PNNL-16678 GR07-10 Volume IV



Volume IV S-Wave Measurements in Borehole C4993 Seismic Records, Wave-Arrival Identifications and Interpreted S-Wave Velocity Profile

K. H. Stokoe S. Li B. Cox F. Menq

June 2007



Pacific Northwest National Laboratory Operated by Battelle for the U.S. Department of Energy

> Prepared by The University of Texas at Austin for the Pacific Northwest National Laboratory under Contract DE-AC05-76RL01830 with the U.S. Department of Energy

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor Battelle Memorial Institute, nor any of their employees, makes **any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or Battelle Memorial Institute. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.**

PACIFIC NORTHWEST NATIONAL LABORATORY operated by BATTELLE for the UNITED STATES DEPARTMENT OF ENERGY under Contract DE-AC05-76RL01830

Printed in the United States of America

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831-0062; ph: (865) 576-8401 fax: (865) 576-5728 email: reports@adonis.osti.goy

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161 ph: (800) 553-6847 fax: (703) 605-6900 email: orders@ntis.fedworld.gov online ordering: http://www.ntis.gov/ordering.htm



Deep Downhole Seismic Testing at the Waste Treatment Plant Site, Hanford, WA

Volume IV of VI

S-Wave Measurements in Borehole C4993 Seismic Records, Wave-Arrival Identifications and Interpreted S-Wave Velocity Profile

for

Pacific Northwest National Laboratory Richland, WA

by

Kenneth H. Stokoe, II Songcheng Li Brady Cox Farn-Yuh Menq

June 28, 2007

Geotechnical Engineering Report GR07-10 Geotechnical Engineering Center Civil Engineering Department The University of Texas at Austin

Volume IV: S-Wave Measurements in Borehole C4993 Seismic Records, Wave-Arrival Identifications and Interpreted S-Wave Velocity Profile

Table of Contents

Section 1	Introduction 1
Section 2	Explanation of Terminology4
Section 3	Vs Profile at Borehole C4993 16
Section 4	Unfiltered S-Wave Records of Lower Horizontal
	Receiver and Derived Rotated In-Line Signals
4.1	Forward S-wave records of the lower in-line receiver
4.2	Reversed S-wave records of the lower in-line receiver
4.3	Forward S-wave records of the lower cross-line receiver
4.4	Reversed S-wave records of the lower cross-line receiver
4.5	Forward S-wave signals of the lower rotated in-line receiver70
4.6	Reversed S-wave signals of the lower rotated in-line receiver79
Section 5	Unfiltered S-Wave Records of Reaction Mass
Section 6	Unfiltered S-Wave Records of Reference Receiver
Section 7	Filtered S-Wave Signals of Lower Rotated In-Line
	Receiver 108
Section 8	Filtered S-Wave Signals of Reaction Mass Acceleration 118
Section 9	Filtered S-Wave Signals of Reference Receiver 128

Section 10	Expanded and Filtered S-Wave Signals of Lower	
	Rotated In-Line Receiver	138
Section 11	Waterfall Plots of Unfiltered S-Wave Signals of Lower	
	Rotated In-Line Receiver	148
Section 12	Waterfall Plots of Filtered S-Wave Signals of Lower	
	Rotated In-Line Receiver	153
Section 13	References	158
Section 13	Rotated In-Line Receiver References	15 15

Volume IV: S-Wave Measurements in Borehole C4993 Seismic Records, Wave-Arrival Identifications and Interpreted S-Wave Velocity Profile

Section 1: Introduction

The U.S. Department of Energy (DOE) and the Pacific Northwest National Laboratory (PNNL) installed three boreholes to a depth of approximately 1400 feet below ground surface (bgs) in 2006 at the Waste Treatment and Immobilization Plant (WTP) construction site on the Hanford Site in southeastern Washington State. The purpose of the new boreholes was to obtain direct shear (S) and compressional (P) wave velocity measurements in the subsurface for use in reducing the uncertainty in the seismic response spectra and design basis for the WTP. The University of Texas at Austin (UTA) was contracted by PNNL to collect S- and P-wave measurements in each of the three new boreholes identified as C4993, C4996 and C4997 (Barnett et al. 2007; Gardner and Price 2007).

Velocity measurements in shallow sediments from the ground surface to approximately 370 to 400 feet bgs were collected by Redpath Geophysics using impulsive S- and P-wave seismic sources (Redpath 2007). Measurements below this depth within basalt and sedimentary interbeds were made by UTA between October and December 2006 using the T-Rex vibratory seismic source (Stokoe et al. 2004) in each of the three boreholes. Results of these measurements including seismic records, wavearrival identifications and interpreted velocity profiles are presented in the following six volumes:

- I. P-Wave Measurements in Borehole C4993,
- II. P-Wave Measurements in Borehole C4996,
- III. P-Wave Measurements in Borehole C4997,
- IV. S-Wave Measurements in Borehole C4993,
- V. S-Wave Measurements in Borehole C4996, and
- VI. S-Wave Measurements in Borehole C4997.

In this volume (IV), all S-wave measurements are presented that were performed in Borehole C4993 at the WTP with T-Rex as the seismic source and the Lawrence Berkeley National Laboratory (LBNL) 3-D wireline geophone as the at-depth borehole receiver. S-wave measurements were performed over the depth range of 370 to 1300 ft, typically in 10-ft intervals. However, in some interbeds, 5-ft depth intervals were used, while below about 1200 ft, depth intervals of 20 ft were used. The field setup is illustrated in Figure 1.1.



Figure 1.1 Field Setup for P- and S-Wave Measurement in Borehole C4993

Shear (S) waves were generated by moving the base plate of T-Rex for a given number of cycles at a fixed frequency as discussed in Section 2. This process was repeated so that signal averaging in the time domain was performed using 3 to about 15 averages, with 5 averages typically used. In addition, a second average shear wave record was recorded by reversing the polarity of the motion of the T-Rex base plate. In this sense, all the signals recorded in the field were averaged signals.

In all cases, the base plate was moving perpendicular to a radial line between the base plate and the borehole which is in and out of the plane of the figure shown in Figure 1.1. The definition of "in-line", "cross-line", "forward", and "reversed" directions are presented in Section 2. The definitions are based on the direction of the movement of the base plate.

In addition to the LBNL 3-D geophone, called the lower receiver herein, a 3-D geophone from Redpath Geophysics was fixed at a depth of 22 ft in Borehole C4993, and a 3-D geophone from the University of Texas (UT) was embedded near the borehole at about 1.5 ft below the ground surface. The Redpath geophone and the UT geophone were properly aligned so that one of the horizontal components in each geophone was aligned with the direction of horizontal shaking of the T-Rex base plate.

This volume is organized into 13 sections as follows.

Section 1: Introduction,

Section 2: Explanation of Terminology,

Section 3: Vs Profile at Borehole C4993,

Sections 4 to 6: Unfiltered S-wave records of lower horizontal receiver, reaction mass, and reference receiver, respectively,

Sections 7 to 9: Filtered S-wave signals of lower horizontal receiver, reaction mass and reference receiver, respectively,

Section 10: Expanded and filtered S-wave signals of lower horizontal receiver,

Sections 11 and 12: Waterfall plots of unfiltered and filtered lower horizontal receiver signals, respectively, and

Section 13: References.

Section 2 Explanation of Terminology

1. Record or Signal

The recorded and sampled time series of analog voltage from a geophone or an accelerometer is called a record. A signal can generally be a raw record, a processed record or any designed or generated (as by function generator) time series.

The magnitude of any signals related to this test is by default in voltage. All signal amplitudes (y-axis for time series, both axes for hodograph) in figures of this report, if not otherwise explicitly labeled, have a unit of volt.

All figures for time series have the y axis scaled independently for legibility for each trace (gain-normalized). This makes them legible when the amplitude varies from trace to trace (large close to the surface, small at depth).

2. Input Signal or Drive Signal

At each measurement depth, an independent fixed sine wave with a frequency of 50 Hz or 30 Hz was sent from a function generator to T-Rex. This signal is called the Input Signal to T-Rex, or the T-Rex Drive Signal. The input signal was a perfect sine wave, with either 5 cycles of 50 Hz or 4 cycles of 30 Hz. Input signals of all measurements were aligned so that they all began at the same instant, which is called time zero, and was marked as time zero (at t = 0) on all recorded signals. The input signal, with either 5 cycles of 50 Hz or 4 cycles of 30 Hz, was sent to T-Rex anywhere from 3 to about 15 times to allow signal averaging of the shear wave to be performed in the time domain. In addition, the polarity of the drive signal was then reversed and the whole process repeated to allow an averaged shear wave signal with reversed polarity to be recorded at the same depth.

3. In-Line and Cross-Line (X-Line)

As discussed in Section 1, in all cases, the base plate was moving perpendicular to a radial line between the base plate and the borehole which is in and out of the plane of the figure shown in Figure 1.1. The radial line is called cross-line (x-line) direction, while the tangential line, which represents the direction of the base plate, is called in-line direction.

4. Forward Signal and Reversed Signal

The initial horizontal direction in which T-Rex was excited is called the forward direction. The opposite initial direction of excitation that was created by reversing the polarity of the drive signal to T-Rex is called the reversed direction. The forward and reversed motions should be out of phase or have a 180-degree in-phase difference. Examples of these two records are shown in Figures 2.1 and 2.2.

5. Reaction Mass Acceleration or T-Rex Output Signal

The horizontal output force of T-Rex was transmitted to the ground surface by a square base plate located on the bottom of T-Rex. The base plate directly contacted the ground surface. The acceleration of the reaction mass that loads the base plate, also called T-Rex Output Signal, was recorded by a horizontal accelerometer on the reaction mass. An example of the reaction mass output signal is presented in Figure 2.1. The upper one represents the forward initial motion, while the lower one represents the reversed input motion.





6. Unfiltered Signals

Unfiltered signals are the averaged original time series directly recorded with the Data Physics Analyzer¹. They are the averaged horizontal outputs of the reaction mass accelerometer or the receiver geophones due to the 50-Hz or 30-Hz input signal. The average amplitude of the unfiltered signal over the record length may not be zero due to

¹ System No. 70270 Mobilyzer II – 16C2S – HS, Data Physics Corporation, San Jose, California

the non-zero initial voltage. Figure 2.2 shows that the average amplitude of an unfiltered signal is less than zero.





7. Filters and Filtered Signals

Filters were used in processing the averaged unfiltered signals. A filter is a transfer function that can modify magnitudes and phases of the signal. A low-pass filter is a filter that attenuates or removes undesired high frequencies. The filtered signal is then smoother, and the input signal transmitted through the geologic column is easier to identify. Unfiltered signals in the time domain were transformed into the frequency domain using the discrete Fast Fourier Transform (FFT), where a low-pass filter was applied by multiplying filter coefficients with both the real and imaginary parts of the frequency magnitudes to get a modified frequency response. Then the inverse FFT was performed on the modified frequency response to obtain a filtered signal in the time domain. Figure 2.3 is the filtered version of the recorded signal in Figure 2.2.

The exact same filtering was performed on all signals with a given fixed frequency. Therefore, any minor shifting in the time domain due to the filtering was the same for each fixed-frequency signal. As a result, the relative travel times determined herein are unaffected by this filtering. Also, the wave-arrival identification on the filtered waveform is denoted by a symbol added to the waveform (the small circle or triangle at t~0.37 sec in Figure 2.3) as discussed below in item "Relative Travel Times".



Figure 2.3 Filtered Lower InLine Receiver (S-Wave) Signals Input Signal: 4 Cycles of 30-Hz Sine Wave

8. Pass Band or Low Pass

By signal processing convention, the "pass band" of a filter is the band of frequencies that lie within 3 decibels of the peak magnitude. The "stop band" or "reject band" is all other frequencies. The word "band" refers to a frequency range. The frequency corresponding to 3 decibels of the peak value is called the "cut-off" frequency. If a pass band of a filter is the frequency range between zero and the cut-off frequency, it is called a "low pass" filter.





Unfiltered signals are all digital discrete time series, whose frequency domain is also discrete, as shown in Figure 2.4, where the input signal is a 30-Hz sine wave. As demonstrated in the figure, except for the 60-Hz noise, the largest magnitude in the spectrum is the frequency near 30-Hz. Because the 60-Hz noise and other noise have a significant contribution in the unfiltered signal, they must be filtered or removed to retrieve and view the desired measurement of the 30-Hz input signal.

A discrete filter in the frequency domain, as shown in Figure 2.5, is applicable to these discrete time series. The pass band is 0 to 50 Hz, the reject band is 60 Hz to the Nyquist frequency (not shown), and there is a transitional band between 50 Hz and 60 Hz, which is a cubic spline curve in this work.

A transitional band is preferred if the magnitude of the reject band is not negligible compared with the magnitude of the desired dominant frequency. For example, in Figure 2.4, if the pass band is 0 to 40 Hz, a transitional band of 40 to 60 Hz would make the filtered signal better. If the contribution of the reject band to the spectrum (or energy) is negligible, an ideal filter makes little difference compared to a transitional filter. For example, if the pass band is 0 to 50 Hz, there is no significant difference between a transitional filter and an ideal filter. If there was a general trough (near 52 Hz) following the peak of the signal energy (near 30 Hz), a cut-off frequency (50 Hz) was chosen near the trough, and an ideal filter was used. Otherwise, a transitional filter was used.





9. Time Shift

The input signal to the ground, represented by the acceleration of the reaction mass, is not a perfect sine wave, as shown in Figure 2.6. It can be distorted when the initial state of the T-Rex mass is not consistently the same, or the soil below the reaction mass is loaded nonlinearly. Therefore, even if the drive signal is always aligned to zero time, the reaction mass initial response may be shifted from zero time, which is called a time shift.

In Figure 2.6, the denoted first arrival is the best point for wave-arrival identification. However, it is not reliable because of the nonlinear initial response of the reaction mass, which may produce different first arrival times for reaction mass and receivers even if the drive signals are exactly aligned. This effect is demonstrated by the first cycle right after the first arrival that shows a transient amplitude and frequency.



Figure 2.7 is used to further explain the unreliability of the first arrival or first movement of the reaction mass, and the transient effect on both frequency and magnitude. The filter is a 40-Hz low pass that removed all frequencies higher than 40 Hz. The first arrival point or "first break" in Figure 2.6 no longer exists in Figure 2.7 because it contains transient frequencies that are higher than 30 Hz. On the other hand, the amplitude of the first peak denoted by a small circle is smaller than other peaks, because reaction mass is beginning to move at 30 Hz. This first peak is the correct point to use in evaluating the relative travel time of a 30-Hz S wave.





Further analysis confirmed that different non-causal low pass filters for the 30-Hz signal in Figure 2.6 will shift the first arrival and first trough, but only slightly shift the first peak if the transient state extends to it, while other peaks and troughs that are in steady state stay unchanged and perfectly aligned. The shift of the first arrival is systematically backward (time is less) and stable because the desired 30-Hz signal remains dominant. Steady-state peaks of output signals have no time shift if the input

signals have no time shift. An FFT low-pass filter can do an excellent job in tracking the desired fixed frequencies.

Nevertheless, steady state peaks and troughs are not a perfect reference for wavearrival identification because of reflected waves and mode conversions that can enter the direct signal and distort the steady-state peaks and troughs.

As a compromise and for convenience, the first-arrival wave identification method is replaced with the first peak or the trough of the waveform for the reaction mass acceleration and other receiver signals. There is little shifting from the steady state of the desired signal frequency (for example 30 Hz), and less interference from reflections and mode conversions.

As an alternative for the non-causal filter, a Butterworth filter may secure the first arrival to be stationary, but it falls short if the frequency of the dominant noise (38-Hz noise in Figure 2.4 has greater magnitude than the desired signal at 30 Hz) is very close to that of the signal. The filtering of the 60-Hz noise from the 50-Hz signal was used in all three boreholes. If the noise can not be significantly attenuated or removed, it will shift not only the first arrival, but also the steady-state peaks and troughs, and the shift is irregular because it is controlled by the noise. The FFT low pass filter, which is non-causal, can remove undesired 60-Hz noise completely and track the desired frequency effectively. Therefore, the FFT low-pass filter was used herein.

10. Relative Travel Times

Relative travel times are the time intervals between the same points on the averaged waveforms of the reaction mass and receivers (lower receiver or reference receiver). The time on each filtered waveform that is used to determine the relative travel time is denoted by a small symbol that has been added to all waveforms. Examples are shown in Figures 2.3 and 2.7 by the small circles or triangles. These points (representing times) are not the wave arrivals but are the same point on the waveform from one measurement depth to the next. These points are called "wave-arrival identifications" herein.

11. Long Lever Arm and Short Lever Arm

The lower borehole geophone from Lawrence Berkeley National Laboratory (LBNL) was fixed to the borehole wall at a depth by rotating the pivoting lever arm that

was attached to the geophone case. As the lever arm rotated outward, the geophone case was pushed into contact with the borehole wall. Two lengths of lever arms were used, the longer one called a long lever arm and the shorter one called a short lever arm. Because of irregularities in the borehole diameter (Gardner and Price 2007), the long lever arm was used to avoid inadequate contact with the borehole wall in regions where washouts may have substantially increased the borehole diameter. Both long and short arms were used at depths 1240 and 1260 ft in borehole C4993 and no significant difference was found in the lower receiver output with the different level arms. For all other depths, only the long lever arm was used.

12. Reference Receiver

The reference receiver is the horizontal receiver that was always fixed at depth of 22 ft in Borehole C4993 while the lower 3-D receiver of LBNL was moved downward along the borehole. When the response of the lower receiver with the long arm and short arm were compared, the same reference receiver was used, but its depth was changed to 17 ft.

13. Lower Horizontal Receivers: In-Line Receiver and Cross-Line (X-Line) Receiver

The lower horizontal receivers are the two horizontal components of the LBNL 3-D geophone. They are at the deeper depth or lower location than the reference receiver. They are the components in the only 3-D geophone that was moved in the borehole.

The two horizontal components are perpendicular to each other. One is called inline receiver, and the other cross-line (x-line) receiver. These receivers were on a wireline and, hence, their orientation could not be controlled while the 3-D geophone was moved along the borehole. Nevertheless, for convenience, the names of "in-line" and "crossline" were used, though they were actually not related to the direction of motion of the base plate. The signals of the two components were used to obtain the actual in-line signal, which is called rotated in-line signal or rotated in-line receiver herein.

14. Rotated In-Line Receiver

As discussed in the item above, the in-line and cross-line (x-line) receivers in the field are generally not aligned with the T-Rex shaking direction. From the signal records of the in-line and cross-line (x-line) receivers, the shaking orientation can be found by the

hodograph as shown in Figure 2.8. The red line represents the statistically strongest motion direction, called the rotated in-line direction. The rotated in-line signal can be composed by combining the directional components of the in-line and cross-line receivers in time. This composition was performed for each waveform record. The resultant waveform is termed the rotated in-line signal. Because the rotated cross-line signal is not our interest, only the rotated in-line signals were used for the relative travel times, and are presented in the subsequent sections.

Figure 2.8 Composition of the Rotated In-line Signal Using the Unfiltered Signals of Both Horizontal Geophones



When the measurements were deep, the strongest motion may be difficult to determine in the unfiltered signals. Reflected, refracted and converted waves can exist in the S-wave records which make the S-wave signal with a fixed frequency and given

number of cycles difficult to recover. In this situation, filtered in-line and cross-line (x-line) signals were used to obtain the rotated in-line signal, as shown in Figure 2.9.

Figure 2.9 Composition of the Rotated In-line Signal Using the Filtered Signals of Both Horizontal Geophones



However, the strongest motion direction is not always available when the desired signal can hardly be detected at significant depths. Figure 2.10 is the hodograph of the filtered in-line and cross-line (x-line) signals at a depth of 1100 ft. Two possible factors can contribute to the loss of the strongest motion. One factor is that the energy of the noise remaining in the filtered signal is rather large compared with the input signal so that the signal-to-remaining-noise ratio becomes smaller and smaller. The other factor is that the P-wave component generated during the S-wave shaking is no longer negligible at

depth. When the energy of the derivative vertical P-wave component is of the same magnitude as the horizontal S-wave components, the particle motion is no longer strongest in the horizontal 2-D surface that is parallel to the base plate; rather, it is a 3-D motion, the projection of which onto the horizontal surface can demonstrate an instantaneous strongest motion in any direction. It is possible that beyond a certain depth, combined with complex layering, only the derivative P-wave survives and determines the strongest motion, which can be vertically oriented.





Even though, based on the statistics, there may exist a relatively stronger horizontal motion for the records as indicated by the red line in Figure 2.10, the horizontal motion can be misleading because the stronger motion may be determined by remaining noise or the derivative P-wave component rather than the desired signal. An invalid strongest motion direction results in a wrongly interpreted rotated in-line signal, whose phase can be shifted up to 180 degrees. When this case was suspected by an unreasonable trend in the data, waveforms were presented but not picked for travel times.

When the signal condition was between the conditions shown in Figures 2.9 and 2.10, the error in the orientation of the red line (rotated in-line direction) probably increased with depth. Scatter was found in the wave-arrival identification of these signals. However, their waveforms were picked and presented. When the trend in the relative travel times was evident, the shear wave velocity was reported. When only a few waveforms could be interpreted (in a thin layer) the scatter in the relative travel times resulted in a lower confidence level in the shear wave velocity.

Section 3: Vs Profile at Borehole C4993

Section 3 contains the geologic profile, interpreted Vs profile and relative S-wave travel times.

- 1. Figure 3.1 presents the geologic profile.
- 2. Figure 3.2 presents all relative S-wave travel times and the interpreted Vs profile at Borehole C4993.
- 3. Figures 3.3 to 3.5 are the expanded relative S-wave travel times and the interpreted Vs profile at Borehole C4993.
- 4. Tables 3.1 to 3.9 list the relative S-wave travel times at Borehole C4993, including the times of the wave-arrival identifications for the peaks or troughs of the reaction-mass acceleration, reference receiver and lower rotated receiver signals.

Figure 3.1 General Stratigraphy of Borehole C4993

(Depths source: Barnett et al. 2007; Rohay and Brouns 2007)



Ground Surface (658 ft above mean sea level)



Figure 3.2 Relative S-Wave Travel Times and Interpreted Vs Profile at Borehole C4993

18



Figure 3.3 Expanded Relative S-Wave Travel Times and Interpreted Vs Profile at Borehole C4993, Depths 300 to 800 ft



Figure 3.4 Expanded Relative S-Wave Travel Times and Interpreted Vs Profile at Borehole C4993, Depths 600 to 1100 ft



Figure 3.5 Expanded Relative S-Wave Travel Times and Interpreted Vs Profile at Borehole C4993, Depths 900 to 1400 ft

Lower	Reference	T-Rex	T-Rex	Time: Peak or	Time: Peak or	Time: Peak or	Travel Time	Travel Time	Average Travel Time *
Receiver	Receiver	Drive Freq./	Excitation	Trough at	Trough at	Trough at	Relative to	Relative to	Relative to
Depth	Depth	No. of Cycles	Direction	Reaction Mass	Ref. Receiver	Lower Receiver	Ref. Receiver	Reaction Mass	Reaction Mass
(ft)	(ft)	(Hz/No.)		(sec)	(sec)	(sec)	(sec)	(sec)	(sec)
370	22	50/5	Forward	0.01618	0.04966	0.22045	0.17079	0.20427	0.20404
370	22	50/5	Reversed	0.01618	0.04966	0.22000	0.17034	0.20382	-
380	22	50/5	Forward	0.01618	0.04966	0.21865	0.16899	0.20247	0.20230
380	22	50/5	Reversed	0.01618	0.04966	0.21831	0.16865	0.20213	-
390	22	50/5	Forward	0.01618	0.04966	0.22000	0.17034	0.20382	0.20365
390	22	50/5	Reversed	0.01618	0.04966	0.21966	0.17000	0.20348	-
400	22	50/5	Forward	0.01618	0.04966	0.22197	0.17230	0.20579	0.20545
400	22	50/5	Reversed	0.01618	0.04966	0.22129	0.17163	0.20511	-
410	22	50/5	Forward	0.01618	0.04966	0.22180	0.17213	0.20562	0.20562
410	22	50/5	Reversed	0.01618	0.04966	0.22180	0.17213	0.20562	-
420	22	50/5	Forward	0.01618	0.04966	0.22331	0.17365	0.20713	0.20699
420	22	50/5	Reversed	0.01618	0.04966	0.22303	0.17337	0.20685	-
430	22	50/5	Forward	0.01618	0.04966	0.22472	0.17506	0.20854	0.20860
430	22	50/5	Reversed	0.01618	0.04966	0.22483	0.17517	0.20865	-
440	22	50/5	Forward	0.01618	0.04966	0.22640	0.17674	0.21022	0.21022
440	22	50/5	Reversed	0.01618	0.04966	0.22640	0.17674	0.21022	-
450	22	50/5	Forward	0.01618	0.04966	0.22871	0.17904	0.21253	0.21236
450	22	50/5	Reversed	0.01618	0.04966	0.22837	0.17871	0.21219	-
460	22	50/5	Forward	0.01618	0.04966	0.23376	0.18410	0.21758	0.21728
460	22	50/5	Reversed	0.01618	0.04966	0.23315	0.18348	0.21697	-
470	22	50/5	Forward	0.01618	0.04966	0.23393	0.18427	0.21775	0.21753
470	22	50/5	Reversed	0.01618	0.04966	0.23348	0.18382	0.21730	-
475	22	50/5	Forward	0.01618	0.04966	0.23393	0.18427	0.21775	0.21753
475	22	50/5	Reversed	0.01618	0.04966	0.23348	0.18382	0.21730	-
480	22	50/5	Forward	0.01618	0.04966	0.23730	0.18764	0.22112	0.22121
480	22	50/5	Reversed	0.01618	0.04966	0.23747	0.18781	0.22129	-

Table 3.1 Relative S-Wave Travel Times at Borehole C4993

* Use of the reaction mass as a reference for calculating relative travel times exhibited less scatter than using the reference receiver.

Lower	Reference	T-Rex	T-Rex	Time: Peak or	Time: Peak or	Time: Peak or	Travel Time	Travel Time	Average Travel Time *
Receiver	Receiver	Drive Freq./	Excitation	Trough at	Trough at	Trough at	Relative to	Relative to	Relative to
Depth	Depth	No. of Cycles	Direction	Reaction Mass	Ref. Receiver	Lower Receiver	Ref. Receiver	Reaction Mass	Reaction Mass
(ft)	(ft)	(Hz/No.)		(sec)	(sec)	(sec)	(sec)	(sec)	(sec)
485	22	50/5	Forward	0.01618	0.04966	**	-	-	-
485	22	50/5	Reversed	0.01618	0.04966	**	-	-	-
490	22	50/5	Forward	0.01618	0.04966	0.24253	0.19287	0.22635	0.22610
490	22	50/5	Reversed	0.01618	0.04966	0.24202	0.19236	0.22584	-
495	22	50/5	Forward	0.01618	0.04966	0.23646	0.18680	0.22028	0.22037
495	22	50/5	Reversed	0.01618	0.04966	0.23663	0.18697	0.22045	-
500	22	50/5	Forward	0.01618	0.04966	0.24421	0.19455	0.22803	0.22795
500	22	50/5	Reversed	0.01618	0.04966	0.24405	0.19438	0.22787	-
505	22	50/5	Forward	0.01618	0.04966	0.24202	0.19236	0.22584	0.22534
505	22	50/5	Reversed	0.01618	0.04966	0.24101	0.19135	0.22483	-
510	22	50/5	Forward	0.01618	0.04966	0.24556	0.19590	0.22938	0.22930
510	22	50/5	Reversed	0.01618	0.04966	0.24539	0.19573	0.22921	-
515	22	50/5	Forward	0.01618	0.04966	0.24860	0.19893	0.23242	0.23216
515	22	50/5	Reversed	0.01618	0.04966	0.24809	0.19843	0.23191	-
520	22	50/5	Forward	0.01618	0.04966	0.24719	0.19753	0.23101	0.23124
520	22	50/5	Reversed	0.01618	0.04966	0.24764	0.19798	0.23146	-
525	22	50/5	Forward	0.01618	0.04966	0.24758	0.19792	0.23140	0.23115
525	22	50/5	Reversed	0.01618	0.04966	0.24708	0.19742	0.23090	-
530	22	50/5	Forward	0.01618	0.04966	0.24961	0.19994	0.23343	0.23317
530	22	50/5	Reversed	0.01618	0.04966	0.24910	0.19944	0.23292	-
540	22	50/5	Forward	0.01618	0.04966	0.25011	0.20045	0.23393	0.23393
540	22	50/5	Reversed	0.01618	0.04966	0.25011	0.20045	0.23393	-
550	22	50/5	Forward	**	0.04966	0.25461	0.20494	-	0.23820
550	22	50/5	Reversed	0.01775	0.05124	0.25596	0.20472	0.23820	-
560	22	50/5	Forward	0.01775	0.05169	0.25775	0.20607	0.24000	0.24011
560	22	50/5	Reversed	0.01775	0.05124	0.25798	0.20674	0.24022	-

Table 3.2 Relative S-Wave Travel Times at Borehole C4993

* Use of the reaction mass as a reference for calculating relative travel times exhibited less scatter than using the reference receiver.

** Waveform was distorted making arrival time unidentifiable.

Lower	Reference	T-Rex	T-Rex	Time: Peak or	Time: Peak or	Time: Peak or	Travel Time	Travel Time	Average Travel Time *
Receiver	Receiver	Drive Freq./	Excitation	Trough at	Trough at	Trough at	Relative to	Relative to	Relative to
Depth	Depth	No. of Cycles	Direction	Reaction Mass	Ref. Receiver	Lower Receiver	Ref. Receiver	Reaction Mass	Reaction Mass
(ft)	(ft)	(Hz/No.)		(sec)	(sec)	(sec)	(sec)	(sec)	(sec)
570	22	50/5	Forward	0.01775	0.05169	0.25730	0.20562	0.23955	0.23955
570	22	50/5	Reversed	0.01775	0.05124	0.25730	0.20607	0.23955	-
580	22	50/5	Forward	0.01775	0.05169	0.25978	0.20809	0.24202	0.24169
580	22	50/5	Reversed	0.01775	0.05124	0.25910	0.20787	0.24135	-
590	22	50/5	Forward	0.01775	0.05169	0.25843	0.20674	0.24067	0.24146
590	22	50/5	Reversed	0.01775	0.05124	0.26000	0.20876	0.24225	-
600	22	50/5	Forward	0.01775	0.05169	0.26090	0.20921	0.24315	0.24315
600	22	50/5	Reversed	0.01775	0.05124	0.26090	0.20966	0.24315	-
610	22	50/5	Forward	0.01775	0.05169	0.26180	0.21011	0.24404	0.24416
610	22	50/5	Reversed	0.01775	0.05124	0.26202	0.21079	0.24427	-
620	22	50/5	Forward	0.01775	0.05169	0.26337	0.21169	0.24562	0.24562
620	22	50/5	Reversed	0.01775	0.05124	0.26337	0.21213	0.24562	-
630	22	50/5	Forward	0.01775	0.05169	0.26472	0.21303	0.24697	0.24708
630	22	50/5	Reversed	0.01775	0.05124	0.26494	0.21371	0.24719	-
640	22	50/5	Forward	0.01775	0.05169	0.26787	0.21618	0.25011	0.25000
640	22	50/5	Reversed	0.01775	0.05124	0.26764	0.21640	0.24989	-
650	22	50/5	Forward	0.01775	0.05169	0.26854	0.21685	0.25079	0.25045
650	22	50/5	Reversed	0.01775	0.05124	0.26787	0.21663	0.25011	-
660	22	50/5	Forward	0.01775	0.05169	0.27056	0.21888	0.25281	0.25270
660	22	50/5	Reversed	0.01775	0.05124	0.27034	0.21910	0.25258	-
670	22	50/5	Forward	0.01775	0.05169	0.26921	0.21753	0.25146	0.25135
670	22	50/5	Reversed	0.01775	0.05124	0.26899	0.21775	0.25124	-
680	22	50/5	Forward	0.01775	0.05169	0.27101	0.21933	0.25326	0.25315
680	22	50/5	Reversed	0.01775	0.05124	0.27079	0.21955	0.25303	-
690	22	50/5	Forward	0.01775	0.05169	0.27236	0.22067	0.25461	0.25461
690	22	50/5	Reversed	0.01775	0.05124	0.27236	0.22112	0.25461	-

Table 3.3 Relative S-Wave Travel Times at Borehole C4993

* Use of the reaction mass as a reference for calculating relative travel times exhibited less scatter than using the reference receiver.

Lower	Reference	T-Rex	T-Rex	Time: Peak or	Time: Peak or	Time: Peak or	Travel Time	Travel Time	Average Travel Time *
Receiver	Receiver	Drive Freq./	Excitation	Trough at	Trough at	Trough at	Relative to	Relative to	Relative to
Depth	Depth	No. of Cycles	Direction	Reaction Mass	Ref. Receiver	Lower Receiver	Ref. Receiver	Reaction Mass	Reaction Mass
(ft)	(ft)	(Hz/No.)		(sec)	(sec)	(sec)	(sec)	(sec)	(sec)
700	22	50/5	Forward	0.01775	0.05169	0.27438	0.22270	0.25663	0.25640
700	22	50/5	Reversed	0.01775	0.05124	0.27393	0.22270	0.25618	-
710	22	50/5	Forward	0.01775	0.05169	**	-	-	-
710	22	50/5	Reversed	0.01775	0.05124	**	-	-	-
718	22	50/5	Forward	0.01775	0.05169	0.27596	0.22427	0.25820	0.25803
718	22	50/5	Reversed	0.01775	0.05124	0.27562	0.22438	0.25787	-
727	22	50/5	Forward	0.01775	0.05169	0.27798	0.22629	0.26022	0.26067
727	22	50/5	Reversed	0.01775	0.05124	0.27888	0.22764	0.26112	-
732	22	50/5	Forward	0.01775	0.05169	**	-	-	-
732	22	50/5	Reversed	0.01775	0.05124	**	-	-	-
737	22	50/5	Forward	0.01775	0.05169	0.28067	0.22899	0.26292	0.26343
737	22	50/5	Reversed	0.01775	0.05124	0.28169	0.23045	0.26393	-
742	22	50/5	Forward	0.01775	0.05169	0.28270	0.23101	0.26494	0.26511
742	22	50/5	Reversed	0.01775	0.05124	0.28303	0.23180	0.26528	-
748	22	50/5	Forward	0.01775	0.05169	0.28292	0.23124	0.26517	0.26539
748	22	50/5	Reversed	0.01775	0.05124	0.28337	0.23213	0.26562	-
760	22	50/5	Forward	0.01775	0.05169	0.28652	0.23483	0.26876	0.26876
760	22	50/5	Reversed	0.01775	0.05124	0.28652	0.23528	0.26876	-
770	22	50/5	Forward	0.01775	0.05169	**	-	-	-
770	22	50/5	Reversed	0.01775	0.05124	**	-	-	-
780	22	50/5	Forward	0.01775	0.05169	**	-	-	-
780	22	50/5	Reversed	0.01775	0.05124	**	-	-	-
790	22	50/5	Forward	0.01775	0.05236	0.28697	0.23461	0.26921	0.26921
790	22	50/5	Reversed	0.01775	0.05169	0.28697	0.23528	0.26921	-
800	22	50/5	Forward	0.01775	0.05236	0.29146	0.23910	0.27371	0.27354
800	22	50/5	Reversed	0.01775	0.05169	0.29112	0.23944	0.27337	-

Table 3.4 Relative S-Wave Travel Times at Borehole C4993

* Use of the reaction mass as a reference for calculating relative travel times exhibited less scatter than using the reference receiver.

** Waveform was distorted making arrival time unidentifiable.

Lower	Reference	T-Rex	T-Rex	Time: Peak or	Time: Peak or	Time: Peak or	Travel Time	Travel Time	Average Travel Time *
Receiver	Receiver	Drive Freq./	Excitation	Trough at	Trough at	Trough at	Relative to	Relative to	Relative to
Depth	Depth	No. of Cycles	Direction	Reaction Mass	Ref. Receiver	Lower Receiver	Ref. Receiver	Reaction Mass	Reaction Mass
(ft)	(ft)	(Hz/No.)		(sec)	(sec)	(sec)	(sec)	(sec)	(sec)
810	22	50/5	Forward	0.01775	0.05236	0.29393	0.24157	0.27618	0.27618
810	22	50/5	Reversed	0.01775	0.05169	0.29393	0.24225	0.27618	-
820	22	50/5	Forward	0.01775	0.05236	0.29326	0.24090	0.27551	0.27551
820	22	50/5	Reversed	0.01775	0.05169	0.29326	0.24157	0.27551	-
830	22	50/5	Forward	0.01775	0.05236	0.29326	0.24090	0.27551	0.27506
830	22	50/5	Reversed	0.01775	0.05169	0.29236	0.24067	0.27461	-
840	22	50/5	Forward	0.01775	0.05236	0.29506	0.24270	0.27730	0.27730
840	22	50/5	Reversed	0.01775	0.05169	0.29506	0.24337	0.27730	-
845	22	50/5	Forward	0.01820	0.05236	0.29596	0.24360	0.27775	0.27787
845	22	50/5	Reversed	0.01820	0.05169	0.29618	0.24449	0.27798	-
853	22	50/5	Forward	0.01820	0.05236	0.29888	0.24652	0.28067	0.28067
853	22	50/5	Reversed	0.01820	0.05169	0.29888	0.24719	0.28067	-
860	22	50/5	Forward	0.01820	0.05236	0.30494	0.25258	0.28674	0.28640
860	22	50/5	Reversed	0.01820	0.05169	0.30427	0.25258	0.28607	-
870	22	50/5	Forward	0.01820	0.05236	0.30584	0.25348	0.28764	0.28764
870	22	50/5	Reversed	0.01820	0.05169	0.30584	0.25416	0.28764	-
880	22	50/5	Forward	0.01820	0.05236	0.31169	0.25933	0.29348	0.29331
880	22	50/5	Reversed	0.01820	0.05169	0.31135	0.25966	0.29315	-
890	22	50/5	Forward	0.01820	0.05236	0.31472	0.26236	0.29652	0.29635
890	22	50/5	Reversed	0.01820	0.05169	0.31438	0.26270	0.29618	-
900	22	50/5	Forward	0.01820	0.05236	0.31843	0.26607	0.30022	0.30022
900	22	50/5	Reversed	0.01820	0.05169	0.31843	0.26674	0.30022	-
910	22	50/5	Forward	0.01820	0.05236	0.32348	0.27112	0.30528	0.30511
910	22	50/5	Reversed	0.01820	0.05169	0.32315	0.27146	0.30494	-
917	22	50/5	Forward	0.01820	0.05236	0.32551	0.27315	0.30730	0.30713
917	22	50/5	Reversed	0.01820	0.05169	0.32517	0.27348	0.30697	-

Table 3.5 Relative S-Wave Travel Times at Borehole C4993

* Use of the reaction mass as a reference for calculating relative travel times exhibited less scatter than using the reference receiver.

Lower	Reference	T-Rex	T-Rex	Time: Peak or	Time: Peak or	Time: Peak or	Travel Time	Travel Time	Average Travel Time *
Receiver	Receiver	Drive Freq./	Excitation	Trough at	Trough at	Trough at	Relative to	Relative to	Relative to
Depth	Depth	No. of Cycles	Direction	Reaction Mass	Ref. Receiver	Lower Receiver	Ref. Receiver	Reaction Mass	Reaction Mass
(ft)	(ft)	(Hz/No.)		(sec)	(sec)	(sec)	(sec)	(sec)	(sec)
927	22	50/5	Forward	0.01820	0.05236	0.32921	0.27685	0.31101	0.31101
927	22	50/5	Reversed	0.01820	0.05169	0.32921	0.27753	0.31101	-
935	22	50/5	Forward	0.01820	0.05236	0.33360	0.28124	0.31539	0.31567
935	22	50/5	Reversed	0.01820	0.05169	0.33416	0.28247	0.31596	-
940	22	50/5	Forward	0.01820	0.05236	0.33461	0.28225	0.31640	0.31624
940	22	50/5	Reversed	0.01820	0.05169	0.33427	0.28258	0.31607	-
950	22	50/5	Forward	0.01820	0.05236	0.33596	0.28360	0.31775	0.31758
950	22	50/5	Reversed	0.01820	0.05169	0.33562	0.28393	0.31742	-
960	22	50/5	Forward	0.01820	0.05236	0.33933	0.28697	0.32112	0.32112
960	22	50/5	Reversed	0.01820	0.05169	0.33933	0.28764	0.32112	-
970	22	50/5	Forward	0.01820	0.05236	0.34101	0.28865	0.32281	0.32253
970	22	50/5	Reversed	0.01820	0.05169	0.34045	0.28876	0.32225	-
980	22	50/5	Forward	0.01820	0.05236	**	-	-	-
980	22	50/5	Reversed	0.01820	0.05169	**	-	-	-
990	22	50/5	Forward	0.01820	0.05236	0.34506	0.29270	0.32685	0.32685
990	22	50/5	Reversed	0.01820	0.05169	0.34506	0.29337	0.32685	-
990	22	30/4	Forward	0.02360	0.05775	0.36899	0.31124	0.34539	0.34725
990	22	30/4	Reversed	0.02360	0.05775	0.37270	0.31494	0.34910	-
1000	22	30/4	Forward	0.02360	0.05865	0.36596	0.30730	0.34236	0.34354
1000	22	30/4	Reversed	0.02360	0.05865	0.36831	0.30966	0.34472	-
1010	22	30/4	Forward	0.02360	0.05865	0.36787	0.30921	0.34427	0.34596
1010	22	30/4	Reversed	0.02360	0.05865	0.37124	0.31258	0.34764	-
1020	22	30/4	Forward	0.02360	0.05865	0.37135	0.31270	0.34775	0.34826
1020	22	30/4	Reversed	0.02360	0.05865	0.37236	0.31371	0.34876	-
1030	22	30/4	Forward	0.02360	0.05865	0.37809	0.31944	0.35449	0.35517
1030	22	30/4	Reversed	0.02360	0.05865	0.37944	0.32079	0.35584	-

Table 3.6 Relative S-Wave Travel Times at Borehole C4993

* Use of the reaction mass as a reference for calculating relative travel times exhibited less scatter than using the reference receiver.

** Waveform was distorted making arrival time unidentifiable.

Lower	Reference	T-Rex	T-Rex	Time: Peak or	Time: Peak or	Time: Peak or	Travel Time	Travel Time	Average Travel Time *
Receiver	Receiver	Drive Freq./	Excitation	Trough at	Trough at	Trough at	Relative to	Relative to	Relative to
Depth	Depth	No. of Cycles	Direction	Reaction Mass	Ref. Receiver	Lower Receiver	Ref. Receiver	Reaction Mass	Reaction Mass
(ft)	(ft)	(Hz/No.)		(sec)	(sec)	(sec)	(sec)	(sec)	(sec)
1040	22	30/4	Forward	0.02360	0.05865	0.37303	0.31438	0.34944	0.35056
1040	22	30/4	Reversed	0.02360	0.05865	0.37528	0.31663	0.35169	-
1050	22	30/4	Forward	0.02360	0.05865	0.37573	0.31708	0.35213	0.35163
1050	22	30/4	Reversed	0.02360	0.05865	0.37472	0.31607	0.35112	-
1060	22	30/4	Forward	0.02360	0.05865	0.37978	0.32112	0.35618	0.35652
1060	22	30/4	Reversed	0.02360	0.05865	0.38045	0.32180	0.35685	-
1070	22	30/4	Forward	0.02360	0.05865	**	-	-	0.35955
1070	22	30/4	Reversed	0.02360	0.05865	0.38315	0.32449	0.35955	-
1080	22	30/4	Forward	0.02360	0.05865	0.37528	0.31663	0.35169	0.35360
1080	22	30/4	Reversed	0.02360	0.05865	0.37910	0.32045	0.35551	-
1090	22	30/4	Forward	0.02360	0.05865	0.37573	0.31708	0.35213	0.35303
1090	22	30/4	Reversed	0.02360	0.05865	0.37753	0.31888	0.35393	-
1095	22	30/4	Forward	0.02360	0.05865	0.37573	0.31708	0.35213	0.35404
1095	22	30/4	Reversed	0.02360	0.05865	0.37955	0.32090	0.35596	-
1100	22	30/4	Forward	0.02360	0.05865	0.37618	0.31753	0.35258	0.35562
1100	22	30/4	Reversed	0.02360	0.05865	0.38225	0.32360	0.35865	-
1110	22	30/4	Forward	0.02360	0.05865	0.38831	0.32966	0.36472	0.36326
1110	22	30/4	Reversed	0.02360	0.05865	0.38539	0.32674	0.36180	-
1120	22	30/4	Forward	0.02360	0.05865	0.38539	0.32674	0.36180	0.36230
1120	22	30/4	Reversed	0.02360	0.05865	0.38640	0.32775	0.36281	-
1130	22	30/4	Forward	0.02360	0.05865	**	-	-	-
1130	22	30/4	Reversed	0.02360	0.05865	**	-	-	-
1140	22	30/4	Forward	0.02360	0.05865	**	-	-	0.37124
1140	22	30/4	Reversed	0.02360	0.05865	0.39483	0.33618	0.37124	-
1150	22	30/4	Forward	0.02360	0.05865	**	-	-	-
1150	22	30/4	Reversed	0.02360	0.05865	**	-	-	-

Table 3.7 Relative S-Wave Travel Times at Borehole C4993

* Use of the reaction mass as a reference for calculating relative travel times exhibited less scatter than using the reference receiver.

** Waveform was distorted making arrival time unidentifiable.

Lower	Reference	T-Rex	T-Rex	Time: Peak or	Time: Peak or	Time: Peak or	Travel Time	Travel Time	Average Travel Time *
Receiver	Receiver	Drive Freq./	Excitation	Trough at	Trough at	Trough at	Relative to	Relative to	Relative to
Depth	Depth	No. of Cycles	Direction	Reaction Mass	Ref. Receiver	Lower Receiver	Ref. Receiver	Reaction Mass	Reaction Mass
(ft)	(ft)	(Hz/No.)		(sec)	(sec)	(sec)	(sec)	(sec)	(sec)
1160	22	30/4	Forward	0.02360	0.05865	0.40899	0.35034	0.38539	0.38539
1160	22	30/4	Reversed	0.02360	0.05865	0.40899	0.35034	0.38539	-
1170	22	30/4	Forward	0.02360	0.05865	0.40787	0.34921	0.38427	0.38427
1170	22	30/4	Reversed	0.02360	0.05865	0.40787	0.34921	0.38427	-
1180	22	30/4	Forward	0.02360	0.05865	0.40899	0.35034	0.38539	0.38596
1180	22	30/4	Reversed	0.02360	0.05865	0.41011	0.35146	0.38652	-
1190	22	30/4	Forward	0.02360	0.05865	0.41326	0.35461	0.38966	0.39034
1190	22	30/4	Reversed	0.02360	0.05865	0.41461	0.35596	0.39101	-
1200	22	30/4	Forward	0.02360	0.05865	0.41573	0.35708	0.39213	0.39337
1200	22	30/4	Reversed	0.02360	0.05865	0.41820	0.35955	0.39461	-
1220	22	30/4	Forward	0.02360	0.05865	0.41955	0.36090	0.39596	0.39685
1220	22	30/4	Reversed	0.02360	0.05865	0.42135	0.36270	0.39775	-
1240	22	30/4	Forward	0.02360	0.05865	0.42472	0.36607	0.40112	0.40157
1240	22	30/4	Reversed	0.02360	0.05865	0.42562	0.36697	0.40202	-
1260	22	30/4	Forward	0.02360	0.05865	0.42404	0.36539	0.40045	0.40101
1260	22	30/4	Reversed	0.02360	0.05865	0.42517	0.36652	0.40157	-
1280	22	30/4	Forward	0.02360	0.05865	0.42494	0.36629	0.40135	0.40202
1280	22	30/4	Reversed	0.02360	0.05865	0.42629	0.36764	0.40270	-
1300	22	30/4	Forward	0.02360	0.05865	0.42697	0.36831	0.40337	0.40337
1300	22	30/4	Reversed	0.02360	0.05865	0.42697	0.36831	0.40337	-

Table 3.8 Relative S-Wave Travel Times at Borehole C4993

* Use of the reaction mass as a reference for calculating relative travel times exhibited less scatter than using the reference receiver.

Lower	Reference	T-Rex	T-Rex	Time: Peak or	Time: Peak or	Time: Peak or	Travel Time	Travel Time	Average Travel Time *
Receiver	Receiver	Drive Freq./	Excitation	Trough at	Trough at	Trough at	Relative to	Relative to	Relative to
Depth	Depth	No. of Cycles	Direction	Reaction Mass	Ref. Receiver	Lower Receiver	Ref. Receiver	Reaction Mass	Reaction Mass
(ft)	(ft)	(Hz/No.)		(sec)	(sec)	(sec)	(sec)	(sec)	(sec)
1240***	17	30/4	Forward	0.02360	0.05618	0.42360	0.36742	0.40000	0.40056
1240***	17	30/4	Reversed	0.02360	0.05573	0.42472	0.36899	0.40112	-
1260***	17	30/4	Forward	0.02360	0.05663	0.42652	0.36989	0.40292	0.40258
1260***	17	30/4	Reversed	0.02360	0.05618	0.42584	0.36966	0.40225	-

* Use of the reaction mass as a reference for calculating relative travel times exhibited less scatter than using the reference receiver. *** Short arm lower receiver was used; others used long arm.

Section 4: Unfiltered S-Wave Records of Lower Horizontal Receiver and Derived Rotated In-Line Signals

Section 4 includes all unfiltered S-wave records at the lower horizontal receiver and signals of rotated in-line receiver. There are 6 groups: forward in-line, reversed inline; forward cross-line (x-line), reversed cross-line (x-line); forward rotated in-line and reversed rotated in-line.

- 4.1 Forward S-wave records of the lower in-line receiver.
 - Figures 4.1 to 4.6 present unfiltered lower in-line receiver (forward S-wave) records in Borehole C4993, depths 370 to 990 ft; input signal: 5 cycles of 50-Hz sine wave.
 - Figures 4.7 and 4.8 present unfiltered lower in-line receiver (forward S-wave) signals in Borehole C4993, depths 990 to 1300 ft; input signal: 4 cycles of 30-Hz sine wave.
 - 3. Figure 4.9 presents unfiltered lower in-line receiver (forward S-wave) signals in Borehole C4993 when short-arm lower in-line receiver was used at depths of 1240 and 1260 ft; input signal: 4 cycles of 30-Hz sine wave.
- 4.2 Reversed S-wave records of the lower in-line receiver.
 - Figures 4.11 to 4.15 present unfiltered lower in-line receiver (reversed Swave) records in Borehole C4993, depths 370 to 990 ft; input signal: 5 cycles of 50-Hz sine wave.
 - Figures 4.16 and 4.17 present unfiltered lower in-line receiver (reversed Swave) signals in Borehole C4993, depths 990 to 1300 ft; input signal: 4 cycles of 30-Hz sine wave.
 - 3. Figure 4.18 presents unfiltered lower in-line receiver (reversed S-wave) signals in Borehole C4993 when short-arm lower in-line receiver was used at depths of 1240 and 1260 ft; input signal: 4 cycles of 30-Hz sine wave.
- 4.3 Forward S-wave records of the lower cross-line receiver.
 - Figures 4.19 to 4.24 present unfiltered lower cross-line receiver (forward Swave) records in Borehole C4993, depths 370 to 990 ft; input signal: 5 cycles of 50-Hz sine wave.
 - Figures 4.25 and 4.26 present unfiltered lower cross-line receiver (forward S-wave) signals in Borehole C4993, depths 990 to 1300 ft; input signal: 4 cycles of 30-Hz sine wave.
 - 3. Figure 4.27 presents unfiltered lower cross-line receiver (forward S-wave) signals in Borehole C4993 when short-arm lower cross-line receiver was used at depths of 1240 and 1260 ft; input signal: 4 cycles of 30-Hz sine wave.
- 4.4 Reversed S-wave records of the lower cross-line receiver.
 - Figures 4.28 to 4.33 present unfiltered lower cross-line receiver (reversed Swave) records in Borehole C4993, depths 370 to 990 ft; input signal: 5 cycles of 50-Hz sine wave.
 - Figures 4.34 and 4.35 present unfiltered lower cross-line receiver (reversed S-wave) signals in Borehole C4993, depths 990 to 1300 ft; input signal: 4 cycles of 30-Hz sine wave.
 - 3. Figure 4.36 presents unfiltered lower cross-line receiver (reversed S-wave) signals in Borehole C4993 when short-arm lower cross-line receiver was used at depths of 1240 and 1260 ft; input signal: 4 cycles of 30-Hz sine wave.
- 4.5 Forward S-wave signals of the lower rotated in-line receiver.
 - Figures 4.37 to 4.42 present unfiltered lower rotated in-line receiver (forward S-wave) signals in Borehole C4993, depths 370 to 990 ft; input signal: 5 cycles of 50-Hz sine wave.
 - 2. Figures 4.43 and 4.44 present unfiltered lower rotated in-line receiver (forward S-wave) signals in Borehole C4993, depths 990 to 1300 ft; input signal: 4 cycles of 30-Hz sine wave.
 - 3. Figure 4.45 presents unfiltered lower rotated in-line receiver (forward S-wave) signals in Borehole C4993 when short-arm lower rotated in-line receiver was used at depths of 1240 and 1260 ft; input signal: 4 cycles of 30-Hz sine wave.

- 4.6 Reversed S-wave signals of the lower rotated in-line receiver.
 - Figures 4.46 to 4.51 present unfiltered lower rotated in-line receiver (reversed S-wave) signals in Borehole C4993, depths 370 to 990 ft; input signal: 5 cycles of 50-Hz sine wave.
 - 2. Figures 4.52 and 4.53 present unfiltered lower rotated in-line receiver (reversed S-wave) signals in Borehole C4993, depths 990 to 1300 ft; input signal: 4 cycles of 30-Hz sine wave.
 - Figure 4.54 presents unfiltered lower rotated in-line receiver (reversed S-wave) signals in Borehole C4993 when short-arm lower rotated in-line receiver was used at depths of 1240 and 1260 ft; input signal: 4 cycles of 30-Hz sine wave.

InLine at 370 ft (50 Hz) -0.0001568 F -0.0003137 -0.0004705 -0.0006274 InLine at 380 ft (50 Hz) -0.0002759 F -0.0003449 -0.0004139 -0.0004829 -InLine at 390 ft (50 Hz) -0.0003107 -0.0003728 -0.0004349 --0.0004970 = InLine at 400 ft (50 Hz) 0.0000000 F -0.0001931 -0.0003863 -0.0005794 InLine at 410 ft (50 Hz) -0.0001180 -0.0002360 -0.0003541 -0.0004721 -InLine at 420 ft (50 Hz) -0.0001929 F -0.0002893 M -0.0003858 -0.0004822 InLine at 430 ft (50 Hz) -0.0001912 F -0.0002868 -0.0003824 -0.0004780 InLine at 440 ft (50 Hz) -0.0001057 -0.0003171 -0.0004228 -InLine at 450 ft (50 Hz) -0.0002019 F -0.0002692 -0.0003365 -0.0004038 -InLine at 460 ft (50 Hz) -0.0001151 F -0.0002303 -0.0003454 --0.0004605 -InLine at 470 ft (50 Hz) -0.0001288 -0.0002577 -0.0003865 -0.0005153 InLine at 475 ft (50 Hz) -0.0002203 --0.0002753 -0.0003304 -0.0003855 0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 Time (sec)

Figure 4.1 Unfiltered Lower In-Line Receiver (S-Wave) Forward Records in Borehole C4993 Depths 370 to 475 ft; Input Signal: 5 Cycles 50-Hz Sine Wave



Figure 4.2 Unfiltered Lower In-Line Receiver (S-Wave) Forward Records in Borehole C4993 Depths 480 to 540 ft; Input Signal: 5 Cycles 50-Hz Sine Wave

Figure 4.3 Unfiltered Lower In-Line Receiver (S-Wave) Forward Records in Borehole C4993 Depths 550 to 660 ft; Input Signal: 5 Cycles 50-Hz Sine Wave

InLine at 550 ft (50 Hz)						
-0.0001813 -0.0002175 -0.0002538 -0.0002900						
InLine at 560 ft (50 Hz)						
-0.0001436 -0.0001915 -0.0002393 -0.0002393						
InLine at 570 ft (50 Hz)						
-0.0001627 -0.0001898 -0.0002169 -0.0002440						
InLine at 580 ft (50 Hz)						
-0.0001030 -0.0001545 -0.0002060 -0.0002575						
InLine at 590 ft (50 Hz)						
-0.0001534 -0.0001789 -0.0002045 -0.0002301						
InLine at 600 ft (50 Hz)						
-0.0001181 -0.0001772 -0.0002362 -0.0002953						
InLine at 610 ft (50 Hz)						
-0.0001302 -0.0001953 -0.0002604						
InLine at 620 ft (50 Hz)						
-0.0001206 -0.0001809 -0.0002413 -0.0003016 -0.0003016 -0.0003016 -0.0003016 -0.0003016 -0.0003016 -0.0003016 -0.0003016 -0.0001208 -0.0001208 -0.0001208 -0.0001208 -0.0001208 -0.0001208 -0.0001208 -0.0001208 -0.0001208 -0.0001208 -0.0001208 -0.0001208 -0.0001208 -0.0001208 -0.0001208 -0.0001208 -0.0001208 -0.0002413 -0.0003016 -0.00000000000000000000000000000000000						
-0.0001f69 -0.0002226 -0.0002782						
-0.0001733 -0.0001981 -0.0002228 -0.0002476						
InLine at 650 ft (50 Hz)						
-0.0001516 -0.0001733 -0.0001949 -0.0002166						
InLine at 660 ft (50 Hz)						
-0.0001048 - -0.0001572 - -0.0002096 - -0.0002620 -						
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 Time (sec)						

Figure 4.4 Unfiltered Lower In-Line Receiver (S-Wave) Forward Records in Borehole C4993 Depths 670 to 760 ft; Input Signal: 5 Cycles 50-Hz Sine Wave

InLine at 670 ft (50 Hz)						
-0.0001535 -0.0001919 -0.0002302 -0.0002686						
-0.0001418 - -0.0001773						
InLine at 690 ft (50 Hz)						
-0.0001280 - -0.0001707 - -0.0002133 - -0.0002560 -						
InLine at 700 ft (50 Hz)						
-0.0001470 -0.0001764 -0.0002058 -0.0002352						
-0.0001471 -0.0001681 -0.0001891 -0.0002101						
-0.0001480 -0.0001973 -0.0002467						
InLine at 727 ft (50 Hz)						
-0.0001468 - -0.0001835 - -0.0002202 - -0.0002569 -						
InLine at 732 ft (50 Hz)						
-0.000843 - -0.0001686 - -0.0002529 - -0.0003372 -						
InLine at 737 ft (50 Hz)						
-0.0001311 -0.0001967 -0.0002622 -0.0003278 InLine at 742 ft (50 Hz)						
-0.0001306 -0.0001306 -0.0001960 -0.0002613						
0.0000609 -0.0001218 -0.0001217 -0.0001247						
InLine at 760 ft (50 Hz)						
-0.0001321 -0.0001761 -0.0002201 -0.0002641						
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 Time (cool)						
i me (sec)						

Figure 4.5 Unfiltered Lower In-Line Receiver (S-Wave) Forward Records in Borehole C4993 Depths 770 to 870 ft; Input Signal: 5 Cycles 50-Hz Sine Wave

InLine at 770 ft (50 Hz)
-0.0001356 - -0.0001627 - -0.000189 - -0.0002170 -
InLine at 780 ft (50 Hz)
-0.0001768 -0.0001866 -0.0001964 -0.0002062 InLine at 790 ft (50 Hz)
-0.0001767 -0.0001847 -0.0001927 -0.0002007 -
InLine at 800 ft (50 Hz)
-0.0001386 -0.0001617 -0.0001848 -0.0002079
InLine at 810 ft (50 Hz)
-0.00007435 -0.0001486 -0.0002229 -0.0002272
InLine at 820 ft (50 Hz)
-0.0001401 F -0.0001681 F -0.0001681 F -0.0001921 F
InLine at 830 ft (50 Hz)
-0.0001207 - -0.0001609 - -0.0002012 - -0.0002414 -
-0.0001414
-0.0001591 - -0.0001768 - -0.0001945 -
InLine at 845 ft (50 Hz)
-0.0001182 -0.0001576 -0.0001970 -0.0002364 -0.000264 -0.0000264 -0.0000264 -0.0000264 -0.0000264 -0.00
-0.0001693 -0.0002257 -0.0002821 InLine at 860 ft (50 Hz)
-0.0001586
-0.0001666 -0.0001897 -0.0002108
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 Time (sec)

Figure 4.6 Unfiltered Lower In-Line Receiver (S-Wave) Forward Records in Borehole C4993 Depths 880 to 990 ft; Input Signal: 5 Cycles 50-Hz Sine Wave

InLine at 880 ft (50 Hz)
-0.0001598 -0.0001698 -0.0001798 -0.0001798
InLine at 890 ft (50 Hz)
-0.0001442 -0.0001922 -0.0001922 -0.0001922
InLine at 900 ft (50 Hz)
-0.0001457 -0.0001457 -0.0001453 -0.0002429
InLine at 910 ft (50 Hz)
-0.0001623 -0.0001854 -0.0002086 -0.0002086 -0.0002318 InLine at 917 ft (50 Hz)
-0.0001793 -0.0002391 -0.0002391 -0.0002988 InLine at 927 ft (50 Hz)
InLine at 935 ft (50 Hz)
-0.00016924 -0.0001974 -0.0001917 -0.0002030
InLine at 940 ft (50 Hz)
-0.0001536 -0.0001676 -0.0001815 -0.0001955
InLine at 950 ft (50 Hz)
-0.0001644 -0.000177 -0.0001897 -0.0001897 -0.0002023 -
InLine at 960 ft (50 Hz)
-0.0001676 -0.0001843 -0.0002178 -0.0002178
InLine at 9/0 ft (50 Hz)
InLine at 980 ft (50 Hz)
-0.0001493 -0.0001617 -0.0001742 -0.0001742 InLine at 990 ft (50 Hz)
Time (sec)

Figure 4.7 Unfiltered Lower In-Line Receiver (S-Wave) Forward Records in Borehole C4993 Depths 990 to 1100 ft; Input Signal: 4 Cycles 30-Hz Sine Wave

InLine at 990 it (50 f	Hz)
------------------------	-----

InLine at 1000 ft (30 Hz)
-0.0001727 -0.0001766 -0.0001806
InLine at 1010 ft (30 Hz)
InLine at 1020 ft (30 Hz)
-0.0001624 -0.0001684 -0.0001744 -0.0001744 InLine at 1030 ft (30 Hz)
-0.0001668
InLine at 1050 ft (30 Hz)
InLine at 1060 ft (30 Hz)
-0.0001740 -0.0001794 -0.0001849 -0.0001849
InLine at 1070 ft (30 Hz)
-0.0003467 -0.0003546 -0.0003625 -0.0003704
InLine at 1080 ft (30 Hz)
-0.0003538 -0.0003528 -0.0003526 -0.0003626 -0.0003671
InLine at 1090 ft (30 Hz)
-0.0003217 -0.0003217 -0.0003255 -0.0003325 -0.0003378
InLine at 1095 ft (30 Hz)
-0.0003204 -0.0003280 -0.0003356 -0.0003432
InLine at 1100 ft (30 Hz)
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

Figure 4.8 Unfiltered Lower In-Line Receiver (S-Wave) Forward Records in Borehole C4993 Depths 1110 to 1300 ft; Input Signal: 4 Cycles 30-Hz Sine Wave

InLine at 1	110 ft (30) Hz)									
-0.0003083 -0.0003140 -0.0003198 -0.0003255			hain an a ireann				1/month	M	WW	*	
InLine at 1	120 ft (30) Hz)									
-0.0003000 -0.0003068 -0.0003136 -0.0003204		en e	*****	No and a start of the second	MM	WW	WM	MAN	WAY	****	m
InLine at 1	130 ft (30) Hz)									
-0.0002873 -0.0002918 -0.0002964 -0.0003010				www.	MM	****		AMAT 144	1. A. MA	m Mar	
InLine at 1	140 ft (30) Hz)									
-0.0002751 -0.0002830 -0.0002908 -0.0002987				minimum	amum	Man			Andrew		*****
InLine at 1	150 ft (30) Hz)									
-0.0002695 -0.0002748 -0.0002801 -0.0002854	Trabulation data dat History (1971)		Printer and a	www.www.	m h	**	~~~~			hat the second	the second second
InLine at 1	160 ft (30) Hz)									
-0.0002674 -0.0002738 -0.0002802 -0.0002865					WWW	Mana and the					4
-0.0002495	FTTTT										
-0.0002584 -0.0002673 -0.0002762				the second second	M/	Am	m		n n n n n n n n n n n n n n n n n n n	~~~~	-
InLine at 1	180 ft (30) Hz)									
-0.0002469 -0.0002532 -0.0002595			ann a suide in pi	MAN ANA	MM/	MWW/	WWW	NAM	m.m.n		M
InLine at 1	190 ft (30) Hz)		_							
-0.0002442 -0.0002493 -0.0002544 -0.0002595				MANANA	MMMM	May have					r Ma
InLine at 1	200 ft (30	J HZ)									_
-0.0002350 -0.0002390 -0.0002429 -0.0002469						M.M.M			Welley With W		₩₩E
-0.0002268	220 ft (30										1.4
-0.0002305 -0.0002342 -0.0002379											
-0.0002216	240 π (30	J HZ)									
-0:0002246 -0:0002276 -0:0002307							When the				
InLine at 1	260 ft (30	J Hz)								11.111	_
-0.0002333 -0.0002361 -0.0002390 -0.0002418 InLine at 1	280 ft (30) Hz)	or bar bar bar bar ann ann a par ba an		A						
-8.8882198	T. L. Hilly I. m. Labor	معارمته ورا المارين	M. Has bushes		المر المراجع والعر	A Inc. M		ة المنهورة (ل. علوم ا	المطلب بالار ال	wells with which	A A A A A A
-0.0002140 -0.0002172 -0.0002203 InLine at 1	300 ft (30) Hz)									
-0.0002215 -0.0002246 -0.0002278					***		when he				
-0.0002509 0.	.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00

Figure 4.9 Unfiltered Lower In-Line Receiver (S-Wave) Forward Records in Borehole C4993 Depths 1240 and 1260 ft; Input Signal: 4 Cycles 30-Hz Sine Wave; Short Arm Used



Figure 4.10 Unfiltered Reversed S-Wave Signals of Lower In-Line Receiver (C4993) Depths 370 to 475 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave

Reversed	Line at 370 ft (50 Hz)	
-0.0001498 -0.0002996 -0.0004494 -0.0005993		
Reversed		
-0.0002724 -0.0003405 -0.0004086 -0.0004766		
Reversed	iLine at 390 ft (50 Hz)	
-0.0002519 -0.0003149 -0.0003779 -0.0004409	MMMMMMM	
Reversed	Line at 400 ft (50 Hz)	
-0.0001673 -0.0003346 -0.0005019 -0.0006691		
Reversed	Line at 410 ft (50 Hz)	
-0.0001226 -0.0002453 -0.0003679 -0.0004905		
Reversed	Line at 420 ft (50 Hz)	
-0.0001922 -0.0002883 -0.0003844 -0.0004804		
Reversed	Line at 430 ft (50 Hz)	
-0.0001935 -0.0002902 -0.0003869 -0.0004836		
-0.0001060	1Line at 440 ft (50 Hz)	
-0.0002120 -0.0003179 -0.0004239	MMM///	
Reversed	Line at 450 ft (50 Hz)	
-0.0002005 -0.0002674 -0.0003342 -0.0004010		
Reversed	ıLine at 460 ft (50 Hz)	
-0.0001130 -0.0002260 -0.0003391 -0.0004521		
Reversed	Line at 470 ft (50 Hz)	
-0.0001289 -0.0002578 -0.0003867 -0.0005155		
Reversed	Line at 475 ft (50 Hz)	
-0.0002144 -0.0002680 -0.0003216	EMMMMM	
-0.0003753 0	<u> </u>	0
0.	Time (sec)	1

Figure 4.11 Unfiltered Reversed S-Wave Signals of Lower In-Line Receiver (C4993) Depths 480 to 540 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 4.12 Unfiltered Reversed S-Wave Signals of Lower In-Line Receiver (C4993) Depths 550 to 660 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 4.13 Unfiltered Reversed S-Wave Signals of Lower In-Line Receiver (C4993) Depths 670 to 760 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave

Reversed InLine at 6	70 ft (50 Hz)
-0.0001229 -0.0001639 -0.0002049 -0.0002459	
Reversed InLine at 6	80 ft (50 Hz)
-0.0001433 - -0.0001791 - -0.0002149 -	MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Reversed InLine at 6	90 ft (50 Hz)
-0.0001246 - -0.0001661 - -0.0002076 - -0.0002491 -	
Reversed InLine at 7	00 ft (50 Hz)
-0.0001199 -0.0001499 -0.0001799 -0.0002098	
Reversed InLine at 7	10 ft (50 Hz)
-0.0001477 -0.0001723 -0.0001969 -0.0002215	Eren and MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Reversed InLine at 7	18 ft (50 Hz)
-0.0000996 -0.0001494 -0.0001991 -0.0002489	Freedom MMM Martin MMM Martin MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
Reversed InLine at 7	27 ft (50 Hz)
-0.0001389 -0.0001736 -0.0002083 -0.0002430	Freedom MM MM Marken MM
Reversed InLine at 7	32 ft (50 Hz)
-0.0000773 -0.0001547 -0.0002320 -0.0003093	
Reversed InLine at 7	37 ft (50 Hz)
-0.0001238 - -0.0001857 - -0.0002476 -	
Reversed InLine at 7	42 ft (50 Hz)
-0.0000682 -0.0001365 -0.0002047 -0.0002729	
Reversed InLine at 7	48 ft (50 Hz)
-0.0001220 - -0.0001830 - -0.0002441 -	
Reversed InLine at 7	60 ft (50 Hz)
-0.0001264 -0.0001685 -0.0002106 -0.0002528	For a company of the second se
0.00 0	.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 Time (sec)

Figure 4.14 Unfiltered Reversed S-Wave Signals of Lower In-Line Receiver (C4993) Depths 770 to 870 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 4.15 Unfiltered Reversed S-Wave Signals of Lower In-Line Receiver (C4993) Depths 880 to 990 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave

Reversed	InLine at 880 ft (50 Hz)
-0.0001760 -0.0001844 -0.0001928 -0.0002012	
Reversed	InLine at 890 ft (50 Hz)
-0.0001408 -0.0001643 -0.0001877 -0.0002112	
Reversed	InLine at 900 ft (50 Hz)
-0.0000967 -0.0001451 -0.0001935 -0.0002418	
Reversed	InLine at 910 ft (50 Hz)
-0.0001313 -0.0001531 -0.0001750 -0.0001969	
Reversed	InLine at 917 ft (50 Hz)
-0.0001163 -0.0001745 -0.0002327	E
Reversed	InLine at 927 ft (50 Hz)
-0.0001438 -0.0001643 -0.0001849 -0.0002054	
Reversed	InLine at 935 ft (50 Hz)
-0.0001647 -0.0001765 -0.0001883 -0.0002000	
Reversed	InLine at 940 ft (50 Hz)
-0.0001595 -0.0001728 -0.0001861 -0.0001994	
Reversed	InLine at 950 ft (50 Hz)
-0.0001674 -0.0001803 -0.0001932 -0.0002060	
Reversed	InLine at 960 ft (50 Hz)
-0.0001700 -0.0001870 -0.0002040 -0.0002210	
Reversed	InLine at 970 ft (50 Hz)
-0.0001601 -0.0001649 -0.0001696 -0.0001743	
Reversed	InLine at 980 ft (50 Hz)
-0.0001581 -0.0001702 -0.0001824 -0.0001946	
Reversed	InLine at 990 ft (50 Hz)
-0.0001720 -0.0001755 -0.0001791 -0.0001827	
0	.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
	Time (sec)

Figure 4.16 Unfiltered Reversed S-Wave Signals of Lower In-Line Receiver (C4993) Depths 990 to 1110 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave

Reversed InLine at 990 ft (30 Hz)

-0.0001678 -0.0001720 -0.0001762 -0.0001804	
Reversed	InLine at 1000 ft (30 Hz)
-0.0001617 -0.0001658 -0.0001699 -0.0001741	
0.0001777	
-0.0001824 -0.0001871 -0.0001918	
0.0001622	
-0.0001632 -0.0001686 -0.0001741 -0.0001795	
-0 0001741	
-0.0001798 -0.0001854 -0.0001910	
Reversed	InLine at 1040 ft (30 Hz)
-0.0001772 -0.0001810 -0.0001847 -0.0001885	
-0.0001516	
-0.0001575 -0.0001633 -0.0001691	
Reversed	InLine at 1060 ft (30 Hz)
-0.0001745 -0.0001810 -0.0001874 -0.0001939	
Reversed	InLine at 1070 ft (30 Hz)
-0.0003680 -0.0003760 -0.0003840	
Reversed	InLine at 1080 ft (30 Hz)
-0.0003463 -0.0003511 -0.0003559	
Reversed	InLine at 1090 ft (30 Hz)
-0.0003334 -0.0003395 -0.0003456 -0.0003516	
Reversed	InLine at 1095 ft (30 Hz)
-0.0003252 -0.0003325 -0.0003417 -0.0003509	
-0 0003113	
-0.0003178 -0.0003243 -0.0003307	
Reversed	InLine at 1110 ft (30 Hz)
-0.0003131 -0.0003189 -0.0003247 -0.0003305	
U.	00 0.10 0.20 0.50 0.40 0.50 0.60 0.70 0.80 0.90 1.00

Figure 4.17 Unfiltered Reversed S-Wave Signals of Lower In-Line Receiver (C4993) Depths 1120 to 1300 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave

Reversed InLi	ne at 11	20 ft	(30 Hz)
---------------	----------	-------	---------

-0.0002955 -0.0003021 -0.0003087 -0.0003152	and the second			-	1	MMM	****			
Reversed -0.0002904 -0.0002950 -0.0002997	InLine at 1130 f	t (30 Hz)	MAMAA	AMAN		MAN	MAN	MAA	MMM]
-0.0003043 Reversed -0.0002768	InLine at 1140 f	t (30 Hz)								! -
-0.0002822 -0.0002877 -0.0002931 Reversed	InLine at 1150 f	t (30 Hz)			VWV VY			N MARAN	MA MM	
-0.0002746 -0.0002793 -0.0002840 -0.0002886			vineelwike/		//////					
-0.0002643 -0.0002695 -0.0002748 -0.0002801				MM	A		<u> </u>	m	MAM	#
Reversed	InLine at 1170 f	t (30 Hz)			hand	han			-	
-0.0002804 Reversed -0.0002414 -0.0002490	InLine at 1180 f	t (30 Hz)								
-0.0002565 -0.0002641 Reversed	InLine at 1190 f	t (30 Hz)		* <u>V~</u> V~	VIVIN					
-0.0002456 -0.0002500 -0.0002545 Reversed	InLine at 1200 f	t (30 Hz)		N M M MM	VM-V/					
-0.0002322 -0.0002352 -0.0002382 -0.0002412										
Reversed	InLine at 1220 f	t (30 Hz)	Mannan							
-0.0002472 Reversed -0.0002212 -0.0002241	InLine at 1240 f	t (30 Hz)							And soften a	
-0.0002269 -0.0002298 Reversed -0.0002186	InLine at 1260 f	t (30 Hz)								-
-0.0002214 -0.0002242 -0.0002269	InLine at 1280 f	t (30 Hz)								
-0.0002092 -0.0002115 -0.0002139 -0.0002162										
Reversed -0.0002100 -0.0002132 -0.0002163 -0.0002194	InLine at 1300 f	t (30 Hz)		47						
0.0002104	00 0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90 1.	L 00.

Figure 4.18 Unfiltered Reversed S-Wave Signals of Lower In-Line Receiver (C4993) Depths 1240 and 1260 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Short Arm Used



Reversed InLine Short Arm at 1240 ft (30 Hz)

XLine at 370 ft (50 Hz) 0.0001245 F 0.0000000 -0.0001245 -0.0002490 XLine at 380 ft (50 Hz) 0.0000688 F 0.0000000 -0.0000688 -0.0001376 -XLine at 390 ft (50 Hz) 0.0000000 -0.0000365 -0.0000731 XLine at 400 ft (50 Hz) 0.0002650 -0.0002650 XLine at 410 ft (50 Hz) 0.0000930 F 0.0000000 -0.0000930 -0.0000930 --0.0001860 -XLine at 420 ft (50 Hz) -0.0000155 -0.0000311 -0.0000466 -0.0000621 -XLine at 430 ft (50 Hz) 0.0000000 F -0.0000268 -0.0000536 -0.0000804 XLine at 440 ft (50 Hz) 0.0000409 0.0000000 -0.0000409 -0.0000818 -XLine at 450 ft (50 Hz) 0.0000896 F 0.0000000 -0.0000896 --0.0001792 -XLine at 460 ft (50 Hz) 0.0000834 F 0.0000000 -0.0000834 -0.0001668 -XLine at 470 ft (50 Hz) 0.0000990 F 0.0000000 -0.0000990 -0.0001980 L XLine at 475 ft (50 Hz) 0.0000554 F 0.0000000 -0.0001109 -0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

Figure 4.19 Unfiltered Forward S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 370 to 475 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave

XLine at 480 ft (50 Hz) 0.0000875 0.0000000 -0.0000875 --0.0001750 -XLine at 485 ft (50 Hz) 0.0001668 0.0000000 -0.0001668 --0.0003337 -XLine at 490 ft (50 Hz) 0.0000533 F 0.0000000 -0.0000533 --0.0001065 -XLine at 495 ft (50 Hz) 0.0002447 0.0000000 -0.0002447 -0.0004894 L XLine at 500 ft (50 Hz) 0.0000623 0.0000000 -0.0000623 --0.0001246 -XLine at 505 ft (50 Hz) 0.0000752 0.0000000 -0.0000752 -0.0001504 L XLine at 510 ft (50 Hz) 0.0001385 0 0000000 -0.0001385 -0.0002771 XLine at 515 ft (50 Hz) 0.0001168 0.0000000 -0.0001168 -0.0002335 XLine at 520 ft (50 Hz) 0.0001015 0.0000000 -0.0001015 -0.0002030 XLine at 525 ft (50 Hz) 0.0002205 0.0000000 -0.0001103 -XLine at 530 ft (50 Hz) 0.0001130 -0.0000000 -0.0001130 -0.0002260 XLine at 540 ft (50 Hz) 0.0000608 F 0.0000000 -0.0000608 V V -0.0001215 0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

Figure 4.20 Unfiltered Forward S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 480 to 540 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave

Figure 4.21 Unfiltered Forward S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 550 to 660 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave

XLine at 550 ft (50 Hz)
$\begin{array}{c} 0.0000000 \\ -0.0000302 \\ -0.0000003 \\ -\end{array}$
-0.0000905
XLine at 570 ft (50 Hz)
0.0000371 0.0000000 -0.0000371 -0.0000371
XLine at 580 ft (50 Hz)
0.0000000 -0.0000269 -0.0000539 -0.0000808
XLine at 590 ft (50 Hz)
0.0000553 - 0.0000553 - 0.0000553 - -0.0001106 -
XLine at 600 ft (50 Hz)
-0.0000176 -0.0000352 -0.0000528
XLine at 610 ft (50 Hz)
0.0000484 0.0000000 -0.0000484 -0.0000484 -0.0000484
-0.000189 -0.0000377 -0.0000566
XLine at 630 ft (50 Hz)
0.0000000 -0.0000418 -0.0000836
XLine at 640 ft (50 Hz)
0.0000249 - 0.0000000 - -0.0000249 - -0.0000249 -
XLine at 650 ft (50 Hz)
0.00000000 0.00000000 -0.0000280 -0.0000259
XLine at 660 ft (50 Hz)
0.0000458 0.00000005 -0.0000458 -0.0000458
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
i ime (sec)

54

XLine at 670 ft (50 Hz) 0.0000320 F 0.0000000 -0.0000320 --0.0000641 -XLine at 680 ft (50 Hz) 0.0000244 F 0.0000000 -0.0000244 -0.0000489 XLine at 690 ft (50 Hz) 0.0000397 F 0.0000000 -0.0000397 -0.0000793 -XLine at 700 ft (50 Hz) 0.0000631 0.0000000 -0.0000631 --0.0001262 -XLine at 710 ft (50 Hz) 0.0000991 ANN 0.0000000 l -0.0000991 -0.0001983 XLine at 718 ft (50 Hz) 0.0000695 0.0000000 -0.0000695 -0.0001390 -XLine at 727 ft (50 Hz) 0.0000723 0.0000000 -0.0000723 -0.0001447 XLine at 732 ft (50 Hz) 0.0001098 0.0000000 -0.0001098 --0.0002197 -XLine at 737 ft (50 Hz) 0.0000536 0.0000000 -0.0000536 -0.0001072 XLine at 742 ft (50 Hz) 0.0000621 F 0.0000000 -0.0000621 -0.0001242 -XLine at 748 ft (50 Hz) 0.0000638 0.0000000 -0.0000638 XLine at 760 ft (50 Hz) 0.0000389 0.0000000 -0.0000389 -0.0000779 0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

Figure 4.22 Unfiltered Forward S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 670 to 760 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave

Figure 4.23 Unfiltered Forward S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 770 to 870 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave

XLine at 770 ft (50 Hz)	
0.0000246 - 0.0000000	-
-0.0000246 F -0.0000493 F	
XLine at 780 ft (50 Hz)	
-0.0000302	
XLine at 790 ft (50 Hz)	
-0.0000197 E	
-0.0000000 - -0.0000278	
XLine at 810 ft (50 Hz)	
0.0000239 0.0000000 -0.0000239	
XLine at 820 ft (50 Hz)	
	~
XLine at 830 ft (50 Hz)	
0.0000000	
XLine at 840 ft (50 Hz)	
0.0000238 F 0.0000000 F -0.0000258 F -0.0000515 F	
XLine at 845 ft (50 Hz)	
	-
	ww.
XLine at 853 ft (50 Hz)	
-0.000296	-
XLine at 860 ft (50 Hz)	
	~
XLine at 870 ft (50 Hz)	
-0.0000182 -0.0000364	-
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90	1.00

Figure 4.24 Unfiltered Forward S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 880 to 990 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave

XLine at 880 ft (50 Hz)	
XLine at 890 ft (50 Hz)	
0.0000000 -0.0000175 -0.0000349 -0.0000324	
XLine at 910 ft (50 Hz)	
0.0000251 0.0000000 -0.0000252	
XLine at 917 ft (50 Hz)	
0.0000000 -0.000135 -0.0000270 -0.0000404	
XLine at 927 ft (50 Hz)	
-0.0000084 -0.0000168 -0.0000252 -0.0000252 -0.0000336	
XLine at 935 ft (50 Hz)	
-0.0000129 -0.0000193 -0.0000258 -0.000252	
XLine at 940 ft (50 Hz)	
0.0000085 - 0.0000000 - 0.0000085 - 0.0000085 - -0.0000171 -	
XLine at 950 ft (50 Hz)	
0.0000136 0.0000000 -0.0000136 -0.0000272	
XLine at 960 ft (50 Hz)	
-0.0000121 -0.0000243 -0.0000244	
XLine at 970 ft (50 Hz)	
XLine at 980 ft (50 Hz)	
0.0000000 -0.0000115 -0.0000229 -0.0000344	
XLine at 990 ft (50 Hz)	
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.0	10

Figure 4.25 Unfiltered Forward S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 990 to 1110 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave

XLine at 990 ft (30 Hz)

-0.0000131 -0.0000175 -0.0000219 -0.0000262	
XLine at 1	000 ft (30 Hz)
-0.0000149 -0.0000186 -0.0000223 -0.0000260	
-0.0000109	
-0.0000145 -0.0000182 -0.0000218	
XLine at 1	020 ft (30 Hz)
-0.0000145 -0.0000181 -0.0000218 -0.0000254 XLine at 1	
-0.0000110 -0.0000165 -0.0000220 -0.0000275	
XLine at 1	040 ft (30 Hz)
0.0000047 0.0000000 -0.0000047 -0.0000093	
XLine at 1	050 ft (30 Hz)
0.0000000 -0.0000032 -0.0000063 -0.0000095	
XLine at 1	060 ft (30 Hz)
-0.0000183 -0.0000219 -0.0000256	
XLine at 1	070 ft (30 Hz)
-0.0000366 -0.0000439 -0.0000512 -0.0000585 XLine at 1	080 ft (30 Hz)
-0.0000348 -0.0000392 -0.0000435 -0.0000479	
XLine at 1	090 ft (30 Hz)
-0.0000308 -0.0000360 -0.0000411 -0.0000462	
XLine at 1	095 ft (30 Hz)
-0.0000273 -0.0000318 -0.0000363 -0.0000409	
XLine at 1	100 ft (30 Hz)
-0.0000271 -0.0000339 -0.0000407 -0.0000475 XLine at 1	110 ft (30 Hz)
-0.0000242 -0.0000291 -0.0000339 -0.0000388	
0	0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

Figure 4.26 Unfiltered Forward S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 1120 to 1300 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave

XLine at 1	120 ft (30 Hz)
-0.0000241 -0.0000301 -0.0000361 -0.0000421	
XLine at 1	130 ft (30 Hz)
-0.0000213 -0.0000285 -0.0000356 -0.0000427 XLine at 1	^Ξ μηση αρχοριατική ματογραφική της ματογραφικής της ματογραφικής της ματογραφικής της της της της της της της της 140 ft (30 Hz)
-0.0000163 -0.0000245 -0.0000327 -0.0000409	
XLine at 1	150 ft (30 Hz)
-0.0000142 -0.0000189 -0.0000236 -0.0000283	man man and the second of the
XLine at 1	160 ft (30 Hz)
-0.0000223 -0.0000267 -0.0000312	
XLine at 1	170 ft (30 Hz)
-0.0000159 -0.0000211 -0.0000264 -0.0000317	
XLine at 1	180 ft (30 Hz)
-0.0000133 -0.0000200 -0.0000267 -0.0000333	
XLine at 1	190 ft (30 Hz)
-0.0000110 -0.0000165 -0.0000219 -0.0000274	Terrenewaren ander ander ander alle Markel Markel Markel Markel Alexandre ander ander ander ander ander and
XLine at 1	200 ft (30 Hz)
-0.0000143 -0.0000178 -0.0000214 -0.0000249	
XLine at 12 -0.0000097	220 ft (30 Hz)
-0.0000146 -0.0000194 -0.0000243	
XLine at 12	240 ft (30 Hz)
-0.0000140 -0.0000168 -0.0000196	
XLine at 12	260 ft (30 Hz)
-0.0000125 -0.0000155 -0.0000181 -0.0000207	
XLine at 12	280 ft (30 Hz)
-0.0000126 -0.0000157 -0.0000189	
XLine at 1	300 ft (30 Hz)
-0.0000105 -0.0000131 -0.0000158 -0.0000184	
0.	00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 Time (sec)

Figure 4.27 Unfiltered Forward S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 1240 and 1260 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Short Arm Used



XLine Short Arm at 1240 ft (30 Hz)

Figure 4.28 Unfiltered Reversed S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 370 to 475 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 4.29 Unfiltered Reversed S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 480 to 540 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Reversed XLine at 480 ft (50 Hz)

Figure 4.30 Unfiltered Reversed S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 550 to 660 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 4.31 Unfiltered Reversed S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 670 to 760 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 4.32 Unfiltered Reversed S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 770 to 870 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 4.33 Unfiltered Reversed S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 880 to 990 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave

Reversed	XLine at 880 ft (50 Hz)
0.0000000 -0.0000151 -0.0000302 -0.0000453	
Reversed	XLine at 890 ft (50 Hz)
0.0000188 0.0000000 -0.0000188 -0.0000376	
Reversed	XLine at 900 ft (50 Hz)
0.0000000 -0.0000179 -0.0000358 -0.0000537	
Reversed	
0.0000233 0.0000000 -0.0000233 -0.0000466	
n nnnnnnn	XLine at 91/π (50 Hz)
-0.0000112 -0.0000224 -0.0000335	
Reversed	XLine at 927 ft (50 Hz)
0.00000073 -0.00000073 -0.0000145	
Reversed	XLine at 935 ft (50 Hz)
-0.0000119 -0.0000179 -0.0000238 -0.0000298	
Reversed	XLine at 940 ft (50 Hz)
0.0000084 0.0000000 -0.0000084 -0.0000168	
Reversed	XLine at 950 ft (50 Hz)
0.0000000 -0.0000135 -0.0000269 -0.0000404	
Reversed	XLine at 960 ft (50 Hz)
0.0000000 -0.0000129 -0.0000258 -0.0000387	
Reversed	
-0.0000130 -0.0000173 -0.0000217 -0.0000260	
Reversed	XLine at 980 ft (50 Hz)
0.0000000 -0.0000107 -0.0000215 -0.0000322	
Reversed	XLine at 990 ft (50 Hz)
-0.0000141 -0.0000177 -0.0000212 -0.0000247	
0	.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

Figure 4.34 Unfiltered Reversed S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 990 to 1110 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave

Reversed XLine at 990 ft (30 Hz)

Reversed XLine at 1000 ft (30 Hz)
0.0000000 -0.000039 -0.000007 -0.0000077 -0.0000116 Reversed XLine at 1010 ft (30 Hz)
Reversed XLine at 1020 ft (30 Hz)
-0.0000240
Reversed XLine at 1040 ft (30 Hz)
Reversed XLine at 1050 ft (30 Hz)
Reversed XLine at 1060 ft (30 Hz)
Reversed XLine at 1070 ft (30 Hz)
-0.0000337
Reversed XLine at 1090 ft (30 Hz)
Reversed XLine at 1095 ft (30 Hz)
Reversed XLine at 1100 ft (30 Hz)
Reversed XLine at 1110 ft (30 Hz)
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
Figure 4.35 Unfiltered Reversed S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 1120 to 1300 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave

Reversed	
-0.0000200 -0.0000266 -0.0000333 -0.0000399	
Reversed	XLine at 1130 ft (30 Hz)
-0.0000218 -0.0000291 -0.0000364 -0.0000436	
Reversed	XLine at 1140 ft (30 Hz)
-0.0000165 -0.0000220 -0.0000275 -0.0000330	
Reversed	XLine at 1150 ft (30 Hz)
-0.0000140 -0.0000187 -0.0000234 -0.0000281	
Reversed	XLine at 1160 ft (30 Hz)
-0.0000215 -0.0000258 -0.0000301	
Reversed	XLine at 1170 ft (30 Hz)
-0.0000127 -0.0000191 -0.0000254 -0.0000318	
Reversed	XLine at 1180 ft (30 Hz)
-0.0000124 -0.0000185 -0.0000247 -0.0000309	
Reversed	XLine at 1190 ft (30 Hz)
-0.0000141 -0.0000176 -0.0000212 -0.0000247	In the second second second in the second in the second second second second second second second second second
Reversed	XLine at 1200 ft (30 Hz)
-0.0000144 -0.0000173 -0.0000202 -0.0000230	
Reversed	XLine at 1220 ft (30 Hz)
-0.0000121 -0.0000182 -0.0000243 -0.0000303	
Reversed	XLine at 1240 ft (30 Hz)
-0.0000280 -0.0000311 -0.0000343	
Reversed	XLine at 1260 ft (30 Hz)
-0.0000121 -0.0000152 -0.0000182 -0.0000212	
Reversed	XLine at 1280 ft (30 Hz)
-0.0000124 -0.0000148 -0.0000173	
Reversed	XLine at 1300 ft (30 Hz)
-0.0000116 -0.0000145 -0.0000174 -0.0000203	
0.	00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

Reversed XLine at 1120 ft (30 Hz)

Time (sec)

Figure 4.36 Unfiltered Reversed S-Wave Signals of Lower Cross-Line Receiver (C4993) Depths 1240 and 1260 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Short Arm Used



Figure 4.37 Unfiltered Forward S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 370 to 475 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



S-Wave Rotated InLine at 370 ft (50 Hz)

Figure 4.38 Unfiltered Forward S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 480 to 540 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



S-Wave Rotated InLine at 480 ft (50 Hz)

Figure 4.39 Unfiltered Forward S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 550 to 660 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



S-Wave Rotated InLine at 550 ft (50 Hz)

Figure 4.40 Unfiltered Forward S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 670 to 760 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 4.41 Unfiltered Forward S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 770 to 870 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



S-Wave Rotated InLine at 770 ft (50 Hz)

Figure 4.42 Unfiltered Forward S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 880 to 990 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 4.43 Unfiltered Forward S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 990 to 1110 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave

S-VVave Rolated InLine at 350 it (50 Hz	S-Wave	Rotated	InLine	at 990	ft	(30	Hz)
---	--------	---------	--------	--------	----	-----	-----

S-Wave Rotated InLine at 1000 ft (30 Hz)
-0.0001727 -0.0001766 -0.0001806 -0.0001845 S-Wave Rotated InLine at 1010 ft (30 Hz)
S-Wave Rotated InLine at 1020 ft (30 Hz)
-0.0001668 -0.0001719 -0.0001769 -0.0001769 -0.0001769
S-Wave Rotated InLine at 1050 ft (30 Hz)
S-Wave Rotated InLine at 1060 ft (30 Hz)
S-Wave Rotated InLine at 1070 ft (30 Hz)
S-Wave Rotated InLine at 1080 ft (30 Hz)
S-Wave Rotated InLine at 1090 ft (30 Hz)
-0.0003378 E E E E E E E E E E E E E E E E E E E
S-Wave Rotated InLine at 1100 ft (30 Hz)
S-Wave Rotated InLine at 1110 ft (30 Hz)
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

Time (sec)

Figure 4.44 Unfiltered Forward S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 1120 to 1300 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave

-0.0003000 -0.0003068 -0.0003136 -0.0003204				Mary A ward	MM		mm	WWW			•
S-Wave R	otated	InLine at 1	130 ft (30	Hz)							
-0.0002873 -0.0002918 -0.0002964 -0.0003010					MAN			//***	*****		y M
0.0003754	otateu	InLine at	140 11 (30								
-0.0002751 -0.0002830 -0.0002908 -0.0002987			and the second sec		man	MM~	Man Martin	Marrie M	Wantan	Hite Mary Hit	111
S-Wave R	otated	InLine at 1	150 ft (30	Hz)							
-0.0002695 -0.0002748 -0.0002801 -0.0002854	Angen in in in the state			NNN	Marrie Marrie	/ ** *			and the second second	th <mark>, Approxim</mark> ter	
S-Wave R	otated	InLine at 1	160 ft (30	Hz)							
-0.0002674 -0.0002738 -0.0002802 -0.0002865					mm	Manat					
S-Wave R	otated	InLine at 1	170 ft (30	Hz)							
-0.0002495 -0.0002584 -0.0002673 -0.0002762		Inline at 1	180 ft (30		m	<u>/</u> ///	whit	~~~ ~		~~~~	~~
-0.0002405	FIL		100 11 (00								
-0.0002469 -0.0002532 -0.0002595				WHMA ANA	MM	MWW	WW	V M	MAN	~~ ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	
S-Wave R	otated	InLine at 1	190 ft (30	Hz)							
-0.0002442 -0.0002493 -0.0002544 -0.0002595					And A Market	why has					
S-Wave R	otated	InLine at 1	200 ft (30	Hz)							
-0.0002350 -0.0002390 -0.0002429 -0.0002469	Heat and Autor	<mark>le ortent on o</mark>				w ^h u ^h ter					
0.0002268	otated	InLine at	220 π (30	HZ)							
-0.00022005 -0.0002305 -0.0002342 -0.0002379					1/1/www.www.ww	w.M.					179 P.F
S-Wave R	otated	InLine at 1	240 ft (30	Hz)							
-0.0002216 -0.0002246 -0.0002276 -0.0002307					***						
S-Wave R	otated	InLine at 1	260 ft (30	Hz)							
-0.0002333 -0.0002361 -0.0002390 -0.0002418		data (nati banata (nati mpa ing pangana (nation)									
S-Wave R	otated	InLine at 1	280 ft (30	Hz)							
-0.0002109 -0.0002140 -0.0002172 -0.0002203		ulu, ha ak ana di an Ing paga ling d									
S-Wave R	otated	InLine at 1	300 ft (30	Hz)							
-0.0002215 -0.0002246 -0.0002278 -0.0002309					MMM/M/						
0	.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00

S-Wave Rotated InLine at 1120 ft (30 Hz)

Time (sec)

Figure 4.45 Unfiltered Forward S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 1240 and 1260 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Short Arm Used



Figure 4.46 Unfiltered Reversed S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 370 to 475 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



S-Wave Rotated Reversed InLine at 370 ft (50 Hz)

Figure 4.47 Unfiltered Reversed S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 480 to 540 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



S-Wave Rotated Reversed InLine at 480 ft (50 Hz)

Figure 4.48 Unfiltered Reversed S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 550 to 660 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



S-Wave Rotated Reversed InLine at 550 ft (50 Hz)

Figure 4.49 Unfiltered Reversed S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 670 to 760 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave

-0.0001229 www.MM -0.0001639 n -0.0002049 -0.0002459 S-Wave Rotated Reversed InLine at 680 ft (50 Hz) -0.0001074 -0.0001433 M MWW/ -0.0001791 -0.0002149 S-Wave Rotated Reversed InLine at 690 ft (50 Hz) -0.0001246 -0.0001661-0.0002076 -0.0002491 S-Wave Rotated Reversed InLine at 700 ft (50 Hz) -0.0001199-0.0001499 -0.0001799 -0.0002098 V S-Wave Rotated Reversed InLine at 710 ft (50 Hz) -0.0001477 -0.0001723 -0.0001969 -0.0002215 S-Wave Rotated Reversed InLine at 718 ft (50 Hz) -0.0000996 -0.0001494 -0.0001991 V -0.0002489 V S-Wave Rotated Reversed InLine at 727 ft (50 Hz) -0.0001389 -0.0001736 MMM -0.0002083 Į V V V -0.0002430 S-Wave Rotated Reversed InLine at 732 ft (50 Hz) -0.0000773 -0.0002320 V -0.0003093 S-Wave Rotated Reversed InLine at 737 ft (50 Hz) -0.0000619 -0.0001238 -0.0001857 -0.0002476 S-Wave Rotated Reversed InLine at 742 ft (50 Hz) -0.0000682 F -0.0001365 -0.0002047 -0.0002729 S-Wave Rotated Reversed InLine at 748 ft (50 Hz) -0.0000610 -0.0001220 -0.0001830 -0.0002441 S-Wave Rotated Reversed InLine at 760 ft (50 Hz) -0.0001264 -0.0001685 -0.0002106 -0.0002528 0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 Time (sec)

Figure 4.50 Unfiltered Reversed S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 770 to 870 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



S-Wave Rotated Reversed InLine at 770 ft (50 Hz)

Figure 4.51 Unfiltered Reversed S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 880 to 990 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



S-Wave Rotated Reversed InLine at 880 ft (50 Hz)

Figure 4.52 Unfiltered Reversed S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 990 to 1110 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave

S-Wave Rotated Reversed InLine at 1000 ft (30 Hz)
-0.0001617 -0.0001658 -0.0001658 -0.0001741 S-Wave Rotated Reversed InLine at 1010 ft (30 Hz)
-0.0001777 -0.0001824 -0.0001871 -0.0001871 -0.0001871 S-Wave Rotated Reversed InLine at 1020 ft (30 Hz)
-0.0001632 -0.0001686 -0.0001741 -0.0001795 -0.0001795 -0.0001795 -0.0001795
-0.0001810 -0.0001847 -0.0001847 S-Wave Rotated Reversed InLine at 1050 ft (30 Hz)
S-Wave Rotated Reversed InLine at 1060 ft (30 Hz)
S-Wave Rotated Reversed InLine at 1070 ft (30 Hz)
S-Wave Rotated Reversed InLine at 1080 ft (30 Hz)
S-Wave Rotated Reversed InLine at 1090 ft (30 Hz)
S-Wave Rotated Reversed InLine at 1095 ft (30 Hz)
S-VVave Rotated Reversed InLine at 1110 ft (30 Hz)

Time (sec)

Figure 4.53 Unfiltered Reversed S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 1120 to 1300 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave

-0.0002955 -0.0003021 -0.0003087 -0.0003152	AMAMAMAN		ter and the second second	1. -	M	NMW	WWW/M	1		******	
S-Wave R	otated Re	versed In	Line at 1	130 ft (30 l	Hz)						
-0.0002904 -0.0002950 -0.0002997 -0.0003043					NAMA	MW Approved	****	NH441		Martin	N
S-Wave R	otated Re	versed In	Line at 1	140 ft (30 l	Hz)						
-0.0002768 -0.0002822 -0.0002877 -0.0002931			MATHINA AND IN	Million	May Am	WWW	WWW	WIN MANY AN	VVM	WY AW	M
S-Wave R	otated Re	versed In	Line at 1	150 ft (30 l	Hz)						
-0.0002746 -0.0002793 -0.0002840 -0.0002886				why why w	WHY	WMW	*\./\/		with		M
S-Wave R	otated Re	versed In	Line at 1	160 ft (30 l	Hz)						_
-0.0002643 -0.0002695 -0.0002748 -0.0002801	- Harley Hardwigh			NIN AND A CONTRACT	MM			And And	www.	Martin P	
S-Wave R	otated Re	versed In	Line at 1	170 ft (30 l	Hz)						_
-0.0002533 -0.0002623 -0.0002714 -0.0002804					WW	Vm	hon	-	n martin	-	
-0.0002414						T. T.T.T.	1111	1111		TILII	T-1
-0.0002490 -0.0002565 -0.0002641				WMM	MMM	m///www	1 Martin	<u>/////////////////////////////////////</u>	MAN	m vvv	M
-0.0002411	otated Re	versed In	Line at 1	190 ft (30 i	HZ)						-
-0.0002456 -0.0002500 -0.0002545				manyl////	ANAMA		MAN MAN	****	A mark		W
S-Wave R -0.0002322	otated Re	versed In	Line at 1	200 ft (30 l	Hz)					-	_
-0.0002352 -0.0002382 -0.0002412											
S-Wave R	otated Re	versed In	Line at 12	220 ft (30 l	Hz)						
-0.0002225 -0.0002307 -0.0002390 -0.0002472				n Within w	al la superior	Marriel 1999		<mark>Algen Synthese</mark> dd	ly of the second second second		- -
S-VVave R	otated Re	versed In	Line at 12	240 ft (30 l	HZ)						
-0.0002241 -0.0002269 -0.0002298						MANA A					
S-Wave R -0.0002186	otated Re	versed In	Line at 1	260 ft (30 l	Hz)						_
-0.0002214 -0.0002242 -0.0002269											
S-Wave R	otated Re	versed In	Line at 1	280 ft (30 l	Hz)						
-0.0002115 -0.0002139 -0.0002162											104 141
S-Wave R	otated Re	versed In	Line at 1	300 ft (30 l	Hz)						
-0.0002100 -0.0002132 -0.0002163 -0.0002194					**** **						
0	.00 0	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00

S-Wave Rotated Reversed InLine at 1120 ft (30 Hz)

Time (sec)

Figure 4.54 Unfiltered Reversed S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 1240 and 1260 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Short Arm Used



S-Wave Rotated Reversed InLine Short Arm at 1240 ft (30 Hz)

Section 5: Unfiltered S-Wave Records of Reaction Mass

Section 5 includes all unfiltered S-wave signals of the reaction mass accelerometer.

- 1. Figures 5.1 to 5.6 present unfiltered reaction mass horizontal (S-wave) acceleration at Borehole C4993, depths 370 to 990 ft; input signal: 5 cycles of 50-Hz sine wave.
- 2. Figures 5.7 to 5.8 present unfiltered reaction mass horizontal (S-wave) acceleration at Borehole C4993, depths 990 to 1300 ft; input signal: 4 cycles of 30-Hz sine wave.
- Figure 9 presents unfiltered reaction mass horizontal (S-wave) acceleration at Borehole C4993 when short-arm lower horizontal receiver was used at depths 1240 and 1260 ft; input signal: 4 cycles of 30-Hz sine wave.

Figure 5.1 Unfiltered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 370 to 475 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 5.2 Unfiltered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 480 to 540 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 5.3 Unfiltered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 550 to 660 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 5.4 Unfiltered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 670 to 760 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 5.5 Unfiltered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 770 to 870 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 5.6 Unfiltered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 880 to 990 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 5.7 Unfiltered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 990 to 1110 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave

S-Wave Reaction Mass for Receiver at 990 ft (30 Hz)
S-Wave Reaction Mass for Receiver at 1000 ft (30 Hz)
S-Wave Reaction Mass for Receiver at 1010 ft (30 Hz)
8.4085125 -0.8170250
S-Wave Reaction Mass for Receiver at 1020 ft (30 Hz)
S-Wave Reaction Mass for Receiver at 1030 ft (30 Hz)
S-vvave Reaction mass for Receiver at 1040 ft (SU HZ)
04173850 -0 4173850 -0 8347700
S-Wave Reaction Mass for Receiver at 1050 ft (30 Hz)
S-Wave Reaction Mass for Receiver at 1060 ft (30 Hz)
S-Wave Reaction Mass for Receiver at 1070 ft (30 Hz)
S-Wave Reaction Mass for Receiver at 1080 ft (30 Hz)
S-Wave Reaction Mass for Receiver at 1090 ft (30 Hz)
S-Wave Reaction Mass for Receiver at 1095 ft (30 Hz)
S-Wave Reaction Mass for Receiver at 1100 ft (30 Hz)
S-Wave Reaction Mass for Receiver at 1110 ft (30 Hz)
0.00 0.02 0.04 0.00 0.00 0.10 0.12 0.14 0.10 0.18 0.20

Time (sec)

Figure 5.8 Unfiltered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 1120 to 1300 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave







Section 6: Unfiltered S-Wave Records of Reference Receiver

Section 6 includes all unfiltered S-wave signals at the reference receiver.

- Figures 6.1 to 6.6 present unfiltered reference horizontal receiver (S-wave) signals in Borehole C4993, depths 370 to 990 ft; input signal: 5 cycles of 50-Hz sine wave.
- Figures 6.7 and 6.8 present unfiltered reference horizontal receiver (S-wave) signals in Borehole C4993, depths 990 to 1300 ft; input signal: 4 cycles of 30-Hz sine wave.
- Figure 6.9 presents unfiltered reference horizontal receiver (S-wave) signals in Borehole C4993, when short-arm lower horizontal receiver was used at depths 1240 and 1260 ft; input signal: 4 cycles of 30-Hz sine wave.

Figure 6.1 Unfiltered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 370 to 475 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



S-Wave Reference for Receiver at 370 ft (50 Hz)

Figure 6.2 Unfiltered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 480 to 540 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



S-Wave Reference for Receiver at 480 ft (50 Hz)

Figure 6.3 Unfiltered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 550 to 660 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



S-Wave Reference for Receiver at 550 ft (50 Hz)

Figure 6.4 Unfiltered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 670 to 760 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



Figure 6.5 Unfiltered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 770 to 870 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave


Figure 6.6 Unfiltered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 880 to 990 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave



S-Wave Reference for Receiver at 880 ft (50 Hz)

Figure 6.7 Unfiltered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 990 to 1110 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave

0.0249443 0.0000000 -0.0249443			KANA			╺┼╍╁╍┾╍┿╸	
-0.0498885	for Receiver at 10	00 ft (30 Hz)					
0.0254008 0.0000000 -0.0254008 -0.0508015		TANK	WHA				
S-Wave Reference	for Receiver at 10	10 ft (30 Hz)					
0.00000000 -0.0264688 -0.0529375		<u> ANNA</u>	XXXX				
S-Wave Reference	for Receiver at 10	20 ft (30 Hz)		1111			
0.00000000 -0.0260518 -0.0521035		TANK	XXXX				
S-Wave Reference	for Receiver at 10	30 ft (30 Hz)					
0.00000000 -0.0262935 -0.0525870	++++	TWW	XXXX				
S-Wave Reference	for Receiver at 10	40 ft (30 Hz)					
0.0263100 -0.0263100 -0.0526200	+++	XMMX	XXXX				
S-Wave Reference	for Receiver at 10	50 ft (30 Hz)					
0.0000000 -0.0264168 -0.0528335	+++	XMMX	WKY4				
S-Wave Reference	for Receiver at 10	60 ft (30 Hz)					
0.0260940 - 0.0260940 - 0.0260940 - 0.0260940 - 0.0521880 - 0.0521800 - 0.0521800 - 0.0521800 - 0.0521800 - 0.		XMMX	NY YA				
S-Wave Reference	for Receiver at 10	70 ft (30 Hz)					r ra
0.0264598 - 0.0000000 -0.0264598 -		KANA	XAADO				
S-Wave Reference	for Receiver at 10	80 ft (30 Hz)					
0.0264920 - 0.0000000 -0.0264920 -	++++KM	KANA	MAD			++++	
S-Wave Reference	for Receiver at 10	90 ft (30 Hz)					- Fa
0.0262615		XAAA	MADO				
S-Wave Reference	for Receiver at 10	95 ft (30 Hz)					
0.0262153		KAAA	MAG				-
S-Wave Reference	for Receiver at 11	00 ft (30 Hz)					
0.0259963 -0.0259963 -0.0259963 -0.0519925		XANA	AAAA	app-			
S-Wave Reference	tor Receiver at 11	10 ft (30 Hz)					
0.0254053 -0.0000000 -0.0254053 -0.0508105 -0.0254053 -0.0508105 -0.050810000 -0.05081000000000000000000000000000000000	HARM	KANAN	MADO				
0,00	0.05 0.1	0 0.15	0.20 Time (sec)	0.25	0.30	0.35	0.40

S-Wave Reference for Receiver at 990 ft (30 Hz)

Figure 6.8 Unfiltered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 1120 to 1300 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave

0.0510885 0.0255443			NAM	ANL				
0.00000000 -0.0255443 -0.0510885		MMA	MAN	MAN	THA			
S-Wave Reference	for Receiv	rer at 1130 ft (30	Hz)					
0.0251568 0.00000000 -0.0251568		MA	AAA					
S-Wave Reference	for Receiv	er at 1140 ft (30	Hz)					
0.0258228 0.0000000 -0.0258228 -0.0516455		MAN	AAA	200				
0.0505280 F	for Receiv	rer at 1150 ft (30	NIALAI					
0.0252640 - 0.0000000 - 0.0252640 - 0.0252660 - 0.0252660 - 0.025660 - 0.025660 - 0.0256600 - 0.02566000000000000000000000000000000000	<u>_</u>	ANN	MAN	MA	-			
0.0514810 F	for Receiv	rer at 1160 ft (30	Hz)					
0.0257405 0.0000000 -0.0257405 -0.0514810 S. Waya Boference			MAA		a pro-			
0.0511160 FTTT	IOI Receiv		NATAT					TTA
0.0255580 0.0000000 -0.0255580 			AAAA	MA	the			+
0.0526145			NATAT		1111		1111	1 1 1
0.0263073 -0.0263073 -0.0526145		ver at 1190 ft (30	MAN	AAA	d prod			
0.0529780			NALAI	ANTI	1111			TTA
0.0000000 -0.0264890 -		YXXX	MAN	MA				
S-Wave Reference	for Receiv	rer at 1200 ft (30	Hz)					
0.0333410 0.0000000 -0.0269705 -0.0539410		ATA	AAA	AAA			<u></u>	
S-Wave Reference	for Receiv	rer at 1220 ft (30	Hz)	1 18 1 1 1				
0.0270760 0.0000000 -0.0270760 -0.0541520		ANN	ANA	AAA	-			
0.0548345	for Receiv	rer at 1240 ft (30	N N N					
0.0274173 0.0000000 -0.0274173 -0.0548345		YYYY	ANA	AAA				
0.0547105	for Receiv	er at 1260 π (30	N TATAT					
0.0273553 0.0000000 -0.0273553 -0.0547105		AW	ANA	APP				
S-Wave Reference	tor Receiv	rer at 1280 ft (30	Hz)					
0.0281295 0.0000000 -0.0281295 -0.0562590		ACTIV	MANA	AAA				
0.0563615	for Receiv	rerat 1300 π (30	N N N				11111	111
0.00281808 0.0000000 -0.0281808 -0.0563615		YYYY	MANA	MAA				
0.00	CU.U	0.10	0.15	Time (sec)	0.20	0.30	0.30	0.40

S-Wave Reference for Receiver at 1120 ft (30 Hz)

Figure 6.9 Unfiltered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 1240 and 1260 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Low Pass 40 Hz; Short Arm Used



S-Wave Reference for Receiver Short Arm at 1240 ft (30 Hz)

Section 7: Filtered S-Wave Signals of Lower Rotated In-Line Receiver

Section 7 includes all filtered S-wave signals at the lower rotated horizontal receiver.

- 1. Figures 7.1 to 7.6 present filtered lower rotated horizontal receiver (S-wave) signals in Borehole C4993, depths 370 to 990 ft; FFT low pass 60 Hz; input signal: 5 cycles of 50-Hz sine wave.
- Figures 7.7 and 7.8 present filtered lower rotated horizontal receiver (S-wave) signals in Borehole C4993, depths 990 to 1300 ft; FFT low pass 40 Hz; input signal: 4 cycles of 30-Hz sine wave.
- Figure 7.9 presents filtered lower rotated horizontal receiver (S-wave) signals in Borehole C4993, when short-arm lower horizontal receiver was used at depths 1240 and 1260 ft; FFT low pass 40 Hz; input signal: 4 cycles of 30-Hz sine wave.

Figure 7.1 Filtered S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 370 to 475 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz

0.0002024	otateu	IIILDIE	alu	011(5	0112)																		
0.0003034					, AAA	AAL .				-		-					-						
0.0000000				-dal	VI Y I I	VWW	ma	WM	mo	5	0	non	00	-	1	00	-			the			
-0.0001517	-			8	MAAA	AM	VMYM	YYVY	V													-	È.
-0.0003034					MMM	IVI I		11		- 1 -				11	11		-		11	1-1-			
S-Wave R	otated	InLine	e at 38	0 ft (5	0 Hz)																		
0.0001394					. AAAA	AAA.								TT			-						í.
0.0000000				JA	NYYYY	NANA	ma					-		1	4		-	L		44			1
-0.0000697	-			Th	MAAAA	MAN	m	T						T	T								
-0.0001394				11	Anda	104.						_			11		_						E.
S-Wave R	otated	InLine	e at 39	0 ft (5	0 Hz)																		
0.0001205	TT	TIT	TIT	111		IAdo Ja			11	T				TT	11	11	1	TT	TT	11	TT		ſ.
0.0000602				1	MAA	WWW	VWVV	MAL		ad a													i I
-0.0000602	-		TTT	T	MAN	Adda	AMAAA	MM	MA	un	m	Vox	1000	YT	1	94		M	9				í.
-0.0001205					000	MANAI	14 14								11			- [
S-Wave R	otated	InLine	at 40	0 ft (5	0 Hz)																		
0.0003895		111	111	111	AL	A a	1.1.1		11					TT	11	11	-	L L	TT	1.1	111		Č.
0.0001947					ANW	MAN	Vina																Ľ.
0.0000000		++++	+++	and the second s			<u>NNNN</u>	1000	444	500	PP	-		$\phi\phi$	$\phi\phi$	-	*	++	\Rightarrow	-	++		È.
-0.0001947	EII				VVV	(VVVV	ΥĽ																
S-Wave R	otated	Inl ine	at 41	0 ft (5	0 Hz)	C																	1
o maro n		TIT			LAND	6.I T						-					-						Ċ.
0.0001264	-			11	ANN	MAA																-	1
0.0000000			++++++	$\Leftrightarrow \alpha$			∞	00	$\Rightarrow \Rightarrow$	p	00	0		+ +	\Leftrightarrow		-	++	44	+ +	++-		r.
-0.0001264					SVM MA	MAN									11								1
S-Mayo B	otatod	Inl inc	at 12	0 # /5					-1-1				<u> </u>		-11		-	4					£.,
S-vvave R	otated	mune	al 42	Un (S								_					_						
0.0000979					MAAN	nAn_											Ť		11				
0.0000000			++++	000	YYYY	1111}-	20ma	-00	$(\Rightarrow \sim$	>~		20	5	*	0	0	->	4	-		10		
-0.0000979					SVMAA	MM	4															-	
-0.0001959				0.0./5	1 4 9 1									11	1-1		-	11	1	1-1-			
S-Wave R	otated	InLine	e at 43	0 ft (5	0 Hz)																		
0.0001002					VANAN	AAAA																	1
0.0000000			┯┿╋	-	A A A A A A	I Y I Y Y	hoho	20		ab		~		<u></u>	-		-			-			
-0.0001002	-				AAAAA	MAAA^																-	
-0.0002003	ELL				ON NO	VAN. 1									11			1 t	11	1.1			6
S-Wave R	otated	InLine	e at 44	0 ft (5	0 Hz)																		
0.0002179		111		111	- a A A	IARAA.								TT	11			TT	11	11			6
0.0001090				LA	XVVVVV	YYYY	M-h-																
-0.0001090	-			TM	MAAA	MAAAA	M	11		T			m	ŤΤ		-	~					_	
-0.0002179					adala	MAN														11			1
S-Wave R	otated	InLine	at 45	0 ft (5	0 Hz)																		
0.0001269		111	111	111	RA.L.	A A A A A	111	11	11	1	111			11	11	11	1	11	11	11	111		ſ.
0.0000634					NMA	WWW	MAAA																1
0.00000000	ETT.	111		200	VI I I I I		MM	MA	9000	20C	200		2	24	204	20	00	P	-	pp	pp		6
-0.0001269					8//AAA	ANNA.											-						p.
S-Wave R	otated	InLine	at 46	0 ft (5	0 Hz)																		
		1 1 1		111	1.10	101	111	11	11					1 1	1 1	1 1	-	1	1 1	11	1 1 1		ř.
0.0001149	F.				XMM	VMAN	Ann.																1
0.0000000			+++		XIII		XXX	XXX	00000	200	\sim	X	000	100	$\diamond \dagger$	-	~~	ÞÞ	-0+	*	**		r.
-0.0001149	ELL				ONNO	MWVY.	VVY																
S-Maya B	otatod	Inl inc	at 17	0 # /5					1 1		1	la de la composición de la composi Composición de la composición de la comp		-dd-			-			4.4	4 1 1		5
0.0002567	Juared	mente	a. 4/	0 11 (0	5 (1Z)												_						
0.0001284	- 1				VNA	MAAA	Ann			-					11							_	
0.0000000					XIII	11111	YYXX	YYXX	2000C)obc	000	-	00	4	4		$ \rightarrow $	-					2
-0.0001284	-				SMM	ANN	WW	MVT		ſ												-	1
-0.0002567					VEL	VVI I		11		_			i i	11	11		-	11	11	11			
S-Wave R	otated	InLine	e at 47	5 ft (5	U HZ)																		
0 0000557	LIT				XMAA	AN																	1
0.0000000				stat	YYYY	MA	YYW	MA	non	Nor	and	00	0	5	30	4	-	4	-	de la	4	200	1
-0.0000557	-				MAN	WY I	JVVV	VVV	YYY	1										11			
-0.0001115	FTT	ц Ļ	لمالح		ANAA			0.40		0.50							1			<u> </u>		وللله	00
~	00									1 I G []		114	DIT.		117	11		11.01				2.0	- 1 B

S-Wave Rotated InLine at 370 ft (50 Hz)

Time (sec)

Figure 7.2 Filtered S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 480 to 540 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz

S-Wave R	otated InL	ine at 4	80 ft (5	U HZ)													
0.0002220 0.0001110 0.0000000 -0.0001110	-		 0		100		Maco		000		*	~~		~~~	\$	~	
-0.0002220	ntated Inl	ine at 4	85 ft (5)					1 1 1							_		
0.0001730 0.0000865 0.0000000 -0.0000865 -0.0001730			⇒~~()				0000000	000000	0000		~~~	×~~	~~	~~ ~		~	
S-Wave Re	otated InL	ine at 4	90 ft (5	0 Hz)													
0.0000819 0.0000000 -0.0000819 -0.0001638					Mind	M)coo		-000-				000	~		×¢	~	
S-Wave Re	otated InL	ine at 4	95 ft (5	0 Hz)													
0.0001230 0.0000615 0.0000000 -0.0000615 -0.0001230	-	-			()oco(()000()00	2000	<u>)0000</u> 0	xxxxx)()() ()	0000	000		×~~~	
S-Wave R	otated InL	ine at 5	00 ft (5	0 Hz)													
0.0001484 0.0000742 0.0000000 -0.0000742 -0.0001484					M	<u>)00~00(</u> x	00000	0000	00000	\sim	~		\sim		>	*	
S-Wave Re	otated InL	ine at 5	05 ft (5)	0 Hz)													
0.0000775 0.0000000 -0.0000775 -0.0001550	-			-sall	No-00	∞	00-0-			-000			~	~0			
S-Wave Re	otated InL	ine at 5	10 ft (5	0 Hz)													
0.0002014 0.0000000 -0.0002014 -0.0004028	-			-200			XXXXXXX	000	000		~	~~~	~~	~~~		~~~	
S-Wave Re	otated InL	ine at 5	15 ft (5	0 Hz)													
0.0000786 0.0000000 -0.0000786 -0.0001573				-800		~2001))()opo(soo			<u>~~</u> ~	<mark> </mark>	~~				
S-Wave Re	otated InL	ine at 5	20 ft (5	0 Hz)													
0.0000504 0.0000000 -0.0000504 -0.0001008	-			$\langle \rangle \rangle$			MA				~~~	~~~	~~~		~~		-
S-Wave Re	otated InL	ine at 5	25 ft (5)	0 Hz)													
0.0000477 0.0000000 -0.0000477 -0.0000955				× M))(0)()~	xxxxxx	-00000	2000c				~~	<u>, 000</u>		3 0 <	
S-Wave Re	otated InL	ine at 5	30 ft (5	0 Hz)													
0.0000811 0.0000000 -0.0000811 -0.0001623		ino at 5		~				~~~	~~~~			~~~	~~~				
S-vvave N		ine al O	10 11 (0		1 10												
0.0000332 0.0000000 -0.0000332 -0.0000665				≫§øQ		MMAX)) cho										
U.	00 1	5.10	0.20		0.50	0.40	, i	00.0	0.60	,	0.70	,	0.80	,	0.90	J	1.00
							Tim	e (sec)									

S-Wave Rotated InLine at 480 ft (50 Hz)

Figure 7.3 Filtered S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 550 to 660 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz

S-vvave Rolaled	i incine al c	550 IL (50 HZ)						
0 0000581			an An An A. a					
0.0000000		10 Acted	WWWWWW/	Moodoon		to to the total		-
-0.0000581 -		Δ X	MMMMM	VIIII				-
-0.0001162 -								-
S-Wave Rotated	InLine at	560 ft (50 Hz)						
0.0000995	TITT	11111	A AA A	Δ		1111		
0.0000498		8	MANNAANA	MA. An An-				-
					MANAX	XXXXXXX		7
0.0000496		4	M. M. M. A.	VIVIII				1
S Mayo Botatad	Inline at l	570 # (50 U-)						-
S-Wave Rolaled	i incine at a					1.1.1.1.1.		_
0.0000283 -		9	Alla an in an					-
0.0000000		Madadat		monto	Salad	data tob	hababbbbbbb	-
-0.0000283 -		χv	WWW WWW					-
-0.0000567			IVW IIII					-
S-Wave Rotated	InLine at	580 ft (50 Hz)						
0.0000544	TITT	TITT	a Aabah.	Λ		TITT		
0.0000544 -		9	L.M.A.WWWWW	MAAAAAA				-
0.0000000			MANNAM	MMMM	and have have	and dood	her have been as the	7
-0.00000044 E		++++	A ANNAAN AAA	V				3
S-Wave Rotated	Inline at !	590 ft (50 Hz)						
0.0001097	intente at t							-
0.0000548 -		80	AAAAAA					-
0.0000000	++++++	()		20000000	popopo		┶╁╤┿┿╱┾┥	-
-0.0000548 -		1 N	IMMMM/PY					-
-0.0001097			Y NOV Y I I I					-
S-Wave Rotated	InLine at 6	600 ft (50 Hz)						
0.0001280			hallalah					
		L John W	NAMAN					
-0.0000640 -	TITI	MALLAN		mm		++++		
-0.0001280		A*	holloh.					
S-Wave Rotated	InLine at 6	610 ft (50 Hz)						
		· · · · · · · · · · · · · · ·	L.Nob LIT					
0.0000824 -		21	MINIMA					-
					popoor	pppp	<u>╆</u> ╋╋╋╋╋╋╋╋	-
-0.0000824 -		4	MMMM -					1
S Mayo Potatod	Inline at (20 # (50 H-)						-
	i incline at t	520 IL (50 I IZ)						-
0.0000599 -		Q.	nannan					_
0.0000000		Madate	1 Mooda	00000000	000000	dadec		-
-0.0000599 -		X	AAAAAAM^ TI''''''''''''''''''''''''''''''''''''					-
-0.0001197			NAMAN I					-
S-Wave Rotated	InLine at 6	630 ft (50 Hz)						
0.0001424			a a A A A A A					
0.0000712 -		N ALAN	WWWW			والدالية المراد		1
-0.0000712 -	Ť I I I	TTTTM	MIMM	ANNA		TTTT		
-0.0001424		· · · · · · · · · · · · · · · · · · ·	VANAA					_
S-Wave Rotated	InLine at 6	640 ft (50 Hz)						
	1111		A AALITI			1111		
0.0000178		I I I I I Å	WWAMAN	halala	hhash	LINIA	hand	-
0.0000000		++++++X()	MIXXXXX	MANNAN	MANAN	Adres to	WPWPWPWW	~
-0.0000176 E		8	VVWVY M					1
S Mayo Potatod	Inlino at 6	SEO # (50 H-)						-
S-wave Rolated	i incline at o	550 IL (50 HZ)						_
0.0000206			AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA	Anna	· · · · · · · · · · · · · · · · · · ·			-
0.0000000	╈╪╤╋╤╋╍╬	tobolder	A XIY IIY IIY IIY X YIY)		()basinink	xpant	approx approx and	Ø
-0.0000206 -		8	TWMM/M/W/V/	YWWY I I YWY		IIIII		-
-0.0000413 E I I								-
S-VVave Rotated	inLine at 6	500 π (50 Hz)		and the second second	a long a			
0.0000642			- MAAAAAAAA	adadadada				1
0.0000000			A Y Y Y Y Y Y Y Y Y Y Y Y Y Y Y Y	VANA AN AN AN AN	MMMM	phone	handbad	_
-0.0000642 -		8	MAAAAAAAAAAAAAA	MAAAAAAAA	wwwww	Y'T MYY		-
-0.0001284			I I NAAAAA.					_
0.00	0.10	0.20	0.30 0.40	0.50	0.60	0.70	0.80 0.90 1	00.1
				Time (sec)				

S-Wave Rotated InLine at 550 ft (50 Hz)

Figure 7.4 Filtered S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 670 to 760 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz

0.0000728	otated	InLin	ie at i	670	π (50	JHZ)										2.4						_
0.0000364	-					XA	MAMAN	100		Ann	A.A.											
0.0000000				++	-	$\sim (1)$		()) or d	XXX	XXXXX	XXXX	XXXX	$() \alpha () \alpha ()$	000-	Dober	000	2000	∞	<u> </u>	Xac	**	30
-0.0000728						99	a MMA	· ·														
S-Wave R	otated	InLin	ne at l	680	ft (50) Hz)																
0.0000368	-					γA	AAAAA	1AA														-
0.0000000				++	++	$\sim ()$		11000	xx~		\Rightarrow	00	$\rightarrow \rightarrow \sim$	000	>oo+	*	200	00				~
-0.0000368						81	VVVV	JVV														
S-Wave R	otated	InLin	ne at l	690	ft (50) Hz)																
0 0000427						V	AAAA	1AA		ПТ	TT	TT					TT					
0.0000000				-	++++	-	HHH)	Im	bb	200	4		00	000	200	+	X	0C	44		┢╍┿╸	-
-0.0000427	ELL					81	MMM	W														
S-Wave R	otated	InLin	ne at	700	ft (50) Hz)						-										
0.0000267		ПП	ПТ		$\hat{\mathbf{T}}$		10000	100				TT									ТТ	
0.00000207					-	mad	YYYYY	MWY	nor	000	4	bo	to	no	200	ada	bala					-
-0.0000267	$\left \cdot \right $					M	MMM	M	N				Iľ	Ň				Ň				-
-0.0000534 S-Wave R	otated	Inl in	ne at '	710	ft (50) Hz)	N. N.		1 1		1 1		1							1 1	1 1	19
							. LAAA					11	11		11		11				TT	
0.0000199	L.			44		-	MMM	MAR	mm	Mh	m	h	why	m	m	m	h		-	h	4	L.
-0.0000199	-					W	WAMA	M	WW	M	TY.	4.40				my y			T			-
-0.0000399	otated	Inlin	no at	718	ft (50	1 Hz)	1001				11										11	1-
O-Wave IX	otated			11	1 (50	T T T	1 4 4	Anh I			11	11	11				11			11	1 1	
0.0000484						2	WW	WWW	inn	WW	MAN	m	h	m	m		-	hr				1
-0.0000484						A	4444	MM	WW	MMM	MM	m	m	mu	MA		$\gamma\gamma$	m	m	$\uparrow \uparrow$	m	
-0.0000968	otatod	L l l l l l		727	# /5C		144	l v v	11													
0.0000680	otateu			121	11 (50		1		1 1			1.1	1 1				1 1					
0.0000340						A	NMN	MAL	1000	m												-
-0.0000340				TT	T	any	1.MM	MMY	WM	hur	uro	yupa	nn		a da	vep	vv	ou	and the		T	
-0.0000680				720	A /F C		A. AA	VY	11												11	
S-vvave R	otated	INLIN	ie at	152	n (su		1 10															
0.0000818	-						MW	WWW	han	hh	Jal											-
-0.00000818	-						MM	k k k k k	MM	MM	XXXX	popo	$\varphi \rightarrow \varphi$	∞	xx	\sim		000			PP	
-0.0001636				707	0 /50		YVY	NAAb.														
0.0001262	otated	InLin	ne at	131	π (50) HZ)																_
0.0000631	-					8	MMA	MAAA.														-
-0.00000000			_			~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	WWW	I I MA	pa	Kaak	()~		$\phi\phi\phi$			000	p	60		**	Ŧ	
-0.0001262	LLL.	ĻĻļ					AAAA	NVV [
S-Wave R	otated	InLin	ne at	742	ft (50) Hz)																_
0.0000656							han	MAAA	AAA	MM	MAN	MAAA	0000									-
0.0000000					+	-	MAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA		NI NI .		1111)	(AXA)	(XXV)	WW.	$\alpha \alpha \phi$	abab	pop	00	00-	\$	0-0-	0
-0.0001311								VVVVV	YVVV	VVVV	NAN	0000										
S-Wave R	otated	InLir	ne at	748	ft (50) Hz)											1.1					
0.0000612	-						.noM	MAAA														_
0.0000000					++	bood) 2000		$\phi\phi$	-0-0	~~	\sim	>++	000	200	00	00	++	++	
-0.0001225							VVV	NVV V														
S-Wave R	otated	InLin	ne at	760	ft (50) Hz)																
0.0000431	-							ANAN	Mm.													
0.0000000						-por	XXXXX		AVAV	MM	Ax	top	000	0000	00	40	doctor (200	44	++	*	0
-0.0000431							VV	WWW	N N N													
0	.00	0.1	10	C	0.20	(0.30	0	.40	C	0.50		0.60		0.7	0	0.	80	0	.90		1.00
										Tim	e (se	c)										

S-Wave Rotated InLine at 670 ft (50 Hz)

Figure 7.5 Filtered S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 770 to 870 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz

S-Wave R	otated	InLir	ie at /	70 ft	(50 Hz	:)									
0.0000255						- N	MAMA	00000							_
0.0000000	╺┿┿╸		++			$\rightarrow \infty$	1111111	YNYNYX	<i>horioci</i> x	x bob bob c	000000	opopoo	2000	000	000
-0.0000255						WW	AMANYYY	ender of							-
S-Wave Re	otated	InLin	e at 7	80 ft	(50 Hz	•)									
0.0000178						-/				1111					
0.0000089	-					ANN	MAAAA	A A4A C							-
0.0000000			-		start	- MIII		KAXXXX	papo	4000	popp	000	boo d		and a
-0.00000039						VVV	VYV								
S-Wave R	otated	InLin	e at 7	90 ft	(50 Hz)									
0.0000128		П			111	I AA	0		ПП	TIT		TIT	ПП		
0.0000064						XIVIV	MMMIN	mm	min	m	m	man		th	m
-0.0000064	- 1			M	T	TANANA I	MWW	MW	YWW	min	mu	mor		\sim	
-0.0000128						1-1-00									
S-Wave Re	otated	InLin	ie at 8	00 ft	(50 Hz	:)								0.00	
0.0000199	_						MAAA								_
0.0000000				┝┿┿	-	×X(X)(1]		x () () () ()	DOODOK	>papabadad	2000	XXXXXXXX	x00000	200	000
-0.0000199						or all	WW								
S-Wave R	otated	Inl in	e at 8	10 8	(50 Hz	2									
0.0001479		1 1 1			1111		1 A b A b A								
0.0000739	-					Vac M	AAAAAAAA	MAAAA	hanna						-
-0.00000000						- SAM	ALALA	LAAAAA	IMMP	and	<u>o o o o o o o o o o o o o o o o o o o </u>	popo			
-0.0001479							VYVVVV	Wvvvv	~						_
S-Wave R	otated	InLin	e at 8	20 ft	(50 Hz	:)									
0.0000444						0.01	AAAAA	AAAAAA	Anan						
0.00000222						MMX	VVVVV	IYYYYYY	WWWW	MMMM	mm	mon	hon	- and and	m
-0.0000222	-					1. SWW	AAAAAA	IAAAAAA	MAAAAN	WWW	man	- And	VIII	Υ¥1	
-0.0000444				20.4	(501)		N N N N N	1. No A A A a	Nels Iel						
S-VVave R	otated	InLin	ie at 8	30 π	(50 Hz)								Correct of	
0.0000398	-					TAN	MAA								_
0.0000000	-		++>		++++	->>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>		000000	0000		0000	20000	 0 0 0		
-0.0000398						ovW	M/W 1								
S-Wave Re	otated	InLin	e at 8	40 ft	(50 Hz	:)									
0.0000454		П		ПТ	<u>,</u>		d. Aal								
0.0000151					J.J.	MM	AMMM	WWW	min	man	h	han	h	L	11
-0.0000151	-					MW	AMAAAA	Mm	mm	mm	m	m	\square	111	YT-
-0.0000301		ĻĻļ				Ч	VYV								
S-Wave Re	otated	InLin	ie at 8	45 ft	(50 Hz	2)									_
0.0000387							AAAAAA	MAAAAAA	AAAAA	A.0.0.0.0.0					
0.0000000			-		+++				(YYYYY))	THANK	(Y YY YYYY)	MAXbook	0000	-0-0-0	00000
-0.0000387						a. vv	VVVVV	MMM	ANANANA	AAAAAAAA	VVVVVV				-
S-Wave R	otated	Inl in	e at 8	53 ft	(50 Hz	•)									
0.0001017							NA AAAAA			1111		TTTT		111	
0.0000509						MAAK	AWWWW	MMMA	man	man-n					
-0.0000509	_	T				- SMW	ALL ALL	A AA AAAAA	MMM	mada	nano-c		20-0-0		~~~~
-0.0001017						1 10	NAMANA	10 0 0							
S-Wave Re	otated	InLin	ie at 8	60 ft	(50 Hz	:)									
0.0000393							ana ana	00 00000	AAAAAA						
0.0000000					+++	-and	YYYYYYY	IYWYYYY		WYNODOOX	00000	200-000	000-000	xohoda	00000
-0.0000393						ovvu	MAMM	WWW	MMM	AAAAA			Í		-
-0.0000/86	ntated	Inlin	e at 8	70 8	(50 H-	9	1 2 2 2								
0.0000421	Jaced					·/	Antel								
0.0000211	-					XAAN	WWW	MALA	Anna	and and					-
0.0000000			++-	Ħ	+++	×91111	111111	MAXIN	WAX KOX	xpapapa	10000/2000	poppo	ppp	-00	200
-0.0000421						o^~V	MANAN,	1.1							
0.	00	0.1	10	0.2	0	0.30	0.40	0	50	0.60	0.70	0.80		0.90	1.00
								Time	(sec)						

S-Wave Rotated InLine at 770 ft (50 Hz)

Figure 7.6 Filtered S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 880 to 990 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz

S-Wever Rotated InLine at 900 ft (50 Hz) S-Wever Rotated InLine at 910 ft (50 Hz) S-Wever Rotated InLine at 910 ft (50 Hz) S-Wever Rotated InLine at 917 ft (50 Hz) S-Wever Rotated InLine at 927 ft (50 Hz) S-Wever Rotated InLine at 927 ft (50 Hz) S-Wever Rotated InLine at 927 ft (50 Hz) S-Wever Rotated InLine at 950 ft (50 Hz)	
0.00000000000000000000000000000000000	
With the set of the set	-0.0000146
S-Wave Rotated InLine at 910 ft (50 Hz) S-Wave Rotated InLine at 910 ft (50 Hz) S-Wave Rotated InLine at 910 ft (50 Hz) S-Wave Rotated InLine at 917 ft (50 Hz) S-Wave Rotated InLine at 917 ft (50 Hz) S-Wave Rotated InLine at 917 ft (50 Hz) S-Wave Rotated InLine at 927 ft (50 Hz) S-Wave Rotated InLine at 927 ft (50 Hz) S-Wave Rotated InLine at 935 ft (50 Hz) S-Wave Rotated InLine at 930 ft (50 Hz) S-Wave Rotated InLine at 930 ft (50 Hz) S-Wave Rotated InLine at 940 ft (50 Hz) S-Wave Rotated InLine at 930 ft (50 Hz) S-Wave Rotated InLine at 940 ft (50 Hz) S-Wave Rotated InLine at 940 ft (50 Hz) S-Wave Rotated InLine at 940 ft (50 Hz) S-Wave Rotated InLine at 950 ft (50 Hz) S-Wave Rotated InLine at 960 ft (50 Hz) S-Wave Rotated InLine at 960 ft (50 Hz) S-Wave Rotated InLine at 960 ft (50 Hz) S-Wave Rotated InLine at 970 ft (50 Hz) S-Wave Rotated InLine at 970 ft (50 Hz) S-Wave Rotated InLine at 980 ft (50 Hz) S-Wave Rotated InLine at 970 ft (50 Hz) S-Wave Rotated InLine at 970 ft (50 Hz) S-Wave Rotated InLine at 990 ft (50 Hz) S-Wave Rotated InLine at 990 ft (50 Hz) S-Wave Rotated In	
S-Wave Rotated InLine at 910 ft (50 Hz) S-Wave Rotated InLine at 910 ft (50 Hz) S-Wave Rotated InLine at 917 ft (50 Hz) S-Wave Rotated InLine at 927 ft (50 Hz) S-Wave Rotated InLine at 927 ft (50 Hz) S-Wave Rotated InLine at 935 ft (50 Hz) S-Wave Rotated InLine at 935 ft (50 Hz) S-Wave Rotated InLine at 950 ft (50 H	
000000000000000000000000000000000000	S-Wave Rotated InLine at 900 ft (50 Hz)
2:000000000000000000000000000000000000	
S-Wave Rotated InLine at 917 ft (50 Hz) S-Wave Rotated InLine at 917 ft (50 Hz) S-Wave Rotated InLine at 927 ft (50 Hz) S-Wave Rotated InLine at 927 ft (50 Hz) S-Wave Rotated InLine at 927 ft (50 Hz) S-Wave Rotated InLine at 935 ft (50 Hz) S-Wave Rotated InLine at 935 ft (50 Hz) S-Wave Rotated InLine at 940 ft (50 Hz) S-Wave Rotated InLine at 940 ft (50 Hz) S-Wave Rotated InLine at 950 ft (50 H	
000000000000000000000000000000000000	S-Wave Rotated InLine at 910 ft (50 Hz)
S-Wave Rotated InLine at 917 ft (50 Hz) S-Wave Rotated InLine at 927 ft (50 Hz) S-Wave Rotated InLine at 935 ft (50 Hz) S-Wave Rotated InLine at 940 ft (50 Hz) S-Wave Rotated InLine at 940 ft (50 Hz) S-Wave Rotated InLine at 940 ft (50 Hz) S-Wave Rotated InLine at 950 ft (50 Hz) S-Wave Rotated InLine at 970 ft (50 Hz) S-Wave Rotated InLine at 990 ft (50 H	-0.0000179 -0.0000357
000000000000000000000000000000000000	S-Wave Rotated InLine at 917 ft (50 Hz)
-0.0001151	
0000010000000000000000000000000000000	-0.0001151 L I I I I I I I I I I I I I I I I I I
000000000000000000000000000000000000	
0.00000000000000000000000000000000000	
00000009 00000009 00000009 00000009 00000009 00000009 00000000	S-Wave Rotated InLine at 935 ft (50 Hz)
- 00000199 - 00000119 - 00000119 - 00000119 - 00000119 - 00000119 - 00000119 - 00000103 - 000000103 - 00000103 - 000000103 - 000000103 - 00000103 - 000000103 - 0000000103 - 000000103 - 00000	
S-Wave Rotated InLine at 950 ft (50 Hz) 0000000 00000000 00000000 00000000	
0,0000119 0,0000019 0,0000019 0,0000010 0,00000000	S-Wave Rotated InLine at 940 ft (50 Hz)
-0.0000139 -0.0000103 -0.0000103 -0.0000103 -0.0000103 -0.0000103 -0.0000103 -0.0000103 -0.0000103 -0.0000153 -0.0000056 -0.000056	
S-Wave Rotated InLine at 950 ft (50 Hz)	
0 00000103 0 000000306 0 00000103 0 0000015 0 0000005 0 000005 0 00005 0 00005	S-Wave Rotated InLine at 950 ft (50 Hz)
-0.0000206 S-Wave Rotated InLine at 960 ft (50 Hz) 0.0000153 0.00000153 0.0000026 S-Wave Rotated InLine at 970 ft (50 Hz) 0.0000026 0.0000026 0.0000026 0.0000026 0.0000026 0.0000026 0.0000026 0.0000026 S-Wave Rotated InLine at 980 ft (50 Hz) 0.0000191 0.0000056 0.00000191 0.0000056 0.00000191 0.0000056 0.00000191 0.0000056 0.00000191 0.0000056 0.00000191 0.0000056 0.00000191 0.0000056 0.00000191 0.0000056 0.00000191 0.0000056 0.00000191 0.0000056 0.00000191 0.00000000 0.00000191 0.000000191 0.00000000000 0.000000000 0.00000000	
0.0000153 0.0000153 -0.000015 -0.0000015 -0.0000015 -0.0000015 -0.0000015 -0.0000015 -0.0	-0.000206 L
0.0000153 0.0000153 0.0000153 0.0000056 0.0000026 0.0000026 0.0000028 0.0000028 0.00000191 0.000000191 0.00000000000 0.000000000 0.00000000	
S-Wave Rotated InLine at 970 ft (50 Hz) 0.0000028 0.0000095 0.00000000	
0.0000056 0.0000028 0.0000000 0.0000028 S-Wave Rotated InLine at 980 ft (50 Hz) 0.0000056 0.0000095 0.0000095 0.0000095 0.0000095 0.0000095 0.0000095 0.0000095 0.0000095 0.0000001 0.0000021 0.00000021 0.00000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.00000021 0.00000021 0.00000021 0.00000021 0.0000000 0.00000000 0.00000000	S-Wave Rotated InLine at 970 ft (50 Hz)
0 0000000 0 00000028 0 0000008 S-Wave Rotated InLine at 980 ft (50 Hz) 0 0000009 0 0000001 0 0000000 0 00000000	
S-Wave Rotated InLine at 980 ft (50 Hz) 0.0000191 0.0000095 0.0000000 0.0000095 0.0000001 0.00000191 S-Wave Rotated InLine at 990 ft (50 Hz) 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 Time (sec)	
0.0000191 0.0000095 0.0000095 0.0000095 0.0000095 0.0000095 0.000001 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000021 0.0000000 0.00000000	S-Wave Rotated InLine at 980 ft (50 Hz)
0.0000000 -0.00000191 S-Wave Rotated InLine at 990 ft (50 Hz) 0.0000001 -0.0000021 -0.0000021 -0.0000021 -0.0000021 -0.0000021 -0.0000021 -0.0000042 -0.000042 -0.000042 -0.000042 -0.0000042 -0.0000042 -0.0000042 -0.0000042 -0.0000042 -0.0000042 -0.0000042 -0.0000042 -0.000042	
S-Wave Rotated InLine at 990 ft (50 Hz) 0.0000001 -0.0000021 -0.0000022 0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 Time (sec)	
0.00000021 0.0000000 -0.0000021 -0.0000021 -0.0000021 0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 Time (sec)	S-Wave Rotated InLine at 990 ft (50 Hz)
-0.0000021 - 0.0000042 - 0.0000042 - 0.0000042 - 0.000 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 Time (sec)	6.0000000
Time (sec)	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
	Time (sec)

S-Wave Rotated InLine at 880 ft (50 Hz)

Figure 7.7 Filtered S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 990 to 1110 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Low Pass 40 Hz

S-Wave Rotated InLine at 1000 ft (30 Hz)
S-Wave Rotated InLine at 1010 ft (30 Hz)
S-Wave Rotated InLine at 1020 ft (30 Hz)
S-Wave Rotated InLine at 1030 ft (30 Hz)
S-Wave Rotated InLine at 1040 ft (30 Hz)
S-VVave Rotated InLine at 1070 π (30 Hz)
S-Wave Rotated InLine at 1080 ft (30 Hz)
S-Wave Rotated InLine at 1090 ft (30 Hz)
0.0000061
S-Wave Rotated InLine at 1100 ft (30 Hz)
Time (sec)

S-Wave Rotated InLine at 990 ft (30 Hz)

Figure 7.8 Filtered S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 990 to 1110 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Low Pass 40 Hz

0.0000022 0.00000000 -0.0000022 -0.0000044 S-Wave Rotated InLine at 1130 ft (30 Hz) 0.0000043 0.0000022 0.0000000 -0.0000022 -0.0000022 -0.0000043 S-Wave Rotated InLine at 1140 ft (30 Hz) 0.0000023 0.00000000 -0.0000023 -0.0000047 S-Wave Rotated InLine at 1150 ft (30 Hz) 0.0000029 0.0000000 -0.0000029 -0.0000029 S-Wave Rotated InLine at 1160 ft (30 Hz) 0.0000046 0.0000000 -0.0000046 -0.0000093 S-Wave Rotated InLine at 1170 ft (30 Hz) 0.0000066 0.0000000 -0.0000066 -0.0000131 S-Wave Rotated InLine at 1180 ft (30 Hz) 0.0000083 0.0000041 0.0000000 -0.0000041 -0.0000083 S-Wave Rotated InLine at 1190 ft (30 Hz) 0.0000012 0.0000000 -0.0000012 -0.0000024 S-Wave Rotated InLine at 1200 ft (30 Hz) 0.0000015 0.0000000 -0.0000015 -0.0000030 S-Wave Rotated InLine at 1220 ft (30 Hz) 0.0000010 S-Wave Rotated InLine at 1240 ft (30 Hz) 0.0000008 0.00000000 -0.0000008 -0.00000017 S-Wave Rotated InLine at 1260 ft (30 Hz) 0.0000010 0.0000000 -0.0000010 -0.0000020 S-Wave Rotated InLine at 1280 ft (30 Hz) 0.0000015 0.0000008 0.0000000 -0.0000008 -0.0000015 S-Wave Rotated InLine at 1300 ft (30 Hz) 0.0000014 0.0000007 0.00000007 -0.0000007 0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

S-Wave Rotated InLine at 1120 ft (30 Hz)

Time (sec)

Figure 7.9 Filtered S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 1240 and 1260 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Low Pass 40 Hz; Short Arm Used



Section 8: Filtered S-Wave Signals of Reaction Mass

Acceleration

- 1. Figures 8.1 to 8.6 present filtered reaction mass horizontal (S-wave) acceleration at Borehole C4993, depths 370 to 990 ft; FFT low pass 60 Hz; input signal: 5 cycles of 50-Hz sine wave.
- 2. Figures 8.7 and 8.8 present filtered reaction mass horizontal (S-wave) acceleration at Borehole C4993, depths 990 to 1300 ft; FFT low pass 40 Hz; input signal: 4 cycles of 30-Hz sine wave.
- 3. Figures 8.9 presents filtered reaction mass horizontal (S-wave) acceleration at Borehole C4993, when short- arm lower horizontal receiver was used at depths 1240 and 1260 ft; input signal: 4 cycles of 30-Hz sine wave.

Figure 8.1 Filtered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 370 to 475 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz



Figure 8.2 Filtered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 480 to 540 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz



Figure 8.3 Filtered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 550 to 660 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz



Figure 8.4 Filtered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 670 to 760 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz



Figure 8.5 Filtered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 770 to 870 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz



Figure 8.6 Filtered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 880 to 990 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz



Figure 8.7 Filtered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 990 to 1110 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Low Pass 40 Hz



S-Wave Reaction Mass for Receiver at 990 ft (30 Hz)

Figure 8.8 Filtered S-Wave Signals of the Reaction Mass Accelerometer (C4993) Depths 1120 to 1300 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Low Pass 40 Hz







Section 9: Filtered S-Wave Signals of Reference Receiver

- 1. Figures 9.1 to 9.6 present filtered reference horizontal receiver (S-wave) signals in Borehole C4993, depths 370 to 990 ft; FFT low pass 60 Hz; input signal: 5 cycles of 50-Hz sine wave.
- Figures 9.7 to 9.8 present filtered reference horizontal receiver (S-wave) signals in Borehole C4993, depths 990 to 1300 ft; FFT low pass 40 Hz; input signal: 4 cycles of 30-Hz sine wave.
- Figures 9.9 presents filtered reference horizontal receiver (S-wave) signals in Borehole C4993, when short-arm lower horizontal receiver was used at depths 1240 and 1260 ft; input signal: 4 cycles of 30-Hz sine wave.

Figure 9.1 Filtered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 370 to 475 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz





Figure 9.2 Filtered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 480 to 540 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz

Time (sec)

Figure 9.3 Filtered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 550 to 660 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz



Figure 9.4 Filtered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 670 to 760 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz



S-Wave Reference for Receiver at 670 ft (50 Hz)

Figure 9.5 Filtered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 770 to 870 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz



S-Wave Reference for Receiver at 770 ft (50 Hz)

Figure 9.6 Filtered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 770 to 870 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz



Figure 9.7 Filtered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 990 to 1110 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Low Pass 40 Hz

0.0413796	e for Receiver at 990 ft (30 Hz)			
0.0206898 -				
-0.0413796				
S-Wave Reference	e for Receiver at 1000 ft (30 Hz)			
0.0209181 0.0000000 -0.0209181 -0.0209181 -0.0209181 -	-\$00000000000			
S-Wave Reference	e for Receiver at 1010 ft (30 Hz)			
0.0434214				
0.0000000				
S-Wave Referenc	e for Receiver at 1020 ft (30 Hz)			_
0.0218179 0.0000000 -0.0218179 -0.0436358				
S-Wave Referenc	e for Receiver at 1030 ft (30 Hz)			
0.0443208				-
-0.0443208	e for Receiver at 1040 ft (30 Hz)			
0.0445395		1111		
0.0000000				
S-Wave Referenc	e for Receiver at 1050 ft (30 Hz)			
0.0430438 0.0225229 0.0000000 -0.0225229 -0.0450458				
S-Wave Referenc	e for Receiver at 1060 ft (30 Hz)			
0.0450922 0.0225461 0.0000000 -0.0225461				
-0.0450922	e for Receiver at 1070 ft (30 Hz)			
0.0400890			11111	
0.0000000 -0.0200445 -0.0400890				
S-Wave Reference	e for Receiver at 1080 ft (30 Hz)			
0.0202308	-\$000000000			
S-Wave Referenc	e for Receiver at 1090 ft (30 Hz)			
0.0398390				1
-0.0199195 -				
-0.0398390	e for Receiver at 1095 ft (30 Hz)			اهما
0.0396984				
0.00000000				
S-Wave Referenc	e for Receiver at 1100 ft (30 Hz)			
0.0194806				
S-Wave Referenc	e for Receiver at 1110 ft (30 Hz)			
0.0387694		TIT		
0.0000000 -0.0193847 -0.0387694				
0.00	0.05 0.10 0.15 0.20 0.25	0.30	0.35	0.40
	Ime (sec)			

S-Wave Reference for Receiver at 990 ft (30 Hz)

Figure 9.8 Filtered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 1120 to 1300 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Low Pass 40 Hz

0.0384657		
-0.0192329 -0.0384657		
S-Wave Reference	for Receiver at 1130 ft (30 Hz)	
0.0193529 0.0000000 -0.0193529 -0.0387057		
S-Wave Referenc	for Receiver at 1140 ft (30 Hz)	
0.0192847 0.0000000 -0.0192847 -0.0385694		
S-Wave Reference 0.0387632	for Receiver at 1150 ft (30 Hz)	
0.0193816 - 0.0000000 -0.0193816 - -0.0387632 -	-\$0XXXXXXXXXX	
S-Wave Referenc	for Receiver at 1160 ft (30 Hz)	
0.0193718 - 0.0000000 - -0.0193718 - -0.0387436 -		
S-Wave Referenc	for Receiver at 1170 ft (30 Hz)	
0.0195593 0.0000000 -0.0195593 -0.0391186		
S-Wave Referenc	for Receiver at 1180 ft (30 Hz)	
0.0197522 - 0.0000000 -0.0197522 - -0.0395044 -		
S-Wave Reference	for Receiver at 1190 ft (30 Hz)	
0.0199858 - 0.0000000 - -0.0199858 - -0.0399717 -	+\$0XXXXXXXXXXXX	
S-Wave Referenc	for Receiver at 1200 ft (30 Hz)	
0.0203949 - 0.0000000 -0.0203949 - -0.0203949 -		
S-Wave Reference	for Receiver at 1220 ft (30 Hz)	
0.0206101 - 0.0000000 - -0.0206101 - -0.0412203 -		
S-Wave Referenc	for Receiver at 1240 ft (30 Hz)	
0.0209475 0.0000000 -0.0209475 -0.0209475 -0.0418950	-\$0000000000000000000000000000000000000	
S-Wave Reference	for Receiver at 1260 ft (30 Hz)	
0.0423980 0.0212980 0.0000000 -0.0212980 -0.0212980 -0.0425961		
S-Wave Referenc	for Receiver at 1280 ft (30 Hz)	
0.0218075 0.0000000 -0.0218075 -0.0218075 -0.0436151		
S-Wave Referenc	for Receiver at 1300 ft (30 Hz)	
0.0220767 - 0.0000000 0.0220767 0.0220767		
0.00	0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.4	0
	Time (sec)	

S-Wave Reference for Receiver at 1120 ft (30 Hz)

Figure 9.9 Filtered S-Wave Signals of Reference Horizontal (In-Line) Receiver (C4993) Depths 1240 and 1260 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Low Pass 40 Hz; Short Arm Used



Section 10: Expanded and Filtered S-Wave Signals of Lower Rotated In-Line Receiver

- Figures 10.1 to 10.6 present expanded lower rotated in-line receiver (S-wave) signals in Borehole C4993, depths 370 to 990 ft; FFT low pass 60 Hz; input signal: 5 cycles of 50-Hz sine wave.
- Figures 10.7 to 10.8 present expanded lower rotated in-line receiver (S-wave) signals in Borehole C4993, depths 990 to 1300 ft; FFT low pass 40 Hz; input signal: 4 cycles of 30-Hz sine wave.
- Figure 10.9 present expanded lower rotated in-line receiver (S-wave) signals in Borehole C4993, when short-arm lower horizontal receiver was used at depths 1240 and 1260 ft; FFT low pass 40 Hz; input signal: 4 cycles of 30-Hz sine wave.

Figure 10.1 Expanded S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 370 to 475 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz

S-Wave Rotated In	nLine at 370 fl	50 Hz)	
0.0001517 -			
0.0000000			
-0.0003034			
S-Wave Rotated In	nLine at 380 fl	50 Hz)	
0.0000697 -			
0.0000000			
-0.0000697 E			
S-Wave Rotated In	nLine at 390 fl	50 Hz)	
0.0001205			
0.0000000			
-0.0000602 -			
-0.0001205 E	nlino at 400 fl	50 Hz)	
0.0003895			
0.0001947 -			
-0 0001947 -			20 20 20 20 20 20 20 20 20 20 20 20 20 2
-0.0003895			
S-Wave Rotated I	nLine at 410 fl	50 Hz)	
0.0001264 -			
	╞╼┾╼┾╼┾═		
-0.0002528			
S-Wave Rotated In	nLine at 420 fl	50 Hz)	
0.0000979			
0.0000000			
-0.0000979 F			
S-Wave Rotated In	nLine at 430 fl	50 Hz)	
0.0001002			
0.0000000			
-0.0001002 -			
S-Wave Rotated I	nl ine at 440 fl	50 Hz)	
0.0002179			
-0.0001090 -			
-0.0002179			
0.0001269	nLine at 450 f	50 HZ)	
0.0000634 -			
	╪╤┾╤┾╼	++++K X X X X X X X X X X X X X X X X X	
-0.0001269			
S-Wave Rotated In	nLine at 460 fl	50 Hz)	
0.0001149 -			
0.0000000			
-0.0001149 -			
S-Wave Rotated In	nLine at 470 fl	50 Hz)	
0.0002567			
0.00000000			
-0.0001284 -			YTT MATI
S-Wave Rotated I	nLine at 475 fl	50 Hz)	
0.0000557			
0.0000000			
-0.0000557 -		I I PM AAMMANYM	YMYYMYY
-0.0001115 E L L 0.10	0.15	0.20 0.25 0.30 0.35 0.4	40 045 050
0.10	0.10		0.00
		(inte (sec)	

CIAL tated Inline at 270 ft (EO LI-)
Figure 10.2 Expanded S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 480 to 540 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz

S-Wave R	otated InLir	ne at 480 ft	(50 Hz)						
0.0002220 0.0001110 0.0000000 -0.0001110 -0.0002220							XXXX	XXXX	
S-Wave R	otated InLin	ne at 485 ft	(50 Hz)						
0.0001730 0.0000865 0.0000000 -0.0000865				b					
-0.0001730			(50 11-)						
S-vvave R	otated InLir	1e at 490 ft	(50 HZ)						
0.0000819 0.0000000 -0.0000819 0.0001638			+++			$\mathcal{W}\mathcal{O}\mathcal{O}$			
S-Wave R	otated InLin	ne at 495 ft	(50 Hz)						
0.0001230 0.0000615 0.0000000					Marc			MM	Ma
-0.0000615				NUV	M III	YYVV	VVVVVV	MUM	
S-Wave R	otated InLir	ne at 500 ft	(50 Hz)						
0.0001484 0.0000742 0.0000000					MM			600	5
-0.0000742				PYY	VVVVV				
S-Wave R	otated InLin	ne at 505 ft	(50 Hz)						
0.0000775					Λ		Mas		
-0.0000775					V	TY	VMIII		
S-Wave R	otated InLin	ne at 510 ft	(50 Hz)						
0.0002014 0.0000000 -0.0002014								XXXX	×
-0.0004028					MANAN	VVVVV			
S-Wave R	otated InLir	ne at 515 ft	(50 Hz)				2		
0.0000786	-			-(x)	MAX		XXXX	XXX	0
-0.0001573				1 YV	NMMT				
S-Wave R	otated InLin	ne at 520 ft	(50 Hz)						
0.0000504	-							MA	XX
-0.0000504				XVV	I MYV	NYYY	WWWY	MYY	
S-Wave R	otated InLin	ne at 525 ft	(50 Hz)						
0.0000477 0.0000000			++++			Mhon	Mobbb	0.0	
-0.0000477				IXYYY	MWW	/VYFYY	MILL		
S-Wave R	otated InLir	ne at 530 ft	(50 Hz)						
0.0000041						1 h h l l l			
0.0000811 0.0000000 -0.0000811			+++++		XXXXX	XXXXXXX	X		
-0.0001623	otated InLin	ne at 540 ft	(50 Hz)						
S-vvave N									
0.0000332 0.0000000 -0.0000332		╺╞╍┢╼╞╾╪	┿┿┿┥		()		(K)}	K X	X
-0.0000665	<u>F I I I</u> 10	0.15	0.20	0.25		0.35		0.45	
0.	10	0.10	0.20	0.20	Time (sec)	0.00	0.10	0.70	0.00

S-Wave Rotated InLine at 480 ft (50 Hz)

Figure 10.3 Expanded S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 550 to 660 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz

S-vvave Rota	ted inLine	at 550 ft	(50 HZ)	
0.0000581				
0.0000000				
-0.0000581 -				
-0.0001162 <u>F</u>				
S-Wave Rota	ted InLine	at 560 ft	(50 Hz)	
0.0000993				
0.0000000				
-0.0000498 -				
-0.0000995 🗠				
S-Wave Rota	ted InLine	at 570 ft	(50 Hz)	
0.0000283				
0.0000000				
-0.0000283 -				
-0.0000567 L				
S-Wave Rota	ted InLine	at 580 ft	(50 Hz)	
0 0000544				
0.0000000				
-0.0000544 -				
-0.0001089				
S-Wave Rota	ted InLine	at 590 ft	(50 Hz)	
0.0001097				
0.0000000				
-0.0000548 -				
-0.0001097 -				
S-Wave Rota	ted InLine	at 600 ft	(50 Hz)	
0.0001280				
0.0000000				
-0.0000640 -				
-0.0001280 L		1010.0	(5011)	
S-Wave Rota	ted InLine	at 610 ft	(50 HZ)	
0.0000824 -				
0.0000000				
-0.0000824 -				
-0.0001648 L		-+ 000 8	(5011-)	
S-Wave Rota	ted inLine	at 620 π	(50 HZ)	
0.0001197				
0.0000000				
-0.0000599 -				
-0.0001197 E		-+ 020 8	(5011-)	
0.0001424	led inLine	at 650 ft		
0.0000712 -				
0.0000000				
-0.0000712 -				
-0.0001424 E	had Inline	at 640 #	(50 11-)	
S-Wave Rola	led inLine	at 640 ft		
0.0000178 -				
0.0000000		+++++		
-0.0000178 -				
S-Mave Rota	tod Inlino	at 650 ft	(50 Hz)	
O-Wave Rola		a. 050 n	(30112)	
0.0000206				

-0.0000413				
S-Wave Rota	ted InLine	at 660 ft	(50 Hz)	
0.0001284		1111		
0.0000642				
-0.0000642				
-0.0001284				
0.10	0	.15	0.20	0.25 0.30 0.35 0.40 0.45 0.50
				Time (sec)

S-Wave Rotated InLine at 550 ft (50 Hz)

Figure 10.4 Expanded S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 670 to 760 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz

0.0000728	nLine at 670	π (50 HZ)		and the second
0.0000364				
0.0000000	┶┿╅┿┷╸		+	
-0.0000364 -				*/////////////////////////////////////
-0.0000728 E	nline at 680	ft (50 Hz)		
O-Wave Notaled I				
0.0000368 -				
	╞╼╪╌╪╼┶╼	╈╪╈╪╤╡	>>>X	
-0.0000368 -				
S-Wave Rotated I	nl ine at 690	ft (50 Hz)		
0-Wave Rotated I				
0.0000427 -				
	╪╪╪╤┿	╈╍╪╍╪╍╪╍╪╍	>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>	
-0.0000427 F				
S-Wave Rotated I	nLine at 700	ft (50 Hz)		
0.0000267 -				
			1	
-0.0000534				
S-Wave Rotated I	nLine at 710	ft (50 Hz)		
			1 1 1 1	
-0.0000399				
S-Wave Rotated In	nLine at 718	ft (50 Hz)		
0 0000494	TITT	TITT		
-0.0000484 -				
-0.0000968				
S-Wave Rotated In	nLine at 727	ft (50 Hz)		
0.0000680				
0.0000000			Lob	
-0.0000340 -			TTY	
-0.0000680				
S-Wave Rotated II	nLine at 732	π (50 HZ)		
0.0000818 -				
0.0000000		┿┿┿╼┾╼┿╾	++++	
-0.0000818 -				
	nline at 737	# /EO LI-)		
0.0001262	Incline at 757			
0.0000631 -				
0.0000000	╆╍╪╍╪╼╪╼	╪╪╪╤╪╼╪═	5-6-4-C	
-0.0000631 -				
S-Wave Rotated I	nl ine at 742	ft (50 Hz)		
			1 1 1 1	
0.0000656 -				
-0.0001311				
S-Wave Rotated In	nLine at 748	ft (50 Hz)		
0.0001225	1111	$\overline{1}$	1111	
-0.0000612 -			TTP	
-0.0001225				
S-Wave Rotated In	nLine at 760	ft (50 Hz)		
0.0000863				
0.0000000				
-0.0000431 -				
-0.0000863				
0.10	0.15	0.20	0.25	0.30 0.35 0.40 0.45 0.50
				Time (sec)

S-Wave Rotated InLine at 670 ft (50 Hz)

Figure 10.5 Expanded S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 770 to 870 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz

0.0000511	otated InLi				
0.0000255					
0.0000000					
-0.0000233					
S-Wave R	otated InLi	ne at 780 f	ft (50 Hz)		
0.0000178					
0.0000089					
-0.0000089					
-0.0000178					
0.0000128	otated InLI	ne at 790 t	t (50 Hz)		
0.0000064	-				
0.0000000		┝╪╪╤	┾╍┾╍┾╍┾╍╞	┝┲╞╼┾╼╡	
-0.0000064					
S-Wave R	otated InLi	ne at 800 f	ft (50 Hz)		
0.0000400			$\overline{1}$		
0.0000199					
-0.0000199	-				
-0.0000397					
0.0001479	otated InLI	ne at 810 i	τ (50 HZ)		
0.0000739	-				
0.0000000					
-0.0000739					
S-Wave R	otated InLi	ne at 820 f	ft (50 Hz)		
0.0000444			$\overline{1}$		
0.0000222					
-0.0000222	-				
-0.0000444					
0 0000797	otated InLI	ne at 830 i	τ (50 HZ)		
0.0000398					
0.0000000			++++	┝╼╪╼╪╼┿	
-0.0000398					
S-Wave R	otated InLi	ne at 840 f	ft (50 Hz)		
0.0000151					
0.0000000					
-0.0000151	-				
-0.0000301	otatod InLi	a at 945 f	9 /50 U->)		
0.0000774					
0.0000387					
-0.0000000					
-0.0000774					
S-Wave R	otated InLi	ne at 853 f	ft (50 Hz)		
0.0001017					
0.0000000					
-0.0000509	-				
S-Wave R	otated InLi	ne at 860 f	ft (50 Hz)		
O-Wave IV					
0.0000393	-				
-0.00000393	-				
-0.0000786					
S-Wave R	otated InLi	ne at 870 f	ft (50 Hz)		
0.0000421	_				
0.0000000			┢┝╞┝╞┝	╞┿╪┿╡	
-0.0000211					
-0.0000421	.10	0.15	0.20	0.25	0.30 0.35 0.40 0.45 0.50
					Time (sec)

S-Wave Rotated InLine at 770 ft (50 Hz)

Figure 10.6 Expanded S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 880 to 990 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Low Pass 60 Hz

0.0000146 0.0000073							Shhh		JA-M		
-0.0000073	-					PAX	XX	pxxx	MAY	MXXX	
S-Wave R	otated I	nLine at	890 ft (50 l	Hz)			<u> </u>		1 1 1 01 0		
0.0000447	-						x ~~/	haar	ALAA	AAAAA	
0.0000000 -0.0000224 -0.0000447							SXX	XXV	(VVV)	MM	X A
S-Wave R	otated I	nLine at	900 ft (50 l	Hz)							
0.0000483 0.0000000 -0.0000483										XXXX	Qđ
-0.0000966	otated	nl ine at	910 ft (50 l					11YV	VVVV	Í	
0.0000357							7				
0.00000000					+++		XXX	X74	XXX	XXXXX	
S-Wave R	otated I	nLine at	917 ft (50 l	Hz)							
0.0001151	-						T A	AAAA			
-0.0000000							- AN	XXXI	(XIXXIX	WWW	XX
-0.0001151 S-Wave R	otated I	nLine at	927 ft (50 l	Hz)				1-1-9-0	ANAA		
0.0000190	FIT							よんへへ			
0.0000000	- + +							WXX,	XXXXX	XXXXXX	XX
-0.0000381 S-Wave R	otated I	nLine at	935 ft (50 l	Hz)	i l i				YVYY		
0.0000192 0.0000096	-						T /			Adda.	
0.0000000						H	- AX	MI	XXX	XXXXXX	XXq
-0.0000192 S-Wave R	otated I	nLine at	940 ft (50 l	Hz)	1 1 1						
0.0000119	FIT						Y (ANAA	MAAA	
0.00000000								XXXX	XXXX	XXXXXX	XXG
-0.0000239 S-Wave R	otated I	nLine at	950 ft (50 l	Hz)					MANAC		
0.0000103	-						V	AAA	MAAA	MALL	-
0.00000000					+-+-+-			XXXX	XXXX	IXIXIXXX	XX
-0.0000206 S-Wave R	otated I	nLine at	960 ft (50 l	Hz)					VYYY		
0.0000306								Lhh			
0.0000000								(XXX)	XXXX	K K K XX	XX
-0.0000306 S-Wave R	otated I	nLine at	970 ft (50 l	Hz)							
0.0000056	ETT							Mach			MA
0.0000000							$\propto \chi$			MXXX	XX
-0.0000056	otated I	nl ine at	980 ft (50 l	└\\ ⊣ z)			δ	MIII			I V A
0.0000191											
0.0000000		***			┿┿┿═			$\phi \alpha \chi$	XXXX	XXXXXX	XX
-0.0000191		nl ino at	990 f /50 l						YYYY	ΙΨΨΨΨΥ	
0.0000034							3				
0.0000000000000000000000000000000000000		-			*			XXXXX	xxxx	XXX XX	XXA
-0.0000042 0.	<u>ні</u> 10	0.15	0.	<u>сі і і</u> 20	0.25	0.30	<u>کا ا</u> ا ا).35	0.40	0.45	0.50
						Time (se	ec)				

S-Wave Rotated InLine at 880 ft (50 Hz)

Figure 10.7 Expanded S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 990 to 1110 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Low Pass 40 Hz

S-Wave Rotated InLine at 990 ft (30 Hz)
S-Wave Rotated InLine at 1000 ft (30 Hz)
S-Wave Rotated InLine at 1010 ft (30 Hz)
S-Wave Rotated InLine at 1020 ft (30 Hz)
0.0000099
S-Wave Rotated InLine at 1070 ft (30 Hz)
S-Wave Rotated InLine at 1080 ft (30 Hz)
S-Wave Rotated InLine at 1090 ft (30 Hz)
S-Wave Rotated InLine at 1095 ft (30 Hz)
S-Wave Rotated InLine at 1100 ft (30 Hz)
S-Wave Rotated InLine at 1110 ft (30 Hz)
0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60
i Ime (sec)

S-Wave Rotated InLine at 990 ft (30 Hz)

Figure 10.8 Expanded S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 990 to 1110 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Low Pass 40 Hz

-0.0000028
S-Wave Rotated InLine at 1140 ft (30 Hz)
S-Wave Rotated InLine at 1150 ft (30 Hz)
S-VVave Rotated InLine at 1160 ft (30 Hz)
0.0000000 -0.0000006 -0.0000006 -0.00000131 -0.00000131
S-Wave Rotated InLine at 1190 ft (30 Hz)
S-Wave Rotated InLine at 1200 ft (30 Hz)
S-Wave Rotated InLine at 1220 ft (30 Hz)
S-Wave Rotated InLine at 1240 ft (30 Hz)
0 0000010
Time (sec)

S-Wave Rotated InLine at 1120 ft (30 Hz)

Figure 10.9 Expanded S-Wave Signals of Lower Rotated In-Line Receiver (C4993) Depths 1240 and 1260 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Low Pass 40 Hz; Short Arm Used



147

Section 11: Waterfall Plots of Unfiltered S-Wave Signals of Lower Rotated In-Line Receiver

- Figures 11.1 to 11.3 present waterfall plots of unfiltered lower rotated in-line receiver (S-wave) signals in Borehole C4993, depths 370 to 990 ft; input signal is 5 cycles of 50-Hz sine wave, time shifted by the acceleration of the reaction mass.
- Figure 11.4 presents waterfall plots of unfiltered lower rotated horizontal receiver (S-wave) signals in Borehole C4993, depths 990 to 1300 ft; input signal is 4 cycles of 30-Hz sine wave, time shifted by the acceleration of the reaction mass.



Figure 11.1 Waterfall Plot of Unfiltered S-Wave Signals of Rotated In-Line Receiver (C4993) Depths 370 to 540 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Time Shifted by Reaction Mass Acceleration



Figure 11.2 Waterfall Plot of Unfiltered S-Wave Signals of Rotated In-Line Receiver (C4993) Depths 550 to 760 ft; Input Signal: 5 Cycles of 50-Hz Sine Wave; Time Shifted by Reaction Mass Acceleration







Figure 11.4 Waterfall Plot of Unfiltered S-Wave Signals of Rotated In-Line Receiver (C4993) Depths 990 to 1300 ft; Input Signal: 4 Cycles of 30-Hz Sine Wave; Time Shifted by Reaction Mass Acceleration

Section 12: Waterfall Plots of Filtered S-Wave Signals of Lower Rotated In-Line Receiver

- Figures 12.1 to 12.3 present waterfall plots of filtered lower rotated horizontal receiver (S-wave) signals in Borehole C4993, depths 370 to 990 ft; input signal is 5 cycles of 50-Hz sine wave; time shifted by reaction mass acceleration, low pass 60 Hz; depth scaled.
- Figure 12.4 presents a waterfall plot of filtered lower rotated horizontal receiver (S-wave) signals in Borehole C4993, depths 990 to 1300 ft; input signal is 4 cycles of 30-Hz sine wave; time shifted by reaction mass acceleration; low pass 40 Hz; depth scaled.



Figure 12.1 Waterfall Plot of Filtered S-Wave Signals of Rotated In-Line Receiver (C4993) is 370 to 660 ft; Input Signal: 50-Hz Sine Wave; Low Pass 60 Hz; Time Shifted by Reaction Mass Acceleration; Depth S













Section 13 References

- Barnett, D.B., K.R. Fecht, S.P. Reidel, B.N. Bjornstad, D.C. Lanigan and C.F. Rust. 2007. "Geology of the Waste Treatment Plant Seismic Boreholes". PNNL-16407, Rev. 1. Pacific Northwest National Laboratory, Richland, Washington.
- Gardner, M.G. and R.K. Price. 2007. "Summary Report of Geophysical Logging for the Seismic Boreholes Project at the Hanford Site Waste Treatment Plant". DTS-RPT-090 / PNNL-16395. EnergySolutions and Pacific Northwest Geophysics, Richland, Washington.
- 3. Redpath, B.B. 2007. "Downhole Measurements of Shear- and Compression-Wave Velocities in Boreholes C4993, C4997, C4997 and C4998 at the Waste Treatment Plant DOE Hanford Site". PNNL-16559. Redpath Geophysics, Murphys, California.
- Stokoe, K.H., II, Rathje, E.M., Wilson, C. and Rosenblad, B., 2004. "Development of Large-Scale Mobile Shakers and Associated Instrumentation for In Situ Evaluation of Nonlinear Characteristics and Liquefaction Resistance of Soils," 13th World Conference on Earthquake Engineering, Vancouver, B.C. Canada, August 1-6.
- Rohay, A.C. and T.M. Brouns. 2007. "Site-Specific Velocity and Density Model for the Waste Treatment Plant, Hanford, Washington". PNNL-16652. Pacific Northwest National Laboratory, Richland, Washington.