Attachment A-4
Stratigraphics Cone Penetrometer Test Report

PIEZOMETRIC CONE PENETRATION TESTING WITH SEISMIC SHEAR WAVE VELOCITY SURVEY CPS-EPS FIELD EXPLORATION AMERGEN NUCLEAR POWER PLANT CLINTON, ILLINOIS

Prepared for:

CH2M Hill
8510 West Higgins
Chicago, Illinois 60631

Prepared by:

STRATIGRAPHICS
The Geotechnical Data Acquisition Corporation
439 Taylor Avenue
Glen Ellyn, Illinois 60137
Phone: (630) 790-4610
www.stratigraphics.com

July, 2002
02-120-110

TABLE OF CONTENTS

	Page
1.0 INTRODUCTION	1
2.0 PENETROMETER EQUIPMENT AND DATA ACQUISITION	1
2.1 Procedure	1
2.1.1 Signal Conditioning and Recording	2
2.2 Soil Shear Resistance Measurements	2
2.3 Piezometric Measurements	2
2.3.1 Piezometer Saturation	2
2.4 Electrical Conductivity Measurements	2
2.5 Natural Gamma Measurements	2
2.6 UV Fluorescence	2
2.7 CPT Seismic Wave Velocity Measurements	2
2.8 CPT-EMOD Measurements	3
2.9 Penetrometer Geometry	3
2.10 Equipment Decontamination and Grouting	3
3.0 PENETROMETER SAMPLING EQUIPMENT	4
3.1 Groundwater Sampler	4
3.2 Gas Sampler	4
3.3 Soil Samplers	4
4.0 PIEZOMETER INSTALLATION TECHNIQUES	4
5.0 DATA REDUCTION	4
6.0 GENERAL DATA EVALUATION	5
6.1 Sounding Log	5
6.2 Soil Type Classification	5
6.3 Potentiometric Surfaces	6
6.4 Soil Saturation	6
6.5 Soil Hydraulic Conductivity	6
6.6 Soil Electrical Conductivity Behavior	6
6.7 EC Evaluation	6
6.8 UV Fluorescence Behavior	6
6.9 CPT-SPT Correlation	7
7.0 OPTIONAL GEOTECHNICAL DATA CORRELATION	7
8.0 PROGRAM RESULTS	7
9.0 STATEMENT OF LIMITATIONS	7
10.0 REFERENCES	8

FIGURES AND TABULATIONS

APPENDIX A - Evaluation of geotechnical parameters
APPENDIX B - CPTU dissipation test evaluation

1.0 INTRODUCTION

STRATIGRAPHICS, The Geotechnical Data Acquisition Corporation, performed cone penetrometer exploration at the AMERGEN Nuclear Power Plant CPS-EPS site in Clinton, Illinois. We performed Piezometric Cone Penetration Test with seismic shear wave velocity measurement (CPTU-S) and CPTU soundings to provide data on geotechnical properties of site soils for evaluation by CH2M Hill.

The work was performed on July 23 and 24, 2002 for a total of about 1.5 days of testing. Two CPTU-S and two CPTU soundings were completed to depths ranging from 54.0 to 78.1 ft, for a total of 264.7 ft of sounding. Four pore water pressure dissipation tests were performed. A total of thirty six seismic shear wave velocity measurements were taken at 1 meter intervals in the two CPTU-S soundings, and interval velocities were calculated. Open hole was pressure grouted at the completion of subsurface activities.

This report includes CPTU-S and CPTU sounding logs and tabulations of recorded data and correlated geotechnical parameters. The soundings are summarized on Table 1 while seismic data are summarized in Tables 2. Dissipation tests are summarized in Table 3. Interval seismic shear wave velocities are also plotted on CPTU-S sounding logs. Digital data summaries are presented for each sounding on the attached data disk, along with JPEG images of the logs. Details of penetrometer exploration techniques are included in the main body of the report.

2.0 PENETROMETER EQUIPMENT AND DATA ACQUISITION

2.1 Procedure The Cone Penetration Test (CPT) consists of smoothly and continuously pushing a small diameter, instrumented probe (penetrometer) deep into the ground while a PC data acquisition system displays and records the soil response to penetration (Figure 1). In geotechnical terms, the CPT penetrometer models a foundation pile under plunging failure load conditions. CPT data are used to develop continuous, high resolution profiles of in situ soil conditions rapidly, accurately and economically.

The soil resistance to penetration, acting on the tip and along the sides of the penetrometer, is measured during CPT. CPT soil resistance measurements are accurate and highly repeatable. The measurements can be used for the evaluation of stratigraphy and various geotechnical parameters. Performance of CPT is specified by ASTM Standard D3441.

A pressure transducer is added to the CPT penetrometer to acquire hydrogeologic data (Saines and others, 1989) and is called a Piezometric Cone Penetration Test (CPTU). A soil electrical conductivity sensor is added to the penetrometer (CPTU-EC) to acquire qualitative moisture information in vadose zone soils, and general groundwater quality data (Strutynsky and others, 1991, 1998). Penetrometer groundwater, soil, and soil gas samplers are used for direct sampling (Strutynsky and Sainey, 1990, Strutynsky and others, 1998). Recent advances in penetrometer instrumentation include a natural gamma sensor, induced UV fluorescence for detection of hydrocarbons and other compounds, and shear wave velocity and stress controlled testing for low and high strain soil deformation evaluation.

The penetrometer is mounted at the tip of a string of sounding rods. A hydraulic ram is used to push the rod string into the ground at a constant rate of 4 ft per minute. Electronic signals from downhole sensors are transmitted by a cable, strung through the sounding rods, to an uphole PC data acquisition system. Measurements are displayed and recorded for definition of subsurface conditions. Downhole equipment can be steam cleaned during retrieval.. Open hole can be grouted using bentonite grout.

Large 3 or 4 axle trucks are used to carry the 2 penetrometer systems used by STRATIGRAPHICS. Truck weight and ballast serve to counteract the thrust of the hydraulic ram. Enclosed rig work areas allow all-weather operations. Computers, samplers, electrical power, lighting, compressed air, steam cleaner, grout pump, and water tank are all included on each rig, providing for self-contained operations. Other portable systems or systems for mounting on drill rigs can be used in areas with poor access or for overseas projects.

Lightning detection systems are mounted on the rigs to monitor dangerous weather conditions that can effect safety and productivity. Differential, carrier phase, post processed Global Positioning Systems (GPS) are also mounted on the rigs to allow surveying exploration locations.

No borehole is required during exploration because penetrometers are directly thrust into the soil from the ground surface. Pressures of over 3 million pounds per square foot can be applied to the tip of the penetrometer for penetration of most soils finer than medium gravel. Asphalt pavements up to 6 inches thick can usually be penetrated by penetrometer methods without pre drilling. Site disturbance is reduced since no borehole cuttings or drilling fluids are generated during penetrometer operations. Personnel exposure to contaminated soil is less than exposures during drilling and sampling operations. CPT equipment can be easily decontaminated during retrieval.

Four to thirteen hundred feet of CPT (with no time dependent piezometric or shear wave measurements) can be performed in a day, depending on site access. Depths of more than 200 ft can be achieved, depending on stratigraphy. Where soils are exceptionally dense or gravelly, an uninstrumented prepunch tool can be used for probing. Information obtained using the prepunch tool can be similar to mechanical (Dutch) cone data especially where friction on the rod string is minimal. Dynamic driving can be used in gravelly soils.

2.1.1 Signal Conditioning and Recording CPT data are acquired using a 16 bit (resolution of 1 part in 32,768) analog to digital data logger and PC computer. Sounding logs are graphically displayed and printed for immediate evaluation of subsurface conditions. Data are recorded on disk for data processing and archiving.

2.2 Soil Shear Resistance Measurements The soil penetration resistance is measured on the tip and along the sides of the CPT penetrometer using strain gage loadcells (Figure 1, Strutynsky and others, 1985). The conical tip of the penetrometer has a projected cross-sectional area of 15 square centimeters (2.3 sq. in., and a diameter of 1.7 inches. The cone tip resistance reflects the deep bearing capacity of a soil. Soil friction is measured along a cylindrical sleeve mounted behind the cone tip. The friction sleeve has a surface area of 200 square centimeters (31.0 sq. in.), a length of 5.8 inches, and a diameter slightly larger than the cone tip. The tip measurement has a layer resolution of about 2 to 4 inches, while the friction resolution is about 6 inches.

2.3 Piezometric Measurements A pressure transducer is used to measure the soil pore water pressure response to penetration. The advance of the penetrometer causes volumetric distortion of surrounding soils, which generates a local pore water pressure field. These generated pressures dissipate almost instantaneously in soils of high permeability, so equilibrium water pressures are measured during CPTU in coarse sand and gravel. In medium or low permeability soils, the generated pore water pressure field is sustained for a lengthy period of time (Saines and others, 1989). The dissipation of generated pressures can be recorded during pauses in penetration. The rate of dissipation is used to estimate soil hydraulic conductivity and consolidation characteristics. If the pauses are long enough for all generated water pressures to dissipate, potentiometric surface measurements can be obtained at multiple depths in a single CPTU sounding. The CPTU piezometric measurement has a layer resolution of about 1 inch.

2.3.1 Piezometer Saturation The CPTU piezometer filter is saturated with an incompressible liquid so that instantaneous response (zero lag time) can be achieved during testing. High filter saturation levels are indicated by sharp responses at interfaces and immediate regeneration of water pressure after pauses in penetration. Low filter saturation levels leading to poor measurements can be caused by inadequate filter preparation, soil suction, or filter damage on coarse soil particles. Clogging of piezometric filters can also lead to poor results. Loss of filter saturation or clogged filters are beyond the control of the operator. Thus, CPTU piezometric measurements can be less repeatable than CPT tip and friction sleeve resistance measurements.

2.4 Electrical Conductivity and Thermal Measurements A CPTU-EC penetrometer including tip, sleeve, piezometric, temperature, and electrical conductivity (EC) sensors can be used to simultaneously acquire geotechnical, hydrogeological and qualitative geochemical information. Soil EC is measured using a two electrode array, energized with a 3 kHz signal, mounted on the penetrometer tip. The EC measurement has a resolution of about 1 inch. The CPT thermal sensor is used to acquire soil thermal properties.

2.5 Natural Gamma Measurements A CPTU-EC-G penetrometer incorporating cone, friction, piezometric, soil electrical conductivity and natural gamma (G) sensors can be used to simultaneously acquire geotechnical, hydrogeological, qualitative geochemical and radiological information. Gamma measurements can be used to detect radionuclide contamination and to enhance lithologic evaluation.

2.6 UV Fluorescence A CPTU-EC-UVF penetrometer incorporating cone, friction, piezometric, soil electrical conductivity, and Ultraviolet Fluorescence (UVF) sensors can be used to simultaneously acquire geotechnical, hydrogeological, and qualitative geochemical information. The UVF system consists of a sapphire window in the penetrometer, a UV excitation light source, and photodiode light detectors. UV light is transmitted through the window into the adjacent soil. If the soil contains compounds such as petroleum hydrocarbons that fluoresce, the photodiodes are used to detect the resulting light. The UV light source is bandpass filtered to provide an excitation wavelength of 254 nm. The photodiode sensors are longpass filtered to monitor resulting fluorescent light emissions above 290 nm.

2.7 CPT Seismic Wave Velocity Measurements A geophone module is attached to the penetrometer to acquire P (compression) and S (shear) wave velocity data. CPT geophones have superior coupling to the soil, resulting in better definition of wave arrival, as compared to borehole deployed geophones. The CPT seismic system consists of three downhole geophones, an uphole wave source with timing trigger, signal conditioning, signal acquisition software, and the PC data acquisition computer. The test procedure is as follows: 1) the CPT penetrometer and geophone module is pushed to a test depth; 2) signal acquisition is initialized; 3) a hammer with timing trigger is used as a wave source; and 4) geophone output is recorded as a function of time. The procedure is repeated at multiple depths to allow calculation of interval wave velocities between adjacent tests.

A source rich in S-wave generation is used for S-wave tests. A sledge hammer is swung to horizontally strike the main leveling jack pad of the CPT rig. The 8-ft long steel jack pad, coupled to the ground surface by the weight of the CPT rig, transmits strong S-waves through the soil into a pair of horizontally opposed downhole geophones. The geophones are aligned with the jack pad to maximize the amplitude of the received signals.

A series of hammer blows is typically used for each test using signal stacking techniques. Signal stacking enhances data evaluation, as random noise rarely reinforces itself, while the repeated shear waves stack onto each other, increasing signal to noise ratios. The stacked output of the geophones typically results in obvious, high amplitude waves 180 degrees out of phase with each other at the instant of S-wave arrival.

After completion of a S-wave test, a P-wave test can be performed at the same depth. The sledge hammer is swung to vertically strike a steel plate placed on the ground next to the CPT rig. A series of blows is also used for each P-wave test. P-wave arrivals are recorded using the vertical CPT geophone.

P-wave arrivals are often much less obvious than S-wave as the amplitude of the P-wave is typically lower, the travel times are much shorter, and P-waves can easily be transmitted through the steel rod string connecting the penetrometer to the surface. The very fast P-wave transmission through the rod string at about 15,000 ft/sec, can set downhole geophones vibrating, thus masking the arrival of the slower soil P-wave. Occasionally, the S-wave geophones can also indicate P-wave arrival, differentiated from S-wave arrival by the fact that each geophone will vibrate in phase, rather than 180 degrees out of phase, as during S-wave arrival.

P-waves typically travel 2 to 4 times faster than S-waves. In saturated soils, the P-wave travels at about the speed of sound in water, about 5000 ft/sec. After arrival of the P-wave, the three downhole geophones will also pick up the arrival of the S-wave. This S-wave arrival during P-wave testing can be used to check S-wave arrivals measured during the first series of S-wave tests.

2.8 CPT-EMOD measurements The standard CPT procedure is conducted as a constant rate of strain test, resulting in a continuous measurement of soil ultimate bearing and frictional strength. By conducting CPT under monotonically increasing stress conditions, soil deformation properties can be evaluated. The CPT-EMOD test is conducted during short pauses in the continuous push process. Load/settlement data are analyzed using elastic theory, as might be done for a plate load test, for evaluation of Young's Modulus at various stress levels.

2.9 Penetrometer Geometry The CPT penetrometer external geometry is specified by ASTM standards. Differences in penetrometer internal design can lead to some variability in response between penetrometers of different manufacture, especially in very soft clays. STRATIGRAPHICS uses a cone with a 20 sq cm tip and a 235 sq cm sleeve. The CPTU measurement of generated water pressure depends on external filter geometry. Measurements of equilibrium water pressures after pauses in the penetration process are not sensitive to geometry, and reflect undisturbed conditions.

CPTU piezometric filters are typically mounted on either the cone tip (U1 position) or just ahead of the friction sleeve (U2 position). Each position has advantages and disadvantages. Measurements taken with the cone tip U1 filter are at a maximum and show high resolution of thin soil seams. The cone tip U1 filter is prone to damage on coarse soil particles. Negative pressures are often measured in dense, silty or clayey sands and hard clays when using the U2 friction sleeve filter. These low pressures are probably caused by soil elastic rebound (expansion) as the soil moves from the intensely loaded region beneath the cone tip to the less loaded region next to the friction sleeve. Soil expansion can induce large suction forces on the U2 friction sleeve filter, which can result in decreased filter saturation levels.

Site characteristics and data usage determine which piezometric filter geometry is appropriate. The piezometric filter is placed at the U2 friction sleeve position on the STRATIGRAPHICS CPTU-EC penetrometer. The filter housing is internal to the cone tip. Generally good results can be obtained using this geometry when proper filter preparation techniques are followed.

2.10 Equipment Decontamination and Grouting The rod string is retrieved through a rodwasher mounted on the hydraulic ram assembly. High pressure hot water is sprayed from internal nozzles to clean the rod string. Wash water (about ½ gallon per 10 ft of rod) can be captured for disposal.

The STRATIGRAPHICS grouting system can be used to seal open hole. As penetrometers are being advanced, bentonite grout (about ¾ gallon per 10 ft of open hole) is pumped into the annular space formed between the smaller diameter sounding rods and the larger diameter penetrometer. A bypass is opened and additional grout is pumped to seal the hole during rod string retrieval. Pressure grouting during sounding advance can control cross-contamination between different strata. The grout decreases the contact of downhole equipment with contaminated soil. The grout also can decrease rod friction which may allow deeper penetration. Grout levels are checked after sounding completion, and more grout is added to account for penetration of grout into permeable strata.

3.0 PENETROMETER SAMPLING EQUIPMENT

Groundwater, soil gas, and soil samplers are deployed in the same manner as CPT penetrometers. Good sample isolation is achieved because no open hole exists during penetrometer operations.

3.1 Groundwater Sampler The STRATIGRAPHICS groundwater sampler is a shielded wellpoint sampler of heavy construction. The shield prevents sampler contamination while penetrating soils above the sampling depth. After shield retraction, groundwater flows under in situ pressure conditions, through a 20 inch long screen, into the 350 ml sample barrel. The sampler is retrieved to pour off the sample and for decontamination. Small diameter pumps can be used with the sampler to acquire large volumes of sample. This sampler can be deployed in any soil capable of being penetrated by the CPTU-EC penetrometer (Strutynsky and others, 1998).

A pressure transducer can be placed inside the sampler barrel. This allows the measurement of sample inflow rate. Analysis of inflow data using rising head slug test methods can provide a means of estimating soil hydraulic conductivities. If equilibrium conditions are reached, a measurement of the static water pressure head is obtained during groundwater sampling.

3.2 Soil Gas Sampler The STRATIGRAPHICS soil gas sampler is a shielded screen sampler, similar to the groundwater sampler. The shield is opened by pulling back the rod string during sampling, and soil gases are then extracted. The shield can be closed, and the rod string advanced to another depth, allowing multiple samples during a single rod trip. Soil gasses are extracted from the rod string. A vacuum box can be used to inflate Tedlar bags for off site analysis. Portable analytical equipment can be used to allow immediate soil gas profiling. The sampler, rod string and any sample tubing are purged before sampling using a vacuum pump.

3.3 Soil Samplers Fixed piston samplers can be used to obtain soil samples during penetrometer exploration. The STRATIGRAPHICS and MOSTAP 2-meter samplers are deployed similarly to a penetrometer. A piston, locked into the tip of the barrel to prevent soil from entering the sampler prematurely, is released at the top of the sampling interval, and the barrel is then advanced. Soil enters the barrel and is retained by a core catcher. The sampler is retrieved to remove the sample and for sampler decontamination.

The MOSTAP Sampler is used to obtain 1 inch diameter samples as long as 2 meters (78 inches). This sampler incorporates a PVC liner and a nylon stocking to allow retrieval of such a long sample. As the sample enters the sampler, it is encased in the nylon stocking. The stocking lessens soil friction around on the sample as it enters the PVC liner. At the end of the 2 meter run, the sampler is rotated to twist the stocking, helping retain the sample. This sampler can only be used in softer soils.

4.0 PIEZOMETER INSTALLATION TECHNIQUES

Penetrometer methods can be used to install piezometers for water level measurements, slug testing, groundwater sampling, and for remediation activities, such as sparging and soil vapor extraction (SVE). Various installation techniques are available (Saines and others, 1989). Proprietary, low volume change piezometers also can be installed using penetrometer equipment. These piezometers are often used for long term water pressure measurements during geotechnical projects. PVC piezometers are installed using a steel casing pushed to depth. The casing is sealed with an expendable tip which prevents soil from entering the casing during deployment. The PVC screen and risers are lowered into the casing, the casing is then withdrawn, leaving the PVC in place.

5.0 DATA REDUCTION

Test data are monitored as the soundings are performed. Data are recorded on hard disk and may consist of: depth, time, tip and sleeve resistance, generated water pressure, EC, UVF, temperature and natural gamma. Data are processed in-house and undergo quality control review prior to final reporting.

Several parameters can be computed to enhance data correlation:

friction ratio, FR (in %):

FR = fs/qc * 100 (Eq. 1); and

pore pressure ratio, Bq (dimensionless):

Bq = (U-Ue)/(qc-Sv) (Eq. 2);

where: *fs* is the measured friction sleeve resistance, in TSF;
qc is the measured cone end bearing resistance, in TSF;
U is the measured generated pore water pressure, in TSF;
Ue is the measured or estimated equilibrium pore water pressure, in TSF; and
Sv is the total soil overburden pressure, in TSF.

Measured data, computed and correlated parameters are presented in a graphical sounding log format for each sounding; numerical data are typically tabulated at 0.5 ft intervals. Digital data are also included on disk.

CPTU dissipation test data are recorded as a function of time during pauses in the penetration process. Dissipation data are normalized using the following equation:

normalized dissipation level, U* (dimensionless):

(Ut - Ue) / (U0 - Ue) (Eq. 3);

where: *Ut* is the excess pore water pressure at time t, in TSF;

Ue is the measured or estimated equilibrium, undisturbed pore water pressure (in situ pore water pressure before penetrometer insertion), in TSF; and

U0 is the excess pore water pressure at time equal to zero, at the start of the dissipation test, in TSF

The normalized dissipation level is plotted versus log time. In uniform soils, the plot takes the shape of a reverse S-curve, beginning at one at zero time (at the instant the penetration process is stopped) and falling to zero when equilibrium pressures are achieved. Boundary effects in interbedded deposits can cause deviation from this ideal.

An estimate of the horizontal coefficient of soil consolidation can be calculated (Baligh and Levadoux, 1980) using: Ch (in cm**2/sec) = (r**2*T)/t (Eq. 4a).

Estimates of soil hydraulic conductivity in the horizontal direction can be calculated using:

kh (in cm/s) = ((r**2*T)/t)*RR*(Gw/(2.3*Sv')) (Eq. 4b);

where: *r* is the penetrometer radial dimension at the plane of the piezometric filter, equal to 2.2 cm for the U2 friction sleeve filter and 1.9 cm for the U1 cone tip filter;

T is a dimensionless time factor at the 50% normalized dissipation level, equal to 5.5 for the U2 friction sleeve filter and 3.8 for the U1 cone tip filter;

t is the measured time, in seconds, at which the normalized dissipation level is 50%;

RR is a dimensionless soil compressibility parameter;

Gw is the unit weight of water, in kg/cm***3; and

Sv' is the effective soil vertical overburden pressure, in kg/cm**2.

Dissipation test data can be presented in graphical plots and are summarized in tabular form.

6.0 GENERAL DATA EVALUATION

6.1 Sounding Log The CPT sounding logs provide high resolution information on subsurface conditions. Soil layering is often highly apparent. Soil relative strength and saturation levels can also be evaluated. Zones of anomalous soil electrical conductivity can be identified. Apparent lateral continuity of conditions can be evaluated by comparing adjacent soundings. Digital CPT data files can be used in two and three dimensional data visualization, CAD or GIS software programs.

6.2 Soil Type Classification Correlations between penetrometer data and soil classification have been developed from geotechnical bearing capacity theory and a relational database on adjacent CPT soundings and drilled boreholes (Douglas and Olsen, 1981). A CPT soil type chart based on cone tip resistance and friction ratio is presented in Appendix A.

The CPT tip resistance increases exponentially with soil grain size. For example, tip resistance in dense sands ranges from about 100 to 400 tons per square foot (TSF), while tip resistance in a stiff clay ranges from about 5 to 15 TSF. The friction ratio (Section 5.0) is also used for indication of soil type. The friction ratio increases with the fines content and compressibility of a soil. The friction ratio is less than about 1% in a sand and greater than about 3% in a clay. CPT soil types reflect the soil shear resistance to penetration. Soil shear resistance is not entirely controlled by grain size distribution. However, CPT soil types generally agree with classifications based on grain size distribution methods, such as the Unified Soil Classification System (USCS).

The generated pore water pressure measurement is also useful for evaluation of saturated soils. Penetration of coarse sand and gravel occurs under drained loading conditions, and thus equilibrium pressures are measured during CPTU. The pore pressure ratio (Section 5.0) is zero in high permeability soils. For saturated soils of permeability less than about 1*10E-2 cm/sec, undrained loading with significant excess water pressure generation occurs during CPTU. Positive excess water pressures are generally measured during penetration of silt or clay soils when using either the U1 cone tip or U2 friction sleeve filter penetrometer (Section 2.7). Pore pressure ratios of fine grained soils typically range from about 0.4 to 1.0.

Positive excess water pressures are also usually measured in dense, silty or clayey sands when using the U1 filter penetrometer, with pore pressure ratios from about 0 to 0.3. Due to geometric effects (Section 2.7), negative pressures are usually measured in dense, silty or clayey sands, sandy silts, or hard sandy clays with the U2 filter penetrometer. Thus, it is important to note the type of piezometer filter in use. The CPTU-EC penetrometer uses a U2 friction sleeve piezometric filter.

6.3 Potentiometric Surfaces Equilibrium water pressures are measured during penetrometer advance in saturated, coarse sand and gravel. Measurements of equilibrium water pressures can be obtained during CPTU in lower permeability soils by pausing during penetration and allowing generated water pressures to dissipate.
6.4 Soil Saturation Soil saturation often can be evaluated using the CPTU sounding log. Atmospheric (zero) pressure is measured during CPTU in unsaturated soils. Hydrostatic pressures are measured in saturated, high permeability soils. Significant water pressures are generated in saturated, low permeability soils due to penetrometer advance. Decreased levels of water pressure generation can be indicative of partially saturated soils. Decreased water pressure generation also may occur in organic soils due to the high compressibility of organic soil particles and the presence of biogenic gases, such as methane and hydrogen sulfide.
6.5 Soil Hydraulic Conductivity Excess water pressures are generated by penetrometer advance in saturated soils with permeability of less than about 1*10E-2 cm/sec. These generated pressures can be allowed to dissipate during pauses in the penetration process. The CPTU dissipation test is similar to a slug test and can be used to estimate soil hydraulic conductivity in the horizontal direction. Very high water pressures are typically generated in low permeability soils by penetrometer advance, so soil compressibility (storage) effects must be included in analyses. The CPTU tip resistance provides an index of soil compressibility for these computations.
6.6 Soil Electrical Conductivity Behavior Soil electrical conductivity (EC) is controlled by the conductance of both the soil particles and soil pore fluids. The ratio between pore fluid and soil-pore fluid electrical conductivity is termed the formation factor (Archie, 1942). Clays can be electrically conductive due to adsorbed water and ionic electrical charges on the clay platelets. Thus, clay EC depends on mineralogy, porosity and pore fluid characteristics. Sand grains are typically non-conductive, so granular soil conductance is primarily dependent on the conductance of pore fluids and the sand's porosity.

Pore fluids play a major role in sand EC. A dry sand has low EC since both the sand grains and the air in the pore space have very low conductance. Sands saturated with conductive liquids, such as brine or landfill leachates, have high EC. Hydrocarbons typically decrease EC because of their low conductance. **Soil saturation** has a pronounced effect on sand EC, as conductance increases with water saturation. Low saturation is typically associated with low EC. The low **porosity** of a dense sand results in less pore fluid available for electrical conductance and thus lower EC; the high porosity of a loose sand is often associated with higher EC. Formation factors vary as an inverse function of porosity, from about 3 at high porosity to about 4.5 at low porosity. The addition of as little as 5% clay to a sand can increase soil EC (Windle, 1977).

The high resolution of the STRATIGRAPHICS CPTU-EC electrode array makes measurements sensitive to gravel content. Two behaviors can occur when penetrating gravelly soils. One can occur when a large particle is crushed against an electrode, masking it from the pore fluids, which results in low EC values. An opposite behavior is observed in gravel deposits which contain few fine grained intersticial soils. The high resolution EC measurement can result in electrical conductance paths within the soil pore space. In this situation, high EC measurements more closely reflect pore fluid EC, rather than soil EC.
6.7 EC Evaluation EC data are evaluated in conjunction with CPTU-EC piezometric data and soil types for qualitative geochemical characteristics. Anomalous zones possibly indicative of contaminants can be directly sampled for quantitative chemical analysis.

Vadose Zone Low or zero EC values are typically measured in dry sandy soils. Increased EC in vadose zone sands may indicate moisture infiltration. Low EC data in vadose zone silty or clayey soils can be anomalous as fine grained soils often retain significant amounts of moisture within their pore spaces due to capillarity. Elevated EC values in the vadose zone may be associated with road deicing salts, buried metals and rusted metal objects, flyash and cinders, among others.

Saturated Soils Low EC values in saturated soils can be indicative of anomalous geochemistry. In particular, depressed EC zones immediately at the water table may be associated with floating (LNAPL) compounds. Very low EC zones at interfaces between aquifers and aquitards may be associated with either LNAPL or DNAPL compounds. Gravel interference must be considered when evaluating depressed EC zones in saturated soils.

Elevated EC values in saturated soils can be due to increased soil clay content or to increased dissolved salts in the ground water. Increased clay contents are evaluated based on the CPTU-EC piezometric data and soil type information. Zones of elevated EC immediately above an aquiclude may be associated with brines or landfill leachates (Strutynsky and others, 1998).
6.8 UV Fluorescence Behavior Fluorimetry (measurement of fluorescence) has been used for many years for the detection and identification of various compounds and minerals. An excitation light of short wavelength is used to expose the specimen. If fluorescent compounds or minerals are present, light of longer wavelength, as compared to the excitation wavelength, will be emitted from the specimen. This resulting light can be monitored for intensity and spectral distribution.

Compounds that fluoresce include a wide range of hydrocarbon and other organic compounds. Heavy hydrocarbons (e.g. fuel oil and coal tars) fluoresce at relatively long wavelength excitation. As excitation wavelength decreases below about 300 nm, fluorescence from lighter hydrocarbons (e.g. jet fuel and gasoline) is observed. In addition to hydrocarbons, other compounds and minerals, such as fluorites and other carbonates, also exhibit fluorescence. Compounds that fluoresce include dyes and optical brighteners, used in paints, detergents, antifreeze compounds, some food additives and cosmetics, among others. UVF response will be affected by the presence of any such compounds.

6.9 CPT-SPT Correlation Since most geoscientists are familiar with drilling and split spoon sampling, CPT data have been correlated with SPT blowcount N-values. The SPT N-value is defined by ASTM to be the number of blows of a 140 lb hammer, dropped 30 inches, required to drive a 2 inch outside diameter sampler 12 inches into the bottom of the borehole, after an initial seating drive of 6 inches. Correlations of CPT to the crude SPT have been based on numerical modeling of the two penetration processes and on side by side comparisons (Douglas and others, 1981). Additional details on CPT-SPT correlations are included in Appendix A.

7.0 GEOTECHNICAL DATA CORRELATION

CPT data have been correlated with soil type, drained friction angle, undrained shear strength, relative density and SPT blowcounts, among others. A correlation scheme including tip resistance and friction ratio has generally proved most useful for evaluating CPT data. Correlation of CPT data with other parameters has been developed using: 1) comparisons between CPT data and results of other in situ and laboratory tests in adjacent boreholes; 2) CPT testing on large scale soil samples of known composition; and 3) geotechnical bearing capacity and cavity expansion theory. Site specific information can be used to fine tune correlations. Additional information on correlation techniques, including overburden pressure normalization, test drainage conditions and recommended practices, is presented in Appendix A.

8.0 PROGRAM RESULTS

Acquired data are presented following the report text and consist of: 1) sounding logs with lithologic evaluation; 2) data presentation sounding logs; and 3) tabulations of correlated geotechnical parameters, including soil classifications. Digital data are presented on the attached disk, and include statistical summaries of evaluated strata for each sounding, among other data presentations. It should be noted that the computerized evaluations of soil types and other geotechnical properties were generated using a global rather than site specific data base. Use of site specific data was beyond the scope of this study.

9.0 STATEMENT OF LIMITATIONS

Subsurface information was gathered only at the sounding locations. Extrapolation of sounding data to develop stratigraphic continuity is conjectural. Actual site conditions between sounding locations may differ. Evaluation of soil saturation and potentiometric surfaces is only representative of conditions encountered during the field program. Seasonal variation must be expected.

Correlation of penetrometer data with other parameters was performed using generalized, global charts rather than on site specific information. Site specific correlation work based on results of detailed, complementary laboratory testing was beyond the scope of this study.

Data gathering for this study was attempted to be performed in general accordance with accepted procedures and practices. Correlation of penetrometer data with other parameters is empirical and should not be considered as the exact equivalent of laboratory testing. STRATIGRAPHICS shall not be responsible for another's interpretation of the information obtained for this study.

10.0 REFERENCES

Archie, G.E.,1942. The Electrical Resistivity Log as an Aid in Determining some Reservoir Characteristics. AIME Vol. 146.

Baligh, M.M. and J. Levadoux, "Pore Pressure Dissipation After Cone Penetration," Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1980.

Davidson, J.L., A. Boghrat, 1983. Displacement and Strains around Probes in Sand. Geotechnical Practice in Offshore Engineering, ASCE.

Douglas, B.J., G. Martin, 1981. Evaluation of the Cone Penetrometer for Liquefaction Studies, Imperial Valley Earthquake, California. Fugro, Inc., report for U.S. Geological Survey, No. 81-502.

Douglas, B.J., R. Olsen, 1981. Soil Classification using the Electric Cone Penetrometer. Cone Penetrometer Testing and Experience, ASCE.

Douglas, B.J., R. Olsen, G. Martin, 1981. Evaluation of the Cone Penetrometer Test for use in SPT Liquefaction Potential Assessment. Cone Penetrometer Testing and Experience, ASCE.

Douglas, B.J., A. Strutynsky, 1984. Cone Penetration Test, Pore Pressure Measurements, and SPT Hammer Energy Calibration for Liquefaction Hazard Assessment. The Earth Technology Corporation, report for U.S. Geological Survey, No. 14-08-0001-19105.

Douglas, B.J., A. Strutynsky, S. Brown, 1984. In Situ Testing II, Peoples' Republic of China. The Earth Technology Corporation, report to the National Science Foundation, No. CEE 8311873.

Douglas, B.J., A. Strutynsky, L. Mahar, J. Weaver, 1985. Soil Strength Determinations from the Cone Penetrometer Test. Civil Engineering in the Arctic Offshore, ASCE.

Durgunoglu, H.T., J. Mitchell, 1974. Influence of Penetrometer Characteristics on Static Penetration Resistance. First European Symposium on Penetration Testing.

Lunne, T., O. Eide, J. de Ruiter, 1976. Correlations between Cone Resistance and Vane Shear Strength in Scandinavian Soft to Medium Stiff Clays. Canadian Geotechnical Journal, Vol. 13.

Mayne, P.W.,1988. Determining OCR in Clays from Laboratory Strength. ASCE Journal of Geotechnical Engineering, Vol.114, No. 1.

Mayne, P.W., 1991. Determination of OCR in clays by piezocone tests using cavity expansion and critical state concepts. Soils and Foundations, 31(2), 65-76.

Mayne, P.W., 1993. In-situ Determination of Clay Stress History by Piezocone. Predictive Soil Mechanics. Proceedings of the Wroth Memorial Symposium.

Olsen, R.S., J. Farr, 1986. Site Characterization using the Cone Penetrometer Test. Use of In Situ Tests in Geotechnical Engineering, ASCE.

Rocha-Filho, P., 1979. Behavior of Cone Penetrometer in Saturated Sands. Ph.D. Thesis, Imperial College, London, England.

Saines, M., A. Strutynsky and G. Lytwynyshyn, 1989. Use of Piezometric Cone Penetration Testing In Hydrogeologic Investigations. First USA/USSR Conference on Hydrogeology, Moscow, USSR.

Sanglerat, G., 1972. The Penetrometer and Soil Exploration. Elsevier Publishing Co.

Schmertmann, J.H., 1978. Guidelines for Cone Penetration Testing, Performance and Design. U.S. Department of Transportation, FHWA-TS78-209.

Seed, H.B., K. Mori, C. Chan, 1977. Influence of Seismic History on Liquefaction of Sands. ASCE Journal of Geotechnical Engineering, Vol. 103, No. GT4.

Seed, H.B., K. Tokimatsu, L. Harder, R. Chung, 1984. The Influence of SPT Procedures in Soil Liquefaction Resistance Evaluations. University of California, report to the National Science Foundation and National Bureau of Standards, No. UCB/EERC84/15.

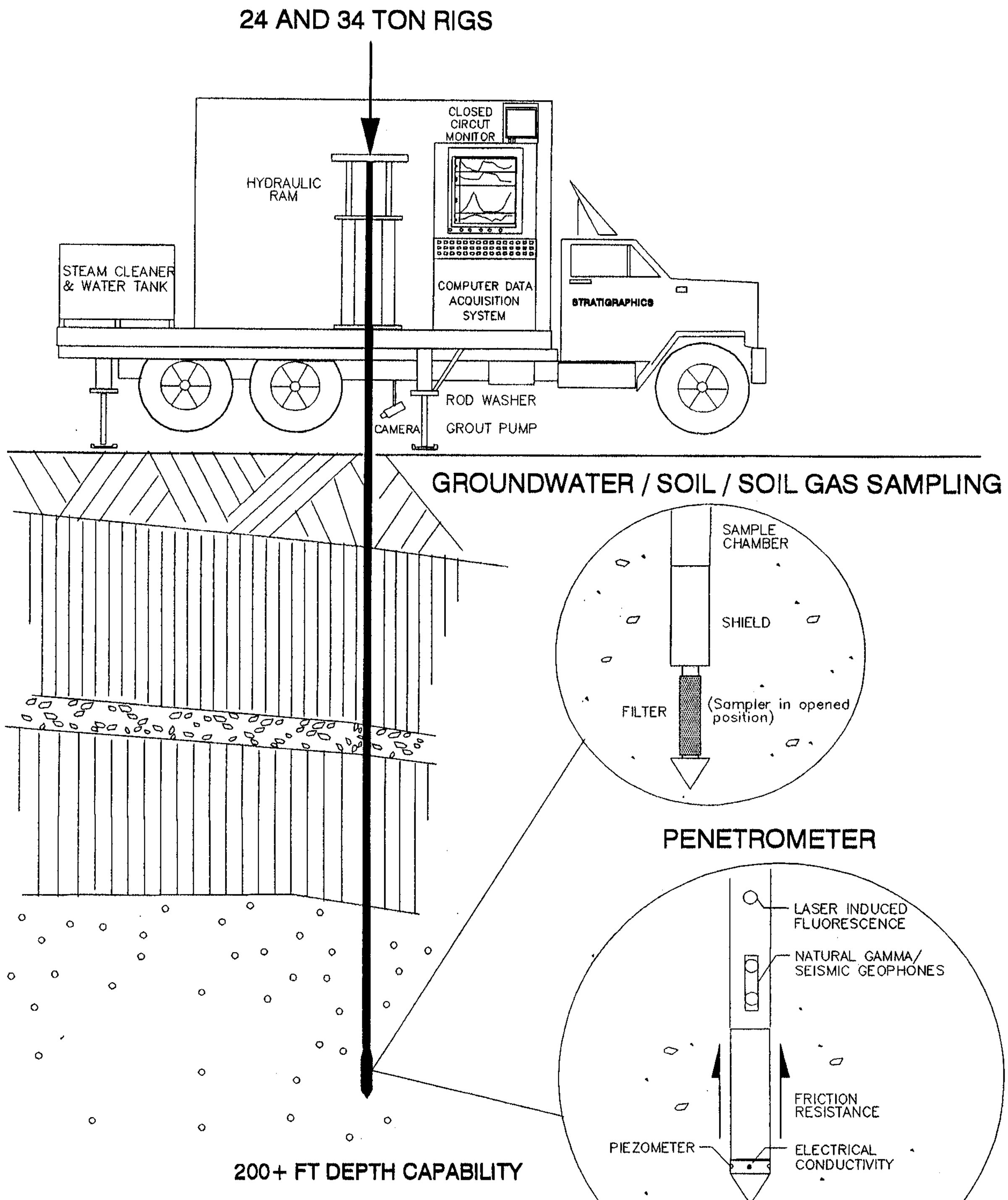
Strutynsky, A.I., 1988. Stress History and Normalized Soil Behavior from CPT. Presented at the session on site characterization, First International Symposium on Penetration Testing.

Strutynsky, A.I., B. Douglas, L. Mahar, G. Edmonds, E. Hencey, 1985. Arctic Penetration Test Systems. Civil Engineering in the Arctic Offshore, ASCE.

Strutynsky, A.I., R. Sandiford, D. Cavaliere, 1991. Use of Piezometric Cone Penetration Testing with Electrical Conductivity Measurements (CPTU-EC) for Detection of Hydrocarbon Contamination in Saturated Granular Soils. Current Practices in Ground Water and Vadose Zone Investigations, ASTM.

Strutynsky, A.I., T. Sainey, 1990. Use of the Piezometric Cone Penetration Test and Penetrometer Groundwater Sampling for Volatile Organic Contaminant Plume Detection. Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection and Restoration. API/NWWA.

Villet, W.C.B., J. Mitchell, 1981. Cone Resistance, Relative Density and Friction Angle. Cone Penetrometer Testing and Experience, ASCE.



