FINAL DATA REPORT Rev 0
GEOTECHNICAL EXPLORATION AND TESTING

EXELON TEXAS COL PROJECT
VICTORIA COUNTY, TEXAS
POWER BLOCK

July 10, 2008

VOLUME 2
Appendix D – Geophysical Test Data

Prepared By:

MACTEC Engineering and Consulting, Inc.
Raleigh, North Carolina

MACTEC Project No. 6468-07-1777

Prepared For:

Bechtel Power Corporation
Subcontract No. 25352-102-HC4-CY00-00001

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FIELD ELECTRICAL RESISTIVITY DATA

REPORT OF FIELD RESISTIVITY SOUNDINGS
EXELON TEXAS COL (Victoria) PROJECT
POWER BLOCK
MACTEC PROJECT NO. 6468-07-1777

Work Instruction No.: 216
Method: Wenner Four-Electrode (ASTM G 57-06)

Data Collected by: S. Criscenzo/K. Rudd, February 14, 2008
Equipment: Mini Res Resistivity Meter, SN # 023 - LRI
Calibration Date: January 17, 2008
Calibration Asset Number: 1464

Test Location R-2101 / R-2102 (Center of Lines):

As-Built Northing:	N 13412470.72
As-Built Easting:	E 2599460.82
Elevation at Center Point:	80.53 feet

Test Location R-2101 Compass Bearing 300 Degrees

Probe Spacing (feet)	Low Range Resistance (ohms)	Resistivity (ohms-feet)
3	1.690	971
5	0.750	718
7.5	0.450	646
10	0.330	632
15	0.210	603
30	0.090	517
50	0.050	479
100	0.030	575
200	0.020	766
300	0.015	862

Test Location R-2102 Compass Bearing 30 Degrees

Probe Spacing (feet)	Low Range Resistance (ohms)	Resistivity (ohms-feet)
3	1.860	1069
5	0.840	804
7.5	0.480	689
10	0.340	651
15	0.210	603
30	0.100	575
50	0.050	479
100	0.030	575
200	0.025	958
280	0.020	1072

(1) Probe spacing of 280 feet modification due to obstruction (ditch)

Prepared By: KAW Date: 3-17-08
Approved By: DJC Date: 3-17-08

REPORT OF FIELD RESISTIVITY SOUNDINGS
EXELON TEXAS COL (Victoria) PROJECT
POWER BLOCK
MACTEC PROJECT NO. 6468-07-1777

Test Location R-2201 / R-2202 (Center of Lines):

As-Built Northing:	N 13413399.51
As-Built Easting:	E 2600266.58
Elevation at Center Point:	80.66 feet

Test Location R-2201 Compass Bearing 300 Degrees

Probe Spacing (feet)	Low Range Resistance (ohms)	Resistivity (ohms-feet)
3	1.340	770
5	0.710	680
7.5	0.410	589
10	0.280	536
15	0.160	460
30	0.080	460
50	0.060	575
100	0.040	766
200	0.030	1149
300	0.020	1149

Test Location R-2202 Compass Bearing 210 Degrees

Probe Spacing (feet)	Low Range Resistance (ohms)	Resistivity (ohms-feet)
3	1.540	885
5	0.730	699
7.5	0.400	575
10	0.270	517
15	0.160	460
30	0.070	402
50	0.050	479
100	0.030	575
200	0.025	958
280	0.015	804

(1) Probe spacing of 280 feet modification due to obstruction (board in road)

Prepared By: KAW Date: 3·17·08
Approved By: DSC Date: 3-17-08

GEOVision
geophysical services

FINAL REPORT

BORING GEOPHYSICAL LOGGING
BORINGS B-11, B-12, B-2162A OFFSET, B-2174A OFFSET, B-2176A OFFSET, B-2182A OFFSET, B-2262A OFFSET, B-2274A OFFSET, B-2276A OFFSET, B-2282A OFFSET, B-2301, B-2302, B-2303, B-2304, B-2305, B-2306 AND B-2307

