APPENDIX C.2

Seismic Reflection Data

TABLE C-1
Summary of Seismic Reflection Testing

Seismic Reflection Line	Approximate Location	City	Purpose/ Feature Evaluated
Z1-G3	Stadium Way (NE/O of Elysian Park Dr.)	Los Angeles	Elysian Park Fault
Z1-G4	Huntington Drive South (NE of Turquoise St.)	Los Angeles	Unnamed Fault
Z1-G5	N. Eastern Avenue (S/O Twining St.)	Los Angeles	Unnamed Fault
Z2-G1	North Avenue 46 (S/O Alumni Ave.)	Los Angeles	York Blvd./Raymond Faults
Z2-G2	N. Figueroa St. (SW/O S. Avenue 54)	Los Angeles	Highland Park Fault
Z2-G3	Pueblo Avenue (NW/O Huntington Dr. N.)	Los Angeles	Subsurface Evaluation
Z3-G1	South Raymond Avenue (N/O E. Glenarm St.)	Pasadena	San Rafael Fault
Z3-G2	South Grand Avenue (S/O Madeline Dr.)	Pasadena	Unnamed Fault
Z3-G3	San Pasqual Avenue (SW/O San Ramon Dr.)	Los Angeles	Raymond Fault
Z3-G4	Pasadena Avenue (NE/O Hawthorne St.)	South Pasadena	Subsurface Evaluation
Z3-G5	Via del Rey (N/O Camino Verde)	South Pasadena	Unnamed Fault
Z3-G6	Winchester Avenue (N/O Concord Ave.)	Alhambra	Highland Park Fault
Z3-G7	Westmont Drive (S/O, Valley Blvd.)	Alhambra	Unnamed Fault
Z4-G1	Oxford Road (S/O Orlando Rd.)	San Marino	Raymond Fault
Z4-G2	Huntington Drive (SW/O N. Granada Ave.)	Alhambra	Alhambra Wash Fault
Z5-G2	East Shorb Street (E/O S. Hildalgo St.)	Alhambra	Alhambra Wash Fault
Z5-G3	Edgewood Drive (S/O W. Valley Blvd.)	Alhambra	Highland Park Fault

REPORT

HIGH RESOLUTION SEISMIC REFLECTION SURVEY

SR-710 Tunnel Technical Study
Los Angeles County, California

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1 INTRODUCTION

A high-resolution, compressional (P) wave seismic reflection survey was conducted at various sites within the SR-710 Tunnel Study Area, located in Los Angeles County, California. The surveys were conducted from January 13, 2009 to March 24, 2009. The purpose of the seismic reflection survey was to locate geologic structures potentially associated with faulting at each site.

Seventeen (17) seismic reflection lines were located strategically throughout five (5) tunnel study zones, labeled Zones 1 to 5 (Figure 1). The seismic investigation consisted of three (3) seismic lines in Zone 1 (Z1-G3 to Z1-G5), 3 seismic lines in Zone 2 (Z1-G1 to Z2-G3), 7 seismic lines in Zone 3 (Z3-G1 to Z3-G7), 2 seismic lines in Zone 4 (Z4-G1 and Z4-G2), and 2 seismic lines in Zone 5 (Z5-G2 and Z5-G3). The length of the seismic reflection lines ranged from 1,195 to 3,832 feet.

This report contains the results of the seismic reflection investigation conducted at the site. An overview of the seismic reflection method is given in Section 2. Equipment and field procedures are discussed in Section 3. Data processing is discussed in Section 4. Interpretation is presented in Section 5. References and our professional certification are presented in Sections 6 and 7, respectively.

2 SEISMIC REFLECTION BACKGROUND

Seismic reflection profiling is a standard subsurface mapping technique employed by the oil and gas exploration industry. The use of this reflection technique in shallow engineering projects has been a relatively recent development, as the formerly high production costs and serious computing requirements were prohibitive. Advances in microelectronics have led to engineering seismographs and PC-based processing that now permit the cost-effective use of reflection seismic methods in a wide variety of applications (Steeples & Miller, 1988).

Details of the general seismic reflection technique can be found in many comprehensive texts, such as Sheriff and Geldart (1995); and, therefore, only a brief synopsis of the technique is included in this report. The seismic reflection method involves projecting a wave down from the surface, and then recording the returning wave back at the surface as it reflects off formations at depth. Seismic energy will also be reflected, refracted, and diffracted at boundaries in the subsurface, in accordance with Snell's Law (Figure 2). The main design consideration for a successful seismic reflection survey is the ability to separate the reflected energy from other arrivals in processing.

Seismic reflection occurs when an acoustic wave front encounters an impedance boundary in the subsurface. Seismic impedance depends on both the velocity and density of the rock, and impedance boundaries occur where these rock properties change abruptly, usually due to changes in lithology. The reflection coefficient, R, across an interface, is expressed by a function relating the acoustic impedance of adjacent layers. R determines the relative amplitude of the reflected wavelet.

$$\mathbf{R} = \frac{\sigma_2 \mathbf{V}_2 - \sigma_1 \mathbf{V}_1}{\sigma_2 \mathbf{V}_2 + \sigma_1 \mathbf{V}_1}$$

where, R = reflection coefficient,

σ_1, σ_2 = mass density of the material on each side of the interface, and

V_1, V_2 = shear wave velocity on each side of the interface.

The sign of the reflection coefficient determines the polarity of the reflected wave. The magnitude of the reflection coefficient is critical to obtaining usable data. The seismic reflection technique will not work if the acoustic contrast is not sufficient to produce a clear reflection, regardless of the survey parameters or processing techniques employed. The ability of the seismic reflection method to detect an individual sedimentary bed is not only a function of the acoustic impedance at the top and bottom of the bed, but also depends on the layer thickness. The minimum resolvable bed thickness is often quoted as 1/4 to 1/8 of the wavelength at the target depth. Wavelength is inversely proportional to frequency.

When a reflecting boundary exists, it is important to optimize the field procedure and acquisition parameters to maximize the quality of the final processed data. Choosing the best field parameters involves determining the relative importance of several competing objectives, such as site constraints, equipment capabilities, and processing needs.

In all geophysical surveys, the objective is to extract the usable data (i.e., in this case, reflections from various lithologic boundaries) from the unwanted background information (source generated and ambient noise). In reflection seismology, it is desirable to record high frequency, high signal-to-noise ratio reflection events from the boundary of interest. The frequency of a reflection event is largely determined by the source input frequency and the filtering effect of the ground. Often, the target reflector frequency is similar to that commonly recorded for coherent noise (in particular, the noise from ground roll), making it difficult or impossible to selectively filter out the noise. Isolation of the reflection events requires careful design of field acquisition parameters, such as the source/receiver geometry, choice of source and receiver types, as well as recording parameters, such as sampling rate and filter settings.

The seismic reflection technique can be divided into two categories based on the type of source used. Compressional (P) waves, propagate through the earth as a change in pressure, and are the same as the sound waves we hear. Particle motion for P-waves is parallel with the direction of propagation of the wave. Shear (S) waves propagate through the earth by shearing adjacent particles. Particle motion in S-waves is perpendicular to the direction of wave propagation.

The frequency content of seismic reflection data is a function of both the energy source and the earth through which the energy travels. Vibratory sources have control of the frequency input to the ground, unlike impulsive sources such as a hammer or explosive. With a vibratory source the frequency input into the ground is a function of the beginning and ending frequencies of the sweep, the length of the sweep and ground coupling. The second factor is the transmission and attenuation of various frequency components in the subsurface, often termed the “earth response”. In general, there are two primary objectives in designing a sweep for high-resolution reflection surveys:

1. To record useful seismic signals at the geophones with as high a frequency as possible.
2. To start the low end of the sweep such that the appropriate depth of penetration is achieved without generating intolerable ground roll.

3 PROCEDURES

3.1 Seismic Equipment

Key equipment used to collect the high resolution seismic reflection data as shown in Figure 3 included:

- Oyo DAS-1 Seismograph (144 channel system) coupled to a computer with SEISNET acquisition software
- Input/Output Inc. RLS240M roll box
- IVI EnviroVibe energy source
- Oyo Geospace 28 Hz vertical geophones
- Seismic cables and jumper cables

The Oyo DAS-1 Seismograph (DAS) is a 24-bit, 48-channel seismic acquisition system. During this investigation the DAS was coupled to two 48-channel expansion modules to obtain 144-channel recording capability. Coupling the DAS to a computer with the SEISNET seismic acquisition software allows for real-time correlation of the seismic records, filtering, display and printing of shot records and writing of data to CD-ROM.

For this project, an IVI EnviroVibe (Figure 3) was used as the P-wave energy source. Vibratory sources function by oscillating a mass through a user-defined range of frequencies, which are transmitted into the ground. This is known as a “sweep.” At the instant the vibrator begins its sweep, the seismograph begins recording the signals received from the geophones. Simultaneously, the sweep being produced by the vibrator is recorded on an auxiliary channel within the seismograph. The seismic record is obtained by cross correlating the recorded signals from the geophones with the known sweep generated by the vibrator.

3.2 Site Preparation

The end points, bends and nominal 300 ft intervals of each seismic line were marked using a Nikon total station system. The appropriate group interval (station/geophone spacing) was then marked using a fiberglass tape measure and surveyors paint with typically every 10^{th} station labeled for reference during data acquisition. The first station was labeled as station 101 with proceeding stations sequentially numbered along the profile. Group intervals of 5 to 8 ft were used for the P-wave reflection data acquisition. The endpoints and inflection points of each line were surveyed using a Trimble ProXRS GPS system with OmniStar submeter differential corrections. The locations of the seismic lines are summarized in Table 1. Relative elevation profiles for each line were surveyed using a Nikon total station system and converted to elevation using the GPS control (accurate to about 2 meters) at the ends of the line. Geophones were hot glued to the asphalt/concrete surface at the appropriate group interval and cabled into the seismograph. Seismic equipment was then set up for parameter testing and data acquisition as discussed in following sections.

3.3 Parameter Testing

Source parameter testing was carried out prior to the respective data acquisition. The receiver interval and geophone array (single geophone) had been determined before the start of the survey. Sweeps of varying frequency bandwidths were recorded into a full (144 trace) off-end or split spread configuration in an effort to bracket the usable frequencies returning to the geophones from the subsurface. The initial testing, aided by frequency filtering in the recording instruments, determined that a sweep range of 20-240 Hz or 20-200 Hz achieved the objectives of broad bandwidth, good depth of penetration and minimal ground roll generation for the P-wave reflection surveys.

With the frequency range selected, the duration and number of sweeps necessary to produce good signal-to-noise content on the shot records remained to be determined. After testing various combinations, it was determined that four, 8 second sweeps provided sufficient energy to overcome ambient noise levels, if at all possible, at the site and satisfy the data acquisition schedule. Longer sweep lengths and additional stacking did not appear to improve signal content on the shot records.

3.4 Data Acquisition Parameters

Generalized data acquisition parameters are summarized in Table 2. Specific data acquisition parameters for each seismic line including shot spacing, group interval (geophone spacing), minimum and maximum shot offset, spread geometry, sweep frequency and length and listen time are listed in Table 3.

3.5 Data Acquisition Procedures

At the start of data acquisition, the source was positioned between the appropriate receiver stations. The IVI EnviroVib communicated with the seismograph by radio link. When the operator pushed the trigger button in the recording truck, a signal was sent to the vibrator to start the sweep sequence, and the OYO DAS-1 seismograph began recording. During the sweep, a synthetic pilot trace was generated by the vibrator and sent to the seismograph. This pilot sweep is recorded on auxiliary channel 1 for correlation with the recorded data from the geophones. Data was transmitted from the seismograph to a computer where seismic acquisition software was used to correlate data, display data, print selected records, and write data to DVD.

At the beginning of the line an uncorrelated sweep was viewed either on the computer screen or on hardcopy. This provided a check to ensure that the vibrator was operating properly, and that the seismograph was being triggered correctly. Array parameters were checked (i.e., source location, sweep configuration, receiver spacing, etc.) as were all connections. The noise monitor on the seismograph was checked to identify any ambient noise problems and to isolate and correct any noisy or dead receiver channels. The noise monitor was also used to confirm the correct setting on the roll box by lightly tapping the first and last active phone.

P-wave seismic reflection data were acquired using a 5 to 8 ft geophone (group) spacing depending on spatial limitations. Seismic lines were oriented as shown in Figure 1. Conventionally, the first geophone was assigned a station number of 101 (0 ft position). Station numbers are converted to distance along the line by subtracting 101 from the station number and multiplying by the group interval (geophone spacing). Seismic lines were started with the source located at station 100.5 (half a station/geophone spacing behind the first geophone on the line) and, therefore, the first shot had 0 channels live behind and 144 channels live in front of the vibrator. The vibrator was then “walked” into the line at 1-station increments recording the first 144 stations until there was the desired number of channels behind and in front of the source. Spread geometry for each line is summarized in Table 3. As an example, an asymmetric 48/96 split spread has 48 channels (geophones) behind and 96 channels in front of the source. Once the vibrator was located in the appropriate position, the survey was run in a symmetric or asymmetric split spread configuration. With a split spread, the live channels and vibrator were moved forward at 1-station increments, keeping the vibrator at the center of the active spread until the last live channel was reached. Once the last live channel of the line was reached, the vibrator was “walked” off the spread, in the reverse process to the start of the line. Typically, the last source location had all 144 channels behind the vibrator.

4 DATA PROCESSING

The seismic reflection data were processed by Sterling Seismic Services of Denver, Colorado. The processing flow for the data is based on a standard common mid point (CMP) reflection processing sequence with modifications for specific conditions at the survey site. Table 4 shows generalized processing sequence steps leading to the final stacks used for interpretation for the P-wave reflection data.

The seismic section resulting from processing sequences 1 to 16 in Table 4 is referred to as the Final Stack. Additional post processing steps consisting of application of a frequency wavenumber (FX) predictive enhancement filter and spectral balancing over the 40 to 240 Hz frequency range were applied to the seismic sections. These seismic sections were used for interpretation after automatic gain control and application of a 10-20-125-175 Hz band pass filter was completed.

5 INTERPRETATION

5.1 Overview and Depth Control

The processed P-wave seismic sections without and with interpretation for the seventeen (17) seismic reflection profiles (Z1-G3 to Z1-G5, Z2-G1 to Z2-G3, Z3-G1 to Z3-G7, Z4-G1 to Z4-G2 and Z5-G2 to Z5-G3) acquired during this investigation are presented in Figures 5 to 38. These figures represent the P-wave seismic reflection data in a trace amplitude format with a band pass filter applied. The trace amplitude format displays the relative signal strength as energy is reflected from various subsurface features using either a color or gray scale display. The seismic sections included herein are displayed using a gray scale color bar with the white and black representing the highest amplitude negative and positive polarity reflections, respectively. The figures are presented with time in seconds on the vertical axis and distance in feet on the horizontal axis. Generally, the seismic images are presented at a scale with only minor estimated vertical exaggeration. A ground surface reference is added to the figures and corresponds to the top of the seismic image, except for Line Z1-G3 where a floating elevation datum was used during processing because of a large bend in the line.

A seismic workstation equipped with either the Seismic Microtechnology, Inc. 2-D interpretation package or SeiSee SEG-Y file viewing package was used for final display of the data. Typical applications of the seismic interpretation packages include: filtering, color display of seismic data, attribute calculation, digital picking (logging) of seismic event travel times, GIS mapping of seismic data, fault tracking and gain functions.

Because the primary purpose of this investigation was to locate potential faults, conversion of the seismic sections from time to depth was not required. However, a rudimentary depth scale was desired to permit identification of potential reflectors (i.e. water table versus top of bedrock). With the exception of seismic lines Z3-G1 and Z3-G3, borehole velocity data were not available to convert the time-sections to approximate depth. Even with borehole control, only rudimentary and approximate depth conversion would be possible in this geologic environment because geologic units are steeply dipping in many areas and, therefore, significant lateral velocity variation may be common. Additionally, a variable water table depth beneath a seismic line would also have a significant impact on depth.

Without borehole control, estimates of depth to groundwater and the P-wave velocity of unsaturated and saturated sediments is necessary to place a rudimentary depth scale on the seismic images. The only available geophysical data to estimate P-wave velocity structure consisted of the seismic reflection shot records and multichannel analysis of surface waves (MASW) soundings located near the ends of the seismic lines. Approximate depth to groundwater was estimated by simple, two or three layer seismic refraction analysis of surface wave seismic records and/or seismic reflection records. The surface wave sounding profiles were generally long enough to estimate depth to groundwater if shallower than 13 m (43 ft). The seismic reflection shot records were long enough to estimate depth to groundwater if shallower than 70 m (230 ft). Ground water depths estimated using this approach are probably only accurate to about 25% of depth because interpretation of unsaturated sediment P-wave velocity was complicated by high velocity asphalt first arrival data. Estimated groundwater depths for each seismic line are summarized in Table 5. Surface wave soundings were conducted near the ends of the seismic lines to develop S-wave velocity models to depths of 200 ft (60m), or more. To use these S-wave velocity models to develop approximate depth scales on the P-wave seismic sections it was necessary to determine an approximate relationship between P- and S-wave velocities. In the unsaturated zone, P-wave velocity was assumed to be twice the S-wave velocity (Poisson's ratio of 0.33), a reasonable assumption. Borehole velocity logs from 23 boreholes collected as part of this investigation and reported separately were used to develop an approximate relationship between S-wave velocity (Vs) and P-wave velocity (Vp) of the saturated sediments and rock. Figure 4 is a plot of over 3,500 Vs-Vp measurements made in saturated sediments and rock as part of the borehole geophysical logging program. A linear trend was fit to these measurements and used to relate S-wave velocity of saturated sediments derived from surface wave modeling to P-wave velocity. Depths on the seismic sections will be overestimated if the depth to the saturated zone is underestimated or if the saturated zone identified in the refraction survey is a perched water-bearing zone with lower-velocity, unsaturated sediments below. If the water table depth is underestimated by 10 ft (3 m) then the depth to underlying geologic structures could be overestimated by depths of 30 ft (10m), or more.

Geophysical data used for depth control are summarized in Table 5. Seismic lines Z3-G1 and Z3-G3 used borehole velocity logs from Z3-B4 and Z3-B7, respectively, for depth control. The remaining seismic lines used the S-wave velocity models derived from surface wave soundings, modeled approximate groundwater depth, and the Vs-Vp function for saturated sediments and rock derived from all available borehole velocity logs to estimate depth control. Estimated depths were extrapolated to 600 ft assuming a constant P-wave velocity below the maximum depth of the surface wave model or borehole velocity log. Table 3 also contains the bedrock formation expected to be encountered in the vicinity of each seismic line.

Surface wave soundings conducted near the ends of each seismic line, and reported separately, were used to determine if a significant lateral velocity variation occurred along each seismic line. Surface wave soundings, however, were not able to determine if the water table depth was highly variable beneath the line.

As is typical with seismic reflection data, data quality decreases on the edges of the section due to a decrease in data redundancy (fold).

Potential faulting is most easily observed by looking for disruptions in continuous reflectors, diffractions, offset bedding, abrupt changes in apparent dip of bedding, and other potential geologic structures indicative of faulting. Without good reflectively in the seismic section (i.e. multiple parallel reflectors from geologic strata), fault interpretation is limited to identification of diffractions and other discontinuities and may be highly subjective. Depending upon the amount of reflectivity in the seismic section, alternate interpretations of the seismic data will be possible. As an example, multiple offset reflectors are necessary to estimate the orientation of a possible fault and to make conclusive interpretation of the presence of a fault. If only a single strong reflector is present in a seismic section, then apparent small offsets or disruptions in the reflector are not conclusive evidence of faulting and accurate identification of fault orientation is not possible.

5.2 Zone 1

Three 1,912 ft (583 m) seismic reflection profiles, Z1-G3 to Z1-G5, were conducted in Zone 1 as shown on Figure 1.

5.2.1 Line Z1-G3

The processed P-wave seismic sections for Line Z1-G3 without and with interpretation are presented in Figures 5 and 6, respectively. An approximate depth scale has been added to Figure 6 using the S-wave velocity model for Z1-S6, estimated groundwater depth of 66 ft (20 m), and approach previously discussed. As shown in Figure 1, surface wave soundings Z1-S5 and Z1-S6 were conducted in the southwestern and northeastern portions of seismic line Z1-G3, respectively. The S-wave velocity models for these soundings are very similar (**GEO***Vision*, 2009) indicating that there may not be significant lateral velocity variation in the immediate vicinity of the seismic line. However, groundwater depth, which impacts P-wave velocity variation, may be highly variable beneath this line because there is over 100 ft (30 m) of elevation change. Therefore, the depth scale shown on Figure 6 may only be applicable to the northeast end of the line and accuracy will be highly dependent on the modeled water table accuracy.

A subhorizontal seismic horizon possibly associated with the top of bedrock or base of a weathering zone within bedrock is interpreted near 0.1 s (~ 50 ft) on the seismic section for line Z1-G3 (Figure 6). This horizon is not a strong continuous reflector and is interpreted as apparent truncation of underlying southwesterly dipping discontinuous reflectors. Bedrock outcrops in the vicinity of the seismic line confirm the apparent southwest dip of seismic reflectors identified in Figure 6. Interpretation of faulting in this seismic image is complicated by the combination of dipping bedding and a significant bend in the seismic line. There are two anomalous zones identified near 850 and 1,150 ft on the seismic line where there are disruptions in bedrock reflectors that could be associated with faulting. However, it is possible that at least one of these anomalies is related to the bend in the seismic line and associated change in apparent (along line) dip of geologic units.

5.2.2 Line Z1-G4

The processed P-wave seismic sections for Line Z1-G4 without and with interpretation are presented in Figures 7 and 8, respectively. An approximate depth scale has been added to Figure 8 using the S-wave velocity model for Z1-S15, estimated groundwater depth of 10 ft (3 m), and procedure discussed in the previous section. As shown in Figure 1, surface wave soundings Z1-S14 and Z1-S15 were conducted in the southwestern and northeastern portions of seismic line Z1-G4, respectively. The S-wave velocity models for these soundings are different (**GEO***Vision*, 2009) indicating that there may be significant lateral velocity variation in the immediate vicinity of the seismic line. Additionally, there may be slight variation in groundwater depth beneath this line associated with the 25 ft (8 m) of elevation change. Therefore, the depth scale shown on Figure 8 is only applicable to the northeast end of the line.

A weak, subhorizontal, discontinuous reflector possibly associated with the top of bedrock is interpreted between 0.05 and 0.08 s (~ 40 to 90 ft) on the seismic section for line Z1-G4 (Figure 8). There is poor reflectivity (absence of seismic reflectors) below the interpreted top of bedrock indicating that geologic units are either too steeply dipping for the seismic reflection method to image or that the geologic units are massive rather than interbedded. There is not enough reflectivity on this seismic line to make an accurate fault interpretation. Possible discontinuities that could be associated with minor faulting are identified in the vicinity of 280, 720 and 1,250 ft on the seismic line; however, there is insufficient reflectivity to make a conclusive interpretation.

5.2.3 Line Z1-G5

The processed P-wave seismic sections for Line Z1-G5 without and with interpretation are presented in Figures 9 and 10, respectively. An approximate depth scale has been added to Figure 10 using the S-wave velocity model for Z1-S16, estimated groundwater depth of 10 ft (3 m), and procedure discussed in the previous section. As shown in Figure 1, surface wave soundings Z1-S16 and Z1-S17 were conducted in the northern and southern portions of seismic line Z1-G5, respectively. It was not possible to develop a model for the surface wave data collected at Z1-S17 and, therefore, data on the potential lateral velocity variation along the seismic line is not available.

There is excellent reflectivity on this seismic line with multiple parallel seismic reflectors with which to interpret offset layers or discontinuities potentially associated with faulting. A subhorizontal seismic horizon possibly associated with the top of bedrock or base of a weathering zone within bedrock is interpreted in the 0.07 to 0.085 s range (~ 70 to 120 ft) on the seismic section for line Z1-G5 (Figure 10). This horizon is interpreted by both a discontinuous reflection event and apparent truncation of underlying dipping reflectors. Seismic reflectors associated with subsurface geologic structures appear to have an apparent northerly dip in the southern portion of the line and are subhorizontal/slightly dipping in the northern portion on the line. There is a significant change in dip of reflectors between 700 and 800 ft on the seismic line, which could be associated with faulting. The change in dip of bedding to the north may just be related to a syncline with the axis of the syncline located between a position of about 1,300 and 1,600 ft. The disrupted reflectors in the 700 to 800 ft range, however, may still be related to faulting rather than only folding.

5.3 Zone 2

Three seismic reflection profiles, Z2-G1 to Z2-G3, were conducted in Zone 2 as shown on Figure 1. Lines Z2-G1 and Z2-G3 have lengths of 1,792.5 ft and Line Z2-G3 has a length of 1,434 ft.

5.3.1 Line Z2-G1

The processed P-wave seismic sections for Line Z2-G1 without and with interpretation are presented in Figures 11 and 12, respectively. An approximate depth scale has been added to Figure 12 using the S-wave velocity model for Z2-S2, estimated groundwater depth of 10 ft (3 m), and approach previously discussed. As shown in Figure 1, surface wave soundings Z2-S2 and Z2-S3 were conducted in the northern and southern portions of seismic line Z2-G1, respectively. The S-wave velocity models for these soundings are very similar (**GEO***Vision*, 2009) indicating that there may not be significant lateral velocity variation in the immediate vicinity of the seismic line. There is only about 25 ft (8 m) of elevation change along the seismic line and groundwater depth may not be highly variable. Therefore, the approximate depth scale shown on Figure 12 may be applicable to the entire line providing that velocity assumptions and the groundwater depth estimate represent actual site conditions.

A subhorizontal, continuous seismic reflector possibly associated with the top of bedrock is interpreted between 0.055 and 0.07 s (~ 60 to 100 ft) on the line Z2-G1 seismic section (Figure 12). There is only minor reflectivity below the interpreted bedrock surface possibly due to bedrock consisting of massive rather than interbedded geologic units or steeply dipping geologic units. The absence of significant reflectivity within the bedrock unit makes accurate and conclusive fault interpretation difficult. There are two anomalous zones identified between 600 and 650 ft and 1,140 and 1,180 ft on the seismic line that could be associated with potential faulting. Both of these anomalous zones were identified based on disruptions of limited bedrock reflectors.