PENETROMETER EXPLORATION SYSTEM

STRATIGRAPHICS

(630) 790-4610
www.STRATIGRAPHICS.com
Glen Ellyn, Illinois

TABLE 1
SUMMARY OF CPTU-EC SOUNDINGS
CPS-ESP FIELD EXPLORATION
CLINTON, ILLINOIS

SOUNDING NUMBER	DATE PERFORMED	SOUNDING TYPE	SOUNDING DEPTH (feet)	COMMENTS
CPT-01	07/24/02	CPTU-EC	78.1	
CPT-02	07/24/02	CPTU-EC-S	55.7	
CPT-03	07/24/02	CPTU-EC	54.0	
CPT-04	07/23/02	CPTU-EC-S	76.9	

STRATIGRAPHICS

Table 2a

Seismic Shear Wave Velocity Computation

Project Name: CPS-EPS Field Exploration

Project No: 02-120-110

Sounding No: CPT-02

S -Source offset:: 4.3 ft

S-Receiver offset: 1.1 ft

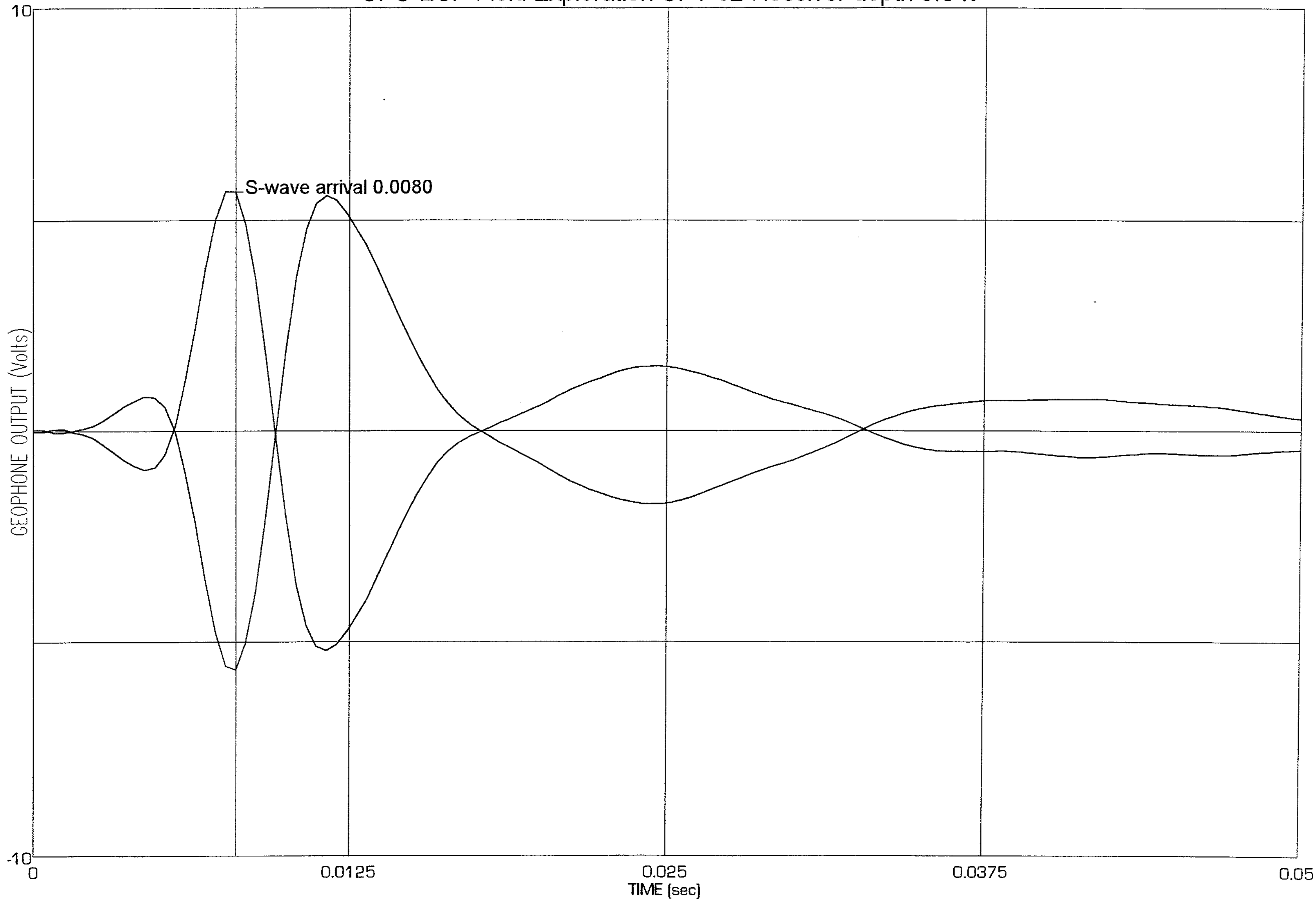
Depth correction factor: 1.002

Recorded CPT Tip Depth (ft)	Corrected CPT Tip Depth (ft)	**Seismic Receiver Depth (ft)**	S-source Slant Distance (ft)	Shear Wave Arrival (sec)	Shear Wave Velocity (ft/sec)	**Interval Shear Wave Velocity (ft/sec)**
7.2	6.9	**5.8**	7.21	0.0080	902	**902**
10.4	10.2	**9.1**	10.03	0.0120	835	**703**
13.7	13.4	**12.3**	13.06	0.0152	859	**948**
17.1	16.8	**15.7**	16.28	0.0180	904	**1148**
20.3	20.0	**18.9**	19.38	0.0208	932	**1107**
23.5	23.3	**22.2**	22.58	0.0240	941	**1002**
26.9	26.6	**25.5**	25.88	0.0264	980	**1162**
30.1	29.8	**28.7**	29.07	0.0294	989	**1062**
33.4	33.1	**32.0**	32.33	0.0324	998	**1088**
36.7	36.4	**35.3**	35.58	0.0348	1022	**1354**
40.0	39.7	**38.6**	38.87	0.0380	1023	**1029**
43.2	43.0	**41.9**	42.13	0.0416	1013	**905**
46.5	46.3	**45.2**	45.40	0.0448	1013	**1022**
49.6	49.4	**48.3**	48.48	0.0476	1018	**1101**
52.9	52.7	**51.6**	51.76	0.0504	1027	**1173**
55.86	55.6	**54.5**	54.72	0.0528	1036	**1231**

STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-02 Receiver depth 5.8 ft

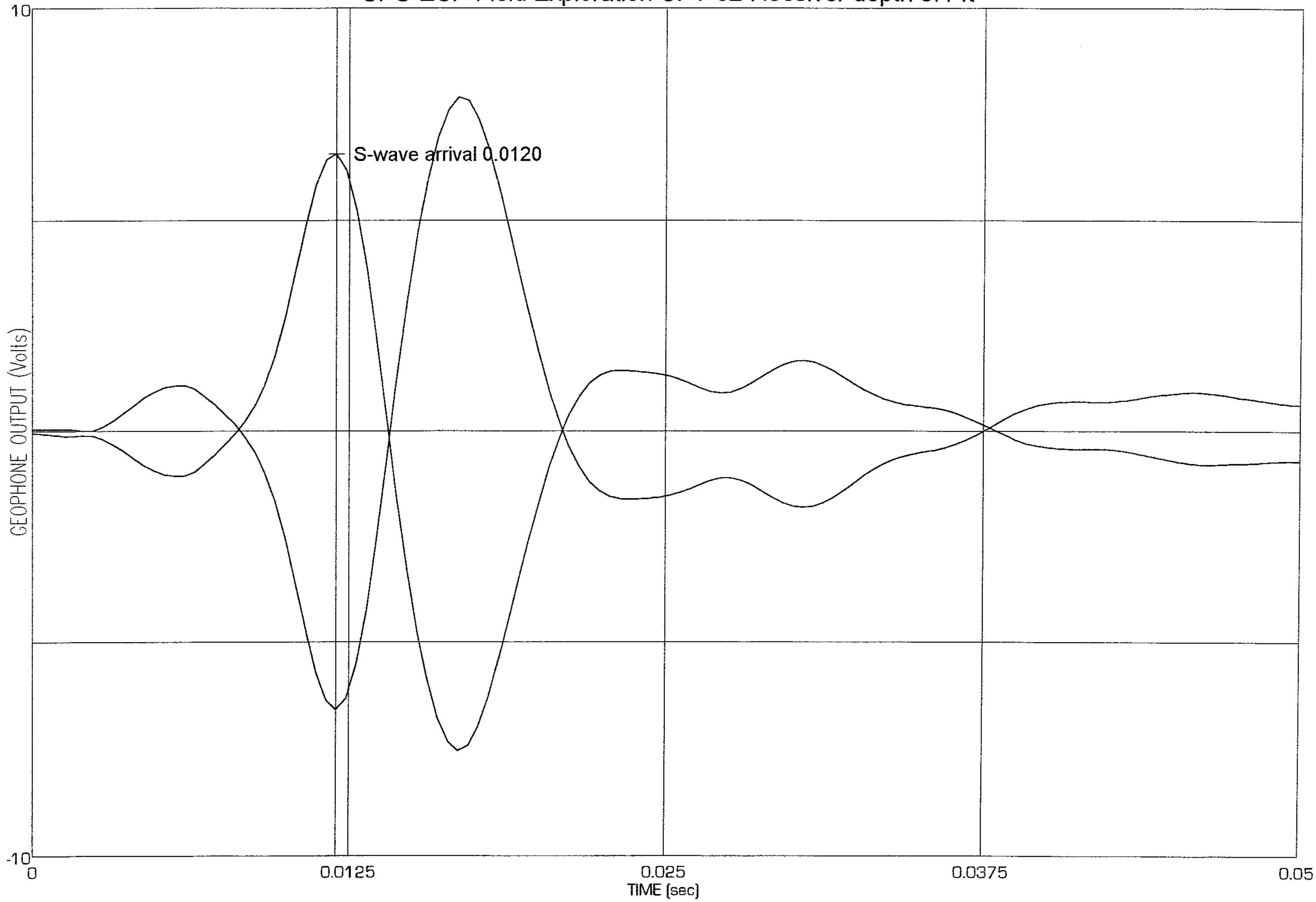
Frame:2



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

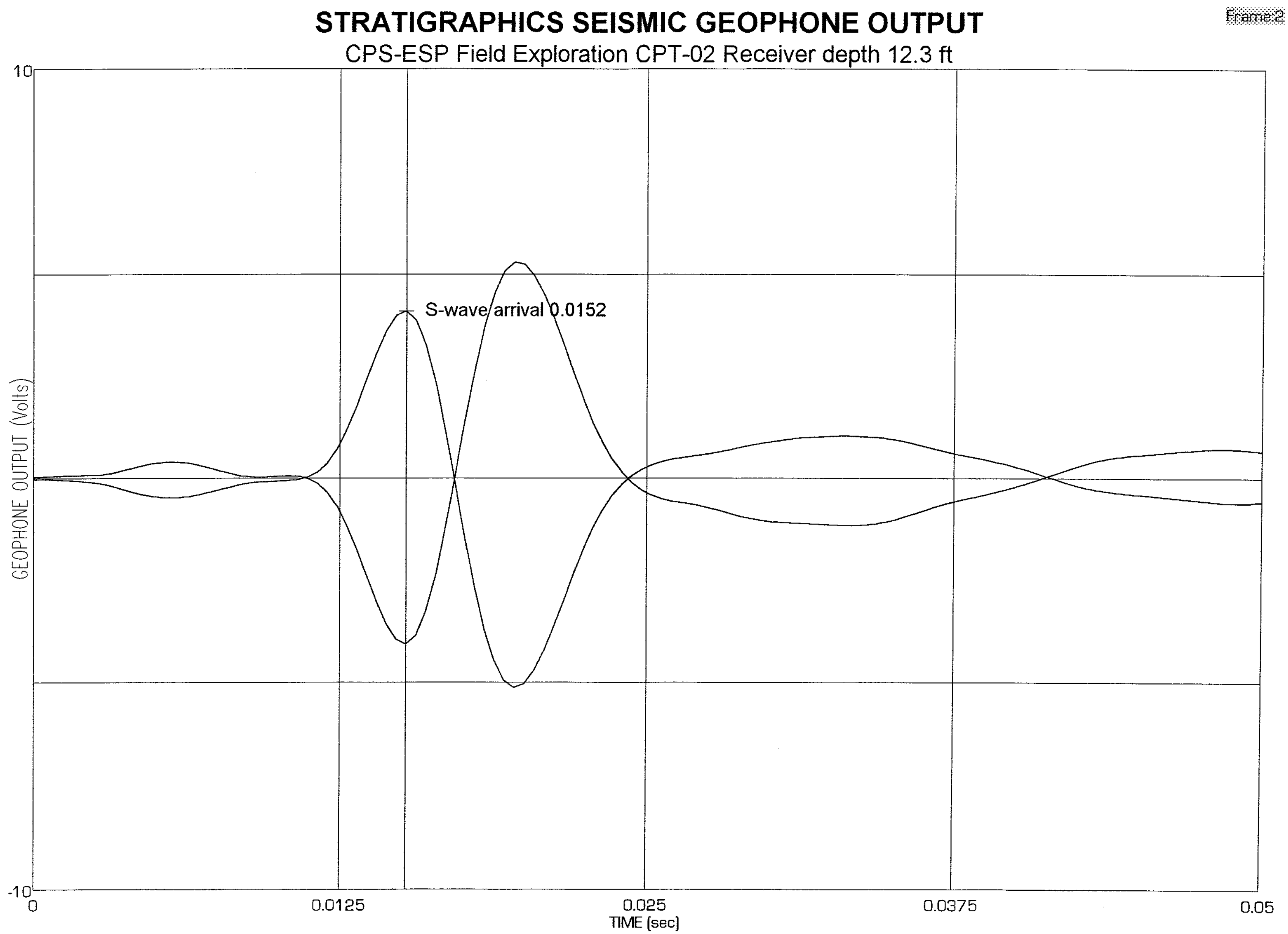
CPS-ESP Field Exploration CPT-02 Receiver depth 9.1 ft

Frame:2



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

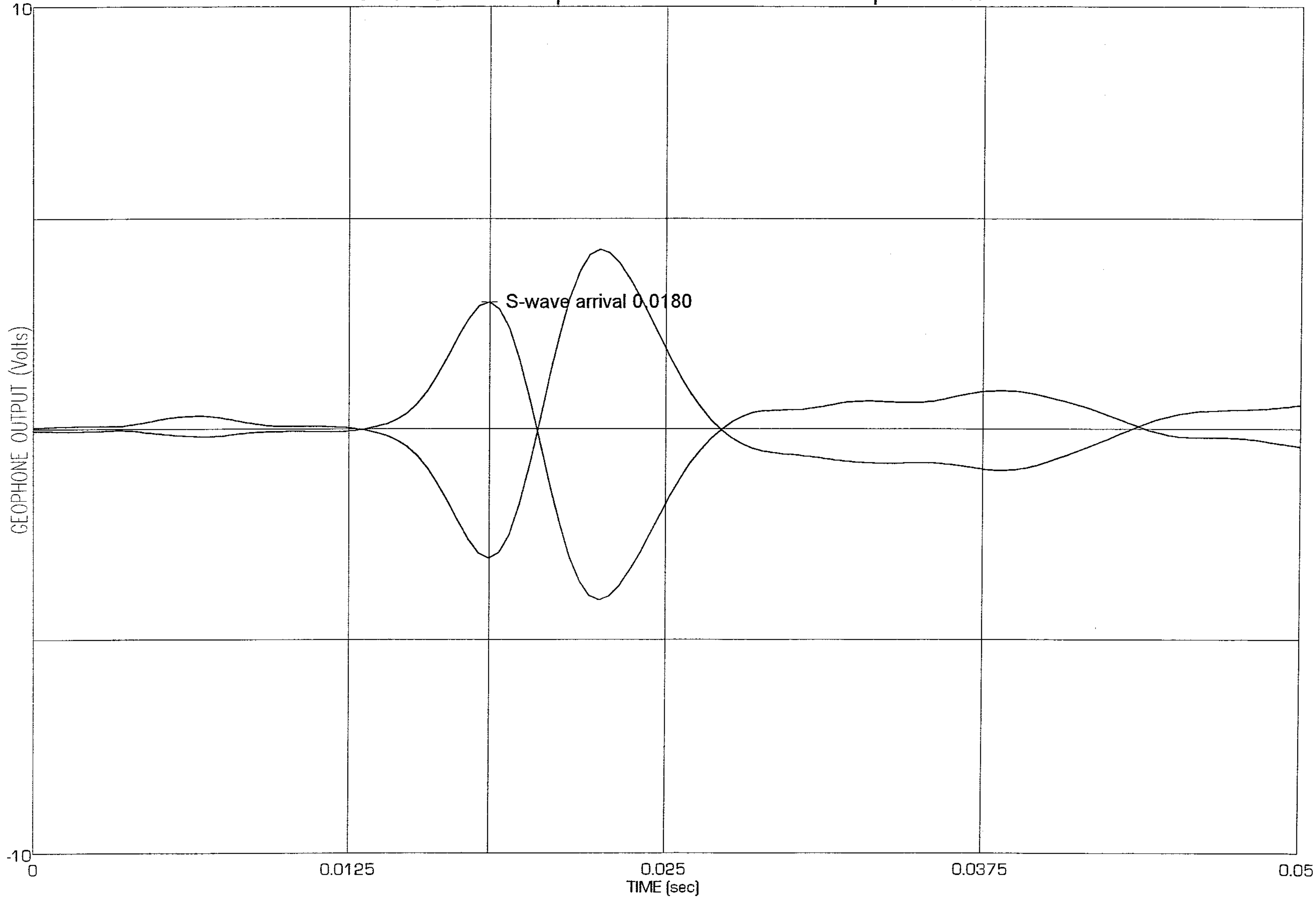
CPS-ESP Field Exploration CPT-02 Receiver depth 12.3 ft



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-02 Receiver depth 15.7 ft

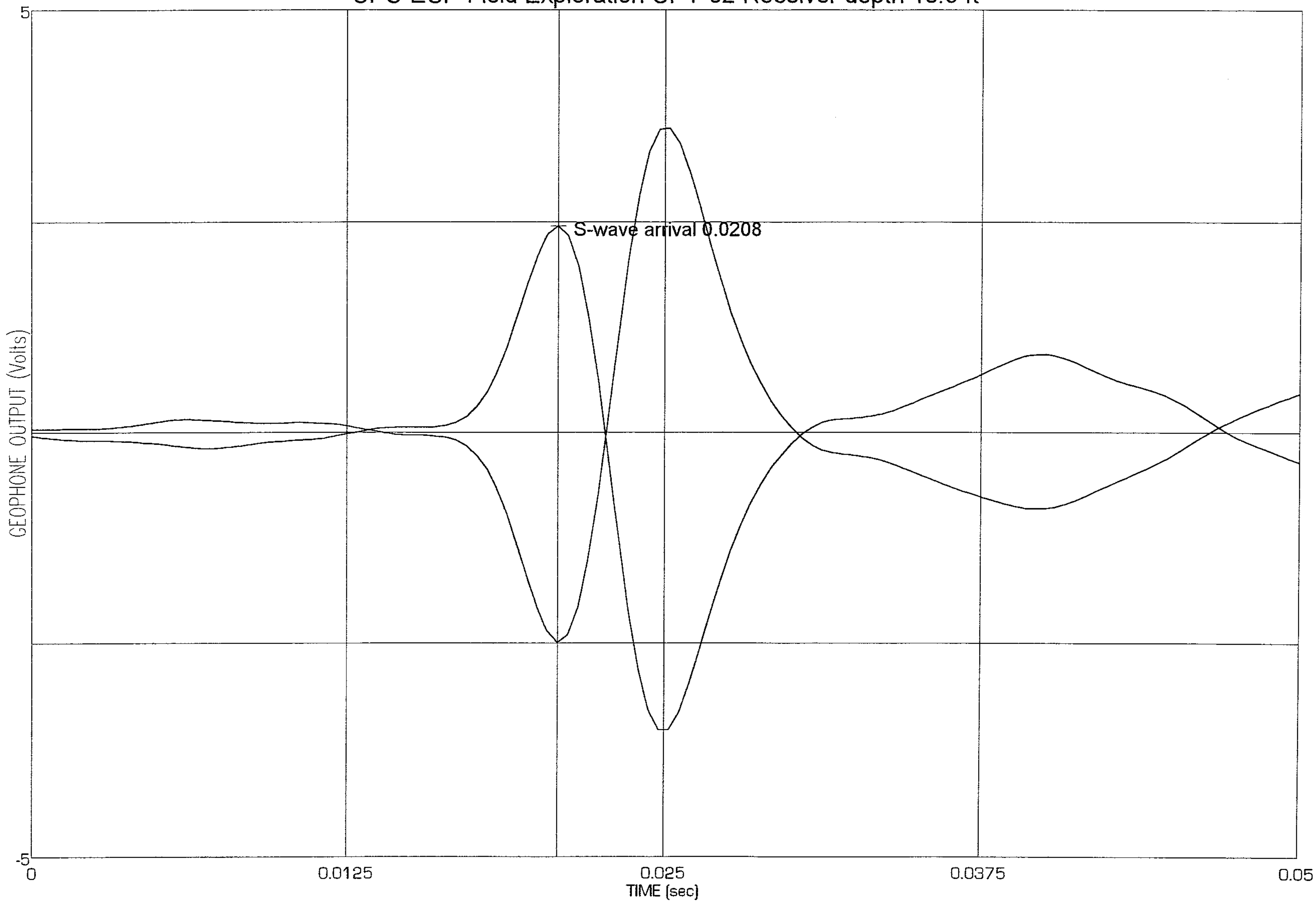
Frame:2



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

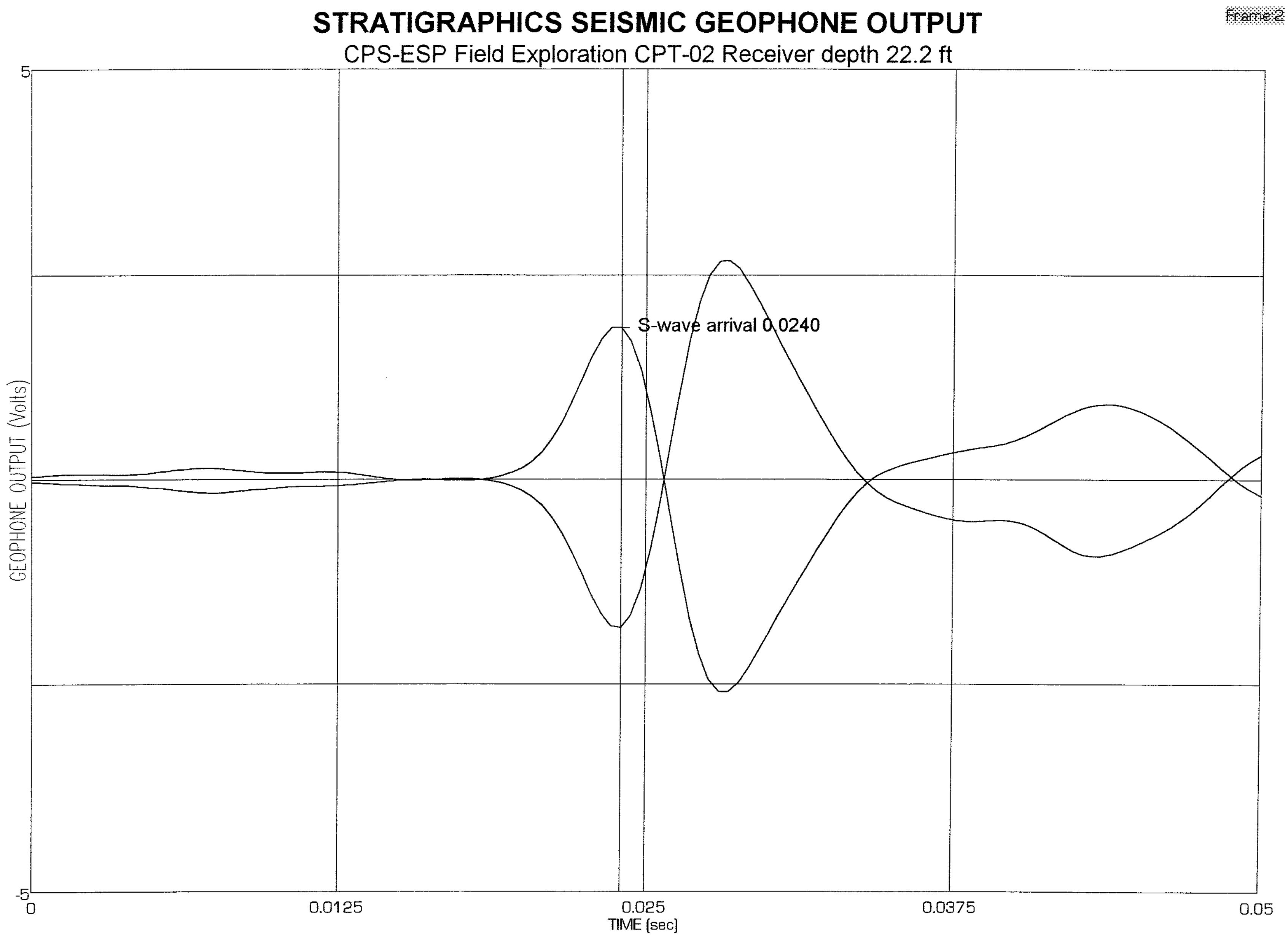
CPS-ESP Field Exploration CPT-02 Receiver depth 18.9 ft

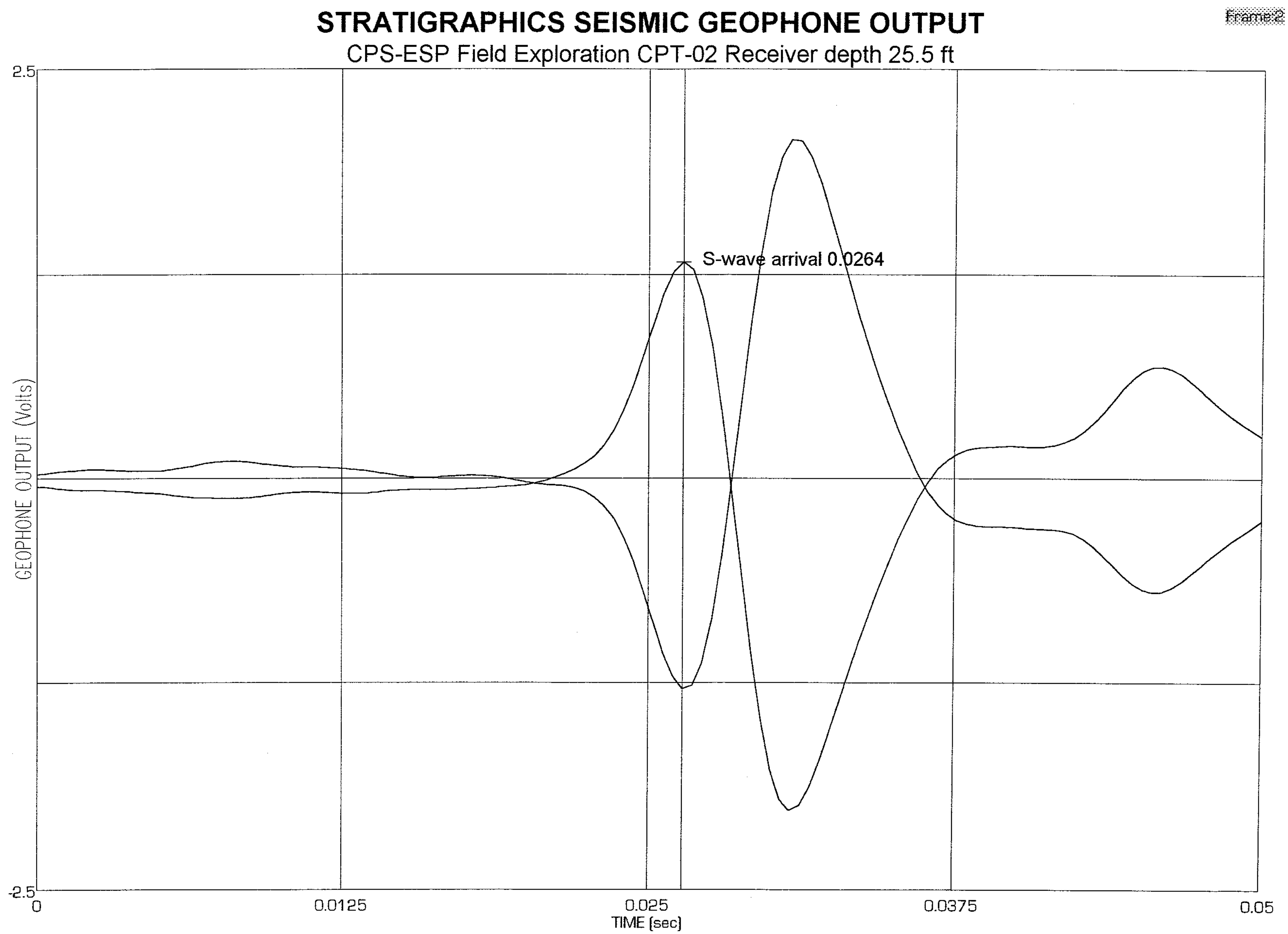
Frame:2



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-02 Receiver depth 22.2 ft



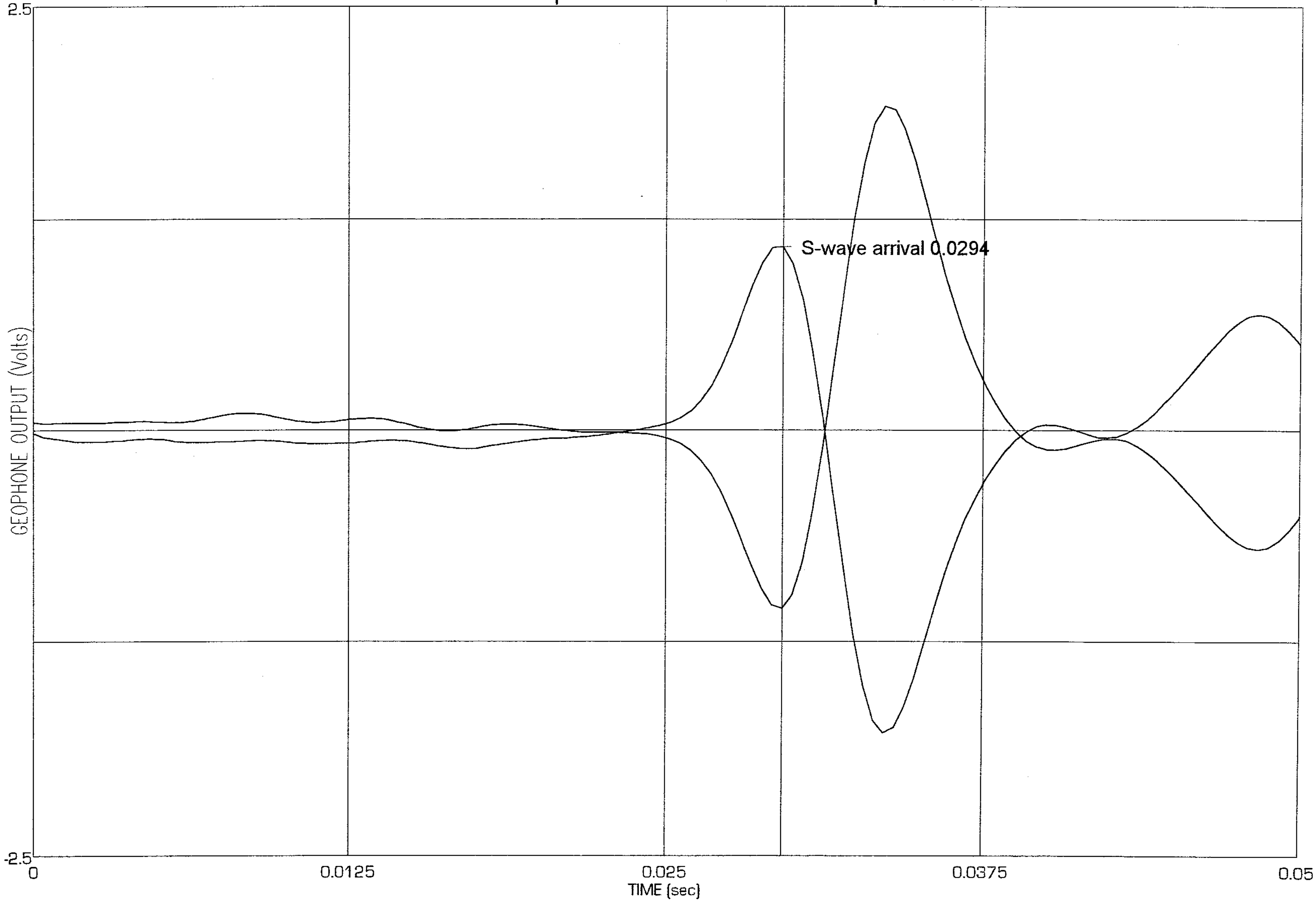


STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT
CPS-ESP Field Exploration CPT-02 Receiver depth 25.5 ft
Frame:2
S-wave arrival 0.0264
GEOPHONE OUTPUT (Volts)
2.5
-2.5
0
0.0125
0.025
0.0375
0.05
TIME (sec)

STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-02 Receiver depth 28.7 ft

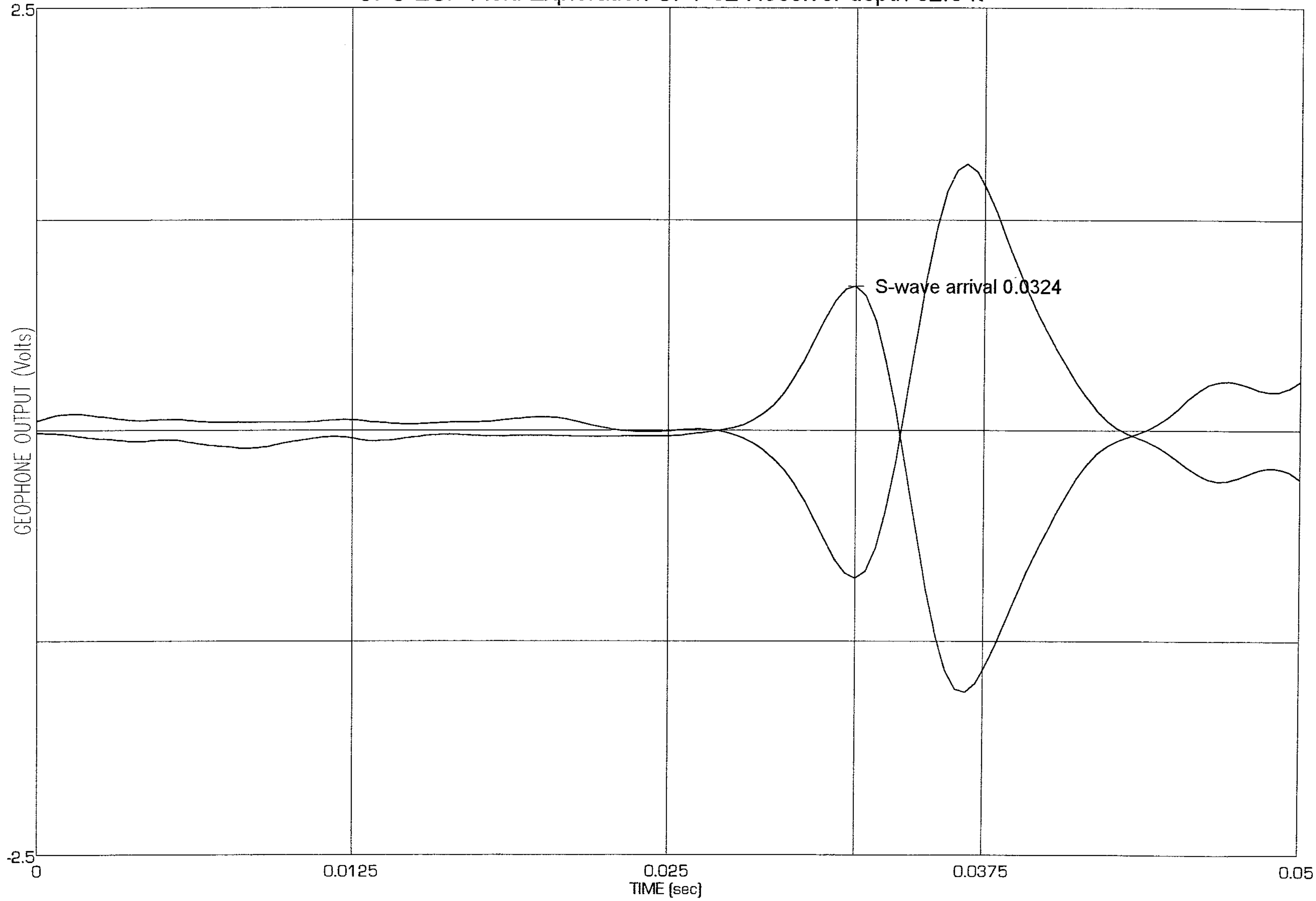
Frame:2



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

Frame 2

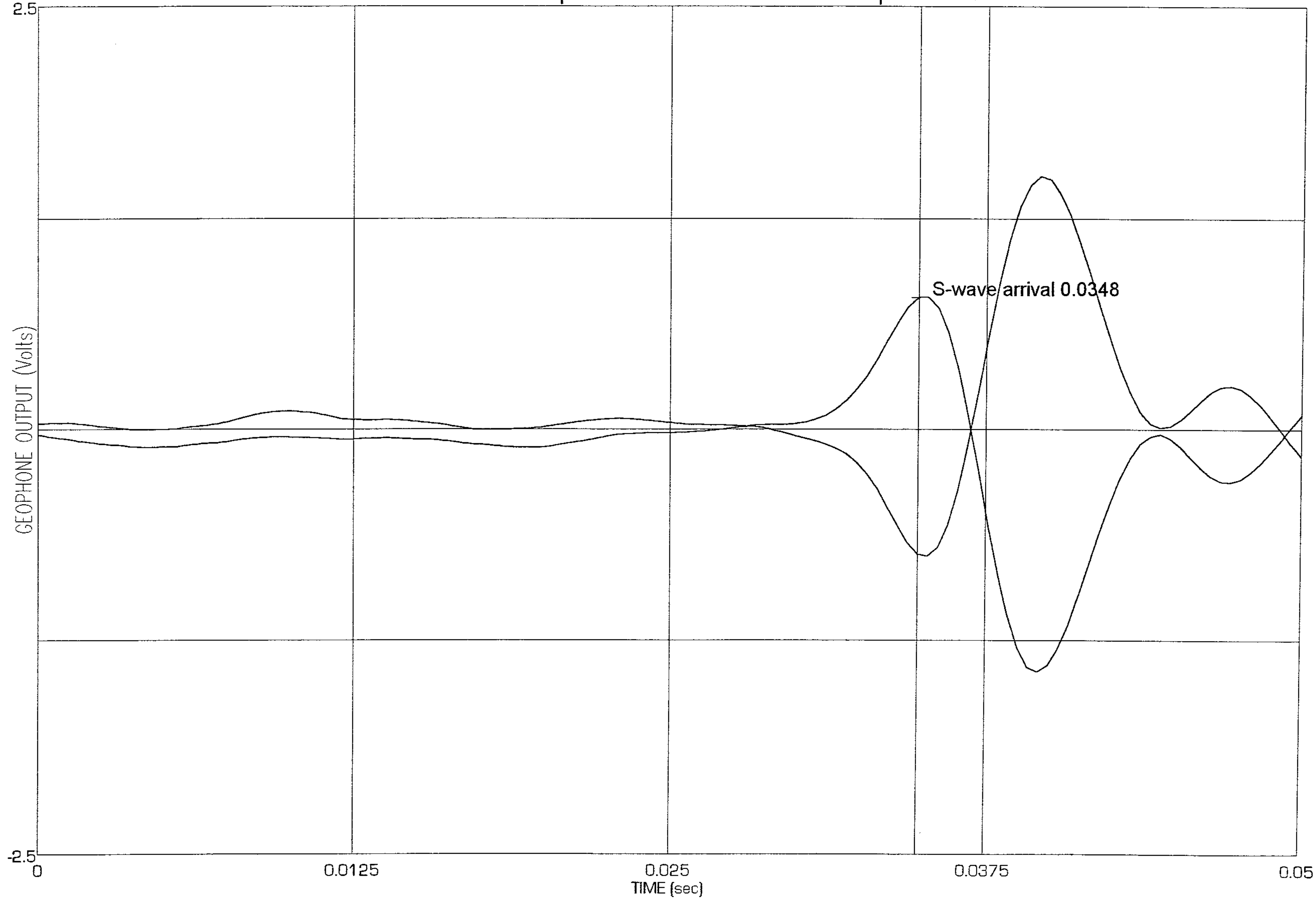
CPS-ESP Field Exploration CPT-02 Receiver depth 32.0 ft



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

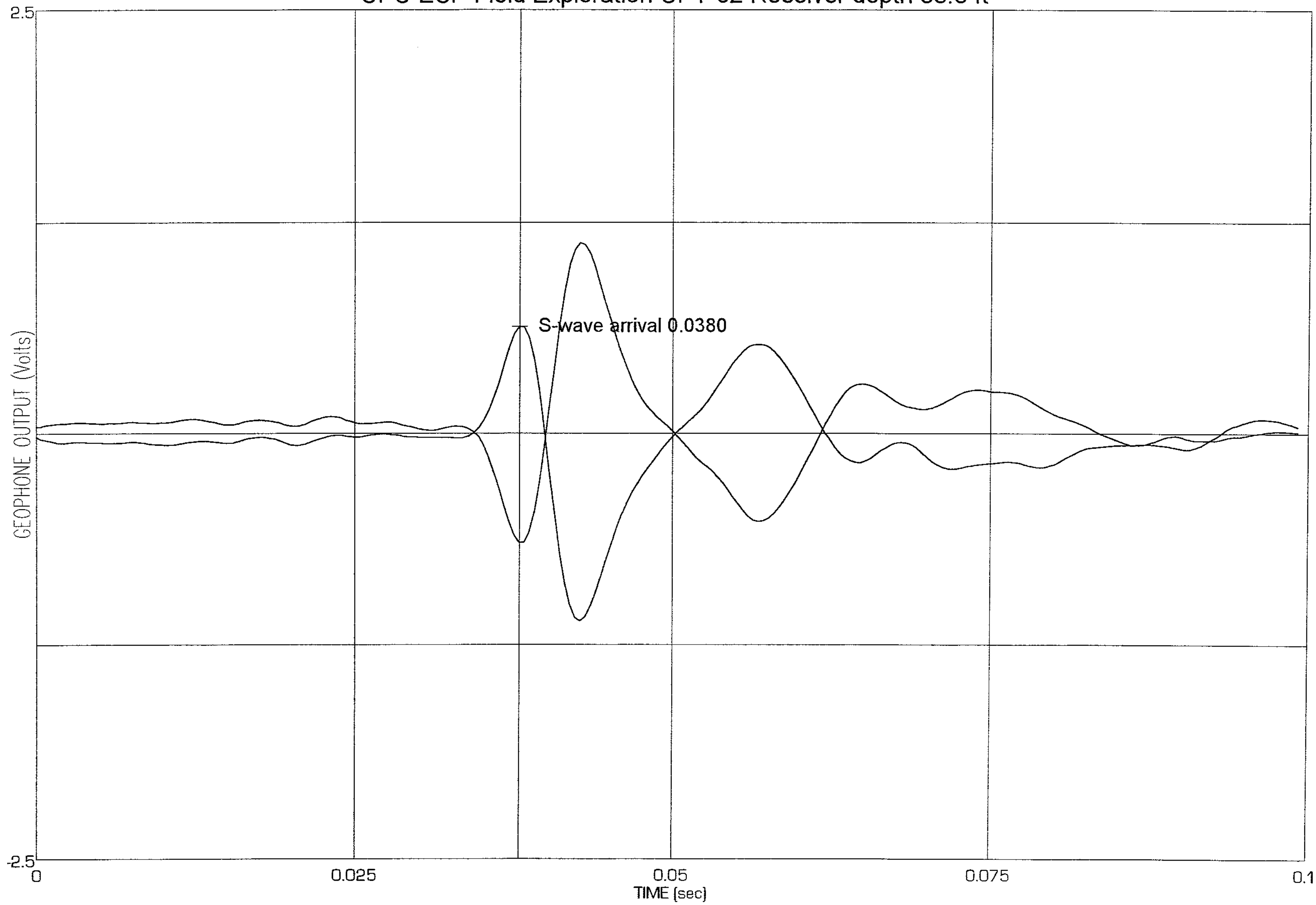
CPS-ESP Field Exploration CPT-02 Receiver depth 35.3 ft

Frame:2



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

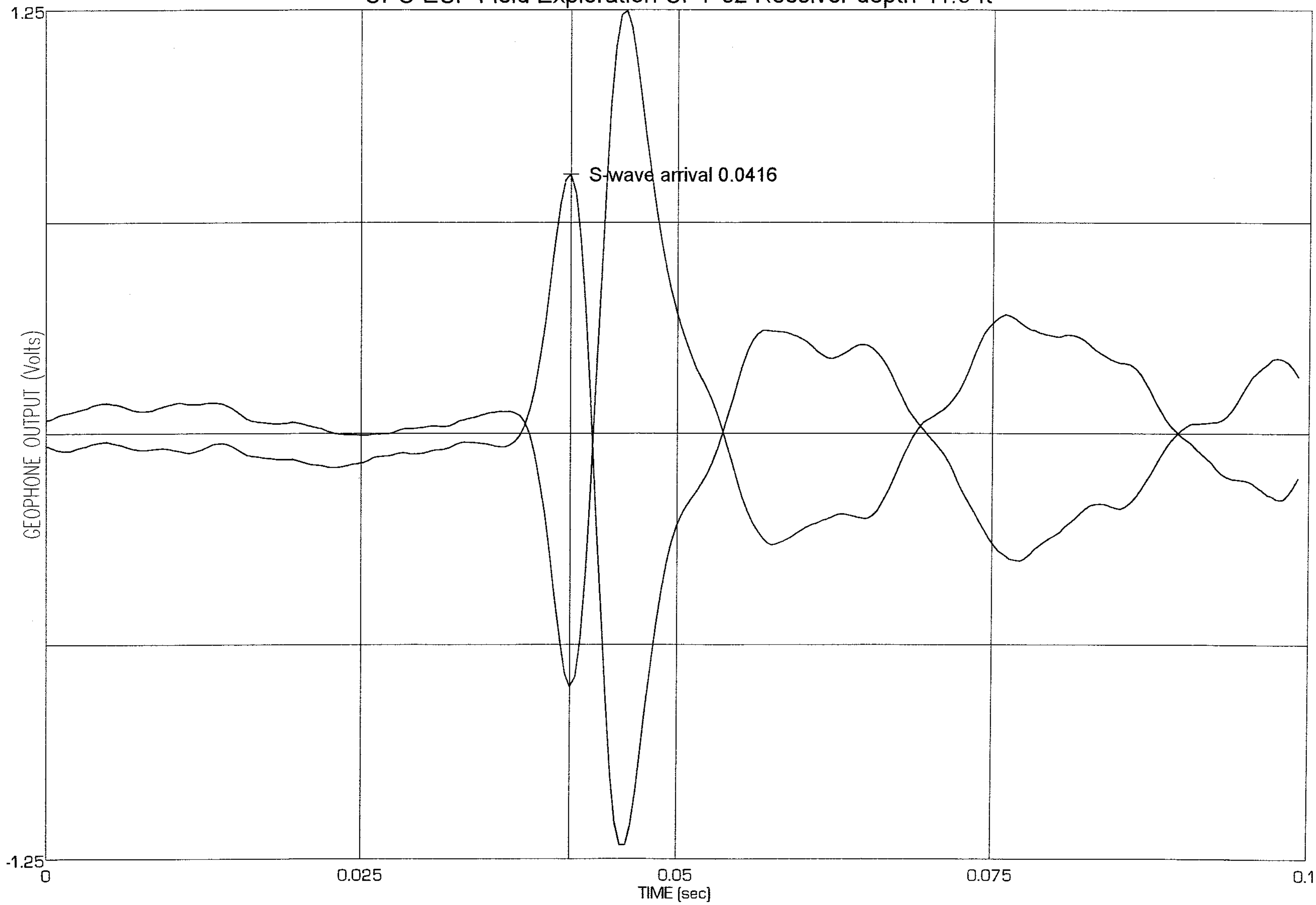
CPS-ESP Field Exploration CPT-02 Receiver depth 38.6 ft