EXELON COL - VICTORIA COUNTY SITE

Report 7534-01 rev 0

April 29, 2008

FINAL REPORT

BORING GEOPHYSICAL LOGGING BORINGS B-11, B-12, B-2162A OFFSET, B-2174A OFFSET, B-2176A OFFSET, B-2182A OFFSET, B-2262A OFFSET, B-2274A OFFSET, B-2276A OFFSET, B-2282A OFFSET, B-2301, B-2302, B-2303, B-2304, B-2305, B-2306 AND B-2307

EXELON COL - VICTORIA COUNTY SITE

Report 7534-01 rev 0

April 29, 2008

Prepared for:

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INTRODUCTION

Boring geophysical measurements were collected in seventeen uncased borings located at the Exelon Combined Operating License (COL) Application Project, located in Victoria County, Texas. Geophysical data acquisition was performed between October 23 and November 18, 2007 by Robert Steller and Charles Carter of **GEO***Vision*. Data analysis and report preparation was performed by Robert Steller and reviewed by John Diehl of GEOVision. The work was performed under subcontract with MACTEC Engineering and Consulting, Inc., (MACTEC) with Steven Crisenzo serving as the point of contact for MACTEC.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between October 23 and November 18, 2007, in seventeen borings, as detailed in Table 1. The purpose of these studies was to supplement stratigraphic information obtained during MACTEC's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth, as a component of the Exelon COL Project, located in Victoria County, Texas.

The B-2100A OFFSET and B-2200A OFFSET series borings were located within the proposed Power Block area. B-11, B-12 and the B-2300 series borings pertain to the proposed Cooling Water Basin and/or the area generally outside the Power Block area.

The OYO/Robertson Suspension PS Logging System (Suspension System) was used to obtain in-situ horizontal shear (S_H) and compressional (P) wave velocity measurements in all 17 borings at 1.6 foot intervals. The acquired data was analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

The Robertson ELGX and 3ACS probes were used to collect long and short normal resistivity, single point resistance (SPR) Spontaneous Potential (SP), natural gamma and 3 arm mechanical caliper data at 0.05 foot intervals in all 17 borings to aid in identification of stratagraphic transitions.

The Robertson High Resolution Acoustic Televiewer (HiRAT) was used to collect deviation data at 0.04 foot intervals in 13 borings. Deviation logs of B-11 and B-12 were not requested by MACTEC, as they were part of the fatal flaw study, not the COL project. B-2274A OFFSET logging was ended at approximately 10:30 pm on November 7, 2007, and the GEOVision field staff (Charles Carter) offered to return the following morning and perform the deviation log. This offer was declined by the Bechtel Site Representative. Several days later, prior to abandonment of the boring, other GEOVision field staff (Robert Steller) again offered to perform a deviation log in B-2274A OFFSET before abandonment. Again, this offer was declined by the Bechtel Site Representative. B-2305 logging was ended at approximately 7:30 pm on November 18, 2007, with a substantial collapse of the boring. The GEOVision field staff, (Robert Steller) after consulting with MACTEC field staff and the Bechtel Site representative, declined to perform a deviation log the boring, citing risk of probe loss due to boring collapse.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

Suspension soil velocity measurements were performed in seventeen borings using the suspension PS logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3 foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 2. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

The probe receives control signals from, and sends the digitized receiver signals to, instrumentation on the surface via an armored 4 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28 foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it passes through the casing and grout annulus and impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 6.3 foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In faster soils or rock, the isolation cylinder is extended to allow greater separation of the P- and S_H-wave signals.
4. In saturated soils, the received P-wave signal is typically of much higher frequency than the received S_H-wave signal, permitting additional separation of the two signals by low pass filtering.
5. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe (meter versus centimeter scale), preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix C.

Caliper / Natural Gamma Instrumentation

Caliper and natural gamma data were collected using a Model 3ACS 3-leg caliper probe, serial number 5368, manufactured by Robertson Geologging, Ltd. With the short arm configuration used in these surveys, the probe permitted measurement of boring diameters between 1.6 and 16 inches. With this tool, caliper measurements were collected concurrent with measurement of natural gamma emission from the boring walls. The probe was 6.82 feet long, and 1.5 inches in diameter.