5.3.2 Line Z2-G2

The processed P-wave seismic sections for Line Z2-G2 without and with interpretation are presented in Figures 13 and 14, respectively. An approximate depth scale has been added to Figure 14 using the S-wave velocity model for Z2-S8, estimated groundwater depth of 23 ft (7 m), and approach previously discussed. As shown in Figure 1, surface wave soundings Z2-S7 and Z2-S8 were conducted in the southwestern and northeastern portions of seismic line Z2-G2, respectively. The S-wave velocity models for these soundings are very similar above a depth of 130 ft (40 m) but somewhat different and greater depths (**GEO***Vision*, 2009) indicating that there may be some lateral velocity variation in the immediate vicinity of the seismic line. There is only about 20 ft (6 m) of elevation change along the seismic line and groundwater depth may not be highly variable. The approximate depth scale shown on Figure 12 may primarily apply to the northeastern side of the seismic line providing that velocity assumptions and the groundwater depth estimate represent actual site conditions.

A subhorizontal, continuous seismic reflector possibly associated with the top of bedrock is interpreted between 0.1 and 0.12 s (~ 175 to 225 ft) on the line Z2-G2 seismic section (Figure 12). The surface wave soundings along this seismic line indicate that bedrock may be shallower, possibly in the 125 to 150 ft depth range. An incorrect groundwater depth estimate, the presence of a perched water table and/or lower P-wave velocities in unsaturated and saturates sediments could easily account for this depth discrepancy. There is only minor reflectivity below the interpreted bedrock surface possibly due to bedrock consisting of massive rather than interbedded geologic units or steeply dipping geologic units. The absence of significant reflectivity within the bedrock unit makes accurate and conclusive fault interpretation difficult. There are two anomalous zones identified between 750 and 775 ft and 1,475 and 1,525 ft on the seismic line that could be associated with potential faulting. Both of these anomalous zones were identified based on disruptions of limited bedrock reflectors.

5.3.3 Line Z2-G3

The processed P-wave seismic sections for Line Z2-G3 without and with interpretation are presented in Figures 15 and 16, respectively. An approximate depth scale has been added to Figure 16 using the S-wave velocity model for Z2-S10, estimated groundwater depth of 30 ft (9 m), and previously discussed approach. As shown in Figure 1, surface wave soundings Z2-S10 and Z2-S11 were conducted in the northwestern and southeastern portions of seismic line Z2-G3, respectively. The S-wave velocity models for these soundings are very similar (**GEO***Vision*, 2009) indicating that there may not be significant lateral velocity variation in the immediate vicinity of the seismic line. There is, however, about 70 ft (21 m) of elevation change along the seismic line increasing the possibility of significant variation in groundwater depth, which would cause variation in depth along the seismic line.

A subhorizontal, continuous seismic reflector possibly associated with the top of bedrock is interpreted between 0.06 and 0.075 s (~ 60 to 125 ft) on the line Z2-G3 seismic section (Figure 12). There is some reflectivity below the interpreted bedrock surface indicating that sedimentary units may have a slight apparent dip to the southeast along the seismic line. There are no apparent large offsets in bedrock reflectors indicative of conclusive faulting. There is, however, a minor discontinuity in the upper bedrock reflectors near 650 ft on the seismic line, which could potentially be associated with minor faulting.

5.4 Zone 3

Seven seismic reflection profiles, Z3-G1 to Z3-G7, were conducted in Zone 3 as shown on Figure 1. Lines Z3-G1 and Z3-G3 have lengths of 1,912 ft. Line Z3-G2 has a length of 1,195 ft. Line Z3-G4 has a length of 1,434 ft. Lines Z3-G5 and Z3-G7 have lengths of 1,578 ft and Line Z3-G6 has a length of 1,506 ft.

5.4.1 Line Z3-G1

The processed P-wave seismic sections for Line Z3-G1 without and with interpretation are presented in Figures 17 and 18, respectively. An approximate depth scale has been added to Figure 18 using the P-wave velocity log from borehole Z3-B4. As shown in Figure 1, surface wave soundings Z3-S3 and Z3-S4 were conducted in the northern and southern portions of seismic line Z3-G1, respectively. The S-wave velocity models for these soundings are very similar (**GEO***Vision*, 2009) indicating that there may not be significant lateral velocity variation in the immediate vicinity of the seismic line. There is only about 15 ft (4.5 m) of elevation change along the seismic line and groundwater depth may not be highly variable. Therefore, the approximate depth scale shown on Figure 12 may be applicable to the entire line providing that velocity assumptions and the groundwater depth estimate represent actual site conditions.

A subhorizontal, continuous seismic reflector possibly associated with the top of bedrock or weathering contact within bedrock is interpreted between 0.14 and 0.16 s (~ 175 to 270 ft) on the line Z3-G1 seismic section (Figure 18). This reflector appears too deep for groundwater or the bedrock surface, which were encountered in borehole Z3-B4 at about 148 ft (45 m) and 185 ft (56 m), respectively. Assuming some lateral velocity variation in P-wave velocity across the site, the reflector may be associated with the top of crystalline bedrock but could also be associated with an abrupt contact between highly weathered and slightly weathered bedrock.

There is no reflectivity below the interpreted bedrock reflector because bedrock consists of crystalline rock, which has no bedding. The absence of significant reflectivity within the bedrock unit makes conclusive fault interpretation impossible. There are multiple discontinuities in the bedrock reflector, approximately located near 200, 550, 840, 1,100, 1,340 and 1,440 ft. Many of these bedrock discontinuities may be associated with topographic variation of the bedrock surface or bedrock weathering contacts. It is also possible that some of the discontinuities are related to bedrock offsets caused by faulting rather than erosion.

5.4.2 Line Z3-G2

The processed P-wave seismic sections for Line Z3-G2 without and with interpretation are presented in Figures 19 and 20, respectively. An approximate depth scale has been added to Figure 20 using the S-wave velocity model for Z3-S6, estimated groundwater depth of 16 ft (5 m), and previously discussed methodology. As shown in Figure 1, surface wave soundings Z3-S6 and Z3-S7 were conducted near the north and south ends of seismic line Z3-G2, respectively. The S-wave velocity models for these soundings differ by more than 10 % (**GEO***Vision*, 2009) indicating that there may be some lateral velocity variation in the immediate vicinity of the seismic line. There is only about 3 ft (1 m) of elevation change along the seismic line and groundwater depth may not be highly variable. The approximate depth scale shown on Figure 12 may vary by 10% or more across the seismic line.

Subhorizontal, continuous seismic reflectors possibly associated with top of bedrock and/or a weathering zone within bedrock are interpreted between 0.03 and 0.04 s (~ 40 to 60 ft) and 0.05 and 0.07 s (~ 100 to 175 ft) on the line Z3-G2 seismic section (Figure 20). The surface wave soundings along this seismic line indicate that bedrock may be associated with the upper reflector with the lower reflector associated with a change in weathering within bedrock or other bedrock structure. There is only minor reflectivity below the interpreted bedrock surface possibly due to bedrock consisting of massive rather than interbedded geologic units or steeply dipping geologic units. The absence of significant reflectivity within the bedrock unit makes accurate and conclusive fault interpretation difficult. There are two anomalous zones identified near 420 and 700 ft on the seismic line that could be associated with potential faulting. Both of these anomalous zones were identified based on disruptions of limited bedrock reflectors.

5.4.3 Line Z3-G3

The processed P-wave seismic sections for Line Z3-G3 without and with interpretation are presented in Figures 21 and 22, respectively. An approximate depth scale has been added to Figure 22 using the P-wave velocity log from borehole Z3-B7. As shown in Figure 1, surface wave soundings Z3-S9 and Z3-S10 were conducted near the southwest and northeast ends of seismic line Z3-G3, respectively. The S-wave velocity models for these soundings are significantly different (**GEO***Vision*, 2009) indicating that there may be some lateral velocity variation in the immediate vicinity of the seismic line. There is also about 26 ft (8 m) of elevation change along the seismic line, which may contribute to variable water table depth and associated lateral velocity variation and groundwater depth may not be highly variable. The approximate depth scale shown on Figure 22 is most applicable in the central portion of the seismic line near the borehole.

Subhorizontal, discontinuous seismic reflectors possibly associated with groundwater, top of bedrock and/or a weathering zone within bedrock are interpreted between 0.04 and 0.055 s (~ 60 to 100 ft) and 0.06 and 0.09 s (~ 120 to 270 ft) on the line Z3-G3 seismic section (Figure 22). The surface wave soundings and borehole along this seismic line indicate that bedrock may be associated with the upper reflector, although there may not be an abrupt change in velocity between weathered bedrock and overlying sediments in the vicinity of the seismic line. The lower reflector may be associated with a change in weathering within bedrock or other bedrock structure. There is only minor reflectivity below the interpreted bedrock surface possibly due to bedrock consisting of massive rather than interbedded geologic units or steeply dipping geologic units. The bedrock reflectors identified on the seismic section (Figure 22) occur at depths below

600 ft. The seismic reflection survey was not designed to image to these depths and there is a possibility that the reflection events are associated with coherent noise. The absence of significant reflectivity within the bedrock unit makes accurate and conclusive fault interpretation difficult. There are two anomalous zones identified between 450 and 500 ft and 1,000 and 1,050 ft that could be associated with potential faulting. Both of these anomalous zones were identified based on disruptions of limited bedrock reflectors.

5.4.4 Line Z3-G4

The processed P-wave seismic sections for Line Z3-G4 without and with interpretation are presented in Figures 23 and 24, respectively. An approximate depth scale has been added to Figure 24 using the S-wave velocity model for Z3-S13, estimated groundwater depth of 56 ft (17 m), and previously discussed methodology. As shown in Figure 1, surface wave soundings Z3-S13 and Z3-S14 were conducted near the northeast and southwest ends of seismic line Z3-G4, respectively. There is also a borehole (Z3-B9) located near this seismic line, which indicates that crystalline basement rock is present beneath the line. The S-wave velocity models for the surface wave soundings are very similar (**GEO***Vision*, 2009) indicating that there may be only minor lateral velocity variation in the immediate vicinity of the seismic line. There is only about 20 ft (6 m) of elevation change along the seismic line and groundwater depth may not be highly variable.

Subhorizontal, continuous seismic reflectors possibly associated with groundwater and top of crystalline bedrock are interpreted between 0.05 and 0.06 s (~ 30 to 45 ft) and 0.085 and 0.115 s (~ 80 to 200 ft) on the line Z3-G4 seismic section (Figure 24). Nearby borehole Z3-B9 indicates that the lower reflector may be associated with the top of crystalline basement. The upper reflector may be associated with the water table or sediment layer above the water table.

There is no reflectivity below the interpreted bedrock reflector because bedrock consists of crystalline rock, which has no bedding. The absence of significant reflectivity within the bedrock unit makes conclusive fault interpretation impossible. There is a significant drop in the interpreted bedrock surface between 220 and 320 ft, which may be erosional or potentially related to faulting. There are also other disruptions in the possible bedrock reflector near 750, 1,030 and 1,210 ft.

5.4.5 Line Z3-G5

The processed P-wave seismic sections for Line Z3-G5 without and with interpretation are presented in Figures 25 and 26, respectively. An approximate depth scale has been added to Figure 26 using the S-wave velocity model for Z3-S17, estimated groundwater depth of 26 ft (8 m), and previously discussed methodology. As shown in Figure 1, surface wave soundings Z3-S17 and Z3-S18 were conducted in the north central and south central portions of seismic line Z3-G5, respectively. The S-wave velocity models for these soundings are generally similar although there is apparent variation in bedrock depth (**GEO***Vision*, 2009) indicating that there may be some lateral velocity variation in the immediate vicinity of the seismic line. There is also about 62 ft (19 m) of elevation change along the seismic line, which may contribute to variable water table depth and associated lateral velocity variation. The approximate depth scale shown on Figure 26 may only apply to the central portion of the seismic line.

A high amplitude, subhorizontal, continuous seismic reflector possibly associated with top of bedrock is interpreted between 0.04 and 0.1 s (~ 140 ft) on the line Z3-G5 seismic section

(Figure 26). The surface wave soundings along this seismic line indicate that bedrock may be located in the 70 to 85 ft (21 to 26 m) depth range. If groundwater were about 15 to 20 ft (4.5 to 6 m) deeper than that used for depth control then the high amplitude reflector would be in the appropriate depth range. The possible bedrock reflector is continuous except for minor discontinuities at 230 and 450 ft, which could be associated with faulting. A more diffuse reflector that may be associated with a possible weathering zone within bedrock is interpreted between 0.14 and 0.17 s (~ 375 to 500 ft). Below the lower reflector, geologic units appear to have apparent dip in a northerly direction. Many of these reflectors are very deep relative to the data acquisition geometry and, therefore, could be related to coherent noise rather than geologic structure. Additionally, several small diffractions appear to line up in the vicinity of 800 ft on the profile beneath the lower reflector. Although unlikely, the possibility that these diffractions are associated with minor faulting cannot be discounted.

5.4.6 Line Z3-G6

The processed P-wave seismic sections for Line Z3-G6 without and with interpretation are presented in Figures 27 and 28, respectively. An approximate depth scale has been added to Figure 28 using the S-wave velocity model for Z3-S21, estimated groundwater depth of 52 ft (16 m), and previously discussed methodology. As shown in Figure 1, surface wave soundings Z3-S21 and Z3-S22 were conducted in the northern and southern portions of seismic line Z3-G6, respectively. The S-wave velocity models for these soundings are generally similar (**GEO***Vision*, 2009) indicating that there may not be significant lateral velocity variation in the immediate vicinity of the seismic line. There is about 45 ft (14 m) of elevation change along the seismic line, which may contribute to variable water table depth and associated lateral velocity variation. The approximate depth scale shown on Figure 28 may apply to much of the seismic line.

A subhorizontal, continuous seismic reflector possibly associated with top of bedrock is interpreted between 0.085 and 0.1 s (~ 100 to 115 ft) on the line Z3-G6 seismic section (Figure 28). The surface wave soundings along this seismic line indicate that bedrock may be located in the 92 to 102 ft (28 to 31 m) depth range, which confirms that the reflector may be associated with the top of bedrock. There is excellent reflectively below the interpreted bedrock surface with multiple parallel seismic reflectors with which to interpret offset layers or discontinuities potentially associated with faulting. There is a significant disruption and possible offset of reflectors in the 910 to 950 ft range, which may be associated with faulting. There is also a minor disruption in reflectors between 375 and 440 ft, which could be associated with faulting.

5.4.7 Line Z3-G7

The processed P-wave seismic sections for Line Z3-G7 without and with interpretation are presented in Figures 29 and 30, respectively. An approximate depth scale has been added to Figure 30 using the S-wave velocity model for Z3-S23, estimated groundwater depth of 39 ft (12 m), and previously discussed methodology. As shown in Figure 1, surface wave soundings Z3-S23 and Z3-S24 were conducted in the northern and southern portions of seismic line Z3-G7, respectively. The S-wave velocity models for these soundings are different (**GEO***Vision*, 2009) indicating that there may be significant lateral velocity variation in the immediate vicinity of the seismic line. There is about 25 ft (8 m) of elevation change along the seismic line, which may contribute to variable water table depth and associated lateral velocity variation. The approximate depth scale shown on Figure 28 may only apply to the northern portion of the seismic line.

A subhorizontal, discontinuous seismic reflector possibly associated with top of bedrock is interpreted between 0.06 and 0.085 s (~ 40 to 100 ft) on the line Z3-G7 seismic section (Figure 30). A borehole located in the vicinity of the seismic line (Z1-B8) indicates that the uppermost bedrock zone may be highly weathered and not easily distinguished from overlying sediments based on S-wave velocity. Therefore, the surface wave soundings along this seismic line were only able to indicate that bedrock may be located in the 23 to 118 ft (7 to 36 m) depth range, which is consistent with the interpretation of the bedrock reflector. There is good reflectively below the interpreted bedrock surface in the southern half of the seismic line with multiple parallel seismic reflectors with which to interpret offset layers or discontinuities potentially associated with faulting. There is a significant change in reflectivity in the northern portion of the line associated with a possible fault interpreted between 880 and 920 ft. Additionally, there is also a minor disruption in reflectors around 250 ft on the line, which could also be associated with faulting.

5.5 Zone 4

Two seismic reflection profiles, Z4-G1 and Z4-G2, were conducted in Zone 4 as shown on Figure 1. Lines Z4-G1 and Z4-G2 have lengths of 3,832 and 1,912 ft, respectively.

5.5.1 Line Z4-G1

The processed P-wave seismic sections for Line Z4-G1 without and with interpretation are presented in Figures 31 and 32, respectively. An approximate depth scale has been added to Figure 32 using the S-wave velocity model for Z4-S2, estimated groundwater depth of 210 ft (64 m), and approach previously discussed. As shown in Figure 1, surface wave soundings Z4-S2, Z4-S3 and Z4-S4 were conducted in the northern, central and southern portions of seismic line Z4-G1, respectively. The S-wave velocity models for these soundings are very different (**GEO***Vision*, 2009) indicating that there may be significant lateral velocity variation in the immediate vicinity of the seismic line. There is also over 120 ft (37 m) of elevation change along the seismic line, which may contribute to variable groundwater depth and associated lateral velocity variation. Additionally, groundwater depths are not accurately resolved on this seismic line, which may contribute to significant depth errors. The approximate depth scale shown on Figure 32 may only be applicable to the northern portion of the seismic line and may have errors in excess of 25%.

Seismic line Z4-G1 crosses the Raymond Fault Zone. A scarp associated with the fault is located between about 1,200 and 2,000 ft on the seismic line. Bedrock may be located at depths in excess of 500 ft beneath this seismic line and there is no clear seismic reflection associated with the top of bedrock. There is not much reflectively in the seismic section, possibly because the old alluvium overlying bedrock does not have laterally extensive continuous bedding, and/or energy attenuation through the thick unsaturated zone. The absence of significant reflectively makes accurate fault interpretation difficult. There is, however, a significant change in reflectively on the seismic line between 800 and 2,000 ft revealed by abrupt termination change in apparent dip of reflectors at the southern end and change in dip of reflectors and possible large diffractions at the northern end of the zone. Potential faults are identified in the vicinity of 900, 1,500 and 2,000 ft on the seismic line although, given the minimal reflectivity, alternative interpretations are possible.

5.5.2 Line Z4-G2

The processed P-wave seismic sections for Line Z4-G2 without and with interpretation are presented in Figures 33 and 34, respectively. An approximate depth scale has been added to Figure 34 using the S-wave velocity model for Z4-S6, estimated groundwater depth of 215 ft (65 m), and approach previously discussed. As shown in Figure 1, surface wave soundings Z4-S6 and Z4-S7 were conducted in the northeastern and southwestern portions of seismic line Z4-G2, respectively. The S-wave velocity models for these soundings are very similar (**GEO***Vision*, 2009) indicating that there may not be significant lateral velocity variation in the immediate vicinity of the seismic line. There is also only 5 ft (1.5 m) of elevation change along the seismic line. Groundwater depths are not accurately resolved beneath this seismic line, however, there is no reason to believe that there is significant depth variation of the water table beneath the line. The approximate depth scale shown on Figure 34 may be applicable to the entire seismic line, providing the assumptions made to estimate depths are reasonably valid.

A high amplitude, subhorizontal, continuous seismic reflector possibly associated with the water table is interpreted between 0.15 and 0.175 s (~ 170 to 220 ft) on the line Z4-G2 seismic section (Figure 34). Another continuous reflector is identified between 0.28 and 0.3 s (~ 525 to 600 ft). The location of this reflector is such that the possibility that it is a multiple reflection from the possible water table cannot be discounted. Other than the two reflectors identified above there is not sufficient reflectivity in the seismic section for detailed fault interpretation. Two possible fault-like anomalies are identified in the seismic section near 1,220 and 1,520 ft. These structures are primarily identified by changes in apparent dip and disruptions of the water table reflector, which may occur if a fault acts as a groundwater barrier. These features cannot be accurately mapped on the seismic section due to absence of reflectivity and, therefore, cannot be confirmed as faults.

5.6 Zone 5

Two seismic reflection profiles, Z5-G2 and Z5-G3, were conducted in Zone 5 as shown on Figure 1. Both lines Z5-G2 and Z5-G3 have a length of 1,912 ft.

5.6.1 Line Z5-G2

The processed P-wave seismic sections for Line Z5-G2 without and with interpretation are presented in Figures 33 and 34, respectively. An approximate depth scale has been added to Figure 34 using the S-wave velocity model for Z5-S8, estimated groundwater depth of 184 ft (56 m), and approach previously discussed. As shown in Figure 1, surface wave soundings Z5-S8, and Z5-S9 were conducted in the eastern and western portions of seismic line Z5-G2, respectively. The S-wave velocity models for these soundings are very similar (**GEO***Vision*, 2009) indicating that there may not be significant lateral velocity variation in the immediate vicinity of the seismic line. There is about 36 ft (11 m) of elevation change along the seismic line, which may contribute to variable groundwater depth and some associated lateral velocity variation. Groundwater depth is not well constrained along this seismic line. The approximate depth scale shown on Figure 36 may be applicable to much of the seismic line providing the groundwater depth estimate is reasonably accurate.

The seismic section has good reflectivity with multiple discontinuous reflectors to approximate depths of over 600 ft. Reflectors associated with the water table or bedrock surface were not identified to a high degree of confidence. Bedrock is expected to be very deep in the vicinity of this seismic line. A possible fault-like anomaly was identified in the seismic section at about 740 ft and was identified by disruptions in several reflectors, particularly those in the 600 ft depth range. A more subtle anomalous zone that could be associated with faulting was identified between 1,600 and 1,650 ft.

5.6.2 Line Z5-G3

The processed P-wave seismic sections for Line Z5-G3 without and with interpretation are presented in Figures 37 and 38, respectively. An approximate depth scale has been added to Figure 38 using the S-wave velocity model for Z5-S12, estimated groundwater depth of 52 ft (16 m), and approach previously discussed. As shown in Figure 1, surface wave soundings Z5-S12, and Z5-S13 were conducted in the northern and southern portions of seismic line Z5-G3, respectively. The S-wave velocity models for these soundings are very similar (**GEO***Vision*, 2009) indicating that there may not be significant lateral velocity variation in the immediate vicinity of the seismic line. There is only about 16 ft (5 m) of elevation change along the seismic line. The approximate depth scale shown on Figure 38 may be applicable to the entire seismic line providing the groundwater depth estimate is accurate.

A high amplitude, subhorizontal, continuous seismic reflector possibly associated with the top of bedrock is interpreted between 0.14 and 0.16 s (~ 280 to 330 ft) on the line Z5-G3 seismic section (Figure 38). This reflector appears to be much too deep to be associated with the water table, although the reflector could be associated with a continuous geologic layer within alluvial sediments rather than bedrock. There is not significant reflectivity below the interpreted bedrock reflector until depths below 600 ft where possible northward dipping geologic units are identified. Several possible, but not conclusive, fault-like anomalies are identified in the seismic section at 300 and 920 ft and 1,350 to 1,450 ft. These structures were identified by disruption of the potential top of bedrock reflector and underlying reflectors at depth. Reduction of fold (data redundancy) at the ends of the seismic line may contribute to possible incorrect interpretation of the structures at 300 ft and 1,400 ft.

6 REFERENCES

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7 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.

October 5, 2009

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* 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.

TABLES

Table 1. Seismic Line Locations

Line	Station	Position (ft)	Northing (US ft)	Easting (US ft)	Elevation (ft MSL)
Z1-G3	101	0	1853598	6487832	579
Z1-G3	251	1200	1854484	6488636	525
Z1-G3	238	1096	1854396	6488580	536
Z1-G3	340	1912	1855142	6488901	477
Z1-G4	101	0	1851571	6503615	427
Z1-G4	340	1912	1853095	6504768	450
Z1-G5	101	0	1851287	6507737	449
Z1-G5	340	1912	1853200	6507732	459
Z2-G1	101	0	1866438	6496103	519
Z2-G1	175	555	1866977	6496229	492
Z2-G1	181	600	1867019	6496244	493
Z2-G1	340	1792.5	1868182	6496515	517
Z2-G2	101	0	1860667	6500501	503
Z2-G2	340	1792.5	1861576	6502044	519
Z2-G3	101	0	1854399	6508688	482
Z2-G3	333	1392	1855642	6508062	541
Z2-G3	340	1434	1855692	6508069	556
Z3-G1	101	0	1868860	6516666	739
Z3-G1	340	1912	1870771	6516652	755
Z3-G2	101	0	1867383	6512290	685
Z3-G2	340	1195	1868579	6512310	687
Z3-G3	101	0	1865627	6509704	584
Z3-G3	340	1912	1866908	6511124	608
Z3-G4	101	0	1863281	6510441	612
Z3-G4	340	1434	1864450	6511274	631
Z3-G5	101	0	1858529	6510383	579
Z3-G5	125	144	1858674	6510377	588
Z3-G5	158	342	1858864	6510328	598
Z3-G5	209	648	1859164	6510324	614
Z3-G5	258	942	1859462	6510322	626
Z3-G5	302	1206	1859727	6510318	633
Z3-G5	336	1410	1859921	6510377	636
Z3-G5	364	1578	1860066	6510461	643
Z3-G6	101	0	1851978	6513112	425
Z3-G6	364	1578	1853555	6513105	471
Z3-G7	101	0	1848225	6513201	423
Z3-G7	170	414	1848639	6513200	432
Z3-G7	244	858	1849084	6513199	415
Z3-G7	300	1194	1849419	6513201	418
Z3-G7	340	1434	1849659	6513201	418
Z3-G7	364	1578	1849803	6513202	415

California State Plane coordinate system, North American Datum 1983, Zone V (0405), US Survey Feet.
Horizontal accuracy is approximately 1m, vertical accuracy is approximately 2m.

Table 1 (continued) Seismic Line Locations

Line	Station	Position (ft)	Northing (US ft)	Easting (US ft)	Elevation (ft MSL)
Z4-G1	101	0	1866934	6528963	569
Z4-G1	180	632	1867563	6528843	580
Z4-G1	209	864	1867761	6528740	584
Z4-G1	580	3832	1869568	6528421	677
Z4-G2	101	0	1861662	6521381	556
Z4-G2	340	1912	1862851	6522877	550
Z4-G3	101	0	1851789	6526290	398
Z4-G3	340	1912	1851899	6528198	362
Z5-G3	101	0	1848497	6516641	420
Z5-G3	340	1912	1850408	6516625	435

California State Plane coordinate system, North American Datum 1983, Zone V (0405), US Survey Feet.
Horizontal accuracy is approximately 1m, vertical accuracy is approximately 2m.