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-02 Receiver depth 41.9 ft

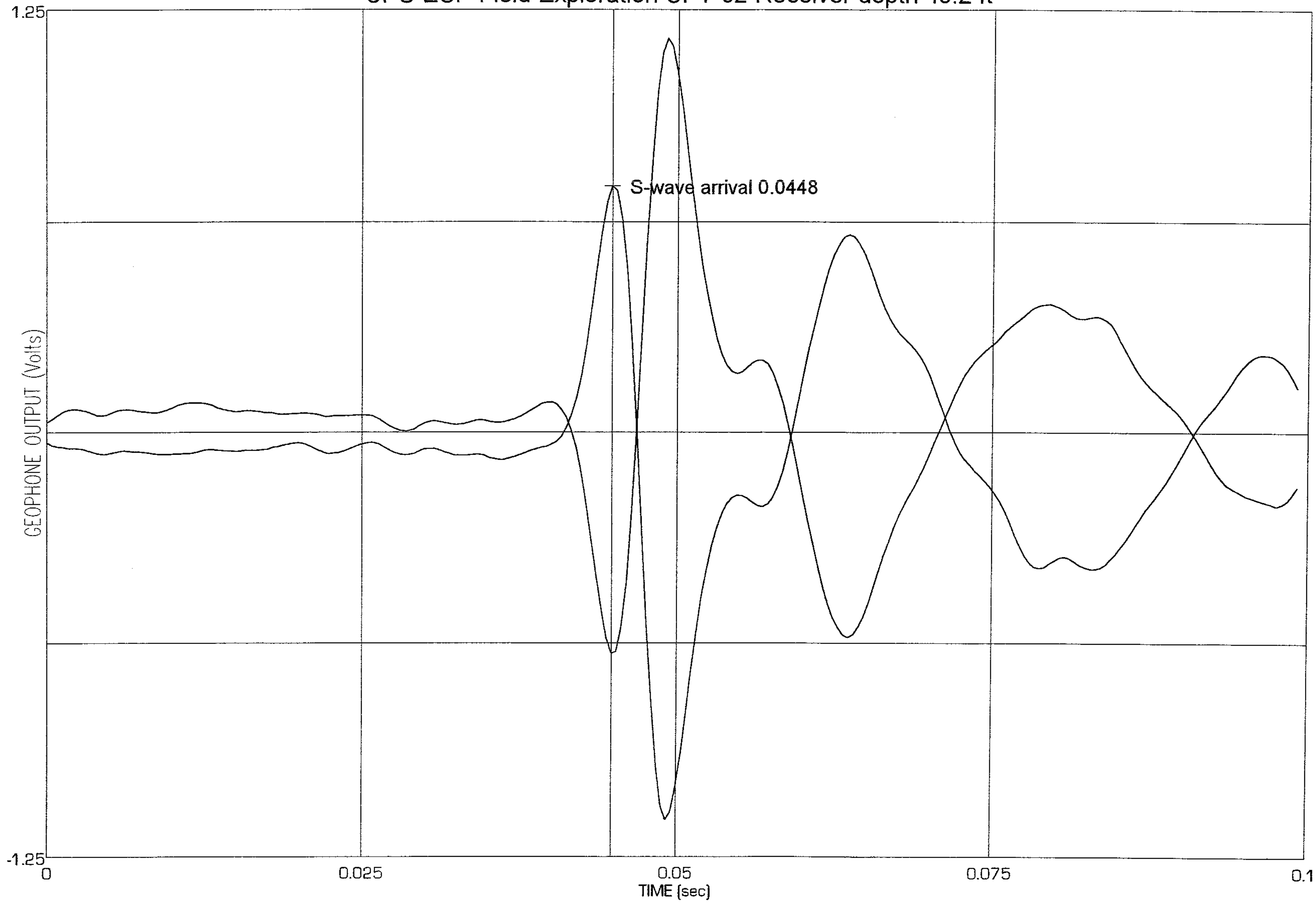
Frame 2



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-02 Receiver depth 45.2 ft

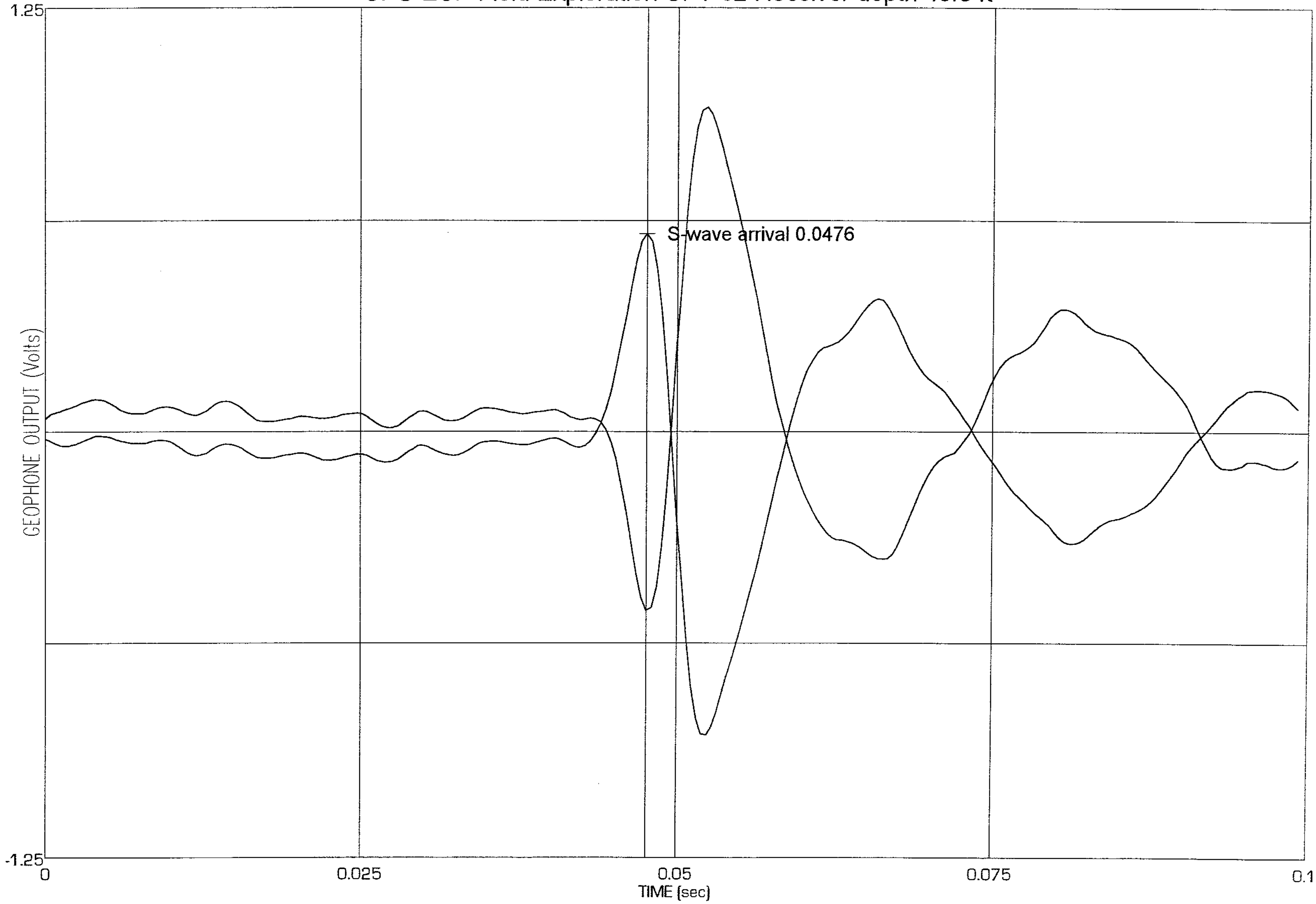
Frame:2



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

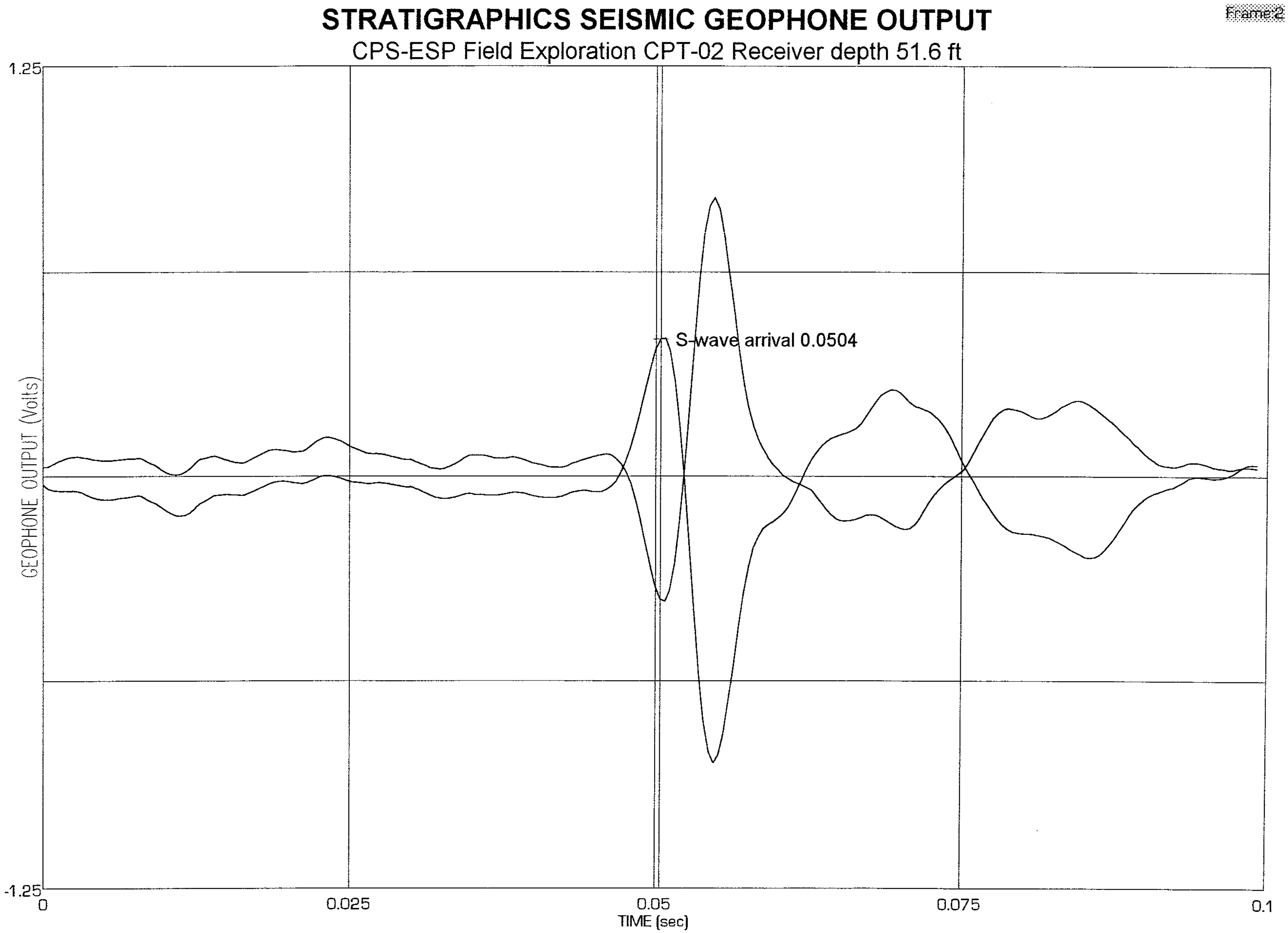
CPS-ESP Field Exploration CPT-02 Receiver depth 48.3 ft

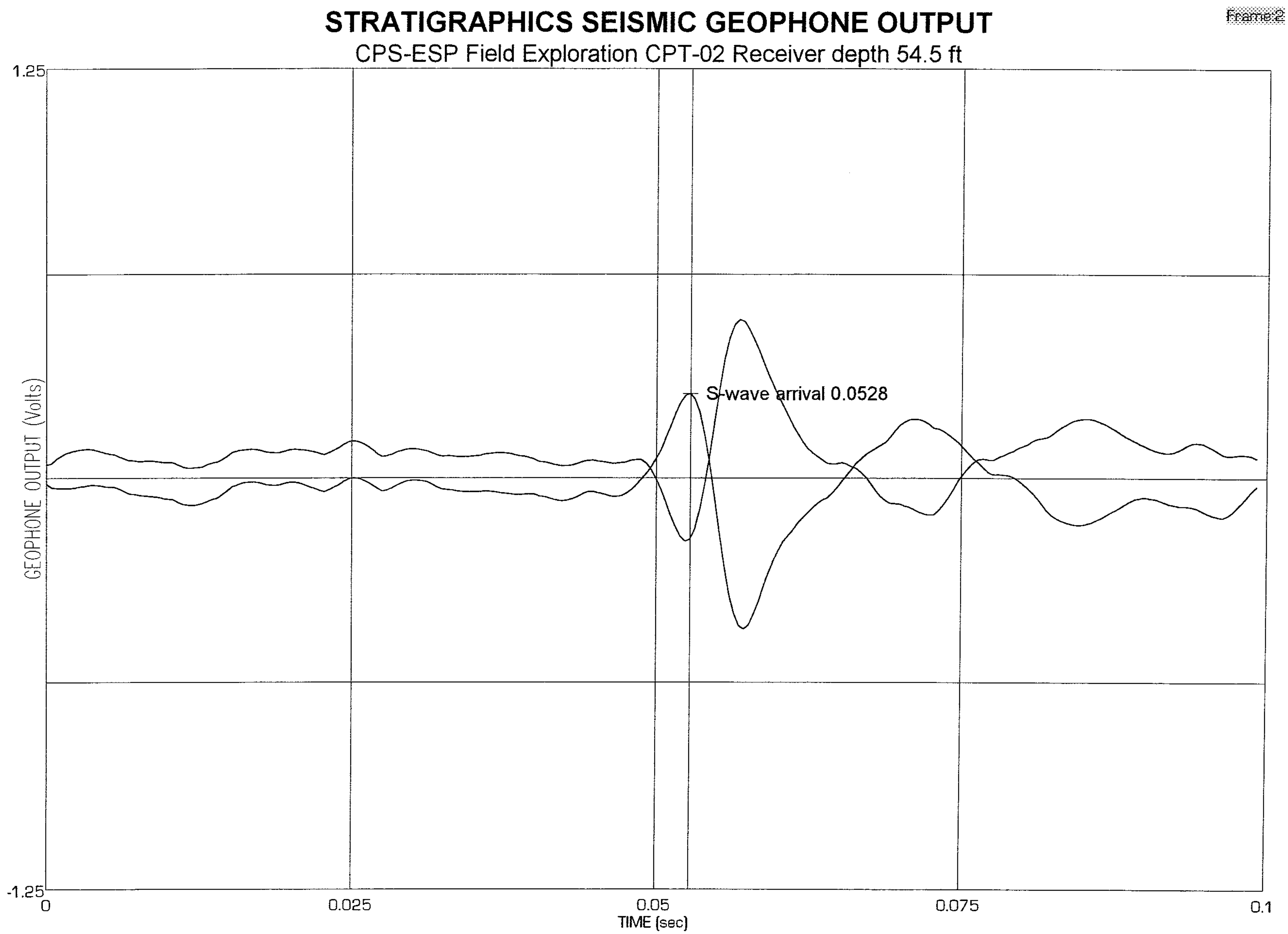
Frame:2



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-02 Receiver depth 51.6 ft





STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT
CPS-ESP Field Exploration CPT-02 Receiver depth 54.5 ft
Frame:2
1.25
-1.25
GEOPHONE OUTPUT (Volts)
S-wave arrival 0.0528
0
0.025
0.05
0.075
0.1
TIME (sec)

STRATIGRAPHICS

Table 2b

Seismic Shear Wave Velocity Computation

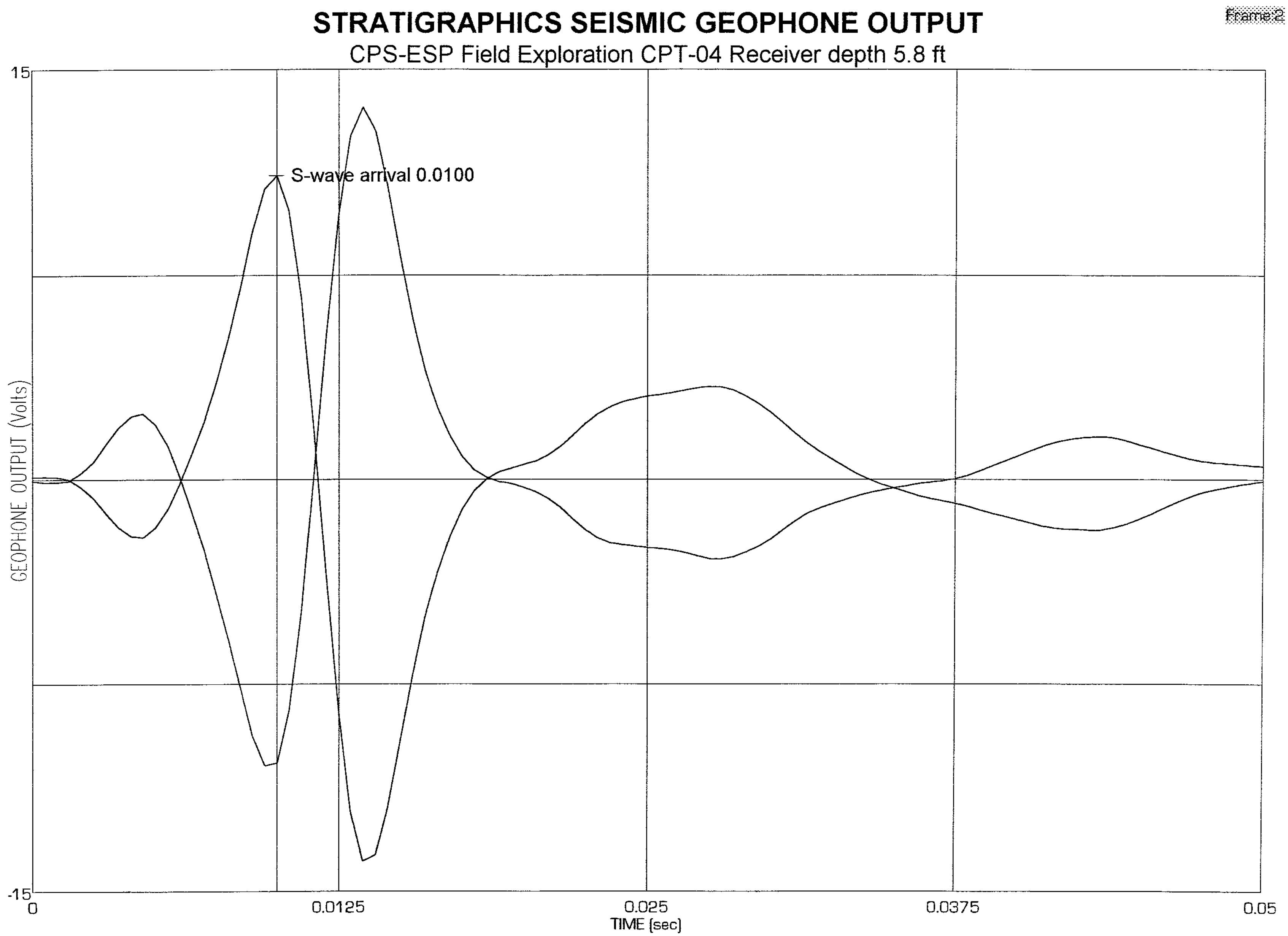
Project Name: CPS-EPS Field Exploration

Project No: 02-120-110

Sounding No: CPT-04

S -Source offset:: 4.3 ft
S-Receiver offset: 1.1 ft
Depth correction factor: 1.004

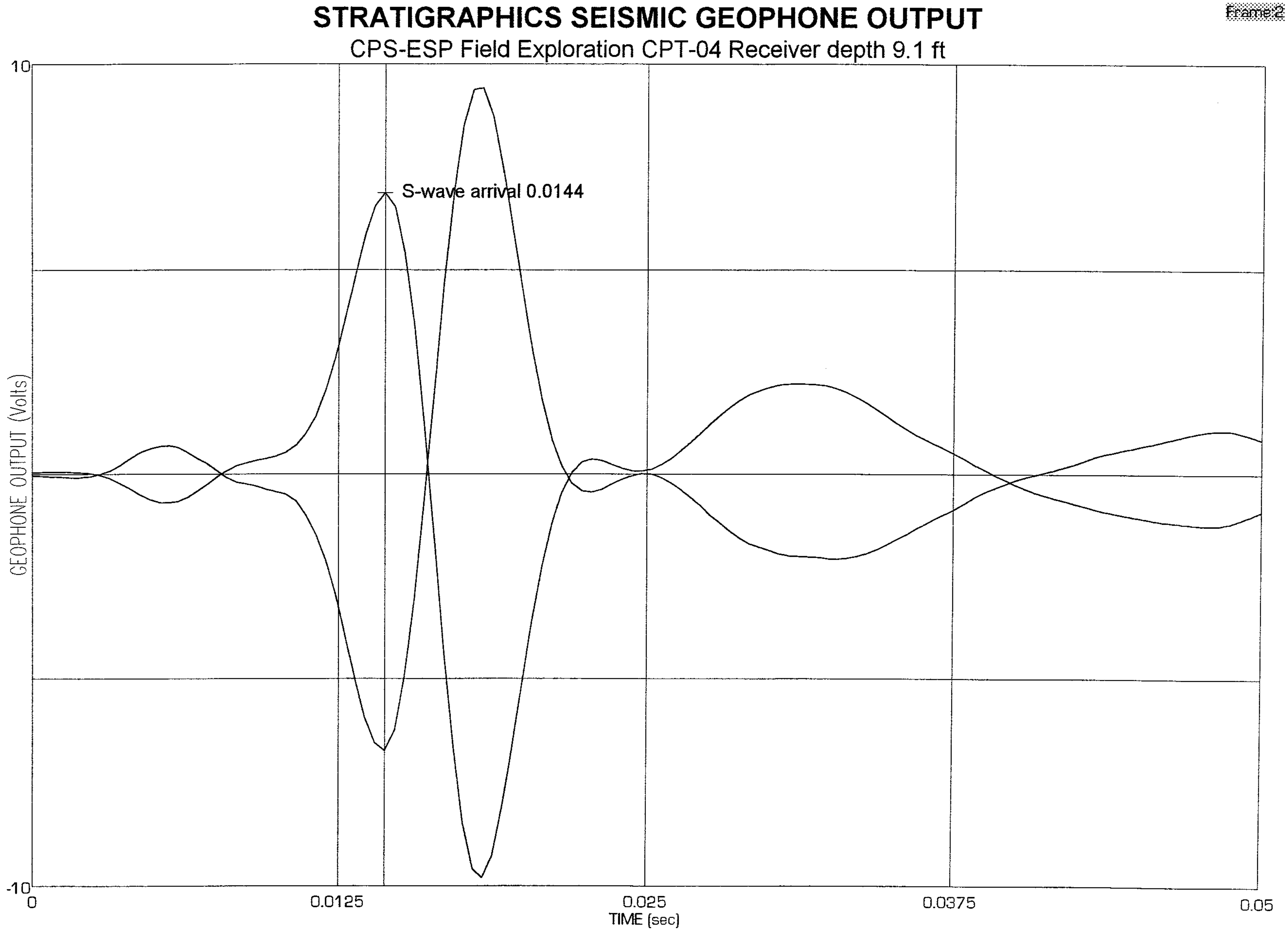
Recorded CPT Tip Depth (ft)	Corrected CPT Tip Depth (ft)	**Seismic Receiver Depth (ft)**	S-source Slant Distance (ft)	Shear Wave Arrival (sec)	Shear Wave Velocity (ft/sec)	**Interval Shear Wave Velocity (ft/sec)**
7.2	6.9	**5.8**	7.23	0.0100	723	**723**
10.4	10.2	**9.1**	10.05	0.0144	698	**641**
13.7	13.5	**12.4**	13.09	0.0188	696	**692**
17.0	16.7	**15.6**	16.22	0.0224	724	**869**
20.3	20.0	**18.9**	19.42	0.0260	747	**890**
26.8	26.6	**25.5**	25.87	0.0336	770	**848**
30.5	30.3	**29.2**	29.53	0.0372	794	**1017**
33.3	33.1	**32.0**	32.32	0.0408	792	**776**
36.7	36.5	**35.4**	35.67	0.0440	811	**1046**
39.9	39.8	**38.7**	38.90	0.0470	828	**1077**
43.1	43.0	**41.9**	42.11	0.0520	810	**643**
46.4	46.3	**45.2**	45.38	0.0548	828	**1167**
49.6	49.5	**48.4**	48.60	0.0580	838	**1006**
52.9	52.8	**51.7**	51.89	0.0608	853	**1175**
56.09	56.0	**54.9**	55.08	0.0632	872	**1330**
59.29	59.2	**58.1**	58.29	0.0652	894	**1602**
62.69	62.6	**61.5**	61.69	0.0680	907	**1216**
65.89	65.9	**64.8**	64.90	0.0708	917	**1145**
69.09	69.1	**68.0**	68.10	0.0728	935	**1603**
72.33	72.3	**71.2**	71.35	0.0756	944	**1160**
75.73	75.7	**74.6**	74.76	0.0776	963	**1704**
76.86	76.9	**75.8**	75.89	0.0780	973	**2832**



Frame:2
STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT
CPS-ESP Field Exploration CPT-04 Receiver depth 5.8 ft
S-wave arrival 0.0100
GEOPHONE OUTPUT (Volts)
15
-15
0
0.0125
0.025
0.0375
0.05
TIME (sec)

STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

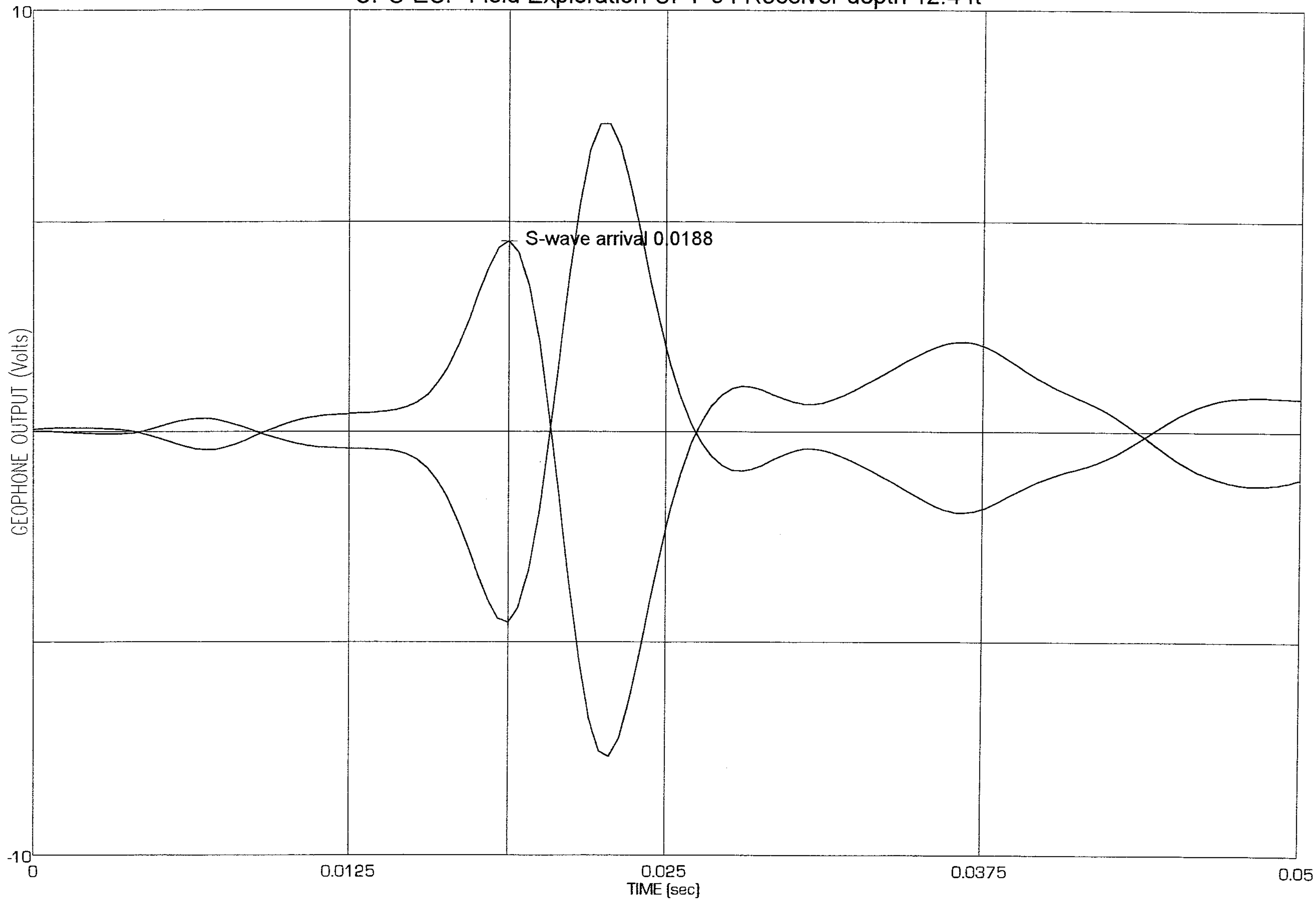
CPS-ESP Field Exploration CPT-04 Receiver depth 9.1 ft



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

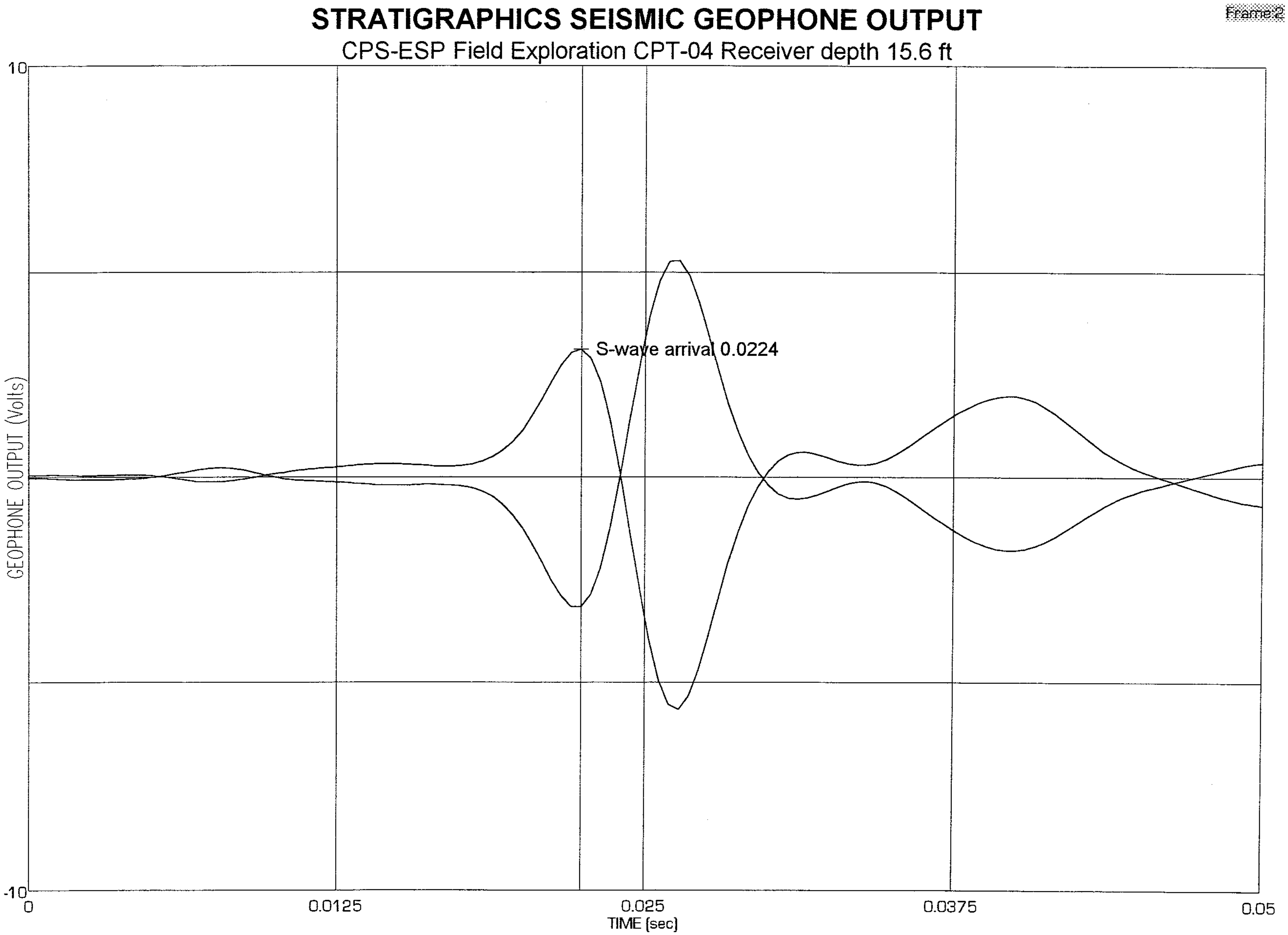
CPS-ESP Field Exploration CPT-04 Receiver depth 12.4 ft

Frame:2



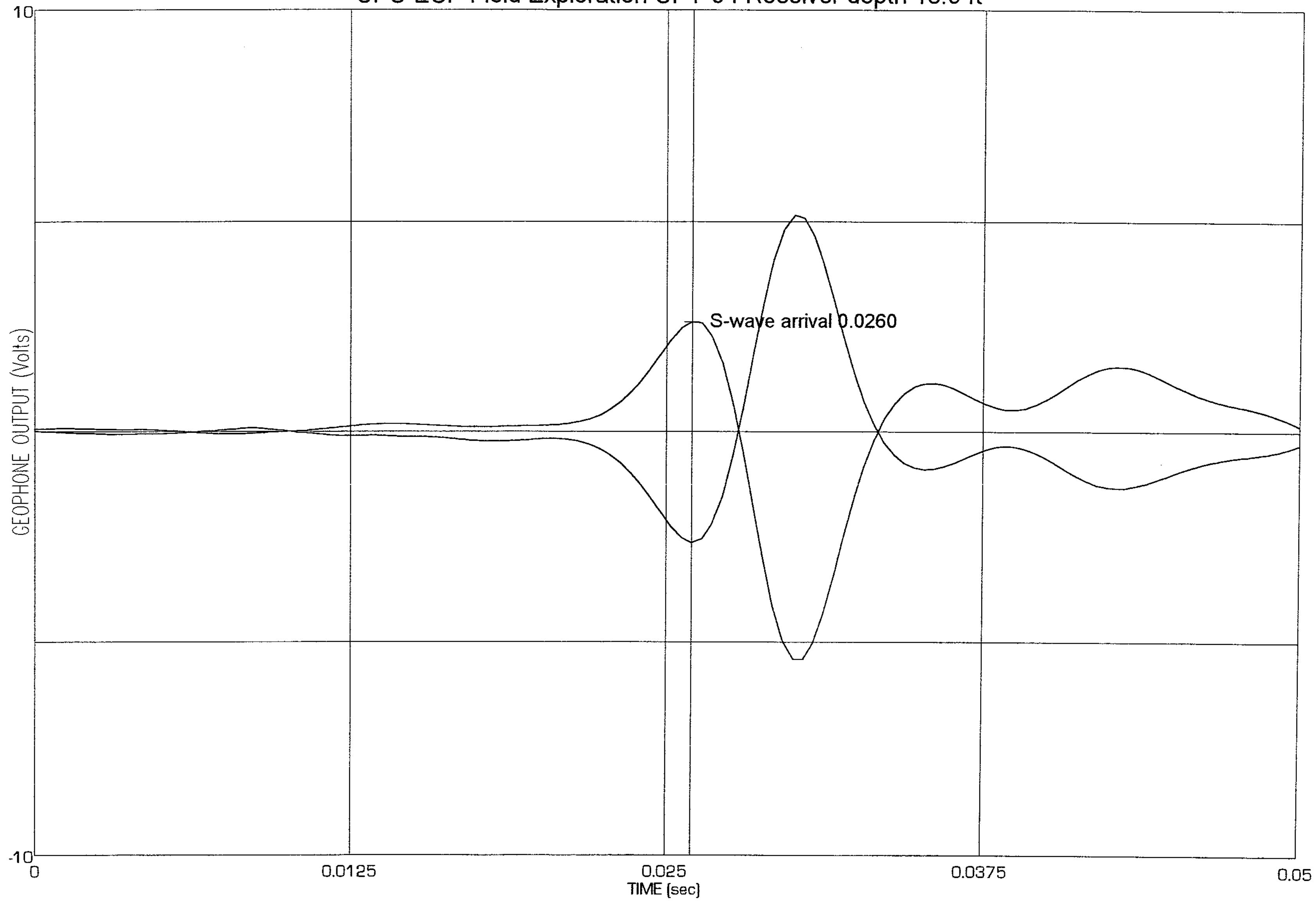
STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-04 Receiver depth 15.6 ft



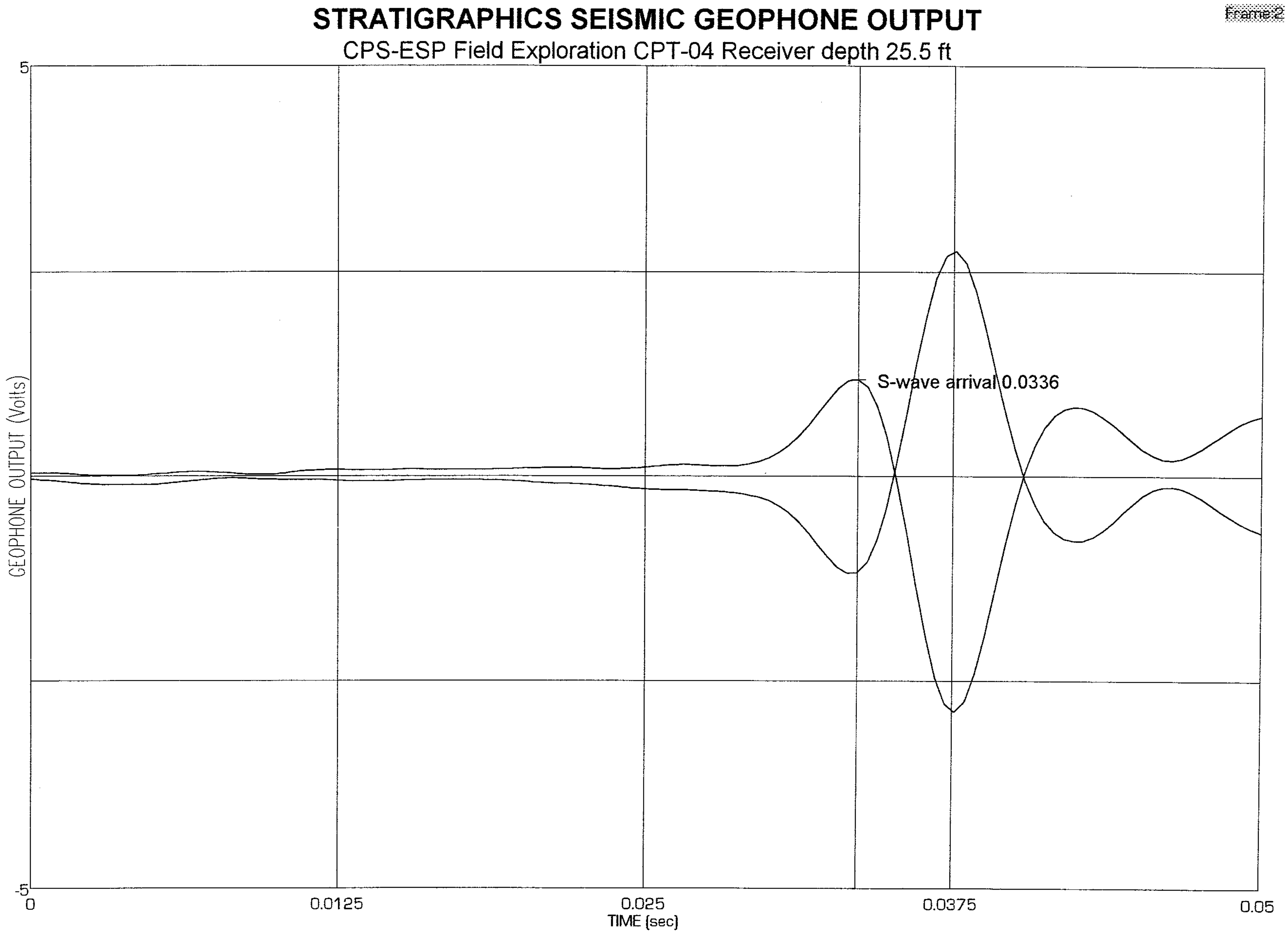
STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-04 Receiver depth 18.9 ft



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

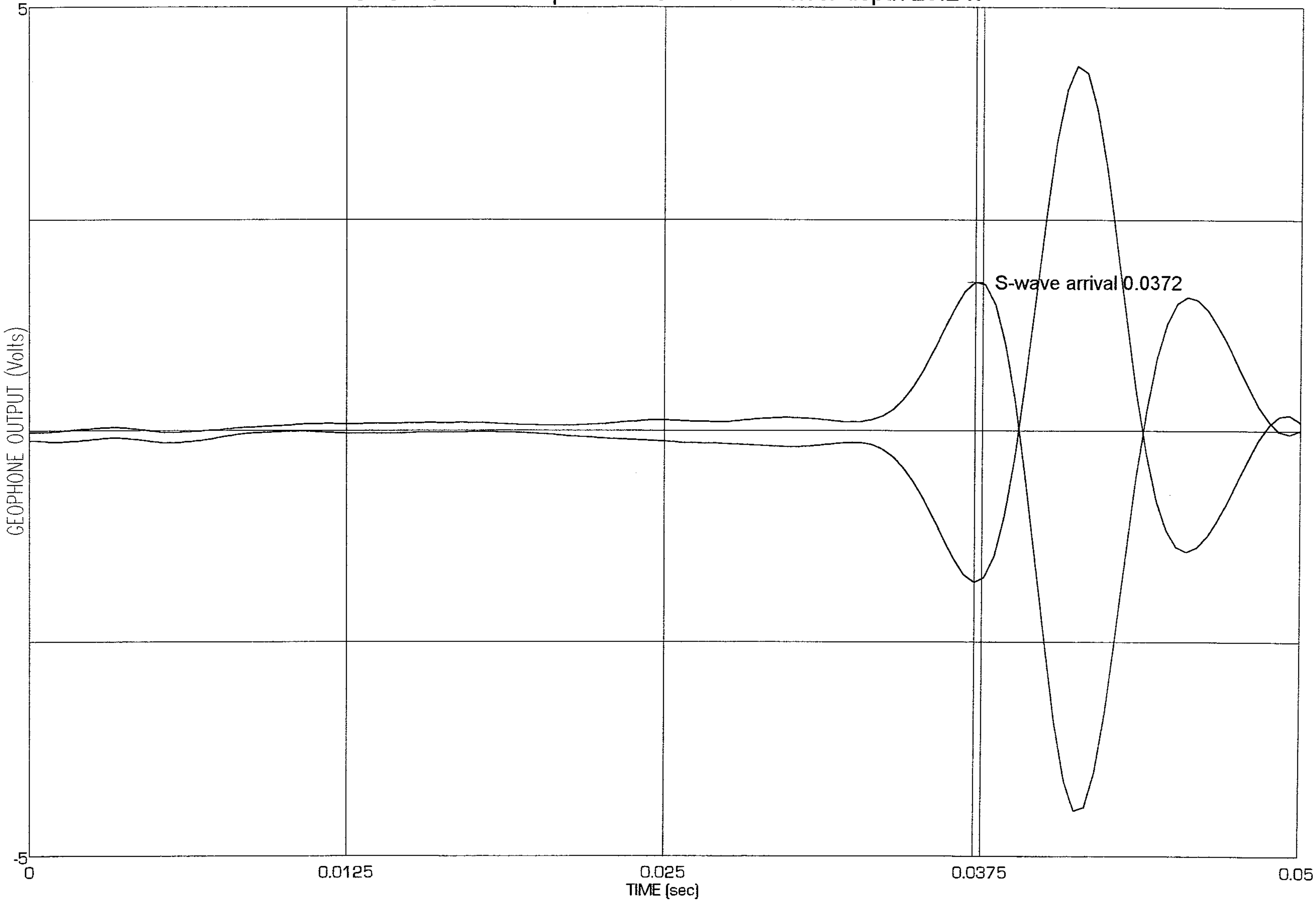
CPS-ESP Field Exploration CPT-04 Receiver depth 25.5 ft



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

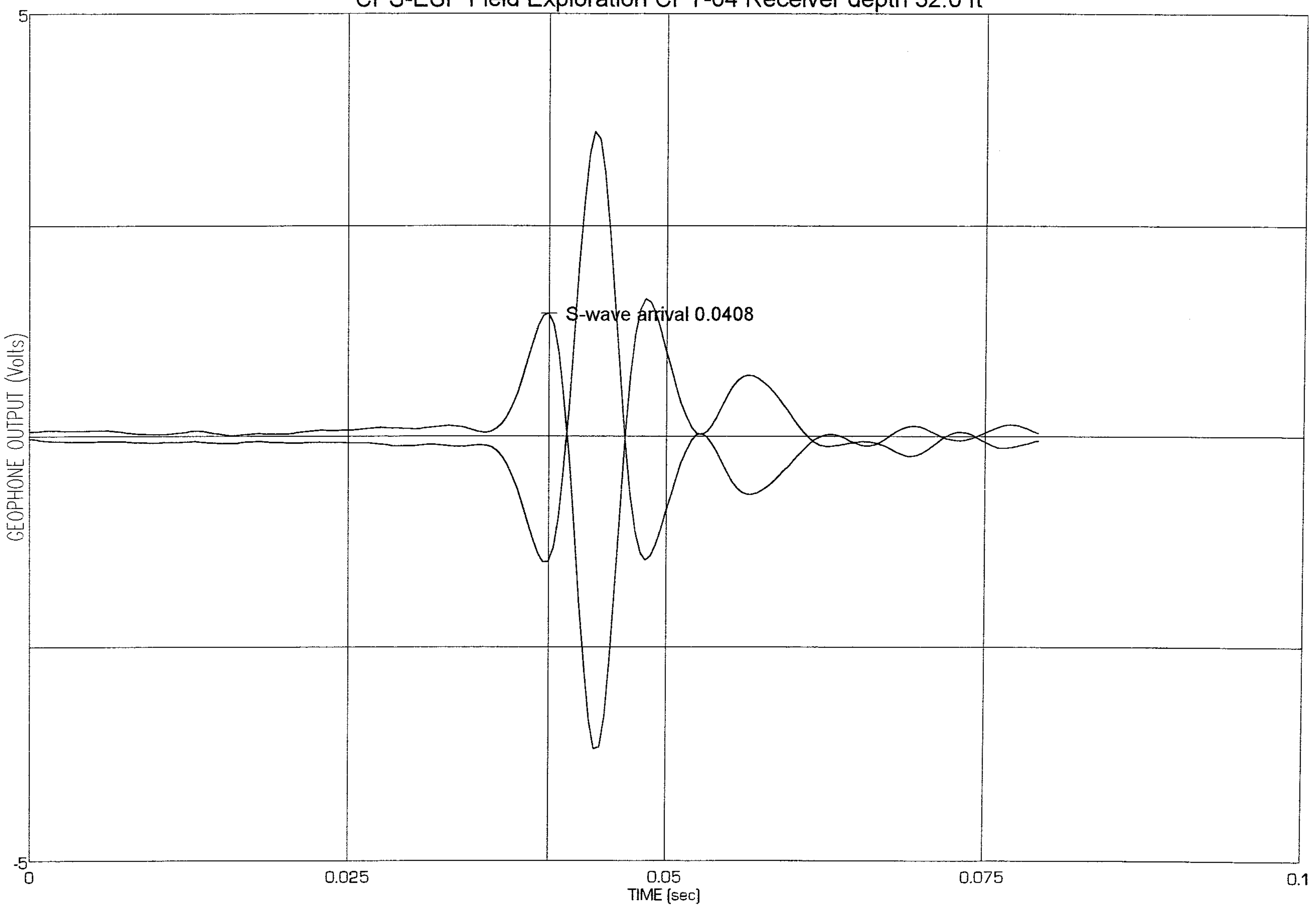
CPS-ESP Field Exploration CPT-04 Receiver depth 29.2 ft

