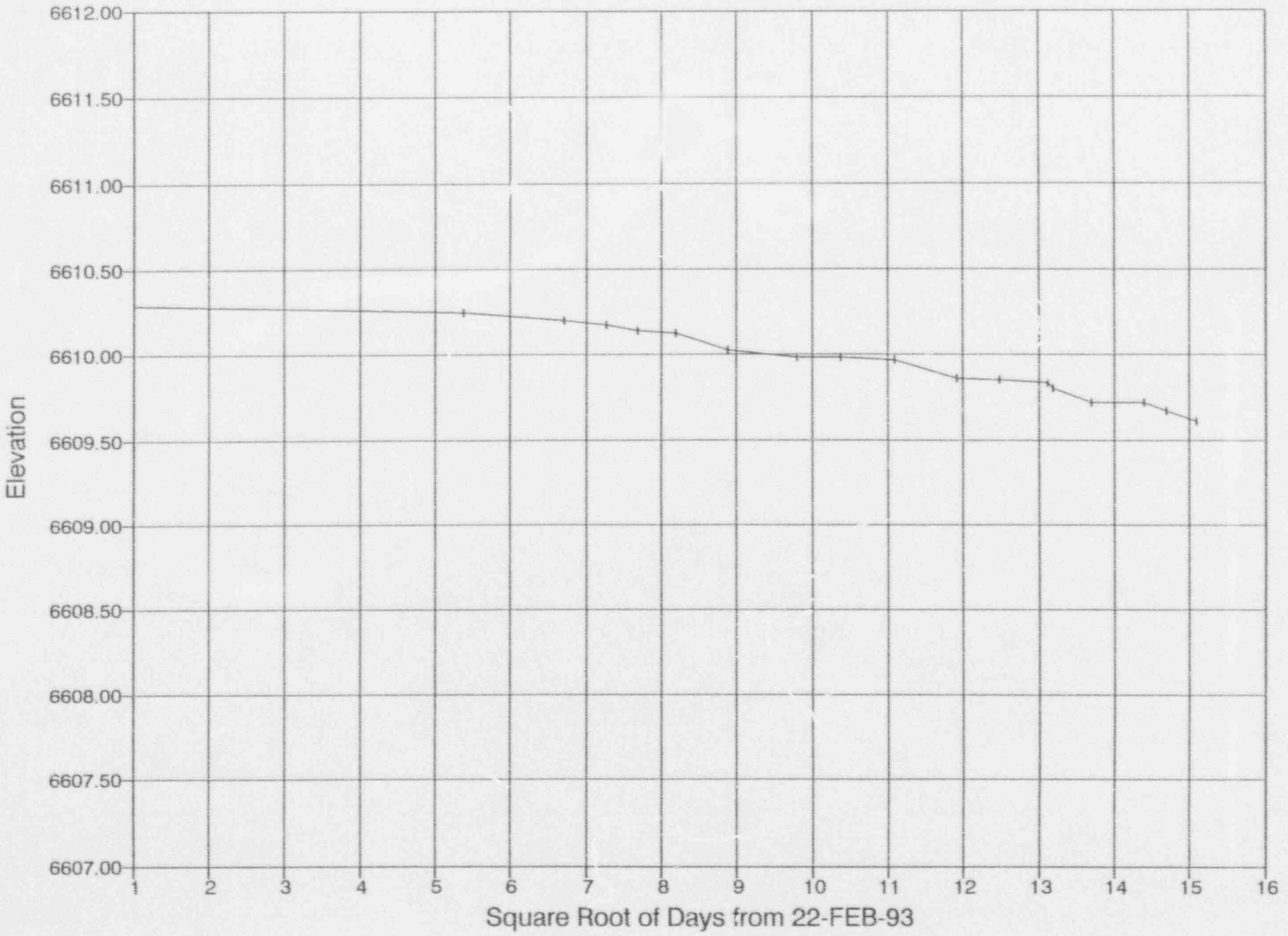
Settlement Point 27



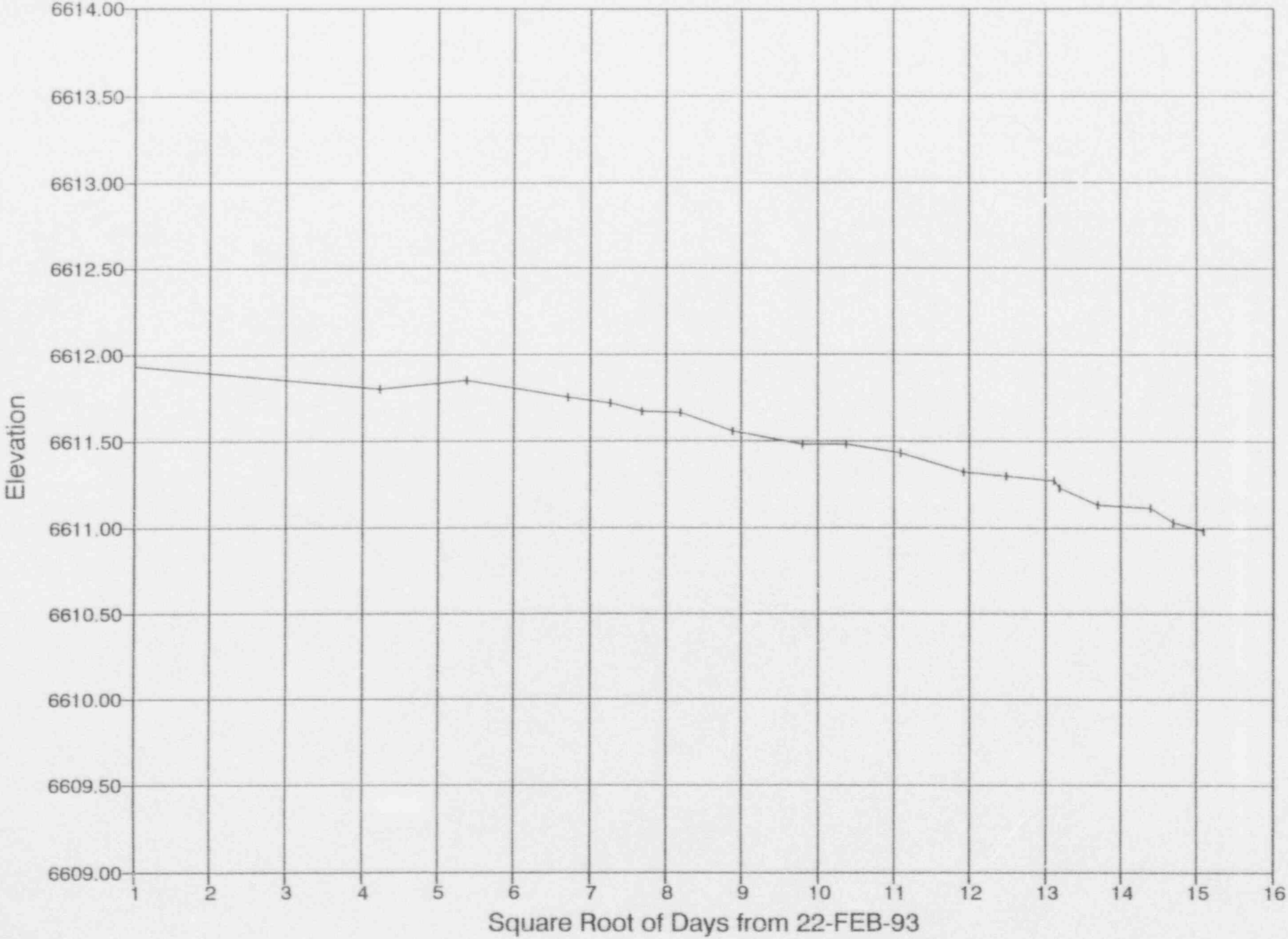