This probe is useful in the following studies:

- Measurement of boring diameter and volume
- Location of hard and soft formations
- Location of fissures, caving, pinching and casing damage
- Bed boundary identification
- Strata correlation between borings

The probe receives control signals from, and sends the digitized measurement values to, a Robertson Micrologger II on the surface via an armored 4 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28 foot circumference sheave fitted with a digital rotary encoder. The probe and depth data are transmitted by USB link from the Micrologger unit to a laptop computer where it is displayed and stored on hard disk.

The caliper consists of three arms, each with a toothed quadrant at their base, pivoted in the lower probe body. A toothed rack engages with each quadrant, thus constraining the arms to move together. Linear movement of the rack is converted to opening and closing of the arms. Springs hold the arms open in the operating position. A motor drive is provided to retract the arms, allowing the probe to be lowered into the boring. The rack is coupled to a potentiometer which converts movement into a voltage sensed by the probe's microprocessor.

Natural gamma measurements rely upon small quantities of radioactive material contained in all soil and rocks to emit gamma radiation as they decay. Trace amounts of Uranium and Thorium are present in a few minerals, where potassium-bearing minerals such as feldspar, mica and clays will include traces of a radioactive isotope of Potassium. These emit gamma radiation as they decay with an extremely long half-life. This radiation is detected by scintillation - the production of a tiny flash of light when gamma rays strike a crystal of sodium iodide. The light is converted into an electrical pulse by a photomultiplier tube. Pulses above a threshold value of 60 thousand electron Volts (KeV) are counted by the probe's microprocessor. The measurement is useful because the radioactive elements are concentrated in certain soil and rock types e.g. clay or shale, and depleted in others e.g. sandstone or coal.

Resistivity / Spontaneous Potential / Natural Gamma Instrumentation

Resistivity, spontaneous potential and natural gamma data were collected using a Model ELXG electric log probe, S/N 5490, manufactured by Robertson Geologging, Ltd. This probe measures Single Point Resistance (SPR), short normal (16 inch) resistivity, long normal (64 inch) resistivity, Spontaneous Potential (SP) and natural gamma. The probe is 8.20 feet long, and 1.73 inches in diameter.

This probe is useful in the following studies:

- Bed boundary identification
- Strata correlation between borings
- Strata geometry and type (shale indication)

The probe receives control signals from, and sends the digitized measurement values to, a Robertson Micrologger II on the surface via an armored 4 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28 foot circumference sheave fitted with a digital rotary encoder. The probe and depth data are transmitted by USB link from the Micrologger unit to a laptop computer where it is displayed and stored on hard disk.

The resistivity section of the probe operates by driving an alternating current into the formation from the central SPR/DRIVE electrode. The current returns via the logging cable armor. To ensure adequate penetration of the formation the logging cable is insulated for approximately 30 feet from the cablehead. Voltages are measured between the 16 inch and 64 inch electrodes and the remote earth connection at surface, as noted below:

- Single Point Resistance (SPR): The current flowing to the cable armor is measured along with the voltage at the SPR electrode. The voltage divided by current gives resistance.

- Spontaneous Potential (SP): This is the DC bias of the 16 inch electrode with respect to the voltage return at the surface (ground stake).

Data quality depends upon good grounding at the surface. This is achieved with a metal stake driven into the mud-pit.

Boring Deviation Instrumentation

Boring deviation data were collected in thirteen borings using a High Resolution Acoustic Televiewer probe (HiRAT), serial number 5174, manufactured by Robertson Geologging, Ltd.

In this application, this probe is useful in the following studies:

- Measurement of boring inclination and deviation from vertical
- Determination of need to correct soil and geophysical log depths to true vertical depths

The probe receives control signals from, and sends the digitized measurement values to a Robertson Micrologger II on the surface via an armored 4 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28 foot circumference sheave fitted with a digital rotary encoder. The probe and depth data are transmitted by USB link from the Micrologger unit to a laptop computer where it is displayed and stored on hard disk.