Frame:2



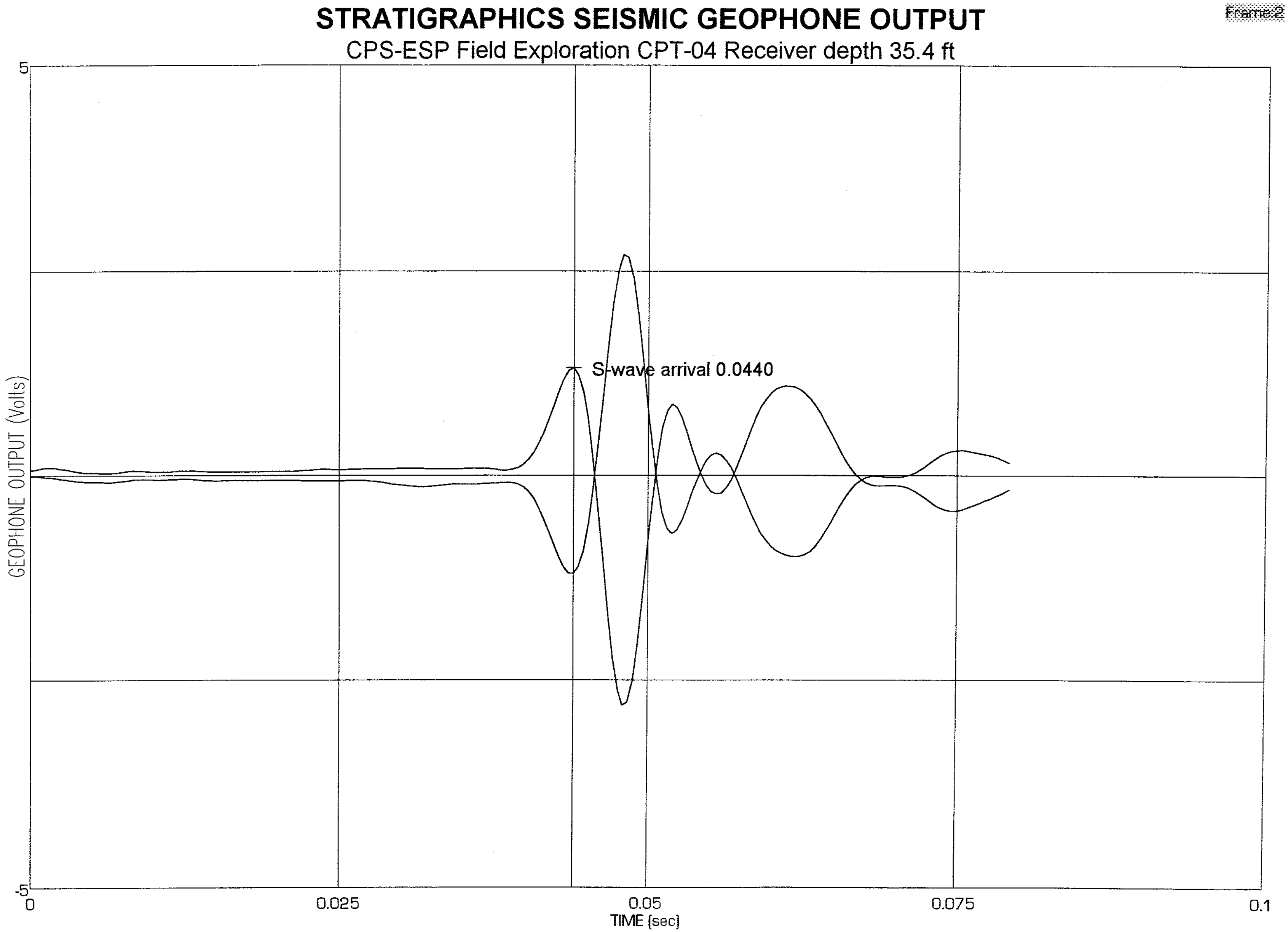
STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-04 Receiver depth 32.0 ft



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

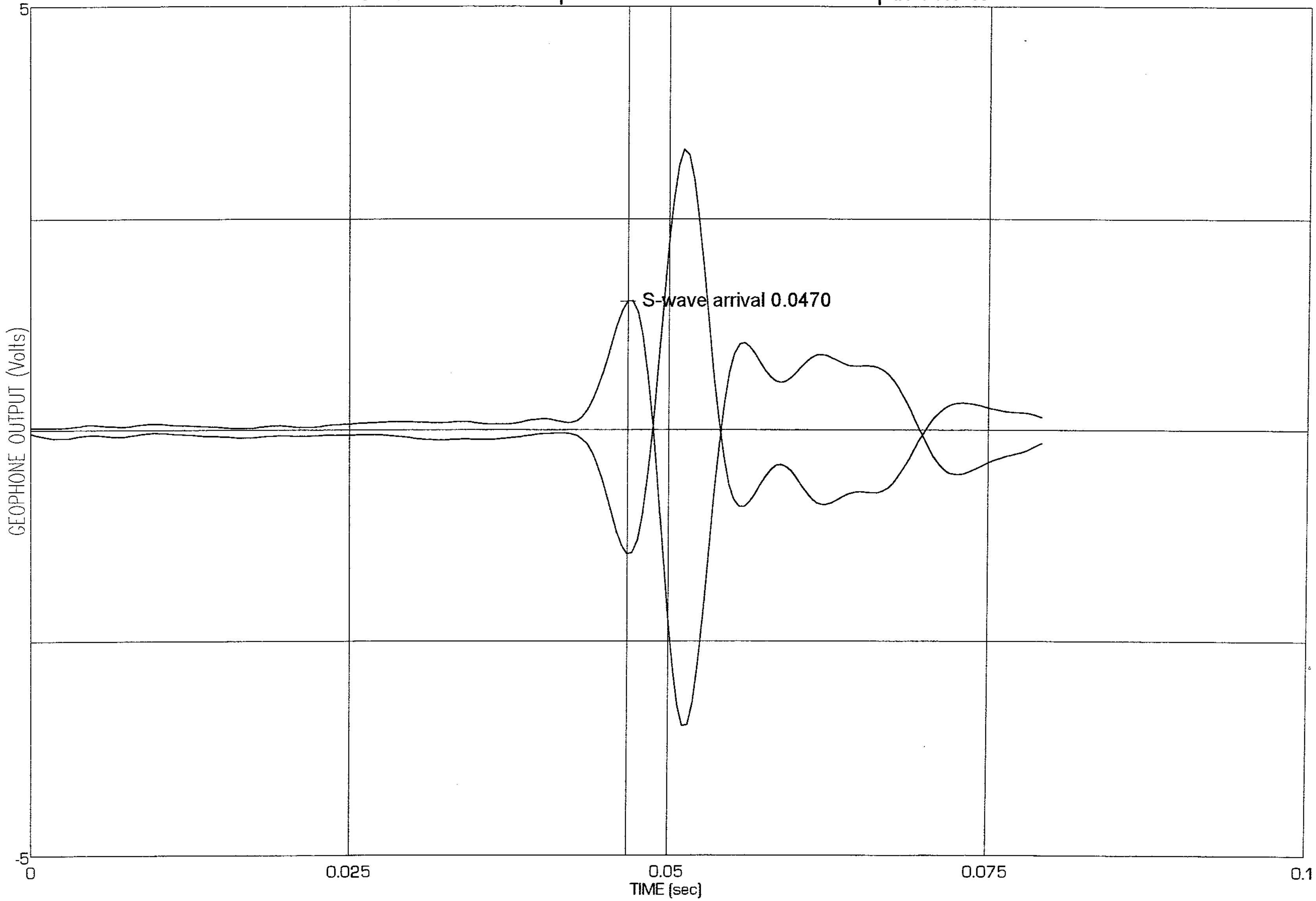
CPS-ESP Field Exploration CPT-04 Receiver depth 35.4 ft

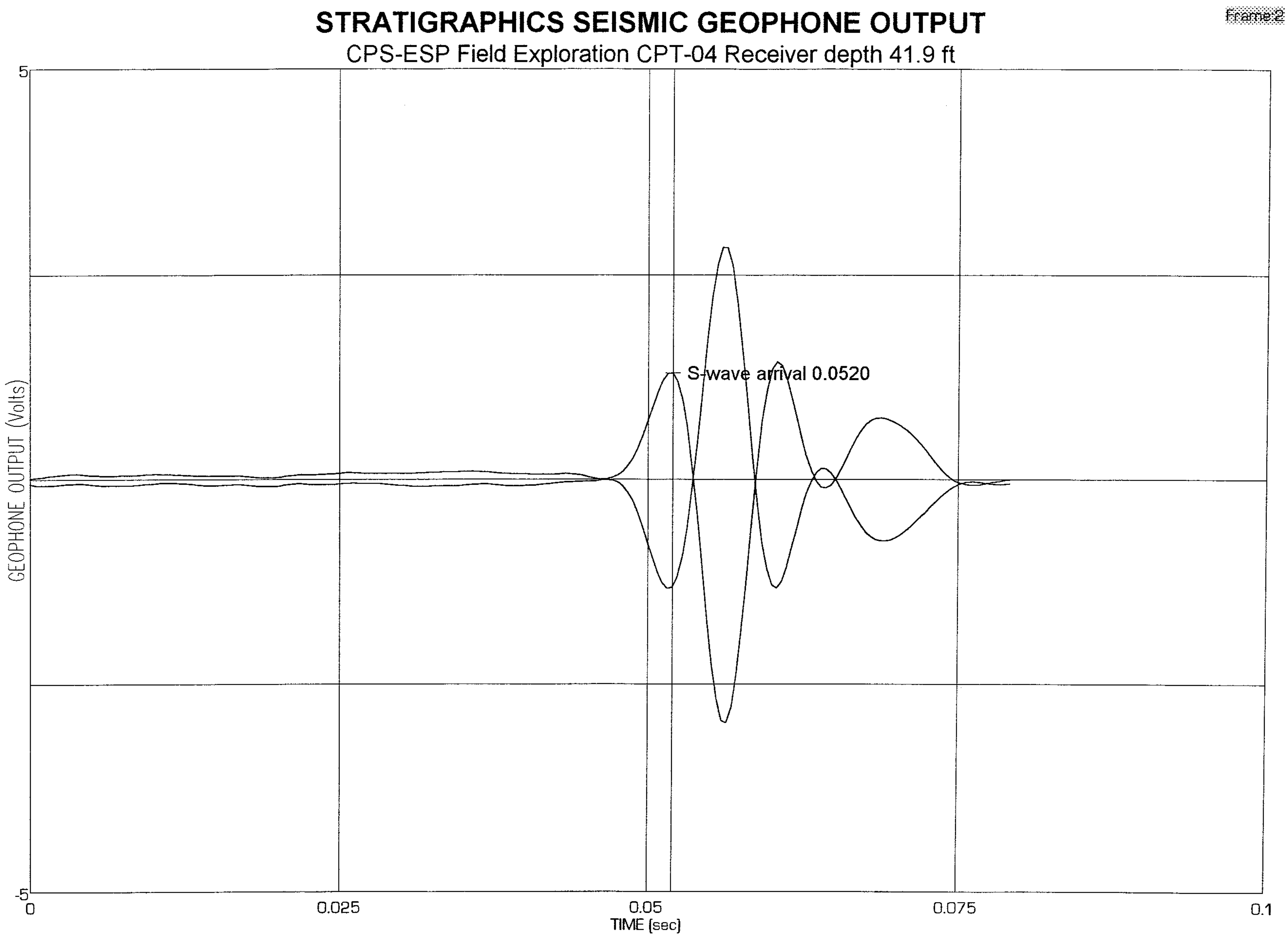


STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-04 Receiver depth 38.7 ft

Frame:2

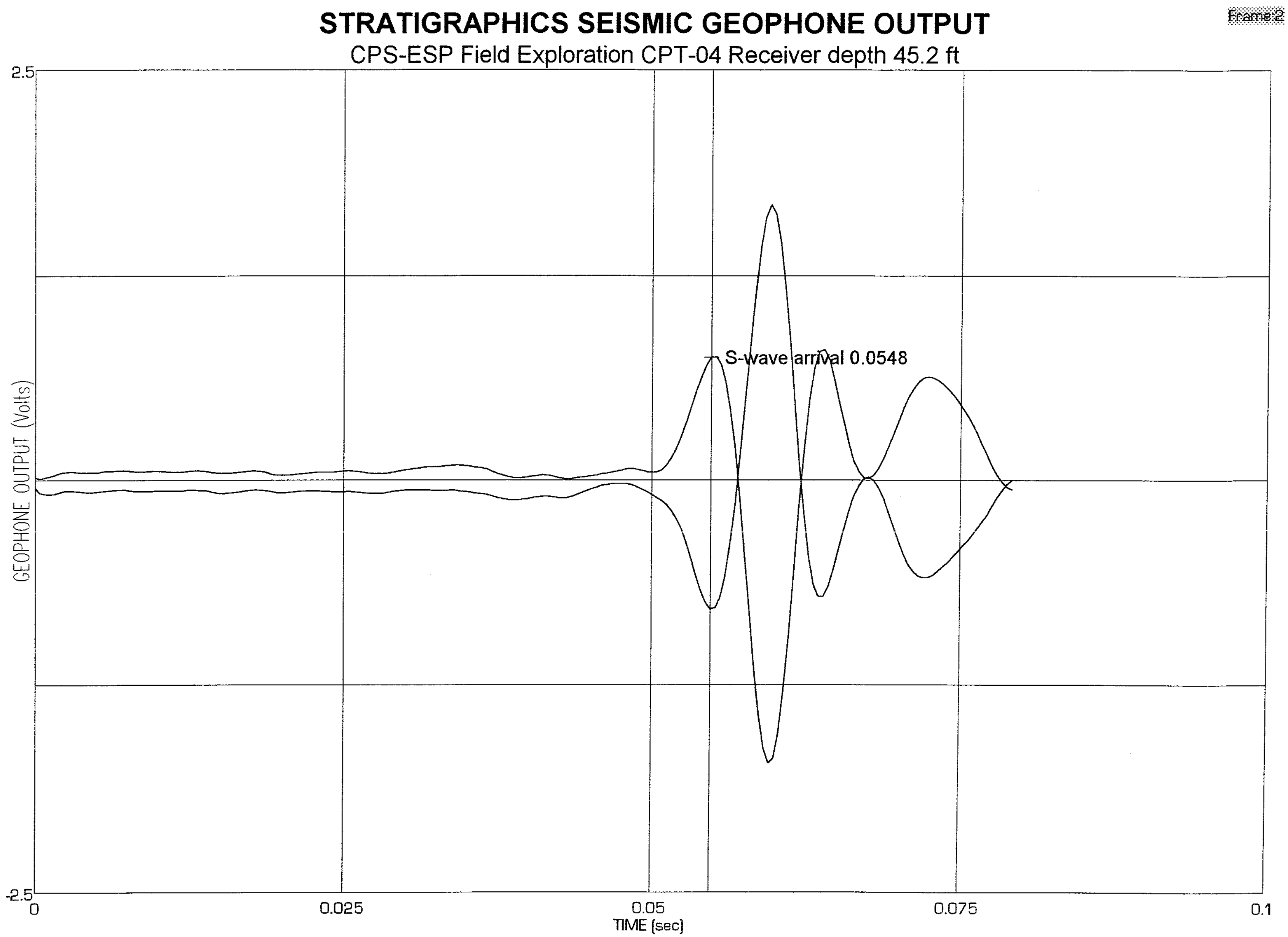




Frame:2
STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT
CPS-ESP Field Exploration CPT-04 Receiver depth 41.9 ft
5
-5
GEOPHONE OUTPUT (Volts)
S-wave arrival 0.0520
0
0.025
0.05
0.075
0.1
TIME (sec)

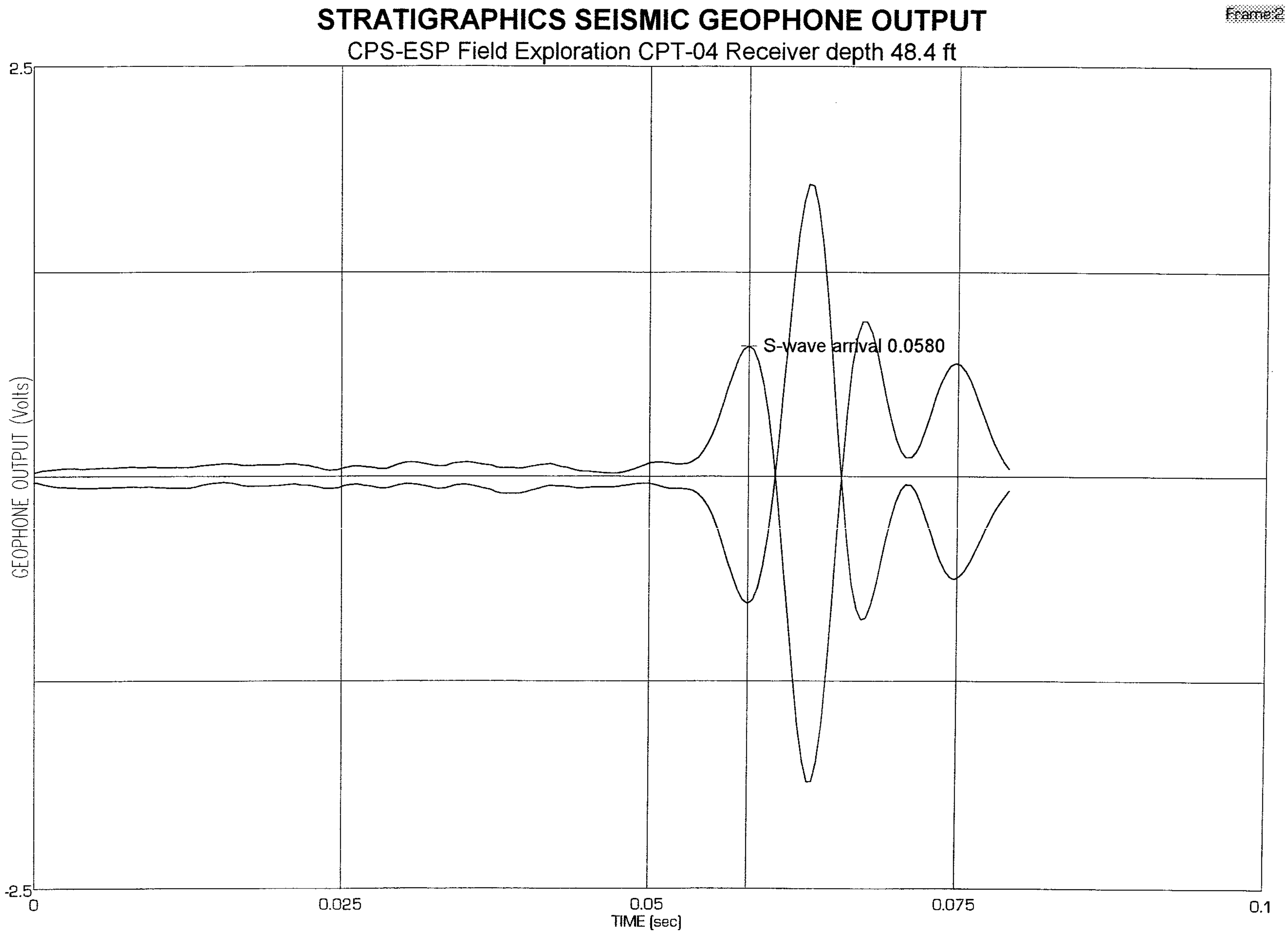
STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-04 Receiver depth 45.2 ft



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

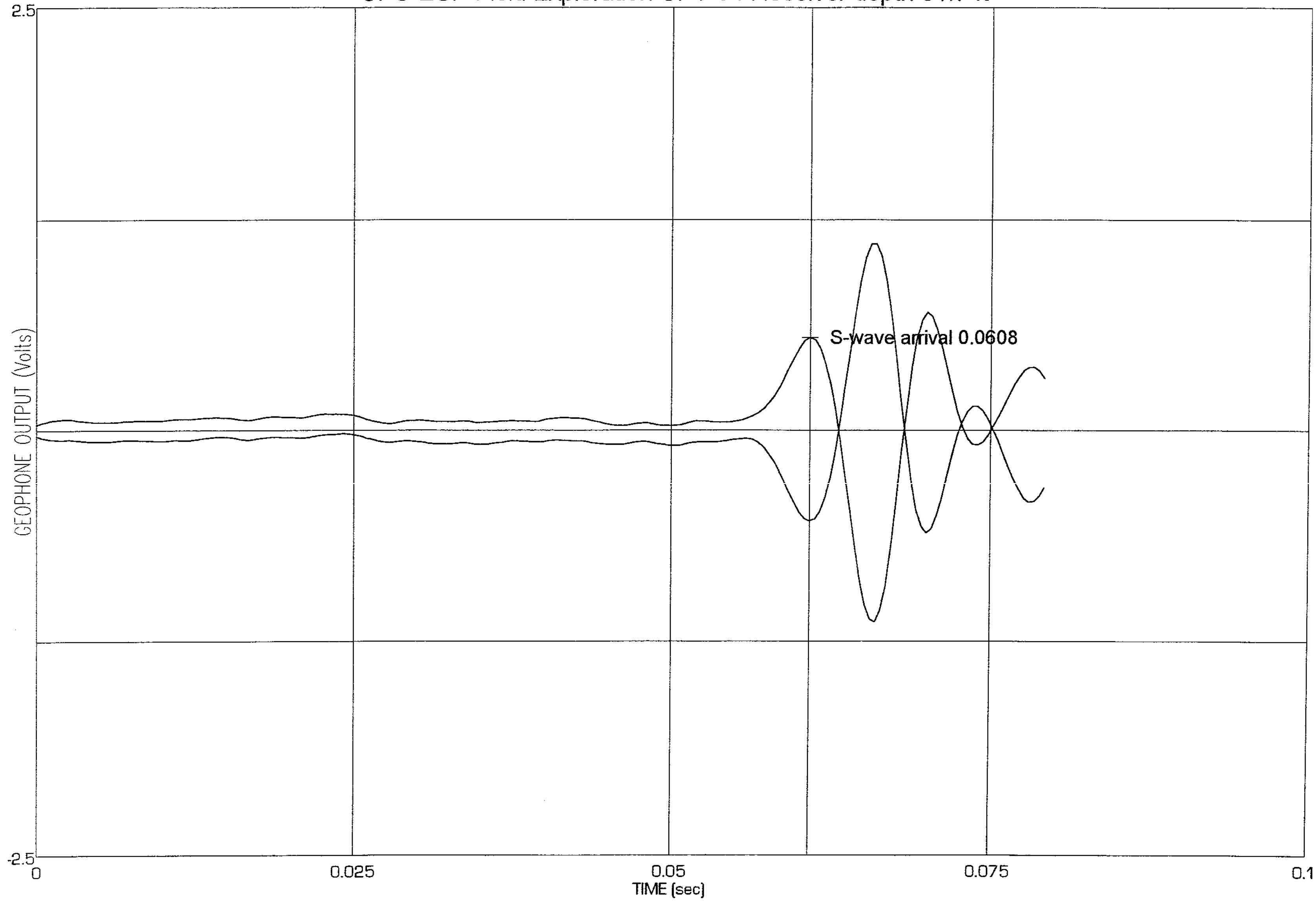
CPS-ESP Field Exploration CPT-04 Receiver depth 48.4 ft



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

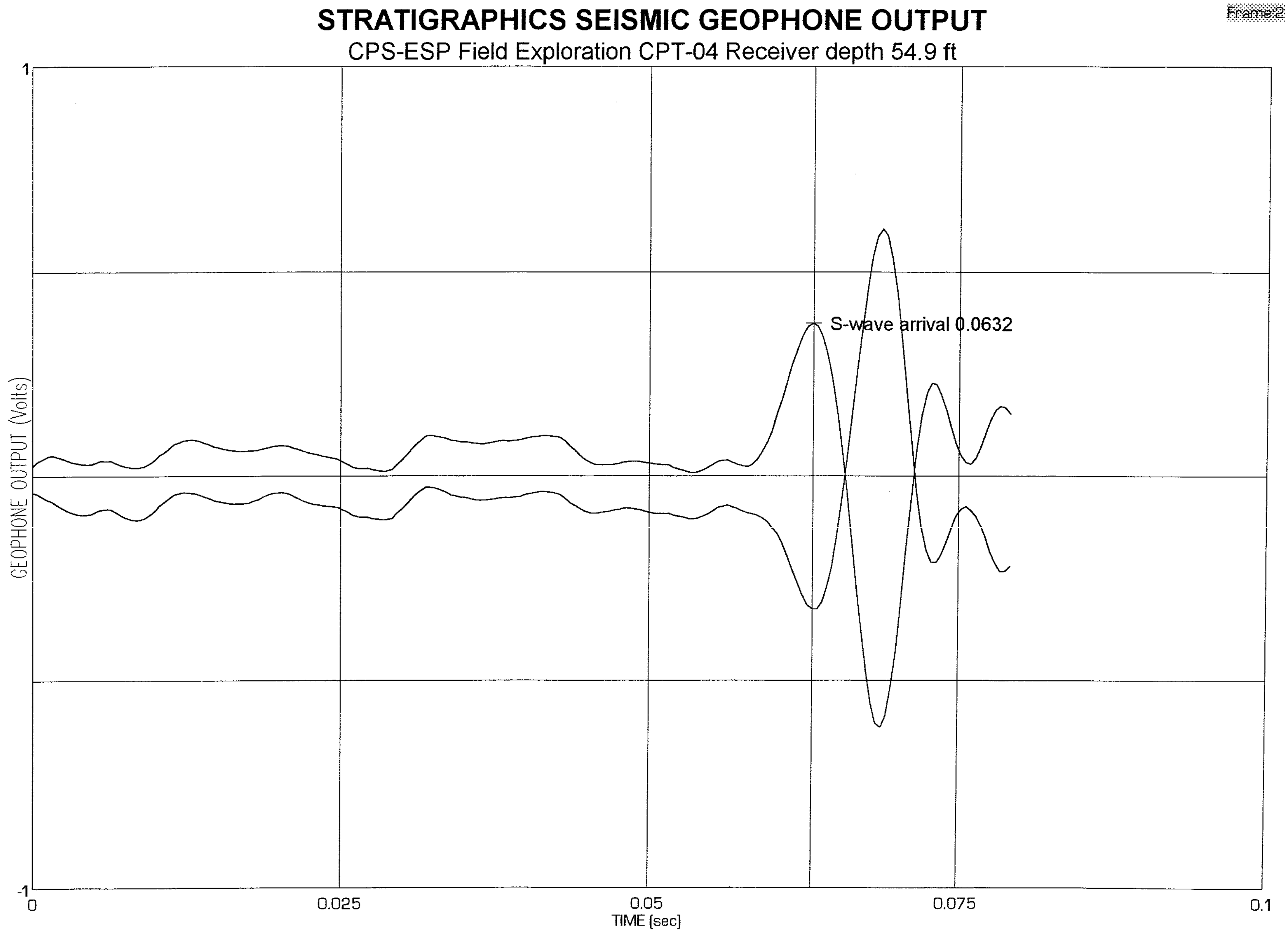
CPS-ESP Field Exploration CPT-04 Receiver depth 51.7 ft

Frame:2



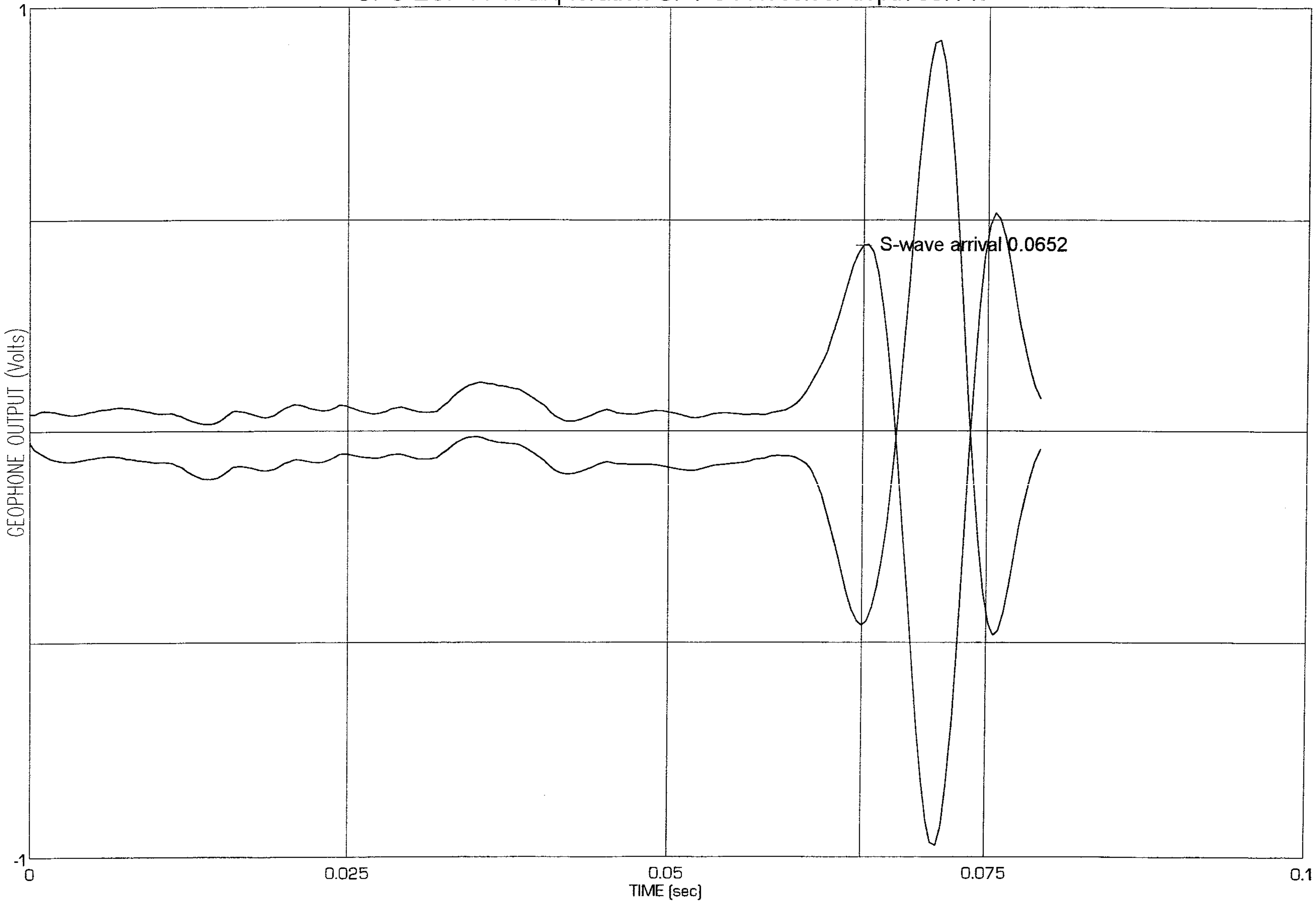
STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-04 Receiver depth 54.9 ft



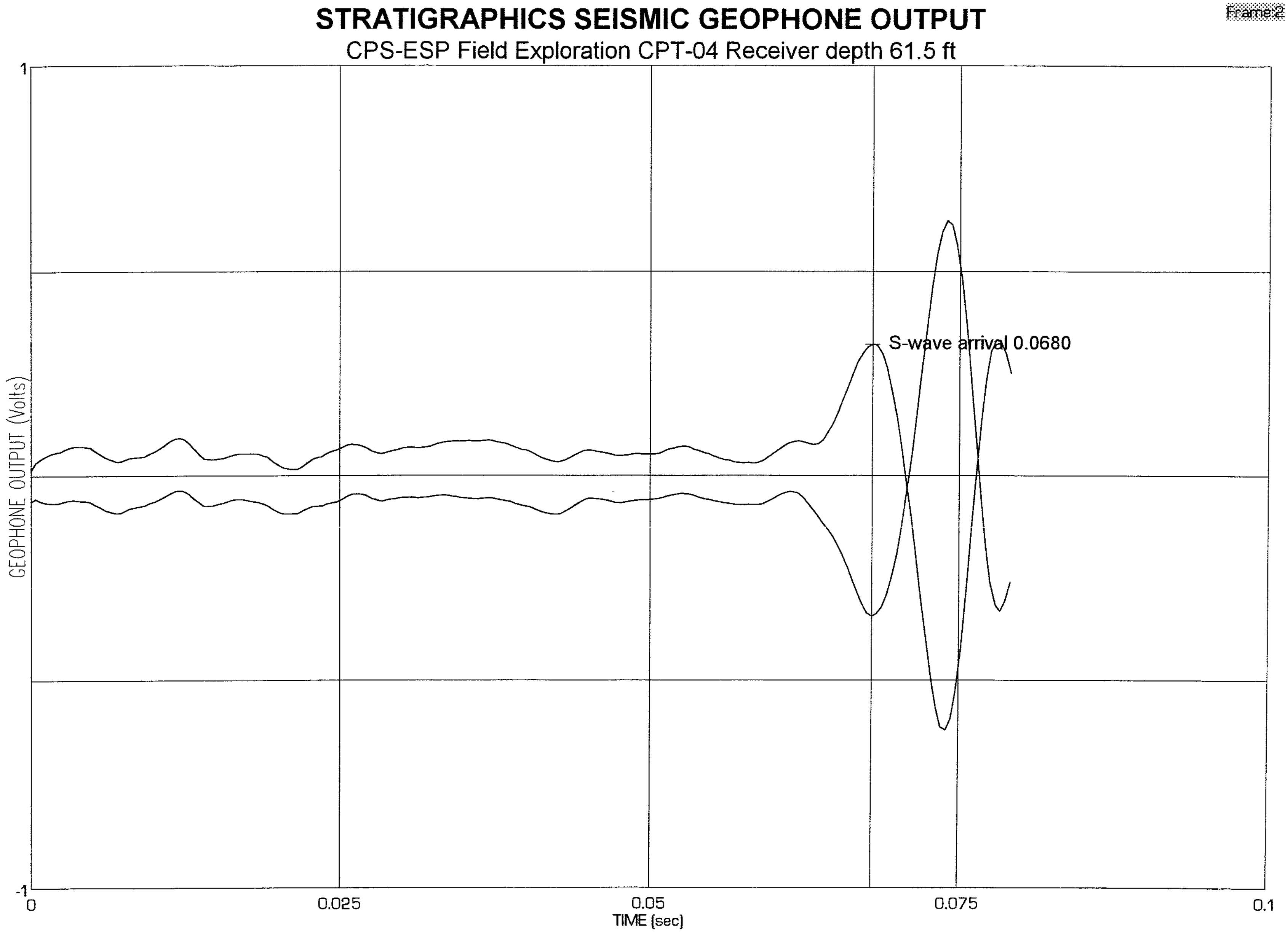
STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-04 Receiver depth 58.1 ft



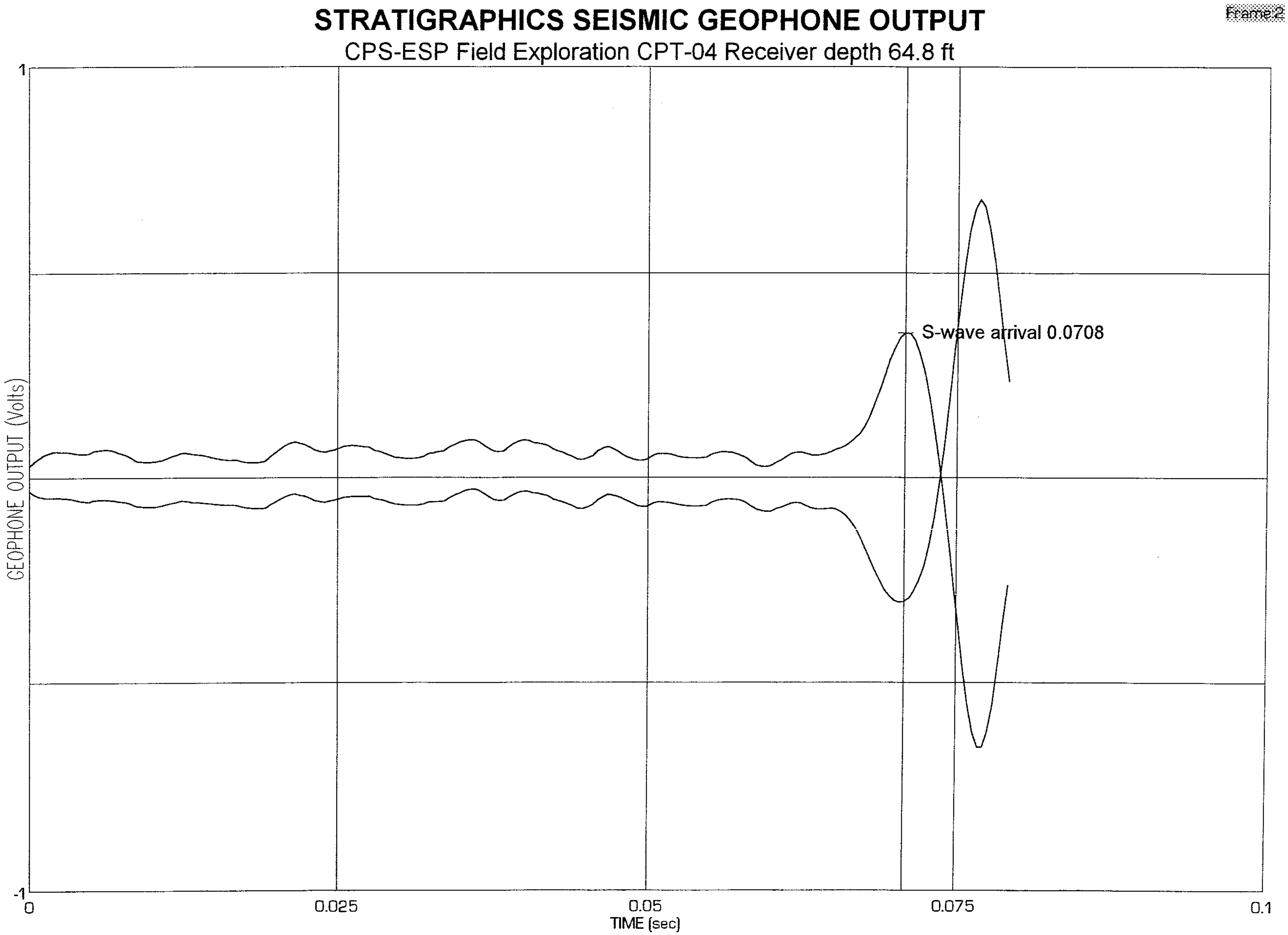
STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-04 Receiver depth 61.5 ft



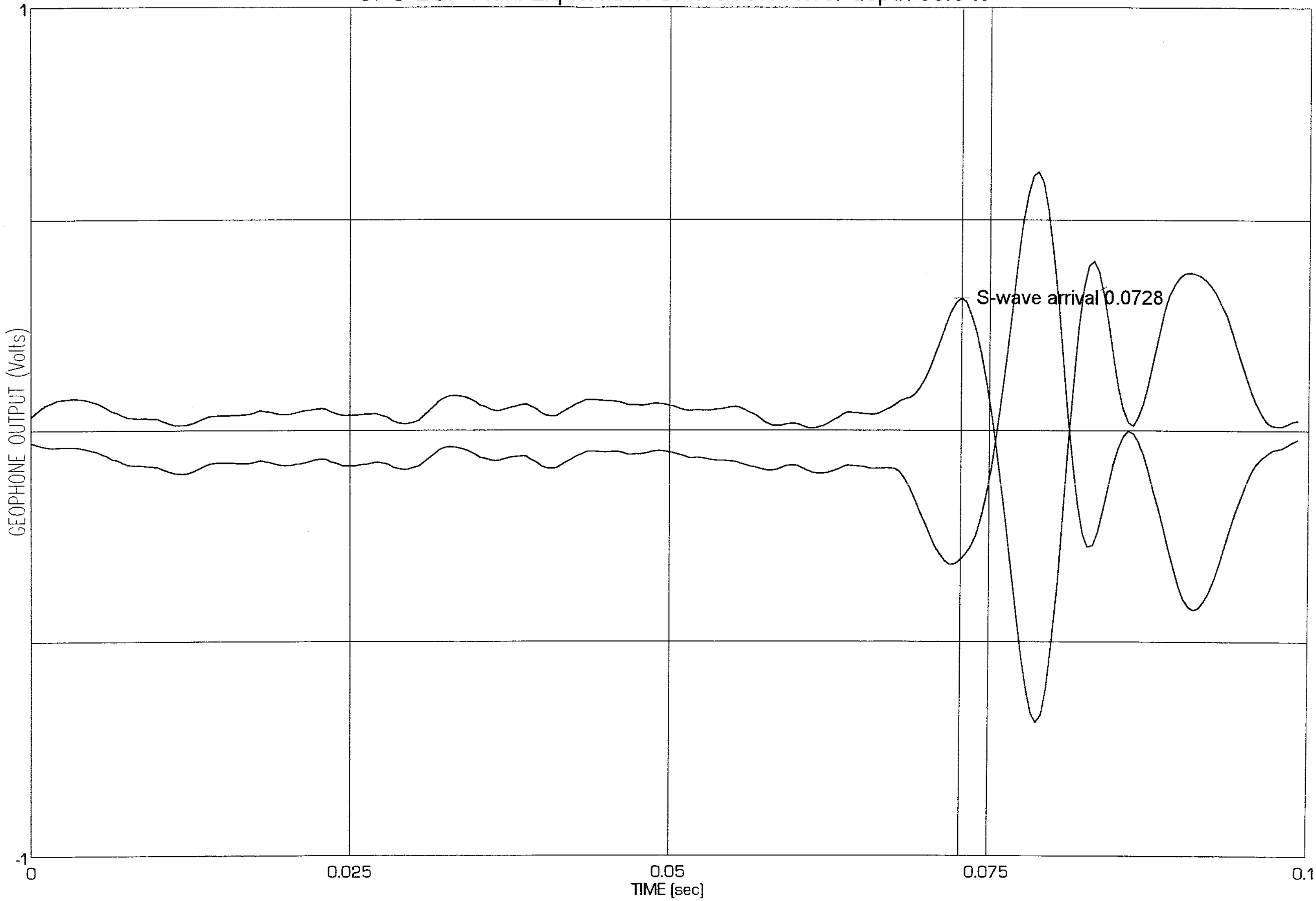
STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-04 Receiver depth 64.8 ft



STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

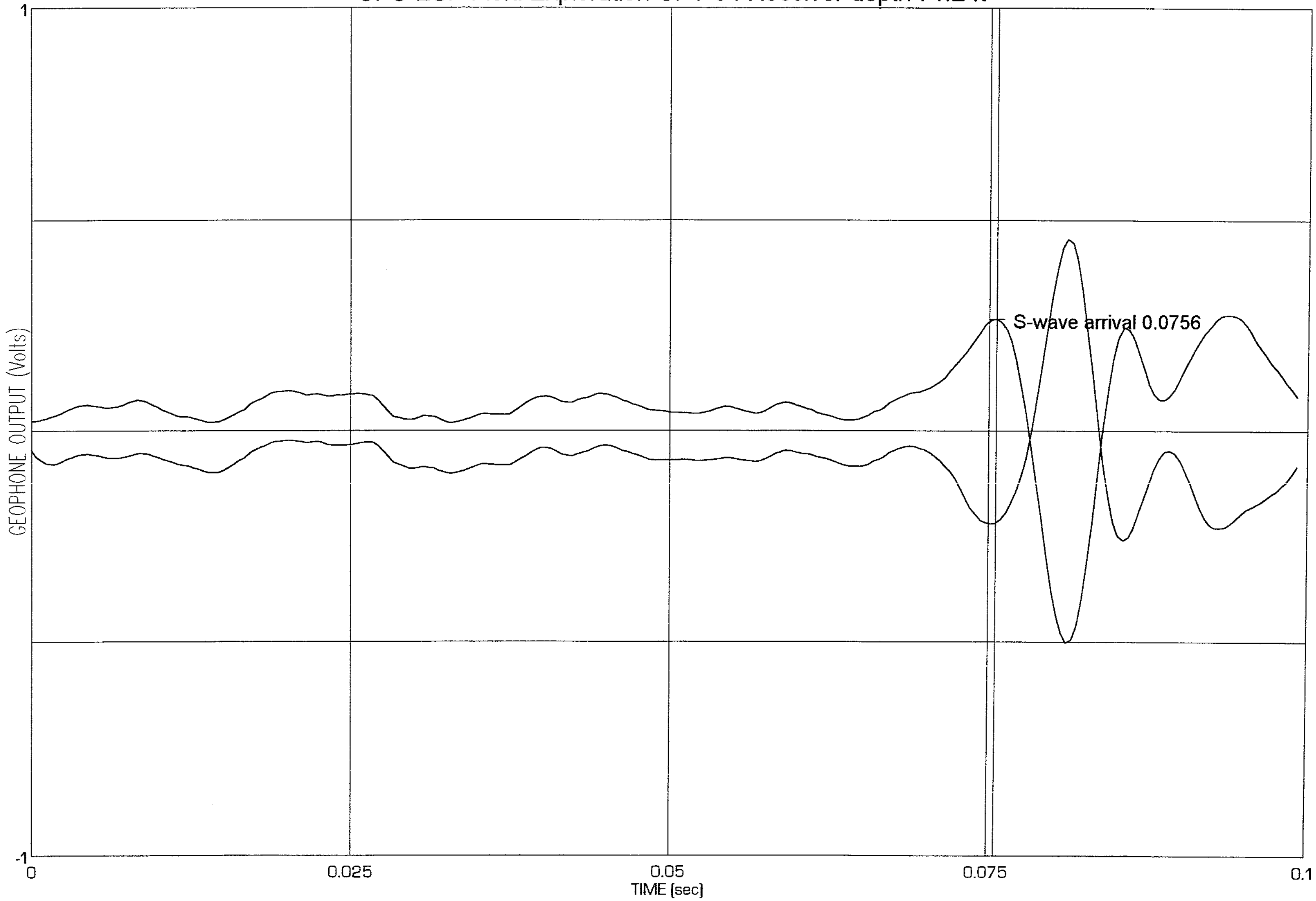
CPS-ESP Field Exploration CPT-04 Receiver depth 68.0 ft

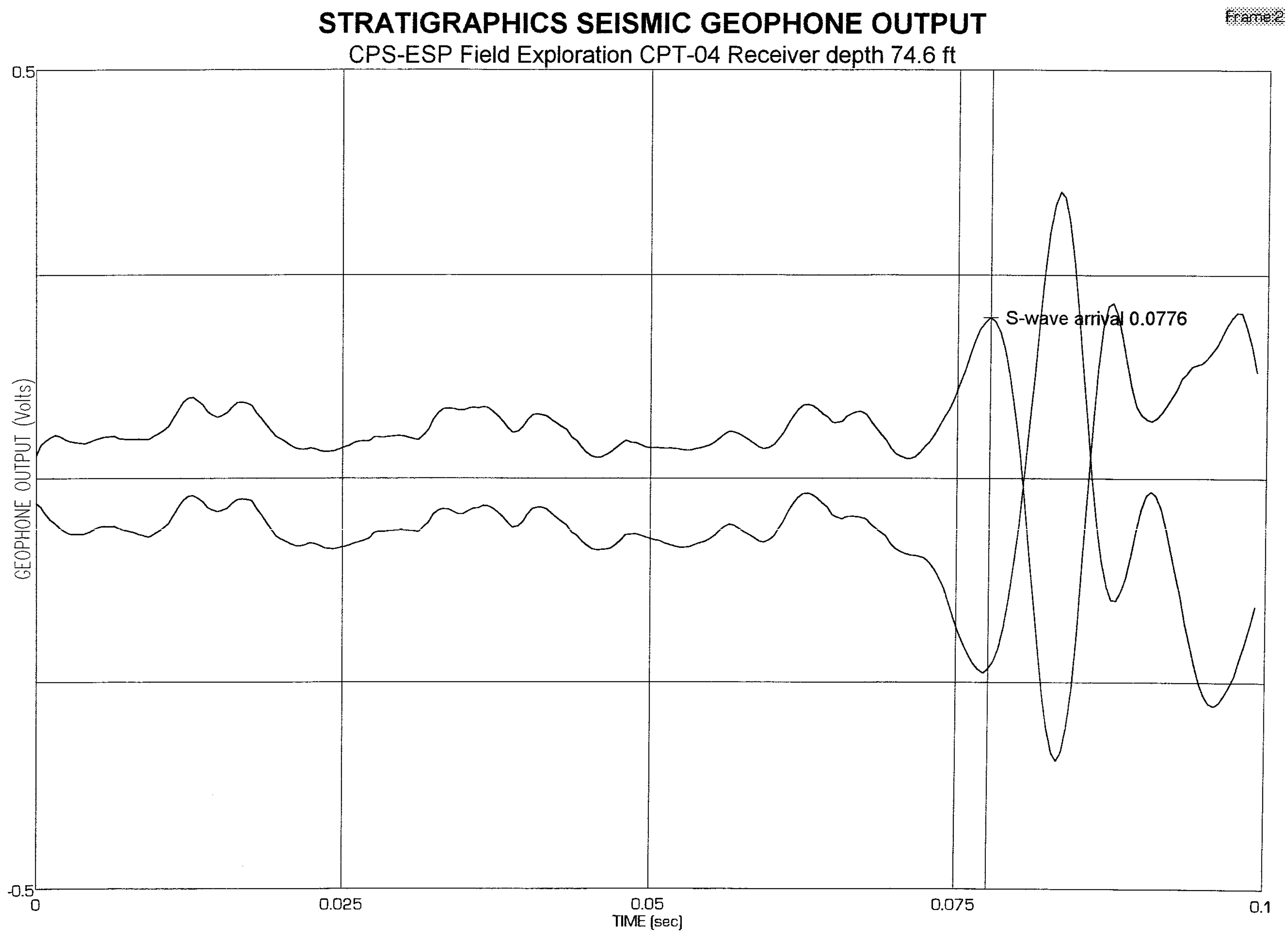


STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-04 Receiver depth 71.2 ft

Frame:2




STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT
CPS-ESP Field Exploration CPT-04 Receiver depth 74.6 ft
Frame:2
GEOPHONE OUTPUT (Volts)
0.5
-0.5
S-wave arrival 0.0776
0
0.025
0.05
0.075
0.1
TIME (sec)

STRATIGRAPHICS SEISMIC GEOPHONE OUTPUT

CPS-ESP Field Exploration CPT-04 Receiver depth 75.8 ft

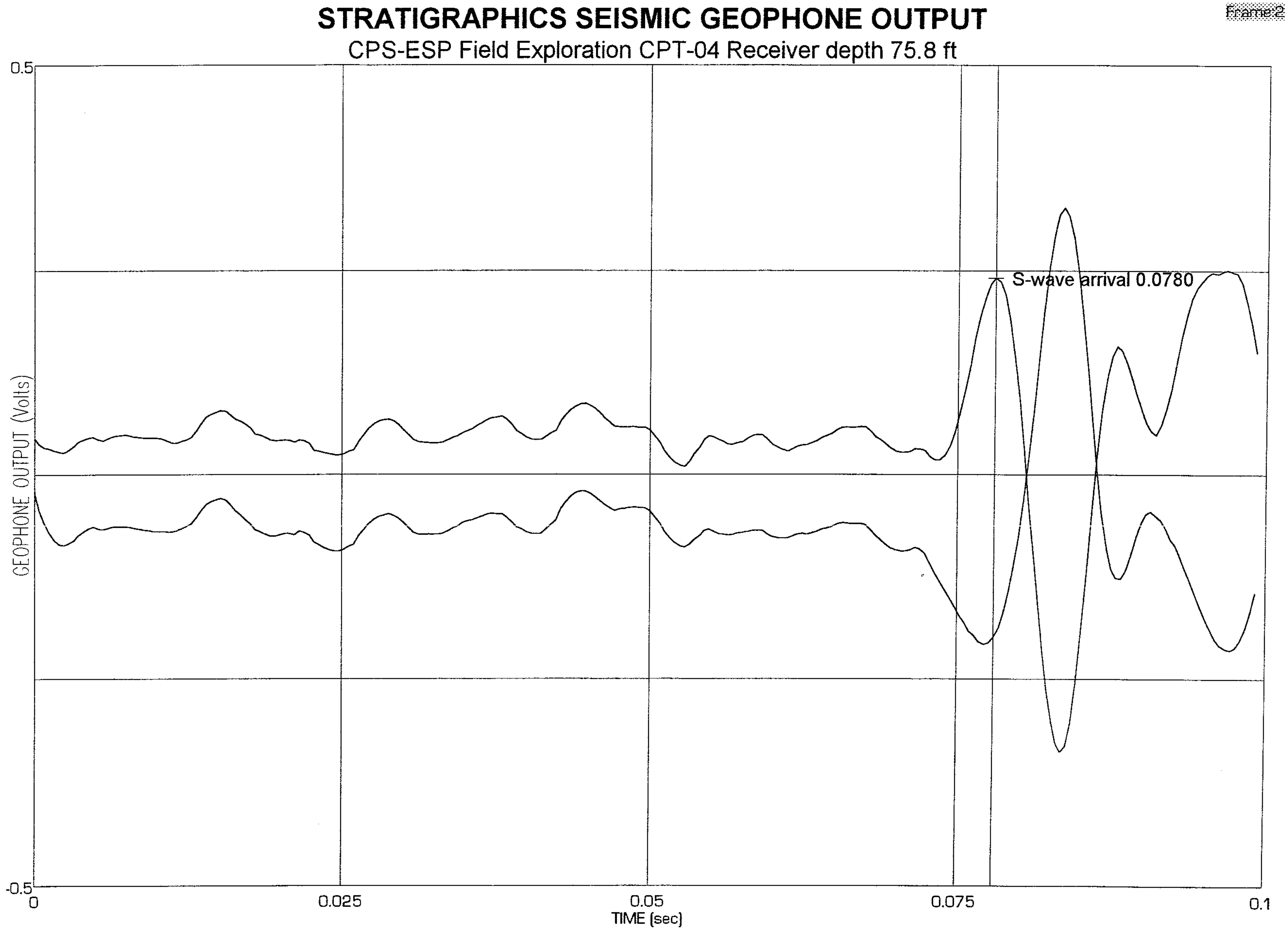


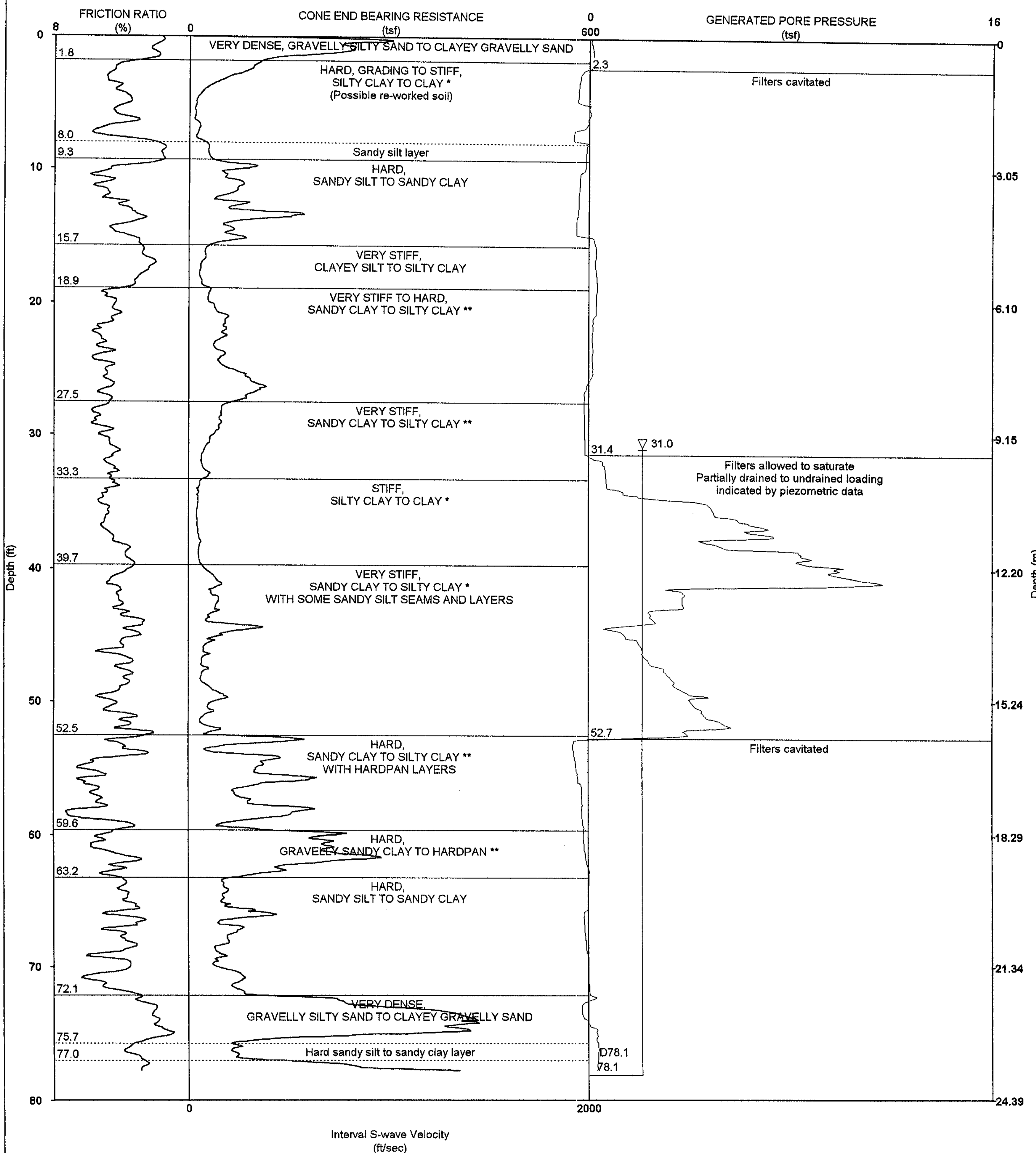
TABLE 3
SUMMARY OF CPTU-EC DISSIPATION TEST DATA
CPS-EPS FIELD EXPLORATION
CLINTON, ILLINOIS

SOUNDING NUMBER	DEPTH (ft)	SOIL TYPE AT DISSIPATION DEPTH	t50 (sec)	ESTIMATED SOIL HORIZONTAL HYDRAULIC CONDUCTIVITY kh (cm/sec)	ESTIMATED HORIZONTAL COEFFICIENT OF CONSOLIDATION IN OVERCONSOLIDATED RANGE* Ch(oc) (cm**2/sec)
CPT-02	42.8	Clayey silt	37.5	2E-06	7E-01
	46.0	Silty clay	300	2E-07	8E-02
CPT-04	49.3	Clayey silt	120	5E-07	2E-01
	50.5	Silty sand	10	1E-05	3E+00

NOTE: All dissipation tests must be performed in lower hydraulic conductivity (less than about 1E-2 cm/s) soil layers and strata, as CPTU-EC generated soil pore water pressures in more conductive soils dissipate faster than the response time of the sensors and data acqusition system. As such, this summary of test results is necessarily biased towards lower conductivity layers at the Site, and must not be considered as representative of the entire soil profile. Inspection of the continuous CPTU-EC sounding logs will indicate the relative frequency of lower and higher hydraulic conductivity soil layers at the Site.

*1. Estimates of the vertical coefficient of consolidation, in the normally consolidated range, can be estimated using:
Cv(nc)= RR(probe)/CR *(kv/kh)*Ch(oc) from Baligh and Levadoux, 1980 (see Appendix B of this report)

CPTU-S LOG WITH LITHOLOGIC EVALUATION

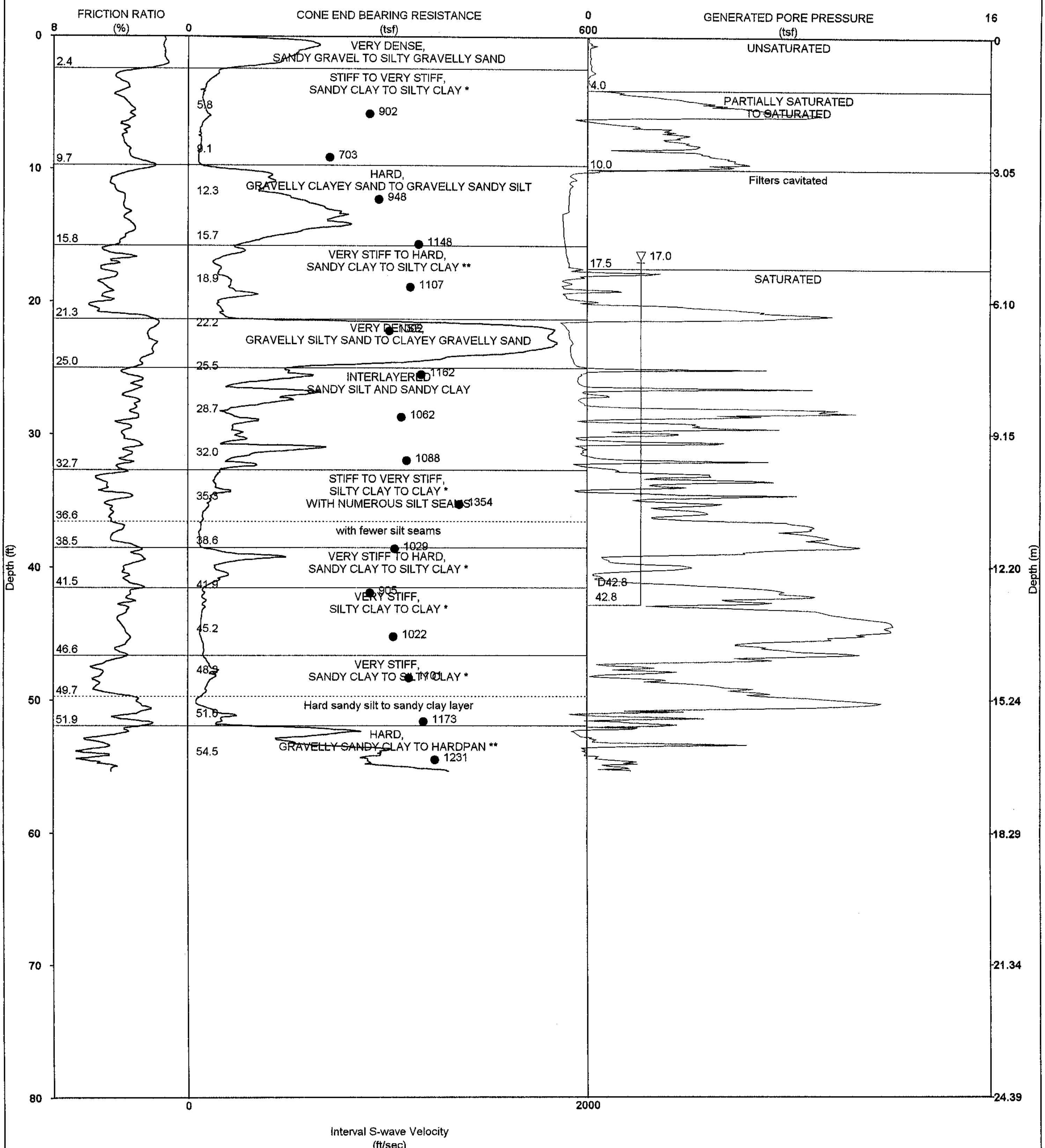


PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110

STRATIGRAPHICS

R2DATE: 7-24-2002 TIME:14:53:33.48
SOUNDING NUMBER:CPT-01

CPTU-S LOG WITH LITHOLOGIC EVALUATION

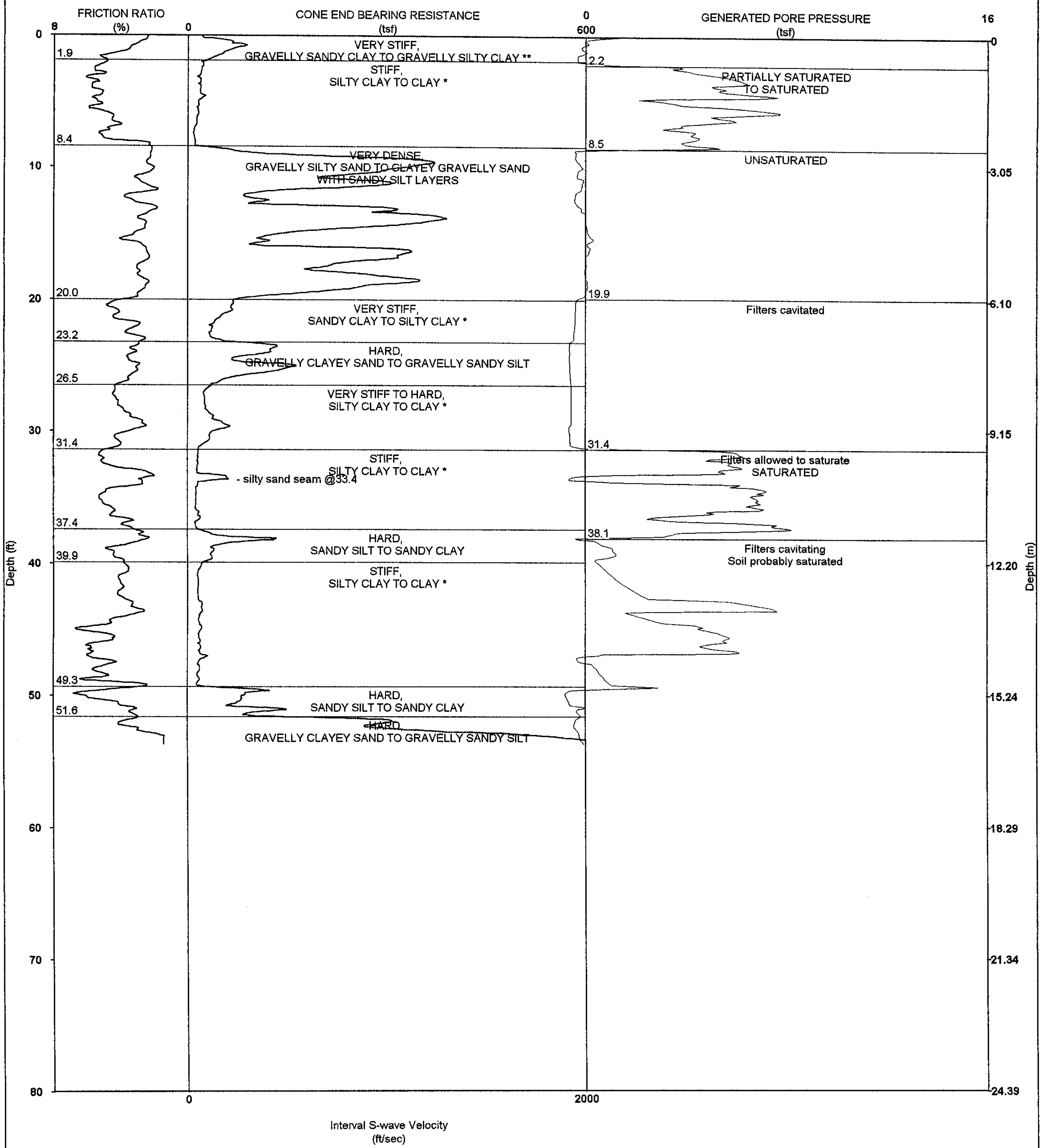


PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110

STRATIGRAPHICS

R2DATE: 7-24-2002 TIME:12:30:47.85
SOUNDING NUMBER:CPT-02

CPTU-S LOG WITH LITHOLOGIC EVALUATION

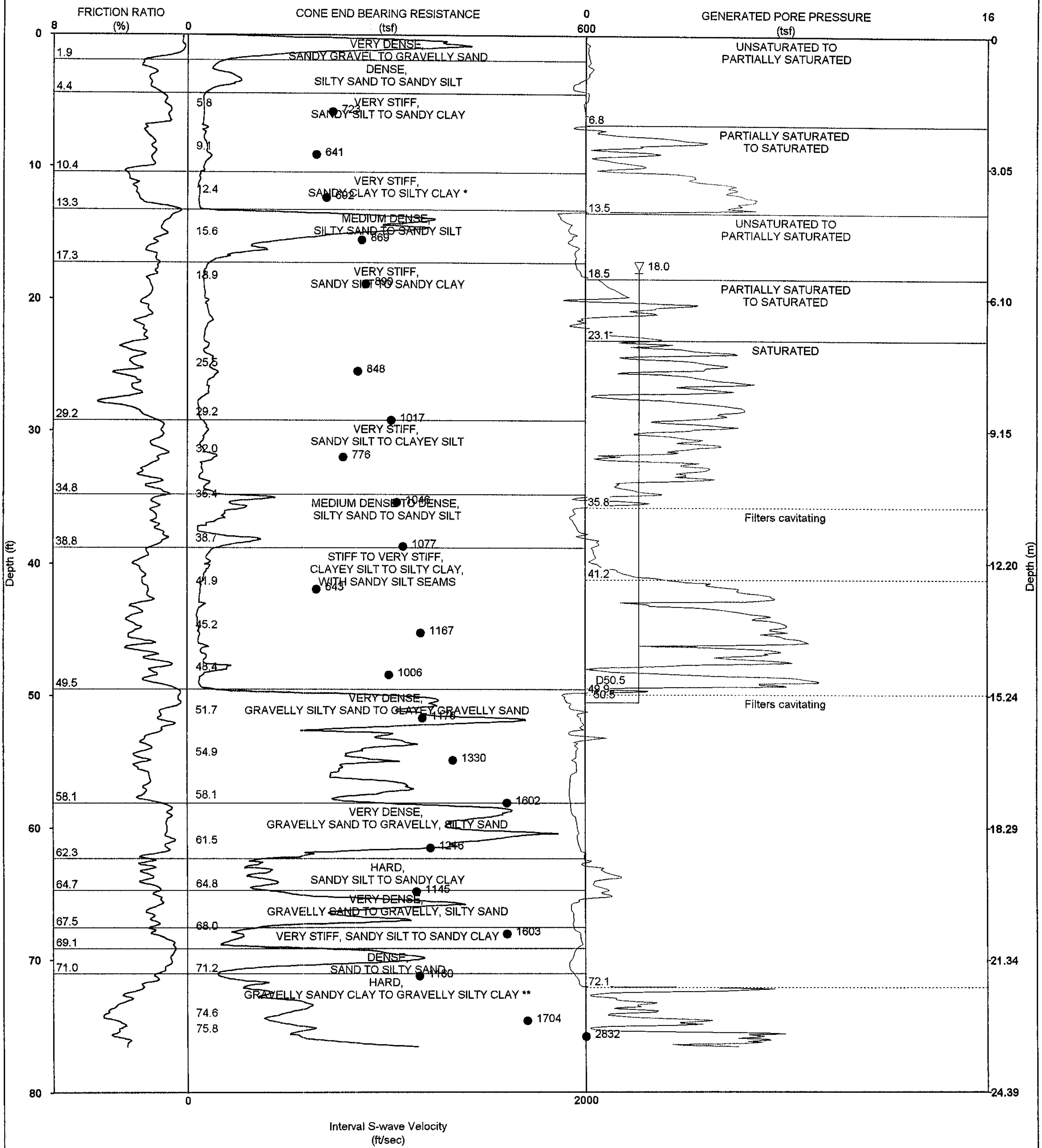


PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110

STRATIGRAPHICS

R2DATE: 7-24-2002 TIME:08:32:19.49
SOUNDING NUMBER:CPT-03

CPTU-S LOG WITH LITHOLOGIC EVALUATION

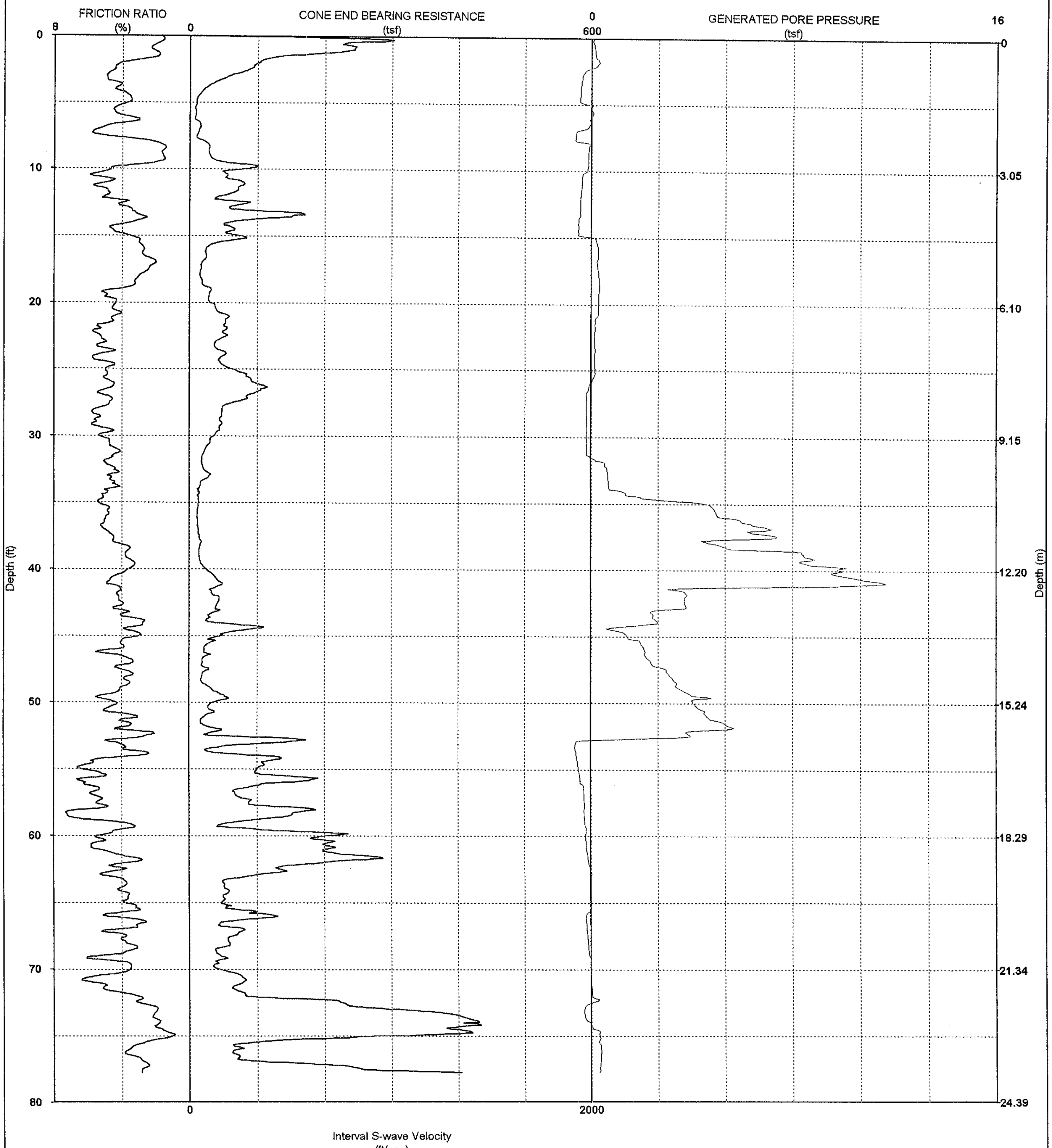


PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110

STRATIGRAPHICS

R2DATE: 7-23-2002 TIME:17:32:39.15
SOUNDING NUMBER:CPT-04

CPTU-S LOG



PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110

STRATIGRAPHICS

R2DATE: 7-24-2002 TIME:14:53:33.48
SOUNDING NUMBER:CPT-01

STRATIGRAPHICS Evaluated Properties Using Global Database

PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110
R2DATE: 7-24-2002 TIME:14:53:33.48
SOUNDING NUMBER:CPT-01

Depth (ft)	Cone (tsf)	Norm Cone (tsf)	Friction (tsf)	Averaged Friction Ratio (%)	Generated Pore Water Pressure (tsf)	Soil Conductivity (uS/cm)	Evaluated Soil Type	Drained Friction Angle (deg)	Relative Density (%)	Nc	Undrained Shear Strength (ksf)	Undrained Large Strain Shear Strength (ksf)	SPT (N)	NORM SPT (N1')
1.0	245.1	394.9	4.98	2.2	0.2	-5	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	+100				+ 62	+ 100
1.5	132.8	202.2	3.57	1.9	0.2	-5	Very dense, Silty sand to sandy silt	40-42	80-100				39 - 65	60 - 99
2.0	101.1	147.6	4.55	4.0	0.2	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	6.12	9.10	+ 68	+ 100
2.5	87.3	123.2	4.12	4.4	-0.3	-5	Hard, Gravelly sandy clay to gravelly silty clay **			33	5.28	8.23	+ 71	+ 100
3.0	57.7	79.2	3.59	4.9	-0.4	-5	Very stiff, Sandy clay to silty clay **			30	3.83	7.18	44 - 72	60 - 99
3.5	36.1	48.3	1.92	4.3	-0.4	-5	Very stiff, Sandy clay to silty clay *			25	2.87	3.84	15 - 22	20 - 30
4.0	20.5	26.9	1.24	4.4	-0.5	-5	Very stiff, Silty clay to clay *			20	2.03	2.48	11 - 15	15 - 20
4.5	12.3	15.7	0.58	3.6	-0.5	-5	Stiff, Silty clay to clay *			15	1.60	1.16	03 - 05	04 - 06
5.0	9.9	12.5	0.37	3.6	-0.1	-5	Stiff, Silty clay to clay *			15	1.28	0.74	03 - 05	04 - 06
5.5	7.7	9.6	0.38	4.5	0.0	-5	Firm, Silty clay to clay *			15	0.99	0.76	03 - 05	04 - 06
6.0	7.8	9.6	0.36	3.8	-0.0	-5	Firm, Silty clay to clay			15	0.99	0.72	02 - 03	02 - 04
6.5	14.4	17.3	0.53	3.6	-0.1	-5	Stiff, Silty clay to clay *			15	1.86	1.06	05 - 08	06 - 10
7.0	13.6	16.2	0.81	5.4	-0.6	-5	Stiff, Silty clay to clay *			15	1.76	1.61	05 - 08	06 - 10
7.5	9.6	11.2	0.75	4.9	-0.6	-5	Stiff, Silty clay to clay *			15	1.22	1.49	03 - 05	04 - 06
8.0	24.8	28.8	0.53	1.9	-0.0	-5	Medium dense, Silty sand to sandy silt	27-31	40-60				05 - 09	06 - 10
8.5	27.9	32.0	0.42	1.5	-0.1	-5	Loose, Silty sand to sandy silt	27-31	20-40				05 - 09	06 - 10
9.0	29.6	33.6	0.59	1.6	-0.2	-5	Medium dense, Silty sand to sandy silt	27-31	40-60				05 - 09	06 - 10
9.5	53.6	60.2	1.70	2.0	-0.2	-5	Dense, Silty sand to sandy silt	36-37	60-80				13 - 18	15 - 20
10.0	76.9	85.5	3.72	4.7	-0.2	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	5.09	7.44	54 - 89	60 - 99
10.5	55.7	61.2	3.84	5.8	-0.4	-5	Very stiff, Sandy clay to silty clay **			30	3.67	7.68	55 - 90	60 - 99
11.0	79.5	86.7	3.68	4.9	-0.4	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	5.26	7.37	55 - 91	60 - 99
11.5	71.9	77.6	3.67	4.9	-0.4	-5	Hard, Sandy clay to silty clay **			30	4.74	7.33	56 - 92	60 - 99
12.0	45.7	48.9	3.06	5.0	-0.4	-5	Very stiff, Sandy clay to silty clay **			25	3.60	6.12	28 - 37	30 - 40
12.5	88.2	93.7	2.70	3.8	-0.4	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	5.83	5.39	56 - 93	60 - 99
13.0	69.6	73.4	4.60	3.4	-0.5	-5	Hard, Sandy silt to sandy clay			30	4.59	9.20	38 - 57	40 - 60
13.5	151.9	158.9	3.66	2.7	-0.5	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	+100				57 - 95	60 - 99
14.0	56.0	58.2	3.35	3.5	-0.5	-5	Hard, Sandy clay to silty clay *			25	4.42	6.70	19 - 29	20 - 30
14.5	66.1	68.1	2.83	4.6	-0.5	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	4.35	5.66	39 - 58	40 - 60
15.0	76.9	78.7	2.38	3.5	0.1	-5	Hard, Gravelly clayey sand to gravelly sandy silt			30	5.07	4.77	39 - 59	40 - 60
15.5	40.5	41.1	1.99	3.0	0.2	-5	Very stiff, Sandy silt to sandy clay			25	3.16	3.98	15 - 20	15 - 20
16.0	23.7	23.9	0.78	2.7	0.3	-5	Very stiff, Sandy clay to silty clay *			20	2.28	1.56	06 - 10	06 - 10
16.5	24.5	24.6	0.63	2.6	0.3	-5	Very stiff, Sandy silt to sandy clay			20	2.35	1.26	06 - 10	06 - 10
17.0	17.8	17.7	0.43	2.0	0.2	-5	Very stiff, Sandy silt to clayey silt			15	2.23	0.85	04 - 06	04 - 06
17.5	16.1	16.0	0.41	2.4	0.3	-5	Very stiff, Clayey silt to silty clay			15	2.00	0.82	04 - 06	04 - 06
18.0	15.3	15.1	0.52	3.0	0.3	-5	Stiff, Sandy clay to silty clay *			15	1.89	1.04	04 - 06	04 - 06
18.5	18.2	17.9	0.78	3.2	0.3	-5	Very stiff, Sandy clay to silty clay *			15	2.27	1.57	04 - 06	04 - 06
19.0	31.9	31.4	1.31	4.5	0.3	-5	Very stiff, Silty clay to clay *			25	2.46	2.61	15 - 20	15 - 20
19.5	28.0	27.5	1.48	5.0	0.3	-5	Very stiff, Silty clay to clay *			20	2.69	2.95	15 - 20	15 - 20
20.0	31.8	31.1	1.58	4.4	0.3	-5	Very stiff, Silty clay to clay *			25	2.45	3.16	15 - 20	15 - 20
20.5	39.3	38.4	2.14	4.5	0.3	-5	Very stiff, Silty clay to clay *			25	3.05	4.29	21 - 31	20 - 30
21.0	58.3	56.7	2.45	4.4	0.2	-5	Hard, Gravelly sandy clay to gravelly silty clay **			25	4.56	4.89	41 - 62	40 - 60
21.5	53.4	51.8	2.56	4.7	0.1	-5	Hard, Sandy clay to silty clay **			25	4.17	5.12	31 - 41	30 - 40
22.0	54.2	52.4	2.82	5.4	0.1	-5	Very stiff, Sandy clay to silty clay **			30	3.52	5.64	41 - 62	40 - 60
22.5	54.2	52.2	2.75	5.3	0.1	-5	Hard, Sandy clay to silty clay **			25	4.22	5.50	41 - 62	40 - 60
23.0	37.6	36.2	2.19	5.0	0.1	-5	Very stiff, Silty clay to clay *			25	2.90	4.38	21 - 31	20 - 30
23.5	41.2	39.5	2.35	4.7	0.1	-5	Very stiff, Silty clay to clay *			25	3.19	4.70	21 - 31	20 - 30
24.0	49.1	47.0	2.77	5.6	0.1	-5	Very stiff, Sandy clay to silty clay **			25	3.81	5.54	42 - 63	40 - 60
24.5	44.9	42.9	2.46	4.9	0.1	-5	Very stiff, Silty clay to clay *			25	3.48	4.92	31 - 42	30 - 40
25.0	62.8	59.7	3.74	5.0	0.1	-5	Hard, Sandy clay to silty clay **			30	4.09	7.48	42 - 63	40 - 60

* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

Mixed soils containing both granular and fine grained particles (e.g. clayey sands) may undergo partial drained failure during CPT.
Both undrained and drained parameters can be estimated for these soils.

Structure rate of loading should be considered in choosing which strength parameters to use for design.
Drained and undrained parameters must not be combined as such combination will result in significant overprediction of in situ shear strength.

STRATIGRAPHICS Evaluated Properties Using Global Database
PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110
R2DATE: 7-24-2002 TIME:14:53:33.48
SOUNDING NUMBER:CPT-01

Depth (ft)	Cone (tsf)	Norm Cone (tsf)	Friction (tsf)	Averaged Friction Ratio (%)	Generated Pore Water Pressure (tsf)	Soil Conductivity (uS/cm)	Evaluated Soil Type	Drained Friction Angle (deg)	Relative Density (%)	Nc	Undrained Shear Strength (ksf)	Undrained Large Strain Shear Strength (ksf)	SPT (N)	NORM SPT (N1')
25.5	83.2	79.0	4.39	4.9	0.1	-5	Hard, Sandy clay to silty clay **			30	5.45	8.77	63 - 104	60 - 99
26.0	95.6	90.4	4.77	4.6	-0.1	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	6.27	9.54	63 - 105	60 - 99
26.5	104.8	98.9	5.21	4.9	-0.1	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	6.88	10.41	+ 106	+ 100
27.0	84.1	79.2	4.61	4.9	-0.2	-5	Hard, Sandy clay to silty clay **			30	5.50	9.23	64 - 105	60 - 99
27.5	62.7	58.9	3.69	4.7	-0.2	-5	Hard, Sandy clay to silty clay **			30	4.07	7.39	43 - 64	40 - 60
28.0	47.8	44.8	2.93	5.6	-0.2	-5	Very stiff, Sandy clay to silty clay **			25	3.69	5.86	43 - 64	40 - 60
28.5	47.5	44.4	2.50	5.3	-0.2	-5	Very stiff, Sandy clay to silty clay **			25	3.66	5.00	32 - 43	30 - 40
29.0	47.5	44.2	2.54	5.6	-0.2	-5	Very stiff, Sandy clay to silty clay **			25	3.66	5.08	32 - 43	30 - 40
29.5	44.4	41.3	2.12	4.7	-0.2	-5	Very stiff, Silty clay to clay *			25	3.41	4.24	22 - 32	20 - 30
30.0	35.0	32.5	2.13	5.4	-0.2	-5	Very stiff, Silty clay to clay *			25	2.66	4.26	22 - 32	20 - 30
30.5	30.0	27.8	1.49	4.7	-0.2	-5	Very stiff, Silty clay to clay *			20	2.82	2.98	16 - 22	15 - 20
31.0	23.0	21.2	1.11	4.3	-0.2	-5	Very stiff, Silty clay to clay *			20	2.11	2.22	11 - 16	10 - 15
31.5	18.6	17.1	0.93	4.6	-0.0	-5	Very stiff, Silty clay to clay *			15	2.23	1.87	07 - 11	06 - 10
32.0	18.2	16.7	0.97	5.0	0.5	-5	Very stiff, Silty clay to clay *			15	2.17	1.94	07 - 11	06 - 10
32.5	21.1	19.3	1.16	4.4	0.6	-5	Stiff, Silty clay to clay *			20	1.92	2.33	07 - 11	06 - 10
33.0	28.9	26.4	1.28	4.7	0.7	-5	Very stiff, Silty clay to clay *			20	2.69	2.56	16 - 22	15 - 20
33.5	15.9	14.5	0.95	4.4	0.7	-5	Stiff, Silty clay to clay *			15	1.85	1.91	07 - 11	06 - 10
34.0	11.5	10.4	0.73	4.8	1.1	-5	Stiff, Silty clay to clay *			15	1.26	1.46	04 - 07	04 - 06
34.5	11.5	10.5	0.66	5.1	2.0	-5	Stiff, Silty clay to clay *			15	1.26	1.32	04 - 07	04 - 06
35.0	13.1	11.9	0.69	5.4	4.6	-5	Stiff, Silty clay to clay *			15	1.47	1.39	07 - 11	06 - 10
35.5	11.6	10.5	0.60	4.8	4.9	-5	Stiff, Silty clay to clay *			15	1.26	1.20	04 - 07	04 - 06
36.0	11.2	10.1	0.59	4.9	5.2	-5	Stiff, Silty clay to clay *			15	1.21	1.18	04 - 07	04 - 06
36.5	12.1	10.9	0.60	5.0	6.4	-5	Stiff, Silty clay to clay *			15	1.33	1.19	04 - 07	04 - 06
37.0	12.9	11.6	0.67	5.0	6.6	-5	Stiff, Silty clay to clay *			15	1.42	1.34	04 - 07	04 - 06
37.5	14.4	12.9	0.70	4.5	7.4	-5	Stiff, Silty clay to clay *			15	1.62	1.39	04 - 07	04 - 06
38.0	16.8	15.0	0.69	4.4	4.9	-5	Stiff, Silty clay to clay *			15	1.93	1.38	07 - 11	06 - 10
38.5	14.2	12.7	0.53	3.5	7.2	-5	Stiff, Silty clay to clay *			15	1.58	1.06	04 - 07	04 - 06
39.0	14.3	12.7	0.56	3.8	8.6	-5	Stiff, Silty clay to clay *			15	1.59	1.13	04 - 07	04 - 06
39.5	16.1	14.3	0.64	3.3	8.6	-5	Stiff, Sandy clay to silty clay *			15	1.84	1.27	05 - 07	04 - 06
40.0	24.6	21.8	1.10	3.6	10.0	-5	Very stiff, Sandy clay to silty clay *			20	2.22	2.20	07 - 11	06 - 10
40.5	36.3	32.2	1.77	4.4	10.2	-5	Very stiff, Silty clay to clay *			25	2.71	3.55	17 - 23	15 - 20
41.0	47.4	41.8	2.09	4.9	11.4	-5	Very stiff, Silty clay to clay *			25	3.59	4.18	23 - 34	20 - 30
41.5	31.2	27.5	1.67	4.1	3.4	-5	Very stiff, Silty clay to clay *			20	2.87	3.34	11 - 17	10 - 15
42.0	41.9	36.9	1.78	4.2	3.8	-5	Very stiff, Silty clay to clay *			25	3.15	3.56	23 - 34	20 - 30
42.5	41.6	36.5	1.69	3.9	3.7	-5	Very stiff, Sandy clay to silty clay *			25	3.12	3.37	17 - 23	15 - 20
43.0	41.5	36.3	1.75	4.3	2.6	-5	Very stiff, Silty clay to clay *			25	3.11	3.51	23 - 34	20 - 30
43.5	28.5	24.9	1.38	4.0	2.4	-5	Very stiff, Silty clay to clay *			20	2.59	2.76	11 - 17	10 - 15
44.0	37.3	32.5	2.27	2.8	2.6	-5	Very stiff, Sandy silt to sandy clay			20	3.47	4.54	11 - 17	10 - 15
44.5	89.4	77.8	3.22	3.8	0.8	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	5.78	6.45	46 - 69	40 - 60
45.0	45.9	39.8	1.65	2.9	1.4	-5	Very stiff, Sandy silt to sandy clay			25	3.45	3.30	17 - 23	15 - 20
45.5	30.4	26.3	1.41	4.1	2.0	-5	Very stiff, Silty clay to clay *			20	2.76	2.83	12 - 17	10 - 15
46.0	21.7	18.7	0.97	4.2	2.1	-5	Very stiff, Silty clay to clay *			15	2.52	1.94	07 - 12	06 - 10
46.5	25.1	21.6	0.96	4.1	2.2	-5	Very stiff, Silty clay to clay *			20	2.23	1.93	12 - 17	10 - 15
47.0	19.1	16.5	0.71	3.3	2.4	-5	Very stiff, Sandy clay to silty clay *			15	2.17	1.42	05 - 07	04 - 06
47.5	28.5	24.5	0.90	4.1	3.0	-5	Very stiff, Silty clay to clay *			20	2.56	1.80	12 - 17	10 - 15
48.0	18.4	15.8	0.74	3.5	3.2	-5	Very stiff, Silty clay to clay *			15	2.07	1.48	05 - 07	04 - 06
48.5	19.2	16.4	0.92	3.5	3.4	-5	Very stiff, Silty clay to clay *			15	2.17	1.85	05 - 07	04 - 06
49.0	33.1	28.3	1.69	4.1	3.6	-5	Very stiff, Silty clay to clay *			20	3.01	3.38	18 - 23	15 - 20
49.5	51.7	44.1	2.62	5.3	4.5	-5	Very stiff, Sandy clay to silty clay **			25	3.90	5.23	35 - 47	30 - 40
50.0	34.5	29.4	2.07	4.3	4.1	-5	Very stiff, Silty clay to clay *			20	3.15	4.14	18 - 23	15 - 20

* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

Mixed soils containing both granular and fine grained particles (e.g. clayey sands) may undergo partial drained failure during CPT.
Both undrained and drained parameters can be estimated for these soils.

Structure rate of loading should be considered in choosing which strength parameters to use for design.
Drained and undrained parameters must not be combined as such combination will result in significant overprediction of in situ shear strength.

