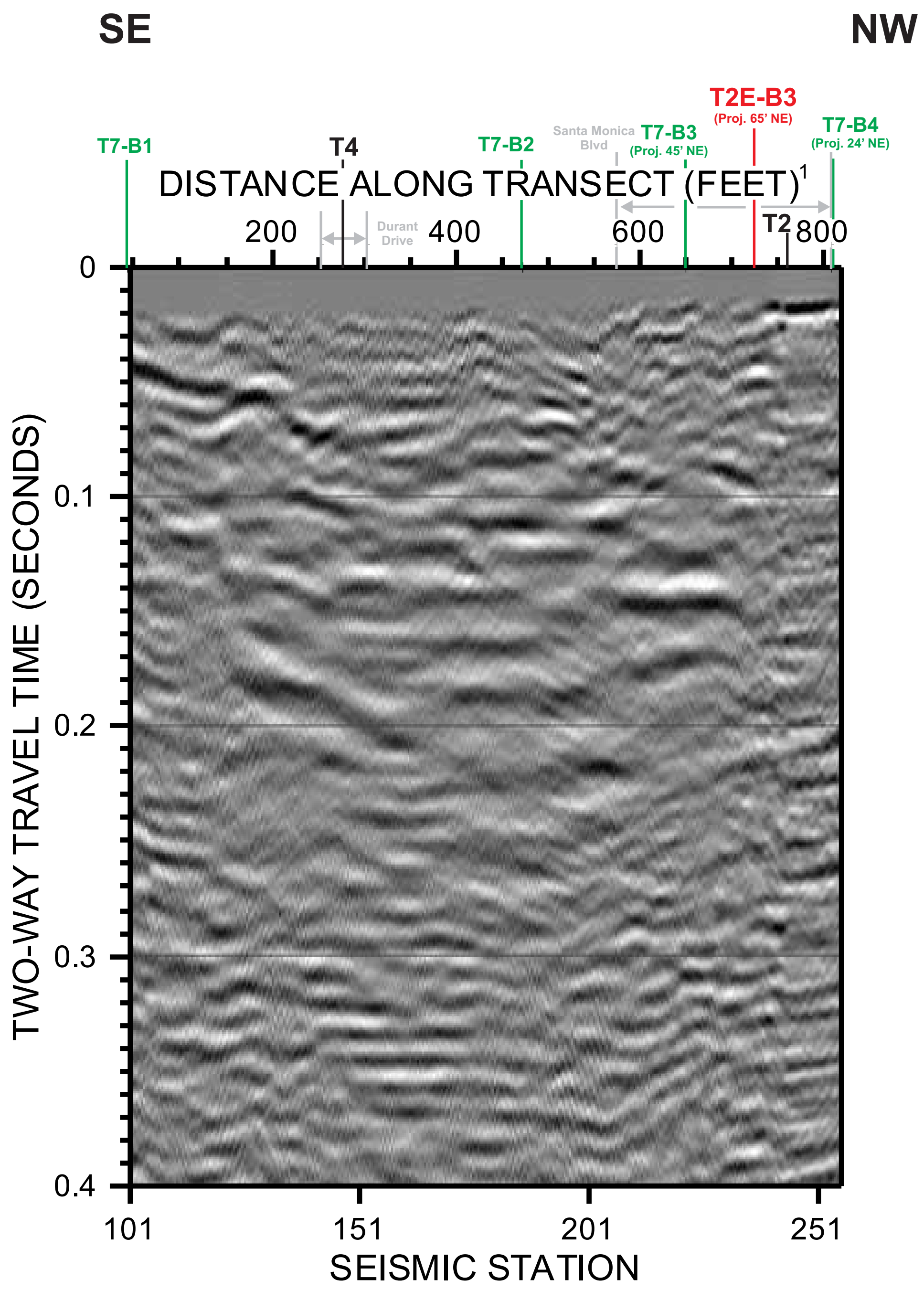
5.6 Transect 7

The location of the Transect 7 P- and S-wave seismic profile, which was acquired along South Moreno Drive, is shown on Figure 1. Unmigrated and migrated P-wave seismic sections for Transect 7, with post stack processing, are presented as Figures 39 and 40, respectively. The interpreted P-wave seismic section for Transect 7 is presented as Figure 41. Unmigrated and migrated S-wave seismic sections for Transect 7 are presented as Figures 42 and 43, respectively and the interpreted S-wave seismic section is presented as Figure 44.

Borehole T2E-B3 is located near this transect and is discussed in Section 5.3.

Both the P- and S-wave seismic sections for Transect 7 (Figures 41 and 44) exhibit poor reflectivity. This line was conducted along South Moreno Drive where there is a large diameter box culvert. Although the seismic line was offset from the box culvert, the box culvert and other subsurface utilities may have degraded the seismic data. Additionally, this seismic line is located subparallel to a possible wide fault zone interpreted on Transects 2 and 4, which may have further degraded data quality. Interpretation is limited to identification of anomalous zones that could be associated with possible faults identified in borehole data. As is often the case with seismic reflection data exhibiting poor reflectivity, multiple interpretations of fault-like structures are possible and many more possible structures could have been identified on the seismic sections.



LEGEND

T2E-B3 (Proj. 65' NE) P-S Logging Borehole Location

T7-B4 (Proj. 24' NE) Borehole Location

T4 Line Intersection

Santa Monica Blvd Street Intersection

Note:
1. Distances approximately tied to the geologic cross section where coincident with the seismic line. See report for details.

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FIGURE 39
TRANSECT 7 - P-WAVE SEISMIC SECTION
WITHOUT INTERPRETATION

MTA-WESTSIDE EXTENSION
MORENO DRIVE
LOS ANGELES, CALIFORNIA

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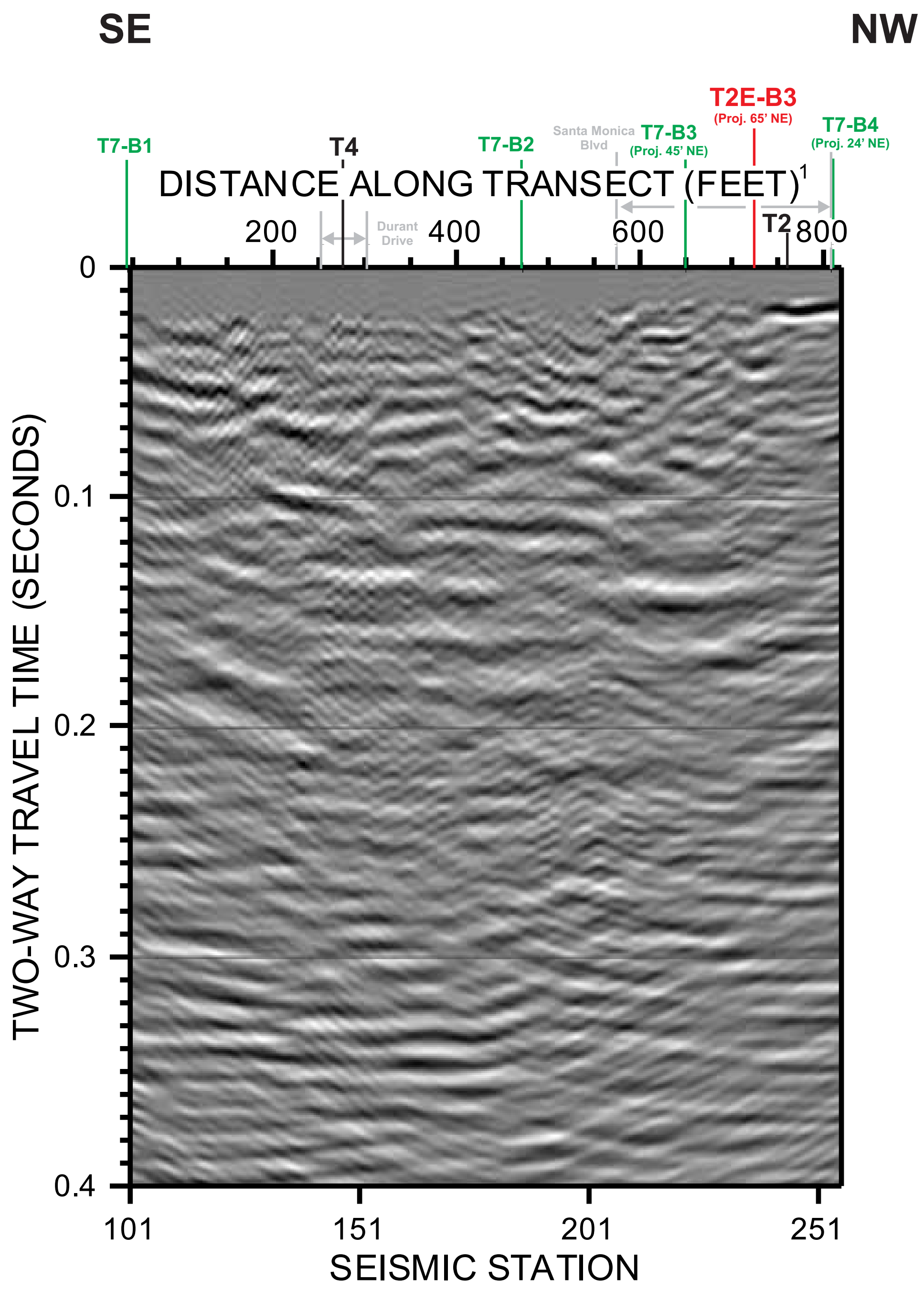
AMEC ENVIRONMENT & INFRASTRUCTURE



LEGEND

T2E-B3 (Proj. 65' NE) P-S Logging Borehole Location

T7-B4 (Proj. 24' NE) Borehole Location

T4 Line Intersection

Santa Monica Blvd Street Intersection

Note:
1. Distances approximately tied to the geologic cross section where coincident with the seismic line. See report for details.

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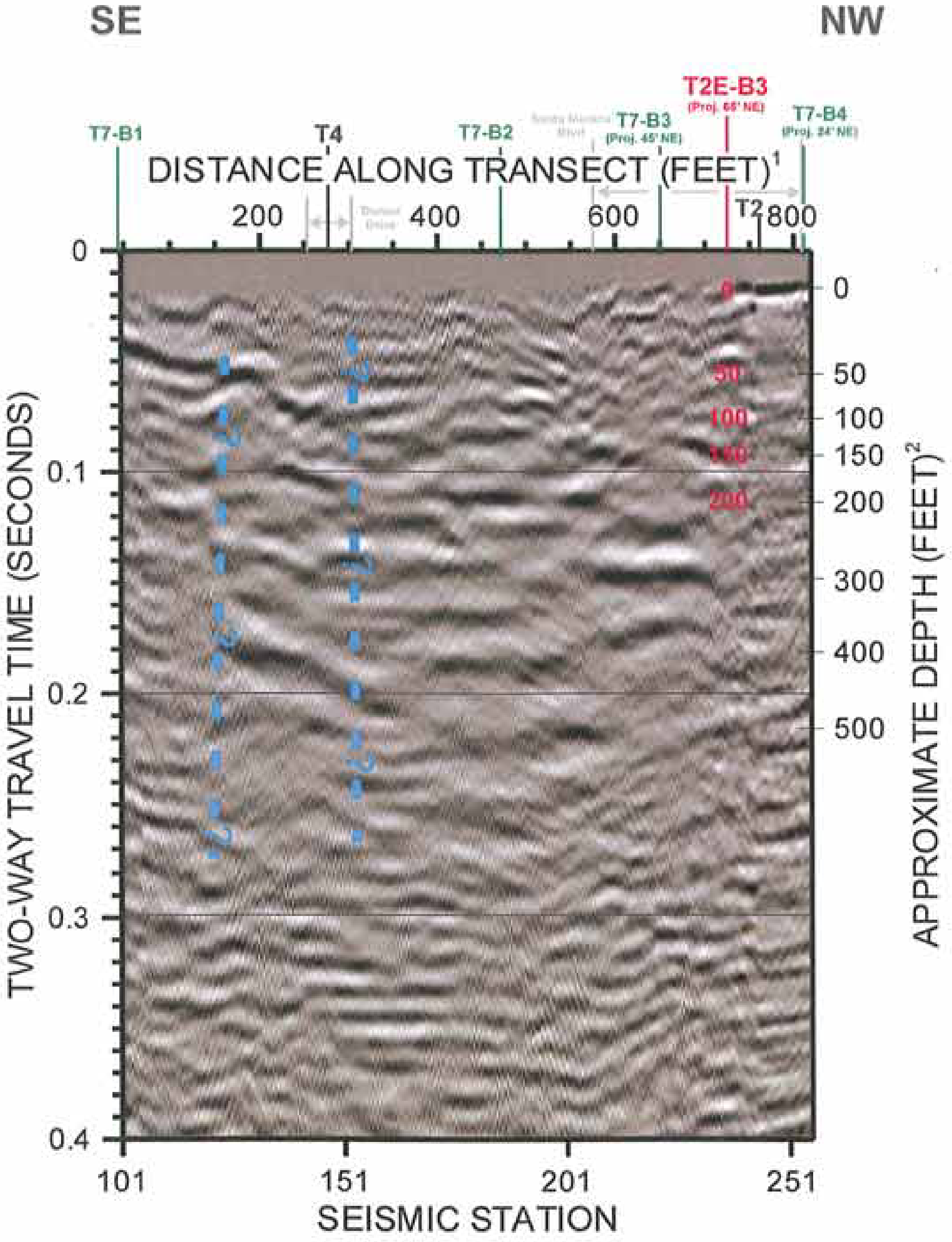
FIGURE 40
TRANSECT 7 - P-WAVE MIGRATED SEISMIC
SECTION WITHOUT INTERPRETATION

MTA-WESTSIDE EXTENSION
MORENO DRIVE
LOS ANGELES, CALIFORNIA

PREPARED FOR
AMEC ENVIRONMENT & INFRASTRUCTURE

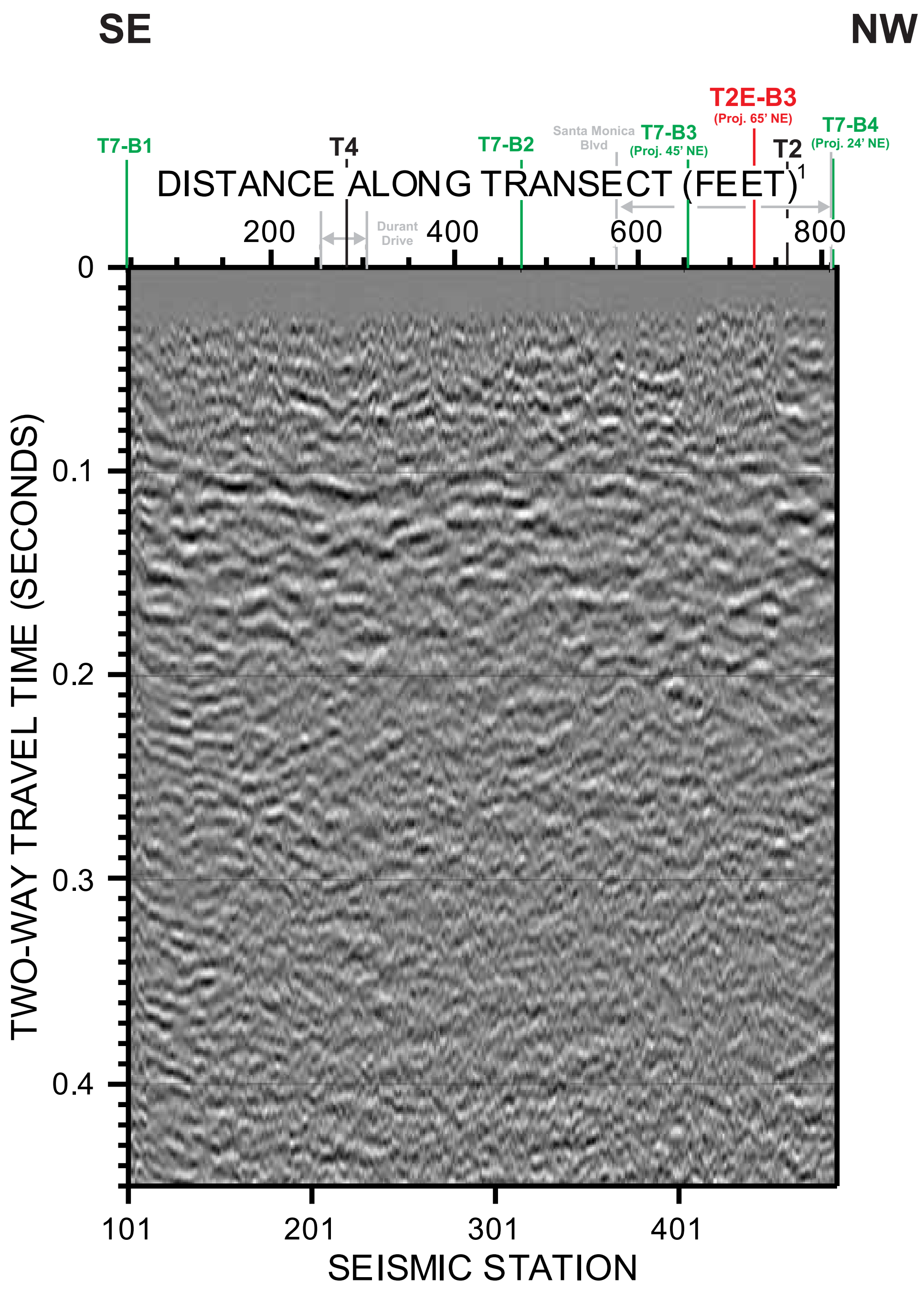


LEGEND

T2E-B3 (Proj. 65' NE)	P-S Logging Borehole Location and Estimated Depths
T7-B4 (Proj. 24' NE)	Borehole Location
T4	Line Intersection
Santa Monica Blvd	Street Intersection
▬ ▬ ?	Possible Fault Identified on Geologic Cross Section but Inconclusive on Seismic Section

Note:
1. Distances approximately tied to the geologic cross section where coincident with the seismic line. See report for details.
2. Depths are approximate and may vary by 20%.

GEOVision geophysical services	FIGURE 41 TRANSECT 7 - P-WAVE SEISMIC SECTION WITH INTERPRETATION
Project # 10500	MTA-WESTSIDE EXTENSION MORENO DRIVE LOS ANGELES, CALIFORNIA
Date: rev OC 14, 2011	
Drawn By: DALRYMPLE	
Approved By: Antony J Martin	PREPARED FOR AMEC ENVIRONMENT & INFRASTRUCTURE
File C:\GVPROJECTS\10500\F41.cdr	



LEGEND

T2E-B3 (Proj. 65' NE) P-S Logging Borehole Location

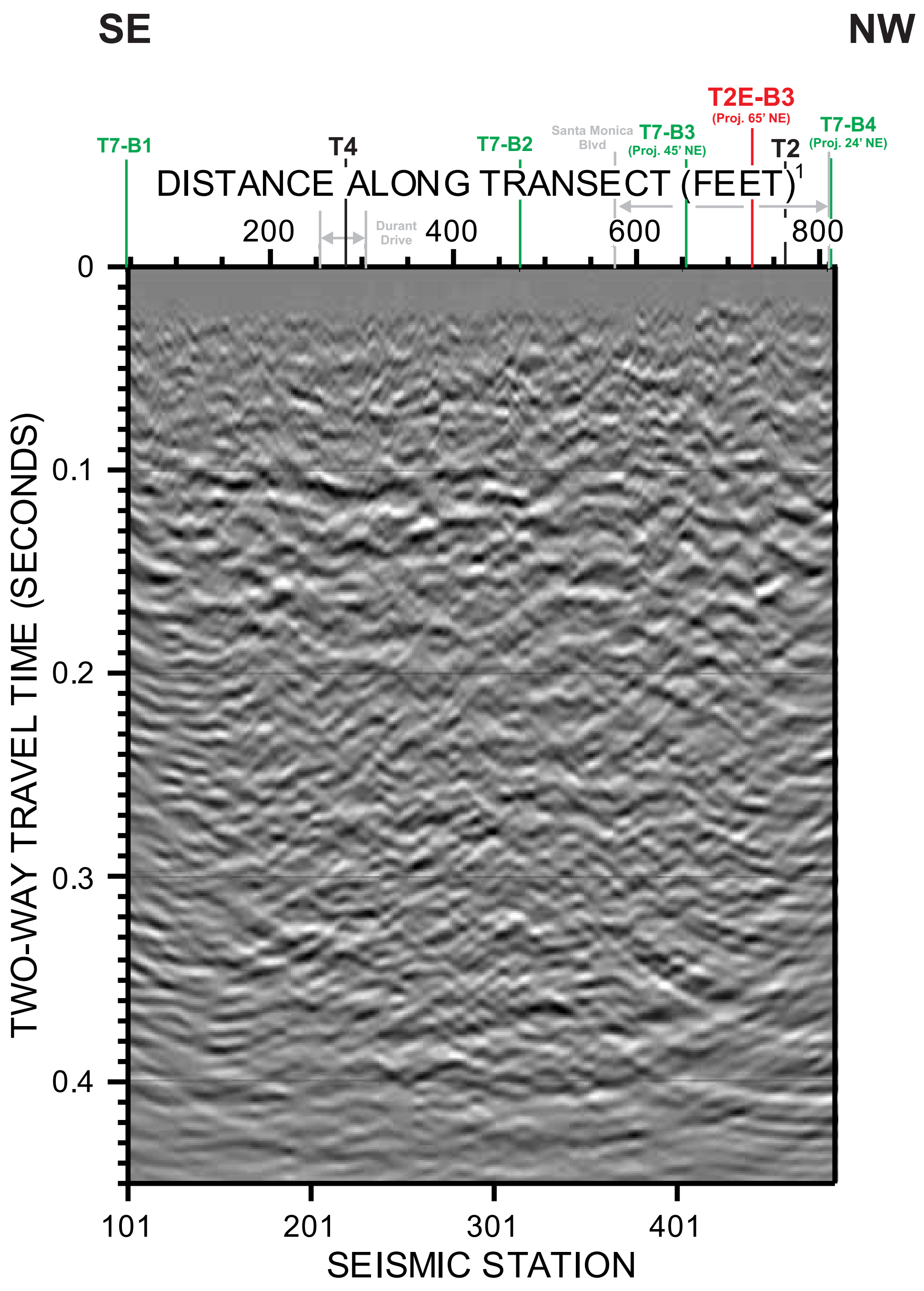
T7-B4 (Proj. 24' NE) Borehole Location

T4 Line Intersection

Santa Monica Blvd Street Intersection

Note:
1. Distances approximately tied to the geologic cross section where coincident with the seismic line. See report for details.

GEOVision geophysical services	FIGURE 42 TRANSECT 7 - S-WAVE SEISMIC SECTION WITHOUT INTERPRETATION
Project # 10500 Date: SEPT 15, 2011	MTA-WESTSIDE EXTENSION MORENO DRIVE LOS ANGELES, CALIFORNIA
Drawn By: DALRYMPLE Approved By: Antony J Martin File C:\GVPROJECTS\10500\F42.cdr	PREPARED FOR AMEC ENVIRONMENT & INFRASTRUCTURE



LEGEND

T2E-B3 (Proj. 65' NE) — P-S Logging Borehole Location

T7-B4 (Proj. 24' NE) — Borehole Location

T4 — Line Intersection

Santa Monica Blvd — Street Intersection

Note:
1. Distances approximately tied to the geologic cross section where coincident with the seismic line. See report for details.

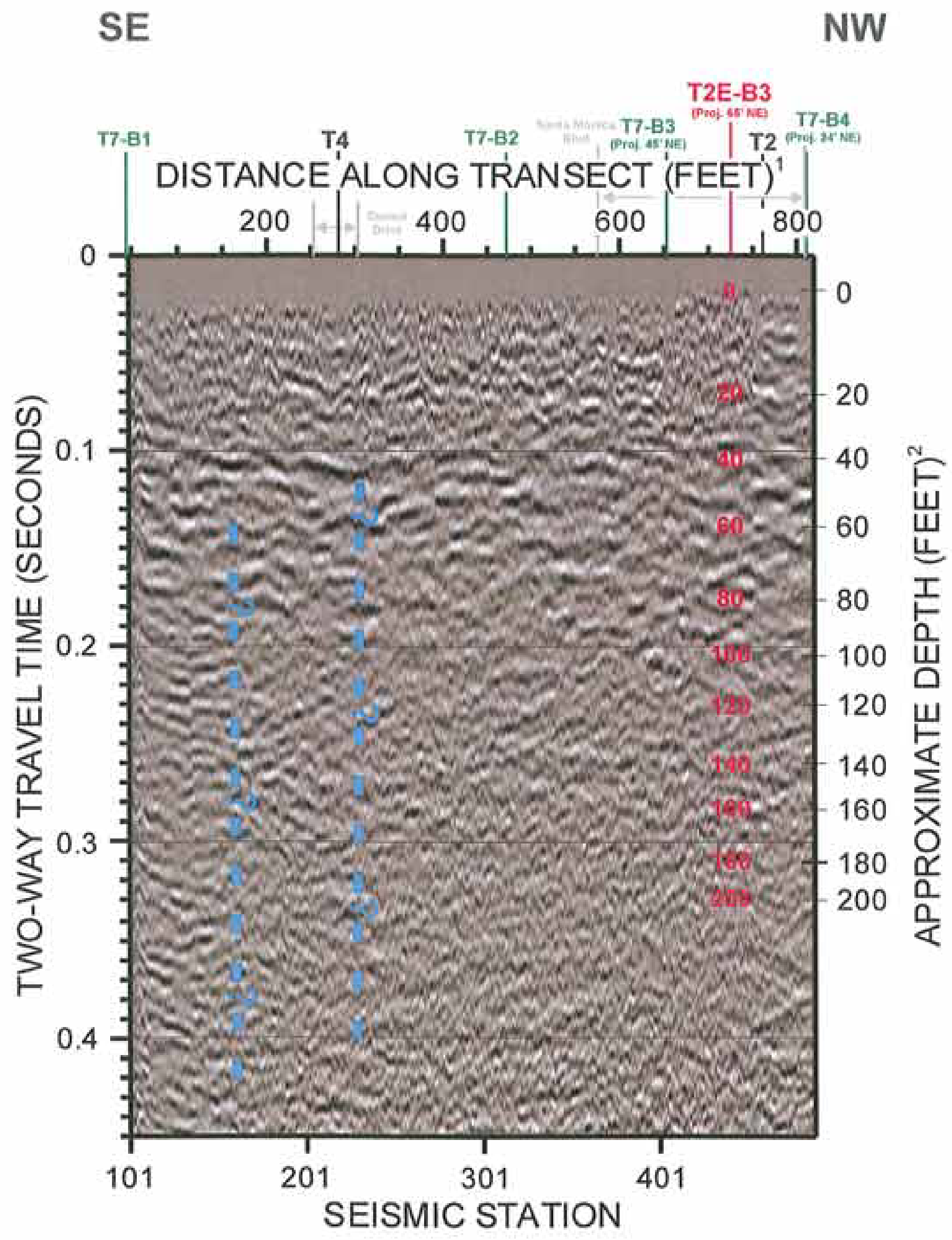
GEOVision geophysical services

FIGURE 43
TRANSECT 7 - S-WAVE MIGRATED SEISMIC
SECTION WITHOUT INTERPRETATION

Project # 10500
Date: SEPT 15, 2011
Drawn By: DALRYMPLE
Approved By: Antony J Martin
File C:\GVPROJECTS\10500\F43.cdr

MTA-WESTSIDE EXTENSION
MORENO DRIVE
LOS ANGELES, CALIFORNIA

PREPARED FOR
AMEC ENVIRONMENT & INFRASTRUCTURE



LEGEND

T2E-B3 (Proj. 65' NE) — P-S Logging Borehole Location and Estimated Depths

T7-B4 (Proj. 24' NE) — Borehole Location

T4 — Line Intersection

Santa Monica Blvd — Street Intersection

▬ ▬ ? — Possible Fault Identified on Geologic Cross Section but Inconclusive on Seismic Section

Note:
1. Distances approximately tied to the geologic cross section where coincident with the seismic line. See report for details.
2. Depths are approximate and may vary by 20%.

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Project # 10500
Date: rev OCT 14, 2011
Drawn By: DALRYMPLE
Approved By:
File C:\GVPROJECTS\10500\F44.cdr

FIGURE 44
TRANSECT 7 - S-WAVE SEISMIC SECTION
WITH INTERPRETATION

MTA-WESTSIDE EXTENSION
MORENO DRIVE
LOS ANGELES, CALIFORNIA

PREPARED FOR
AMEC ENVIRONMENT & INFRASTRUCTURE

6 SUMMARY

A high-resolution seismic reflection survey was conducted in the vicinity of a portion of the proposed MTA-Westside Extension along or near Santa Monica Blvd in Los Angeles County, California, to map the location of the north strand of the Santa Monica Fault and associated faulting. This investigation supplements a previous investigation conducted in 2010 and summarized in **GEO***Vision*, 2010.

P- and S-wave seismic reflection data were acquired along five (5) profiles (Transect 1, 2, 3, 4 and 7) as shown in Figure 1 totaling about 8,400 linear feet. Transects 1 and 2 intersect and are located along Avenue of the Stars and Santa Monica Blvd., respectively. Transect 3 is located along Century Park West and is effectively the southward extension of the 2010 Line 1. Transects 4 and 7 intersect and are located along Durant Drive and South Moreno Drive, respectively.

The P-wave seismic reflection survey was designed to image to a depth on the order of 500 ft. The S-wave reflection survey was designed to image to shallower depth than possible with the P-wave technique and obtain better vertical resolution, particularly in shallow saturated sediments where P-wave velocity increases to over 5,000 ft/s, but S-wave velocity remains relatively unchanged. Generally, P-wave data quality was significantly better than S-wave data quality for a number of reasons, as follows: the larger energy source used for P-wave acquisition was better able to overcome noise from vehicle traffic in the site vicinity, shallow geologic conditions in some areas may not be conducive to imaging with the S-wave reflection technique (i.e. absence of continuous geologic layers with significant change in S-wave velocity and/or density), the smaller wavelength (high frequency) S-wave energy appears to be more significantly impacted by subsurface infrastructure, and lateral velocity variation may be more significant in the S-wave data as the shallow saturated zone beneath many of the lines tends to lower lateral velocity variation in the P-wave data. Additionally, saturated sediments efficiently transmit P-wave energy and transitions from saturated to unsaturated sediment layers at depth may give rise to strong P-wave reflections, thereby, improving reflectivity in the P-wave seismic sections. One exception is Transect 4, where both P- and S-wave seismic sections exhibit excellent reflectivity with the S-wave seismic section offering both shallower imaging and improved vertical resolution.

Approximate depth scales were added to the seismic sections for reference. These depth scales were developed from P- and S-wave velocity logs of one or two boreholes on or near the seismic lines. If multiple velocity logs were made on a seismic line, the depth scales were averaged. These depth scales should be considered a depth guide rather than exact depth as they do not account for lateral velocity variation and are only valid in close proximity to the borehole that was logged. As an example, the average S-wave velocity of the upper 100 ft varies by 28% for the 5 borehole logs. Therefore, the depth scales should be assumed to vary by 10 to 20% along each seismic line. Approximate depths on the P-wave sections were extrapolated to a depth of 500 ft by assuming that P-wave velocity was 6,000 ft/s below the bottom of each borehole, an additional source of error. Where useful, synthetic seismograms were generated from the velocity logs to facilitate correlation of geologic horizons with seismic reflectors. Synthetic seismograms for the P-wave velocity logs of boreholes T2-B4 and T2E-B3 (Figures 16 and 17) clearly show a relationship between a high amplitude reflector in the 0.08 to 0.12 s range on many of the seismic sections and a layer(s) of unsaturated sand between saturated sediment units at a depth on the order of 180 ft.

Interpreted P-wave seismic sections for Transects 1 to 4 and 7 are presented as Figures 10, 18, 25, 35 and 41, respectively. The interpreted P-wave seismic section for the 2010 Line 1, the northward extension of Transect 3, is also included as Figure 31. Interpreted S-wave seismic sections for Transects 1 to 4 and 7 are presented as Figures 13, 21, 28, 38 and 44, respectively. A distance scale, approximately tied to the AMEC geologic cross-sections has been added to the seismic sections for spatial reference. Where the seismic lines are relatively coincident with the cross sections locations, the relative positions should be within about 5 ft. Where the seismic line and geologic cross-section locations diverge, the relative positions on the cross-sections differ from the seismic lines (up to 40 ft in associated portion of Transect 1 and 10 ft on Transect 4). The projected locations of boreholes have also been added to the seismic lines for spatial reference.

Interpretation of the seismic reflection data were generally limited to the identification of discontinuities caused by offset geologic layers or termination of geologic units that could be tracked through the seismic section and, thereby, possibly associated with faulting.

On the Transect 1 P-wave seismic section (Figure 10), several anomalous zones that could be associated with faulting are identified at approximate relative positions of: 500; 925; 1,050; 1,290; 1,450 and 1,700 ft, with the most significant structures located at 1,290 to 1,700 ft. Borehole and CPT data, acquired and interpreted by AMEC, support potential faulting near the structures identified at 1,290 to 1,700 ft. Independent interpretation was not made of the S-wave seismic section (Figure 13) due to inadequate reflectivity. However, structures identified on the P-wave seismic section were transferred to the S-wave seismic section, which indicates that the potential faulting is plausible, but not conclusive. Two additional shallow dipping potential faults, depicting a possible zone of faulting identified in borehole and CPT data, are shown on the P-wave and S-wave seismic sections for reference. Because these structures are located near the northwest end of the seismic line and have shallow dip, they cannot be confirmed on the P-wave seismic section. Faulting in this area is plausible based on the S-wave seismic section, but cannot be confirmed due to poor reflectivity.

The most significant structure on the P-wave seismic section for Transect 2 (Figure 18) is a possible wide zone of faulting between a position of about 1,850 and 2,400 ft. Interpretation of the fault-like structures is primarily based on minor disruptions and termination of reflectors in the 0.08 to 0.2 second range on the P-wave section and is supported by borehole and CPT data. Due to poor reflectivity, the S-wave seismic section (Figure 21) neither support nor refute potential faulting in this portion of the seismic line. One other potential fault-like structure is identified on the seismic line at a relative position of about 350 ft, based on an apparent pull down of a high amplitude reflector at 0.11 s. The orientation of this possible structure cannot be accurately determined from the seismic data. Continuous reflectors between 0.1 and 0.2 s indicates that faulting is not present beneath other portions of the seismic line.

The most significant structure identified in the P-wave reflection data acquired along Transect 3 (Figure 25) is a significant groundwater barrier at a relative position of about 1,000 ft, which was initially identified directly from seismic refraction data on seismic records. This groundwater barrier was previously identified at an approximate position of 1,010 ft on the 2010 Line 1, which is located on the opposite side of Century Park West and is the northward extension of Transect 3. This groundwater barrier is believed to be formed by a fault as approximately depicted on the P- and S-wave seismic sections for Transect 3 (Figures 25 and 28) and the P-wave seismic section for the 2010 Line 1 (Figure 31). Another potential fault-like structure is identified on the P- and S-wave seismic sections at a position of about 290 ft, but does not pass through the subhorizontal S-wave reflection events in the 0.05 to 0.1 s range (approximate 15 to 50 ft depth range). Between a relative position of about 500 and 800 ft, there are several other disruptions in a prominent P-wave reflection at about 0.07 s that may also correspond to disruptions in S-wave reflections. However, reflectivity is not sufficient on the seismic sections to make conclusive statements regarding faulting in this part of the line without borehole evidence. Two other possible fault-like structures are identified at positions of about 1,200 and 1,400 ft on the P-wave seismic section for the 2010 Line 1, based on disruptions in reflectors between 0.07 and 0.11 s.

The P- and S-wave seismic sections for Transect 4 have excellent reflectivity, which permitted interpretation of potential fault-like structures common to both data sets. Multiple possible fault-like structures are interpreted over a wide zone between about 125 and 500 ft on the seismic sections (Figures 35 and 38). The fault-like structures were interpreted based on disruptions, termination or changes in dip of reflectors. Alternate geologic explanations may be possible for some, but not all, of the anomalous zones. Faulting over this portion of the seismic line is also supported by borehole and CPT data acquired and interpreted by AMEC.

The P- and S-wave seismic sections for Transect 7 (Figures 41 and 44) exhibit very poor reflectivity, likely because of subsurface infrastructure in the street and because the seismic line is located subparallel to the potential fault zone indentified on Transect 2 and 4. Interpretation of the Transect 7 seismic sections was limited to identification of anomalous zones that could be associated with possible faults identified in borehole data.

Alternate interpretations of the P- and S-wave seismic sections are possible and review of the data by professionals with extensive knowledge of the Santa Monica Fault system and future geologic investigations may lead to revision of the interpretation.

7 REFERENCES

Dobrin, M.S., and Savit, J., 1988, Introduction to Geophysical Prospecting, McGraw-Hill Co., New York.

GEO*Vision*, Inc., 2010, Draft Report, “High Resolution Seismic Survey, LA Metro Westside Subway Extension Project”, Los Angeles, California, report 9464, May 10, 2010.

GEO*Vision*, Inc., 2011, “Westside Extension Borings T1-B6, T2-B4, T2E-B3, T3-B3, and T4-B5 Suspension Velocities”, Report 11021-01, July 26, 2011

Telford, W. M., Geldart, L.P., Sheriff, R.E., 1990, Applied Geophysics, Second Edition, Cambridge University Press.

8 CERTIFICATION

All geophysical data, analysis, interpretations, conclusions, and recommendations in this document have been prepared under the supervision of and reviewed by a **GEO*Vision*** California Professional Geophysicist.

Antony J Martin

October 14, 2011

Antony J. Martin Date
California Professional Geophysicist GP989
GEO*Vision* Geophysical Services

* This geophysical investigation was conducted under the supervision of a California Professional Geophysicist using industry standard methods and equipment. A high degree of professionalism was maintained during all aspects of the project from the field investigation and data acquisition, through data processing interpretation and reporting. All original field data files, field notes and observations, and other pertinent information are maintained in the project files and are available for the client to review for a period of at least one year.

A professional geophysicist's certification of interpreted geophysical conditions comprises a declaration of his/her professional judgment. It does not constitute a warranty or guarantee, expressed or implied, nor does it relieve any other party of its responsibility to abide by contract documents, applicable codes, standards, regulations or ordinances.

WEST SIDE EXTENSION
BORINGS T1-B6, T2-B4, T2E-B3,
T3-B3 AND T4-B5
SUSPENSION PS VELOCITIES

Report 11021-01 Rev 0

July 26, 2011

WEST SIDE EXTENSION
BORINGS T1-B6, T2-B4, T2E-B3, T3-B3 AND T4-B5
SUSPENSION PS VELOCITIES

Report 11021-01 Rev 0

July 26, 2011

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APPENDIX A **SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS**

APPENDIX B **GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION RECORDS**

INTRODUCTION

Boring geophysical measurements were collected in five uncased borings located along the proposed alignment of the West Side Extension, in Los Angeles, California. Geophysical data acquisition was performed between January 27 and June 30, 2011 by Charles Carter and Robert Steller of **GEO***Vision*. Data analysis and report preparation was performed by Robert Steller and reviewed by John Diehl of **GEO***Vision*. The work was performed for AMEC, with Rosalind Munro as the point of contact for AMEC.

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

SCOPE OF WORK

This report presents the results of suspension PS velocity measurements collected between January 27 and June 30, 2011, in five uncased borings, as detailed below. The purpose of these studies was to supplement stratigraphic information obtained during AMEC's soil and rock sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING	DATES LOGGED	ELEVATION	COORDINATES (1)	
			NORTHING	EASTING
T1-B6	4/18/2011	278	1,845,353	6,434,752
T2-B4	6/28/2011	NA	1,844,976	6,434,928
T2E-B3	6/30/2011	NA	1,845,941	6,436,124
T3-B3	4/13/2011	279	1,843,648	6,434,394
T4-B5	1/27/2011	260	1,845,828	6,436,695

(1) Coordinates supplied by AMEC. CA State Plane, NAD83, Zone V (0405) US Survey Feet

Table 1 Boring locations and logging dates

The OYO Suspension PS Logging System (Suspension System) was used to obtain in-situ horizontal shear (S_H) and compressional (P) wave velocity measurements at 1.6 foot intervals. Measurements followed **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.5. The acquired data was analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

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

> Guidelines for Determining Design Basis Ground Motions, Report T1-B602293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension Instrumentation

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

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 21 feet, with the center point of the receiver pair 12.5 feet above the bottom end of the probe.

The probe receives control signals from, and sends the digitized receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

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

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 7.0-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In faster soils or rock, the isolation cylinder is extended to allow greater separation of the P- and S_H-wave signals.
4. In saturated soils, the received P-wave signal is typically of much higher frequency than the received S_H-wave signal, permitting additional separation of the two signals by low pass filtering.
5. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the

dimension of the fluid annulus surrounding the probe (meter versus centimeter scale), preventing significant energy transmission through the fluid medium.

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

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

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

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

MEASUREMENT PROCEDURES

Suspension Measurement Procedures

The borings were logged uncased, while filled with bentonite based drilling mud. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.5. The suspension probe was positioned with the mid-point of the receivers at grade level, and the electronic depth counter was set to zero. The probe was lowered to the bottom of the boring, stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

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

Upon completion of the measurements, the probe zero depth indication at the surface was verified prior to removal from the boring.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	OPEN HOLE (FEET)	DEPTH TO BOTTOM OF CASING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
T1-B6	SUSPENSION 1	3.3 – 139.4	151.9	NONE	1.6	4/18/2011
T2-B4	SUSPENSION 1	1.6 – 182.1	194.6	NONE	1.6	6/28/2011
T2E-B3	SUSPENSION 1	3.3 – 197.2	209.7	NONE	1.6	6/30/2011
T3-B3	SUSPENSION 1	6.6 – 136.2	148.7	NONE	1.6	4/13/2011
T4-B5	SUSPENSION 1	3.3 – 136.2	148.7	NONE	1.6	1/27/2011

Table 2. Logging dates and depth ranges

DATA ANALYSIS

Suspension Analysis

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

The P-wave velocity over the 7.0-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 5.2 feet to correspond to the mid-point of the 7.0-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.3 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

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

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

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 7.0-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 5.2 feet to correspond to the mid-point of the 7.0-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.3 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact. These data and analysis were reviewed by John Diehl as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

RESULTS

Suspension Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4 through 8. The suspension velocity data presented in these figures are presented in Tables 3 through 7. These plots and data are included in the EXCEL analysis files accompanying this report.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-5 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 7.0 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-5, and included in the EXCEL analysis file for the boring.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in a partially cased fluid filled boring, drilled with rotary mud (rotary wash) methods. These borings were ideal for collection of suspension PS velocity data.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show excellent correlation between R1 – R2 and S – R1 data, as well as good correlation between P-wave and S_H-wave velocities, except at transitions between saturated and unsaturated formations. P- and S_H-wave onsets are clear, and later oscillations are well damped. P-wave velocities in the bottom of borings T2-B4, T2E-B3 and T3-B3 drop below water velocity (5000 ft/sec), even though they appear to be below static water table, indicating the presence of perched water tables.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. Individual measurements are very reliable with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of these data.

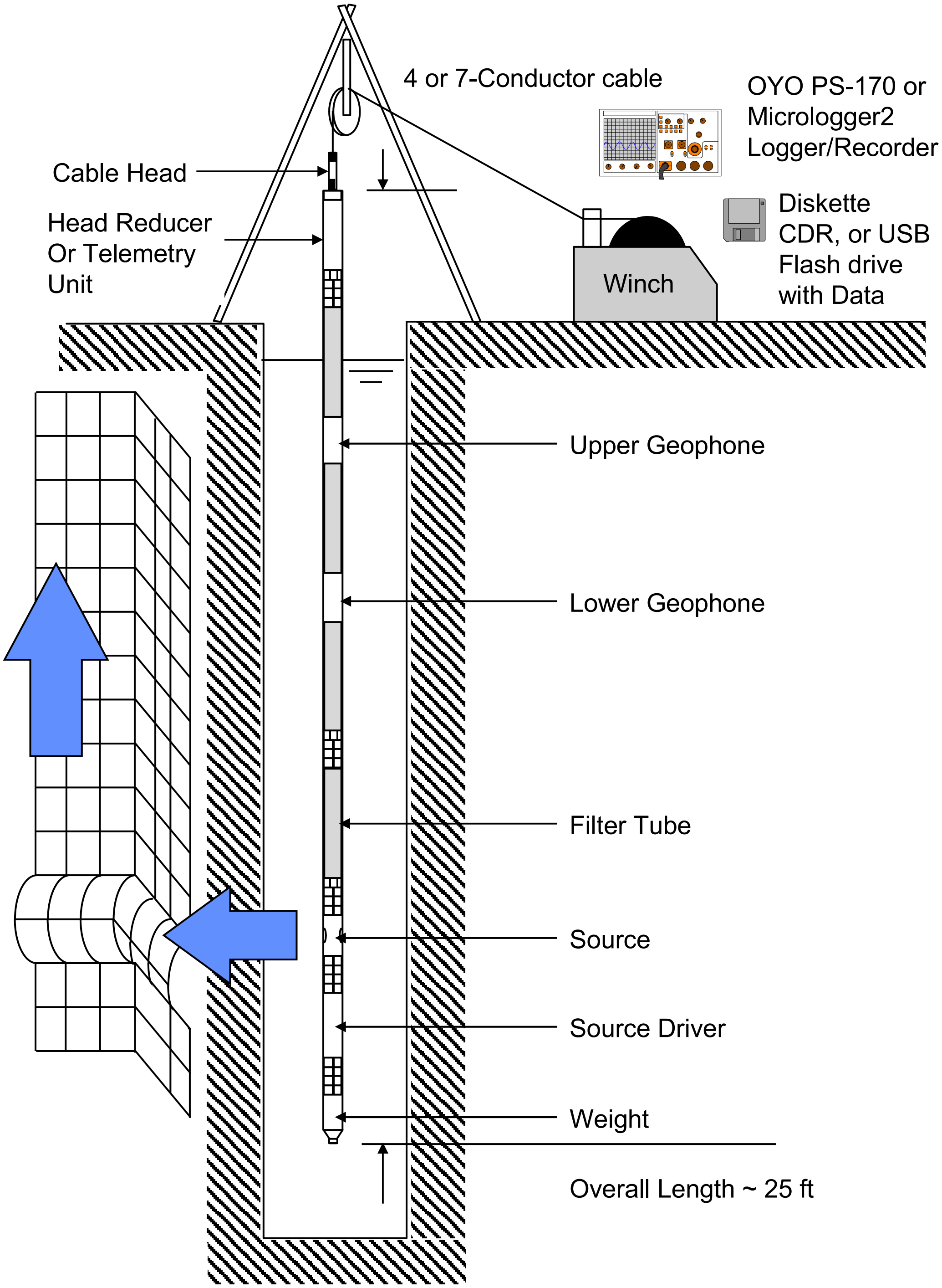

Figure 1: Concept illustration of P-S logging system

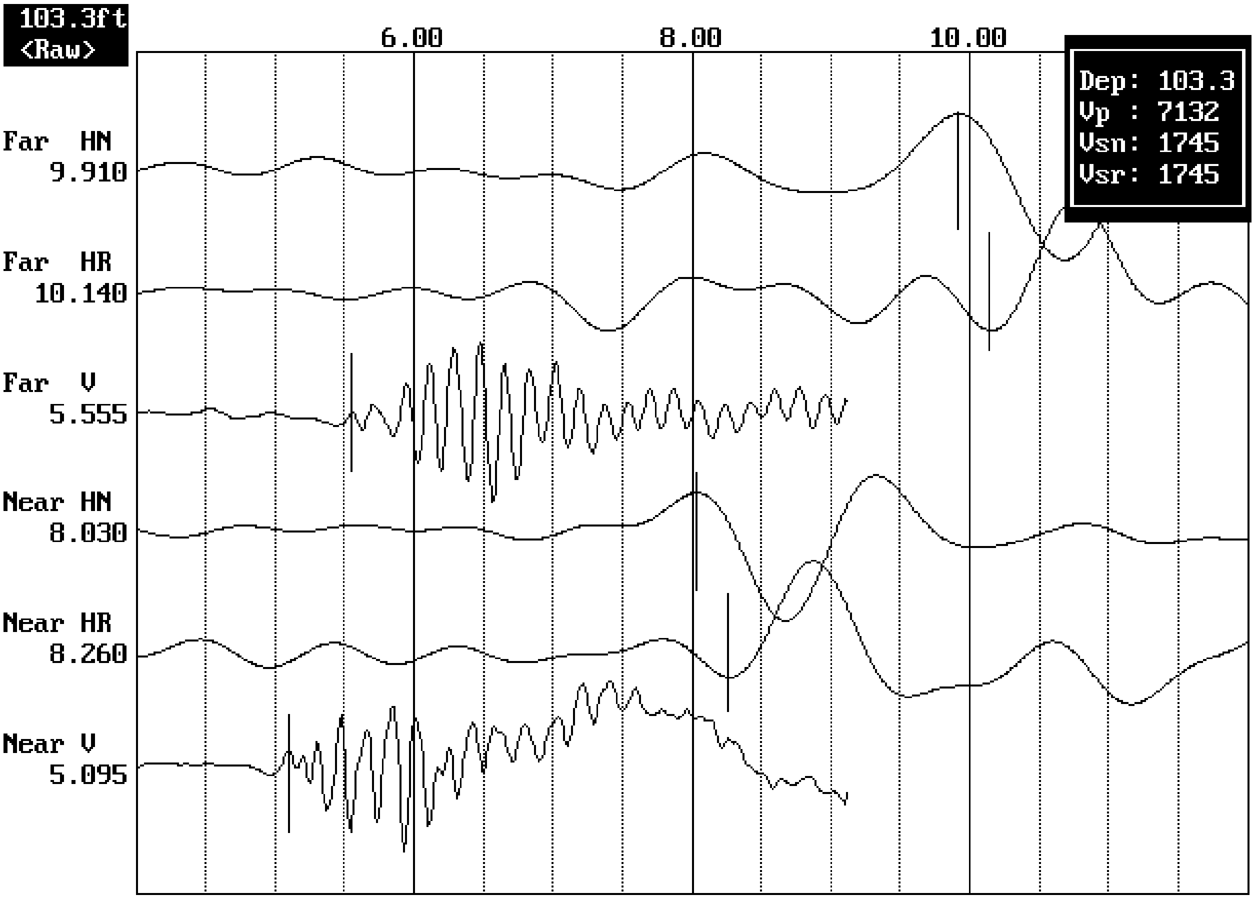

Figure 2: Example of filtered (1400 Hz lowpass) record

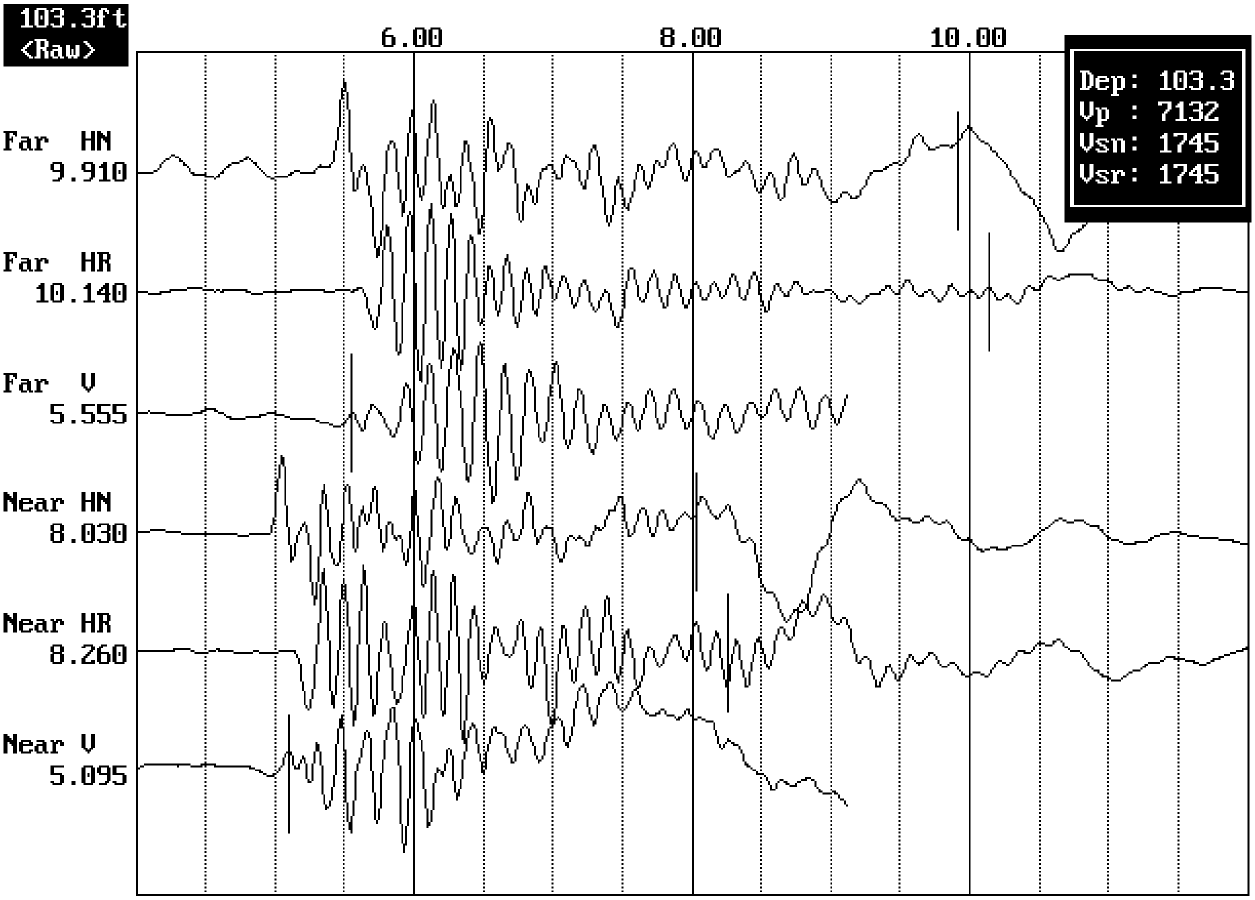

Figure 3. Example of unfiltered record

WSE BOREHOLE T1-B6
Receiver to Receiver V_s and V_p Analysis

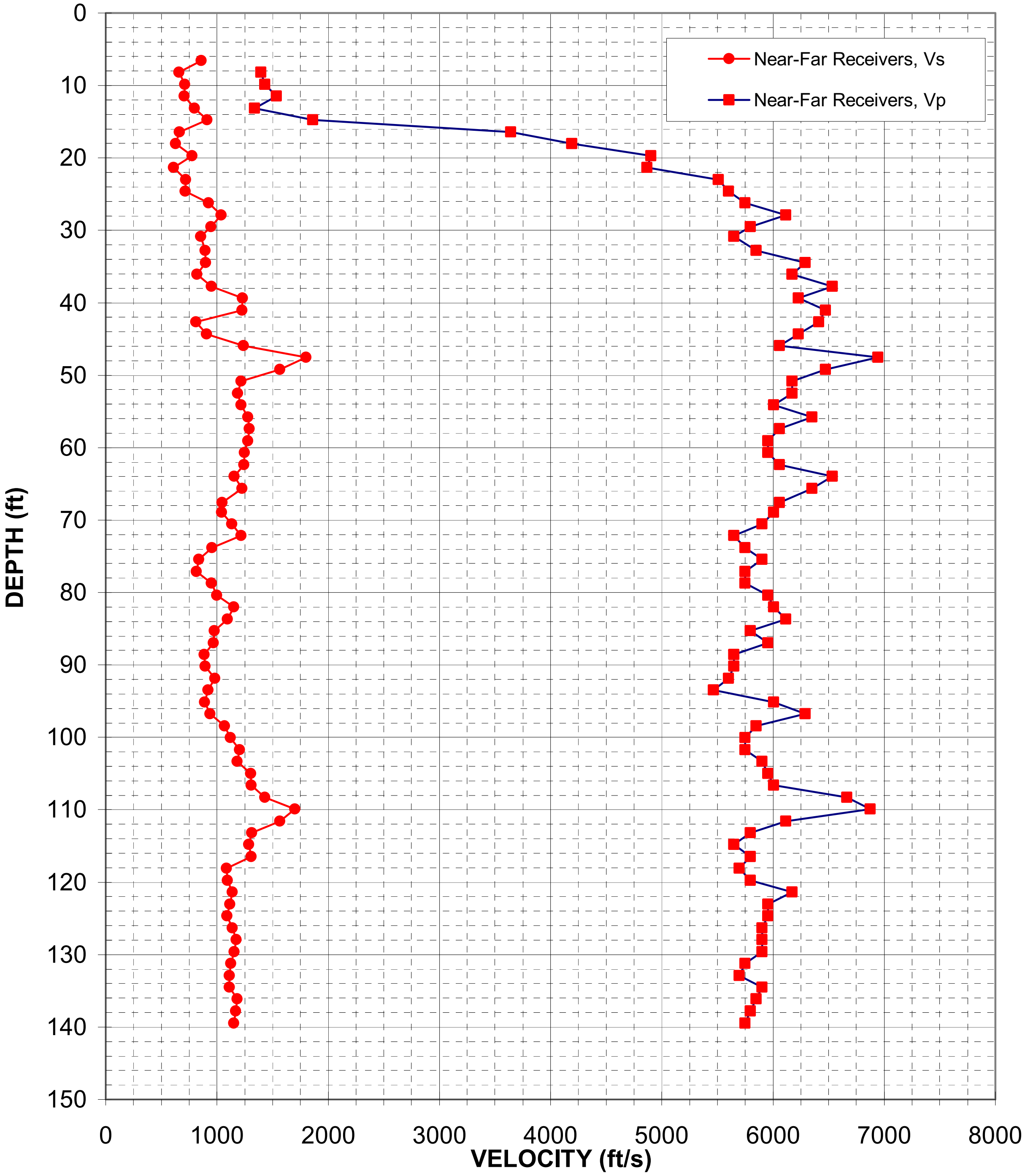

Figure 4: Boring T1-B6, Suspension R1-R2 P- and S_H-wave velocities

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
3.3	-	-
4.9	-	-
6.6	860	-
8.2	660	1390
9.8	710	1430
11.5	710	1540
13.1	800	1340
14.8	910	1860
16.4	660	3640
18.0	630	4190
19.7	780	4900
21.3	610	4870
23.0	720	5510
24.6	720	5600
26.3	930	5750
27.9	1040	6120
29.5	950	5800
30.8	860	5650
32.8	890	5850
34.5	900	6290
36.1	820	6170
37.7	950	6540
39.4	1230	6230
41.0	1230	6470
42.7	810	6410
44.3	910	6230
45.9	1240	6060
47.6	1800	6940
49.2	1560	6470
50.9	1220	6170
52.5	1190	6170
54.1	1220	6010
55.8	1280	6350
57.4	1290	6060
59.1	1280	5950
60.7	1250	5950
62.3	1240	6060
64.0	1160	6540
65.6	1230	6350
67.6	1040	6060
68.9	1040	6010
70.5	1130	5900
72.2	1220	5650
73.8	960	5750
75.5	840	5900
77.1	820	5750
78.7	950	5750
80.4	1000	5950
82.0	1150	6010
83.7	1100	6120
85.3	980	5800
86.9	970	5950
88.6	890	5650
90.2	890	5650
91.9	980	5600
93.5	920	5460
95.1	890	6010
96.8	940	6290
98.4	1070	5850
100.1	1120	5750
101.7	1200	5750
103.4	1180	5900
105.0	1300	5950
106.6	1310	6010
108.3	1430	6670
109.9	1700	6870
111.6	1560	6120
113.2	1310	5800
114.8	1290	5650
116.5	1310	5800
118.1	1090	5700
119.8	1090	5800
121.4	1140	6170
123.0	1120	5950
124.7	1090	5950
126.3	1140	5900
128.0	1170	5900
129.6	1160	5900
131.2	1130	5750
132.9	1110	5700
134.5	1110	5900
136.2	1180	5850
137.8	1170	5800
139.4	1150	5750

Table 3. Boring T1-B6, Suspension R1-R2 depths and P- and S_H-wave velocities

WSE BOREHOLE T2-B4
Receiver to Receiver V_s and V_p Analysis

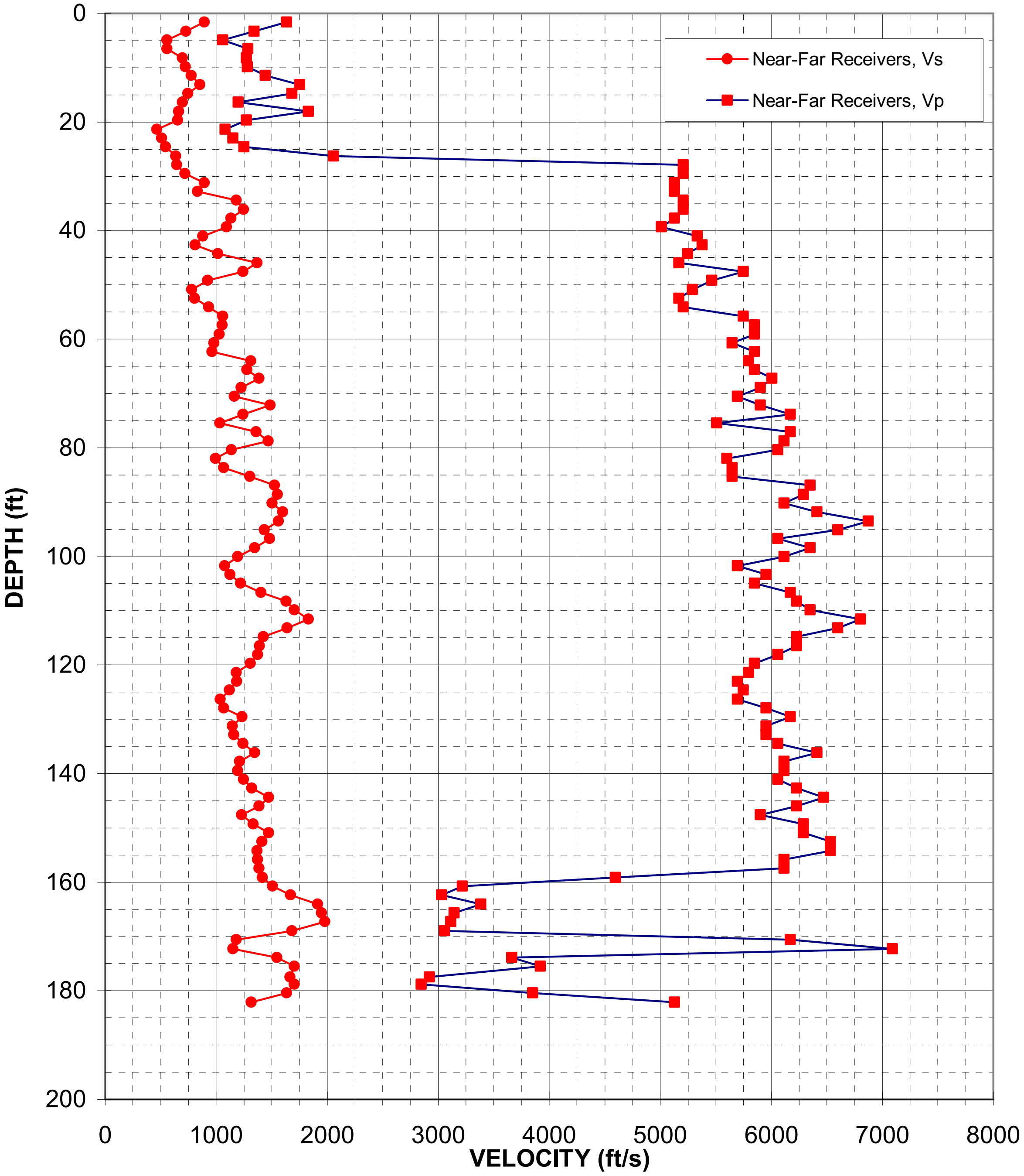

Figure 5: Boring T2-B4, Suspension R1-R2 P- and S_H-wave velocities

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
1.6	890	1630
3.3	730	1340
4.9	560	1060
6.6	560	1290
8.2	700	1270
9.8	720	1280
11.5	780	1440
13.1	850	1750
14.8	740	1680
16.4	700	1200
18.0	660	1830
19.7	650	1270
21.3	460	1080
23.0	510	1150
24.6	550	1250
26.3	640	2060
27.9	650	5210
29.5	720	5210
31.2	900	5130
32.8	830	5130
34.5	1180	5210
36.1	1250	5210
37.7	1130	5130
39.4	1100	5010
41.0	880	5330
42.7	810	5380
44.3	1020	5250
45.9	1370	5170
47.6	1240	5750
49.2	930	5460
50.9	780	5290
52.5	810	5170
54.1	930	5210
55.8	1060	5750
57.4	1050	5850
59.1	1030	5850
60.7	980	5650
62.3	960	5850
64.0	1310	5800
65.6	1280	5850
67.3	1390	6010
68.9	1230	5900
70.5	1170	5700
72.2	1490	5900
73.8	1240	6170
75.5	1030	5510
77.1	1360	6170
78.7	1470	6120
80.4	1140	6060
82.0	1000	5600
83.7	1070	5650
85.3	1300	5650
86.9	1530	6350
88.6	1550	6290
90.2	1500	6120
91.9	1600	6410
93.5	1560	6870
95.1	1430	6600
96.8	1480	6060
98.4	1350	6350
100.1	1200	6120
101.7	1080	5700
103.4	1130	5950
105.0	1220	5850
106.6	1400	6170
108.3	1630	6230
109.9	1710	6350
111.6	1830	6800
113.2	1640	6600
114.8	1420	6230
116.5	1390	6230
118.1	1370	6060
119.8	1310	5850
121.4	1180	5800
123.0	1190	5700
124.7	1120	5750
126.3	1040	5700
128.0	1070	5950
129.6	1230	6170
131.2	1150	5950
132.9	1160	5950
134.5	1240	6060
136.2	1350	6410
137.8	1210	6120
139.4	1190	6120
141.1	1250	6060
142.7	1320	6230
144.4	1470	6470
146.0	1390	6230
147.6	1230	5900
149.3	1340	6290
150.9	1470	6290
152.6	1420	6540
154.2	1370	6540
155.8	1370	6120
157.5	1390	6120
159.1	1420	4600
160.8	1510	3220
162.4	1670	3030
164.0	1920	3380
165.7	1950	3140
167.3	1980	3120
169.0	1680	3060
170.6	1180	6170
172.2	1150	7090
173.9	1550	3660
175.5	1710	3920
177.5	1670	2920
178.8	1710	2850
180.5	1630	3850
182.1	1320	5130

Table 4. Boring T2-B4, Suspension R1-R2 depths and P- and S_H-wave velocities

WSE BOREHOLE T2E-B3
Receiver to Receiver V_s and V_p Analysis

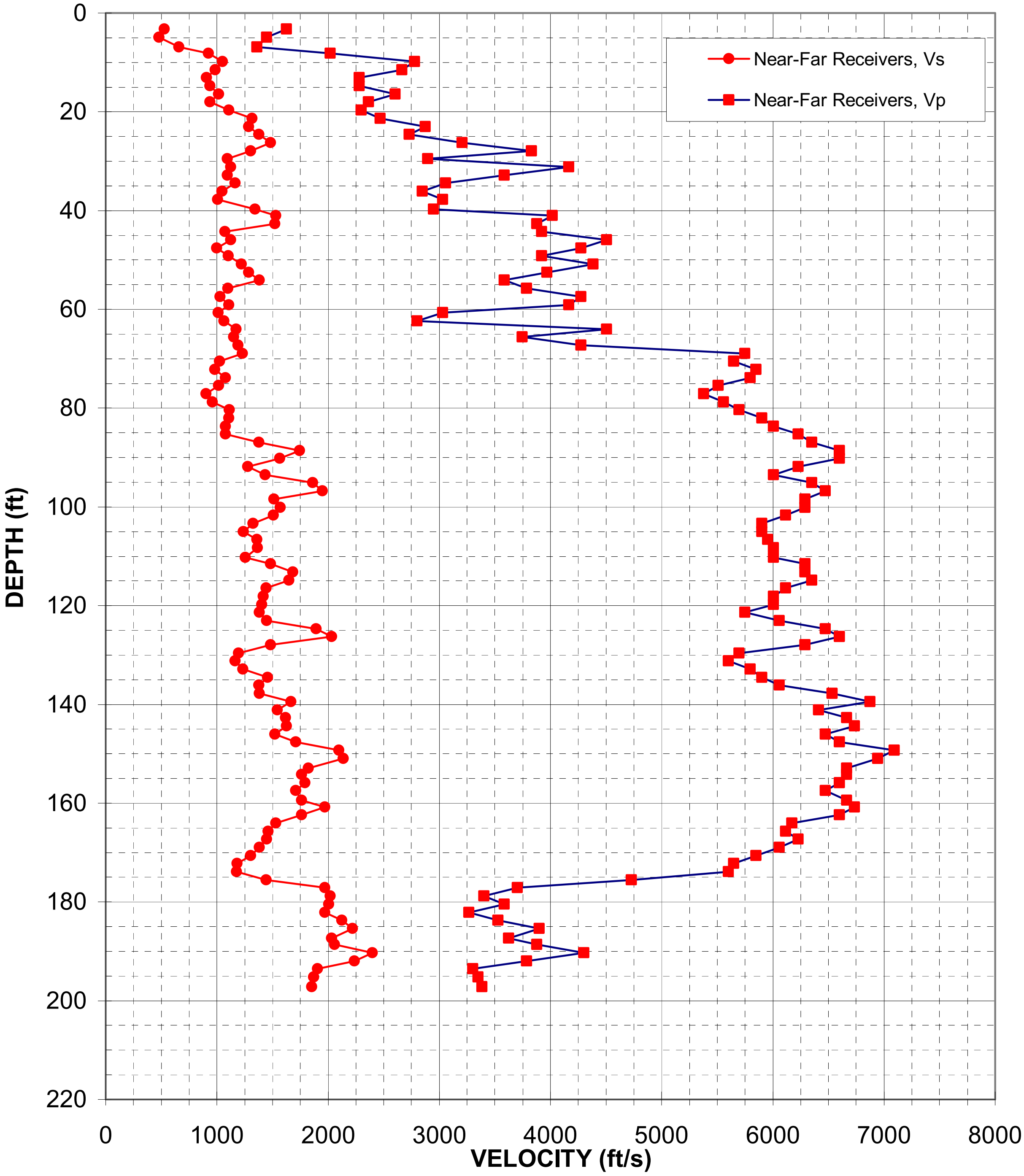

Figure 6: Boring T2E-B3, Suspension R1-R2 P- and S_H-wave velocities

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
3.3	530	1630
4.9	480	1450
6.9	660	1360
8.2	930	2020
9.8	1050	2780
11.5	990	2670
13.1	910	2280
14.8	940	2280
16.4	1020	2600
18.0	940	2360
19.7	1110	2300
21.3	1320	2470
23.0	1290	2870
24.6	1380	2730
26.3	1480	3210
27.9	1300	3830
29.5	1090	2900
31.2	1130	4170
32.8	1100	3580
34.5	1170	3060
36.1	1050	2850
37.7	1010	3030
39.7	1340	2950
41.0	1530	4020
42.7	1520	3880
44.3	1070	3920
45.9	1130	4500
47.6	1000	4270
49.2	1100	3920
50.9	1220	4390
52.5	1290	3970
54.1	1380	3580
55.8	1100	3790
57.4	1030	4270
59.1	1110	4170
60.7	1010	3030
62.3	1060	2800
64.0	1170	4500
65.6	1150	3750
67.3	1190	4270
68.9	1230	5750
70.5	1030	5650
72.2	980	5850
73.8	1080	5800
75.5	1020	5510
77.1	900	5380
78.7	960	5560
80.4	1110	5700
82.0	1110	5900
83.7	1080	6010
85.3	1080	6230
86.9	1380	6350
88.6	1750	6600
90.2	1560	6600
91.9	1280	6230
93.5	1440	6010
95.1	1860	6350
96.8	1950	6470
98.4	1520	6290
100.1	1570	6290
101.7	1510	6120
103.4	1330	5900
105.0	1240	5900
106.6	1360	5950
108.3	1370	6010
110.2	1260	6010
111.6	1480	6290
113.2	1680	6290
114.8	1650	6350
116.5	1440	6120
118.1	1420	6010
119.8	1410	6010
121.4	1380	5750
123.0	1450	6060
124.7	1890	6470
126.3	2030	6600
128.0	1480	6290
129.6	1190	5700
131.2	1170	5600
132.9	1230	5800
134.5	1460	5900
136.2	1380	6060
137.8	1380	6540
139.4	1670	6870
141.1	1540	6410
142.7	1620	6670
144.4	1630	6730
146.0	1520	6470
147.6	1710	6600
149.3	2100	7090
150.9	2140	6940
152.9	1820	6670
154.2	1760	6670
155.8	1790	6600
157.5	1710	6470
159.5	1760	6670
160.8	1970	6730
162.4	1760	6600
164.0	1530	6170
165.7	1460	6120
167.3	1450	6230
169.0	1380	6060
170.6	1300	5850
172.2	1180	5650
173.9	1180	5600
175.5	1440	4730
177.2	1970	3700
178.8	2020	3400
180.5	2010	3580
182.1	1970	3270
183.7	2120	3530
185.4	2220	3900
187.3	2030	3620
188.7	2060	3880
190.3	2400	4300
191.9	2240	3790
193.6	1900	3300
195.2	1870	3350
197.2	1850	3380

Table 5. Boring T2E-B3, Suspension R1-R2 depths and P- and S_H-wave velocities

WSE BOREHOLE T3-B3
Receiver to Receiver V_s and V_p Analysis

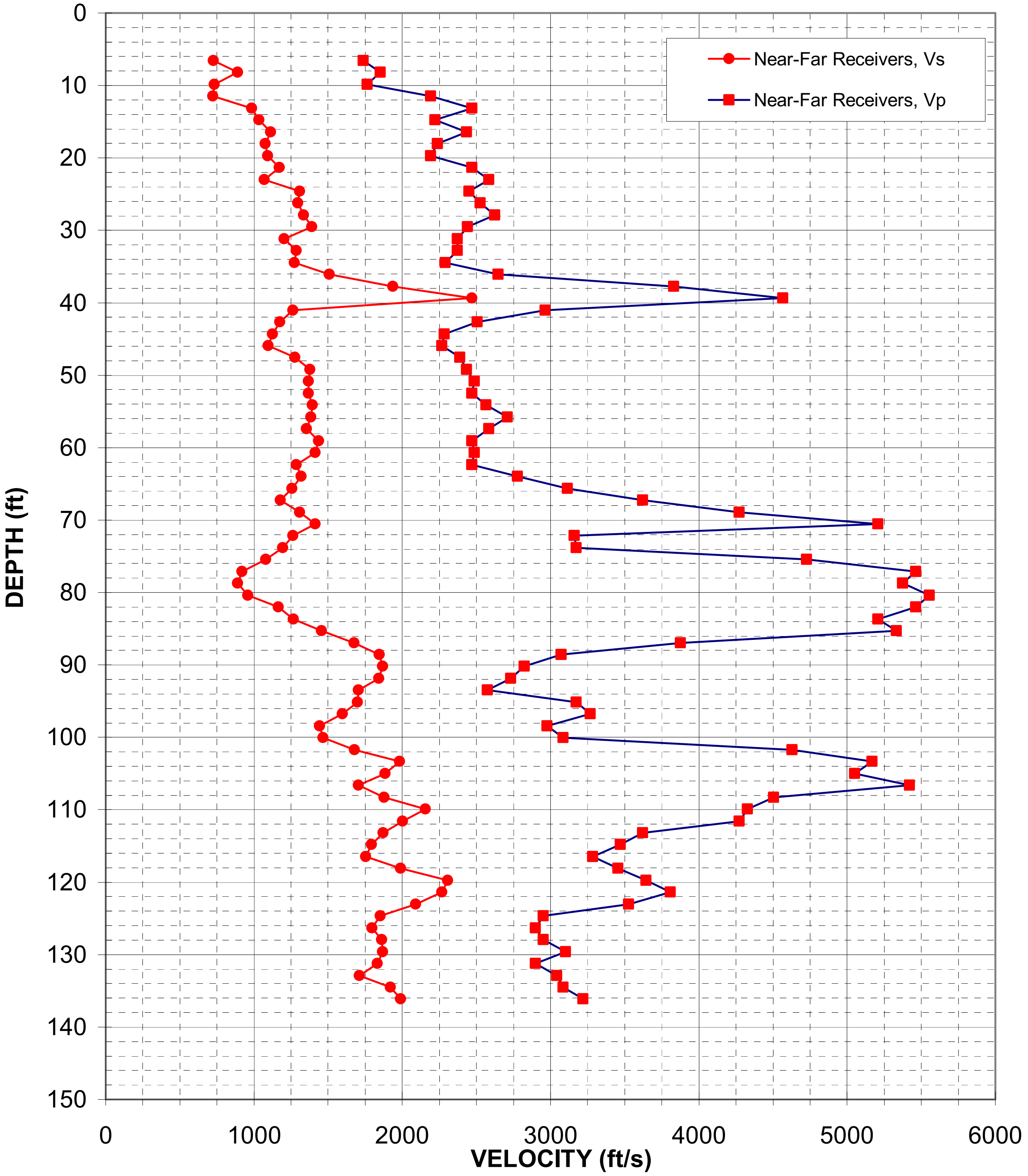

Figure 7: Boring T3-B3, Suspension R1-R2 P- and S_H-wave velocities

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
6.6	730	1740
8.2	890	1850
9.8	730	1760
11.5	720	2190
13.1	990	2470
14.8	1040	2220
16.4	1110	2430
18.0	1080	2240
19.7	1090	2190
21.3	1170	2470
23.0	1070	2580
24.6	1310	2450
26.3	1300	2530
27.9	1330	2620
29.5	1390	2440
31.2	1200	2370
32.8	1290	2370
34.5	1270	2290
36.1	1510	2650
37.7	1940	3830
39.4	2470	4570
41.0	1260	2960
42.7	1170	2510
44.3	1130	2280
45.9	1100	2270
47.6	1280	2390
49.2	1380	2430
50.9	1370	2490
52.5	1370	2470
54.1	1390	2560
55.8	1380	2710
57.4	1360	2580
59.1	1440	2470
60.7	1410	2490
62.3	1290	2470
64.0	1320	2780
65.6	1260	3120
67.3	1180	3620
68.9	1310	4270
70.5	1410	5210
72.2	1260	3160
73.8	1190	3170
75.5	1080	4730
77.1	920	5460
78.7	890	5380
80.4	960	5560
82.0	1170	5460
83.7	1270	5210
85.3	1460	5330
86.9	1680	3880
88.6	1850	3070
90.2	1870	2820
91.9	1840	2730
93.5	1710	2570
95.1	1700	3170
96.8	1590	3270
98.4	1440	2980
100.1	1470	3090
101.7	1680	4630
103.4	1980	5170
105.0	1880	5050
106.6	1710	5420
108.3	1880	4500
109.9	2160	4330
111.6	2000	4270
113.2	1870	3620
114.8	1790	3470
116.5	1750	3280
118.1	1990	3450
119.8	2310	3640
121.4	2270	3810
123.0	2090	3530
124.7	1850	2950
126.3	1800	2900
128.0	1860	2950
129.6	1870	3100
131.2	1830	2900
132.9	1710	3040
134.5	1920	3090
136.2	1990	3220

Table 6. Boring T3-B3, Suspension R1-R2 depths and P- and S_H-wave velocities

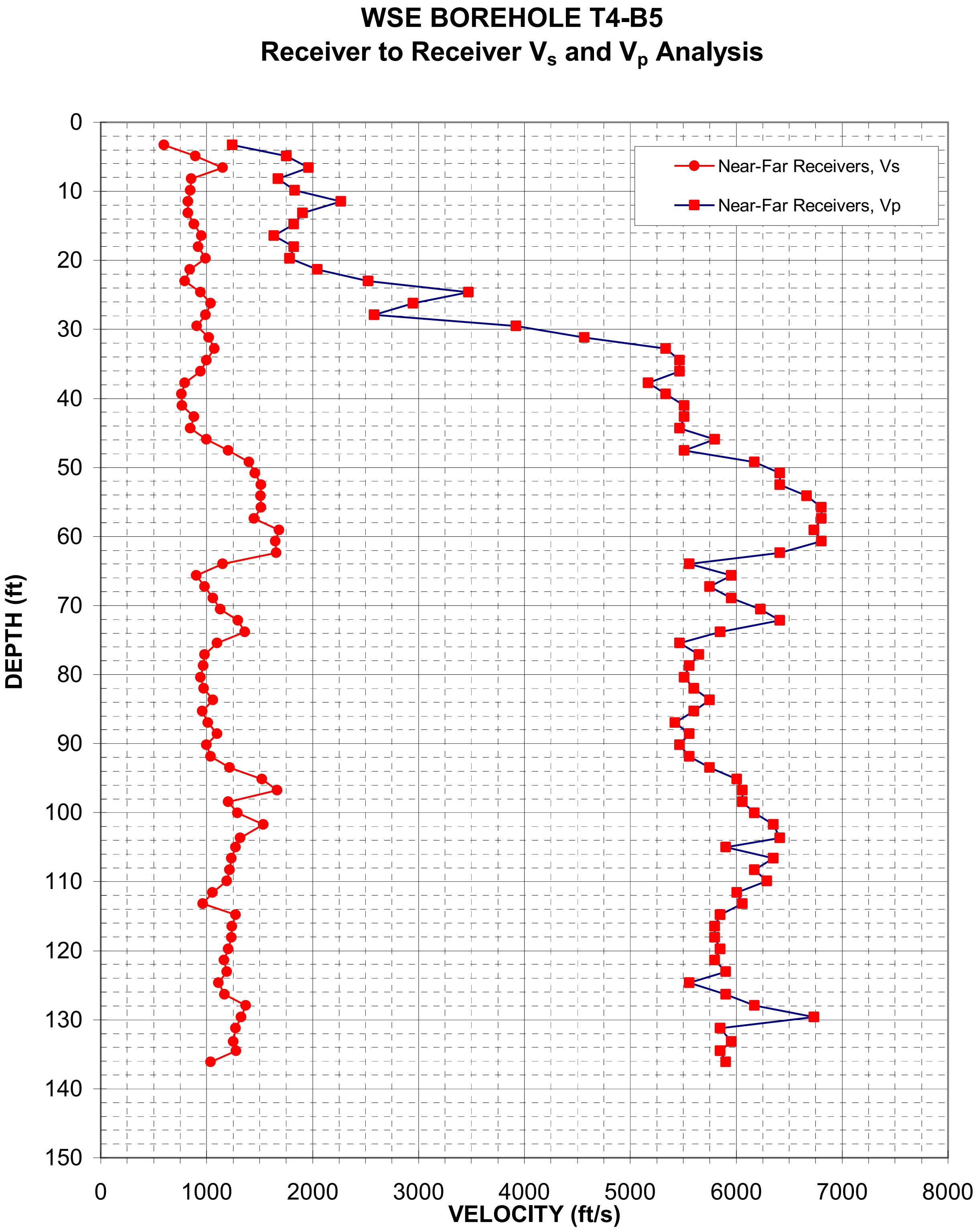

Figure 8: Boring T4-B5, Suspension R1-R2 P- and S_H-wave velocities

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
3.3	600	1240
4.9	890	1750
6.6	1150	1960
8.2	850	1680
9.8	850	1830
11.5	820	2270
13.1	820	1900
14.8	880	1820
16.4	950	1630
18.0	920	1820
19.7	990	1780
21.3	840	2040
23.0	800	2530
24.6	940	3470
26.3	1040	2950
27.9	990	2580
29.5	910	3920
31.2	1020	4570
32.8	1070	5330
34.5	1000	5460
36.1	940	5460
37.7	790	5170
39.4	760	5330
41.0	770	5510
42.7	880	5510
44.3	850	5460
45.9	1000	5800
47.6	1200	5510
49.2	1400	6170
50.9	1460	6410
52.5	1520	6410
54.1	1510	6670
55.8	1520	6800
57.4	1450	6800
59.1	1680	6730
60.7	1650	6800
62.3	1660	6410
64.0	1150	5560
65.6	900	5950
67.3	980	5750
68.9	1060	5950
70.5	1130	6230
72.2	1300	6410
73.8	1360	5850
75.5	1100	5460
77.1	980	5650
78.7	970	5560
80.4	940	5510
82.0	970	5600
83.7	1060	5750
85.3	960	5600
86.9	1010	5420
88.6	1100	5560
90.2	1000	5460
91.9	1040	5560
93.5	1220	5750
95.1	1520	6010
96.8	1670	6060
98.4	1200	6060
100.1	1290	6170
101.7	1540	6350
103.7	1320	6410
105.0	1270	5900
106.6	1230	6350
108.3	1220	6170
109.9	1190	6290
111.6	1050	6010
113.2	960	6060
114.8	1270	5850
116.5	1240	5800
118.1	1230	5800
119.8	1200	5850
121.4	1170	5800
123.0	1190	5900
124.7	1110	5560
126.3	1170	5900
128.0	1370	6170
129.6	1330	6730
131.2	1270	5850
133.2	1250	5950
134.5	1280	5850
136.2	1040	5900

Table 7. Boring T4-B5, Suspension R1-R2 depths and P- and S_H-wave velocities

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

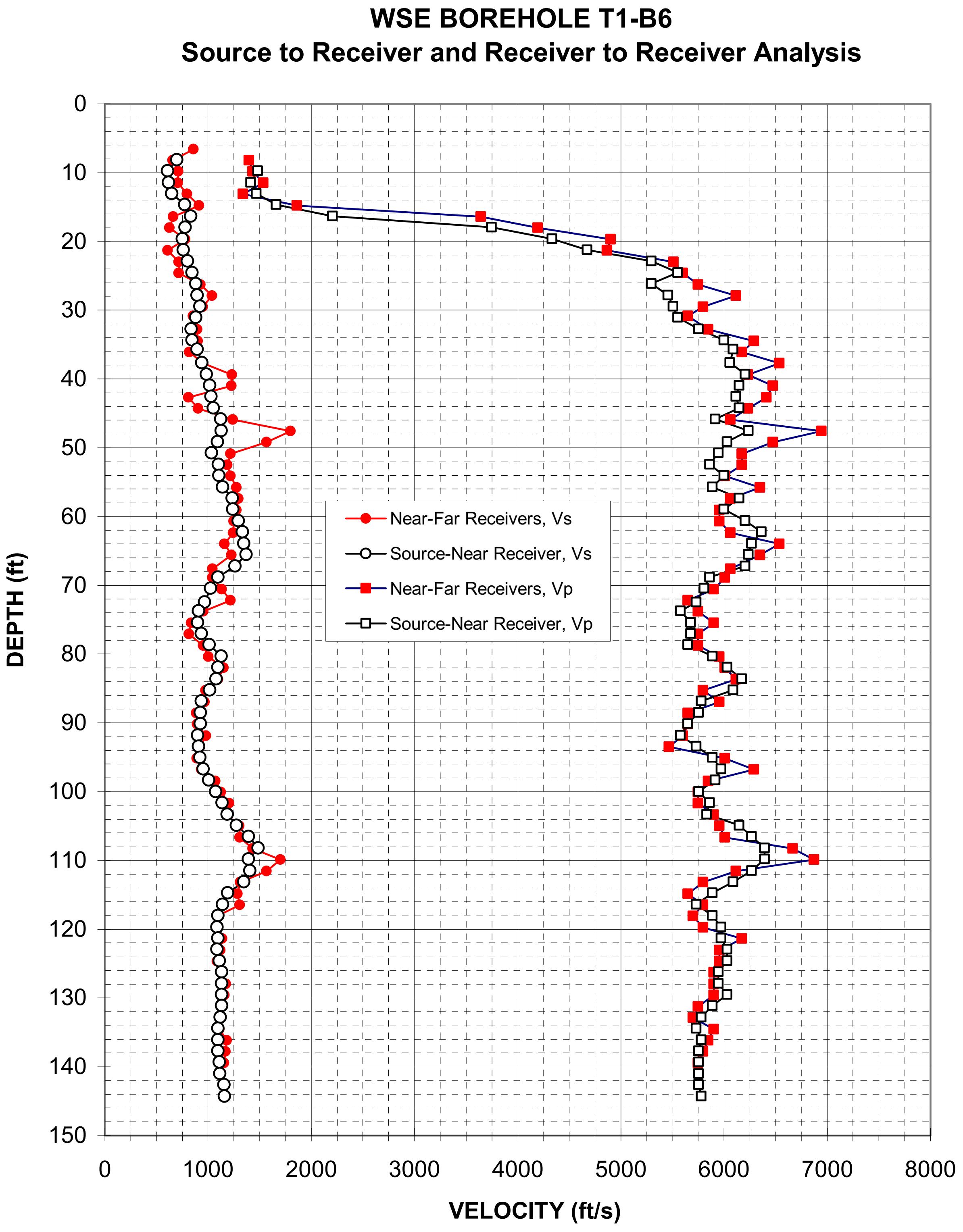

Figure A-1. Boring T1-B6, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
8.1	700	-
9.8	610	1480
11.4	620	1420
13.0	650	1470
14.7	770	1660
16.3	830	2210
18.0	780	3750
19.6	750	4340
21.2	760	4670
22.9	800	5300
24.5	840	5550
26.2	880	5300
27.8	900	5460
29.4	920	5500
31.1	880	5550
32.7	840	5750
34.4	840	6000
35.7	900	6090
37.6	940	6060
39.3	990	6210
40.9	1020	6150
42.6	1030	6120
44.2	1050	6150
45.8	1120	5920
47.5	1130	6240
49.1	1090	6030
50.8	1030	5940
52.4	1100	5860
54.0	1110	6000
55.7	1140	5890
57.3	1240	6150
59.0	1240	6000
60.6	1290	6210
62.2	1340	6360
63.9	1350	6270
65.5	1370	6240
67.2	1260	6210
68.8	1100	5860
70.5	1020	5810
72.4	970	5730
73.7	910	5580
75.4	900	5680
77.0	930	5680
78.7	1010	5650
80.3	1130	5890
81.9	1100	6030
83.6	1080	6180
85.2	1010	6090
86.9	940	5780
88.5	930	5750
90.1	930	5650
91.8	900	5580
93.4	910	5730
95.1	920	5890
96.7	950	5970
98.3	1010	5920
100.0	1070	5750
101.6	1140	5860
103.3	1190	5830
104.9	1280	6150
106.5	1390	6270
108.2	1490	6390
109.8	1390	6390
111.5	1410	6270
113.1	1350	6090
114.7	1190	5890
116.4	1140	5730
118.0	1100	5890
119.7	1090	5970
121.3	1100	5970
122.9	1090	6030
124.6	1110	6030
126.2	1130	5940
127.9	1130	5940
129.5	1130	6030
131.1	1130	5890
132.8	1120	5780
134.4	1100	5730
136.1	1100	5780
137.7	1100	5750
139.3	1110	5750
141.0	1110	5750
142.6	1160	5750
144.3	1160	5780

Table A-1. Boring T1-B6, S - R1 quality assurance analysis P- and S_H-wave data

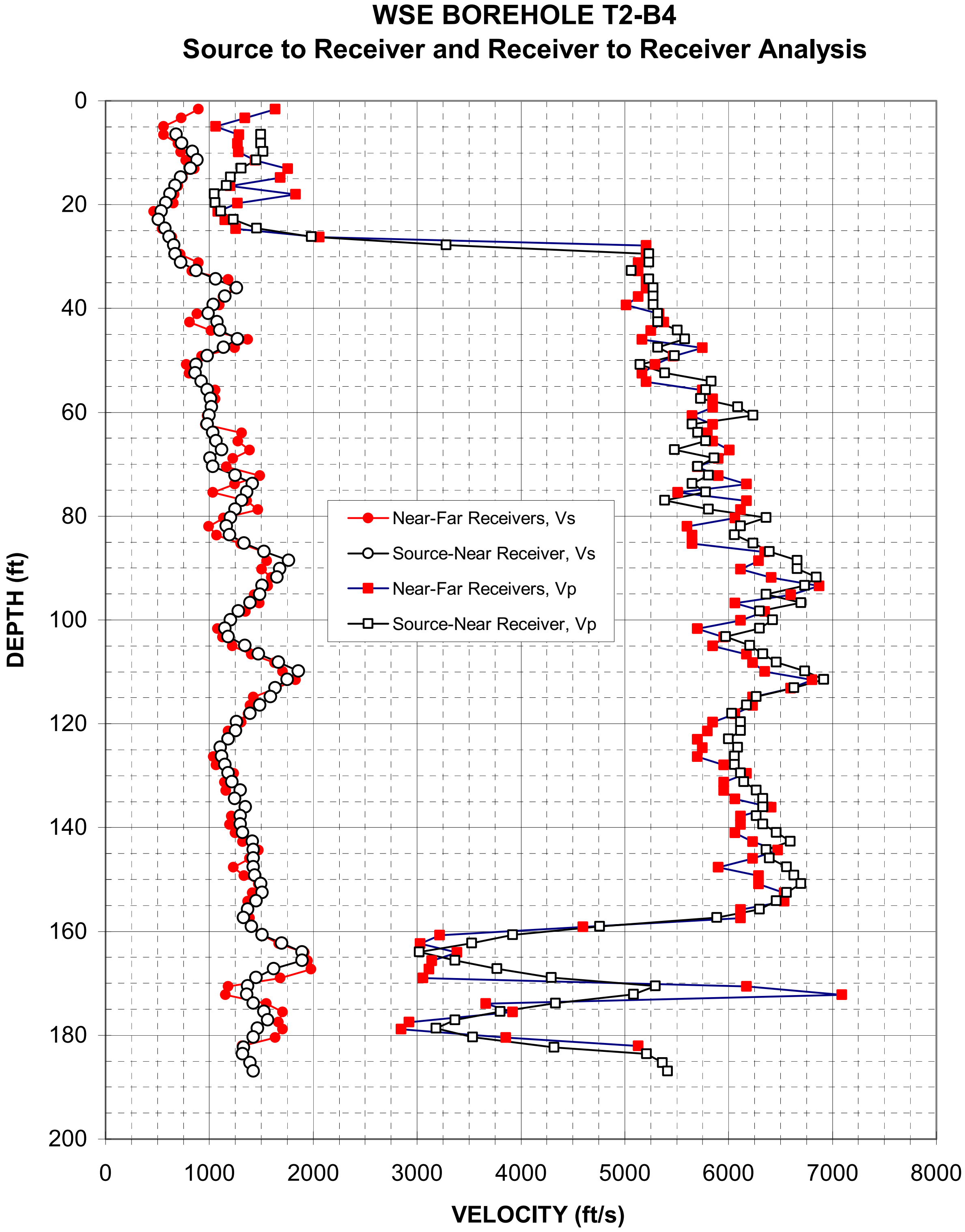

Figure A-2. Boring T2-B4, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
6.5	680	1500
8.1	740	1500
9.8	840	1520
11.4	880	1450
13.0	820	1310
14.7	730	1200
16.3	670	1170
18.0	620	1050
19.6	580	1060
21.2	540	1110
22.9	510	1230
24.5	570	1460
26.2	610	1980
27.8	660	3280
29.4	670	5230
31.1	720	5230
32.7	870	5060
34.4	1060	5230
36.0	1260	5280
37.6	1150	5280
39.3	1040	5280
40.9	990	5320
42.6	1070	5320
44.2	1100	5500
45.8	1270	5580
47.5	1140	5320
49.1	980	5480
50.8	870	5150
52.4	860	5390
54.0	920	5830
55.7	980	5780
57.3	1010	5730
59.0	1020	6090
60.6	1000	6240
62.2	980	5650
63.9	1040	5700
65.5	1070	5780
67.2	1120	5480
68.8	1010	5860
70.5	1040	5700
72.1	1250	5810
73.7	1420	5650
75.4	1360	5780
77.0	1310	5390
78.7	1250	5810
80.3	1210	6360
81.9	1170	6120
83.6	1200	6060
85.2	1330	6240
86.9	1530	6390
88.5	1760	6660
90.1	1680	6660
91.8	1650	6840
93.4	1510	6730
95.1	1490	6360
96.7	1390	6700
98.3	1280	6300
100.0	1200	6430
101.6	1150	6300
103.3	1180	5970
104.9	1340	6210
106.5	1470	6330
108.2	1670	6460
109.8	1860	6730
111.5	1750	6920
113.1	1640	6630
114.7	1590	6270
116.4	1490	6180
118.0	1390	6030
119.7	1260	6120
121.3	1250	6120
122.9	1180	6000
124.6	1110	6090
126.2	1120	6060
127.9	1150	6060
129.5	1180	6120
131.1	1220	6150
132.8	1300	6270
134.4	1250	6330
136.1	1350	6330
137.7	1300	6270
139.3	1300	6330
141.0	1320	6460
142.6	1420	6590
144.3	1430	6360
145.9	1430	6390
147.6	1430	6560
149.2	1440	6630
150.8	1500	6700
152.5	1510	6560
154.1	1450	6460
155.8	1370	6300
157.4	1330	5890
159.0	1400	4760
160.7	1510	3920
162.3	1700	3530
164.0	1900	3020
165.6	1900	3370
167.2	1620	3770
168.9	1450	4290
170.5	1370	5300
172.2	1360	5080
173.8	1430	4340
175.4	1530	3800
177.1	1560	3370
178.7	1460	3180
180.4	1430	3540
182.3	1330	4320
183.6	1320	5210
185.3	1390	5360
186.9	1430	5410

Table A-2. Boring T2-B4, S - R1 quality assurance analysis P- and S_H-wave data

WSE BOREHOLE T2E-B3
Source to Receiver and Receiver to Receiver Analysis

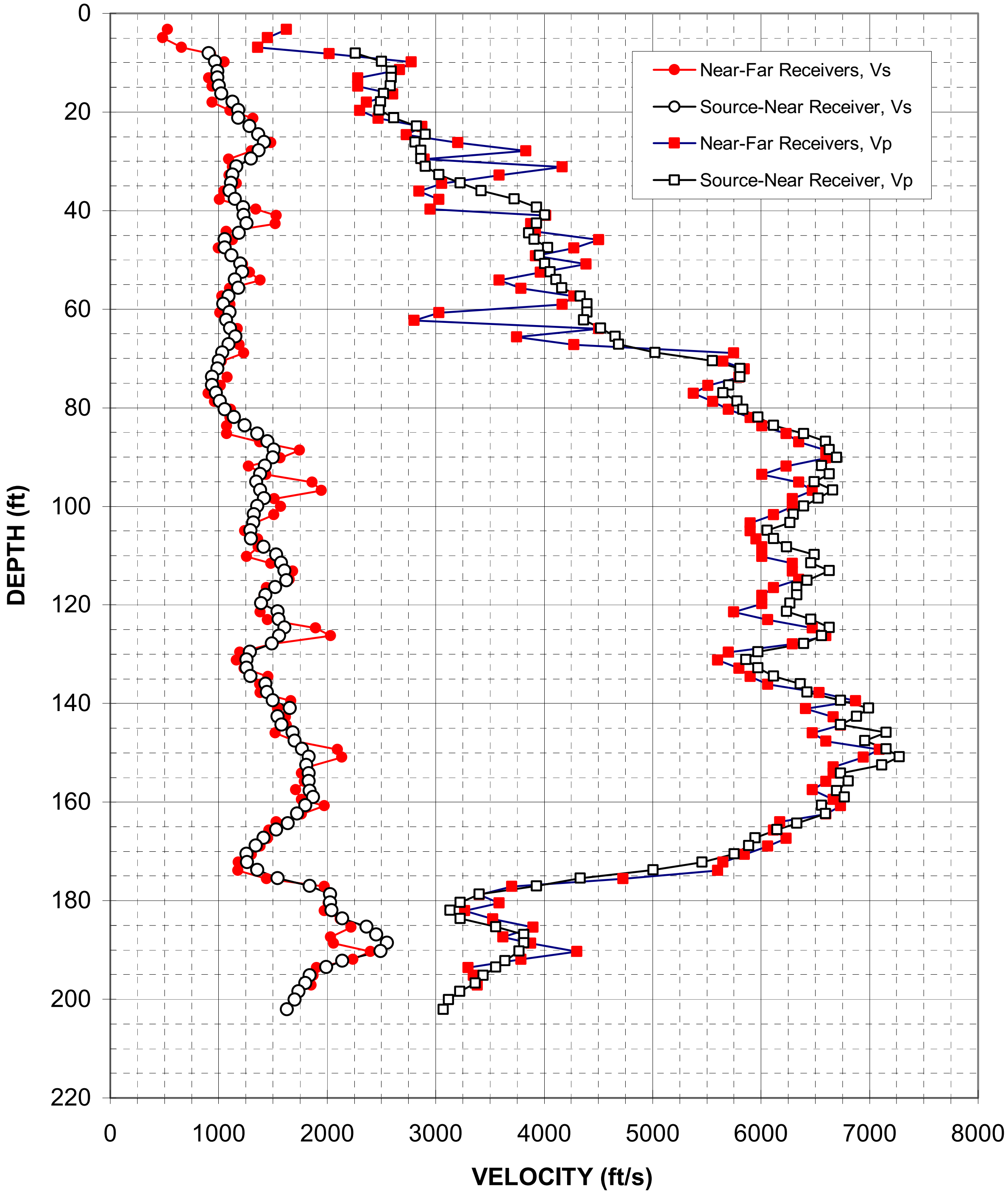

Figure A-3. Boring T2E-B3, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
8.1	910	2260
9.8	970	2500
11.7	990	2590
13.0	990	2590
14.7	1000	2580
16.3	1020	2520
18.0	1130	2490
19.6	1180	2480
21.2	1180	2620
22.9	1290	2830
24.5	1360	2900
26.2	1420	2810
27.8	1370	2860
29.4	1300	2860
31.1	1160	2900
32.7	1130	3030
34.4	1110	3230
36.0	1100	3420
37.6	1150	3720
39.3	1230	3930
40.9	1230	4010
42.6	1260	3930
44.5	1190	3860
45.8	1060	3910
47.5	1060	4030
49.1	1120	3960
50.8	1200	4010
52.4	1220	4060
54.0	1150	4110
55.7	1180	4160
57.3	1090	4340
59.0	1040	4400
60.6	1100	4400
62.2	1070	4370
63.9	1110	4520
65.5	1160	4650
67.2	1090	4690
68.8	1030	5020
70.5	1000	5550
72.1	990	5810
73.7	940	5810
75.4	940	5700
77.0	970	5650
78.7	1010	5780
80.3	1060	5830
81.9	1140	5970
83.6	1240	6120
85.2	1360	6390
86.9	1450	6590
88.5	1510	6630
90.1	1500	6700
91.8	1430	6560
93.4	1380	6630
95.1	1350	6490
96.7	1380	6660
98.3	1420	6530
100.0	1360	6390
101.6	1320	6300
103.3	1320	6270
104.9	1290	6060
106.5	1300	6120
108.2	1410	6240
109.8	1530	6490
111.5	1570	6460
113.1	1610	6630
115.1	1620	6430
116.4	1520	6330
118.0	1430	6330
119.7	1390	6270
121.3	1540	6240
122.9	1550	6460
124.6	1610	6630
126.2	1560	6560
127.9	1490	6390
129.5	1290	5970
131.1	1260	5860
132.8	1260	5970
134.4	1290	6120
136.1	1430	6360
137.7	1450	6430
139.3	1500	6730
141.0	1660	6990
142.6	1540	6880
144.3	1580	6730
145.9	1680	7150
147.6	1700	6960
149.2	1770	7150
150.8	1830	7280
152.5	1810	7110
154.1	1830	6730
155.8	1830	6810
157.7	1840	6700
159.0	1870	6770
160.7	1800	6560
162.3	1720	6590
164.3	1640	6330
165.6	1530	6150
167.2	1410	5940
168.9	1340	5890
170.5	1260	5750
172.2	1260	5460
173.8	1360	5000
175.4	1540	4340
177.1	1840	3930
178.7	2030	3400
180.4	2030	3230
182.0	2040	3130
183.6	2140	3230
185.3	2360	3560
186.9	2450	3810
188.6	2550	3810
190.2	2490	3770
192.2	2140	3640
193.5	1990	3560
195.1	1840	3440
196.8	1800	3370
198.4	1740	3220
200.0	1700	3120
202.0	1630	3070

Table A-3. Boring T2E-B3, S - R1 quality assurance analysis P- and S_H-wave data

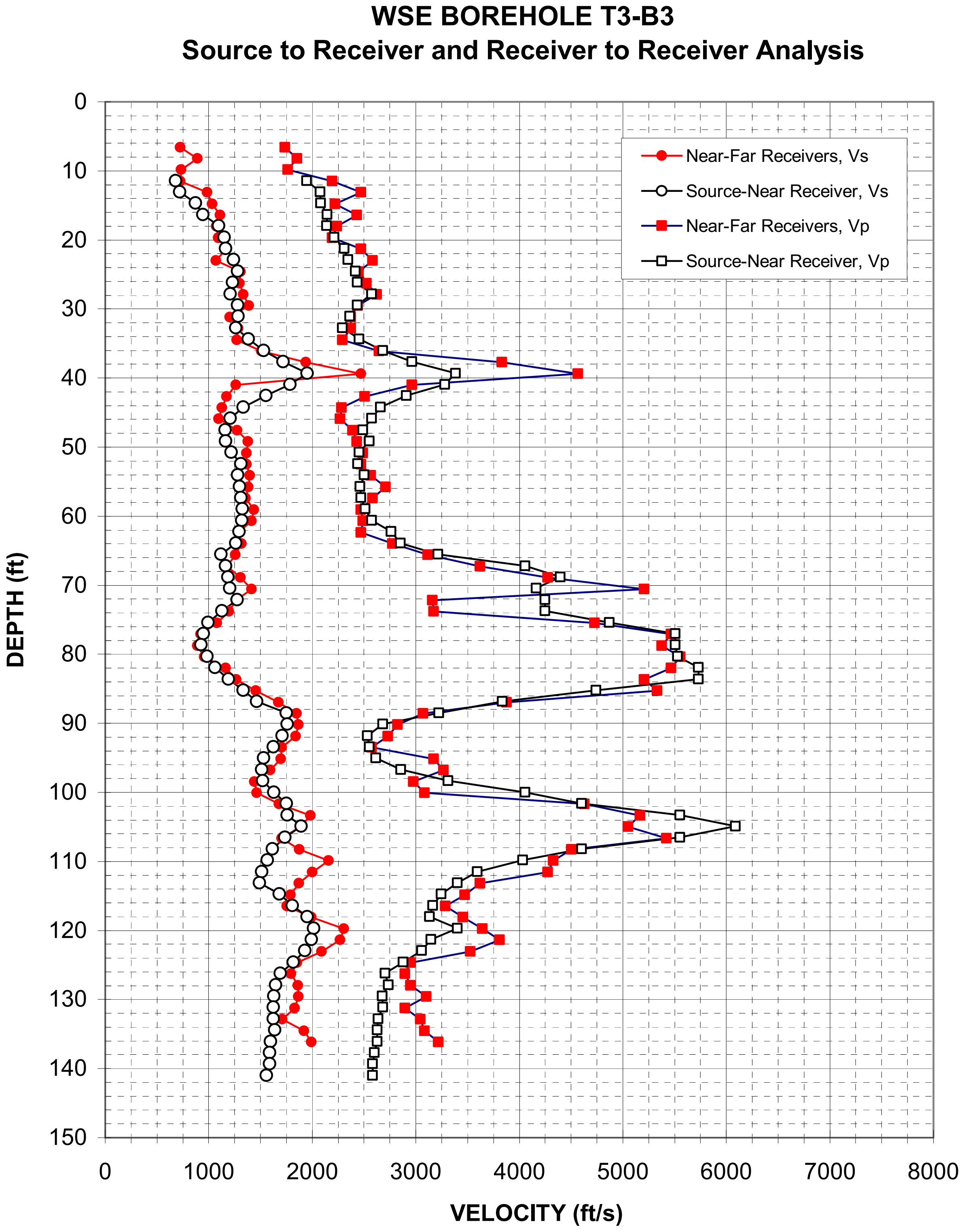

Figure A-4. Boring T3-B3, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
11.4	680	1950
13.0	720	2080
14.7	870	2080
16.3	940	2150
18.0	1100	2140
19.6	1150	2210
21.2	1160	2310
22.9	1240	2340
24.5	1280	2420
26.2	1230	2430
27.8	1210	2570
29.4	1280	2430
31.1	1290	2360
32.7	1260	2290
34.4	1380	2450
36.0	1530	2680
37.6	1720	2960
39.3	1950	3390
40.9	1790	3280
42.6	1550	2910
44.2	1340	2660
45.8	1210	2570
47.5	1160	2490
49.1	1160	2550
50.8	1220	2450
52.4	1310	2440
54.0	1280	2500
55.7	1300	2460
57.3	1310	2470
59.0	1320	2510
60.6	1320	2570
62.2	1290	2760
63.9	1260	2850
65.5	1120	3210
67.2	1160	4060
68.8	1190	4400
70.5	1200	4160
72.1	1280	4250
73.7	1130	4250
75.4	990	4870
77.0	950	5500
78.7	930	5500
80.3	980	5530
81.9	1060	5730
83.6	1190	5730
85.2	1340	4740
86.9	1470	3840
88.5	1750	3220
90.1	1760	2680
91.8	1710	2530
93.4	1630	2550
95.1	1530	2620
96.7	1510	2860
98.3	1520	3310
100.0	1630	4060
101.6	1750	4600
103.3	1760	5550
104.9	1900	6090
106.5	1740	5550
108.2	1610	4600
109.8	1570	4030
111.5	1510	3600
113.1	1490	3400
114.7	1680	3250
116.4	1810	3170
118.0	1950	3130
119.7	2020	3400
121.3	1990	3150
122.9	1930	3060
124.6	1820	2880
126.2	1690	2710
127.9	1650	2730
129.5	1630	2680
131.1	1620	2680
132.8	1620	2640
134.4	1640	2630
136.1	1600	2630
137.7	1590	2600
139.3	1590	2580
141.0	1560	2580

Table A-4. Boring T3-B3, S - R1 quality assurance analysis P- and S_H-wave data

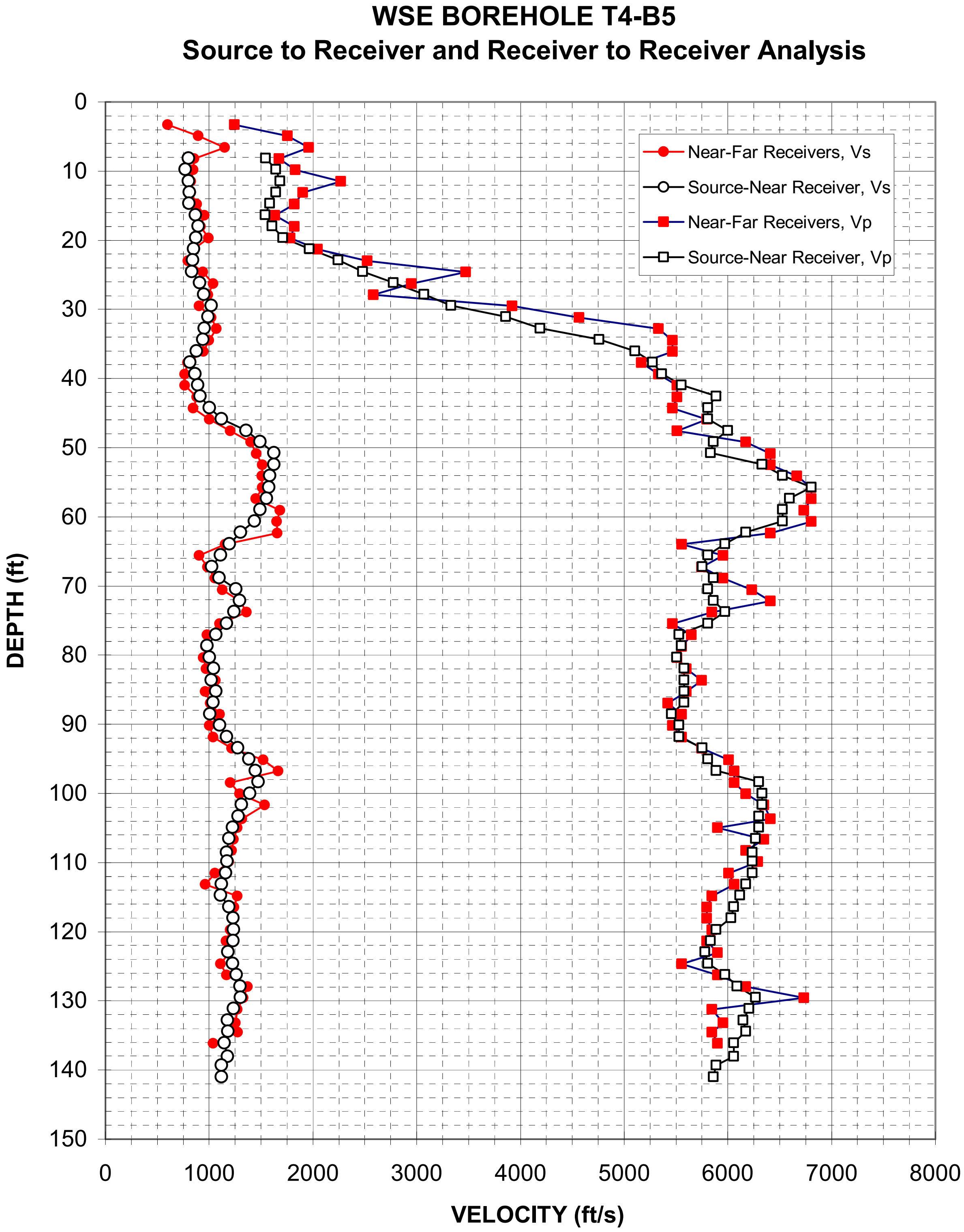

Figure A-5. Boring T4-B5, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
8.1	800	1540
9.8	770	1640
11.4	800	1680
13.0	810	1640
14.7	810	1590
16.3	870	1540
18.0	890	1610
19.6	870	1710
21.2	850	1970
22.9	840	2240
24.5	830	2480
26.2	910	2780
27.8	950	3070
29.4	1020	3330
31.1	990	3860
32.7	950	4190
34.4	940	4760
36.0	880	5100
37.6	820	5280
39.3	860	5360
40.9	890	5550
42.6	910	5890
44.2	1000	5810
45.8	1120	5810
47.5	1360	6000
49.1	1490	5860
50.8	1620	5830
52.4	1620	6330
54.0	1590	6530
55.7	1570	6810
57.3	1550	6590
59.0	1490	6530
60.6	1440	6530
62.2	1300	6180
63.9	1190	5970
65.5	1110	5810
67.2	1020	5750
68.8	1100	5860
70.5	1260	5810
72.1	1290	5860
73.7	1240	5970
75.4	1170	5810
77.0	1070	5530
78.7	980	5550
80.3	1000	5500
81.9	1040	5580
83.6	1020	5580
85.2	1070	5580
86.9	1040	5580
88.5	1010	5460
90.1	1100	5530
91.8	1170	5530
93.4	1280	5750
95.1	1380	5810
96.7	1450	5890
98.3	1470	6300
100.0	1390	6330
101.6	1310	6330
103.3	1280	6300
104.9	1230	6300
106.5	1190	6270
108.5	1170	6240
109.8	1170	6240
111.5	1160	6240
113.1	1120	6180
114.7	1110	6120
116.4	1190	6060
118.0	1230	6030
119.7	1240	5890
121.3	1230	5830
122.9	1180	5780
124.6	1230	5810
126.2	1260	5970
127.9	1300	6090
129.5	1300	6270
131.1	1240	6210
132.8	1180	6150
134.4	1180	6180
136.1	1150	6060
138.0	1180	6060
139.3	1120	5890
141.0	1120	5860

Table A-5. Boring T4-B5, S - R1 quality assurance analysis P- and S_H-wave data

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION RECORDS

MICRO PRECISION CALIBRATION, INC.
12686 HOOVER STREET
GARDEN GROVE, CA, 92841
(714) 901-5659

Certificate of Calibration

Date: 10/15/2010

ACCREDITED
Lab # 935.11

Certificate #: 1125043

Customer:
GEOVISION
1124 OLYMPIC DRIVE
CORONA, CA, 92881

Purchase Order:	OH-101004-01
Work Order:	N/A

MPC Control #:	AM6767	Serial Number:	160023
Asset ID:	160023	Department:	N/A
Gage Type:	LOGGER	Performed By:	JIM WILLIAMS
Manufacturer:	OYO	Received Condition:	IN TOLERANCE
Model Number:	3403	Returned Condition:	IN TOLERANCE
Size:	N/A	Cal Date:	October 15, 2010
Temp./RH:	70 °F / 41 %	Cal. Interval:	12 MONTHS
		Cal. Due Date:	October 15, 2011

Found conditions meet or exceed manufacturer specifications.

***Calibration Notes:**
See attached data sheet for calculations.
Calibrated IAW customer supplied calibration data form Rev 2.0

Test Points

Description	Standard	Tolerance -	Tolerance +	As Found	As Left	UOM	Result
Test Frequency	50.000	49.500	50.500	49.890	49.890	Hz	Pass
Test Frequency	100.000	99.000	101.000	100.100	100.100	Hz	Pass
Test Frequency	200.000	198.000	202.000	200.000	200.000	Hz	Pass
Test Frequency	500.000	495.000	505.000	500.000	500.000	Hz	Pass
Test Frequency	1000.000	990.000	1010.000	1001.100	1001.100	Hz	Pass
Test Frequency	2000.000	1980.000	2020.000	2000.000	2000.000	Hz	Pass

Standards Used To Calibrate Equipment

I.D.	Description	Model	Serial	Manufacturer	Cal. Due Date	Traceability #
BD7715	COUNTER	53131A	3416A05377	HEWLETT PACKARD	6/8/2011	991939
BD9000	CALIBRATOR	5500A	7375008	FLUKE	5/27/2011	1105086
T1700	TIME & FREQUENCY SYSTEM	365-211	96072	ODETICS	7/6/2012	258817

Calibrating Technician: JIM WILLIAMS

QC Approval: Jim Williams

Unless Otherwise Noted, Uncertainty Estimated at >= 4 to 1. Uncertainties have been estimated at a 95 percent confidence level (k=2). Services rendered comply with ISO 17025:2005, ISO 9001:2008, ANSI/NCSL Z540-1, MPC Quality Manual, MPC CSD and with customer purchase order instructions.

Calibration cycles and resulting due dates were submitted/approved by the customer. Any number of factors may cause an instrument to drift out of tolerance before the next scheduled calibration. Recalibration cycles should be based on frequency of use, environmental conditions and customer's established systematic accuracy. The information on this report, pertains only to the instrument identified.

All standards are traceable to the National Institute of Standards and Technology (NIST). Services rendered include proper manufacture's service instructions and are warranted for no less than (30) days. This report may not be reproduced in part or in whole without the prior written approval of the issuing MPC lab.

MICRO PRECISION CALIBRATION, INC.
12686 HOOVER STREET
GARDEN GROVE, CA, 92841
(714) 901-5659

Certificate of Calibration

Date: 10/15/2010

ACCREDITED
Lab # 935.11

Certificate #: 1125043

Procedures Used In This Event:

Procedure Name	Description
CALIBRATION GENERAL	GENERAL CALIBRATION INSTRUCTION

Calibrating Technician: JIM WILLIAMS

QC Approval: Jim Williams

AM 6767

GEOVision
geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	OYO	Model no.:	3403
Serial no.:	160023	Calibration date:	10/15/2010
By:	Charles Carter	Due date:	10/15/2011
Counter mfg.:	Hewlett Packard	Model no.:	53131A
Serial no.:	3416A05377	Calibration date:	6/8/2010
By:	Micro Precision Calibration	Due date:	6/8/2011
Signal generator mfg.:	Fluke	Model no.:	5500A
Serial no.:	7376008	Calibration date:	5/27/2010
By:	Micro Precision Calibration	Due date:	5/27/2011

SYSTEM SETTINGS:

Gain:	2
Filter	Analog:10kHz; Digital: Off
Range:	See sample period in table below
Delay:	0ms
Stack (1 std)	1
System date = correct date and time	10/15/2010 9:05am

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.22 As left -0.22

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.000	200	1	180.2	49.94	180	50.0	180.4	49.89
100.0	100.001	100	2	89.9	100.1	90	100.0	89.9	100.1
200.0	200.001	50	3	44.95	200.2	45.05	199.8	45	200.0
500.0	500.001	20	4	18.0	500.0	18.0	500.0	18.0	500.0
1000	1000.002	10	5	8.99	1001	9.01	998.9	8.99	1001.1
2000	2000.003	5	6	4.5	2000	4.5	2000	4.5	2000

Calibrated by: Jim Williams 10/15/2010
Name Date Signature

Witnessed by: Charles Carter 10/15/2010 Charles Carter
Name Date Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

MICRO PRECISION CALIBRATION, INC.
12686 HOOVER STREET
GARDEN GROVE, CA, 92841
(714) 901-5659

ACCREDITED
Lab # 935.11

Certificate of Calibration

Date: 10/15/2010

Certificate #: 1125048

Customer:
GEOVISION
1124 OLYMPIC DRIVE
CORONA, CA, 92881

Purchase Order: OH-101004-01
Work Order: N/A

MPC Control #: AM6768
Asset ID: 160024
Gage Type: LOGGER
Manufacturer: OYO
Model Number: 3403
Size: N/A
Temp./RH: 70 °F / 41 %

Serial Number: 160024
Department: N/A
Performed By: JIM WILLIAMS
Received Condition: IN TOLERANCE
Returned Condition: IN TOLERANCE
Cal Date: October 15, 2010
Cal. Interval: 12 MONTHS
Cal. Due Date: October 15, 2011

Found conditions meet or exceed manufacturer specifications.

***Calibration Notes:**
See attached data sheet for calculations.
Calibrated IAW customer supplied calibration data form Rev 2.0

Test Points

Description	Standard	Tolerance -	Tolerance +	As Found	As Left	UOM	Result
Test Frequency	50.000	49.500	50.500	49.890	49.890	Hz	Pass
Test Frequency	100.000	99.000	101.000	100.100	100.100	Hz	Pass
Test Frequency	200.000	198.000	202.000	199.800	199.800	Hz	Pass
Test Frequency	500.000	495.000	505.000	500.000	500.000	Hz	Pass
Test Frequency	1000.000	990.000	1010.000	1000.000	1000.000	Hz	Pass
Test Frequency	2000.000	1980.000	2020.000	2000.000	2000.000	Hz	Pass

Standards Used To Calibrate Equipment

I.D.	Description	Model	Serial	Manufacturer	Cal. Due Date	Traceability #
BD7715	COUNTER	53131A	3416A05377	HEWLETT PACKARD	6/8/2011	991939
BD9000	CALIBRATOR	5500A	7375008	FLUKE	5/27/2011	1105086
T1700	TIME & FREQUENCY SYSTEM	365-211	96072	ODETICS	7/6/2012	258817

Calibrating Technician: JIM WILLIAMS

QC Approval: Jim Williams

Unless Otherwise Noted, Uncertainty Estimated at >= 4 to 1. Uncertainties have been estimated at a 95 percent confidence level (k=2). Services rendered comply with ISO 17025:2005, ISO 9001:2008, ANSI/NCSL Z540-1, MPC Quality Manual, MPC CSD and with customer purchase order instructions.

Calibration cycles and resulting due dates were submitted/approved by the customer. Any number of factors may cause an instrument to drift out of tolerance before the next scheduled calibration. Recalibration cycles should be based on frequency of use, environmental conditions and customer's established systematic accuracy. The information on this report, pertains only to the instrument identified.

All standards are traceable to the National Institute of Standards and Technology (NIST). Services rendered include proper manufacture's service instructions and are warranted for no less than (30) days. This report may not be reproduced in part or in whole without the prior written approval of the issuing MPC lab.

MICRO PRECISION CALIBRATION, INC.
12686 HOOVER STREET
GARDEN GROVE, CA, 92841
(714) 901-5659

Certificate of Calibration

Date: 10/15/2010

Lab # 935.11

Certificate #: 1125048

Procedures Used In This Event:

Procedure Name	Description
CALIBRATION GENERAL	GENERAL CALIBRATION INSTRUCTION

Calibrating Technician:

JIM WILLIAMS

QC Approval:

Jim Williams

AM 6768

GEOVision
geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	OYO	Model no.:	3403
Serial no.:	160024	Calibration date:	10/15/2010
By:	Charles Carter	Due date:	10/15/2011
Counter mfg.:	Hewlett Packard	Model no.:	53131A
Serial no.:	3416A05377	Calibration date:	6/8/2010
By:	Micro Precision Calibration	Due date:	6/8/2011
Signal generator mfg.:	Fluke	Model no.:	5500A
Serial no.:	7376008	Calibration date:	5/27/2010
By:	Micro Precision Calibration	Due date:	5/27/2011

SYSTEM SETTINGS:

Gain:	2
Filter	Analog:10kHz; Digital: Off
Range:	See sample period in table below
Delay:	0ms
Stack (1 std)	1
System date = correct date and time	10/15/2010 9:30am

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found -0.22 As left -0.22

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.001	200	1	180.0	50.00	179.8	50.06	180.4	49.89
100.0	100.001	100	2	90.1	99.9	89.9	100.1	89.9	100.1
200.0	200,001	50	3	45.05	199.8	45.05	199.8	45.05	199.8
500.0	500.001	20	4	18.0	500.0	18.0	500.0	18.0	500.0
1000	1000.001	10	5	9.0	1000.0	9.0	1000.0	9.0	1000.0
2000	2000.001	5	6	4.5	2000.0	4.5	2000.0	4.5	2000.0

Calibrated by: Jim Williams 10/15/2010
Name Date Signature

Witnessed by: Charles Carter 10/15/2010 Charles Carter
Name Date Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008

MICRO PRECISION CALIBRATION, INC.
12686 HOOVER STREET
GARDEN GROVE, CA, 92841
(714) 901-5659

Certificate of Calibration

Date: 10/6/2010

Lab # 935.11

Certificate #: 1114924

Customer:
GEOVISION
1124 OLYMPIC DRIVE
CORONA, CA, 92881

		Purchase Order:	OH-101004-01
		Work Order:	N/A
MPC Control #:	BG9698	Serial Number:	15014
Asset ID:	15014	Department:	N/A
Gage Type:	LOGGER	Performed By:	STEVE BORING
Manufacturer:	OYO	Received Condition:	IN TOLERANCE
Model Number:	03331-0000	Returned Condition:	IN TOLERANCE
Size:	N/A	Cal Date:	October 4, 2010
Temp./RH:	70 °F / 35 %	Cal. Interval:	12 MONTHS
		Cal. Due Date:	October 4, 2011

Found conditions meet or exceed manufacturer specifications.

***Calibration Notes:**
The UUT (unit under test) was calibrated using the customers procedures in our Garden Grove lab.
The UUT was operated by the customers personnel and data collection was observed by MPC personnel.
The UUT was found to be in tolerance to customer supplied specifications. The reference standards used are in compliance with ISO/IEC 17025:2005, ISO9001:2000, ANSI/NCSL Z540-1-1994 and laboratory accreditation for lab code 935.11. Frequency is accredited. Measurement uncertainty is 0.2 x E12 Hz.
Please see attached data sheet.

Standards Used To Calibrate Equipment

I.D.	Description	Model	Serial	Manufacturer	Cal. Due Date	Traceability #
AM4000	WAVEFORM GENERATOR	33250A	MY40000703	AGILENT	8/17/2011	1063979
T1100	COUNTER	53131A	3546A09912	HEWLETT PACKARD	1/20/2011	646688

Calibrating Technician:

STEVE BORING

QC Approval:

Tammy Webster

BG 9698

GEOVision
geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	OYO	Model no.:	3331
Serial no.:	15014	Calibration date:	10/4/2010
By:	Charles Carter	Due date:	10/4/2011
Counter mfg.:	Hewlett Packard	Model no.:	53131A
Serial no.:	3416A05377	Calibration date:	6/8/2010
By:	Micro Precision (LN)	Due date:	6/8/2011
Signal generator mfg.:	Agilent	Model no.:	33250A
Serial no.:	MY4000703	Calibration date:	8/17/2010
By:	Micro Precision (LN)	Due date:	8/17/2011

SYSTEM SETTINGS:

Gain:	20
Filter	LCF: 5Hz; HCF: 20kHz
Range:	See sample period in table below
Delay:	4 ms
Stack (1 std)	1
System date = correct date and time	10/4/2010 3:20pm

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found 0.22% As left 0.22%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	1	180.2	49.94	179.8	50.06	180.0	50.00
100.0	100.0	100	2	90.10	99.89	90.00	100.0	90.10	99.89
200.0	200.0	50	3	45.00	200.0	45.05	199.8	45.05	199.8
500.0	500.0	20	4	18.00	500.0	18.02	499.5	17.96	501.1
1000	1000	10	5	9.010	998.9	8.990	1001	9.000	1000
2000	2000	5	6	4.510	1996	4.505	1998	4.500	2000

Calibrated by:	Charles Carter	10/4/2010	Charles Carter
	Name	Date	Signature
Witnessed by:	Steve Boring	10/4/2010	
	Name	Date	Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.0 July 21, 2008