Table 2. Generalized Data Acquisition Parameters

Shot Spacing	6 – 8 ft , centered on half stations
Geophone Group Interval	5 – 8 ft
Maximum CDP Fold	72
Maximum Offset	429 to 956 ft
Minimum Offset	2.5 – 4 ft
Spread Geometry	Walk on to asymmetric split spread/symmetric split spread, walk off
Seismograph	OYO DAS-1 Recorder
Number of Channels	144
Sample Rate	0.5 ms
Record Length	8 second sweep, 0.5 – 1 seconds after correlation
Field Filters	3 Hz lo-cut
Seismic Source	IVI Envirovibe
Geophones	OYO Geospace 28 Hz vertical

Table 3. Data Acquisition and Vibrator Parameters

Line	Line Length (feet)	Shot Spacing (feet)	Group Interval (feet)	Minimum Offset (feet)	Nominal Maximum Offset (feet)	Normal Spread Geometry	Sweep Frequency (Hz)	Sweep Length (sec)	Listen Time (sec)
Z1-G3	1912	8	8	4	860	asymmetric 36/108 split	20 - 240	8	1
Z1-G4	1912	8	8	4	764	asymmetric 48/96 split	20 - 240	8	1
Z1-G5	1912	8	8	4	764	asymmetric 48/96 split	20 - 240	8	1
Z2-G1	1792.5	7.5	7.5	3.75	716.25	asymmetric 48/96 split	20 - 200	8	1
Z2-G2	1792.5	7.5	7.5	3.75	716.25	asymmetric 48/96 split	20 - 240	8	1
Z2-G3	1434	6	6	3	645	asymmetric 36/108 split	20 - 240	8	1
Z3-G1	1912	8	8	4	764	asymmetric 48/96 split	20 - 240	8	1
Z3-G2	1195	5	5	2.5	597.5	asymmetric 24/120 split	20 -240	8	0.5
Z3-G3	1912	8	8	4	764	asymmetric 48/96 split	20 - 240	8	1
Z3-G4	1434	6	6	3	573	asymmetric 48/96 split	20 - 240	8	1
Z3-G5	1578	6	6	3	573	asymmetric 48/96 split	20 - 240	8	1
Z3-G6	1506	6	6	3	429	symmetric 72/72 split	20 - 240	8	0.5
Z3-G7	1578	6	6	3	429	symmetric 72/72 split	20 - 240	8	0.5
Z4-G1	3832	8	8	4	764	asymmetric 48/96 split	20 - 200	8	1
Z4-G2	1912	8	8	4	764	asymmetric 48/96 split	20 - 240	8	1
Z5-G2	1912	8	8	4	956	asymmetric 24/120 split	20 - 240	8	1
Z5-G3	1912	8	8	4	860	asymmetric 36/108 split	20 - 240	8	1

Table 4. Generalized Processing Sequence

Sequence #	Description
1	SEG2 TO INTERNAL FORMAT CONVERSION
2	VIBROSEIS CORRELATION
3	GEOMETRY, SURVEY IMPORT AND TRACE EDITING
4	TRUE AMPLITUDE GAIN RECOVERY
5	TRACE TO TRACE EDITING
6	ELEVATION / DATUM STATICS APPLICATION:
	DATUM: INTERMEDIATE FLOATING/NMO DATUM
	VC: 6000 FEET/SEC
7	SURFACE CONSISTENT AMPLITUDE ANALYSIS AND COMPENSATION
8	MINIMUM PHASE CORRECTION FILTER FOR VIBROSEIS DATA
9	SURFACE CONSISTENT DECONVOLUTION:
	TYPE: SPIKING OPERATOR LENGTH: 160 MSEC NOISE: 0.1%
10	SPECTRAL WHITENING: 20-240 HZ
11	COMMON DEPTH POINT GATHERS:
	CDP BIN SIZE: 2.5 – 4 FEET
	PASS 1: VELOCITY AND MUTE ANALYSIS
	PASS 1: NORMAL MOVEOUT CORRECTION AND MUTE APPLICATION
	PASS 1: SURFACE CONSISTENT AUTOMATIC STATICS APPLICATION
	PASS 2: VELOCITY AND MUTE ANALYSIS
	PASS 2: NORMAL MOVEOUT CORRECTION AND MUTE APPLICATION
	PASS 2: SURFACE CONSISTENT AUTOMATIC STATICS APPLICATION
12	SURFACE/SOURCE WAVE / LINEAR NOISE ATTENUATION
13	TIME-VARIANT AMPLITUDE EQUALIZATION
	PASS 3: VELOCITY AND MUTE ANALYSIS
	PASS 3: NORMAL MOVEOUT CORRECTIONS AND MUTE APPLICATION
	PASS 3: SURFACE CONSISTENT AUTOMATIC STATICS APPLICATION
14	CDP CONSISTENT TRIM STATICS: 4 MSEC MAXIMUM SHIFT
15	COMMON DEPTH POINT STACK
16	FINAL DATUM CORRECTION:
	DATUM: FIXED FOR EACH LINE
	VC: 6000 FEET/SEC
17	FX PREDICTIVE ENHANCEMENT FILTER
18	SPECTRAL BALANCING: 40-240 HZ

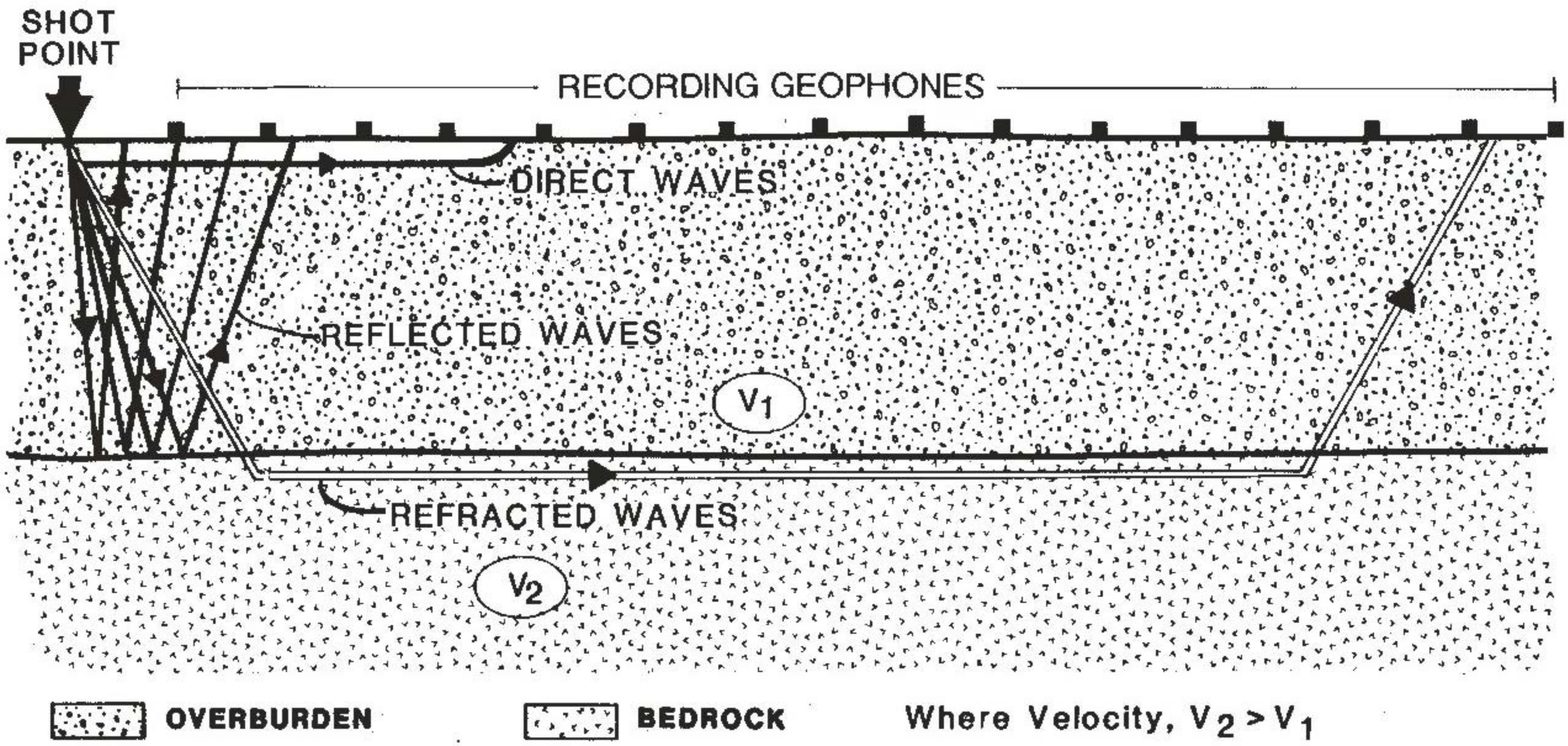
Table 5. Seismic Reflection Depth Control

Line	Depth Control Source	Estimated Groundwater Depth		Groundwater Depth Source[1]	Expected Bedrock Type
		m	ft		
Z1-G3	Z1-S6	20	66	SR	Puente Fm
Z1-G4	Z1-S15	3	10	SW	Puente Fm
Z1-G5	Z1-S16	3	10	SW	Puente Fm
Z2-G1	Z2-S2	3	10	SW	Topanga Fm
Z2-G2	Z2-S8	7	23	SW	Puente Fm/Topanga Fm
Z2-G3	Z2-S10	9	30	SW	Puente Fm
Z3-G1	Z3-S3 & Z3-B4	45	148	B	Crystalline Basement
Z3-G2	Z3-S6	5	16	SW	Topanga Fm
Z3-G3	Z3-S10 & Z3-B7	3	10	B/SW	Topanga Fm
Z3-G4	Z3-S13	17	56	SR	Topanga Fm/Crystalline Basement
Z3-G5	Z3-S17	8	26	SW	Topanga Fm
Z3-G6	Z3-S21	16	52	SR	Puente Fm
Z3-G7	Z3-S23	12	39	SW	Puente Fm
Z4-G1	Z4-S2	64	210	SR	Puente Fm
Z4-G2	Z4-S6	65	213	SR	Puente Fm
Z5-G2	Z5-S8	56	184	SR	Puente Fm
Z5-G3	Z5-S12	16	52	SW	Puente Fm

1) SR - Seismic Reflection Data, SW - Surface Wave Data, B - Borehole Data

FIGURES

Zone 1
Zone 2
Zone 3
Zone 4
Zone 5
Legend
Active and Passive Surface Wave Sounding
Borehole
Seismic Line
NOTES:
1. COORDINATES SYSTEM - NAD 1983
California State Plane Zone V (0405) US Feet
2. AERIAL PHOTOGRAPHIC SOURCE - USA Prime Imagery
2,000 1,000 0 2,000
Feet
N
GEOVision geophysical services
GV Project: 9001
Date: 10-05-09
Developed by: A Martin
Drawn by: T Rodriguez
Approved by: A Martin
File: 9001.MXD
FIGURE 1
SITE MAP
SR-710 TUNNEL
TECHNICAL STUDY
LOS ANGELES COUNTY, CALIFORNIA
PREPARED FOR
CH2M HILL



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Date: AUG 4, 2009

Drawn By: A MARTIN

Approved By: Antony J Martin

File R:\...Project Files\2009\9001ch2mhill\REFLReport\FIGURES\Figure2.cdr

FIGURE 2
SEISMIC RAYPATH GEOMETRY

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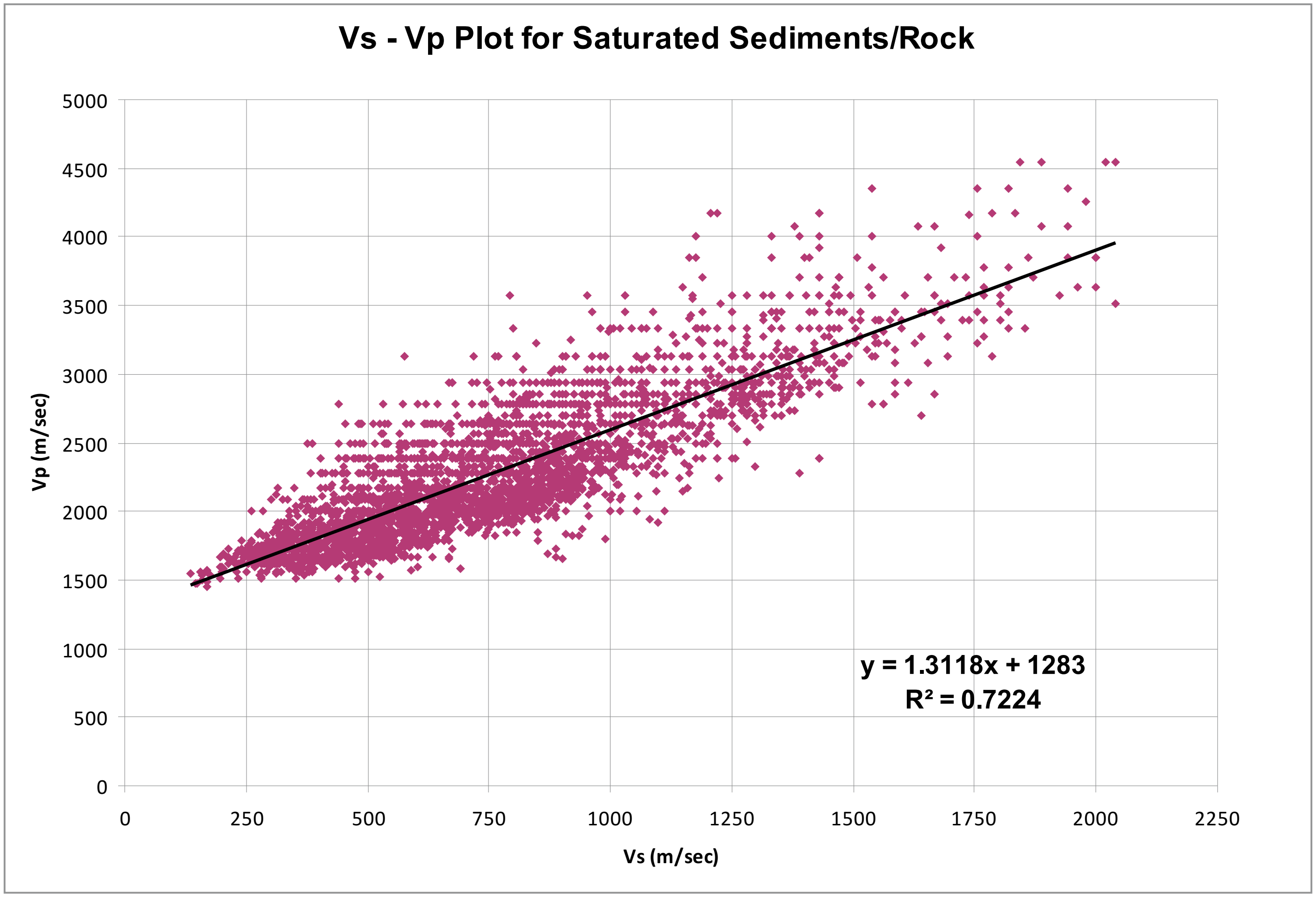
TYPICAL SEISMIC LINE

IVI ENVIROVIBE

SEISMIC RECORDING SYSTEM

GEOVision geophysical services	FIGURE 3 PHOTOGRAPHS OF TYPICAL SEISMIC REFLECTION FIELD SETUP
Project # 9001 Date: AUG 4, 2009 Drawn By: A MARTIN	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Approved By: Antony J Martin File R:\...Project Files\2009\9001ch2mhill\REFLReport\FIGURES\Figure3.cdr	PREPARED FOR CH2M HILL



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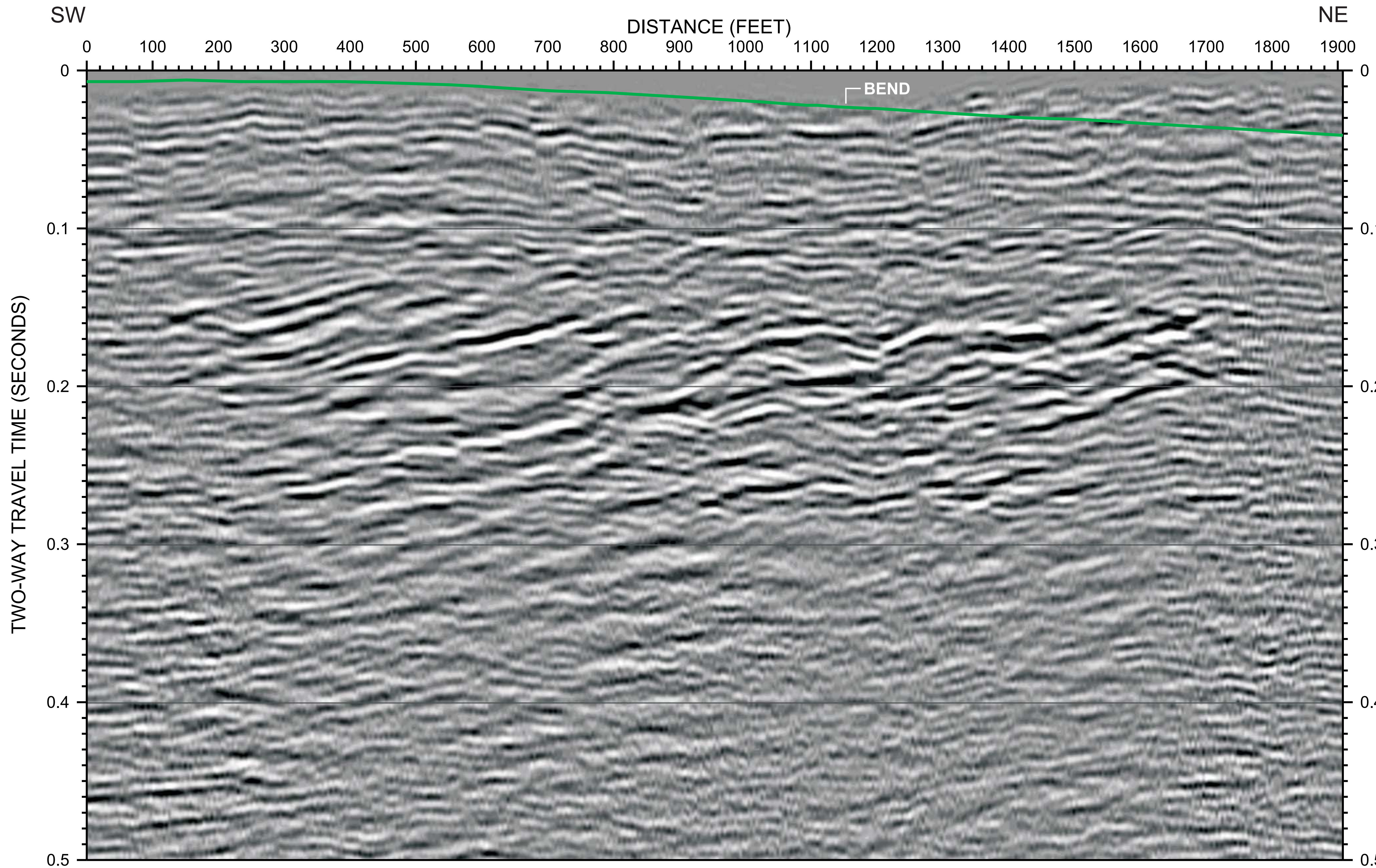
Project # 9001	FIGURE 4 V_S - V_P PLOT FOR SATURATED SEDIMENTS/ROCK
Date: AUG 4, 2009	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Drawn By: A MARTIN	
Approved By: *Antony J Martin*	PREPARED FOR CH2M HILL
File R:\...Project Files\2009\9001ch2mhill\REFLReport\FIGURES\Figure4.cdr	



LINE Z1-G3

LEGEND

Ground Surface Reference

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Project # 9001
Date: AUG 5, 2009
Drawn By: A MARTIN
Approved By:

FIGURE 5
LINE Z1-G3 SEISMIC SECTION
WITHOUT INTERPRETATION

SR-710 TUNNEL TECHNICAL STUDY
LOS ANGELES COUNTY, CALIFORNIA

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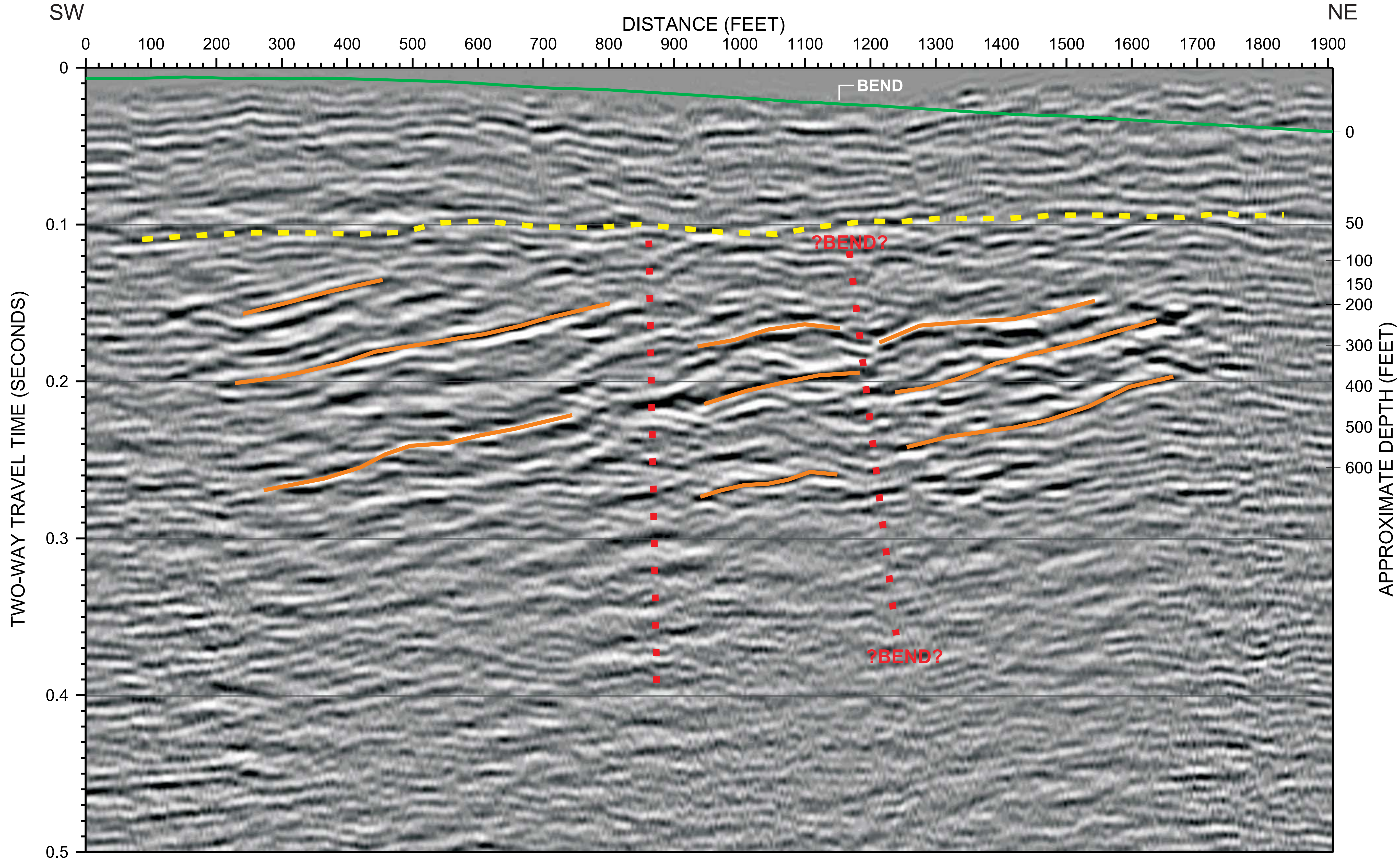
CH2M HILL



LINE Z1-G3

LEGEND

Ground Surface Reference	Example Seismic Reflector
Interpreted Water Table or Top of Bedrock	Possible Fault, dotted where uncertain
Interpreted Top of Bedrock or Weathering Contact within Bedrock	

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File R:\...Project Files\2009\9001ch2mhill\REFLReport\FIGURES\Figure6.cdr

FIGURE 6
LINE Z1-G3 SEISMIC SECTION
WITH INTERPRETATION

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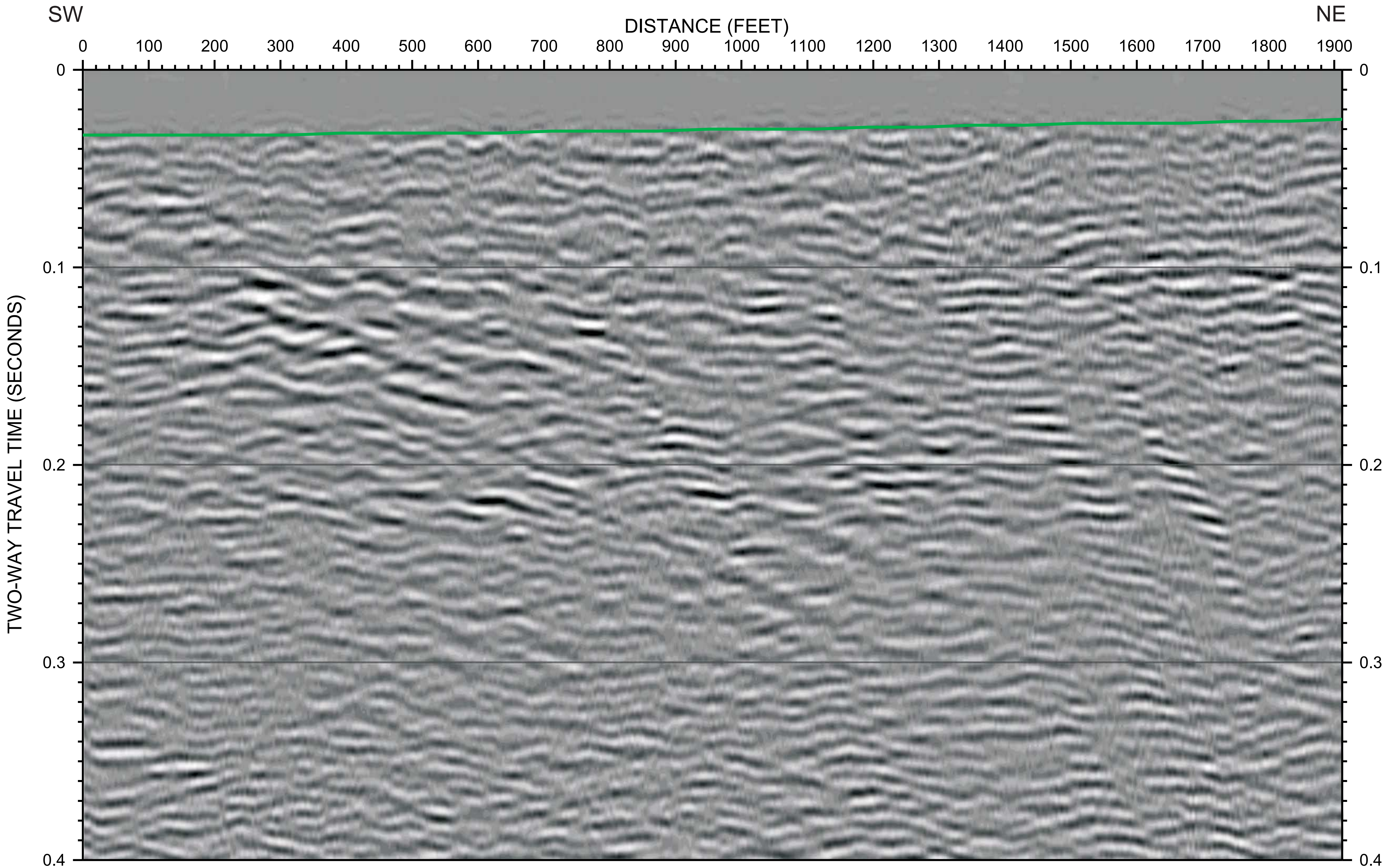