STRATIGRAPHICS Evaluated Properties Using Global Database

PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110
R2DATE: 7-24-2002 TIME:14:53:33.48
SOUNDING NUMBER:CPT-01

Depth (ft)	Cone (tsf)	Norm Cone (tsf)	Friction (tsf)	Averaged Friction Ratio (%)	Generated Pore Water Pressure (tsf)	Soil Conductivity (uS/cm)	Evaluated Soil Type	Drained Friction Angle (deg)	Relative Density (%)	Nc	Undrained Shear Strength (ksf)	Undrained Large Strain Shear Strength (ksf)	SPT (N)	NORM SPT (N1')
50.5	28.9	24.6	1.48	4.9	4.4	-5	Very stiff, Silty clay to clay *			20	2.58	2.97	18 - 24	15 - 20
51.0	22.7	19.3	0.95	3.2	4.6	-5	Very stiff, Sandy clay to silty clay *			15	2.62	1.91	07 - 12	06 - 10
51.5	16.8	14.3	0.93	3.6	5.3	-5	Stiff, Silty clay to clay *			15	1.83	1.86	05 - 07	04 - 06
52.0	47.1	39.8	1.69	4.4	4.5	-5	Very stiff, Silty clay to clay *			25	3.52	3.38	24 - 35	20 - 30
52.5	43.2	36.4	3.45	2.6	3.8	-5	Very stiff, Sandy silt to sandy clay			25	3.20	6.91	12 - 18	10 - 15
53.0	132.0	111.2	5.77	4.5	-0.6	-5	Hard, Gravelly sandy clay to gravelly silty clay **			33	7.81	11.55	+ 119	+ 100
53.5	24.8	20.9	2.67	3.9	-0.6	-5	Very stiff, Silty clay to clay *			20	2.16	5.34	07 - 12	06 - 10
54.0	112.7	94.6	3.49	3.0	-0.6	-5	Hard, Sandy silt to sandy clay			30	7.30	6.98	48 - 71	40 - 60
54.5	107.4	90.0	6.83	5.7	-0.5	-5	Hard, Sandy clay to silty clay **			30	6.94	13.66	+ 119	+ 100
55.0	99.5	83.2	7.25	6.5	-0.5	-5	Hard, Sandy clay to silty clay **			30	6.41	14.50	+ 120	+ 100
55.5	148.4	124.0	7.85	4.9	-0.5	-5	Hard, Gravelly sandy clay to gravelly silty clay **			33	8.80	15.70	+ 120	+ 100
56.0	127.9	106.6	9.79	6.1	-0.4	-5	Hard, Sandy clay to silty clay **			33	7.55	19.58	+ 120	+ 100
56.5	69.5	57.8	4.99	5.3	-0.3	-5	Hard, Sandy clay to silty clay **			30	4.41	9.97	48 - 72	40 - 60
57.0	70.4	58.5	4.60	5.5	-0.3	-5	Hard, Sandy clay to silty clay **			30	4.47	9.20	48 - 72	40 - 60
57.5	87.5	72.6	7.08	5.5	-0.3	-5	Hard, Sandy clay to silty clay **			30	5.61	14.15	72 - 119	60 - 99
58.0	187.6	155.3	9.92	6.1	-0.3	-5	Hard, Hardpan to weak rock			33	11.16	19.84	+ 121	+ 100
58.5	145.8	120.5	11.57	7.2	-0.3	-5	Hard, Hardpan to weak rock			33	8.62	23.15	+ 121	+ 100
59.0	59.0	48.7	3.78	3.9	-0.3	-5	Hard, Sandy clay to silty clay *			25	4.43	7.55	24 - 36	20 - 30
59.5	101.6	83.6	7.21	4.0	-0.2	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	6.53	14.42	49 - 73	40 - 60
60.0	200.6	164.9	11.03	5.5	-0.2	-5	Hard, Gravelly sandy clay to hardpan **			33	11.94	22.06	+ 122	+ 100
60.5	208.7	171.3	11.37	5.5	-0.2	-5	Hard, Gravelly sandy clay to hardpan **			33	12.43	22.74	+ 122	+ 100
61.0	201.5	165.1	11.92	5.4	-0.2	-5	Hard, Gravelly sandy clay to hardpan **			33	11.99	23.83	+ 122	+ 100
61.5	266.3	217.9	9.63	3.8	-0.1	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	15.92	19.25	+ 122	+ 100
62.0	198.5	162.1	8.84	3.5	-0.1	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	11.80	17.68	+ 122	+ 100
62.5	133.7	109.1	5.53	3.8	-0.0	-5	Hard, Gravelly clayey sand to gravelly sandy silt			30	8.67	11.05	74 - 121	60 - 99
63.0	88.8	72.3	5.95	4.9	0.0	-5	Hard, Sandy clay to silty clay **			30	5.67	11.91	74 - 122	60 - 99
63.5	50.2	40.8	2.22	3.7	0.0	-5	Very stiff, Sandy clay to silty clay *			25	3.71	4.44	25 - 37	20 - 30
64.0	56.9	46.2	2.35	4.2	-0.0	-5	Hard, Sandy clay to silty clay *			25	4.24	4.70	25 - 37	20 - 30
64.5	49.1	39.8	2.01	3.6	-0.0	-5	Very stiff, Sandy clay to silty clay *			25	3.62	4.03	19 - 25	15 - 20
65.0	47.4	38.3	2.13	3.8	-0.0	-5	Very stiff, Sandy clay to silty clay *			25	3.48	4.25	19 - 25	15 - 20
65.5	71.2	57.5	2.67	2.9	-0.0	-5	Hard, Sandy silt to sandy clay			25	5.38	5.35	25 - 37	20 - 30
66.0	130.7	105.4	5.10	4.9	-0.2	-5	Hard, Gravelly sandy clay to gravelly silty clay **			33	7.68	10.20	+ 124	+ 100
66.5	45.2	36.4	2.16	2.7	-0.2	-5	Very stiff, Sandy silt to sandy clay			25	3.30	4.31	12 - 19	10 - 15
67.0	80.4	64.6	3.47	4.7	-0.2	-5	Hard, Sandy clay to silty clay **			30	5.09	6.93	50 - 75	40 - 60
67.5	60.4	48.4	2.65	3.8	-0.2	-5	Hard, Sandy clay to silty clay *			25	4.51	5.29	25 - 37	20 - 30
68.0	60.2	48.2	2.21	3.7	-0.1	-5	Hard, Sandy clay to silty clay *			25	4.49	4.42	25 - 37	20 - 30
68.5	38.3	30.7	1.66	3.4	-0.1	-5	Very stiff, Sandy clay to silty clay *			20	3.42	3.32	13 - 19	10 - 15
69.0	49.4	39.4	2.79	5.7	-0.1	-5	Very stiff, Sandy clay to silty clay **			25	3.62	5.57	38 - 50	30 - 40
69.5	43.1	34.4	1.63	3.6	-0.0	-5	Very stiff, Sandy clay to silty clay *			25	3.11	3.25	19 - 25	15 - 20
70.0	45.8	36.5	2.20	3.5	-0.0	-5	Very stiff, Sandy clay to silty clay *			25	3.33	4.40	19 - 25	15 - 20
70.5	76.8	61.1	4.47	5.5	-0.0	-5	Hard, Sandy clay to silty clay **			30	4.84	8.94	50 - 75	40 - 60
71.0	77.3	61.4	4.39	5.5	-0.0	-5	Hard, Sandy clay to silty clay **			30	4.87	8.77	50 - 76	40 - 60
71.5	67.5	53.5	3.94	5.0	0.0	-5	Hard, Sandy clay to silty clay **			25	5.05	7.87	50 - 76	40 - 60
72.0	83.9	66.4	5.12	3.0	0.0	-5	Hard, Sandy silt to sandy clay			25	6.37	10.24	38 - 51	30 - 40
72.5	225.9	178.4	7.61	3.0	0.0	-5	Very dense, Gravelly silty sand to clayey gravelly sand	36-37	+100				+ 127	+ 100
73.0	307.9	242.9	6.93	1.9	-0.3	-5	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	80-100				+ 127	+ 100
73.5	404.0	318.2	9.11	2.2	-0.3	-5	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	+100				+ 127	+ 100
74.0	408.2	321.0	7.37	1.8	-0.0	-5	Very dense, Sandy gravel to silty gravelly sand	42-46	80-100				+ 127	+ 100
74.5	392.5	308.2	6.54	1.6	0.1	-5	Very dense, Sandy gravel to silty gravelly sand	42-46	80-100				+ 127	+ 100
75.0	291.5	228.6	3.74	1.0	0.3	-5	Dense, Sand to silty sand	42-46	60-80				51 - 77	40 - 60

* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

Mixed soils containing both granular and fine grained particles (e.g. clayey sands) may undergo partial drained failure during CPT.
Both undrained and drained parameters can be estimated for these soils.

Structure rate of loading should be considered in choosing which strength parameters to use for design.
Drained and undrained parameters must not be combined as such combination will result in significant overprediction of in situ shear strength.

STRATIGRAPHICS Evaluated Properties Using Global Database

PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110
R2DATE: 7-24-2002 TIME:14:53:33.48
SOUNDING NUMBER:CPT-01

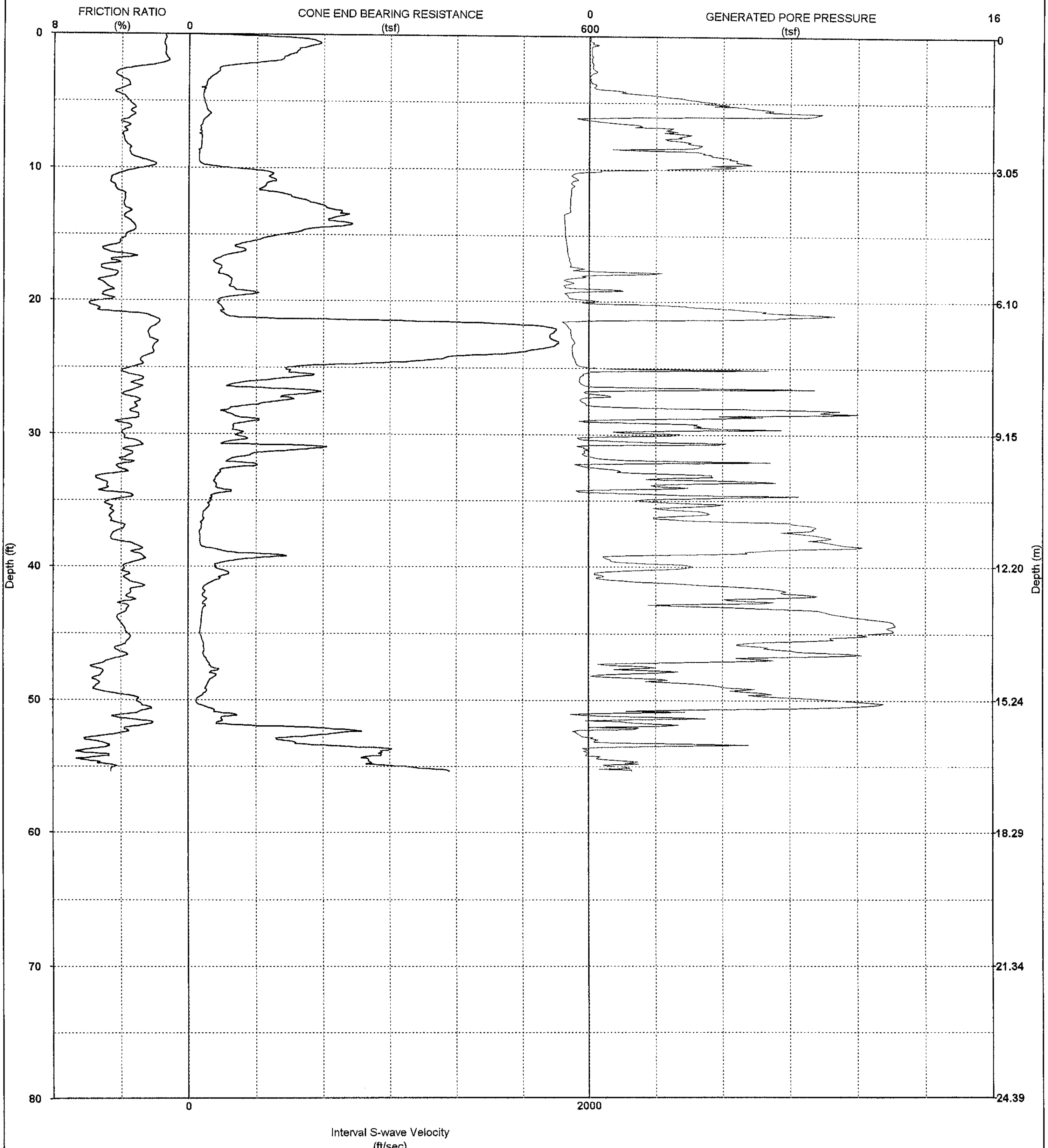
Depth (ft)	Cone (tsf)	Norm Cone (tsf)	Friction (tsf)	Averaged Friction Ratio (%)	Generated Pore Water Pressure (tsf)	Soil Conductivity (uS/cm)	Evaluated Soil Type	Drained Friction Angle (deg)	Relative Density (%)	Nc	Undrained Shear Strength (ksf)	Undrained Large Strain Shear Strength (ksf)	SPT (N)	NORM SPT (N1')
75.5	90.4	70.8	4.72	2.7	0.3	-5	Hard, Sandy silt to sandy clay			25	6.87	9.43	26 - 38	20 - 30
76.0	72.2	56.4	2.59	3.5	0.4	-5	Hard, Sandy clay to silty clay *			25	5.41	5.18	26 - 38	20 - 30
76.5	73.7	57.5	2.82	3.3	0.4	-5	Hard, Sandy silt to sandy clay			25	5.53	5.65	26 - 38	20 - 30
77.0	135.1	105.3	5.38	2.6	0.4	-5	Very dense, Silty sand to sandy silt	36-37	80-100				51 - 77	40 - 60
77.5	255.9	199.2	7.30	2.8	0.3	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	+100				+ 128	+ 100

* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

Mixed soils containing both granular and fine grained particles (e.g. clayey sands) may undergo partial drained failure during CPT.
Both undrained and drained parameters can be estimated for these soils.

Structure rate of loading should be considered in choosing which strength parameters to use for design.
Drained and undrained parameters must not be combined as such combination will result in significant overprediction of in situ shear strength.

CPTU-S LOG



PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110

STRATIGRAPHICS

R2DATE: 7-24-2002 TIME:12:30:47.85
SOUNDING NUMBER:CPT-02

STRATIGRAPHICS Evaluated Properties Using Global Database
PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110
R2DATE: 7-24-2002 TIME:12:30:47.85
SOUNDING NUMBER:CPT-02

Depth (ft)	Cone (tsf)	Norm Cone (tsf)	Friction (tsf)	Averaged Friction Ratio (%)	Generated Pore Water Pressure (tsf)	Soil Conductivity (uS/cm)	Evaluated Soil Type	Drained Friction Angle (deg)	Relative Density (%)	Nc	Undrained Shear Strength (ksf)	Undrained Large Strain Shear Strength (ksf)	SPT (N)	NORM SPT (N1')
1.0	166.1	267.7	2.87	1.4	0.1	-5	Very dense, Sand to silty sand	42-46	80-100				37 - 61	60 - 99
1.5	149.5	227.6	2.30	1.4	0.1	-5	Dense, Sand to silty sand	42-46	60-80				39 - 65	60 - 99
2.0	128.6	187.9	1.60	1.2	0.1	-5	Dense, Sand to silty sand	42-46	60-80				27 - 41	40 - 60
2.5	47.2	66.7	2.58	3.1	0.1	-5	Very stiff, Sandy silt to sandy clay			25	3.77	5.15	21 - 28	30 - 40
3.0	39.0	53.6	1.90	4.3	0.0	-5	Very stiff, Sandy clay to silty clay *			25	3.11	3.80	22 - 29	30 - 40
3.5	27.3	36.5	1.13	3.6	0.1	-5	Very stiff, Sandy clay to silty clay *			25	2.17	2.27	11 - 15	15 - 20
4.0	17.8	23.3	0.94	3.8	0.4	-5	Stiff, Silty clay to clay *			20	1.76	1.88	08 - 11	10 - 15
4.5	20.8	26.7	0.89	4.1	2.9	-5	Very stiff, Silty clay to clay *			20	2.05	1.77	08 - 12	10 - 15
5.0	22.6	28.5	0.85	3.6	4.8	-5	Very stiff, Sandy clay to silty clay *			20	2.23	1.70	08 - 12	10 - 15
5.5	25.2	31.3	0.89	3.2	7.2	-5	Very stiff, Sandy clay to silty clay *			20	2.49	1.78	08 - 12	10 - 15
6.0	30.9	37.7	0.86	3.2	8.6	-5	Very stiff, Sandy clay to silty clay *			25	2.44	1.72	12 - 16	15 - 20
6.5	20.8	25.0	1.01	4.0	1.0	-5	Very stiff, Silty clay to clay *			20	2.04	2.01	08 - 12	10 - 15
7.0	17.2	20.4	0.70	3.8	3.1	-5	Stiff, Silty clay to clay *			20	1.67	1.40	05 - 08	06 - 10
7.5	17.6	20.7	0.73	3.9	3.7	-5	Stiff, Silty clay to clay *			20	1.72	1.46	05 - 09	06 - 10
8.0	18.1	21.0	0.72	3.8	3.9	-5	Stiff, Silty clay to clay *			20	1.76	1.44	05 - 09	06 - 10
8.5	17.9	20.6	0.63	3.4	1.3	-5	Stiff, Sandy clay to silty clay *			20	1.74	1.26	05 - 09	06 - 10
9.0	14.6	16.5	0.53	3.5	5.0	-5	Stiff, Silty clay to clay *			15	1.87	1.07	04 - 05	04 - 06
9.5	15.3	17.2	0.64	2.3	6.2	-5	Stiff, Sandy silt to sandy clay			15	1.97	1.29	04 - 05	04 - 06
10.0	60.5	67.2	2.90	2.7	3.0	-5	Hard, Sandy silt to sandy clay			25	4.79	5.80	18 - 27	20 - 30
10.5	123.5	135.9	5.21	4.2	-0.7	-5	Hard, Gravelly sandy clay to gravelly silty clay **			33	7.45	10.42	+ 91	+ 100
11.0	125.1	136.3	5.81	4.7	-0.7	-5	Hard, Gravelly sandy clay to gravelly silty clay **			33	7.54	11.62	+ 92	+ 100
11.5	108.4	117.2	5.24	4.3	-0.7	-5	Hard, Gravelly sandy clay to gravelly silty clay **			33	6.53	10.48	+ 93	+ 100
12.0	147.4	158.0	6.08	3.8	-0.8	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	8.89	12.16	+ 93	+ 100
12.5	177.9	189.0	7.38	3.8	-0.8	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	10.74	14.76	+ 94	+ 100
13.0	206.6	217.8	8.44	3.8	-0.8	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	12.47	16.89	+ 95	+ 100
13.5	232.5	243.1	8.40	3.8	-1.0	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	14.04	16.81	+ 96	+ 100
14.0	220.3	228.7	7.70	3.5	-1.0	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	13.30	15.40	+ 96	+ 100
14.5	189.2	194.9	6.95	3.1	-1.0	-5	Very dense, Gravelly silty sand to clayey gravelly sand	36-37	+100				+ 97	+ 100
15.0	137.5	140.7	6.12	3.7	-1.0	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	8.28	12.24	+ 98	+ 100
15.5	93.4	94.8	4.59	4.1	-0.9	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	6.16	9.18	59 - 97	60 - 99
16.0	75.4	76.0	3.97	5.1	-0.9	-5	Hard, Sandy clay to silty clay **			30	4.96	7.94	59 - 98	60 - 99
16.5	60.6	60.8	2.81	3.7	-0.9	-5	Hard, Sandy clay to silty clay *			25	4.77	5.61	30 - 40	30 - 40
17.0	36.8	36.6	2.06	4.4	-0.8	-5	Very stiff, Silty clay to clay *			25	2.86	4.12	20 - 30	20 - 30
17.5	48.6	48.3	2.32	5.2	-0.3	-5	Very stiff, Sandy clay to silty clay **			25	3.81	4.64	40 - 60	40 - 60
18.0	45.5	45.1	2.50	4.2	0.4	-5	Very stiff, Sandy clay to silty clay *			25	3.56	5.00	20 - 30	20 - 30
18.5	63.1	62.2	3.37	5.3	-0.9	-5	Hard, Sandy clay to silty clay **			30	4.13	6.75	41 - 61	40 - 60
19.0	63.9	62.9	3.90	4.7	-0.7	-5	Hard, Sandy clay to silty clay **			30	4.19	7.80	41 - 61	40 - 60
19.5	96.5	94.6	4.13	5.1	-0.9	-5	Hard, Sandy clay to silty clay **			30	6.35	8.25	+ 102	+ 100
20.0	43.8	42.8	3.18	5.1	0.4	-5	Very stiff, Silty clay to clay *			25	3.41	6.36	31 - 41	30 - 40
20.5	49.1	47.8	2.70	5.4	5.0	-5	Very stiff, Sandy clay to silty clay **			25	3.83	5.40	41 - 62	40 - 60
21.0	52.7	51.2	3.21	3.1	9.4	-5	Hard, Sandy silt to sandy clay			25	4.12	6.42	21 - 31	20 - 30
21.5	311.4	301.9	7.84	1.7	-0.7	-5	Very dense, Sandy gravel to silty gravelly sand	42-46	80-100				+ 103	+ 100
22.0	545.7	527.6	11.89	2.2	-0.8	-5	Very dense, Sandy gravel to silty gravelly sand	40-42	+100				+ 103	+ 100
22.5	541.4	522.0	13.10	2.4	-0.7	-5	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	+100				+ 104	+ 100
23.0	552.4	531.1	9.86	1.9	-0.6	-5	Very dense, Sandy gravel to silty gravelly sand	42-46	+100				+ 104	+ 100
23.5	533.0	511.1	11.64	2.1	-0.7	-5	Very dense, Sandy gravel to silty gravelly sand	40-42	+100				+ 104	+ 100
24.0	446.1	426.6	10.86	2.2	-0.7	-5	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	+100				+ 105	+ 100
24.5	343.3	327.4	11.05	2.9	-0.6	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	+100				+ 105	+ 100
25.0	148.8	141.6	7.84	3.3	0.5	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	8.93	15.67	+ 105	+ 100

* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

Mixed soils containing both granular and fine grained particles (e.g. clayey sands) may undergo partial drained failure during CPT.
Both undrained and drained parameters can be estimated for these soils.

Structure rate of loading should be considered in choosing which strength parameters to use for design.
Drained and undrained parameters must not be combined as such combination will result in significant overprediction of in situ shear strength.

STRATIGRAPHICS Evaluated Properties Using Global Database
PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110
R2DATE: 7-24-2002 TIME:12:30:47.85
SOUNDING NUMBER:CPT-02

Depth (ft)	Cone (tsf)	Norm Cone (tsf)	Friction (tsf)	Averaged Friction Ratio (%)	Generated Pore Water Pressure (tsf)	Soil Conductivity (uS/cm)	Evaluated Soil Type	Drained Friction Angle (deg)	Relative Density (%)	Nc	Undrained Shear Strength (ksf)	Undrained Large Strain Shear Strength (ksf)	SPT (N)	NORM SPT (N1')
25.5	181.3	172.0	5.69	3.6	-0.2	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	10.89	11.39	+ 105	+ 100
26.0	101.6	96.1	4.45	3.0	-0.4	-5	Hard, Sandy silt to sandy clay			30	6.67	8.90	42 - 63	40 - 60
26.5	81.7	77.1	4.63	2.9	4.8	-5	Hard, Sandy silt to sandy clay			30	5.34	9.26	32 - 42	30 - 40
27.0	166.7	157.0	6.46	3.9	0.6	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	10.01	12.92	+ 106	+ 100
27.5	135.4	127.1	4.15	2.9	-0.3	-5	Very dense, Gravelly silty sand to clayey gravelly sand	36-37	80-100				64 - 105	60 - 99
28.0	62.1	58.2	3.03	3.1	3.5	-5	Hard, Sandy silt to sandy clay			25	4.84	6.06	21 - 32	20 - 30
28.5	63.3	59.2	2.43	3.0	8.4	-5	Hard, Sandy silt to sandy clay			25	4.93	4.85	21 - 32	20 - 30
29.0	98.8	92.1	3.66	4.2	-0.3	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	6.47	7.33	64 - 106	60 - 99
29.5	66.5	61.8	2.52	3.4	5.1	-5	Hard, Sandy silt to sandy clay			25	5.18	5.04	32 - 43	30 - 40
30.0	71.3	66.1	3.05	3.9	3.6	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	4.63	6.10	43 - 65	40 - 60
30.5	69.2	64.0	3.18	3.1	1.0	-5	Hard, Sandy silt to sandy clay			25	5.39	6.36	32 - 43	30 - 40
31.0	202.0	186.4	5.10	3.4	-0.2	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	12.13	10.19	+ 108	+ 100
31.5	93.3	85.9	4.96	3.4	-0.3	-5	Hard, Gravelly clayey sand to gravelly sandy silt			30	6.10	9.92	43 - 65	40 - 60
32.0	57.3	52.6	2.79	3.7	4.2	-5	Hard, Sandy clay to silty clay *			25	4.43	5.58	22 - 33	20 - 30
32.5	69.1	63.3	3.43	4.2	0.2	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	4.47	6.87	44 - 65	40 - 60
33.0	43.7	40.0	2.35	4.7	4.2	-5	Very stiff, Silty clay to clay *			25	3.34	4.69	22 - 33	20 - 30
33.5	37.3	34.1	2.04	5.1	6.5	-5	Very stiff, Silty clay to clay *			25	2.83	4.09	22 - 33	20 - 30
34.0	40.1	36.5	2.40	4.8	4.0	-5	Very stiff, Silty clay to clay *			25	3.05	4.80	22 - 33	20 - 30
34.5	41.0	37.2	1.74	3.5	2.7	-5	Very stiff, Sandy clay to silty clay *			25	3.11	3.47	17 - 22	15 - 20
35.0	33.1	30.0	1.59	4.6	2.0	-5	Very stiff, Silty clay to clay *			25	2.48	3.18	17 - 22	15 - 20
35.5	29.0	26.2	1.36	4.5	2.9	-5	Very stiff, Silty clay to clay *			20	2.68	2.72	17 - 22	15 - 20
36.0	21.2	19.2	1.12	4.6	4.8	-5	Stiff, Silty clay to clay *			20	1.91	2.24	11 - 17	10 - 15
36.5	21.1	19.0	1.00	4.6	4.3	-5	Stiff, Silty clay to clay *			20	1.89	2.01	07 - 11	06 - 10
37.0	18.7	16.8	0.74	3.8	9.0	-5	Very stiff, Silty clay to clay *			15	2.19	1.47	07 - 11	06 - 10
37.5	16.4	14.7	0.78	4.5	8.6	-5	Stiff, Silty clay to clay *			15	1.89	1.56	07 - 11	06 - 10
38.0	16.7	15.0	0.80	4.5	8.7	-5	Stiff, Silty clay to clay *			15	1.93	1.60	07 - 11	06 - 10
38.5	20.8	18.5	1.32	2.9	10.8	-5	Very stiff, Sandy clay to silty clay *			15	2.46	2.64	04 - 07	04 - 06
39.0	89.7	79.8	3.30	3.0	5.6	-5	Hard, Sandy silt to sandy clay			30	5.82	6.60	45 - 67	40 - 60
39.5	69.7	61.9	3.11	2.8	0.9	-5	Hard, Sandy silt to sandy clay			25	5.38	6.22	23 - 34	20 - 30
40.0	38.8	34.4	1.92	3.8	4.2	-5	Very stiff, Sandy clay to silty clay *			25	2.91	3.84	17 - 23	15 - 20
40.5	60.0	53.0	1.75	3.5	0.2	-5	Hard, Sandy clay to silty clay *			25	4.60	3.51	23 - 34	20 - 30
41.0	42.5	37.5	1.80	3.6	0.9	-5	Very stiff, Sandy clay to silty clay *			25	3.20	3.59	17 - 23	15 - 20
41.5	22.5	19.8	0.79	2.7	6.1	-5	Very stiff, Sandy clay to silty clay *			15	2.66	1.58	05 - 07	04 - 06
42.0	22.6	19.9	0.78	3.4	7.7	-5	Very stiff, Sandy clay to silty clay *			20	2.01	1.56	07 - 11	06 - 10
42.5	25.9	22.7	0.70	3.2	5.7	-5	Very stiff, Sandy clay to silty clay *			20	2.33	1.40	07 - 11	06 - 10
43.0	24.0	21.0	0.81	3.5	4.8	-5	Very stiff, Sandy clay to silty clay *			20	2.14	1.61	07 - 11	06 - 10
43.5	19.9	17.4	0.82	3.9	9.6	-5	Very stiff, Silty clay to clay *			15	2.31	1.64	07 - 11	06 - 10
44.0	18.5	16.2	0.79	4.1	11.6	-5	Very stiff, Silty clay to clay *			15	2.12	1.58	07 - 11	06 - 10
44.5	17.8	15.5	0.70	3.8	12.0	-5	Very stiff, Silty clay to clay *			15	2.02	1.39	07 - 11	06 - 10
45.0	16.9	14.7	0.68	3.6	11.0	-5	Stiff, Silty clay to clay *			15	1.89	1.35	05 - 07	04 - 06
45.5	20.5	17.8	0.79	3.6	8.8	-5	Very stiff, Silty clay to clay *			15	2.37	1.59	07 - 12	06 - 10
46.0	21.7	18.8	0.99	4.3	7.1	-5	Very stiff, Silty clay to clay *			15	2.53	1.98	07 - 12	06 - 10
46.5	21.7	18.7	0.87	3.6	10.4	-5	Very stiff, Silty clay to clay *			15	2.52	1.74	07 - 12	06 - 10
47.0	27.4	23.6	1.47	4.8	6.8	-5	Very stiff, Silty clay to clay *			20	2.45	2.94	12 - 17	10 - 15
47.5	34.0	29.2	2.16	5.7	2.5	-5	Very stiff, Silty clay to clay *			25	2.49	4.33	23 - 35	20 - 30
48.0	37.2	31.9	1.97	5.2	1.4	-5	Very stiff, Silty clay to clay *			25	2.75	3.94	23 - 35	20 - 30
48.5	31.5	27.0	2.01	5.5	2.9	-5	Very stiff, Silty clay to clay *			20	2.86	4.02	18 - 23	15 - 20
49.0	26.0	22.2	1.58	5.6	5.4	-5	Very stiff, Silty clay to clay *			20	2.30	3.15	18 - 23	15 - 20
49.5	22.5	19.2	1.10	4.3	7.2	-5	Stiff, Silty clay to clay *			20	1.95	2.19	07 - 12	06 - 10
50.0	11.7	10.0	0.53	3.1	10.1	-5	Stiff, Silty clay to clay			15	1.16	1.06	02 - 05	02 - 04

* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

Mixed soils containing both granular and fine grained particles (e.g. clayey sands) may undergo partial drained failure during CPT.
Both undrained and drained parameters can be estimated for these soils.

Structure rate of loading should be considered in choosing which strength parameters to use for design.
Drained and undrained parameters must not be combined as such combination will result in significant overprediction of in situ shear strength.

STRATIGRAPHICS Evaluated Properties Using Global Database

PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110
R2DATE: 7-24-2002 TIME:12:30:47.85
SOUNDING NUMBER:CPT-02

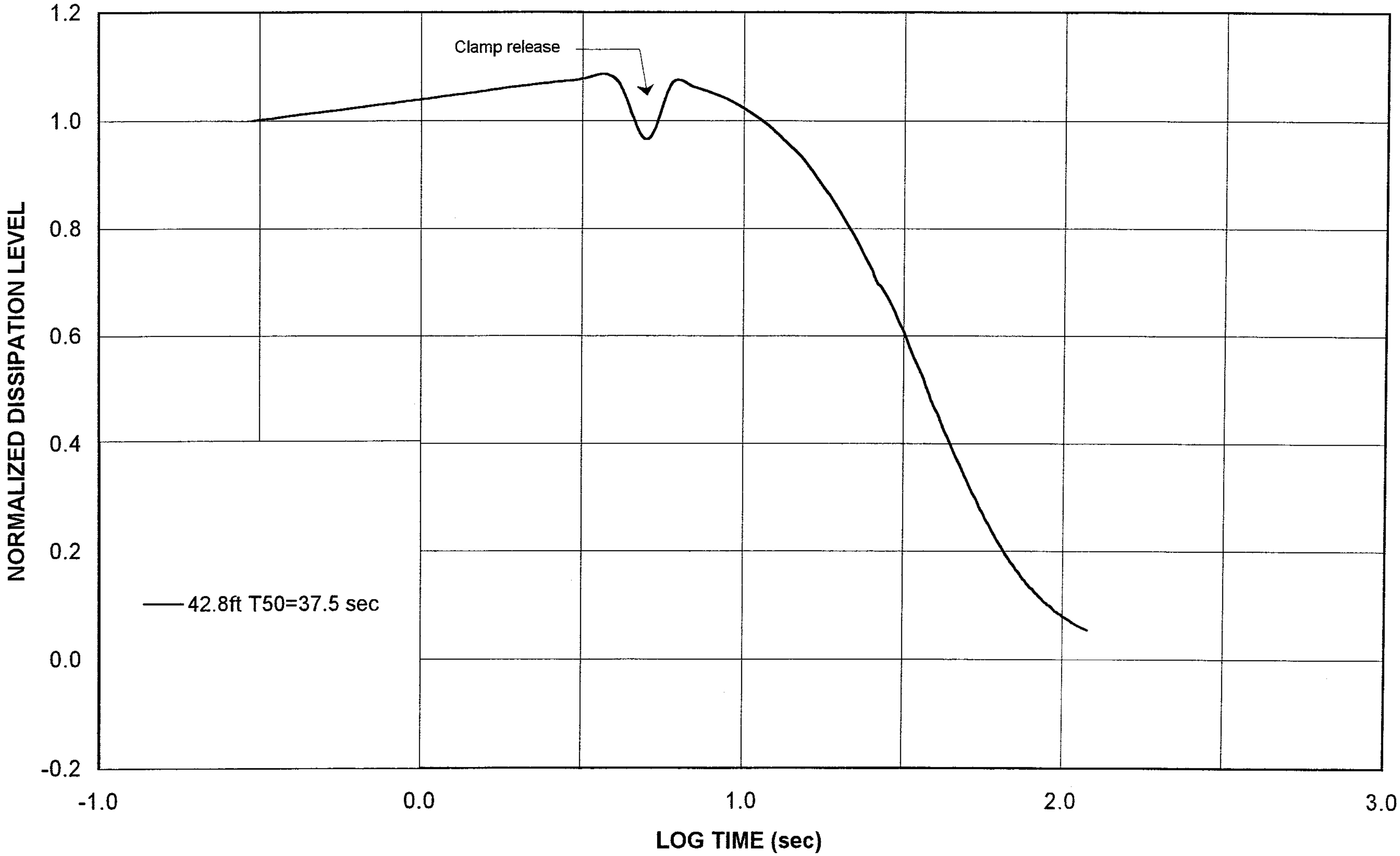
Depth (ft)	Cone (tsf)	Norm Cone (tsf)	Friction (tsf)	Averaged Friction Ratio (%)	Generated Pore Water Pressure (tsf)	Soil Conductivity (uS/cm)	Evaluated Soil Type	Drained Friction Angle (deg)	Relative Density (%)	Nc	Undrained Shear Strength (ksf)	Undrained Large Strain Shear Strength (ksf)	SPT (N)	NORM SPT (N1')
50.5	25.0	21.3	0.89	2.4	10.0	-5	Very stiff, Sandy silt to sandy clay			15	2.93	1.79	05 - 07	04 - 06
51.0	59.4	50.4	1.81	3.3	-0.2	-5	Hard, Sandy clay to silty clay *			25	4.51	3.61	24 - 35	20 - 30
51.5	50.2	42.5	1.93	3.0	0.4	-5	Very stiff, Sandy silt to sandy clay			25	3.77	3.86	18 - 24	15 - 20
52.0	158.0	133.7	7.53	3.4	-0.1	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	9.39	15.06	+ 118	+ 100
52.5	218.6	184.5	8.82	4.1	-0.5	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	13.06	17.64	+ 118	+ 100
53.0	136.9	115.3	10.51	5.9	0.3	-5	Hard, Sandy clay to silty clay **			33	8.10	21.02	+ 119	+ 100
53.5	240.4	202.2	13.58	4.9	1.3	-5	Hard, Gravelly sandy clay to hardpan **			33	14.37	27.16	+ 119	+ 100
54.0	283.3	237.8	14.69	5.4	-0.1	-5	Hard, Gravelly sandy clay to hardpan **			33	16.97	29.38	+ 119	+ 100
54.5	268.5	225.0	18.54	6.2	0.9	-5	Hard, Hardpan to weak rock			33	16.08	37.08	+ 119	+ 100
55.0	319.7	267.4	15.81	4.3	1.2	-5	Hard, Gravelly clayey sand to gravelly sandy clay			33	19.17	31.63	+ 120	+ 100

* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

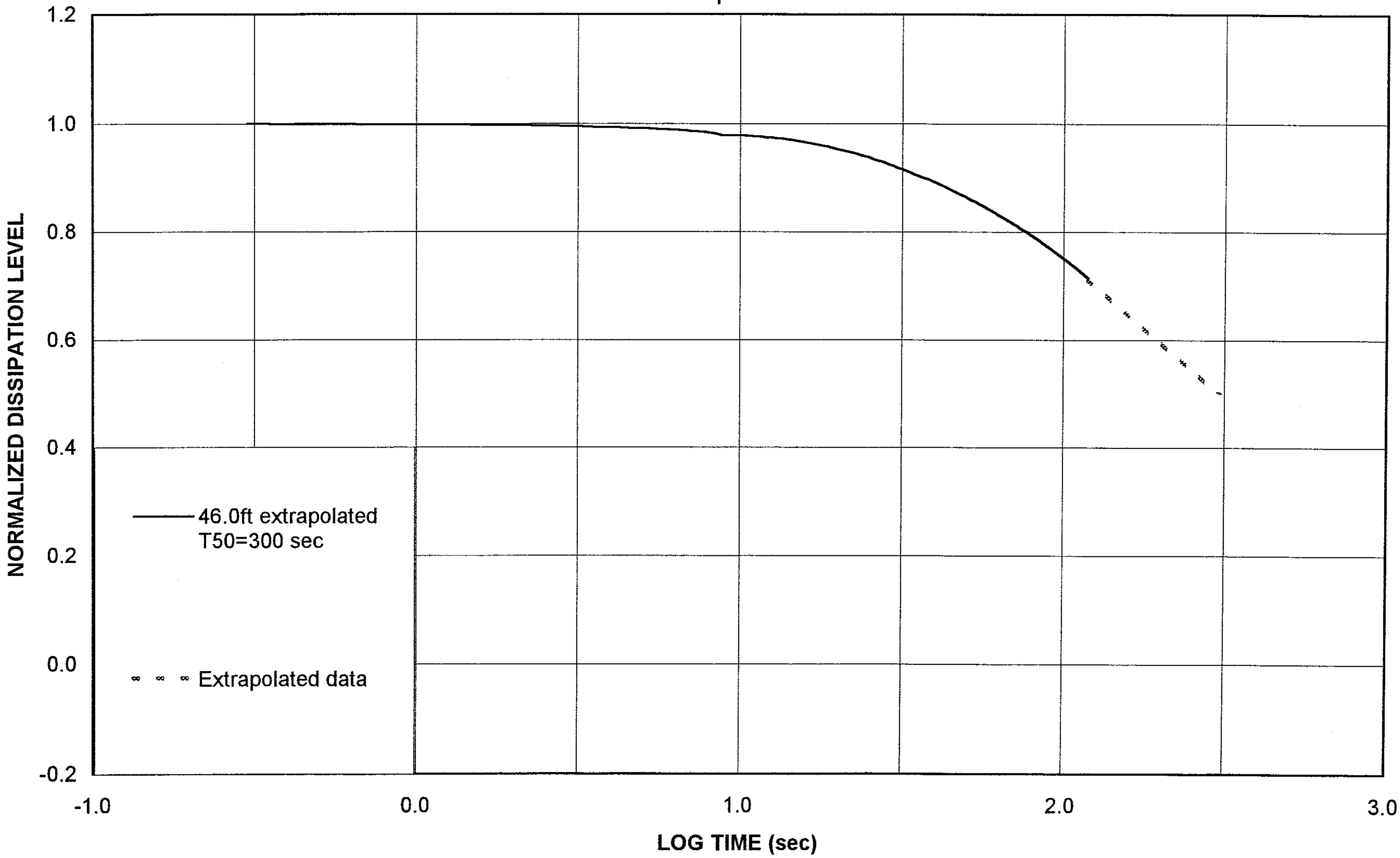
Mixed soils containing both granular and fine grained particles (e.g. clayey sands) may undergo partial drained failure during CPT.
Both undrained and drained parameters can be estimated for these soils.

Structure rate of loading should be considered in choosing which strength parameters to use for design.
Drained and undrained parameters must not be combined as such combination will result in significant overprediction of in situ shear strength.

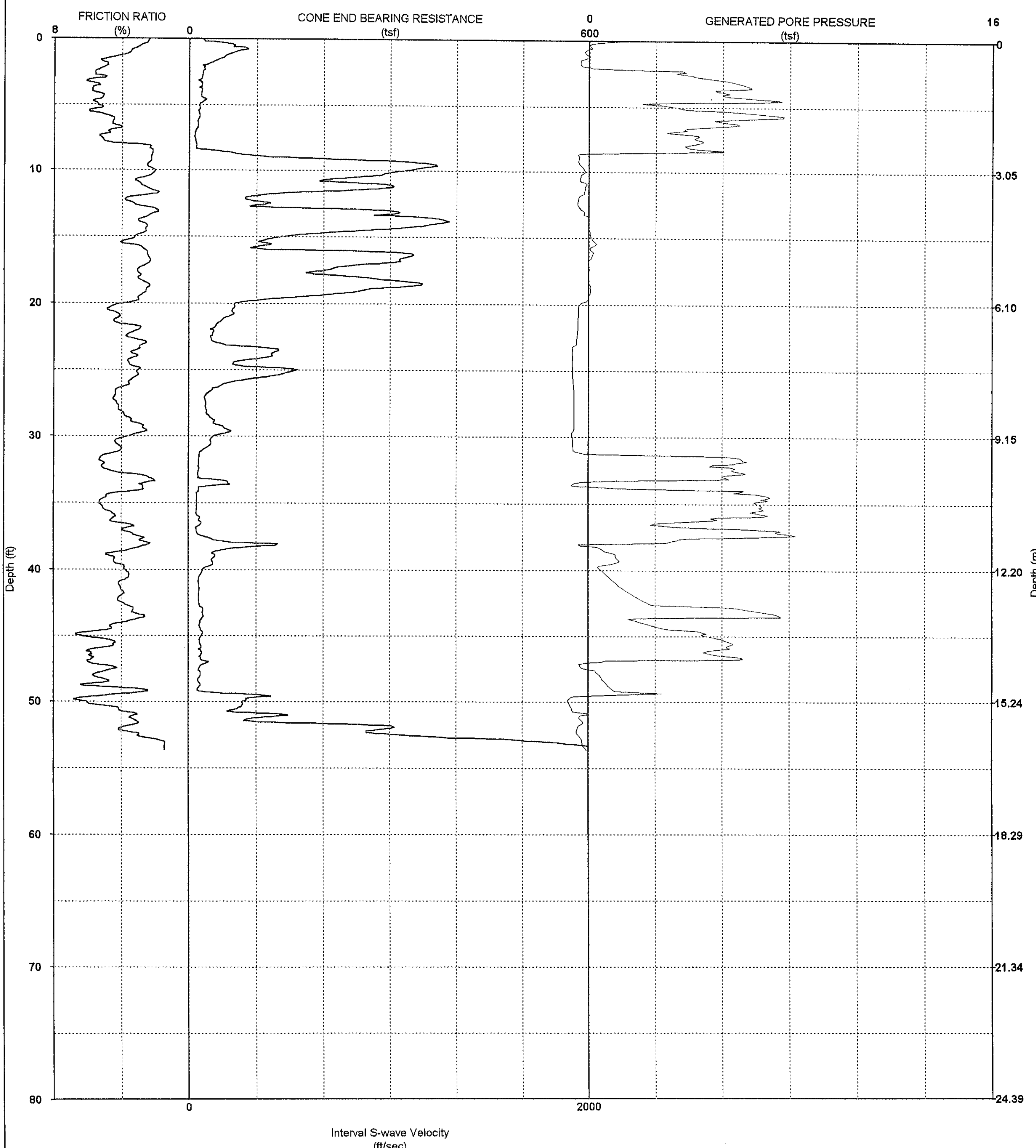
STRATIGRAPHICS
PORE WATER PRESSURE DISSIPATION TEST
CPS-EPS Field Exploration CPT-02



STRATIGRAPHICS
PORE WATER PRESSURE DISSIPATION TEST
CPS-EPS Field Exploration CPT-02



CPTU-S LOG



PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110

STRATIGRAPHICS

R2DATE: 7-24-2002 TIME:08:32:19.49
SOUNDING NUMBER:CPT-03

STRATIGRAPHICS Evaluated Properties Using Global Database

PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110
R2DATE: 7-24-2002 TIME:08:32:19.49
SOUNDING NUMBER:CPT-03

Depth (ft)	Cone (tsf)	Norm Cone (tsf)	Friction (tsf)	Averaged Friction Ratio (%)	Generated Pore Water Pressure (tsf)	Soil Conductivity (uS/cm)	Evaluated Soil Type	Drained Friction Angle (deg)	Relative Density (%)	Nc	Undrained Shear Strength (ksf)	Undrained Large Strain Shear Strength (ksf)	SPT (N)	NORM SPT (N1')
1.0	64.9	104.6	2.63	3.4	-0.1	-4	Hard, Gravelly clayey sand to gravelly sandy silt			30	4.32	5.26	37 - 61	60 - 99
1.5	45.0	68.5	2.70	4.9	-0.3	-4	Very stiff, Sandy clay to silty clay **			30	2.99	5.39	26 - 39	40 - 60
2.0	19.3	28.2	1.58	4.8	0.1	-4	Stiff, Silty clay to clay *			20	1.92	3.16	10 - 14	15 - 20
2.5	20.1	28.3	1.20	5.6	3.8	-4	Stiff, Silty clay to clay *			25	1.59	2.39	14 - 21	20 - 30
3.0	17.8	24.5	1.01	5.3	5.6	-4	Stiff, Silty clay to clay *			20	1.77	2.03	11 - 15	15 - 20
3.5	18.3	24.6	0.93	5.3	6.5	-4	Stiff, Silty clay to clay *			20	1.81	1.85	11 - 15	15 - 20
4.0	17.9	23.5	1.05	5.8	5.3	-4	Stiff, Silty clay to clay *			20	1.77	2.10	11 - 15	15 - 20
4.5	21.8	28.0	0.97	5.2	7.5	-4	Very stiff, Silty clay to clay *			20	2.16	1.94	12 - 16	15 - 20
5.0	14.7	18.5	1.07	5.4	3.5	-4	Stiff, Silty clay to clay *			20	1.44	2.13	08 - 12	10 - 15
5.5	14.3	17.7	0.89	5.9	7.0	-4	Stiff, Silty clay to clay *			15	1.86	1.78	08 - 12	10 - 15
6.0	14.2	17.3	0.65	4.5	5.0	-4	Stiff, Silty clay to clay *			15	1.84	1.30	05 - 08	06 - 10
6.5	13.0	15.6	0.59	4.5	5.0	-4	Stiff, Silty clay to clay *			15	1.68	1.17	05 - 08	06 - 10
7.0	8.9	10.6	0.56	4.8	3.3	-4	Stiff, Silty clay to clay *			15	1.14	1.12	03 - 05	04 - 06
7.5	8.3	9.8	0.48	5.2	4.3	-4	Stiff, Silty clay to clay *			15	1.05	0.96	03 - 05	04 - 06
8.0	10.3	12.0	0.52	3.7	3.8	-4	Stiff, Silty clay to clay *			15	1.31	1.04	03 - 05	04 - 06
8.5	36.0	41.3	1.62	2.2	2.8	-4	Medium dense, Silty sand to sandy silt	27-31	40-60				09 - 13	10 - 15
9.0	138.1	156.6	6.13	2.3	-0.4	-4	Very dense, Silty sand to sandy silt	37-40	80-100				53 - 87	60 - 99
9.5	366.4	411.1	8.60	2.5	-0.4	-4	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	+100				+ 89	+ 100
10.0	321.0	356.6	6.86	2.0	-0.1	-4	Very dense, Sandy gravel to silty gravelly sand	40-42	+100				+ 90	+ 100
10.5	248.0	272.9	7.16	2.5	-0.4	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	+100				+ 91	+ 100
11.0	274.5	299.3	8.24	2.9	-0.1	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	+100				+ 92	+ 100
11.5	235.2	254.2	6.33	2.2	-0.2	-5	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	+100				+ 93	+ 100
12.0	89.2	95.5	4.77	3.3	-0.4	-5	Hard, Gravelly clayey sand to gravelly sandy silt			30	5.90	9.54	37 - 56	40 - 60
12.5	118.6	126.0	4.72	3.3	-0.5	-5	Hard, Gravelly clayey sand to gravelly sandy silt			30	7.86	9.44	56 - 93	60 - 99
13.0	286.3	301.8	5.73	1.9	-0.2	-5	Very dense, Sandy gravel to silty gravelly sand	40-42	80-100				+ 95	+ 100
13.5	343.1	358.8	9.13	2.5	-0.0	-5	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	+100				+ 96	+ 100
14.0	368.7	382.7	10.00	2.7	-0.1	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	+100				+ 96	+ 100
14.5	266.1	274.1	8.33	2.6	0.0	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	+100				+ 97	+ 100
15.0	139.5	142.7	6.22	3.2	0.1	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	8.40	12.43	+ 98	+ 100
15.5	118.7	120.6	4.89	3.9	0.3	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	7.14	9.79	+ 98	+ 100
16.0	191.0	192.7	7.77	2.6	0.1	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	+100				+ 99	+ 100
16.5	324.5	325.2	7.57	2.4	0.1	-5	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	+100				+ 100	+ 100
17.0	271.0	269.8	7.36	2.4	-0.0	-5	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	+100				+ 100	+ 100
17.5	201.3	199.8	6.89	3.1	-0.0	-5	Very dense, Gravelly silty sand to clayey gravelly sand	36-37	+100				+ 101	+ 100
18.0	256.4	253.8	9.16	3.0	-0.0	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	+100				+ 101	+ 100
18.5	347.9	343.3	7.79	2.5	0.0	-5	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	+100				+ 101	+ 100
19.0	257.4	253.2	7.68	2.5	0.1	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	+100				+ 102	+ 100
19.5	160.7	157.6	6.39	3.0	-0.0	-5	Very dense, Gravelly silty sand to clayey gravelly sand	36-37	+100				+ 102	+ 100
20.0	67.4	65.9	4.12	3.9	-0.4	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	4.41	8.24	41 - 61	40 - 60
20.5	63.7	62.1	3.25	4.8	-0.4	-5	Hard, Sandy clay to silty clay **			30	4.16	6.50	41 - 62	40 - 60
21.0	56.6	55.0	2.57	4.1	-0.4	-5	Hard, Sandy clay to silty clay *			25	4.43	5.15	31 - 41	30 - 40
21.5	42.0	40.8	2.07	4.2	-0.4	-5	Very stiff, Sandy clay to silty clay *			25	3.26	4.14	21 - 31	20 - 30
22.0	36.1	34.9	1.14	3.0	-0.5	-5	Very stiff, Sandy clay to silty clay *			25	2.78	2.28	10 - 16	10 - 15
22.5	31.7	30.6	1.34	3.7	-0.5	-5	Very stiff, Sandy clay to silty clay *			20	3.04	2.68	16 - 21	15 - 20
23.0	44.9	43.2	2.20	2.6	-0.5	-5	Very stiff, Sandy silt to sandy clay			25	3.48	4.40	16 - 21	15 - 20
23.5	133.1	127.6	3.91	3.1	-0.7	-5	Hard, Gravelly clayey sand to gravelly sandy silt			30	8.78	7.83	63 - 103	60 - 99
24.0	121.0	115.7	3.82	3.1	-0.7	-5	Hard, Gravelly clayey sand to gravelly sandy silt			30	7.97	7.64	63 - 104	60 - 99
24.5	65.3	62.3	3.63	3.6	-0.7	-5	Hard, Sandy clay to silty clay *			25	5.11	7.26	31 - 42	30 - 40
25.0	159.7	151.9	4.22	3.0	-0.7	-5	Very dense, Gravelly silty sand to clayey gravelly sand	36-37	+100				+ 105	+ 100

* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

Mixed soils containing both granular and fine grained particles (e.g. clayey sands) may undergo partial drained failure during CPT.
Both undrained and drained parameters can be estimated for these soils.

Structure rate of loading should be considered in choosing which strength parameters to use for design.
Drained and undrained parameters must not be combined as such combination will result in significant overprediction of in situ shear strength.

STRATIGRAPHICS Evaluated Properties Using Global Database

PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110
R2DATE: 7-24-2002 TIME:08:32:19.49
SOUNDING NUMBER:CPT-03

Depth (ft)	Cone (tsf)	Norm Cone (tsf)	Friction (tsf)	Averaged Friction Ratio (%)	Generated Pore Water Pressure (tsf)	Soil Conductivity (uS/cm)	Evaluated Soil Type	Drained Friction Angle (deg)	Relative Density (%)	Nc	Undrained Shear Strength (ksf)	Undrained Large Strain Shear Strength (ksf)	SPT (N)	NORM SPT (N1')
25.5	116.9	110.9	4.39	3.1	-0.6	-5	Hard, Gravelly clayey sand to gravelly sandy silt			30	7.69	8.78	63 - 104	60 - 99
26.0	55.3	52.3	2.93	3.6	-0.6	-5	Hard, Sandy clay to silty clay *			25	4.30	5.86	21 - 32	20 - 30
26.5	34.8	32.8	1.89	4.3	-0.6	-5	Very stiff, Silty clay to clay *			25	2.65	3.79	16 - 21	15 - 20
27.0	23.5	22.1	1.25	4.4	-0.6	-5	Very stiff, Silty clay to clay *			20	2.18	2.49	11 - 16	10 - 15
27.5	25.0	23.5	1.07	4.3	-0.6	-5	Very stiff, Silty clay to clay *			20	2.33	2.14	11 - 16	10 - 15
28.0	25.6	24.0	1.12	4.2	-0.6	-5	Very stiff, Silty clay to clay *			20	2.39	2.24	11 - 16	10 - 15
28.5	30.2	28.2	1.33	3.8	-0.6	-5	Very stiff, Sandy clay to silty clay *			20	2.84	2.65	11 - 16	10 - 15
29.0	35.9	33.5	1.49	3.2	-0.6	-5	Very stiff, Sandy clay to silty clay *			20	3.42	2.98	11 - 16	10 - 15
29.5	57.5	53.4	1.31	2.5	-0.6	-5	Hard, Sandy silt to sandy clay			25	4.46	2.62	22 - 32	20 - 30
30.0	36.2	33.6	1.80	3.5	-0.7	-5	Very stiff, Sandy clay to silty clay *			25	2.76	3.60	16 - 22	15 - 20
30.5	32.7	30.2	1.45	4.4	-0.6	-5	Very stiff, Silty clay to clay *			25	2.47	2.89	16 - 22	15 - 20
31.0	21.4	19.8	1.10	4.0	-0.6	-5	Stiff, Silty clay to clay *			20	1.96	2.20	07 - 11	06 - 10
31.5	15.4	14.2	0.88	5.1	5.8	-5	Stiff, Silty clay to clay *			15	1.80	1.76	07 - 11	06 - 10
32.0	14.6	13.4	0.71	5.0	5.8	-5	Stiff, Silty clay to clay *			15	1.69	1.42	07 - 11	06 - 10
32.5	14.8	13.6	0.74	4.9	5.8	-5	Stiff, Silty clay to clay *			15	1.72	1.47	07 - 11	06 - 10
33.0	14.0	12.8	0.86	2.6	5.4	-5	Stiff, Clayey silt to silty clay			15	1.61	1.71	02 - 04	02 - 04
33.5	58.5	53.4	1.06	2.6	-0.6	-5	Hard, Sandy silt to sandy clay			25	4.52	2.12	22 - 33	20 - 30
34.0	14.9	13.6	0.80	2.7	6.2	-5	Stiff, Clayey silt to silty clay			15	1.72	1.60	04 - 07	04 - 06
34.5	12.0	10.9	0.63	4.9	7.2	-5	Stiff, Silty clay to clay *			15	1.32	1.25	04 - 07	04 - 06
35.0	11.8	10.7	0.63	5.3	6.8	-5	Stiff, Silty clay to clay *			15	1.29	1.26	04 - 07	04 - 06
35.5	11.5	10.4	0.60	5.0	6.7	-5	Stiff, Silty clay to clay *			15	1.25	1.20	04 - 07	04 - 06
36.0	15.4	13.9	0.70	4.3	5.2	-5	Stiff, Silty clay to clay *			15	1.77	1.40	07 - 11	06 - 10
36.5	18.6	16.7	0.67	4.1	2.6	-5	Very stiff, Silty clay to clay *			15	2.18	1.35	07 - 11	06 - 10
37.0	11.2	10.0	0.60	4.0	7.3	-5	Stiff, Silty clay to clay *			15	1.19	1.19	04 - 07	04 - 06
37.5	22.6	20.2	1.25	2.9	6.3	-5	Very stiff, Sandy clay to silty clay *			15	2.71	2.50	07 - 11	06 - 10
38.0	96.9	86.7	2.02	2.3	1.4	-5	Dense, Silty sand to sandy silt	36-37	60-80				34 - 45	30 - 40
38.5	51.8	46.2	3.24	3.5	0.6	-5	Very stiff, Sandy clay to silty clay *			25	3.96	6.48	22 - 34	20 - 30
39.0	38.5	34.3	1.77	4.5	1.1	-5	Very stiff, Silty clay to clay *			25	2.89	3.55	22 - 34	20 - 30
39.5	36.1	32.0	1.57	4.3	0.9	-5	Very stiff, Silty clay to clay *			25	2.69	3.14	17 - 23	15 - 20
40.0	20.1	17.8	1.07	3.8	0.5	-5	Very stiff, Silty clay to clay *			15	2.36	2.14	07 - 11	06 - 10
40.5	15.4	13.6	0.64	3.5	0.8	-5	Stiff, Silty clay to clay *			15	1.73	1.28	05 - 07	04 - 06
41.0	14.5	12.8	0.63	4.2	1.1	-5	Stiff, Silty clay to clay *			15	1.61	1.27	05 - 07	04 - 06
41.5	15.7	13.8	0.62	4.0	1.5	-5	Stiff, Silty clay to clay *			15	1.76	1.24	05 - 07	04 - 06
42.0	14.6	12.8	0.62	4.1	1.9	-5	Stiff, Silty clay to clay *			15	1.61	1.24	05 - 07	04 - 06
42.5	15.4	13.5	0.68	3.9	2.4	-5	Stiff, Silty clay to clay *			15	1.72	1.36	05 - 07	04 - 06
43.0	20.8	18.2	0.68	3.3	6.4	-5	Very stiff, Sandy clay to silty clay *			15	2.43	1.36	07 - 11	06 - 10
43.5	22.0	19.2	0.50	2.6	7.6	-5	Very stiff, Sandy clay to silty clay *			15	2.59	1.01	05 - 07	04 - 06
44.0	16.5	14.4	0.73	4.0	2.2	-5	Stiff, Silty clay to clay *			15	1.85	1.46	05 - 07	04 - 06
44.5	17.6	15.3	0.88	4.7	3.3	-5	Stiff, Silty clay to clay *			15	1.99	1.76	07 - 11	06 - 10
45.0	18.6	16.2	1.27	6.5	4.8	-5	Very stiff, Silty clay to clay *			14	2.27	2.54	12 - 17	10 - 15
45.5	15.9	13.8	0.73	4.3	5.7	-5	Stiff, Silty clay to clay *			15	1.75	1.45	05 - 07	04 - 06
46.0	15.0	12.9	1.02	5.7	5.3	-5	Stiff, Silty clay to clay *			15	1.63	2.04	07 - 12	06 - 10
46.5	17.1	14.8	1.14	5.9	5.3	-5	Stiff, Silty clay to clay *			15	1.91	2.28	07 - 12	06 - 10
47.0	27.8	23.9	1.25	5.9	0.2	-5	Very stiff, Silty clay to clay *			20	2.50	2.51	17 - 23	15 - 20
47.5	15.0	12.9	0.87	4.5	-0.1	-5	Stiff, Silty clay to clay *			15	1.62	1.74	05 - 07	04 - 06
48.0	17.1	14.7	0.94	5.7	0.4	-5	Stiff, Silty clay to clay *			15	1.90	1.88	07 - 12	06 - 10
48.5	14.3	12.3	0.72	4.8	0.6	-5	Stiff, Silty clay to clay *			15	1.52	1.44	05 - 07	04 - 06
49.0	13.2	11.3	1.14	3.4	0.9	-5	Stiff, Silty clay to clay *			15	1.37	2.28	05 - 07	04 - 06
49.5	104.2	89.0	4.70	4.7	0.7	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	6.75	9.41	70 - 116	60 - 99
50.0	79.6	67.8	5.56	6.1	-0.8	-5	Hard, Sandy clay to silty clay **			30	5.11	11.12	70 - 116	60 - 99

* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

Mixed soils containing both granular and fine grained particles (e.g. clayey sands) may undergo partial drained failure during CPT.
Both undrained and drained parameters can be estimated for these soils.

Structure rate of loading should be considered in choosing which strength parameters to use for design.
Drained and undrained parameters must not be combined as such combination will result in significant overprediction of in situ shear strength.

STRATIGRAPHICS Evaluated Properties Using Global Database

PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110
R2DATE: 7-24-2002 TIME:08:32:19.49
SOUNDING NUMBER:CPT-03

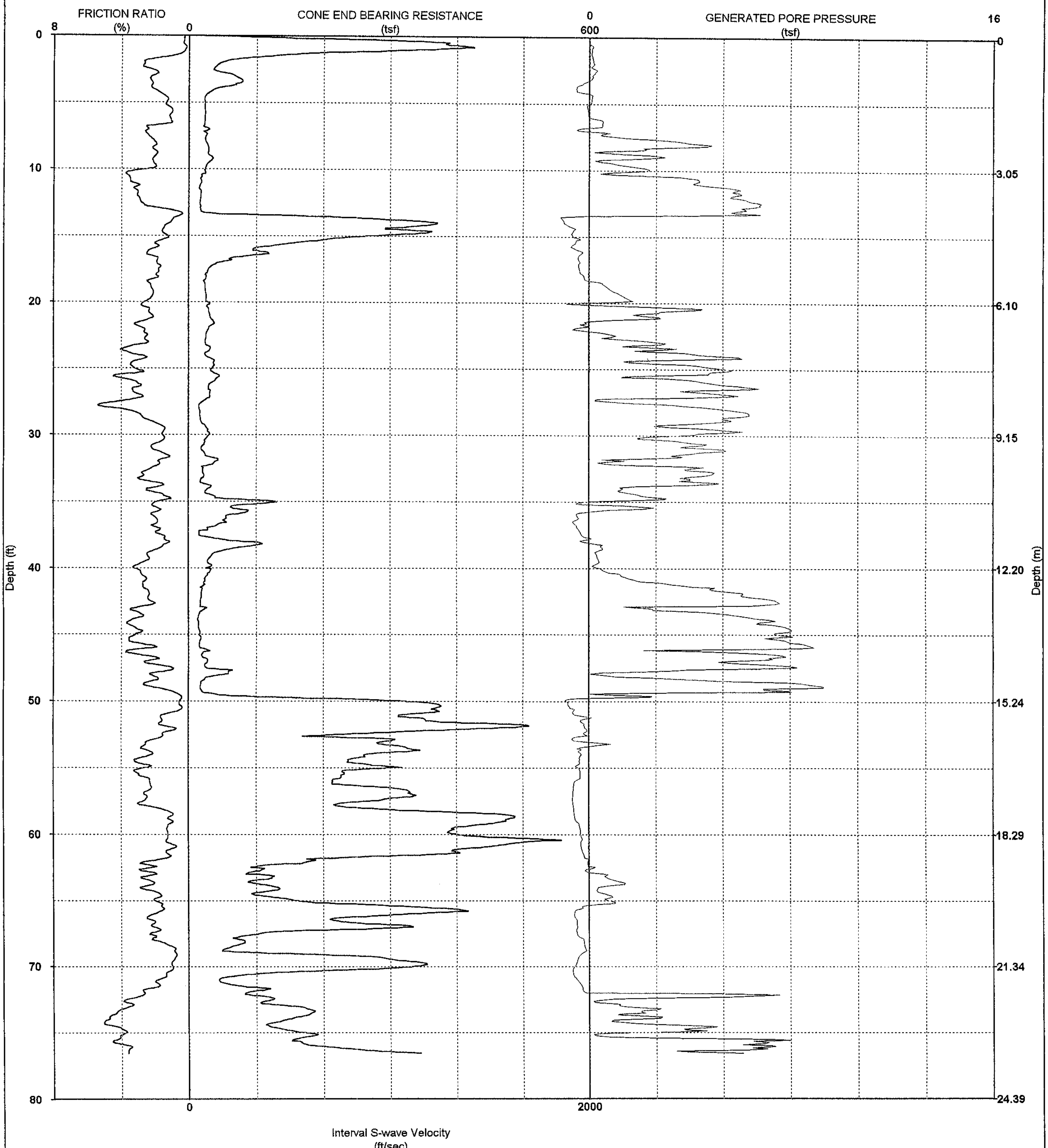
Depth (ft)	Cone (tsf)	Norm Cone (tsf)	Friction (tsf)	Averaged Friction Ratio (%)	Generated Pore Water Pressure (tsf)	Soil Conductivity (uS/cm)	Evaluated Soil Type	Drained Friction Angle (deg)	Relative Density (%)	Nc	Undrained Shear Strength (ksf)	Undrained Large Strain Shear Strength (ksf)	SPT (N)	NORM SPT (N1')
50.5	73.0	62.1	3.48	4.2	-0.7	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	4.67	6.96	47 - 71	40 - 60
51.0	144.6	122.8	3.29	3.2	-0.2	-5	Hard, Gravelly clayey sand to gravelly sandy silt			30	9.44	6.58	71 - 117	60 - 99
51.5	95.3	80.8	6.83	3.0	-0.3	-5	Hard, Sandy silt to sandy clay			30	6.15	13.67	47 - 71	40 - 60
52.0	301.9	255.3	11.64	4.1	-0.5	-5	Hard, Gravelly clayey sand to gravelly sandy clay			33	18.11	23.28	+ 118	+ 100
52.5	306.3	258.6	12.02	3.0	-0.4	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	+100				+ 118	+ 100
53.0	518.4	436.8	8.21	1.5	-0.3	-5	Very dense, Sandy gravel to silty gravelly sand	42-46	+100				+ 119	+ 100
53.5	626.8	527.2	9.46	1.4	-0.2	-5	Very dense, Sandy gravel to silty gravelly sand	42-46	+100				+ 119	+ 100

* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

Mixed soils containing both granular and fine grained particles (e.g. clayey sands) may undergo partial drained failure during CPT.
Both undrained and drained parameters can be estimated for these soils.

Structure rate of loading should be considered in choosing which strength parameters to use for design.
Drained and undrained parameters must not be combined as such combination will result in significant overprediction of in situ shear strength.

CPTU-S LOG



PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110

STRATIGRAPHICS

R2DATE: 7-23-2002 TIME:17:32:39.15
SOUNDING NUMBER:CPT-04

STRATIGRAPHICS Evaluated Properties Using Global Database

PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110
R2DATE: 7-23-2002 TIME:17:32:39.15
SOUNDING NUMBER:CPT-04

Depth (ft)	Cone (tsf)	Norm Cone (tsf)	Friction (tsf)	Averaged Friction Ratio (%)	Generated Pore Water Pressure (tsf)	Soil Conductivity (uS/cm)	Evaluated Soil Type	Drained Friction Angle (deg)	Relative Density (%)	Nc	Undrained Shear Strength (ksf)	Undrained Large Strain Shear Strength (ksf)	SPT (N)	NORM SPT (N1')
1.0	356.6	574.5	0.92	0.2	0.1	-5	Very dense, Sandy gravel to gravelly sand	+46	80-100				37 - 61	60 - 99
1.5	127.3	193.9	1.93	0.9	0.1	-5	Dense, Sand to silty sand	42-46	60-80				26 - 39	40 - 60
2.0	49.8	72.8	2.08	2.6	0.2	-5	Dense, Silty sand to sandy silt	27-31	60-80				14 - 21	20 - 30
2.5	36.4	51.4	1.10	2.3	0.3	-5	Dense, Silty sand to sandy silt	27-31	60-80				11 - 14	15 - 20
3.0	67.5	92.6	1.61	2.1	0.1	-5	Dense, Silty sand to sandy silt	37-40	60-80				22 - 29	30 - 40
3.5	77.0	103.1	1.62	2.2	-0.3	-5	Dense, Silty sand to sandy silt	37-40	60-80				30 - 45	40 - 60
4.0	37.9	49.6	1.21	2.1	-0.5	-5	Medium dense, Silty sand to sandy silt	27-31	40-60				11 - 15	15 - 20
4.5	24.2	31.1	0.43	1.4	0.1	-5	Loose, Silty sand to sandy silt	27-31	20-40				05 - 08	06 - 10
5.0	23.4	29.5	0.31	1.3	0.0	-5	Loose, Silty sand to sandy silt	27-31	20-40				03 - 05	04 - 06
5.5	23.2	28.8	0.23	1.0	-0.1	-5	Loose, Silty sand to sandy silt	31-36	20-40				03 - 05	04 - 06
6.0	23.6	28.8	0.28	1.2	-0.0	-5	Loose, Silty sand to sandy silt	27-31	20-40				03 - 05	04 - 06
6.5	22.7	27.3	0.24	1.0	0.5	-5	Loose, Silty sand to sandy silt	31-36	20-40				03 - 05	04 - 06
7.0	29.4	34.9	0.59	2.4	-0.5	-5	Very stiff, Sandy silt to sandy clay			20	2.90	1.18	08 - 13	10 - 15
7.5	25.2	29.6	0.63	2.4	1.1	-5	Very stiff, Sandy silt to sandy clay			20	2.48	1.25	05 - 09	06 - 10
8.0	24.9	28.9	0.55	2.0	4.4	-5	Very stiff, Sandy silt to sandy clay			20	2.44	1.10	05 - 09	06 - 10
8.5	28.7	32.9	0.62	2.1	1.8	-5	Very stiff, Sandy silt to sandy clay			20	2.82	1.25	05 - 09	06 - 10
9.0	31.0	35.1	0.65	2.0	2.8	-5	Medium dense, Silty sand to sandy silt	27-31	40-60				05 - 09	06 - 10
9.5	29.0	32.5	0.69	2.1	1.0	-5	Very stiff, Sandy silt to sandy clay			20	2.84	1.38	05 - 09	06 - 10
10.0	23.0	25.6	0.59	2.5	2.4	-5	Very stiff, Sandy silt to sandy clay			20	2.24	1.18	05 - 09	06 - 10
10.5	18.1	19.9	0.77	3.6	3.7	-5	Stiff, Silty clay to clay *			20	1.74	1.55	05 - 09	06 - 10
11.0	18.3	20.0	0.63	3.4	4.2	-5	Stiff, Sandy clay to silty clay *			20	1.77	1.25	06 - 09	06 - 10
11.5	15.7	16.9	0.56	3.2	5.8	-5	Stiff, Sandy clay to silty clay *			15	2.00	1.11	04 - 06	04 - 06
12.0	17.3	18.5	0.54	3.1	5.6	-5	Very stiff, Sandy clay to silty clay *			15	2.21	1.08	04 - 06	04 - 06
12.5	16.1	17.1	0.48	2.8	6.8	-5	Very stiff, Sandy clay to silty clay *			15	2.04	0.96	04 - 06	04 - 06
13.0	17.1	18.0	0.57	1.4	6.1	-5	Loose, Silty sand to sandy silt	27-31	20-40				02 - 04	02 - 04
13.5	156.9	164.1	1.56	0.6	-0.9	-5	Medium dense, Sand to silty sand	42-46	40-60				29 - 38	30 - 40
14.0	371.6	385.6	3.68	1.1	-1.0	-5	Very dense, Sand to silty sand	42-46	80-100				+ 96	+ 100
14.5	303.2	312.4	5.16	1.5	-0.6	-5	Very dense, Sandy gravel to silty gravelly sand	42-46	80-100				+ 97	+ 100
15.0	267.9	274.0	3.98	1.3	-0.7	-5	Dense, Sand to silty sand	42-46	60-80				59 - 97	60 - 99
15.5	159.8	162.3	4.19	2.0	-0.6	-5	Very dense, Silty sand to sandy silt	40-42	80-100				39 - 59	40 - 60
16.0	94.3	95.2	2.70	2.2	-0.5	-5	Dense, Silty sand to sandy silt	37-40	60-80				30 - 40	30 - 40
16.5	89.1	89.3	2.38	2.2	-0.5	-5	Dense, Silty sand to sandy silt	37-40	60-80				30 - 40	30 - 40
17.0	44.9	44.7	1.20	1.9	-0.4	-5	Medium dense, Silty sand to sandy silt	27-31	40-60				10 - 15	10 - 15
17.5	28.7	28.5	0.66	1.8	-0.4	-5	Medium dense, Silty sand to sandy silt	27-31	40-60				06 - 10	06 - 10
18.0	26.0	25.7	0.52	1.9	-0.2	-5	Very stiff, Sandy silt to sandy clay			20	2.49	1.04	04 - 06	04 - 06
18.5	22.9	22.6	0.58	2.4	0.5	-5	Very stiff, Sandy silt to sandy clay			20	2.18	1.16	06 - 10	06 - 10
19.0	24.2	23.8	0.54	2.2	0.8	-5	Very stiff, Sandy silt to sandy clay			20	2.31	1.08	04 - 06	04 - 06
19.5	25.6	25.1	0.56	2.1	1.4	-5	Very stiff, Sandy silt to sandy clay			20	2.44	1.11	06 - 10	06 - 10
20.0	28.2	27.6	0.76	2.7	-0.7	-5	Very stiff, Sandy silt to sandy clay			20	2.70	1.52	06 - 10	06 - 10
20.5	29.1	28.4	0.67	2.3	4.2	-5	Very stiff, Sandy silt to sandy clay			20	2.79	1.34	06 - 10	06 - 10
21.0	31.0	30.1	0.71	2.1	2.4	-5	Very stiff, Sandy silt to sandy clay			20	2.97	1.42	06 - 10	06 - 10
21.5	37.0	35.9	0.97	2.9	-0.1	-5	Very stiff, Sandy silt to sandy clay			25	2.86	1.94	10 - 15	10 - 15
22.0	29.3	28.3	0.86	2.6	-0.7	-5	Very stiff, Sandy silt to sandy clay			20	2.79	1.72	06 - 10	06 - 10
22.5	25.2	24.3	0.63	2.4	1.0	-5	Very stiff, Sandy silt to sandy clay			20	2.39	1.26	06 - 10	06 - 10
23.0	23.8	22.9	0.63	2.4	2.9	-5	Very stiff, Sandy silt to sandy clay			20	2.24	1.25	06 - 10	06 - 10
23.5	31.7	30.4	1.10	3.9	3.0	-5	Very stiff, Sandy clay to silty clay *			20	3.03	2.19	16 - 21	15 - 20
24.0	23.8	22.7	0.93	3.0	5.2	-5	Very stiff, Sandy clay to silty clay *			20	2.23	1.86	06 - 10	06 - 10
24.5	36.9	35.2	1.20	3.3	1.8	-5	Very stiff, Sandy clay to silty clay *			25	2.83	2.40	16 - 21	15 - 20
25.0	33.9	32.2	1.18	3.2	5.5	-5	Very stiff, Sandy clay to silty clay *			20	3.24	2.36	11 - 16	10 - 15

* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

Mixed soils containing both granular and fine grained particles (e.g. clayey sands) may undergo partial drained failure during CPT.
Both undrained and drained parameters can be estimated for these soils.

Structure rate of loading should be considered in choosing which strength parameters to use for design.
Drained and undrained parameters must not be combined as such combination will result in significant overprediction of in situ shear strength.

STRATIGRAPHICS Evaluated Properties Using Global Database

PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110
R2DATE: 7-23-2002 TIME:17:32:39.15
SOUNDING NUMBER:CPT-04

Depth (ft)	Cone (tsf)	Norm Cone (tsf)	Friction (tsf)	Averaged Friction Ratio (%)	Generated Pore Water Pressure (tsf)	Soil Conductivity (uS/cm)	Evaluated Soil Type	Drained Friction Angle (deg)	Relative Density (%)	Nc	Undrained Shear Strength (ksf)	Undrained Large Strain Shear Strength (ksf)	SPT (N)	NORM SPT (N1')
25.5	44.4	42.1	1.84	4.3	1.8	-5	Very stiff, Silty clay to clay *			25	3.43	3.68	21 - 32	20 - 30
26.0	36.0	34.0	1.24	3.1	4.7	-5	Very stiff, Sandy clay to silty clay *			25	2.75	2.48	11 - 16	10 - 15
26.5	28.7	27.1	1.05	3.3	5.8	-5	Very stiff, Sandy clay to silty clay *			20	2.71	2.09	11 - 16	10 - 15
27.0	30.9	29.0	0.86	2.8	5.7	-5	Very stiff, Sandy clay to silty clay *			20	2.92	1.72	11 - 16	10 - 15
27.5	20.0	18.8	1.14	4.2	1.3	-5	Very stiff, Silty clay to clay *			15	2.45	2.29	06 - 11	06 - 10
28.0	15.3	14.3	0.69	4.4	5.3	-5	Stiff, Silty clay to clay *			15	1.81	1.38	06 - 11	06 - 10
28.5	16.3	15.2	0.48	2.8	6.3	-5	Stiff, Sandy clay to silty clay *			15	1.95	0.95	04 - 06	04 - 06
29.0	17.9	16.7	0.48	2.2	4.9	-5	Very stiff, Sandy silt to clayey silt			15	2.16	0.95	04 - 06	04 - 06
29.5	26.8	25.0	0.40	1.4	4.9	-5	Loose, Silty sand to sandy silt	27-31	20-40				04 - 06	04 - 06
30.0	30.0	27.8	0.46	1.6	3.4	-5	Loose, Silty sand to sandy silt	27-31	20-40				04 - 06	04 - 06
30.5	23.8	22.0	0.42	1.6	3.8	-5	Loose, Silty sand to sandy silt	27-31	20-40				04 - 06	04 - 06
31.0	18.1	16.7	0.48	2.2	5.0	-5	Very stiff, Sandy silt to clayey silt			15	2.16	0.96	04 - 07	04 - 06
31.5	24.2	22.3	0.45	1.3	3.4	-5	Loose, Silty sand to sandy silt	27-31	20-40				04 - 07	04 - 06
32.0	39.8	36.6	0.64	1.8	0.8	-5	Medium dense, Silty sand to sandy silt	27-31	40-60				07 - 11	06 - 10
32.5	21.0	19.3	0.68	2.2	4.1	-5	Very stiff, Sandy silt to sandy clay			15	2.54	1.36	04 - 07	04 - 06
33.0	22.1	20.2	0.55	2.7	4.7	-5	Very stiff, Sandy clay to silty clay *			15	2.68	1.10	04 - 07	04 - 06
33.5	17.0	15.5	0.58	2.3	4.4	-5	Stiff, Clayey silt to silty clay			15	1.99	1.17	04 - 07	04 - 06
34.0	30.6	27.8	0.62	2.2	1.3	-5	Very stiff, Sandy silt to sandy clay			20	2.86	1.24	07 - 11	06 - 10
34.5	32.1	29.1	0.89	1.5	2.0	-5	Loose, Silty sand to sandy silt	27-31	20-40				04 - 07	04 - 06
35.0	127.4	115.4	1.77	1.8	-0.1	-5	Dense, Silty sand to sandy silt	37-40	60-80				44 - 66	40 - 60
35.5	65.3	59.0	1.61	1.8	2.2	-5	Medium dense, Silty sand to sandy silt	36-37	40-60				17 - 22	15 - 20
36.0	58.7	53.0	1.70	2.2	-0.5	-5	Dense, Silty sand to sandy silt	27-31	60-80				17 - 22	15 - 20
36.5	54.1	48.7	1.02	1.8	-0.6	-5	Medium dense, Silty sand to sandy silt	36-37	40-60				11 - 17	10 - 15
37.0	27.5	24.7	0.68	1.7	-0.5	-5	Loose, Silty sand to sandy silt	27-31	20-40				04 - 07	04 - 06
37.5	15.1	13.5	0.58	1.6	-0.3	-5	Stiff, Sandy silt to clayey silt			15	1.71	1.16	00 - 02	00 - 02
38.0	78.8	70.4	0.99	1.1	-0.3	-5	Medium dense, Sand to silty sand	37-40	40-60				17 - 22	15 - 20
38.5	69.2	61.7	1.56	1.7	0.5	-5	Medium dense, Silty sand to sandy silt	36-37	40-60				17 - 22	15 - 20
39.0	34.3	30.5	1.17	2.5	0.3	-5	Very stiff, Sandy silt to sandy clay			20	3.19	2.35	07 - 11	06 - 10
39.5	27.5	24.5	0.81	2.6	0.4	-5	Very stiff, Sandy silt to sandy clay			20	2.52	1.62	07 - 11	06 - 10
40.0	25.5	22.6	0.99	3.2	0.5	-5	Very stiff, Sandy clay to silty clay *			20	2.31	1.98	07 - 11	06 - 10
40.5	27.8	24.6	0.82	2.8	1.3	-5	Very stiff, Sandy clay to silty clay *			20	2.54	1.65	07 - 11	06 - 10
41.0	23.0	20.3	0.67	2.7	2.4	-5	Very stiff, Sandy clay to silty clay *			15	2.74	1.33	05 - 07	04 - 06
41.5	20.0	17.6	0.56	2.6	4.9	-5	Very stiff, Sandy clay to silty clay *			15	2.33	1.12	05 - 07	04 - 06
42.0	18.6	16.4	0.44	2.3	6.0	-5	Very stiff, Clayey silt to silty clay			15	2.15	0.88	05 - 07	04 - 06
42.5	17.3	15.1	0.42	2.2	7.5	-5	Stiff, Clayey silt to silty clay			15	1.96	0.84	02 - 05	02 - 04
43.0	25.4	22.2	0.67	3.3	2.3	-5	Very stiff, Sandy clay to silty clay *			20	2.28	1.34	07 - 11	06 - 10
43.5	14.7	12.8	0.53	2.7	5.7	-5	Stiff, Clayey silt to silty clay			15	1.61	1.05	02 - 05	02 - 04
44.0	14.8	12.9	0.51	3.5	7.1	-5	Stiff, Silty clay to clay *			15	1.63	1.02	05 - 07	04 - 06
44.5	14.4	12.5	0.50	3.2	7.9	-5	Stiff, Sandy clay to silty clay *			15	1.56	1.00	05 - 07	04 - 06
45.0	15.9	13.8	0.53	3.2	7.5	-5	Stiff, Sandy clay to silty clay *			15	1.76	1.07	05 - 07	04 - 06
45.5	16.4	14.2	0.62	3.5	7.9	-5	Stiff, Silty clay to clay *			15	1.82	1.23	05 - 07	04 - 06
46.0	16.4	14.2	0.45	2.1	8.3	-5	Stiff, Sandy silt to clayey silt			15	1.82	0.90	02 - 05	02 - 04
46.5	18.9	16.3	0.72	3.1	7.4	-5	Very stiff, Sandy clay to silty clay *			15	2.15	1.45	05 - 07	04 - 06
47.0	27.7	23.9	0.66	2.5	5.4	-5	Very stiff, Sandy silt to sandy clay			20	2.49	1.32	07 - 12	06 - 10
47.5	26.4	22.7	0.47	1.0	7.0	-5	Loose, Silty sand to sandy silt	31-36	20-40				05 - 07	04 - 06
48.0	52.0	44.7	1.19	2.3	0.3	-5	Medium dense, Silty sand to sandy silt	27-31	40-60				17 - 23	15 - 20
48.5	20.2	17.3	0.66	2.2	5.9	-5	Very stiff, Sandy silt to clayey silt			15	2.30	1.32	05 - 07	04 - 06
49.0	16.8	14.4	0.42	1.9	8.1	-5	Stiff, Sandy silt to clayey silt			15	1.85	0.83	02 - 05	02 - 04
49.5	41.8	35.6	0.94	0.6	0.8	-5	Loose, Sand to silty sand	36-37	20-40				05 - 07	04 - 06
50.0	324.8	276.7	2.02	0.6	-0.9	-5	Dense, Sand to silty sand	42-46	60-80				47 - 70	40 - 60

* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

Mixed soils containing both granular and fine grained particles (e.g. clayey sands) may undergo partial drained failure during CPT.
Both undrained and drained parameters can be estimated for these soils.

Structure rate of loading should be considered in choosing which strength parameters to use for design.
Drained and undrained parameters must not be combined as such combination will result in significant overprediction of in situ shear strength.

STRATIGRAPHICS Evaluated Properties Using Global Database

PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110
R2DATE: 7-23-2002 TIME:17:32:39.15
SOUNDING NUMBER:CPT-04

Depth (ft)	Cone (tsf)	Norm Cone (tsf)	Friction (tsf)	Averaged Friction Ratio (%)	Generated Pore Water Pressure (tsf)	Soil Conductivity (uS/cm)	Evaluated Soil Type	Drained Friction Angle (deg)	Relative Density (%)	Nc	Undrained Shear Strength (ksf)	Undrained Large Strain Shear Strength (ksf)	SPT (N)	NORM SPT (N1')
50.5	368.5	313.4	1.35	0.4	-0.8	-5	Dense, Sandy gravel to gravelly sand	+46	60-80				47 - 71	40 - 60
51.0	318.8	270.6	5.41	1.5	-0.6	-5	Very dense, Sand to silty sand	42-46	80-100				71 - 117	60 - 99
51.5	368.9	312.5	7.11	1.6	-0.3	-5	Very dense, Sandy gravel to silty gravelly sand	42-46	80-100				+ 118	+ 100
52.0	456.7	386.2	3.50	0.9	-0.2	-5	Very dense, Sand to silty sand	42-46	80-100				71 - 117	60 - 99
52.5	224.7	189.7	4.78	1.6	-0.2	-5	Dense, Sand to silty sand	40-42	60-80				47 - 71	40 - 60
53.0	295.8	249.2	7.28	2.4	-0.4	-5	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	+100				+ 119	+ 100
53.5	326.3	274.4	8.98	2.8	-0.4	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	+100				+ 119	+ 100
54.0	263.6	221.4	6.55	2.2	-0.3	-5	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	80-100				+ 119	+ 100
54.5	237.5	199.1	8.69	3.2	-0.4	-5	Very dense, Gravelly silty sand to clayey gravelly sand	36-37	+100				+ 119	+ 100
55.0	301.5	252.2	7.24	2.6	-0.4	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	+100				+ 120	+ 100
55.5	227.9	190.3	7.18	3.0	-0.4	-5	Very dense, Gravelly silty sand to clayey gravelly sand	36-37	+100				+ 120	+ 100
56.0	214.6	178.9	5.72	2.3	-0.6	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	80-100				72 - 119	60 - 99
56.5	305.4	254.2	7.07	2.2	-0.6	-5	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	+100				+ 120	+ 100
57.0	336.7	279.7	8.38	2.6	-0.7	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	+100				+ 120	+ 100
57.5	260.2	215.8	8.18	2.7	-0.7	-5	Very dense, Gravelly silty sand to clayey gravelly sand	37-40	+100				+ 121	+ 100
58.0	256.3	212.2	6.57	1.8	-0.6	-5	Very dense, Silty sand to sandy silt	40-42	80-100				72 - 120	60 - 99
58.5	471.9	390.0	4.26	0.9	-0.6	-5	Very dense, Sand to silty sand	42-46	80-100				+ 121	+ 100
59.0	471.0	388.6	4.07	0.9	-0.5	-5	Very dense, Sand to silty sand	42-46	80-100				+ 121	+ 100
59.5	393.9	324.4	5.65	1.3	-0.4	-5	Very dense, Sand to silty sand	42-46	80-100				+ 121	+ 100
60.0	401.7	330.3	5.89	1.2	-0.3	-5	Very dense, Sand to silty sand	42-46	80-100				+ 122	+ 100
60.5	513.6	421.6	6.68	1.3	-0.3	-5	Very dense, Sandy gravel to silty gravelly sand	42-46	80-100				+ 122	+ 100
61.0	424.9	348.2	3.89	0.9	-0.3	-5	Dense, Sand to silty sand	42-46	60-80				73 - 121	60 - 99
61.5	358.4	293.2	4.57	1.2	-0.2	-5	Dense, Sand to silty sand	42-46	60-80				73 - 121	60 - 99
62.0	180.8	147.7	5.88	2.4	-0.1	-5	Very dense, Silty sand to sandy silt	37-40	80-100				73 - 121	60 - 99
62.5	97.2	79.2	2.79	2.2	0.2	-5	Dense, Silty sand to sandy silt	36-37	60-80				25 - 37	20 - 30
63.0	98.6	80.2	2.15	2.0	0.6	-5	Dense, Silty sand to sandy silt	37-40	60-80				25 - 37	20 - 30
63.5	91.8	74.6	2.48	2.2	1.1	-5	Dense, Silty sand to sandy silt	36-37	60-80				25 - 37	20 - 30
64.0	133.6	108.4	3.54	2.9	0.3	-5	Very dense, Silty sand to sandy silt	36-37	80-100				49 - 74	40 - 60
64.5	94.7	76.8	2.16	1.7	0.6	-5	Medium dense, Silty sand to sandy silt	37-40	40-60				25 - 37	20 - 30
65.0	161.4	130.5	5.00	2.0	0.8	-5	Dense, Silty sand to sandy silt	37-40	60-80				49 - 74	40 - 60
65.5	354.5	286.3	5.73	1.5	-0.3	-5	Very dense, Sand to silty sand	42-46	80-100				+ 124	+ 100
66.0	318.5	256.8	7.87	2.1	-0.6	-5	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	80-100				+ 124	+ 100
66.5	218.2	175.6	5.55	2.1	-0.5	-5	Very dense, Silty sand to sandy silt	40-42	80-100				75 - 123	60 - 99
67.0	323.0	259.6	5.48	2.0	-0.5	-5	Very dense, Gravelly silty sand to clayey gravelly sand	40-42	80-100				+ 124	+ 100
67.5	103.7	83.2	4.62	2.3	-0.5	-5	Dense, Silty sand to sandy silt	36-37	60-80				37 - 50	30 - 40
68.0	82.2	65.8	1.64	2.0	-0.2	-5	Dense, Silty sand to sandy silt	36-37	60-80				25 - 37	20 - 30
68.5	62.8	50.2	0.76	1.0	-0.2	-5	Loose, Silty sand to sandy silt	37-40	20-40				08 - 13	06 - 10
69.0	140.5	112.2	1.76	0.7	-0.3	-5	Medium dense, Sand to silty sand	40-42	40-60				25 - 38	20 - 30
69.5	307.4	245.1	2.98	0.9	-0.5	-5	Dense, Sand to silty sand	42-46	60-80				50 - 75	40 - 60
70.0	332.6	264.8	3.27	1.0	-0.6	-5	Dense, Sand to silty sand	42-46	60-80				75 - 124	60 - 99
70.5	115.4	91.7	3.10	1.3	-0.7	-5	Medium dense, Silty sand to sandy silt	37-40	40-60				25 - 38	20 - 30
71.0	44.4	35.3	1.28	1.9	-0.5	-5	Medium dense, Silty sand to sandy silt	27-31	40-60				08 - 13	06 - 10
71.5	82.0	65.0	1.67	1.8	-0.3	-5	Medium dense, Silty sand to sandy silt	36-37	40-60				19 - 25	15 - 20
72.0	83.3	65.9	2.68	2.6	-0.2	-5	Dense, Silty sand to sandy silt	27-31	60-80				25 - 38	20 - 30
72.5	124.1	98.1	4.51	3.7	0.9	-5	Hard, Gravelly clayey sand to gravelly sandy silt			30	7.98	9.03	76 - 125	60 - 99
73.0	156.7	123.7	6.15	3.5	1.3	-5	Hard, Gravelly clayey sand to gravelly sandy silt			30	10.16	12.30	76 - 125	60 - 99
73.5	182.5	143.7	7.52	4.3	2.2	-5	Hard, Gravelly sandy clay to gravelly silty clay **			33	10.79	15.05	+ 127	+ 100
74.0	145.7	114.6	7.80	4.8	1.9	-5	Hard, Gravelly sandy clay to gravelly silty clay **			33	8.56	15.60	+ 127	+ 100
74.5	118.8	93.3	6.13	4.4	4.2	-5	Hard, Gravelly sandy clay to gravelly silty clay **			30	7.62	12.25	76 - 126	60 - 99
75.0	170.4	133.6	6.47	3.7	2.2	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	10.05	12.94	+ 128	+ 100

* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

Mixed soils containing both granular and fine grained particles (e.g. clayey sands) may undergo partial drained failure during CPT.
Both undrained and drained parameters can be estimated for these soils.

Structure rate of loading should be considered in choosing which strength parameters to use for design.
Drained and undrained parameters must not be combined as such combination will result in significant overprediction of in situ shear strength.

STRATIGRAPHICS Evaluated Properties Using Global Database
PROJECT NAME:CPS-EPS Field Exploration
PROJECT NUMBER:02-120-110
R2DATE: 7-23-2002 TIME:17:32:39.15
SOUNDING NUMBER:CPT-04

Depth (ft)	Cone (tsf)	Norm Cone (tsf)	Friction (tsf)	Averaged Friction Ratio (%)	Generated Pore Water Pressure (tsf)	Soil Conductivity (uS/cm)	Evaluated Soil Type	Drained Friction Angle (deg)	Relative Density (%)	Nc	Undrained Shear Strength (ksf)	Undrained Large Strain Shear Strength (ksf)	SPT (N)	NORM SPT (N1')
75.5	156.1	122.2	7.34	4.2	6.1	-5	Hard, Gravelly sandy clay to gravelly silty clay **			33	9.18	14.68	+ 128	+ 100
76.0	189.1	147.8	8.11	3.4	7.3	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	11.18	16.22	+ 128	+ 100
76.5	316.8	247.3	10.50	3.6	4.5	-5	Hard, Gravelly clayey sand to gravelly sandy silt			33	18.92	21.00	+ 128	+ 100

* Indicates lightly overconsolidated soil
** Indicates heavily overconsolidated or cemented soil

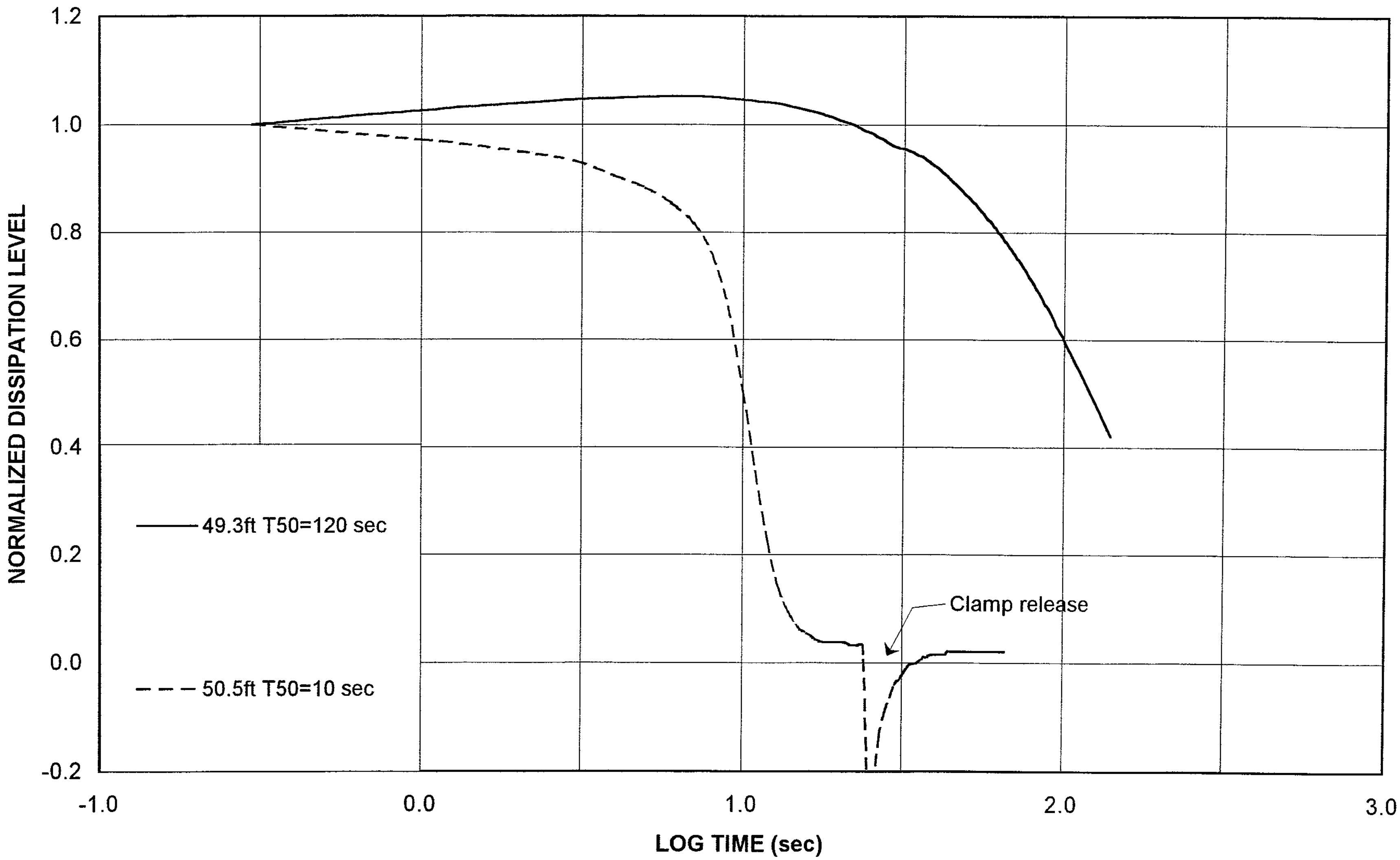
Mixed soils containing both granular and fine grained particles (e.g. clayey sands) may undergo partial drained failure during CPT.
Both undrained and drained parameters can be estimated for these soils.

Structure rate of loading should be considered in choosing which strength parameters to use for design.
Drained and undrained parameters must not be combined as such combination will result in significant overprediction of in situ shear strength.

STRATIGRAPHICS

PORE WATER PRESSURE DISSIPATION TEST

CPS-EPS Field Exploration CPT-04



APPENDIX A

TABLE OF CONTENTS

A1.0 EVALUATION OF GEOTECHNICAL PARAMETERS A1

- A1.1 Soil Behavior Types A1
- A1.2 Relative Density A1
- A1.3 Static Drained Strength A1
- A1.4 Static Undrained Strength A1
- A1.5 Evaluation of Stress History A2
- A1.6 SPT Blowcount Values A2

A2.0 OVERBURDEN PRESSURE NORMALIZATION A3

A3.0 TEST DRAINAGE CONDITIONS A3

A4.0 RECOMMENDED PRACTICES A3

1.0 EVALUATION OF GEOTECHNICAL PARAMETERS

CPT data have been correlated with soil type, drained friction angle, undrained shear strength, relative density, and equivalent SPT blowcounts, among others. Correlations have been developed by comparing CPT results to laboratory tests on drilled samples and to other in situ tests, such as vane and pressuremeter. Laboratory CPT testing on large scale samples of known composition and classical bearing capacity and cavity expansion theory have also been used. Site specific information, where available, can be used to fine tune correlations.

A two parameter correlation scheme has proved useful for CPT data evaluation. Geotechnical properties often exhibit well defined trends when plotted against the logarithm of the CPT cone end bearing resistance and friction ratio. For instance, increased grain size increases cone end bearing resistance, while increased plasticity and compressibility increase friction ratio. A chart illustrating these and other trends is presented in Figure A2. A discussion of CPT data evaluation is presented in Douglas and Olsen, 1981.

<u>A1.1 CPT Soil Behavior Types</u> CPT soil behavior type correlations (Figure A3) have been developed from geotechnical theory and comparisons of borehole data with CPT data (Douglas and Olsen, 1981). The CPT soil type tabulations are indicative of the response of the soil to the large shear deformations imposed on the soil during penetrometer advance. Soil shear response is not entirely controlled by grain size distribution. However, it has been found that CPT soil types generally agree with classifications based on soil grain size distribution methods such as the Unified Soil Classification System (USCS).

<u>A1.2 CPT Relative Density</u> Relative densities of granular soils are correlated with CPT data (Figure A4) on the basis of laboratory CPT on large scale samples of known composition (Schmertmann, 1978, and Villet and Mitchell, 1981). The effect of soil fines content has been empirically accounted for by extrapolating trends in the two parameter correlation model (Douglas and Strutynsky, 1984).

<u>A1.3 CPT Drained Static Strength</u> Drained friction angles have been correlated with CPT data (Figure A4) on the basis of CPT soundings and laboratory tests on drilled samples, and on theoretical analyses of the cone end bearing capacity problem (Schmertmann, 1978, Durgunoglu and Mitchell, 1974, and Villet and Mitchell, 1981). The effect of soil fines content on friction angles has been accounted for by extrapolating trends in the two parameter correlation model, as was done for the relative density correlation.

<u>A1.4 CPT Undrained Static Strength</u> The correlation between CPT data and undrained shear strength has been extensively studied (Douglas and others, 1984, Lunne and others, 1976, Sanglerat, 1972, and Schmertmann, 1978). The following bearing capacity equation can be used for computing undrained shear strength from CPT data: qu = (Su * Nc) + Sv (Eq. A1); where: qu = ultimate bearing capacity; Su = undrained shear strength; Nc = a dimensionless bearing capacity factor; and Sv = the estimated total vertical stress. By setting qu equal to the cone end bearing resistance, qc, and rearranging the equation, a value of the undrained shear strength can be computed as: Su = (qc - Sv) / Nk (Nk is equivalent to Nc in Eq. A1) (Eq. A2).

The primary difficulty in using this equation has been the selection of Nk applicable to cone penetration in a particular soil. Bearing capacity and cavity expansion theory and other in situ and laboratory test results performed adjacent to CPT soundings have been used to calculate Nk values. These Nk values have ranged from 5 to over 25, but are most often between about 12 and 20. Higher Nk values are typically associated with overconsolidated clays and lower plasticity clays and clayey silts.

A compilation of Nk values as a function of cone end bearing resistance and friction ratio is presented in Figure A5. This figure was developed from comparisons of CPT to results of laboratory consolidated-undrained (CU) strength tests. This is important to note as undrained shear strength is not a unique property of a soil - it is test type and stress path dependent.

Many design methodologies are based on a particular strength test on a particular type of sample. These semi-empirical design methods are successfully used by experienced designers. Engineering judgment must be applied in using the results of any type of testing to assure both adequate safety and design economy.

High Strain, Remolded Strength Another measure of the in situ undrained shear strength is provided by the CPT friction sleeve resistance. The friction sleeve interacts with soil that has already undergone bearing capacity failure induced by the tip of the penetrometer. Thus, the friction sleeve resistance is a measure of soil large strain, remolded strength. The ratio between strengths calculated from the cone end bearing and from the friction sleeve is indicative of soil sensitivity.

In moderately to highly overconsolidated, non-sensitive clays, friction sleeve resistances can indicate higher strengths than those calculated using the cone end bearing resistance. This often reflects the dilative (strain hardening) nature of shear failure in overconsolidated soils. Engineering judgment must be applied in deciding which strain level, and thus which strength, is representative for the design problem to be solved.

A1.5 Evaluation of Soil Stress History The results of penetrometer testing can often be evaluated for indication of clay soil stress history or pre-consolidation pressure. Several methods are available for this evaluation. The first method consists of computing a normally consolidated cone end bearing resistance profile, based on estimated soil unit weights, water table information, cohesion at the ground surface, and an assumed c/p ratio and cone factor Nk for the clay strata in question. This normally consolidated profile is then compared to the measured profile, and differences between the two can be assumed to be due to past stress history events (Schmertmann, 1977). A back calculation is then performed on the difference, using the assumed c/p ratio and Nk, and a pre-consolidation pressure is calculated. OCR's can then be calculated based on estimated existing stress conditions. SHANSEP procedures used during triaxial testing of clay soils may be useful in this method, especially for definition of c/p ratios.

Other methods for estimating stress history from CPT data are summarized in Mayne (1991 and 1993). These include approaches based on cavity expansion theory and critical state soil mechanics or on empirical methods based on data sets, primarily from sites in offshore oil fields. Results from each method should be compared, and engineering judgment should be used to decide which method gives the most appropriate result for the design at hand.

A1.6 Equivalent SPT Blowcount N-Values An equivalent SPT blowcount can be correlated with CPT data by using an analytical model of the SPT procedure (Douglas and Olsen, 1981). This procedure has been checked by comparison to SPT results at various sites throughout the world (Douglas and others, 1981, Douglas and Strutynsky, 1984, and Olsen and Farr, 1986) with generally good results.

The particular SPT equipment used to develop the CPT-SPT correlation chart (Figure A6) consisted of a SPT trip hammer system. This SPT hammer is characterized by reasonably repeatable, measured hammer input energy efficiencies of about 60 to 70% (Douglas and Strutynsky, 1984). This hammer input energy level is similar to that recommended (Seed and others, 1984) as the "standard" Standard Penetration Test input energy.

SPT results are both equipment and operator dependent. SPT hammer efficiencies have been measured to range from 35 to over 90% of the theoretical 4200 in-lbs (30 inch fall, 140 lbs hammer) SPT input energy. Variable SPT input energy results in variable blowcounts (Douglas and Strutynsky, 1984, Seed and others, 1984). Non-uniform SPT input energy is a limitation for use of SPT for quantitative design purposes.

The approach of using the extensive SPT data base by performing CPT and then deriving equivalent SPT blowcount N-values, can result in better site characterization. This is because CPT is continuous, has higher resolution, is less expensive, and is much more consistent and repeatable than SPT. The chart that was used for correlating CPT to SPT for this study is presented in Figure A6. After determining the overburden normalized equivalent SPT N'-value, the equivalent SPT blowcount N-value was calculated by dividing the overburden normalized value by the overburden normalization factor CN, as defined in Eq. A3.

The equivalent SPT N-values reflect the higher resolution of the CPT measurements as compared to actual SPT. Performance of actual SPT includes averaging of soil resistance over about a 24 inch interval (18 inch sampler embedment and 2 to 3 sampler diameters ahead of the sampler). Equivalent SPT values have a resolution of about six inches. Rather than coarsen the 6 inch resolution equivalent SPT N-value to fit a 24 inch resolution actual SPT N-value, equivalent values are based on point by point CPT data. These high resolution, equivalent SPT values should be more useful for design purposes, especially in interlayered deposits, where thin, weak soil seams cannot be adequately characterized by actual SPT blowcount methods. The high resolution equivalent SPT values and actual SPT measurements should be similar in thick homogeneous strata.

Discrepancies between CPT equivalent SPT N-values and actual, measured SPT N-values are often due to inconsistencies in the performance of actual SPT. Poor fit of CPT equivalent and actual SPT in weak soils with very low blowcounts (0 to 3) can be due to limited accuracy of high capacity CPT loadcells used at the extreme low end of their range, but are more likely caused by extensive borehole disturbance in easily disturbed soil, and set of the SPT sampler under the self-weight of the hammer and drillrods. Discrepancies between equivalent and actual SPT values in very dense or hard soils with high blowcounts, especially in gravelly soils, can be due to both erratic penetrometer or SPT sampler interaction with large soil particles, and basic differences in modes of penetration of the two techniques. Indications of weak soils, using any method, should strongly encourage additional testing, including undisturbed sampling and sophisticated laboratory testing.

A2.0 OVERBURDEN PRESSURE NORMALIZATION

Overburden normalization of CPT data for correlation purposes is necessary in order to remove the effects of increasing overburden pressure with depth on measured results. Cone tip resistances can be normalized to an effective vertical overburden pressure of 1 TSF by using the following equations: qc1 = qc * CN (Eq. A3); and CN = 1.0 - 0.5 * log (Sv') (Eq. A4); where: qc1 is the overburden normalized cone tip resistance, in TSF; qc is the measured cone tip resistance, in TSF; CN is the overburden normalization factor; and Sv' is the effective vertical overburden stress in TSF.

Overburden normalization curves are variable (Douglas and Martin, 1980) and were developed using laboratory CPT and SPT on large samples of clean sands. Application of these laboratory results to natural soils may be limited. The CN presented in Equation A4 is similar to that proposed (Seed and others, 1977) for the effect of overburden on SPT blowcounts.

The friction ratio is not normalized based on the assumption that overburden pressure affects friction sleeve and cone tip resistance similarly. Since the quantities are divided by each other to compute friction ratio, overburden effects should cancel. Some experience (Olsen and Farr, 1986) indicates that this assumption may oversimplify actual conditions for deep soundings. The friction resistance may be less sensitive to overburden pressure than the cone tip resistance. Thus, in soundings deeper than about 100 ft, the friction ratio may gradually decrease with increased penetration, independent of any changes in soil conditions, other than overburden pressure. Due to the variability in overburden normalization curves, no specific correction for overburden pressure on friction ratio has been recommended or used for this study. For this study, effective stresses in Equation A4 were computed using assumed water tables and soil unit weights.

A3.0 TEST DRAINAGE CONDITION

The CPT loading rate is such that drained and undrained conditions exist during testing of sands and clays, respectively. Partial drainage may occur in mixed (granular and fine grained) soils. CPTU piezometric data indicate that minor differences in cone tip and friction ratio response can correspond with major changes in pore water pressure response (Douglas and others, 1985). The complex volumetric strain field around the penetrometer (Davidson and Boghrat, 1983) precludes reliable geotechnical effective stress analysis of CPTU results in partially drained soil.

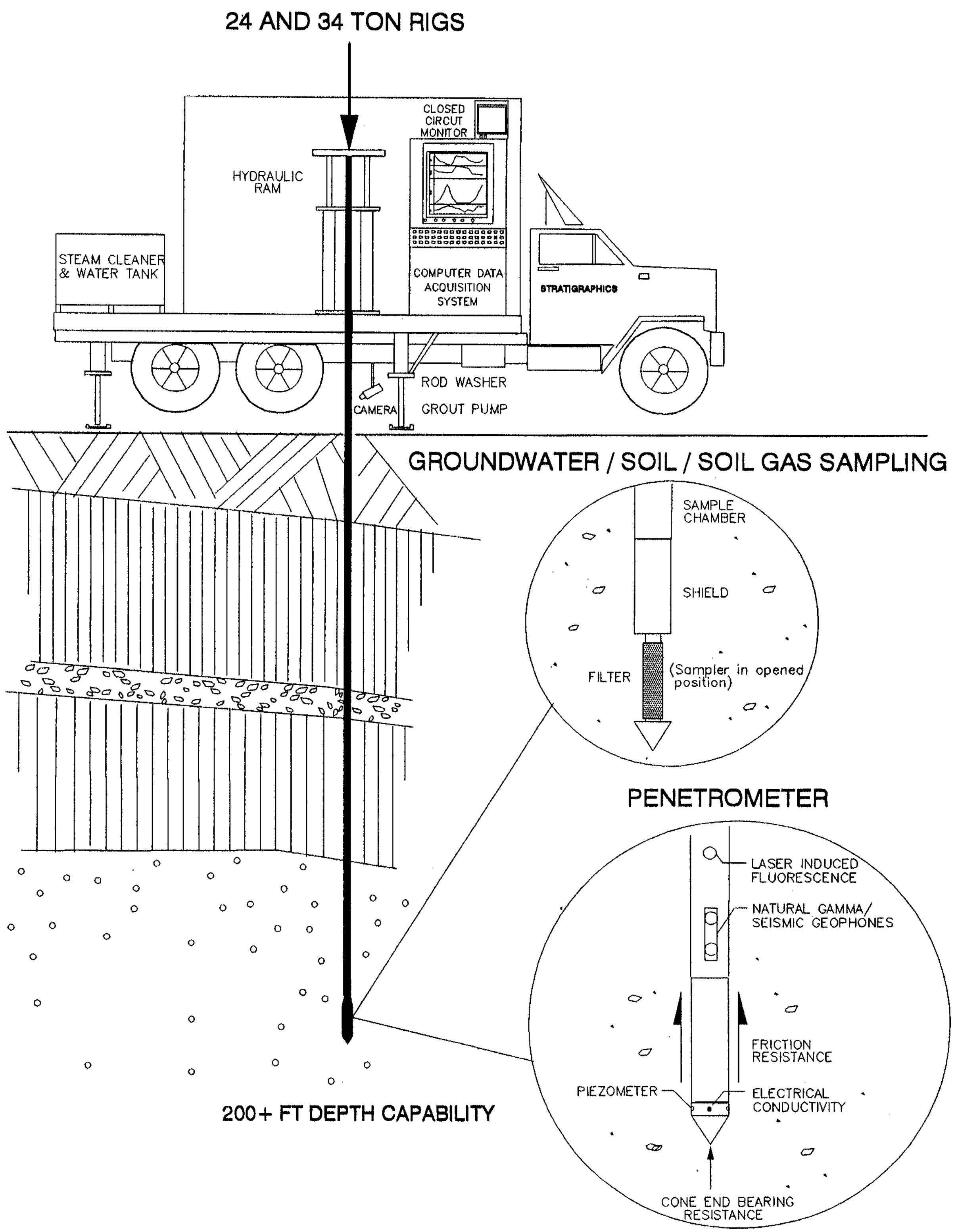
Empirical estimates of either drained or undrained parameters can be made in mixed soils. These parameters must not be combined and must be used alternatively. Combination of drained and undrained parameters will result in significant overestimation of in situ shear strength. Structure rate of loading will help determine whether drained or undrained parameters should be appropriate for design use. Depending on project needs and site conditions, geotechnical laboratory testing including consolidation and CU tests with pore pressure measurements will also be useful in assigning appropriate design parameters. Field instrumentation during construction using low volume change piezometers may be appropriate for some projects.

A4.0 RECOMMENDED PRACTICES

The STRATIGRAPHICS data evaluation program uses a series of global correlation charts, Figures A2 through A6. Parameters are computer evaluated and tabulated at discrete intervals. Stratigraphic units should be defined on the basis of the continuous sounding logs and project requirements. The correlations are then used in evaluation of layer properties. Use of the tabulations without the review of the CPT sounding logs can lead to the choice of non-representative parameters, especially in interlayered deposits. It should be noted that taking discontinuous borehole soil samples also often provides a poor representation of subsurface conditions.

CPT correlations have been developed using empiricism. The data base is world-wide and includes decades of CPT experience. However, local conditions may differ from those in the global data base. Thus, the evaluated parameters should be viewed as indicating trends rather than as the exact equivalent of specific laboratory tests performed under boundary and drainage controlled conditions. The derived parameters are not intended to replace appropriate drilling and undisturbed sampling, other in situ and laboratory testing, and use of engineering judgment.

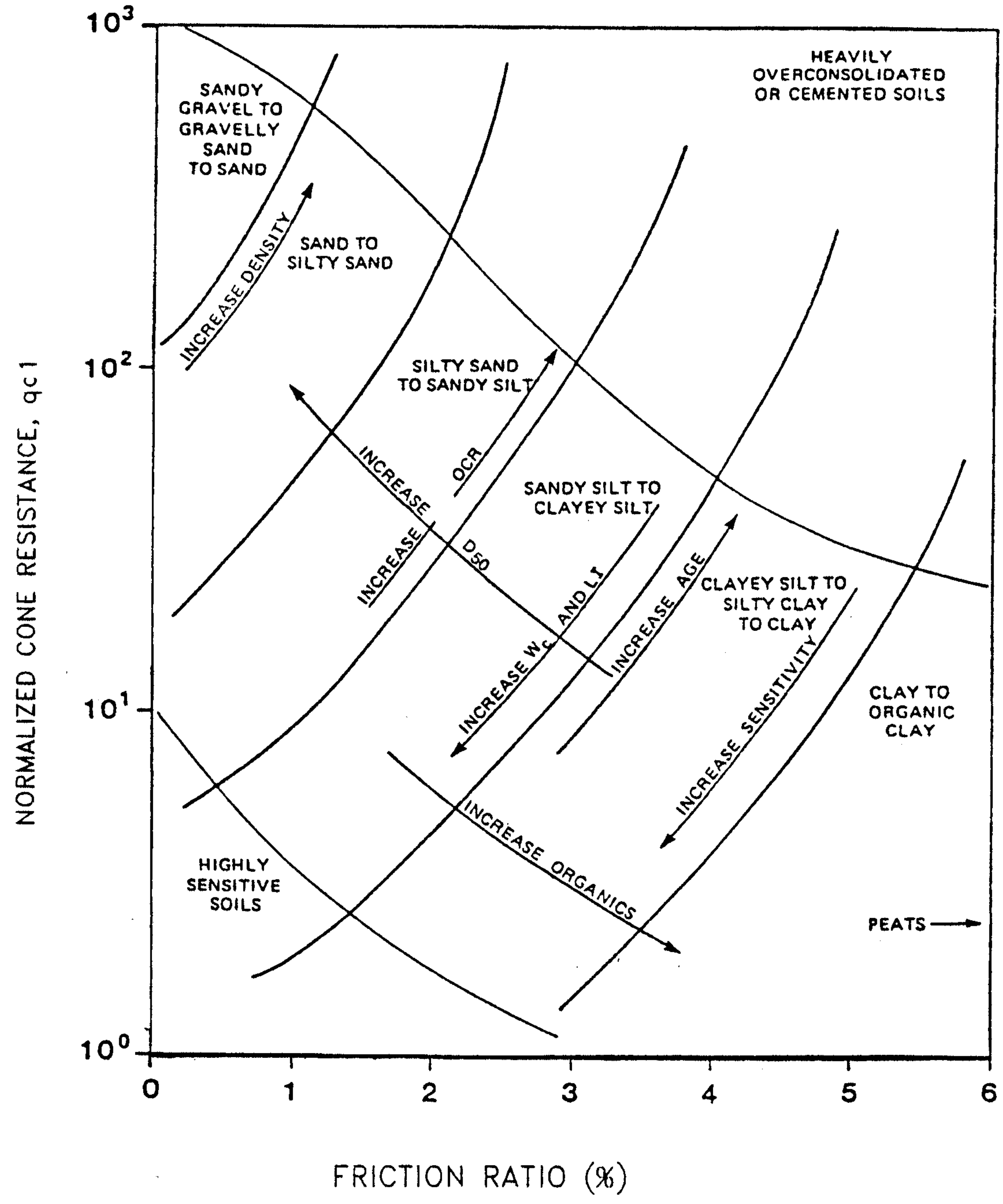
Review of CPT results and project requirements is used to define the need for additional information. Zones delineated by CPT (or, in fact, any other test) providing low factors of safety should be further explored. For example, high quality undisturbed sampling followed by geotechnical triaxial and consolidation testing may be indicated for low strength cohesive or partially drained mixed soil strata. Monitoring wells may be installed or groundwater samples taken in high hydraulic conductivity strata during geo-environmental exploration. Non-CPT test results can often be extrapolated across the site based on CPT evaluated stratigraphy.



PENETROMETER EXPLORATION SYSTEM

STRATIGRAPHICS

(630) 790-4610
www.STRATIGRAPHICS.com
Glen Ellyn, Illinois



SOIL BEHAVIOR TYPE CLASSIFICATION CHART

After Douglas and Olsen, 1981

STRATIGRAPHICS

Figure 2

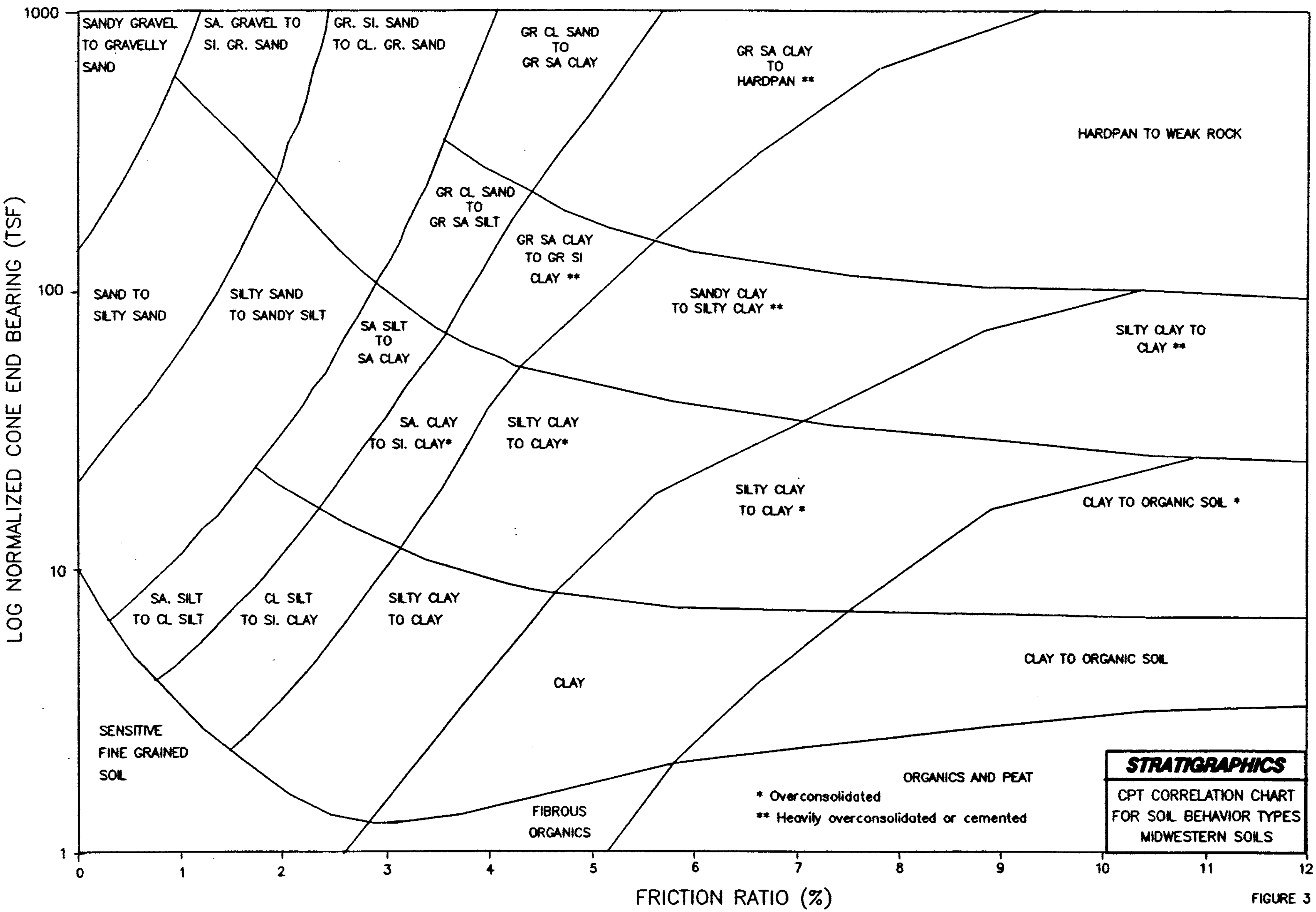
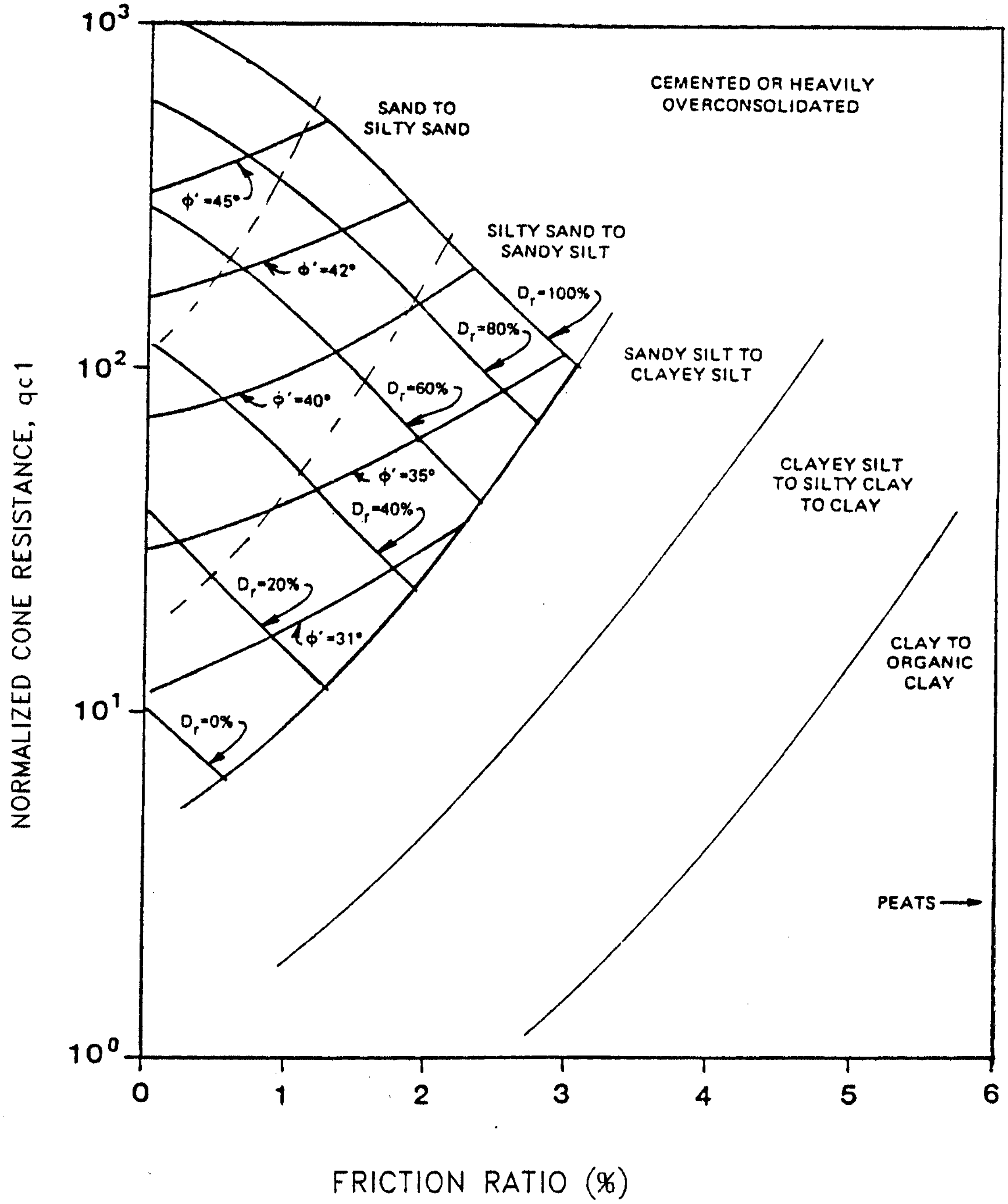

1000
100
10
1
0
1
2
3
4
5
6
7
8
9
10
11
12
LOG NORMALIZED CONE END BEARING (TSF)
FRICTION RATIO (%)
SANDY GRAVEL TO GRAVELLY SAND
SA. GRAVEL TO SI. GR. SAND
GR. SI. SAND TO CL. GR. SAND
GR CL SAND TO GR SA CLAY
GR SA CLAY TO HARDPAN **
HARDPAN TO WEAK ROCK
GR CL SAND TO GR SA SILT
GR SA CLAY TO GR SI CLAY **
SAND TO SILTY SAND
SILTY SAND TO SANDY SILT
SA SILT TO SA CLAY
SANDY CLAY TO SILTY CLAY **
SILTY CLAY TO CLAY **
SA. CLAY TO SI. CLAY*
SILTY CLAY TO CLAY*
SILTY CLAY TO CLAY *
CLAY TO ORGANIC SOIL *
SA. SILT TO CL SILT
CL SILT TO SI. CLAY
SILTY CLAY TO CLAY
CLAY
CLAY TO ORGANIC SOIL
SENSITIVE FINE GRAINED SOIL
FIBROUS ORGANICS
ORGANICS AND PEAT
* Overconsolidated
** Heavily overconsolidated or cemented
STRATIGRAPHICS
CPT CORRELATION CHART FOR SOIL BEHAVIOR TYPES MIDWESTERN SOILS

FIGURE 3

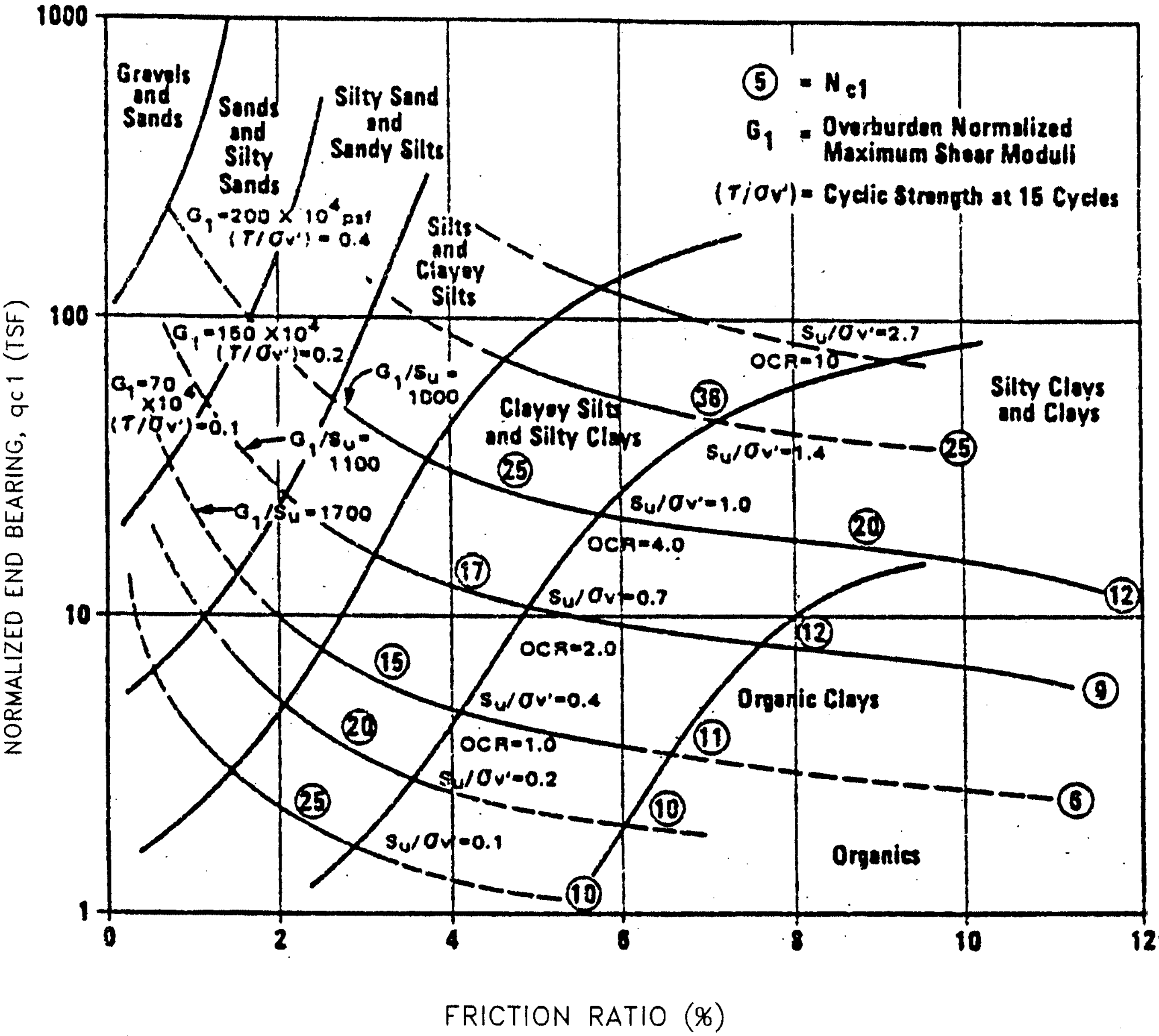


EXPANDED SOIL BEHAVIOR TYPE CLASSIFICATION CHART WITH EQUIVALENT OVERBURDEN NORMALIZED FRICTION ANGLE AND RELATIVE DENSITY TRENDS

After Douglas and Strutynsky, 1984

STRATIGRAPHICS

Figure 4



COMPOSITE TRENDS IN UNDRAINED SOIL PROPERTIES

After Douglas, Strutynsky, et. al., 1985

STRATIGRAPHICS

Figure 5

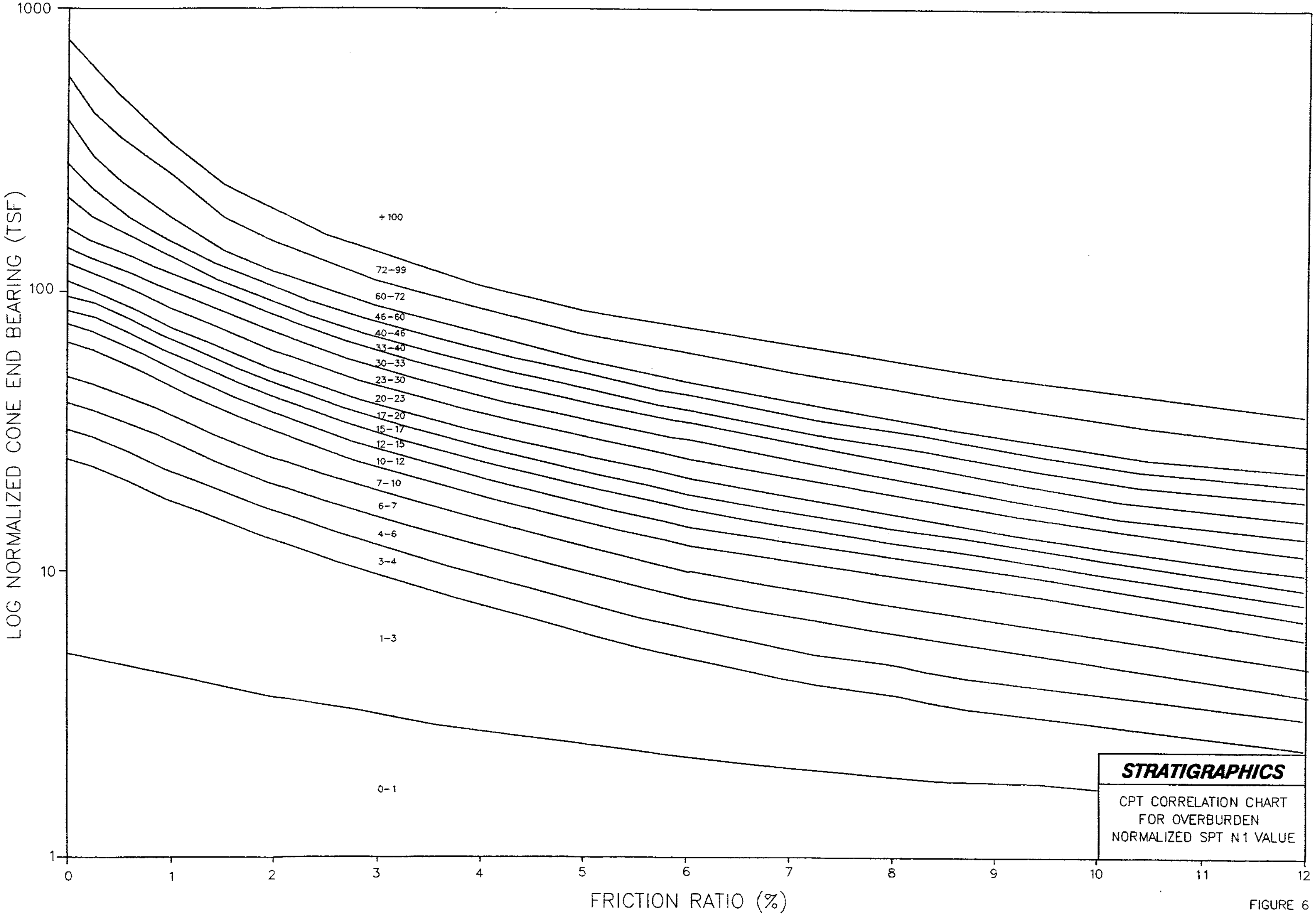

1000
100
10
1
LOG NORMALIZED CONE END BEARING (TSF)
0
1
2
3
4
5
6
7
8
9
10
11
12
FRICTION RATIO (%)
+100
72–99
60–72
46–60
40–46
33–40
30–33
23–30
20–23
17–20
15–17
12–15
10–12
7–10
6–7
4–6
3–4
1–3
0–1
STRATIGRAPHICS
CPT CORRELATION CHART
FOR OVERBURDEN
NORMALIZED SPT N1 VALUE

FIGURE 6

APPENDIX B

from Baligh, M.M. and J. Levadoux, "Pore Pressure Dissipation After Cone Penetration," Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1980.

6.2.4 Evaluation of c_h (probe)

At a given degree of consolidation, the predicted horizontal coefficient of consolidation c_h (probe) is obtained from the expression: c_h (probe) = R^2T/t (6.2)
where R is the radius of the cone shaft, t is the measured time to reach this degree of consolidation; and T is the time factor. Table 5.1 provides values of T for different probe types at various degrees of consolidation.

An analytical method {equivalent to the graphical method described in Section 6.2.3} to check the validity of the prediction method consists of determining c_h at different dissipation stages, i.e., different u. Large differences between c_h at various degrees of consolidation indicate an inadequate initial distribution of excess pore pressure or significant coupling, or creep behavior.

The estimated values of c_h (probe) at 50% dissipation can be used in foundation problems involving horizontal water flow due to unloading or reloading of clays above the maximum past pressure. For problems involving vertical water flow in the overconsolidated range, the vertical coefficient of consolidation, c_v(probe), can be estimated from the expression: c_v (probe) = (k_v/k_h) c_h (probe) (6.3)
where k_v and k_h are the vertical and horizontal coefficients of permeability, respectively. Reliable estimates of the in situ anisotropy of clays as expressed by the ratio k_h/k_v is difficult to determine in the laboratory because of the effects of sample size, sample disturbance, ... etc. and is the subject of controversy (Rowe, 1972; Casagrande and Poulos, 1969). In situ tests to determine k_h/k_v are almost nonexistent. Table 6.2 provides rough estimates of k_h/k_v for different clays.

6.2.5 Prediction of k_h (probe)

Approximate estimates of the horizontal coefficient of permeability, k_h (probe), can be obtained from the expression: k_h (probe) = $(g_w/2.3s_{vo})$ * RR(probe) * c_h (probe) (6.4)
where s_{vo} is the initial vertical effective stress (kg/cm^2); g_w is the unit weight of water (=10^{-3} kg/cm^3); and RR(probe) is the recompression ratio during early stages of consolidation (50% dissipation, say). Results in both the upper and lower Boston Blue Clays indicate that: the average RR(probe) =10^{-2} (6.5)
and generally $0.5 * 10^{-2} < RR(probe) < 2 * 10^{-2}$ (6.6)

6.2.6 Prediction of c_v(NC)

For foundation clays consolidated in the normally consolidated range, estimates of the coefficients of consolidation can be obtained from c_h (probe) by means of the expressions:

c_h(NC) = (RR(probe)/CR) * c_h (probe) (6.7)

for horizontal water flow, and c_v(NC) = (RR(probe)/CR) * (k_v/k_h) * c_h(probe) (6.8)
for vertical water flow.

The compression of ratio CR is the average slope of the strain vs. log effective stress plot in the appropriate effective stress range expected during consolidation of the foundation clay. Values of CR should be obtained from good quality samples carefully tested in the laboratory. Table 6.2 provides rough estimates of CR based on empirical correlation with index properties of various clays.

Table 6.2 Empirical Correlation and Typical Properties of Clays

1. Compression Ratio CR (from Ladd, 1973)
   - CR = $C_c/1+e_o$ = slope of the strain vs. log stress curve
   - e_o = initial void ratio
   - c_c = virgin compression index = slope of e vs. log stress
   - w_L = liquid limit
   - w_N = natural water content

c_c = 0.009 (w_L% - 10%)	Terzaghi and Peck (1967)
C_c = 0.54 (e_o - 0.35)	Nishida (1958)
C_c = 0.01 to 0.15 (w_N%)	MPMR (1958)
C_c = 0.6 (e_o - 1) for e_o < 6	
C_c = 0.85 (e_o - 2) for 6 < e_o <14	Kapp, (1966)

2. Anisotropic Permeability of Clays (from Ladd, 1976)

Nature of Clay	k_h/k_v
1. No evidence of layering	1.2 +- 0.2
2. Slight layering, e.g., sedimentary clays with occasional silt dustings to random lenses	2 to 5
3. Varved clays in northeastern U.S.	10 +/-5