Settlement Point 28



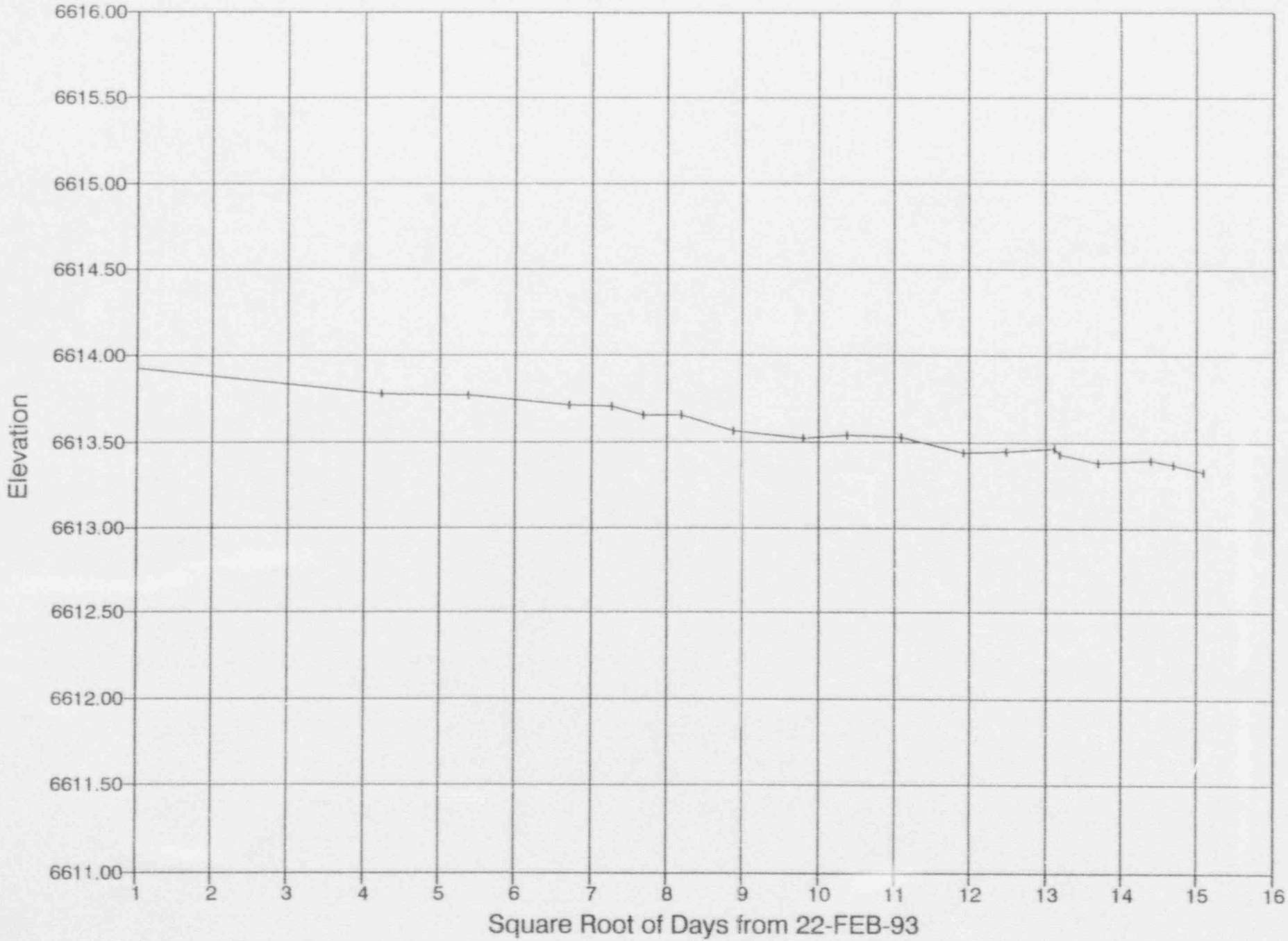
Settlement Point 29



Settlement Point 30



Settlement Point 31



Settlement Point 32