LINE Z1-G4

LEGEND

Ground Surface Reference

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geophysical services

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FIGURE 7
LINE Z1-G4 SEISMIC SECTION
WITHOUT INTERPRETATION

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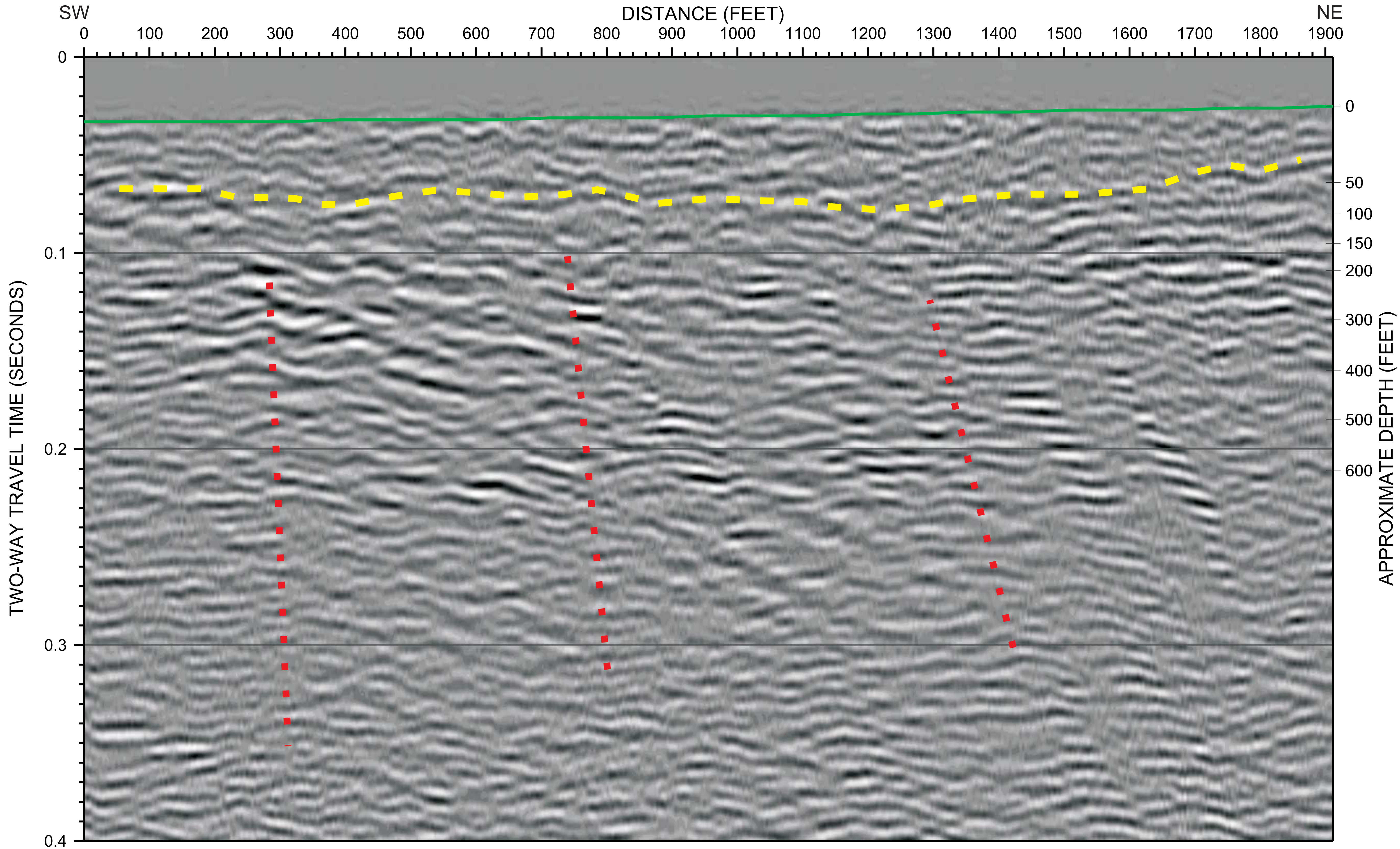

LINE Z1-G4

LEGEND

- Ground Surface Reference
- Interpreted Water Table or Top of Bedrock
- Interpreted Top of Bedrock or Weathering Contact within Bedrock
- Example Seismic Reflector
- Possible Fault, dotted where uncertain

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FIGURE 8
LINE Z1-G4 SEISMIC SECTION
WITH INTERPRETATION

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LOS ANGELES COUNTY, CALIFORNIA

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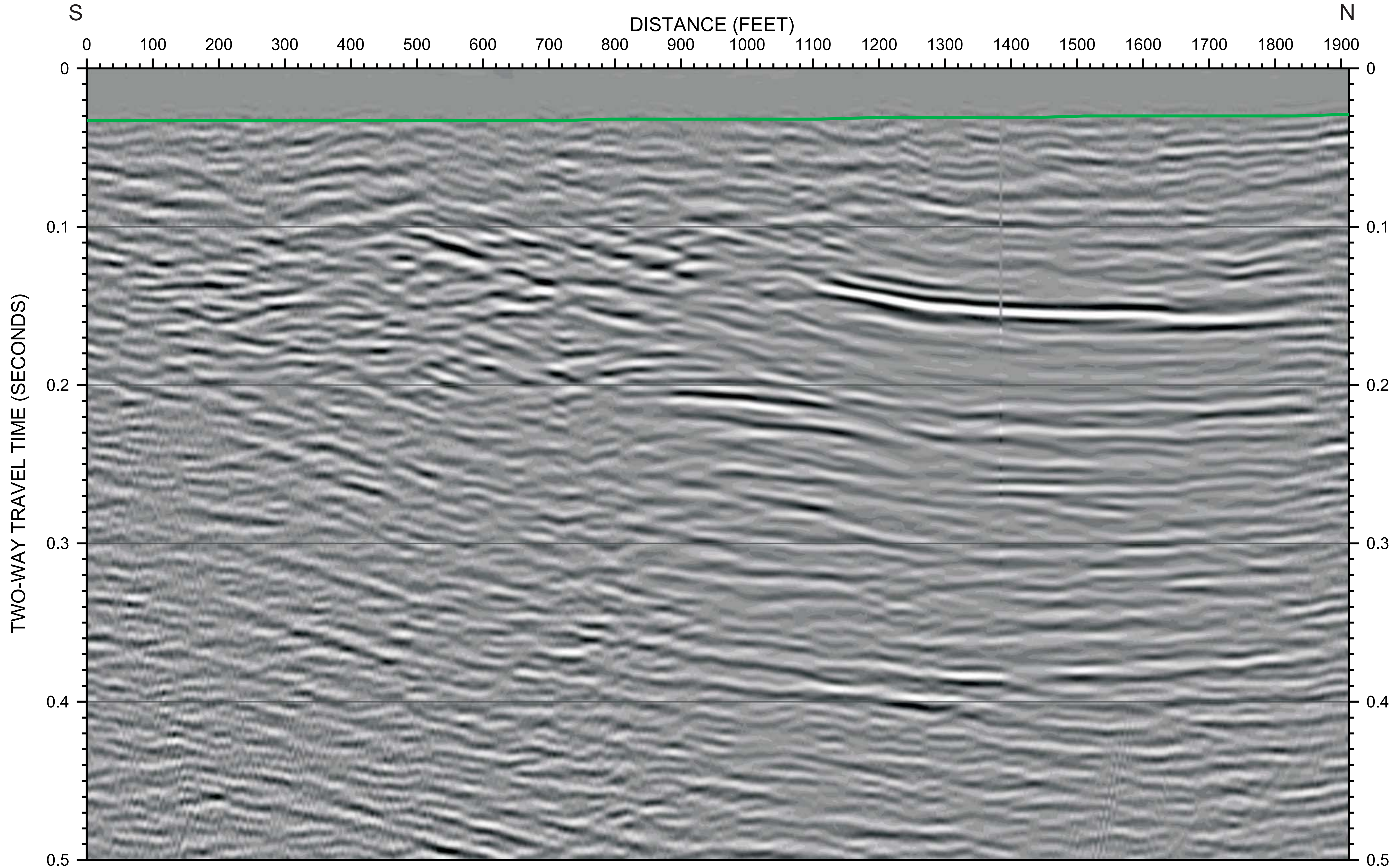

LINE Z1-G5

LEGEND

Ground Surface Reference

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Project # 9001	FIGURE 9 LINE Z1-G5 SEISMIC SECTION WITHOUT INTERPRETATION
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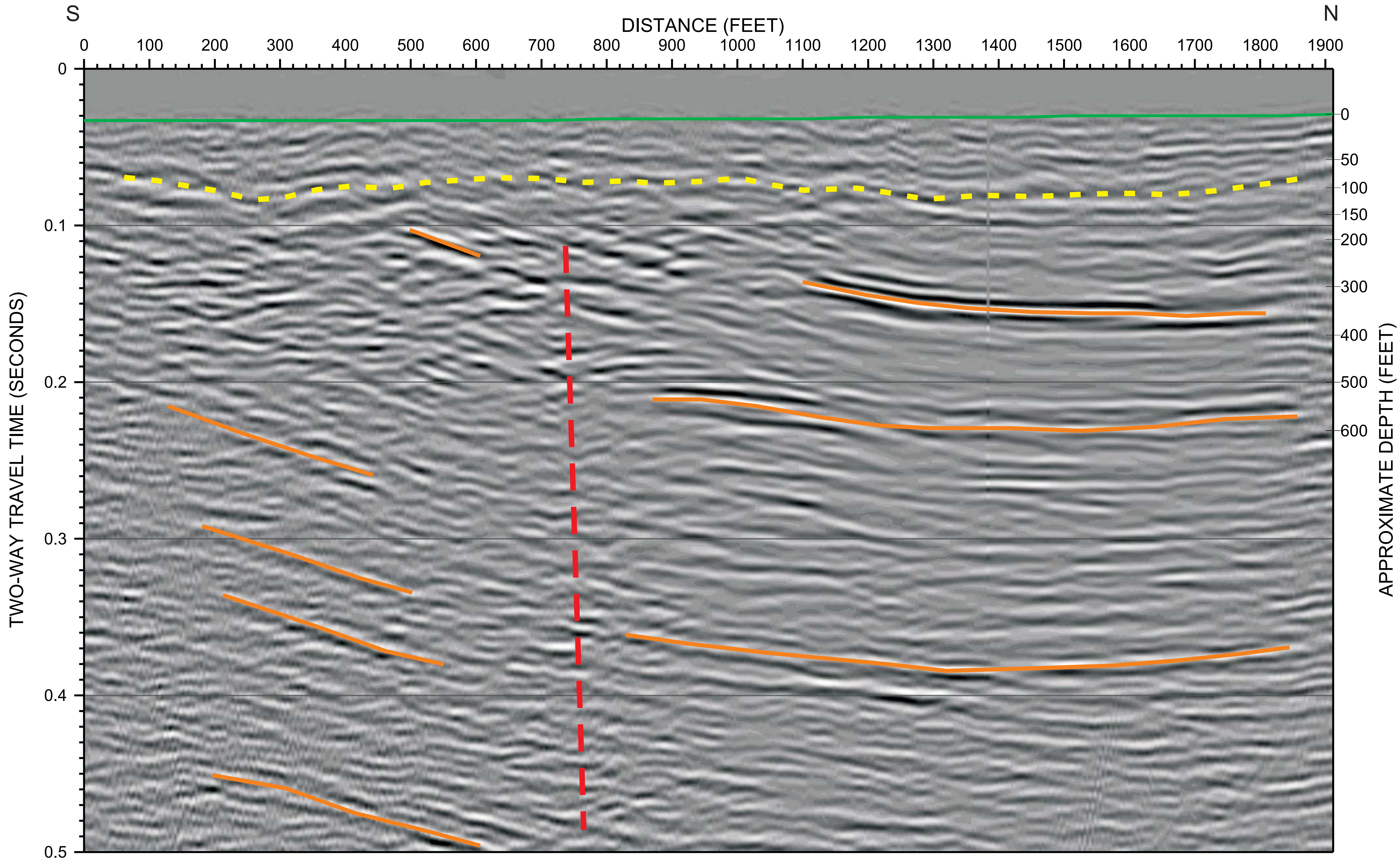
Drawn By: A MARTIN	
Approved By: Antony J Martin	PREPARED FOR CH2M HILL
File R:\...Project Files\2009\9001ch2mhill\REFLReport\FIGURES\Figure9.cdr	



LINE Z1-G5

LEGEND

- Ground Surface Reference
- Interpreted Water Table or Top of Bedrock
- Interpreted Top of Bedrock or Weathering Contact within Bedrock
- Example Seismic Reflector
- Possible Fault, dotted where uncertain

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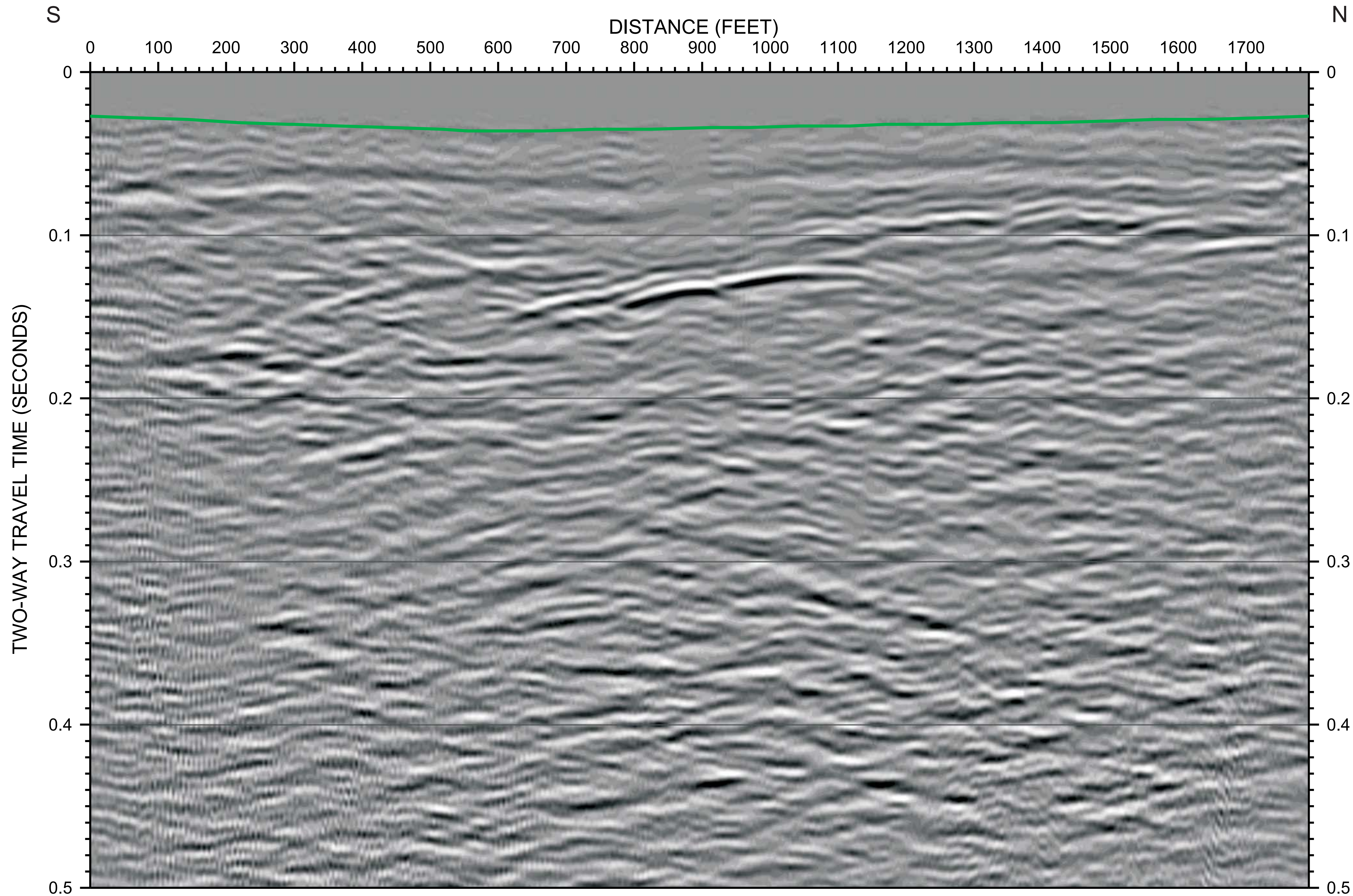
Project # 9001	FIGURE 10 LINE Z1-G5 SEISMIC SECTION WITH INTERPRETATION
Date: AUG 5, 2009	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Drawn By: A MARTIN	PREPARED FOR CH2M HILL
Approved By:	



LINE Z2-G1

LEGEND

Ground Surface Reference

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Date: AUG 5, 2009

Drawn By: A MARTIN

Approved By:

FIGURE 11
LINE Z2-G1 SEISMIC SECTION
WITHOUT INTERPRETATION

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LOS ANGELES COUNTY, CALIFORNIA

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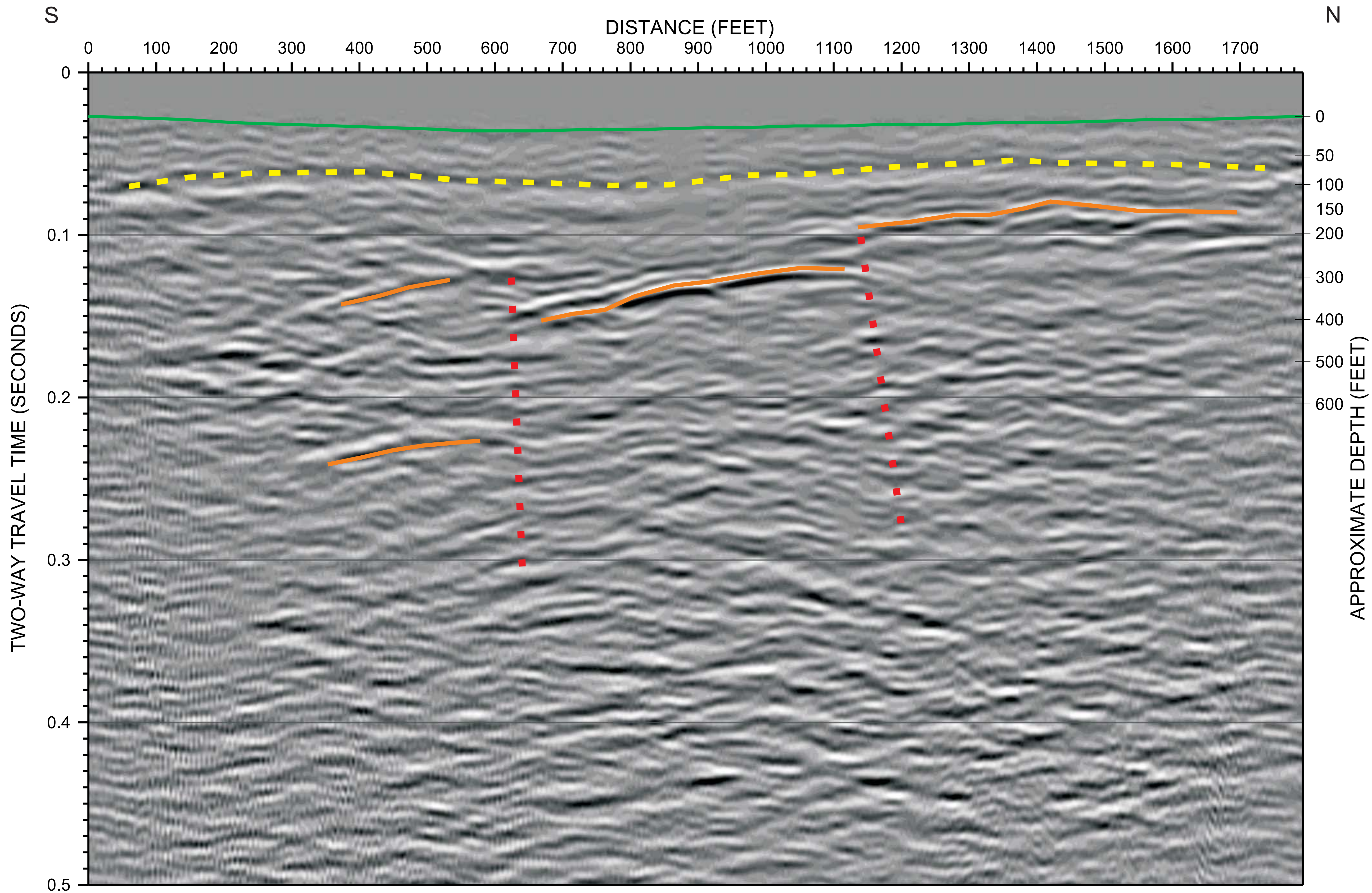
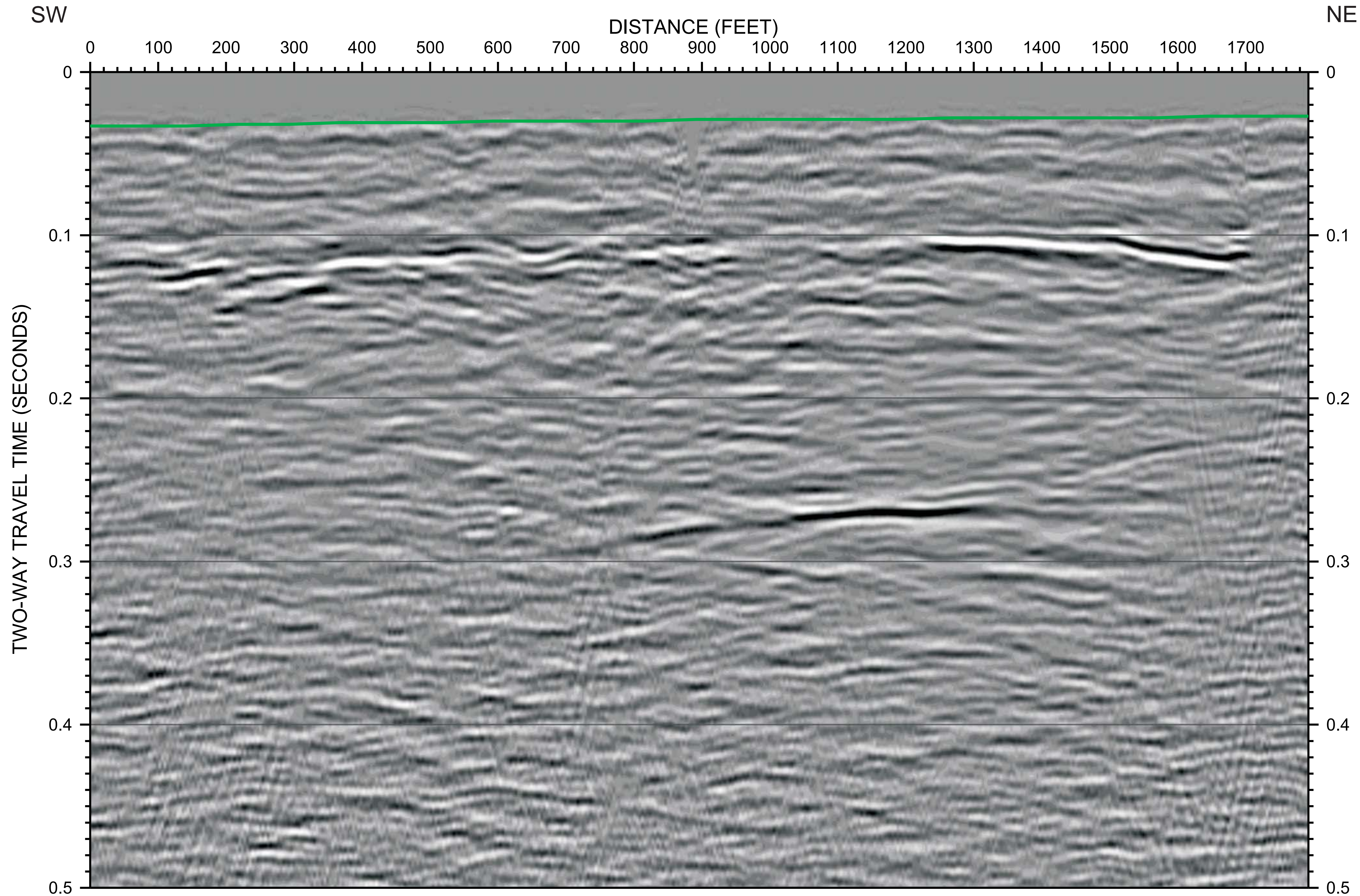


LINE Z2-G1

LEGEND

- Ground Surface Reference
- Interpreted Water Table or Top of Bedrock
- Interpreted Top of Bedrock or Weathering Contact within Bedrock
- Example Seismic Reflector
- Possible Fault, dotted where uncertain

GEOVision geophysical services	FIGURE 12 LINE Z2-G1 SEISMIC SECTION WITH INTERPRETATION
Project # 9001 Date: AUG 5, 2009	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Drawn By: A MARTIN Approved By:	PREPARED FOR CH2M HILL