The probe contains a fluxgate magnetometer to monitor magnetic north, and all raw televiewer data are referenced to magnetic north. A three-axis accelerometer is enclosed in the probe, providing boring dip data that, when processed with the orientation data, allows boring deviation data to be obtained.

The data are presented on a computer screen for operator review during the logging run, and stored on hard disk for later processing.

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

All seventeen borings were logged uncased, filled with bentonite or polymer based drilling mud. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.31, as presented in Appendix E. These procedures were supplied and approved in advance of the work. In each boring, the probe was positioned with the top of the probe at the top of the casing, and the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the casing stick-up, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring, and then returned to the surface, stopping at 1.6 foot intervals to collect data, as summarized in Table 3.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the depth reference point was verified prior to removal from the boring, and the after survey depth error (ASDE) was calculated, as summarized in Table 4.

Caliper / Natural Gamma Measurement Procedures

All seventeen borings were logged uncased, filled with bentonite or polymer based drilling mud. Measurements followed ASTM D6167 Conducting Borehole Geophysical Logging – Mechanical Caliper.

Prior to and following each logging run, the caliper tool was verified, using the manufacturer's supplied three point calibration jig, and a PVC coupling provided by MACTEC with an inside diameter traceable to NIST. The three point jig is a circular plate with a series of holes in the top surface into which the tips of the caliper arms fit. This has circles of diameters from 2 to 12 inches. The calibration jig is placed over a bucket with the probe standing upright with its nose section passing through the jig's central hole. The caliper probe arms are opened under program control, and a log is recorded as the tips of the arms are placed in the holes on the calibration jig and inside the PVC coupling. The measured dimensions, as displayed on the recording computer screen was recorded on the field log sheet, as well as in the digital files, and compared with the calibration jig dimensions. These files are presented in LAS 2.0 format in the boring specific sub-directories of the data directory on the data disk (CD-R) labeled Report 7534-02 that accompanies this report. If the verification records did not fall within +/- 0.05 inches of the calibration jig values, the caliper tool was re-calibrated, using the three point calibration jig, and the log repeated. As with the verification, the tips of the caliper arms are placed in the holes marked with the required diameter. During calibration, the value of the current calibration point, as stamped on the jig, is entered via the control computer. The system counts for 15 seconds to make an average of the response. The procedure is repeated for the second and third required openings.

The computation and generation of the calibration coefficient file is entirely automatic. The calibration file is simply the set of coefficients of a quadratic curve which fits the three data points. Figure 1 shows the response of a caliper probe using data gathered during calibration.

Natural gamma was not calibrated in the field, as it is a qualitative measurement, not a quantitative value, and is used only to assist in picking transitions between stratigraphic units, as described in ASTM D6274, Conducting Borehole Geophysical Logging - Gamma.

In each boring, the probe was positioned with the top of the probe at the top of the mud box, and the electronic depth counter was set to 6.82 feet, the specified length of the probe, minus the height of the mud box, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring, where the caliper legs were opened, and data collection begun. The probe was then returned to the surface at 10 feet/minute, collecting data continuously at 0.05 foot spacing, as summarized in Table 3.

Upon completion of the measurements, the probe zero depth indication at the depth reference point was verified prior to removal from the boring, and the after survey depth error (ASDE) was calculated, as summarized in Table 4.

Resistivity / Spontaneous Potential / Natural Gamma Procedures

All seventeen borings were logged uncased, filled with bentonite or polymer based drilling mud. The probe was connected to the logging cable using a 32.8 foot long insulating cable section or "yoke". The probe head was insulated by wrapping all exposed metal of the cablehead and probe with self-amalgamating insulation tape. The 32.8 foot insulating yoke was checked for any damage, and repaired with self-amalgamating insulation tape as needed.

The reference ground stake was driven firmly into the mud pit, and connected to the ground socket on the winch switch box.