LINE Z2-G2

LEGEND

Ground Surface Reference

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Drawn By: A MARTIN
Approved By:

FIGURE 13
LINE Z2-G2 SEISMIC SECTION
WITHOUT INTERPRETATION

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LOS ANGELES COUNTY, CALIFORNIA

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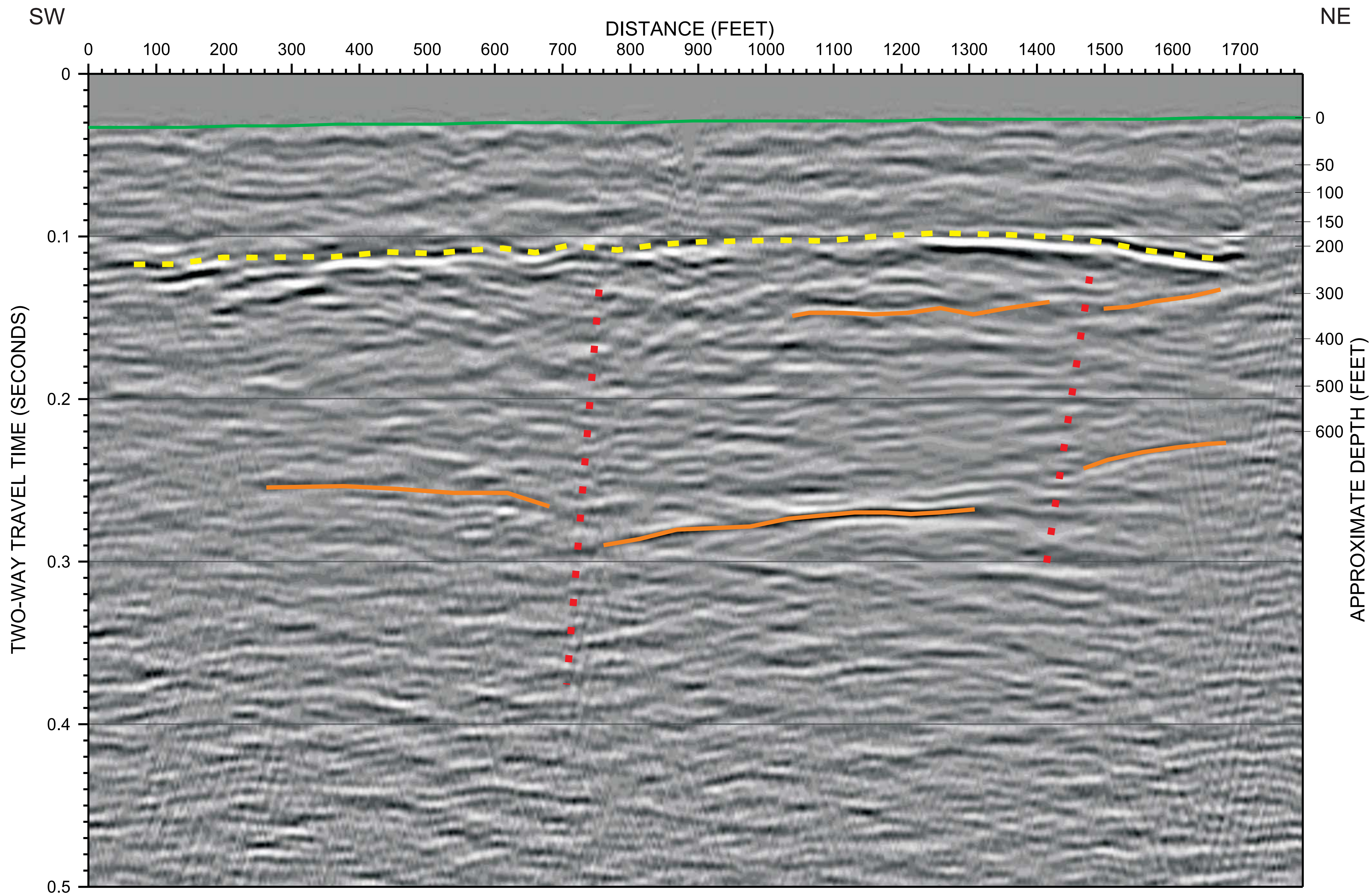

LINE Z2-G2

LEGEND

Ground Surface Reference	Example Seismic Reflector
Interpreted Water Table or Top of Bedrock	Possible Fault, dotted where uncertain
Interpreted Top of Bedrock or Weathering Contact within Bedrock	

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FIGURE 14
LINE Z2-G2 SEISMIC SECTION
WITH INTERPRETATION

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LOS ANGELES COUNTY, CALIFORNIA

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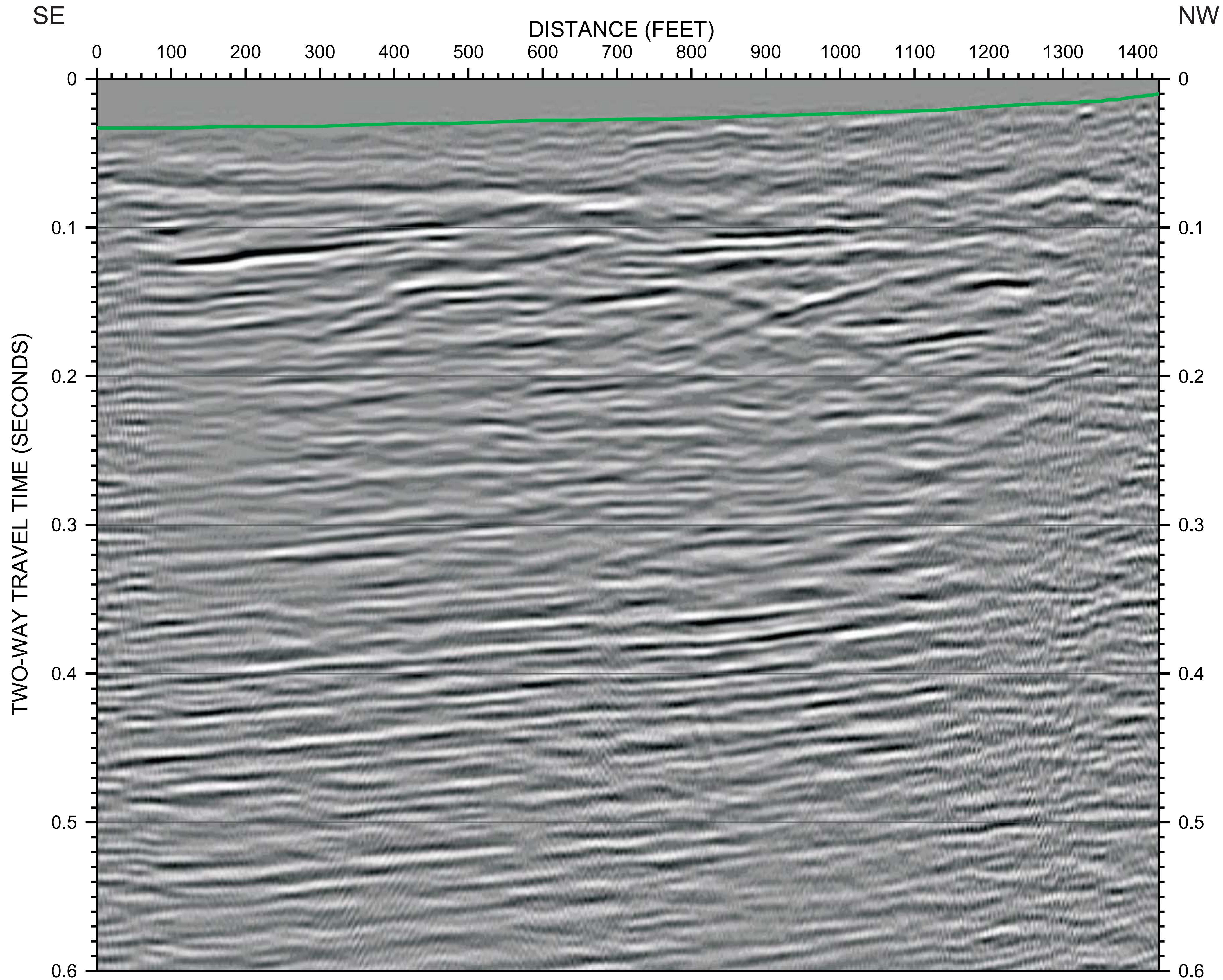

LINE Z2-G3

LEGEND

Ground Surface Reference

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Project # 9001	FIGURE 15 LINE Z2-G3 SEISMIC SECTION WITHOUT INTERPRETATION
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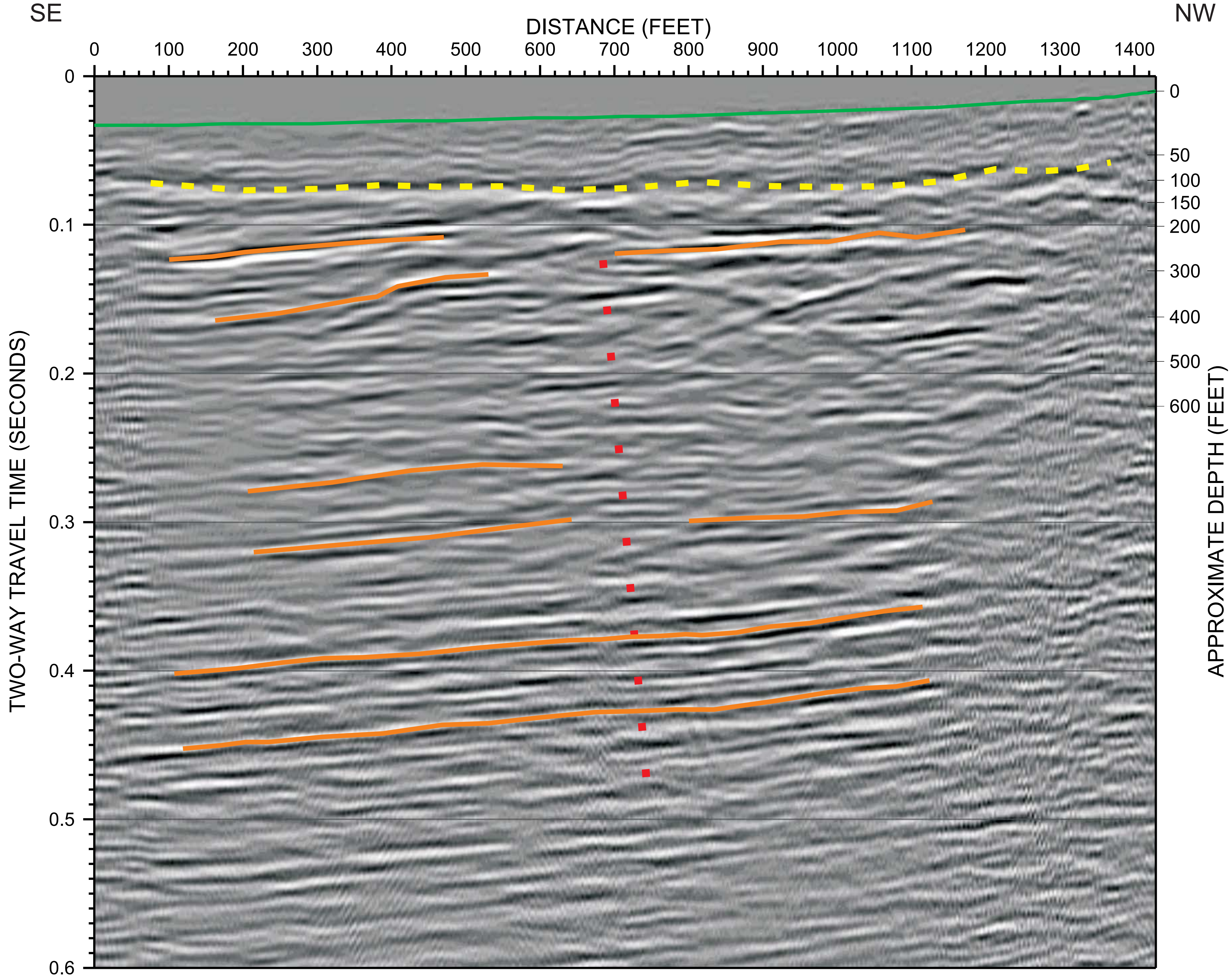
Drawn By: A MARTIN	
Approved By:	PREPARED FOR CH2M HILL



LINE Z2-G3

LEGEND

- Ground Surface Reference
- Interpreted Water Table or Top of Bedrock
- Interpreted Top of Bedrock or Weathering Contact within Bedrock
- Example Seismic Reflector
- Possible Fault, dotted where uncertain

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Project # 9001
Date: AUG 5, 2009
Drawn By: A MARTIN
Approved By:

FIGURE 16
LINE Z2-G3 SEISMIC SECTION
WITH INTERPRETATION

SR-710 TUNNEL TECHNICAL STUDY
LOS ANGELES COUNTY, CALIFORNIA

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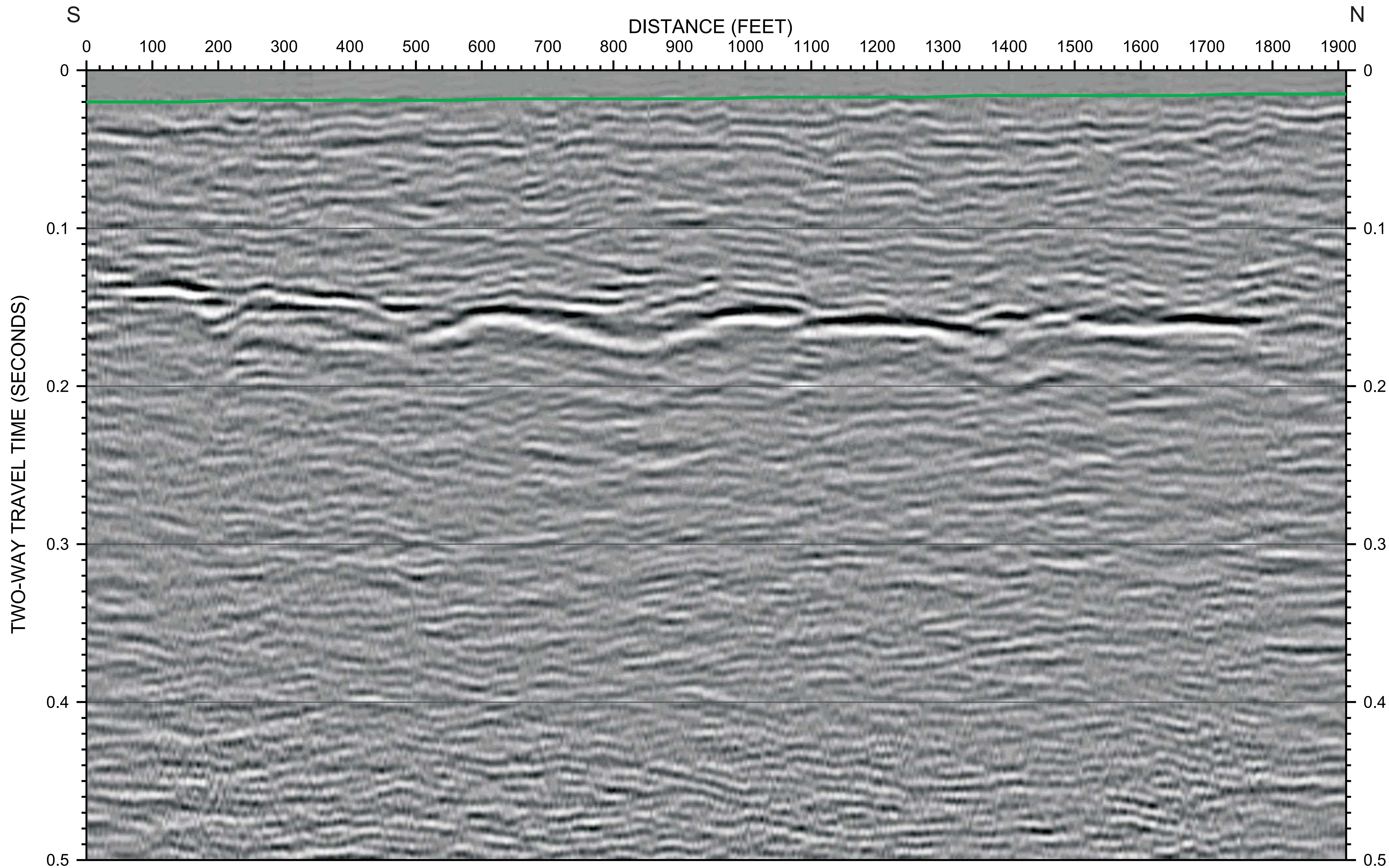

LINE Z3-G1

LEGEND

Ground Surface Reference

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Project # 9001

Date: AUG 5, 2009

Drawn By: A MARTIN

Approved By:

FIGURE 17
LINE Z3-G1 SEISMIC SECTION
WITHOUT INTERPRETATION

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LOS ANGELES COUNTY, CALIFORNIA

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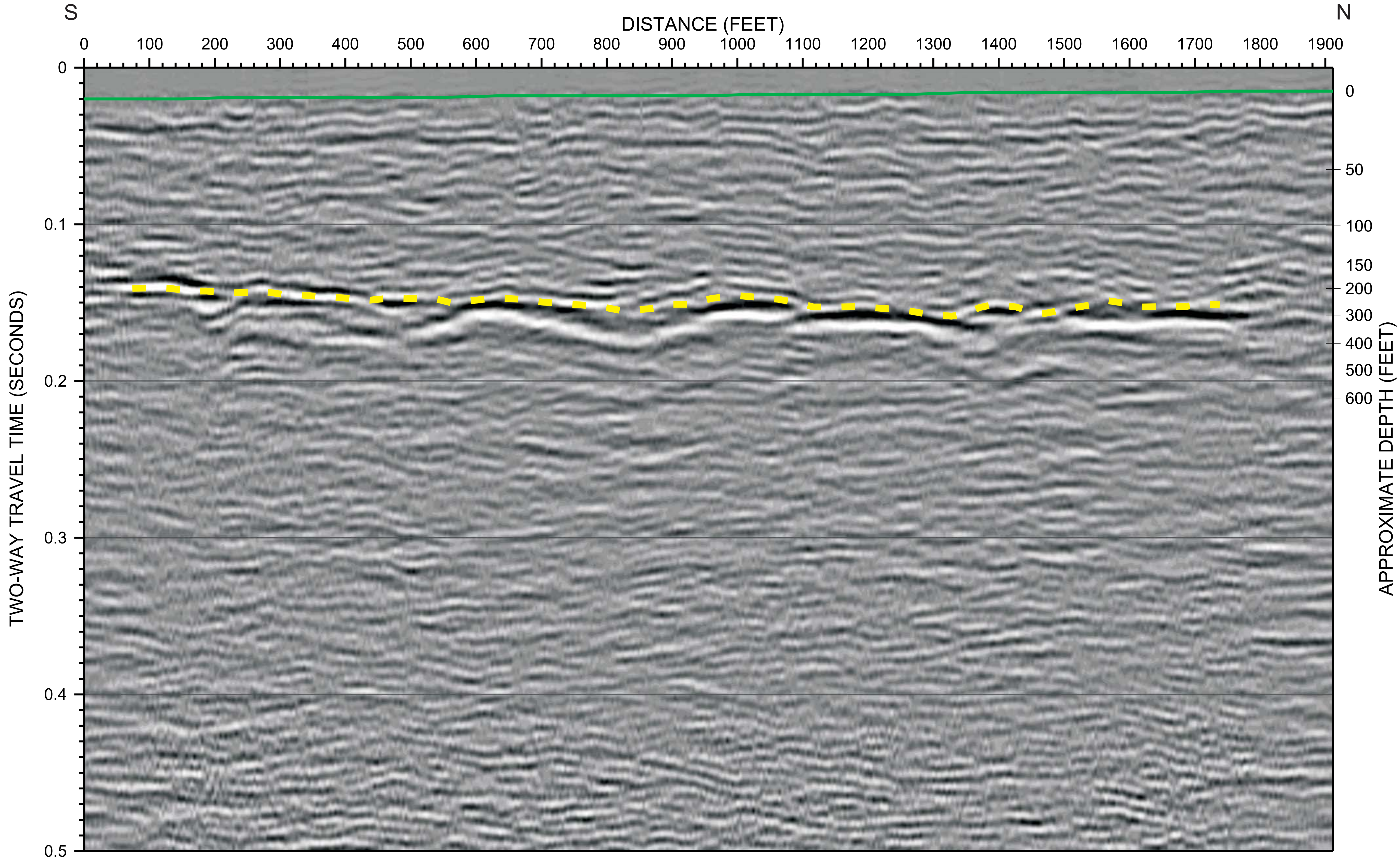

LINE Z3-G1

LEGEND

Ground Surface Reference

Interpreted Water Table or Top of Bedrock

Interpreted Top of Bedrock or Weathering Contact within Bedrock

Example Seismic Reflector

Possible Fault, dotted where uncertain

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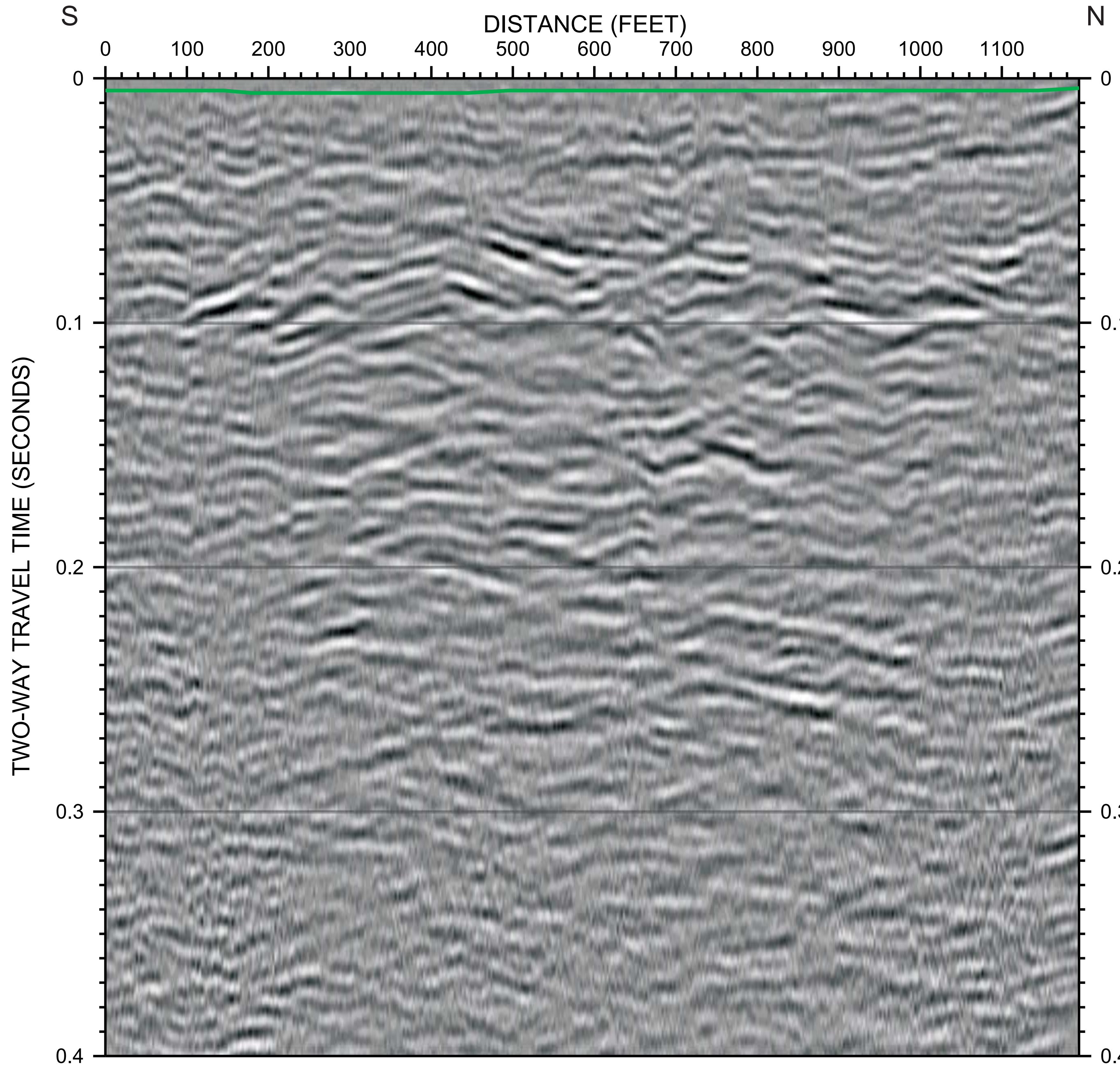
Project # 9001	FIGURE 18 LINE Z3-G1 SEISMIC SECTION WITH INTERPRETATION
Date: AUG 5, 2009	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Drawn By: A MARTIN	
Approved By:	PREPARED FOR CH2M HILL



LINE Z3-G2

LEGEND

Ground Surface Reference

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Project # 9001

Date: AUG 5, 2009

Drawn By: A MARTIN

Approved By:

FIGURE 19
LINE Z3-G2 SEISMIC SECTION
WITHOUT INTERPRETATION

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LOS ANGELES COUNTY, CALIFORNIA

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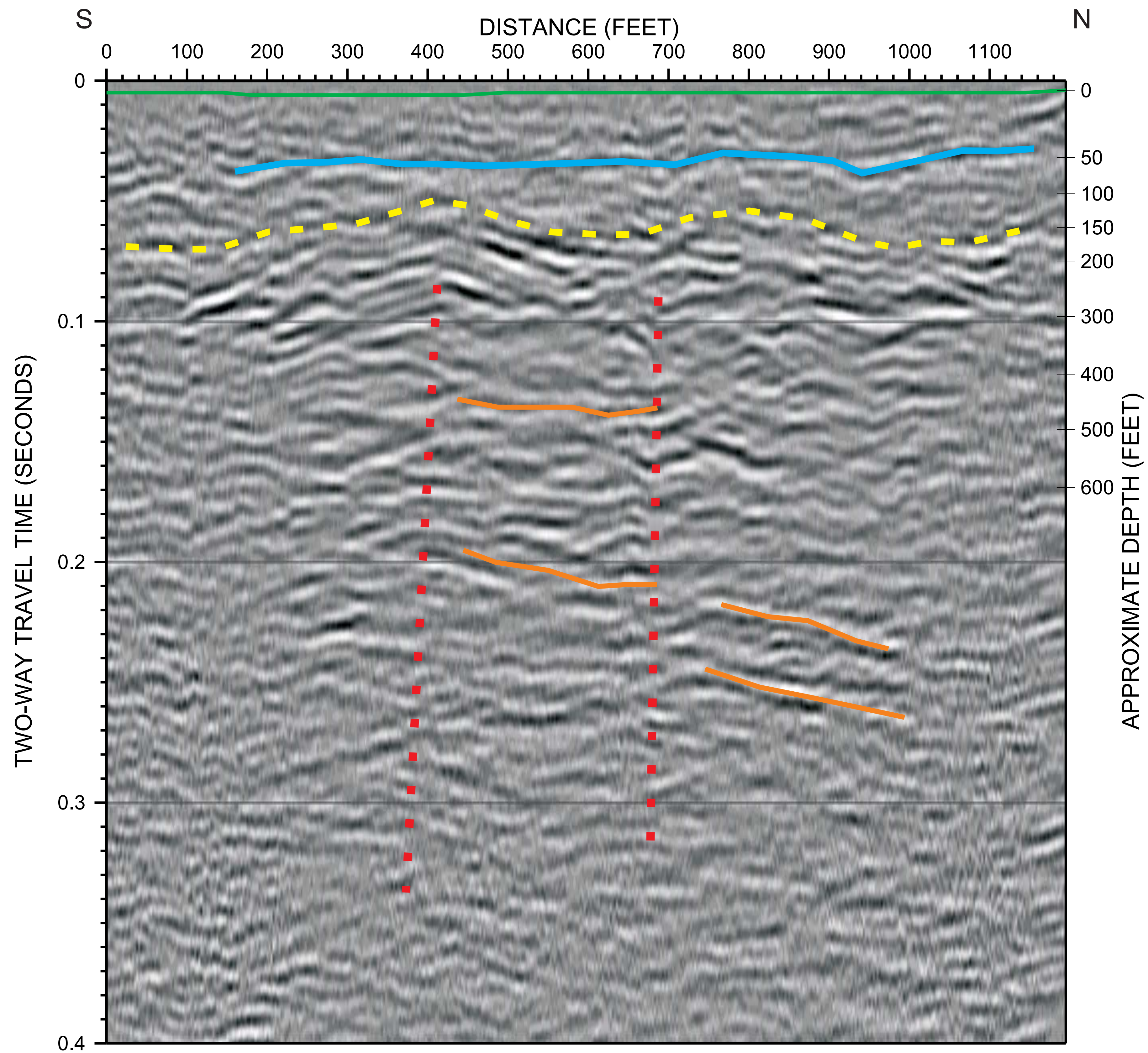

LINE Z3-G2

LEGEND

- Ground Surface Reference
- Interpreted Water Table or Top of Bedrock
- Interpreted Top of Bedrock or Weathering Contact within Bedrock
- Example Seismic Reflector
- Possible Fault, dotted where uncertain

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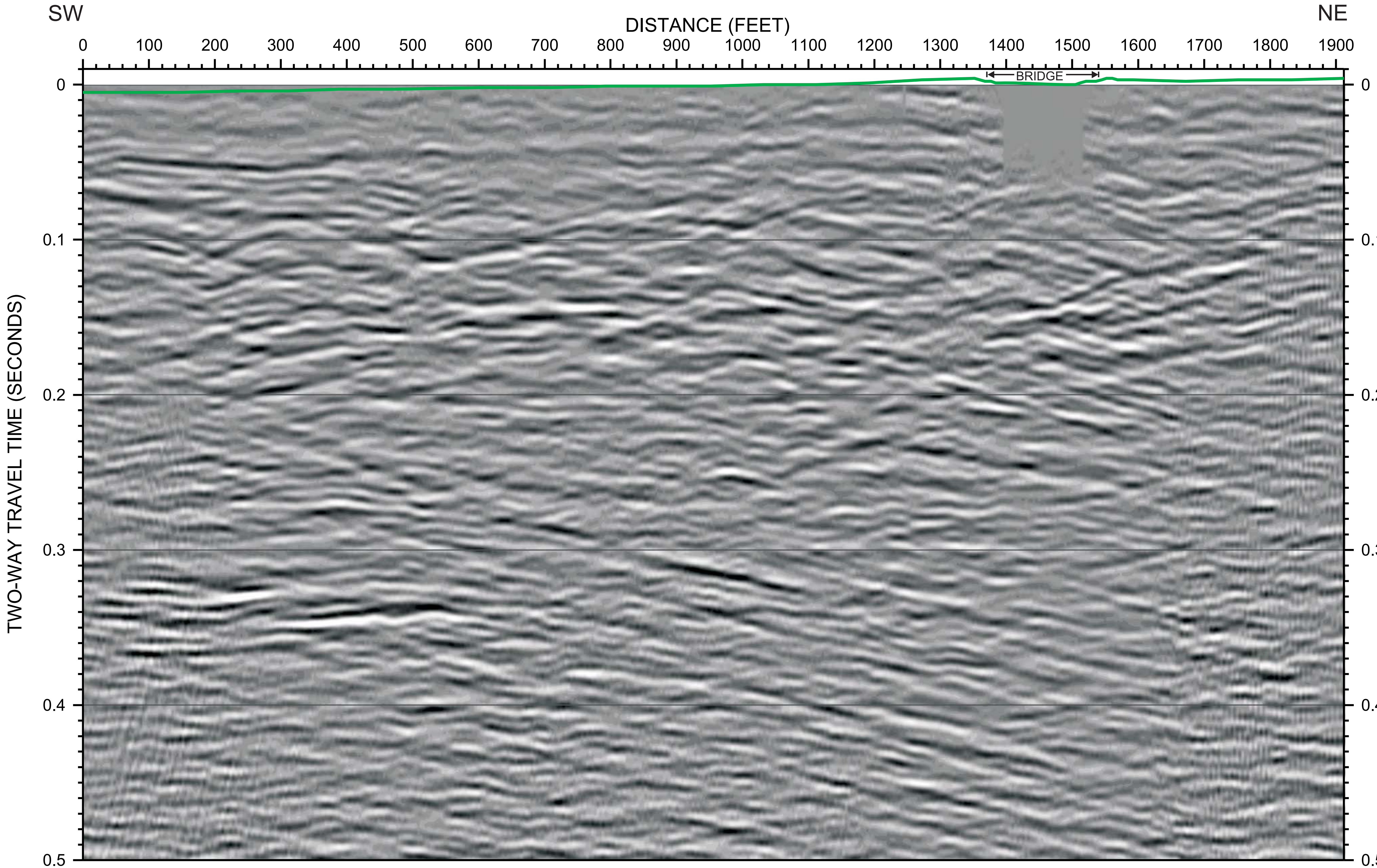
Project # 9001
Date: AUG 5, 2009
Drawn By: A MARTIN
Approved By:

FIGURE 20
LINE Z3-G2 SEISMIC SECTION
WITH INTERPRETATION

SR-710 TUNNEL TECHNICAL STUDY
LOS ANGELES COUNTY, CALIFORNIA

PREPARED FOR
CH2M HILL



LINE Z3-G3

LEGEND

Ground Surface Reference

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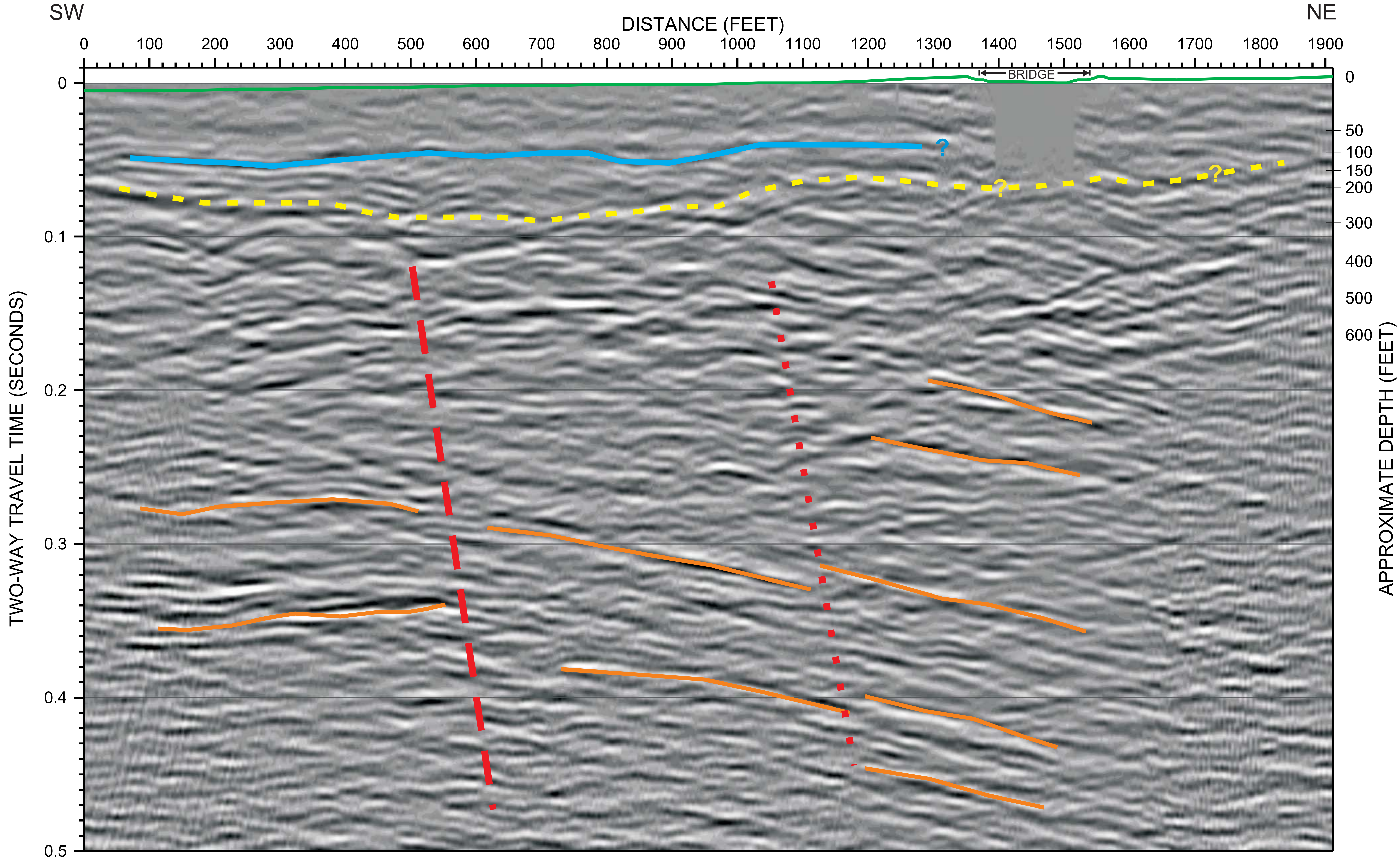
Project # 9001	FIGURE 21 LINE Z3-G3 SEISMIC SECTION WITHOUT INTERPRETATION
Date: AUG 5, 2009	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Drawn By: A MARTIN	
Approved By:	PREPARED FOR CH2M HILL



LEGEND

- Ground Surface Reference
- Interpreted Water Table or Top of Bedrock
- Interpreted Top of Bedrock or Weathering Contact within Bedrock
- Example Seismic Reflector
- Possible Fault, dotted where uncertain

LINE Z3-G3

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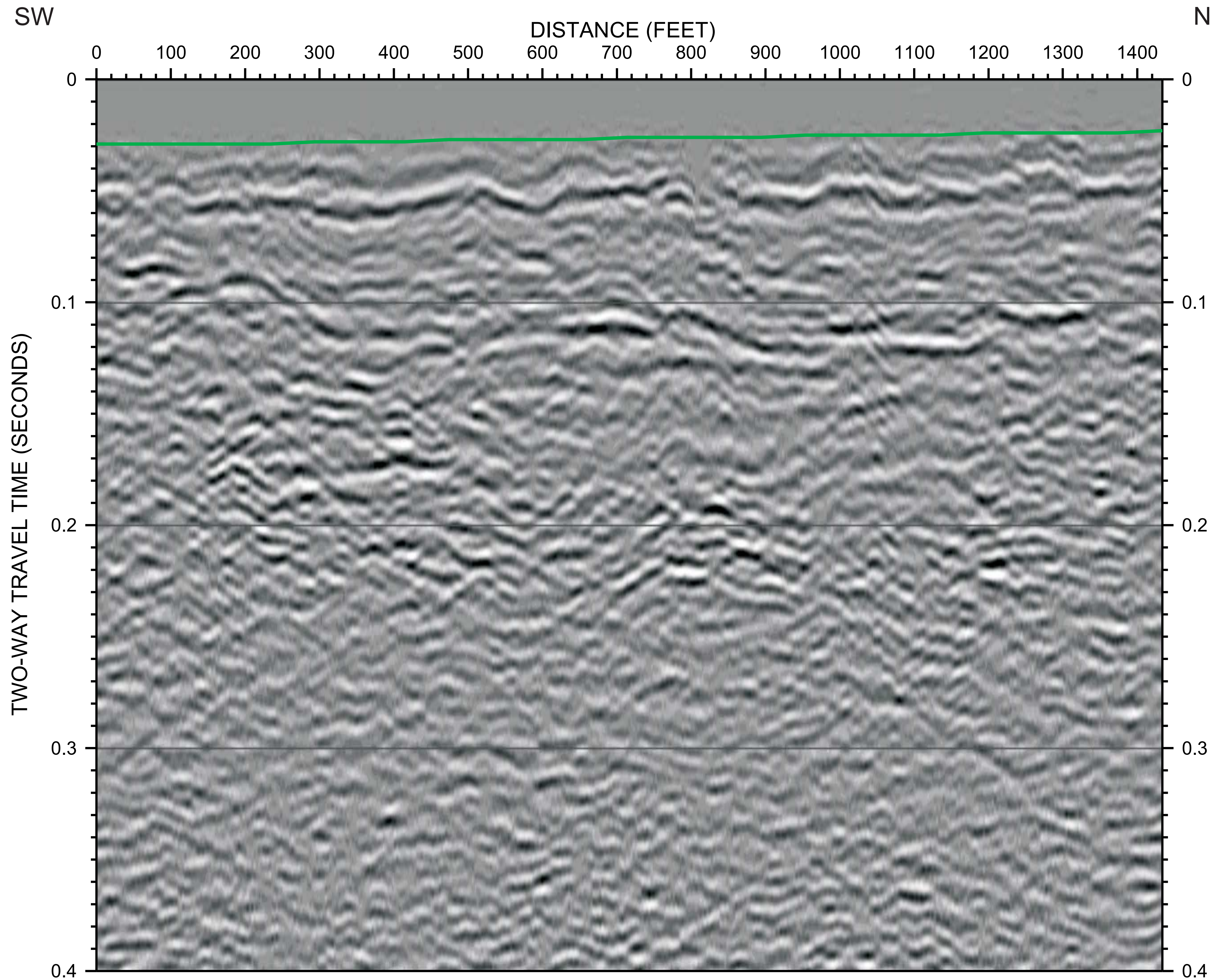
Project # 9001	FIGURE 22 LINE Z3-G3 SEISMIC SECTION WITH INTERPRETATION
Date: AUG 5, 2009	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Drawn By: A MARTIN	
Approved By:	PREPARED FOR CH2M HILL



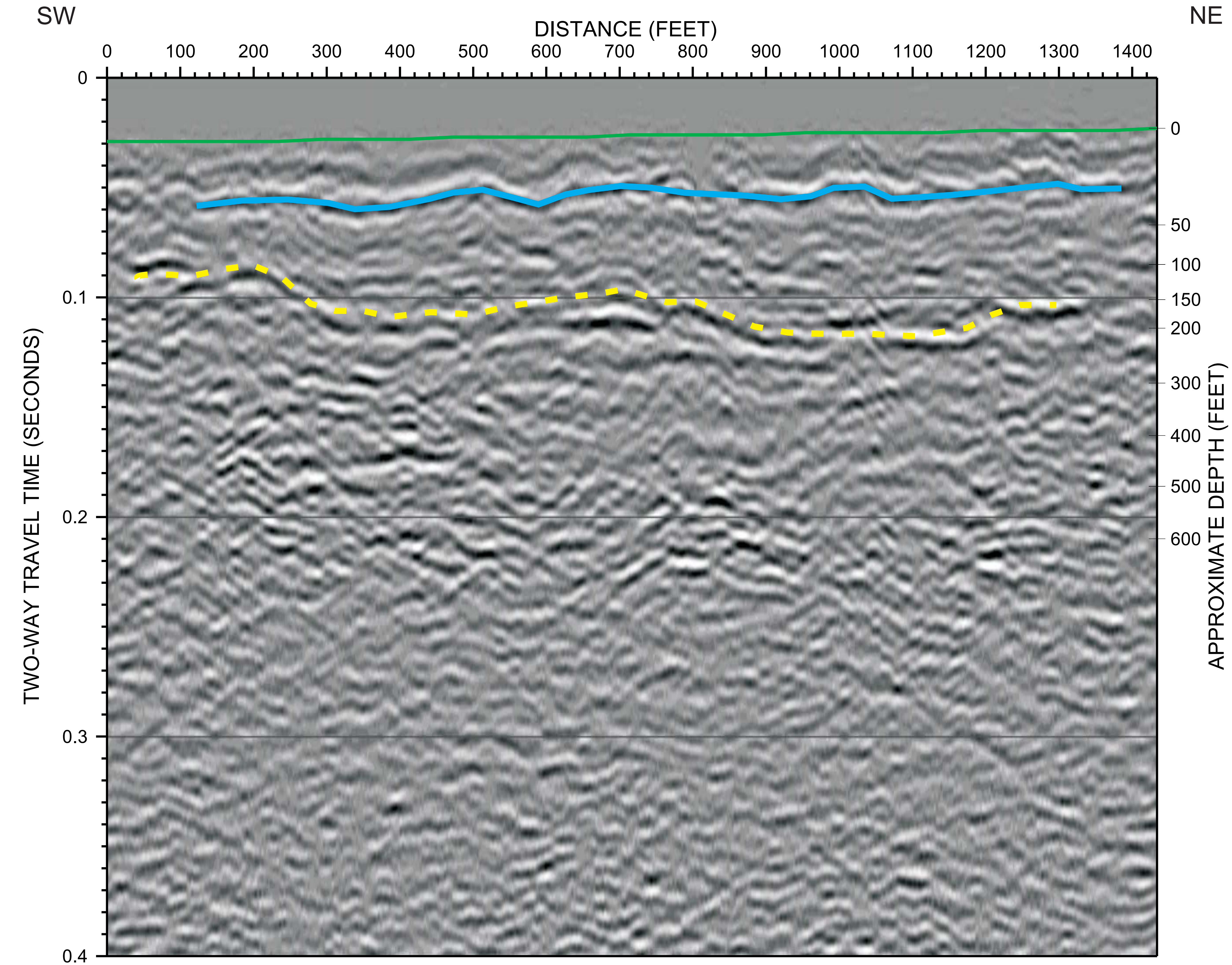
LINE Z3-G4

LEGEND

Ground Surface Reference

GEOVision geophysical services

Project # 9001	FIGURE 23 LINE Z3-G4 SEISMIC SECTION WITHOUT INTERPRETATION
Date: AUG 5, 2009	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Drawn By: A MARTIN	
Approved By:	PREPARED FOR CH2M HILL



LEGEND

- Ground Surface Reference
- Interpreted Water Table or Top of Bedrock
- Interpreted Top of Bedrock or Weathering Contact within Bedrock
- Example Seismic Reflector
- Possible Fault, dotted where uncertain

LINE Z3-G4

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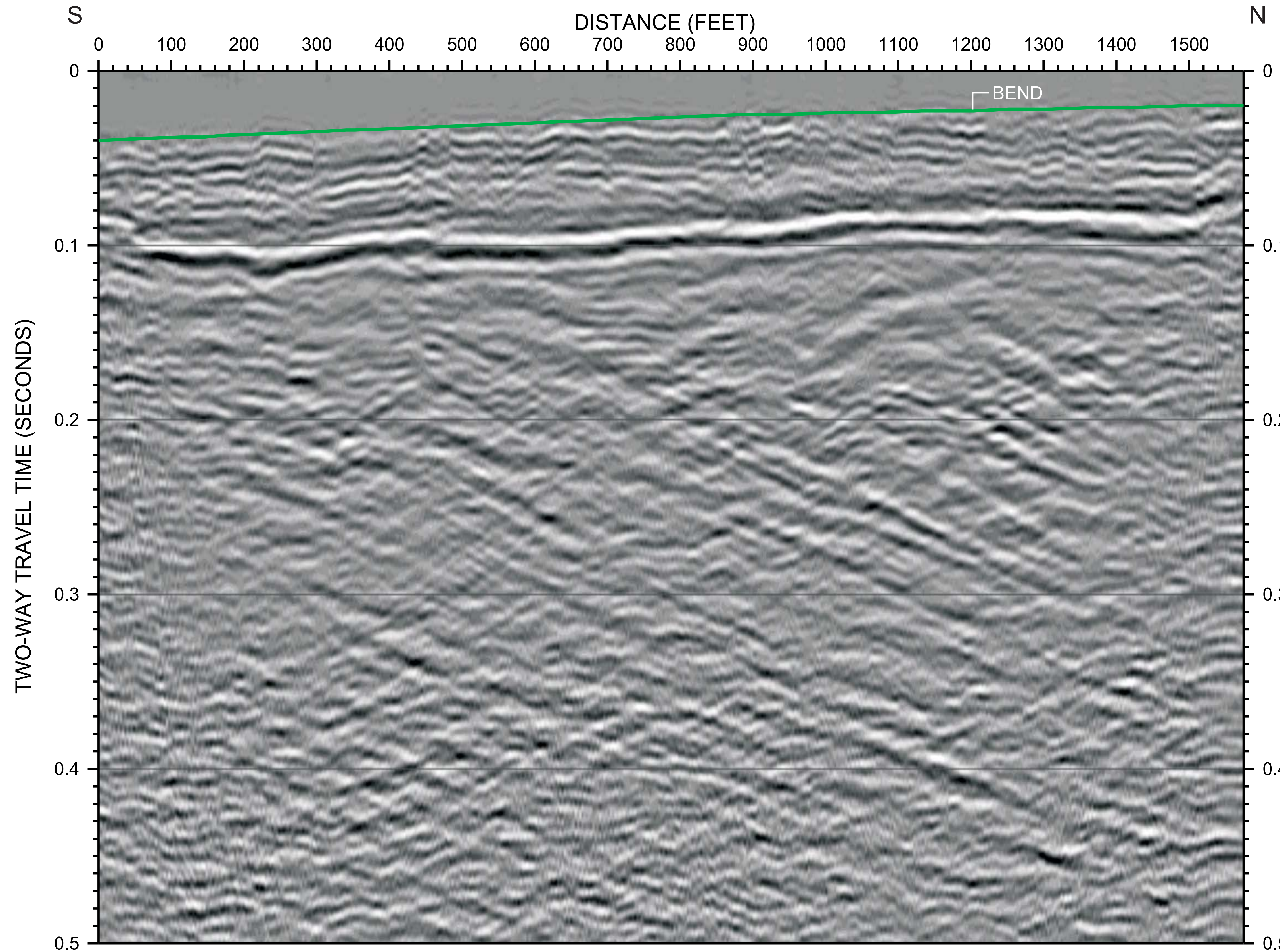
Project # 9001	FIGURE 24 LINE Z3-G4 SEISMIC SECTION WITH INTERPRETATION
Date: AUG 5, 2009	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Drawn By: A MARTIN	
Approved By:	PREPARED FOR CH2M HILL



LINE Z3-G5

LEGEND

Ground Surface Reference

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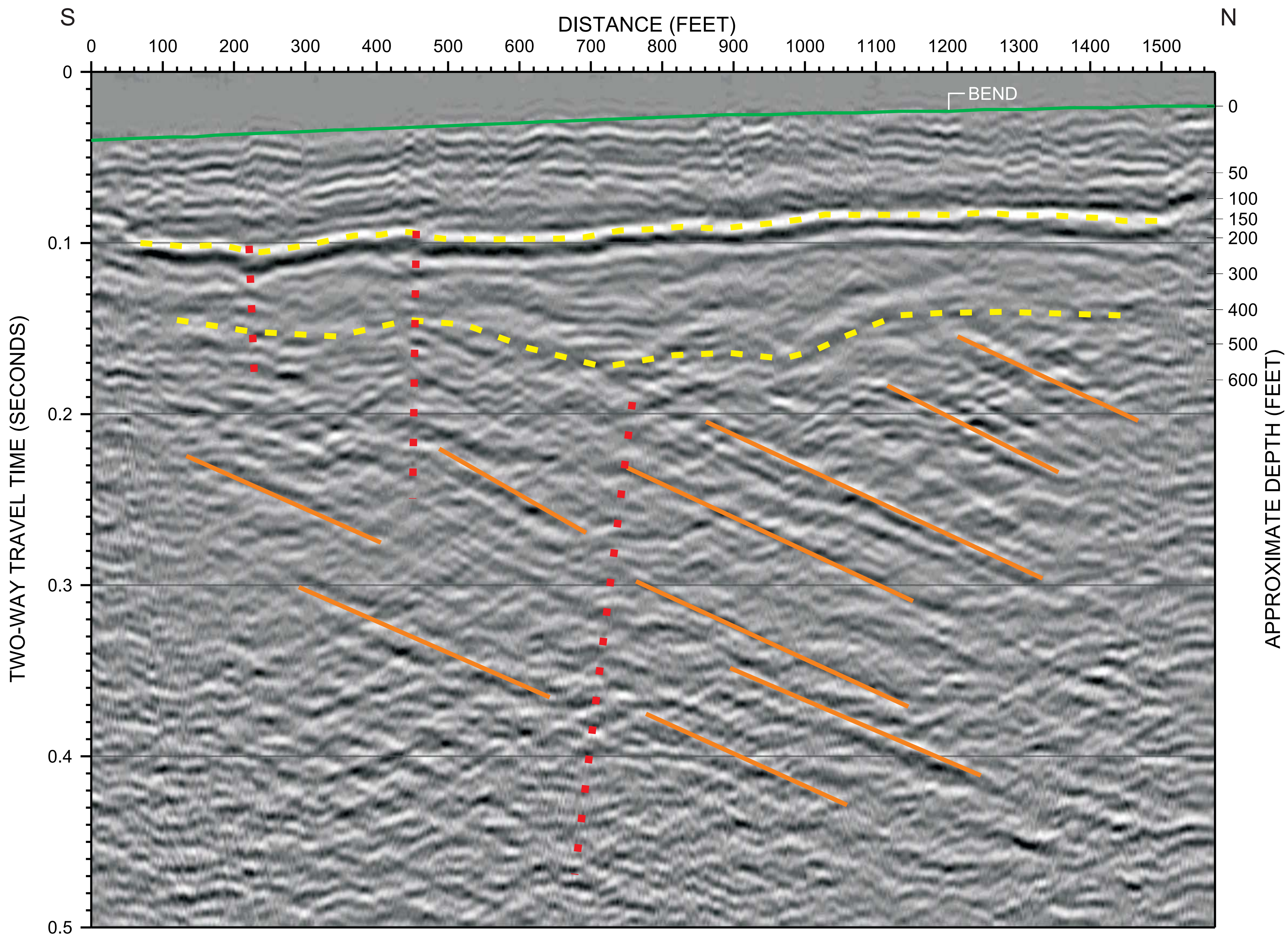
Project # 9001	FIGURE 25 LINE Z3-G5 SEISMIC SECTION WITHOUT INTERPRETATION
Date: AUG 5, 2009	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Drawn By: A MARTIN	
Approved By:	PREPARED FOR CH2M HILL



LINE Z3-G5

LEGEND

Green solid line	Ground Surface Reference	Orange solid line	Example Seismic Reflector
Blue solid line	Interpreted Water Table or Top of Bedrock	Red dashed line	Possible Fault, dotted where uncertain
Yellow dashed line	Interpreted Top of Bedrock or Weathering Contact within Bedrock		

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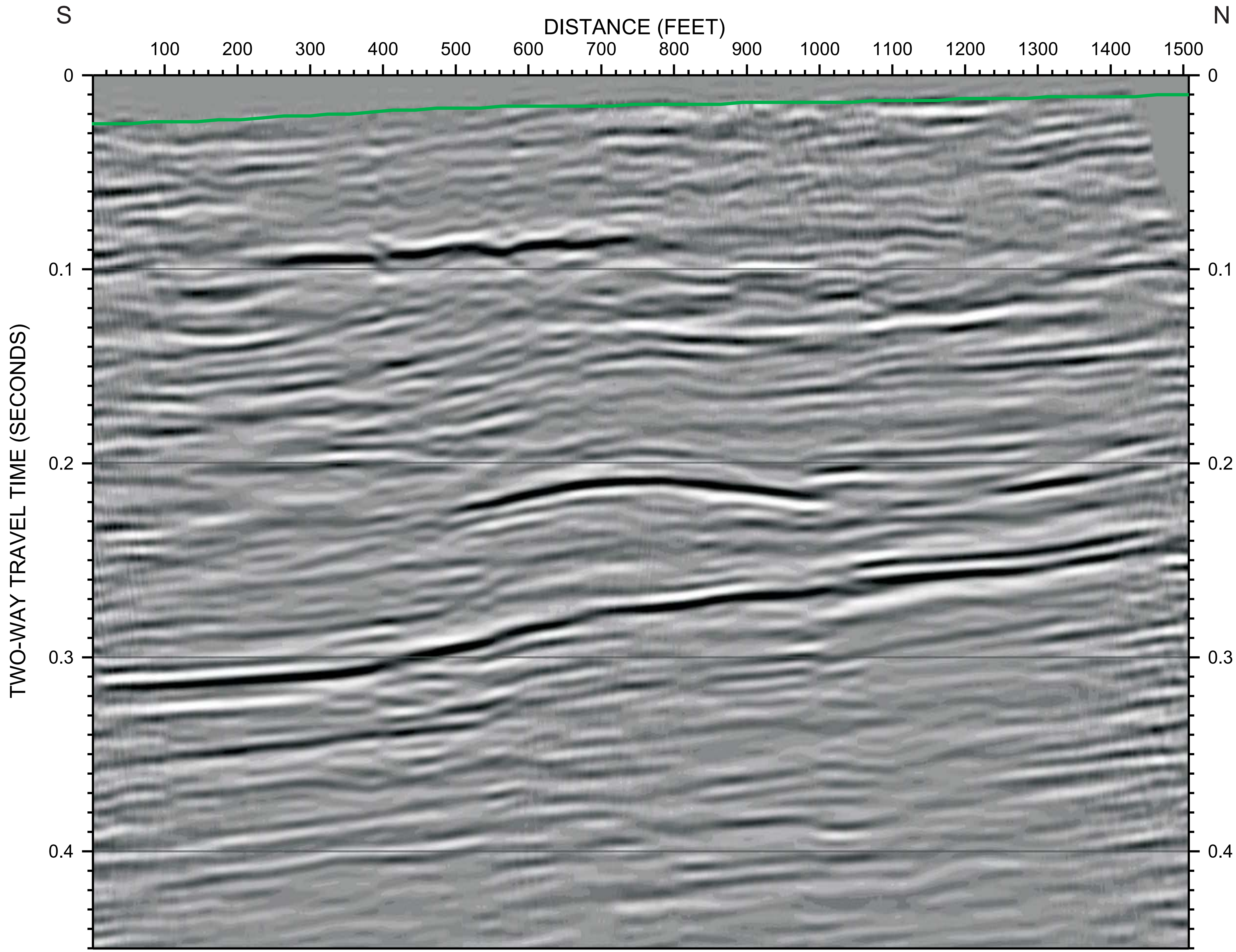
Project # 9001
Date: AUG 5, 2009
Drawn By: A MARTIN
Approved By:

FIGURE 26
LINE Z3-G5 SEISMIC SECTION
WITH INTERPRETATION

SR-710 TUNNEL TECHNICAL STUDY
LOS ANGELES COUNTY, CALIFORNIA

PREPARED FOR
CH2M HILL



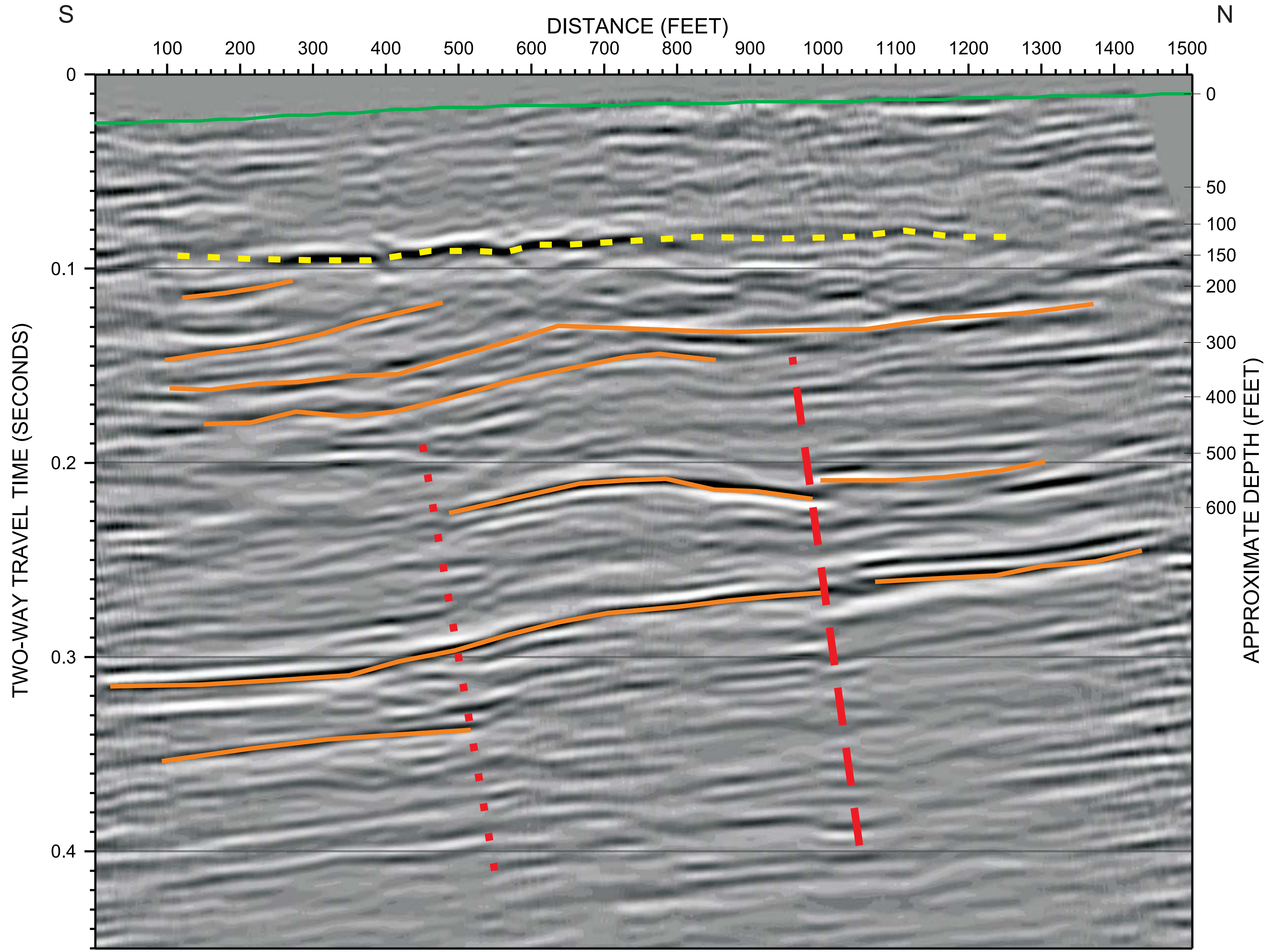
LINE Z3-G6

LEGEND

Ground Surface Reference

GEOVision geophysical services

Project # 9001	FIGURE 27 LINE Z3-G6 SEISMIC SECTION WITHOUT INTERPRETATION
Date: AUG 5, 2009	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Drawn By: A MARTIN	
Approved By:	PREPARED FOR CH2M HILL



LINE Z3-G6

LEGEND

- Ground Surface Reference
- Interpreted Water Table or Top of Bedrock
- Interpreted Top of Bedrock or Weathering Contact within Bedrock
- Example Seismic Reflector
- Possible Fault, dotted where uncertain

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Project # 9001
Date: AUG 5, 2009
Drawn By: A MARTIN
Approved By:

FIGURE 28
LINE Z3-G6 SEISMIC SECTION
WITH INTERPRETATION

SR-710 TUNNEL TECHNICAL STUDY
LOS ANGELES COUNTY, CALIFORNIA

PREPARED FOR
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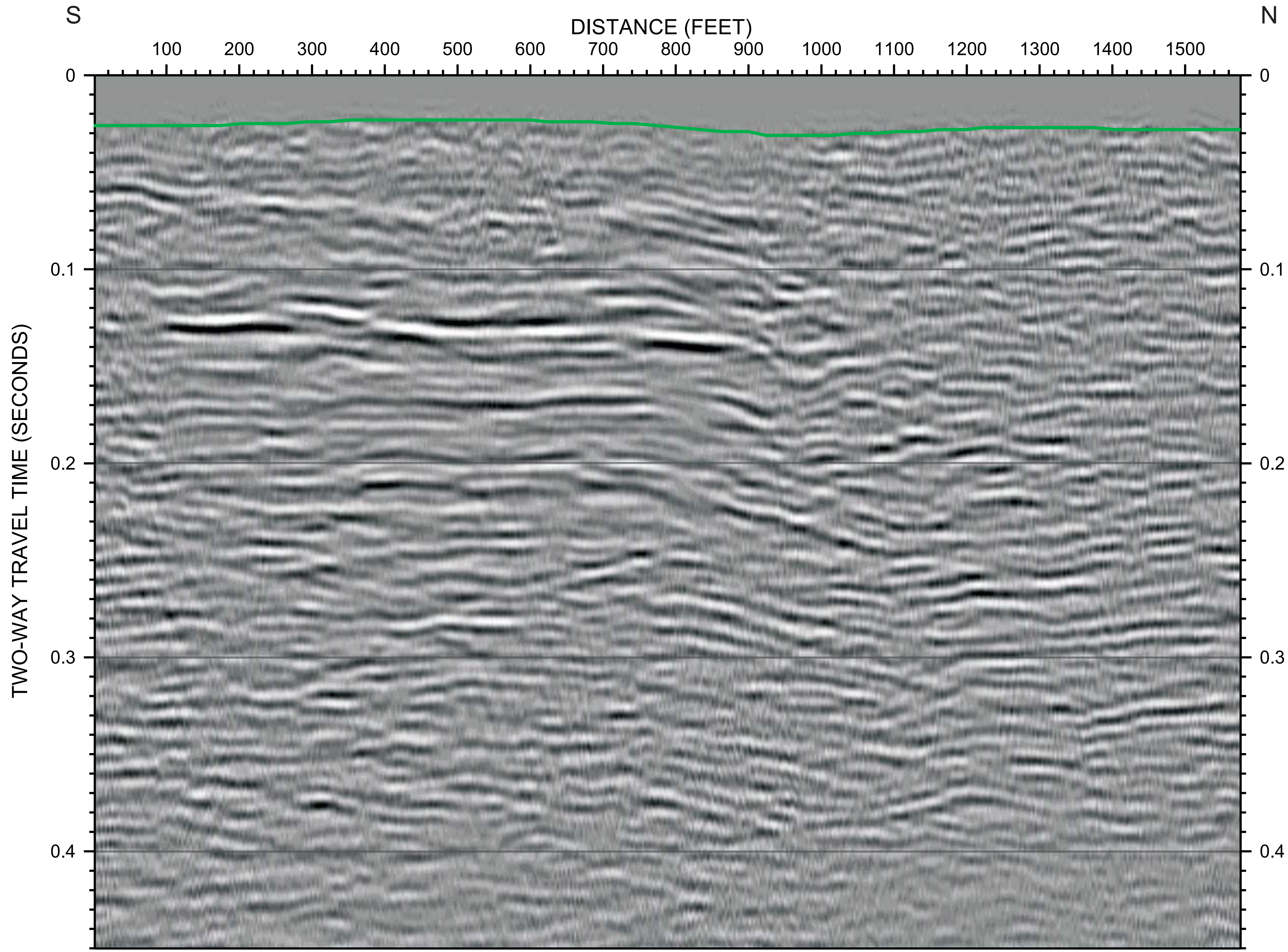


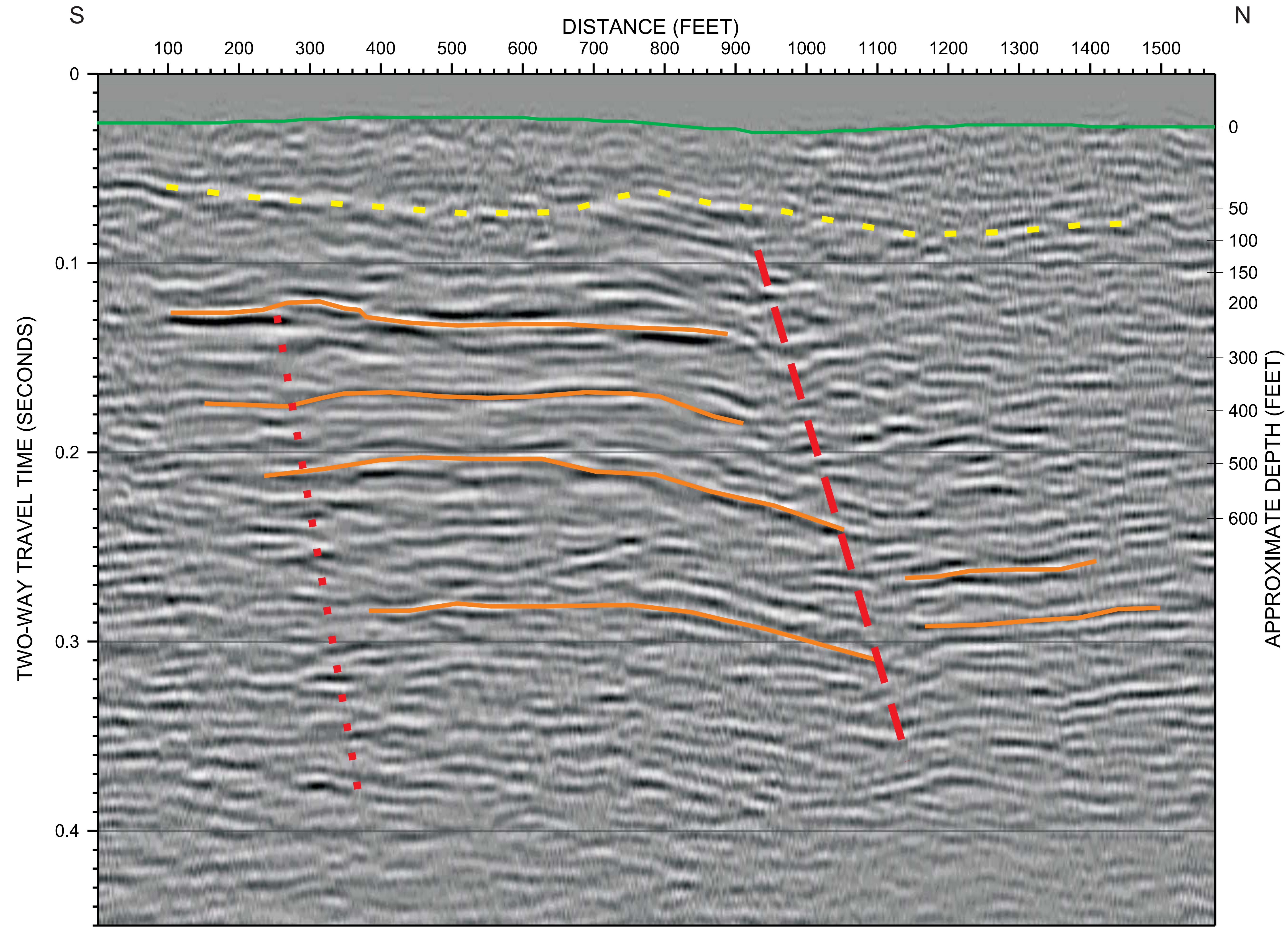
LINE Z3-G7

LEGEND

Ground Surface Reference

GEOVision geophysical services

Project # 9001	FIGURE 29 LINE Z3-G7 SEISMIC SECTION WITHOUT INTERPRETATION
Date: AUG 5, 2009	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Drawn By: A MARTIN	PREPARED FOR CH2M HILL
Approved By:	



LINE Z3-G7

LEGEND

Ground Surface Reference	Example Seismic Reflector
Interpreted Water Table or Top of Bedrock	Possible Fault, dotted where uncertain
Interpreted Top of Bedrock or Weathering Contact within Bedrock	

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Project # 9001
Date: AUG 5, 2009
Drawn By: A MARTIN
Approved By:

FIGURE 30
LINE Z3-G7 SEISMIC SECTION
WITH INTERPRETATION

SR-710 TUNNEL TECHNICAL STUDY
LOS ANGELES COUNTY, CALIFORNIA

PREPARED FOR
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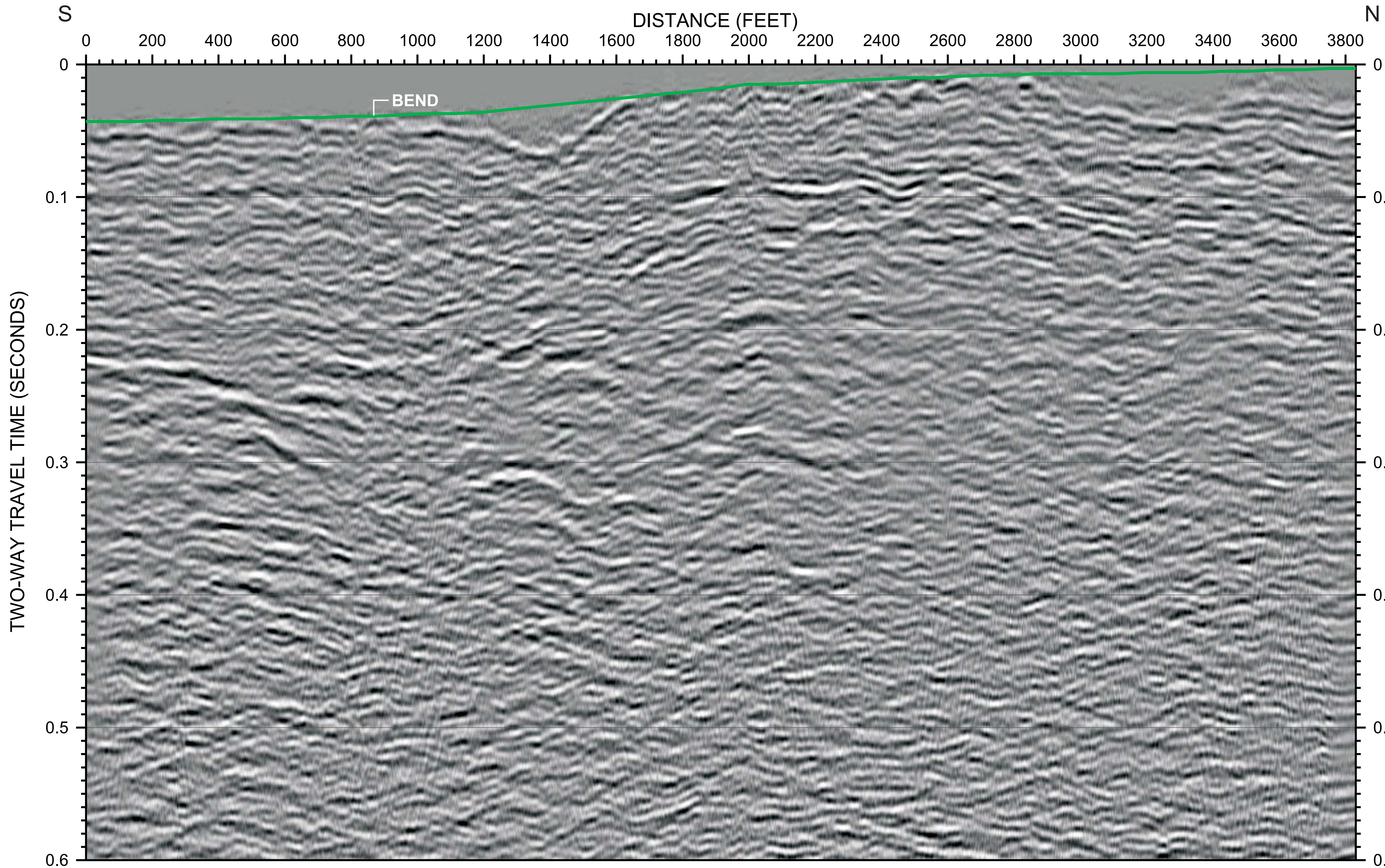

LINE Z4-G1

LEGEND

Ground Surface Reference

GEOVision geophysical services

Project # 9001
Date: AUG 5, 2009
Drawn By: A MARTIN
Approved By:

FIGURE 31
LINE Z4-G1 SEISMIC SECTION
WITHOUT INTERPRETATION

SR-710 TUNNEL TECHNICAL STUDY
LOS ANGELES COUNTY, CALIFORNIA

PREPARED FOR
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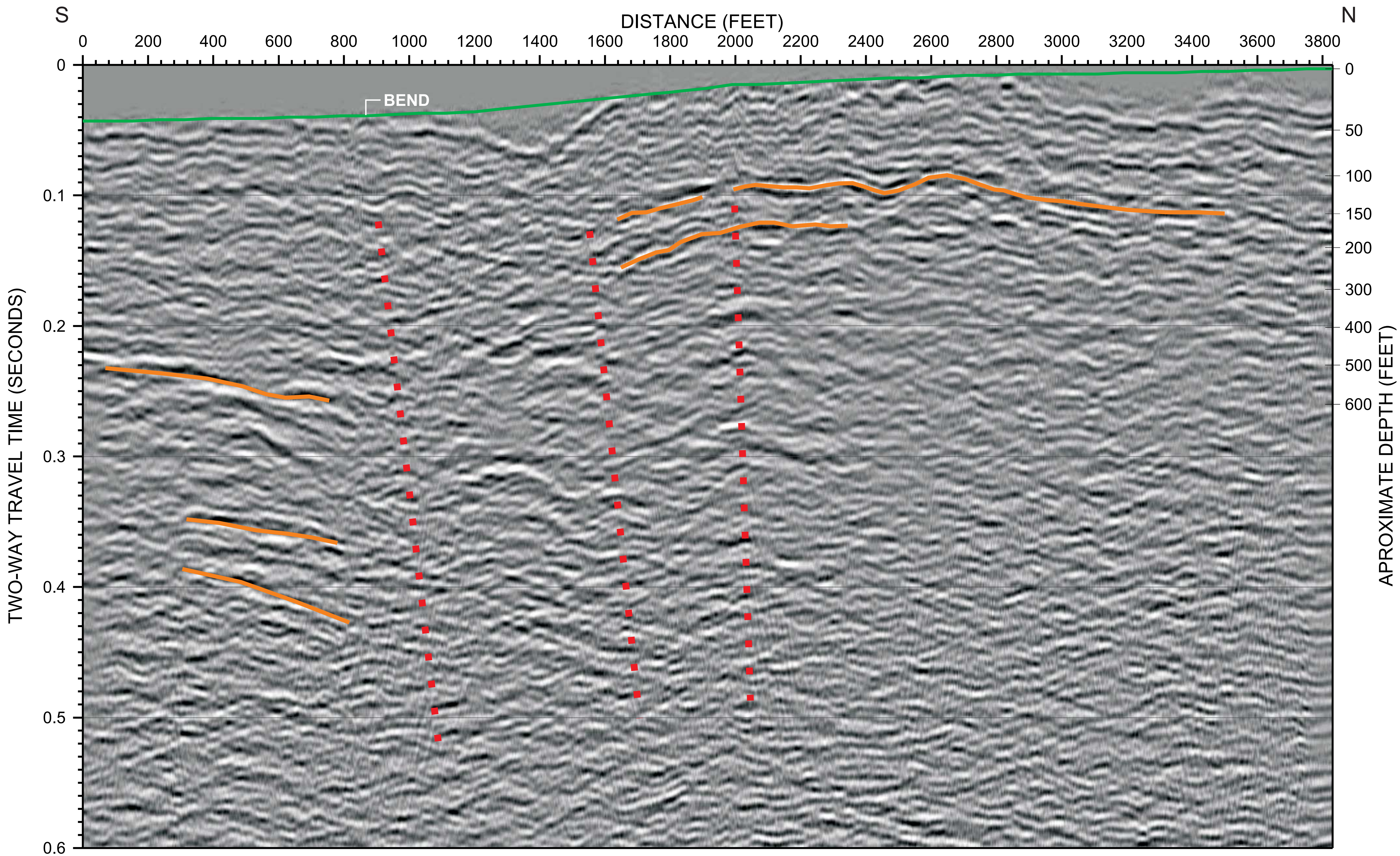

LINE Z4-G1

LEGEND

Ground Surface Reference	Example Seismic Reflector
Interpreted Water Table or Top of Bedrock	Possible Fault, dotted where uncertain
Interpreted Top of Bedrock or Weathering Contact within Bedrock	

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Project # 9001
Date: AUG 5, 2009
Drawn By: A MARTIN
Approved By:

FIGURE 32
LINE Z4-G1 SEISMIC SECTION
WITH INTERPRETATION

SR-710 TUNNEL TECHNICAL STUDY
LOS ANGELES COUNTY, CALIFORNIA

PREPARED FOR
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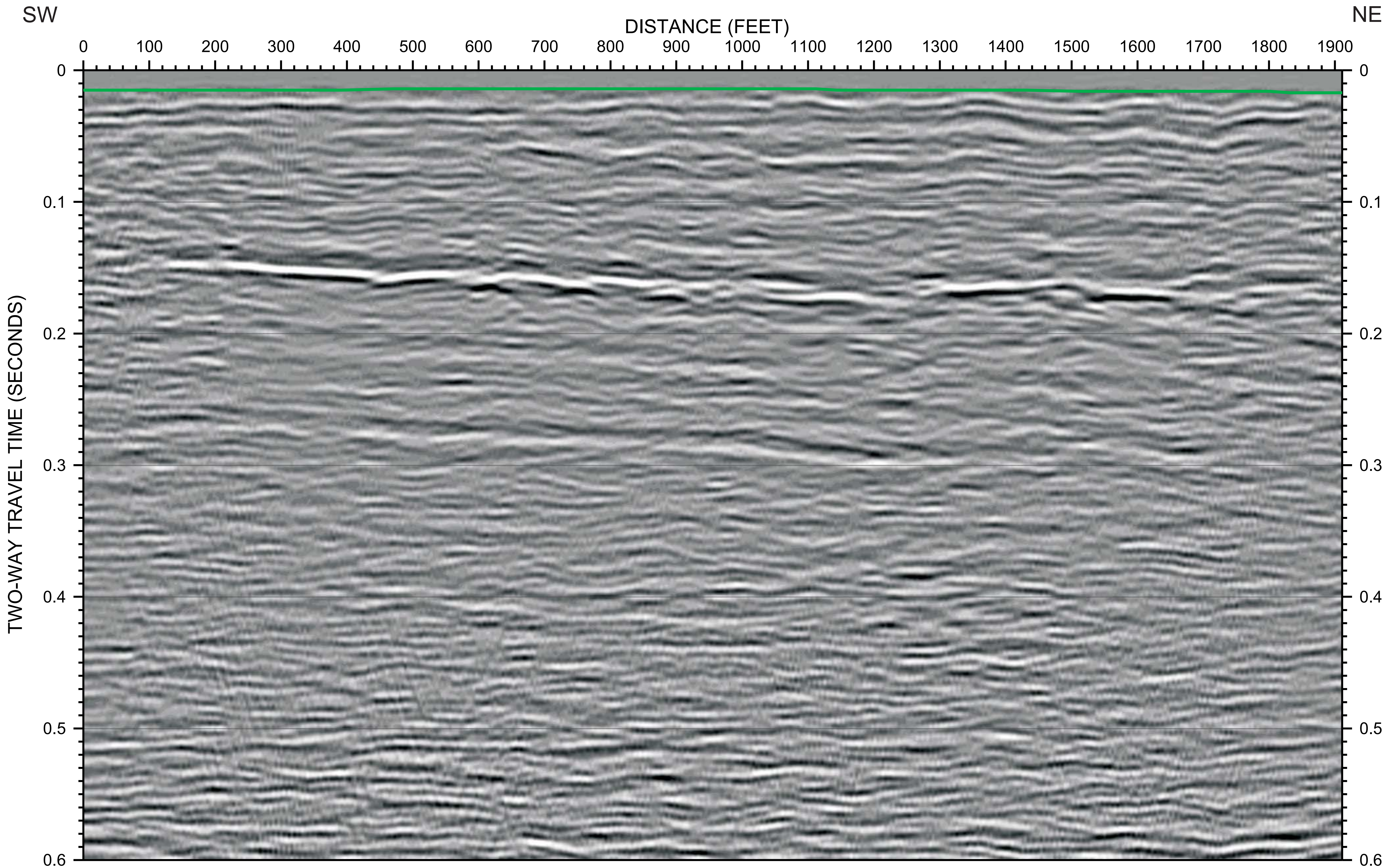

LINE Z4-G2

LEGEND

Ground Surface Reference

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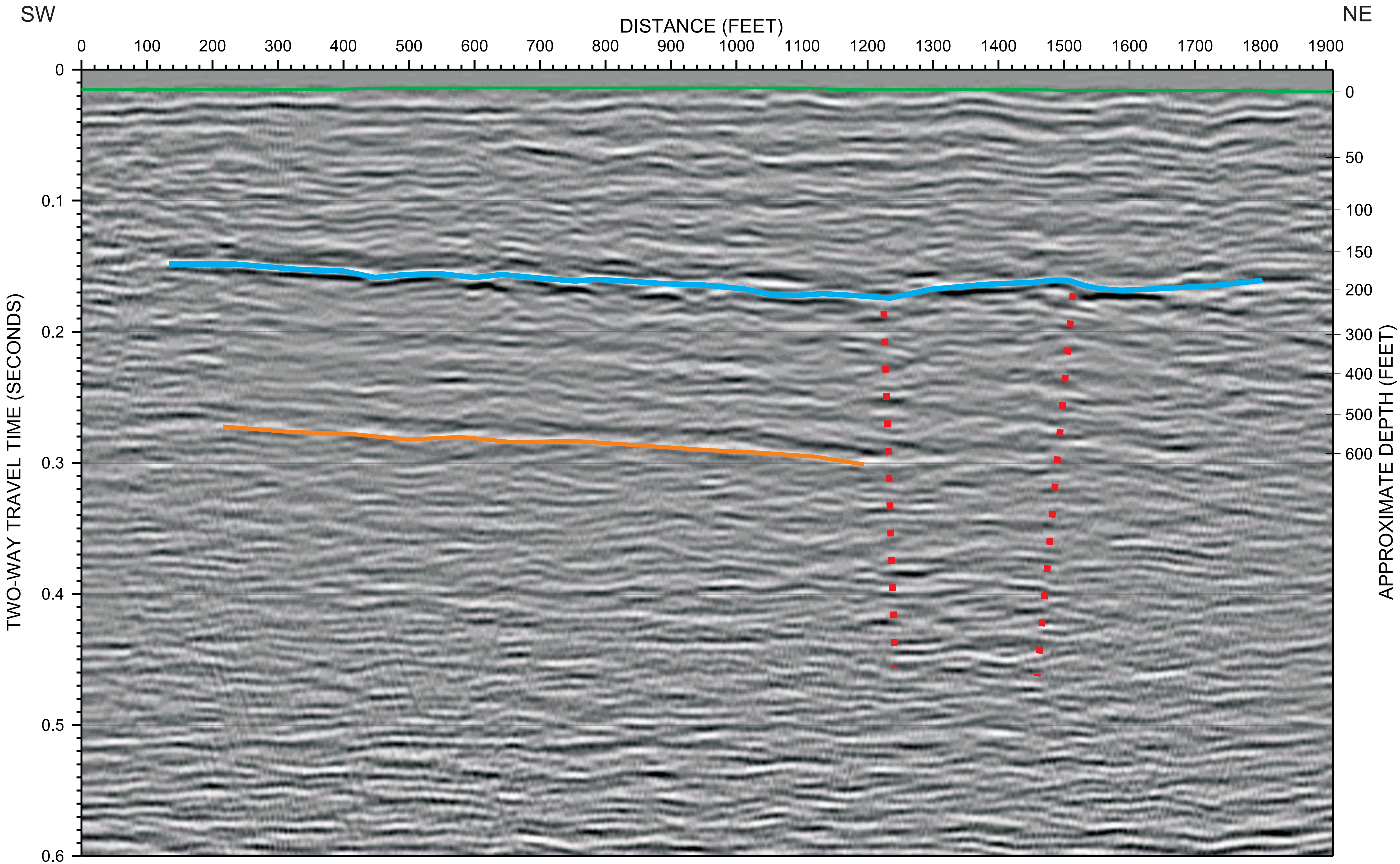
Project # 9001	FIGURE 33 LINE Z4-G2 SEISMIC SECTION WITHOUT INTERPRETATION
Date: AUG 5, 2009	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Drawn By: A MARTIN	
Approved By:	PREPARED FOR CH2M HILL



LINE Z4-G2

LEGEND

Ground Surface Reference

Interpreted Water Table or Top of Bedrock

Interpreted Top of Bedrock or Weathering Contact within Bedrock

Example Seismic Reflector

Possible Fault, dotted where uncertain

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Project # 9001

Date: AUG 5, 2009

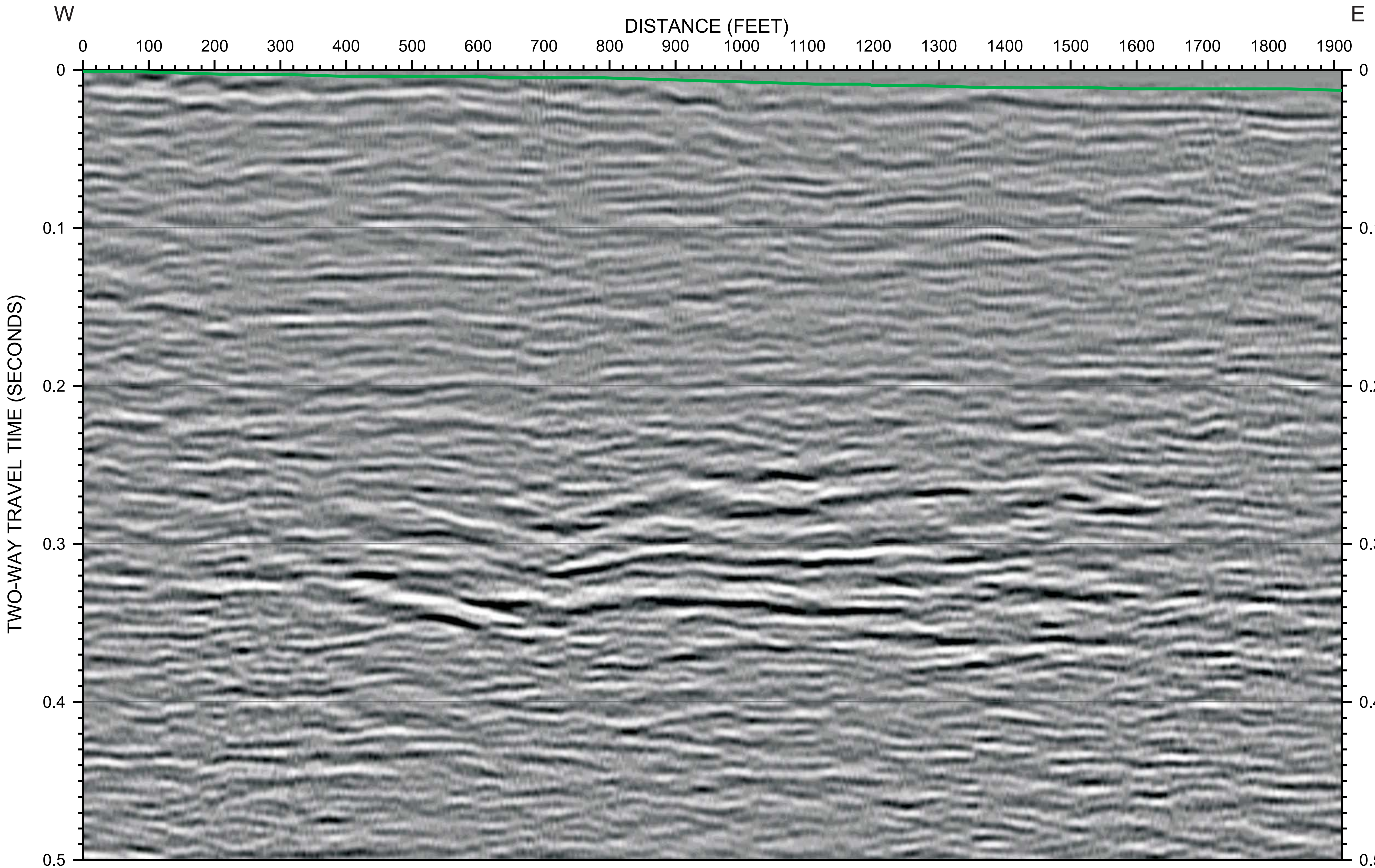
Drawn By: A MARTIN

Approved By:

FIGURE 34
LINE Z4-G2 SEISMIC SECTION
WITH INTERPRETATION

SR-710 TUNNEL TECHNICAL STUDY
LOS ANGELES COUNTY, CALIFORNIA

PREPARED FOR
CH2M HILL



LINE Z5-G2

LEGEND

Ground Surface Reference

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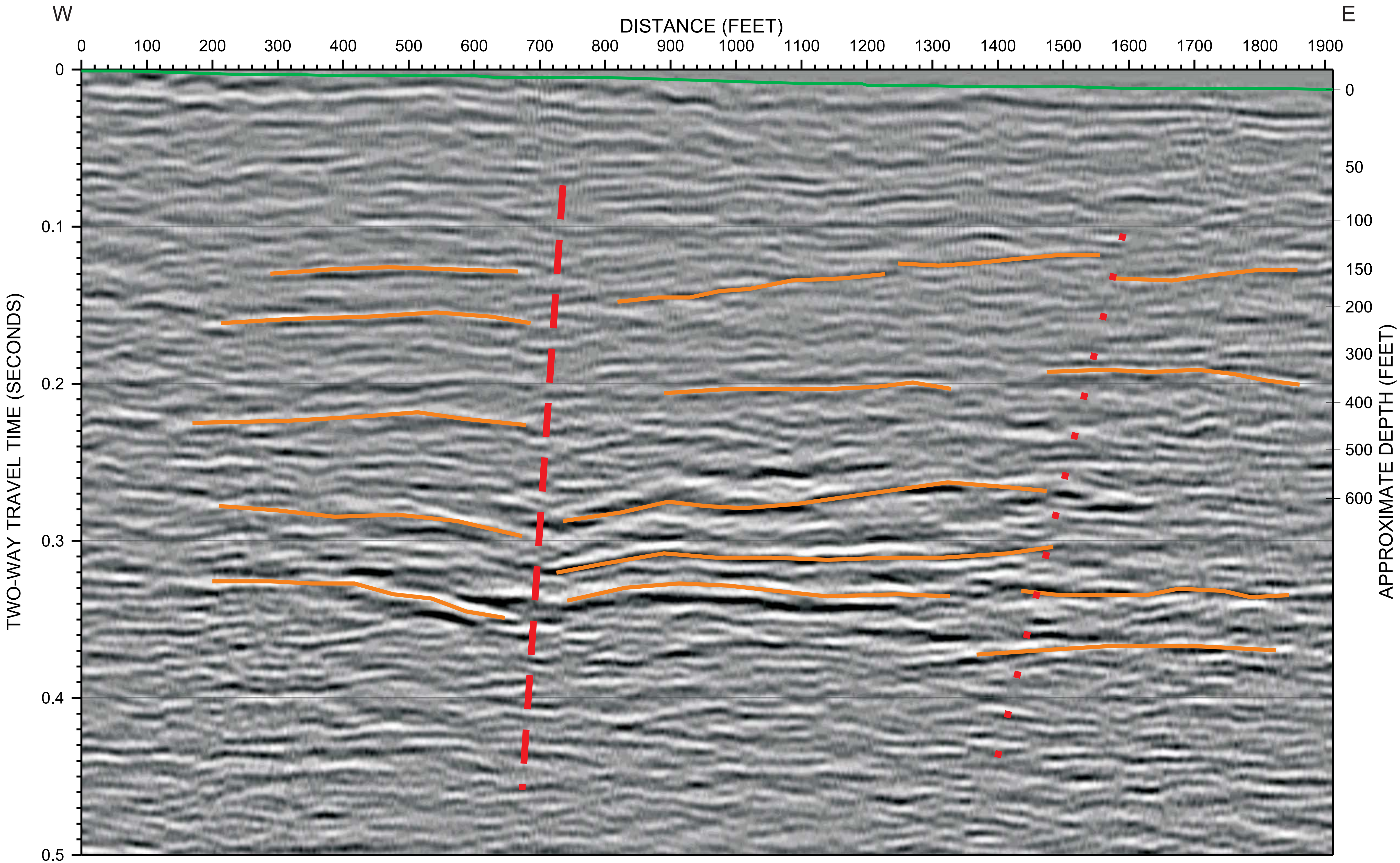
Project # 9001	FIGURE 35 LINE Z5-G2 SEISMIC SECTION WITHOUT INTERPRETATION
Date: AUG 5, 2009	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Drawn By: A MARTIN	
Approved By:	PREPARED FOR CH2M HILL



LINE Z5-G2

LEGEND

Ground Surface Reference

Interpreted Water Table or Top of Bedrock

Interpreted Top of Bedrock or Weathering Contact within Bedrock

Example Seismic Reflector

Possible Fault, dotted where uncertain

GEOVision geophysical services

Project # 9001

Date: AUG 5, 2009

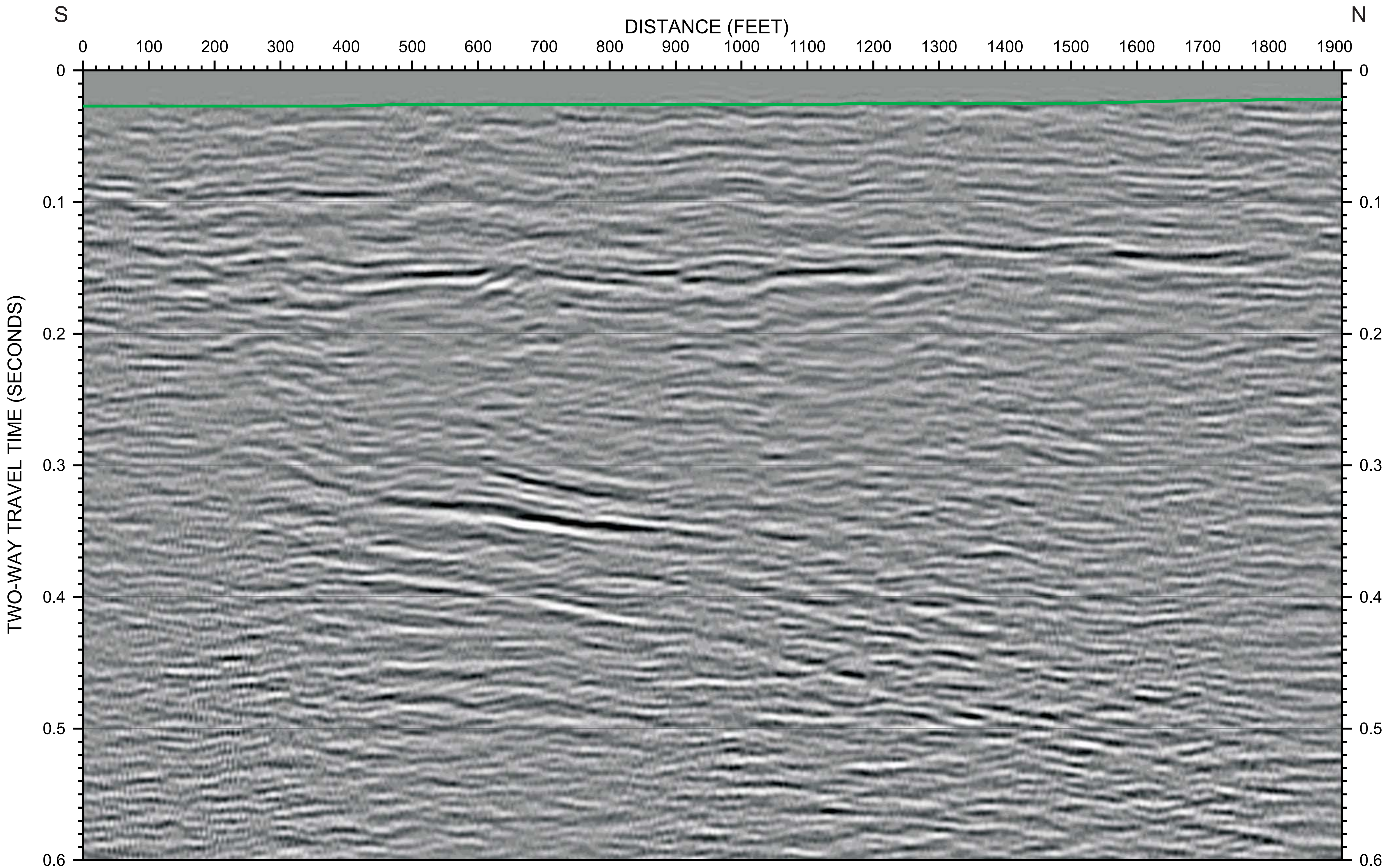
Drawn By: A MARTIN

Approved By:

FIGURE 36
LINE Z5-G2 SEISMIC SECTION
WITH INTERPRETATION

SR-710 TUNNEL TECHNICAL STUDY
LOS ANGELES COUNTY, CALIFORNIA

PREPARED FOR
CH2M HILL



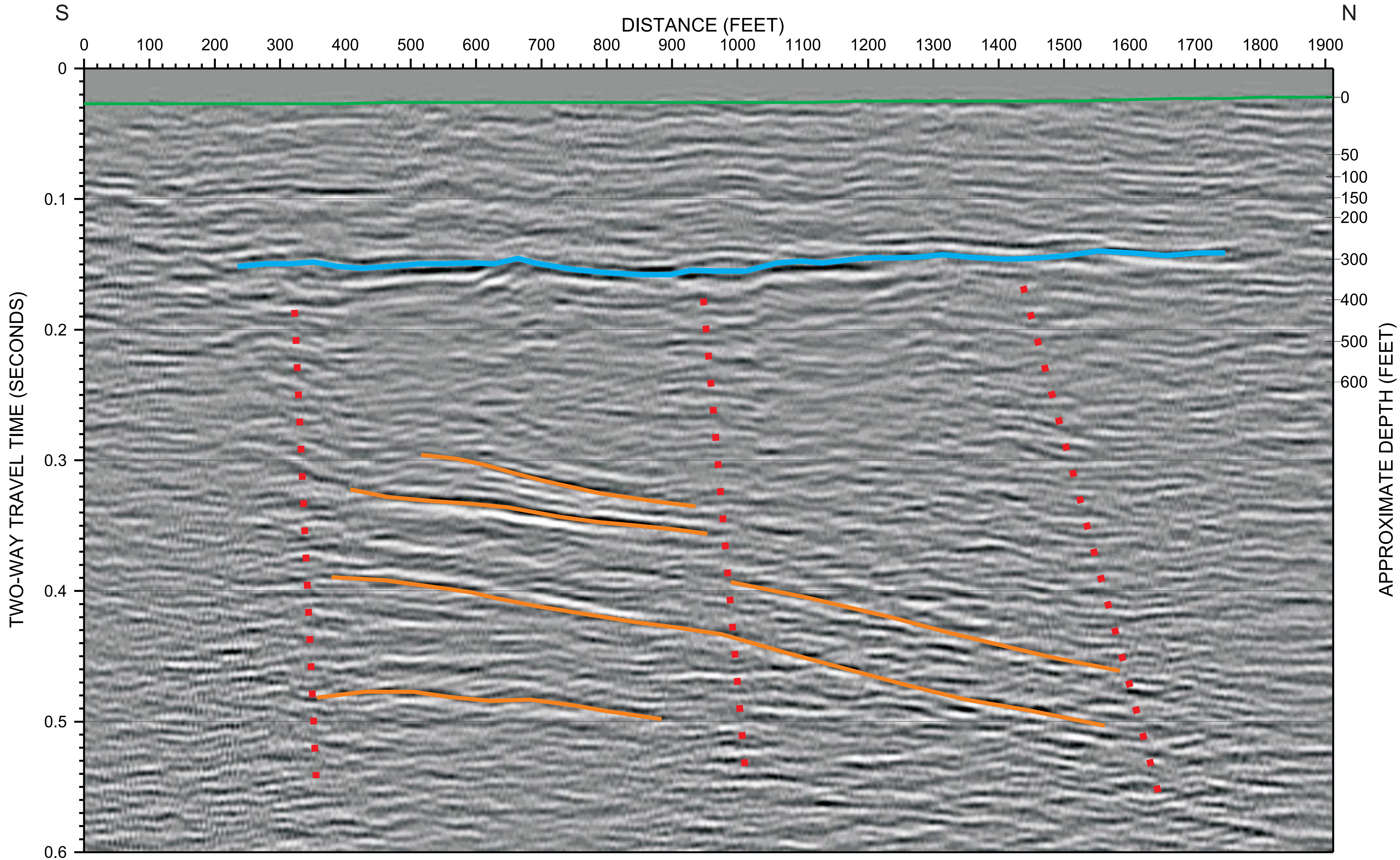
LINE Z5-G3

LEGEND

Ground Surface Reference

GEOVision geophysical services

Project # 9001	FIGURE 37 LINE Z5-G3 SEISMIC SECTION WITHOUT INTERPRETATION
Date: AUG 5, 2009	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Drawn By: A MARTIN	
Approved By:	PREPARED FOR CH2M HILL



LINE Z5-G3

LEGEND

- Ground Surface Reference (green line)
- Interpreted Water Table or Top of Bedrock (blue line)
- Interpreted Top of Bedrock or Weathering Contact within Bedrock (yellow dashed line)
- Example Seismic Reflector (orange line)
- Possible Fault, dotted where uncertain (red dashed line)

GEOVision geophysical services	FIGURE 38 LINE Z5-G3 SEISMIC SECTION WITH INTERPRETATION
Project # 9001 Date: AUG 5, 2009	SR-710 TUNNEL TECHNICAL STUDY LOS ANGELES COUNTY, CALIFORNIA
Drawn By: A MARTIN Approved By:	PREPARED FOR CH2M HILL