This sonde was not calibrated in the field, as it is used to provide qualitative measurements, not quantitative values, and is used only to assist in picking transitions between stratigraphic units, as described in ASTM D5753, Planning and Conducting Borehole Geophysical Surveys. A functional test is performed prior to each logging run by applying fixed resistance values across the probe electrodes, as well as a 100 millivolt signal across the SP electrodes, and recording the resultant output of the system. These functional checks are presented in LAS 2.0 format in the boring specific sub-directories of the data directory on the data disk (CD-R) labeled Report 7534-02 that accompanies this report.

Natural gamma was not calibrated in the field, as it is a qualitative measurement, not a quantitative value, and is used only to assist in picking transitions between stratigraphic units, as described in ASTM D6274, Conducting Borehole Geophysical Logging - Gamma.

In each boring, the probe was positioned with the top of the probe at the top of the casing or mud box, and the electronic depth counter was set to 8.2 feet, the specified length of the probe, minus the height of the casing stick-up or mud box, as verified with a tape measure. When logging on smaller drill rigs, the depth was zeroed to the top of the yoke, and 32.8 feet was added to the zero depth, as recorded in the field logs. The probe was lowered to the bottom of the boring, where data collection was begun. The probe was then returned to the surface at 10 feet/minute, collecting data continuously at 0.05 foot spacing, as summarized in Table 3. The natural gamma data collected in these logs is redundant with the data collected in the caliper / natural gamma logs, and the caliper / natural data may be used to verify the natural gamma data collected in these logs.

Normally, when the un-insulated section of the logging cable leaves the boring fluid, the log is terminated, as the electrical measurements do not function under these conditions. However, in these surveys, the log was continued, in order to collect as much natural gamma data as possible before the yoke connector reached the measuring wheel.

Upon completion of the measurements, the probe zero depth indication at the depth reference point was verified prior to removal from the boring, and the after survey depth error (ASDE) was calculated, as summarized in Table 4.

Boring Deviation Measurement Procedures

Thirteen of the seventeen borings were logged for deviation as uncased borings, filled with bentonite or polymer based drilling mud. Although the televiewer is intended for use in cored hard rock borings where it is used to image jointing and bedding planes, and it cannot produce a useful image in the soils at this site, the logs were run in order to provide a deviation log for the borings. Measurements followed the **GEO***Vision* standard field procedures, as presented in Appendix E.

Prior to use, the televiewer probe tiltmeter and compass functions were checked by comparison with a Brunton surveyors' compass.

In each boring, the televiewer probe was positioned with the top of the probe at the top of the casing, and the electronic depth counter was set to the specified length of the probe, minus the height of the casing stick-up, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring, and data collection begun. The probe was then returned to the surface at 10.0 feet/minute, collecting data continuously at 0.04 foot intervals, as summarized in Table 3.

Upon completion of the measurements, the probe zero depth indication at grade was verified prior to removal from the boring and the after survey depth error (ASDE) was calculated, as summarized in Table 4.

DATA ANALYSIS

Suspension Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, included in the data disk (CD-R) labeled Report 7534-02 that accompanies this report, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3 foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based upon the arrival time picks made in PSLOG. The PSLOG pick files and the EXCEL analysis files are included in the boring specific directories on the data disk (CD-R) labeled Report 7534-02 that accompanies this report.

The P-wave velocity over the 6.3 foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.8 feet to correspond to the mid-point of the 6.3 foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.3 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, the recorded digital waveforms were analyzed to locate clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital Fast Fourier Transform – Inverse Fast Fourier Transform (FFT – IFFT) lowpass filtering was used to remove the higher frequency P-wave signal from the S_H-wave signal. Different filter cutoffs were used to separate P- and S_H-waves at different depths, ranging from 600 Hz in the slowest zones to 2000 Hz in the regions of highest velocity. At each depth, the filter frequency was selected to be at least twice the fundamental frequency of the S_H-wave signal being filtered.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.3 foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.8 foot to correspond to the mid-point of the 6.3 foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.3 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

These data and analysis were reviewed by John Diehl as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 3 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 3, the time difference over the 3.3 foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 4 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating