SEISMIC REFRACTION SURVEY
CAMPUS POINTE
SAN MARCOS, CALIFORNIA

PREPARED FOR:

Richard and Richard Construction Company, Inc.
234 Venture Street, Suite 100
San Marcos, CA 92078

PREPARED BY:

Southwest Geophysics, Inc.
8057 Raytheon Road, Suite 9
San Diego, CA 92111

May 16, 2014
Project No. 114175

SOUTHWEST GEOPHYSICS, INC.
YOUR SUBSURFACE SOLUTION

May 16, 2014
Project No. 114175

Mr. Bryan Toscani
Richard and Richard Construction Company, Inc.
234 Venture Street, Suite 100
San Marcos, CA 92078

Subject: Seismic Refraction Survey
Campus Pointe
San Marcos, California

Dear Mr. Toscani:

In accordance with your authorization, we have performed a seismic refraction survey pertaining to the proposed grading at the subject project located in San Marcos, California. Specifically, our survey consisted of performing 10 seismic refraction traverses within the limits of the proposed property. The purpose of our study was to develop subsurface velocity profiles of the areas surveyed, and to assess the apparent rippability and depth to bedrock of the subsurface materials. This data report presents our survey methodology, equipment used, analysis, and results.

We appreciate the opportunity to be of service on this project. Should you have any questions related to this report, please contact the undersigned at your convenience.

Sincerely,
SOUTHWEST GEOPHYSICS, INC.

Edward Verdugo, G.I.T.
Senior Staff Geologist/Geophysicist

Patrick Lehrmann, P.G., P.Gp.
Principal Geologist/Geophysicist

REGISTERED GEOPHYSICIST ☆ PATRICK F. LEHRMANN ☆ No. 1043 ☆ Exp. 1/31/16 ☆ STATE OF CALIFORNIA

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8057 Raytheon Road, Suite 9 • San Diego • California 92111 • Telephone 858-527-0849 • Fax 858-225-0114

TABLE OF CONTENTS

Page

Table

Figures

1. INTRODUCTION

In accordance with your authorization, we have performed a seismic refraction survey pertaining to the proposed grading at the subject project located in San Marcos, California (Figure 1). Specifically, our survey consisted of performing 10 seismic refraction traverses within the limits of the proposed property. The purpose of our study was to develop subsurface velocity profiles of the areas surveyed, and to assess the apparent rippability and depth to bedrock of the subsurface materials. This data report presents our survey methodology, equipment used, analysis, and results.

2. SCOPE OF SERVICES

Our scope of services included:

- Performance of 10 seismic refraction lines at the project site.
- Compilation and analysis of the data collected.
- Preparation of this data report presenting our results, conclusions and recommendations.

3. SITE DESCRIPTION

The project site is located to the south of Interstate 78 and to the northwest of the intersection of Enterprise Street and Venture Street in San Marcos, California (Figure 1). A residence and various outbuildings including a large chicken coup are present onsite. Vegetation in the project area includes trees, bushes, and minor amounts of brush. A large ravine runs southeast to northwest along a portion of the property. Figures 2 and 3 depict the general site conditions in the area of the lines.

4. SURVEY METHODOLOGY

A seismic P-wave (compression wave) refraction survey was conducted at the site to evaluate the rippability characteristics of the subsurface materials and to develop subsurface velocity profiles of the areas surveyed. The seismic refraction method uses first-arrival times of refracted seismic waves to estimate the thicknesses and seismic velocities of subsurface layers. Seismic P-waves generated at the surface, using a hammer and plate, are refracted at boundaries separating materials of contrasting velocities. These refracted seismic waves are then detected by a series of surface vertical component geophones and recorded with a 24-channel Geometrics StrataView seismograph. The travel times of the seismic P-waves are used in conjunction with the shot-to-geophone distances to obtain thickness and velocity information on the subsurface materials.

Ten seismic lines (SL-1 through SL-10) were conducted in the study area. The general locations and lengths of the lines were selected by your office. Shot points (signal generation locations) were conducted along the lines at the ends, midpoint, and intermediate points between the ends and the midpoint for a total of five shot points along each line. In general, the effective depth of evaluation for a seismic refraction traverse is approximately one-third to one-fifth the length of the traverse.

The seismic refraction theory requires that subsurface velocities increase with depth. A layer having a velocity lower than that of the layer above will not generally be detectable by the seismic refraction method and, therefore, could lead to errors in the depth calculations of subsequent layers. In addition, lateral variations in velocity, such as those caused by core stones, intrusions or boulders can also result in the misinterpretation of the subsurface conditions.

In general, seismic wave velocities can be correlated to material density and/or rock hardness. The relationship between rippability and seismic velocity is empirical and assumes a homogenous mass. Localized areas of differing composition, texture, and/or structure may affect both the measured data and the actual rippability of the mass. The rippability of a mass is also dependent on the excavation equipment used and the skill and experience of the equipment operator.

The rippability values presented in Table 1 are based on our experience with similar materials and assume that a Caterpillar D-9 dozer ripping with a single shank is used. We emphasize that the cutoffs in this classification scheme are approximate and that rock characteristics, such as fracture spacing and orientation, play a significant role in determining rock rippability. These characteristics may also vary with location and depth. For trenching operations, the rippability values should be scaled downward. For example, velocities as low as 3,500 feet/second may indicate difficult ripping during trenching operations. In addition, the presence of boulders, which can be troublesome in a narrow trench, should be anticipated.

Table 1 – Rippability Classification

Seismic P-wave Velocity	Rippability
0 to 2,000 feet/second	Easy
2,000 to 4,000 feet/second	Moderate
4,000 to 5,500 feet/second	Difficult, Possible Blasting
5,500 to 7,000 feet/second	Very Difficult, Probable Blasting
Greater than 7,000 feet/second	Blasting Generally Required

It should be noted that the rippability cutoffs presented in Table 1 are slightly more conservative than those published in the Caterpillar Performance Handbook (Caterpillar, 2011). Accordingly, the above classification scheme should be used with discretion, and contractors should not be relieved of making their own independent evaluation of the rippability of the on-site materials prior to submitting their bids.

5. RESULTS

As previously indicated, 10 seismic traverses were conducted as part of our study. The collected data were processed using SIPwin (Rimrock Geophysics, 2003), a seismic interpretation program, and analyzed using SeisOpt Pro (Optim, 2008). SeisOpt Pro uses first arrival picks and elevation data to produce subsurface velocity models through a nonlinear optimization technique called adaptive simulated annealing. The resulting velocity model provides a tomography image of the estimated geologic conditions. Both vertical and lateral velocity information is contained in the tomography model. Changes in layer velocity are revealed as gradients rather than discrete contacts, which typically are more representative of actual conditions.

Figures 4a through 4j present the velocity models generated from our study. The approximate locations of the seismic refraction traverses are shown on the Line Location Map (Figure 2).

6. CONCLUSIONS AND RECOMMENDATIONS

The results from our seismic survey revealed distinct layers/zones in the near surface that likely represent soil overlying granitic bedrock with varying degrees of weathering. Figures 4a through 4j provide the velocity models calculated from SeisOpt Pro. Distinct vertical and lateral velocity variations are evident in the models. These inhomogeneities are likely related to the presence of remnant boulders, intrusions and differential weathering of the bedrock materials. It is also evident in the tomography models that the depth to bedrock is highly variable across the site.

Based on the refraction results, variability in the excavatability (including depth of rippability) of the subsurface materials should be expected across the project area. Furthermore, blasting may be required depending on the excavation depth, location, equipment used, and desired rate of production. In addition, oversized materials should be expected. A contractor with excavation experience in similar difficult conditions should be consulted for expert advice on excavation methodology, equipment and production rate.

7. LIMITATIONS

The field evaluation and geophysical analyses presented in this report have been conducted in general accordance with current practice and the standard of care exercised by consultants performing similar tasks in the project area. No warranty, express or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be present. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface surveying will be performed upon request.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Southwest Geophysics, Inc. should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document. This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

8. SELECTED REFERENCES

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Mooney, H.M., 1976, Handbook of Engineering Geophysics, dated February.

Optim, Inc., 2008, SeisOpt Pro, V-5.0.

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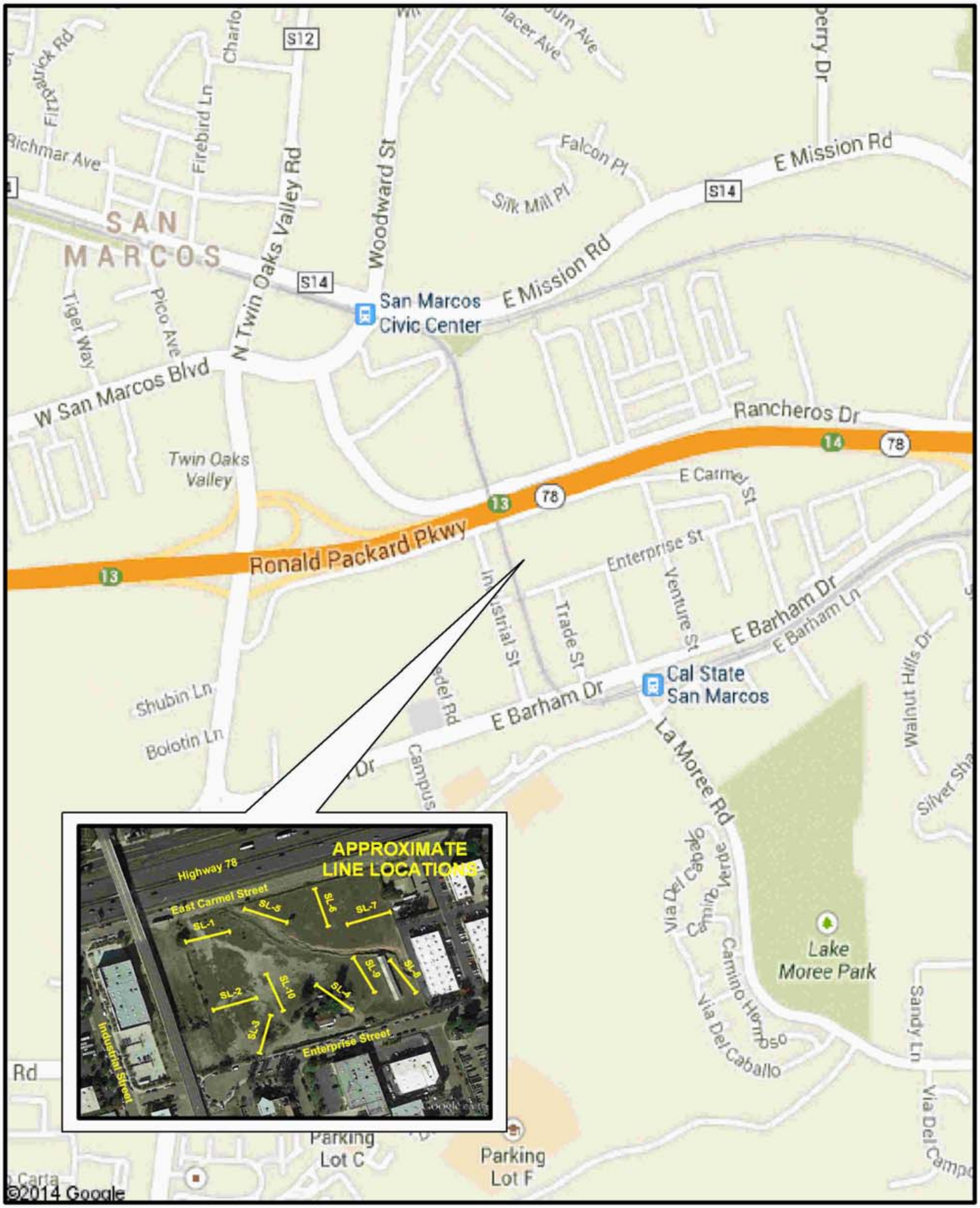
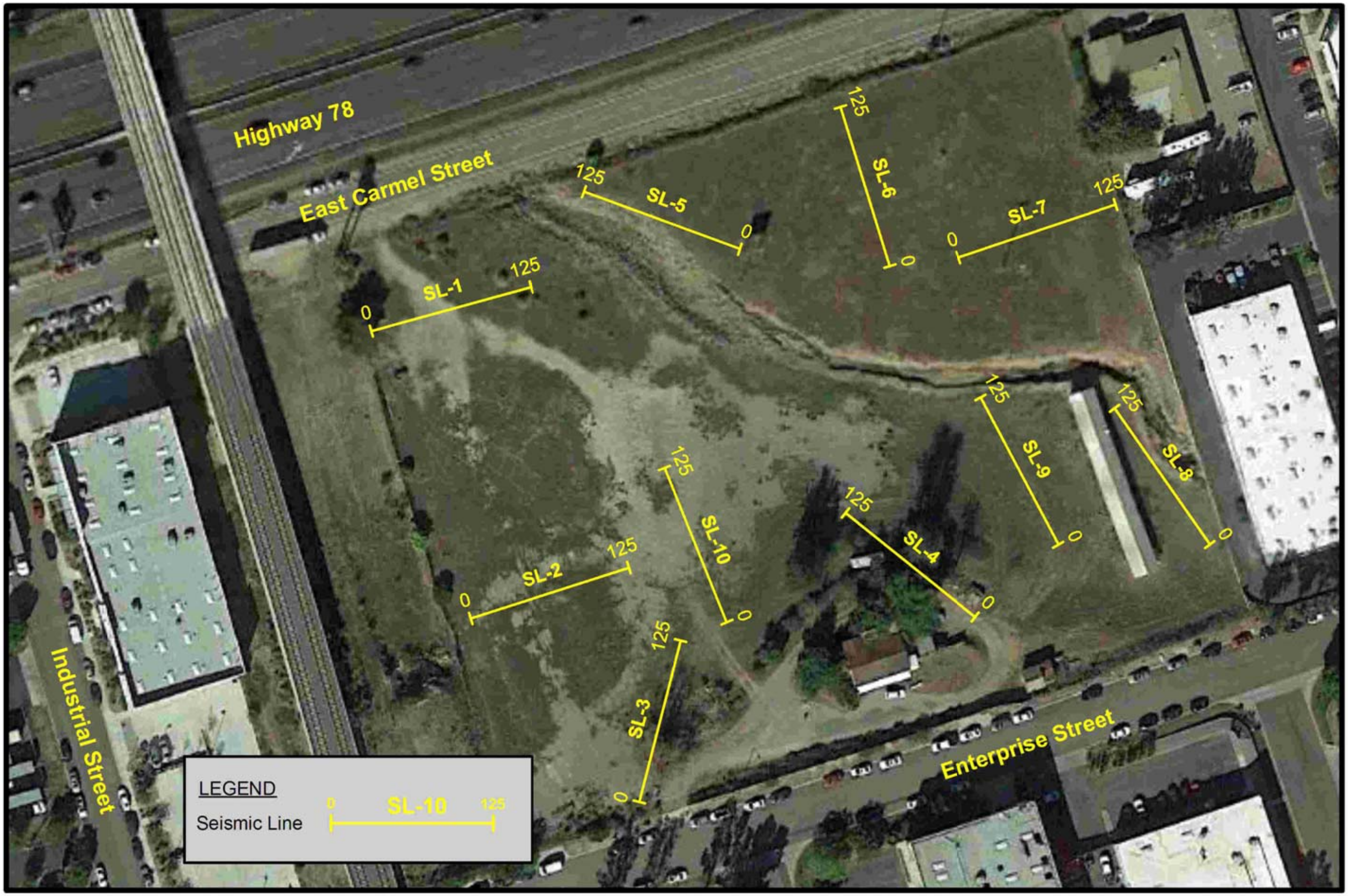


LINE LOCATION MAP	N	Campus Pointe San Marcos, California Project No.: 114175 — Date: 05/14	SOUTHWEST GEOPHYSICS INC. Figure 1



LINE LOCATION MAP

N

Campus Pointe
San Marcos, California

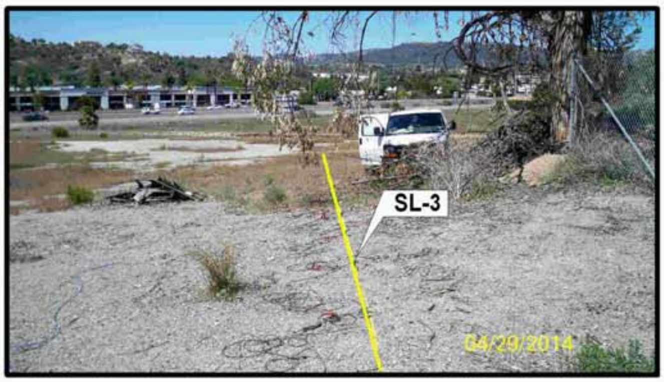
Project No.: 114175 | Date: 05/14

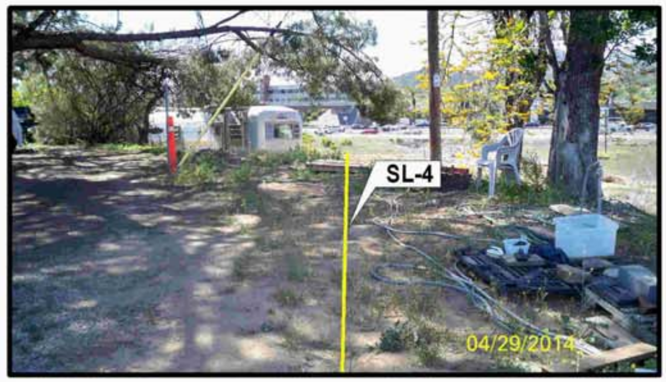
SOUTHWEST GEOPHYSICS INC.

Figure 2

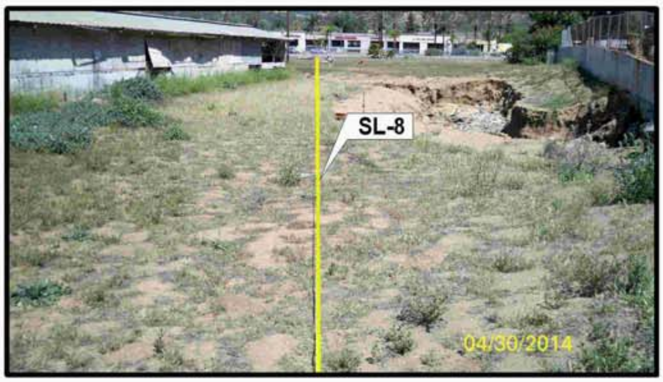
0 100 200

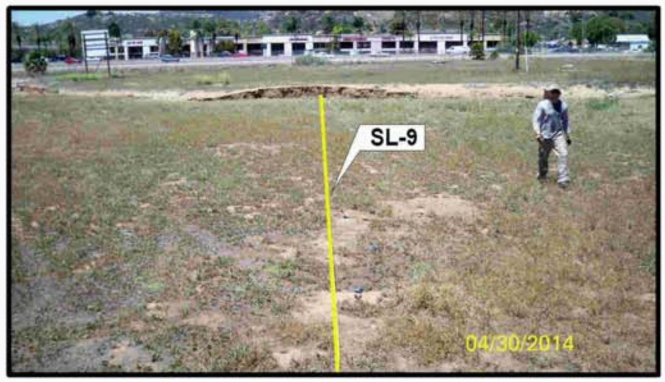
approximate scale in feet

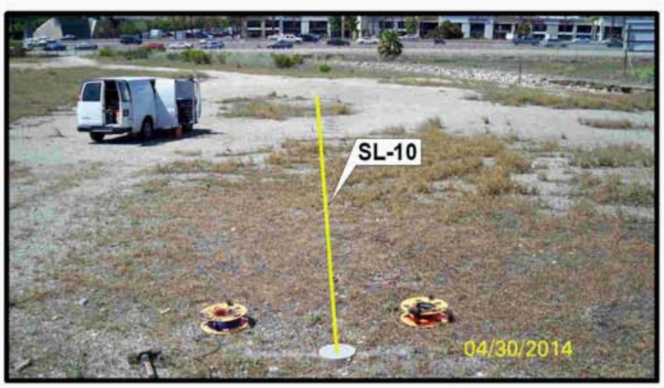




SITE PHOTOGRAPHS	Campus Pointe San Marcos, California		SOUTHWEST GEOPHYSICS INC. Figure 3a
	Project No.: 114175	Date: 05/14	



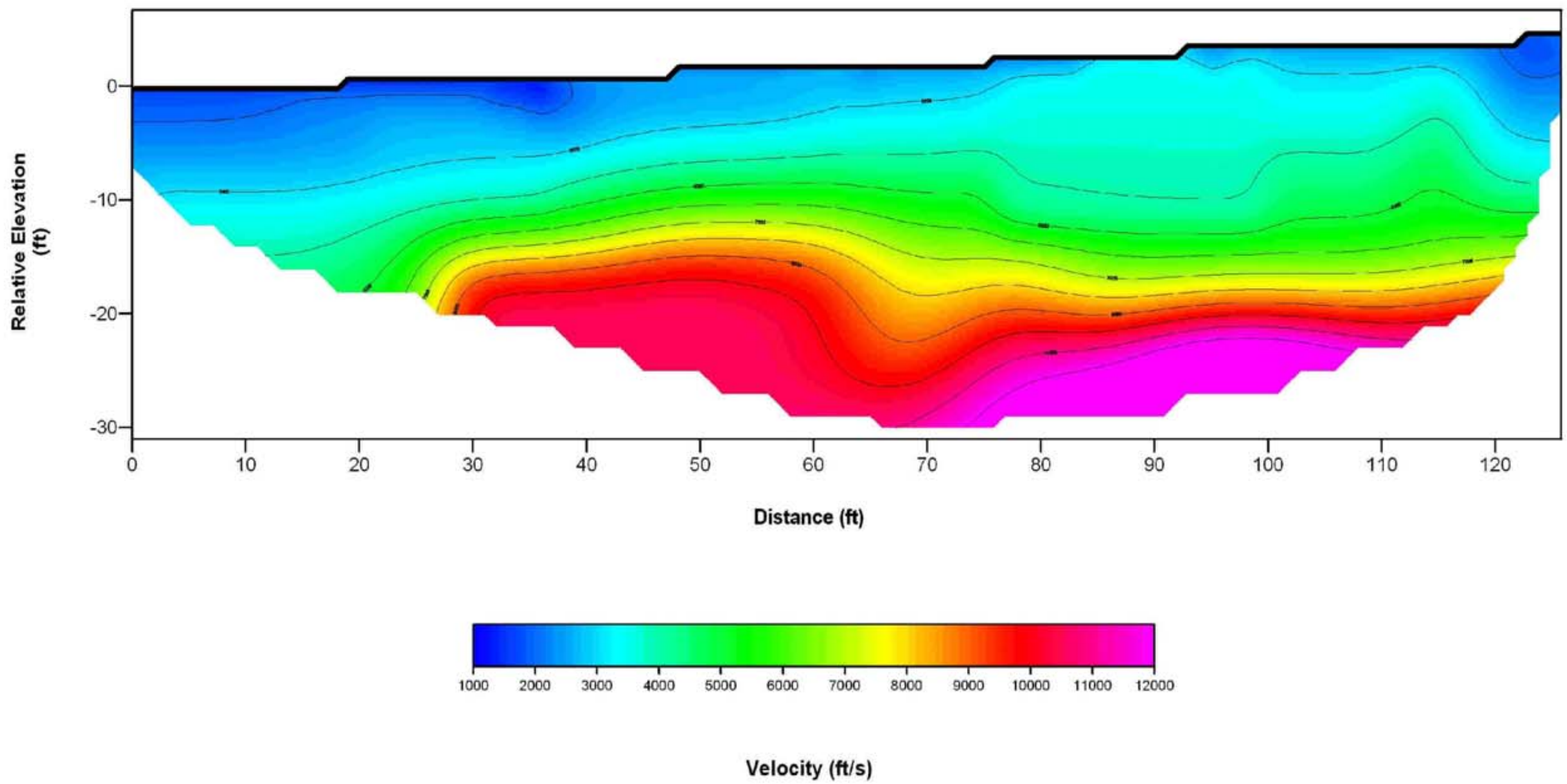




SITE PHOTOGRAPHS	Campus Pointe San Marcos, California	SOUTHWEST GEOPHYSICS INC.
	Project No.: 114175 / Date: 05/14	Figure 3b

TOMOGRAPHY MODEL

SL-1

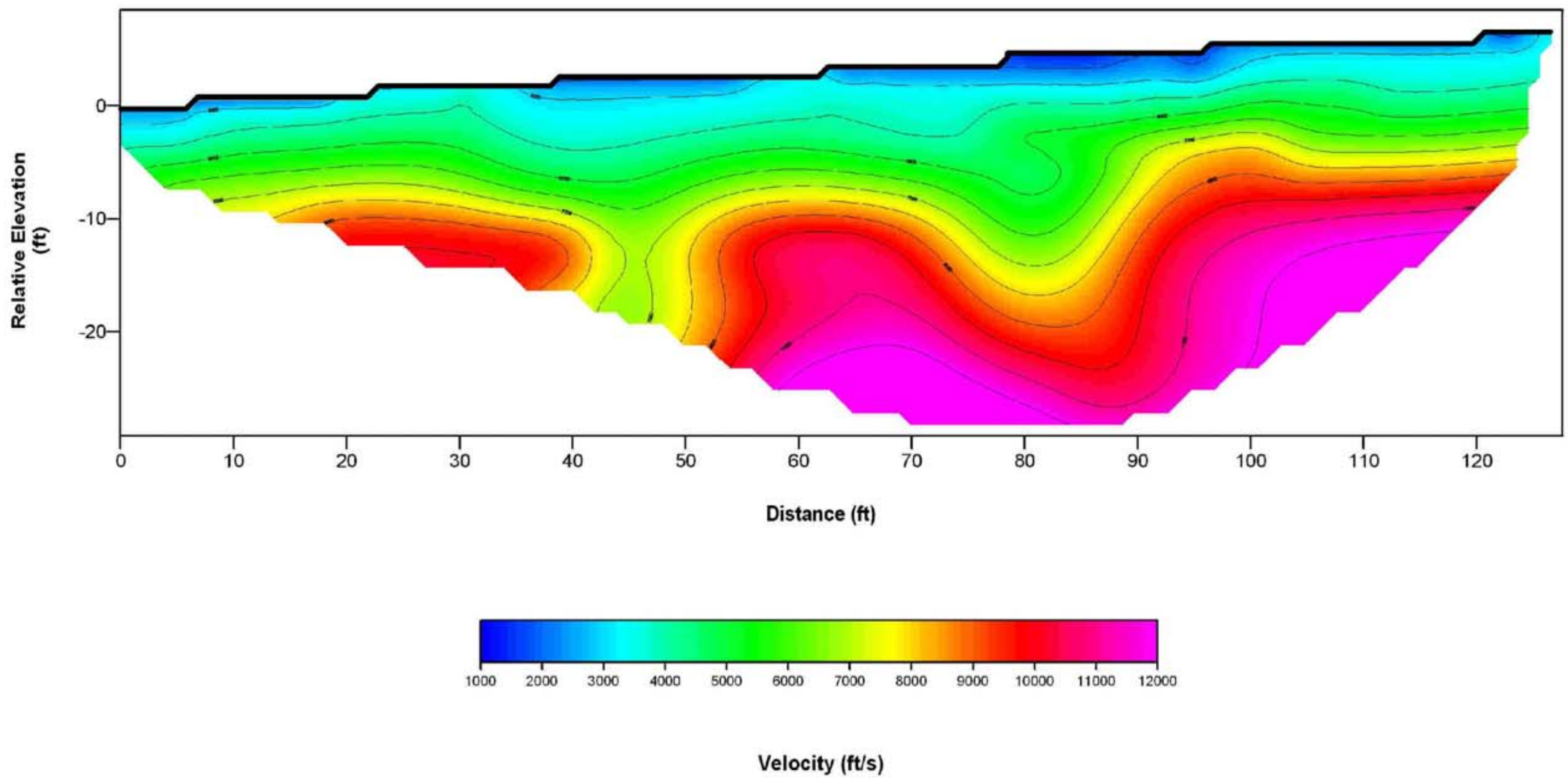


SEISMIC PROFILE	Campus Pointe San Marcos, California Project No.: 114175 · Date: 05/14	SOUTHWEST GEOPHYSICS INC. Figure 4a

Note: Contour Interval = 1,000 feet per second

TOMOGRAPHY MODEL

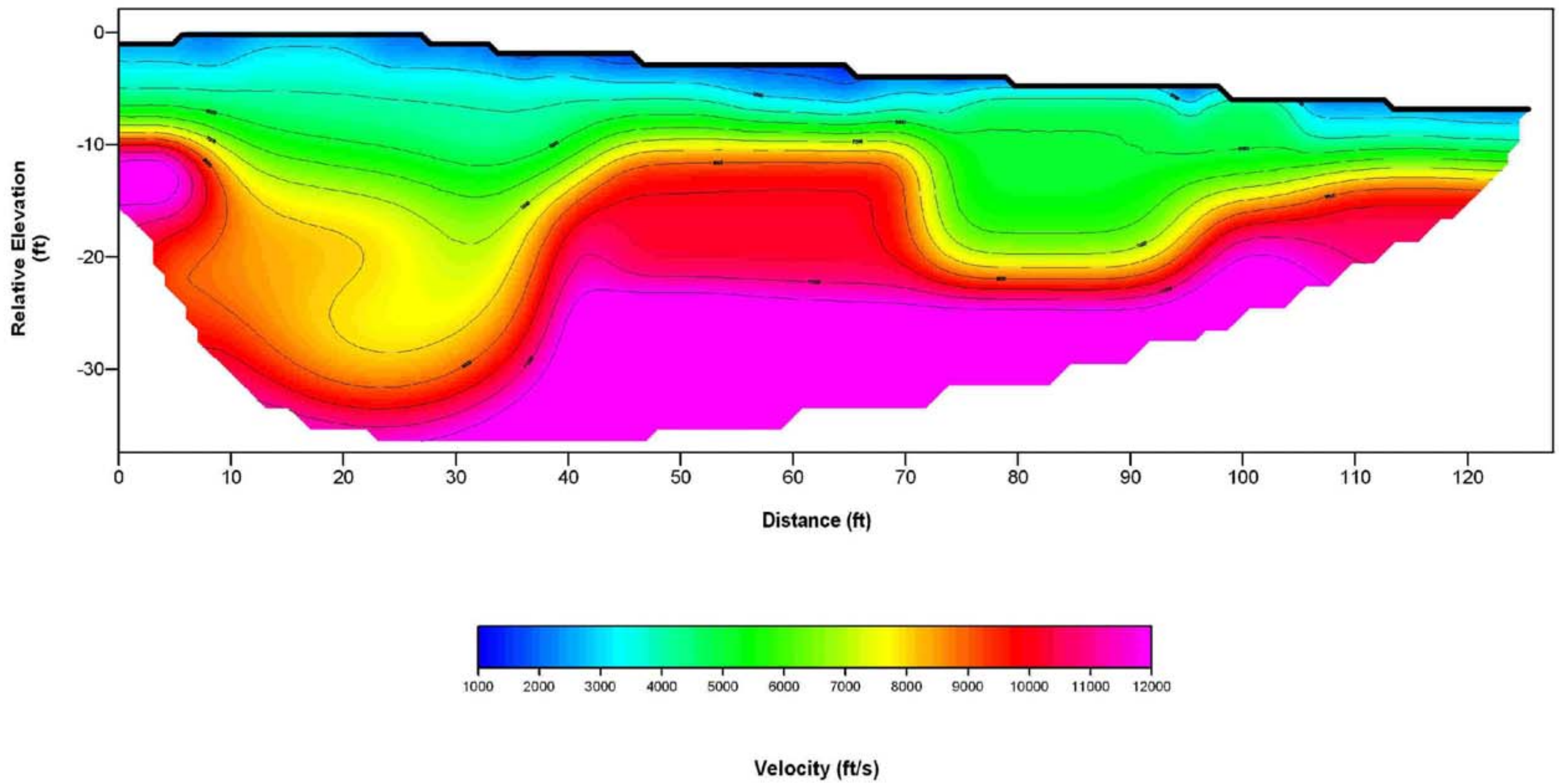
SL-2



SEISMIC PROFILE	Campus Pointe San Marcos, California Project No.: 114175 Date: 05/14	SOUTHWEST GEOPHYSICS INC. Figure 4b	**Note: Contour Interval = 1,000 feet per second**

TOMOGRAPHY MODEL

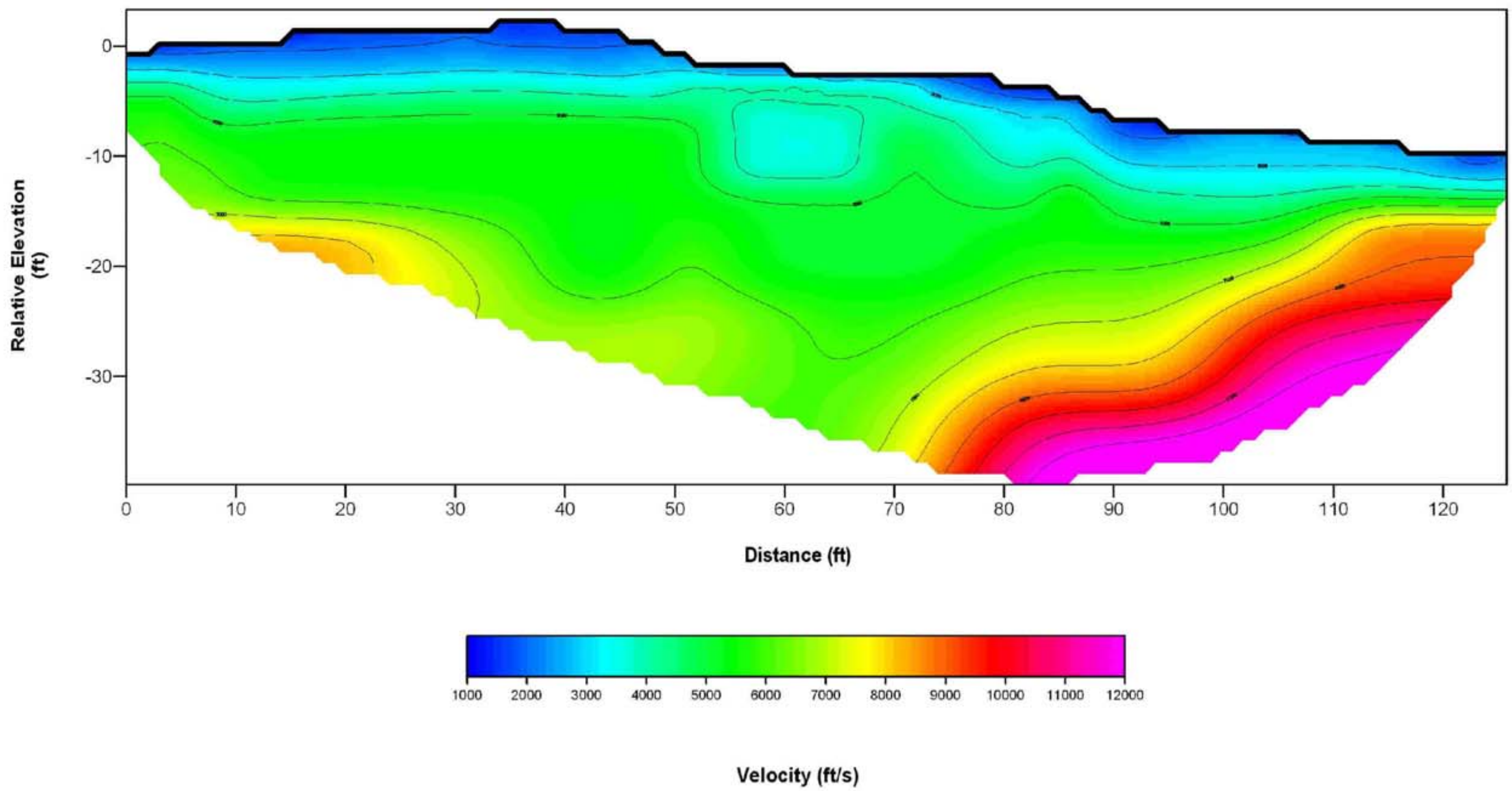
SL-3



SEISMIC PROFILE	Campus Pointe San Marcos, California Project No.: 114175 — Date: 05/14	SOUTHWEST GEOPHYSICS INC. Figure 4c	**Note: Contour Interval = 1,000 feet per second**

TOMOGRAPHY MODEL

SL-4

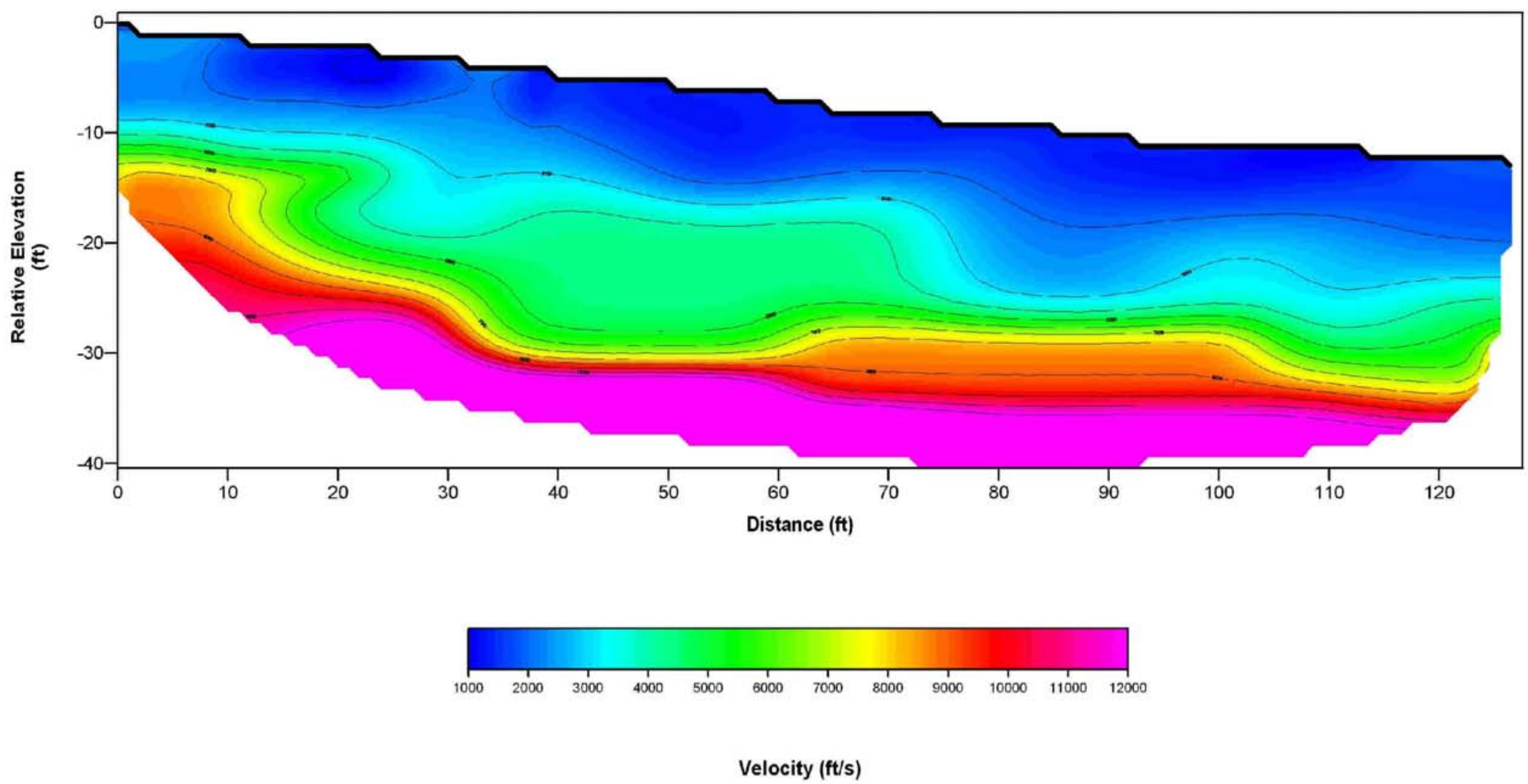


SEISMIC PROFILE	Campus Pointe San Marcos, California Project No.: 114175 — Date: 05/14	SOUTHWEST GEOPHYSICS INC. Figure 4d

Note: Contour Interval = 1,000 feet per second

TOMOGRAPHY MODEL

SL-5

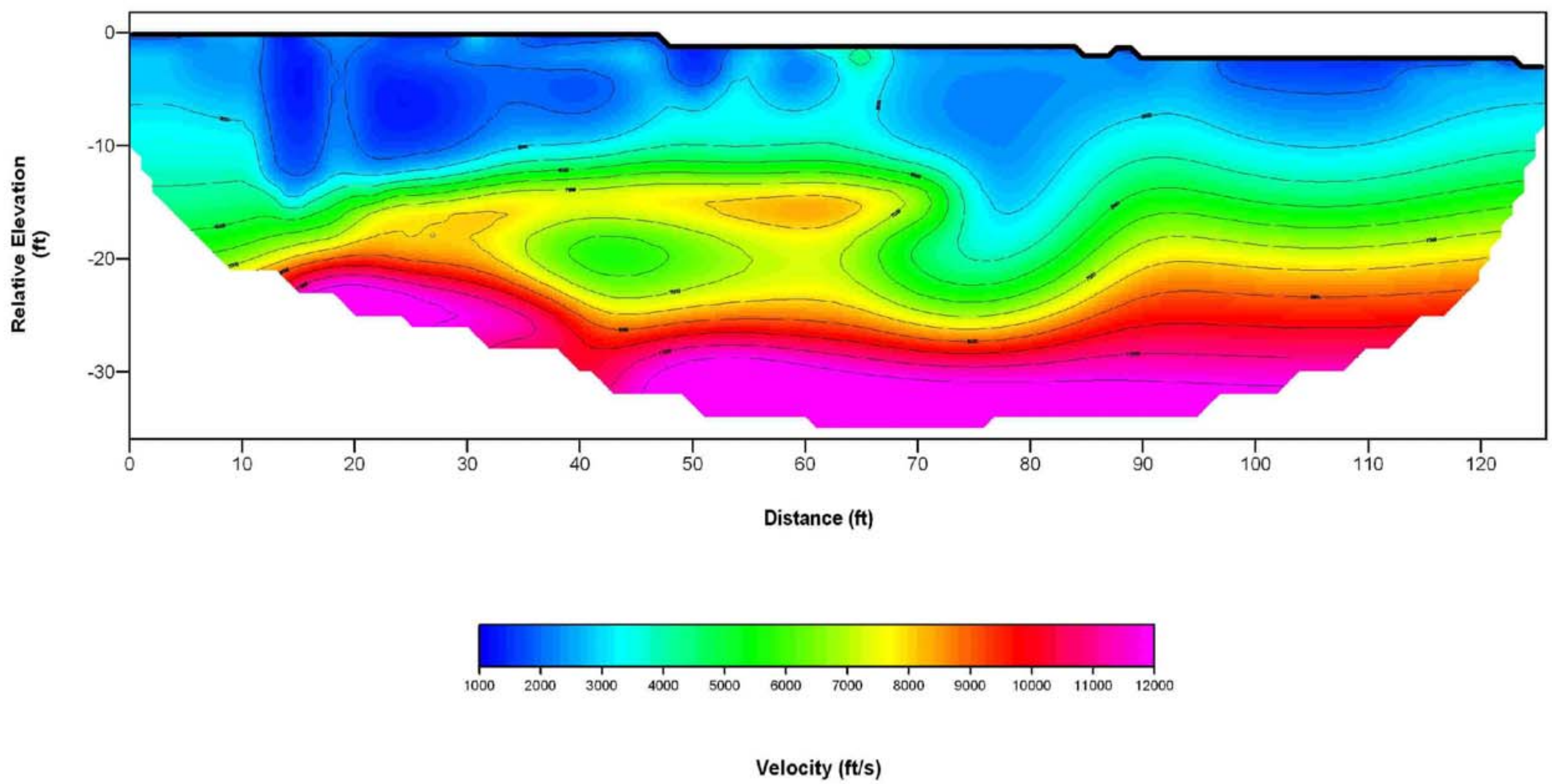


SEISMIC PROFILE	Campus Pointe San Marcos, California	SOUTHWEST GEOPHYSICS INC. Figure 4e
	Project No.: 114175 / Date: 05/14	

Note: Contour Interval = 1,000 feet per second

TOMOGRAPHY MODEL

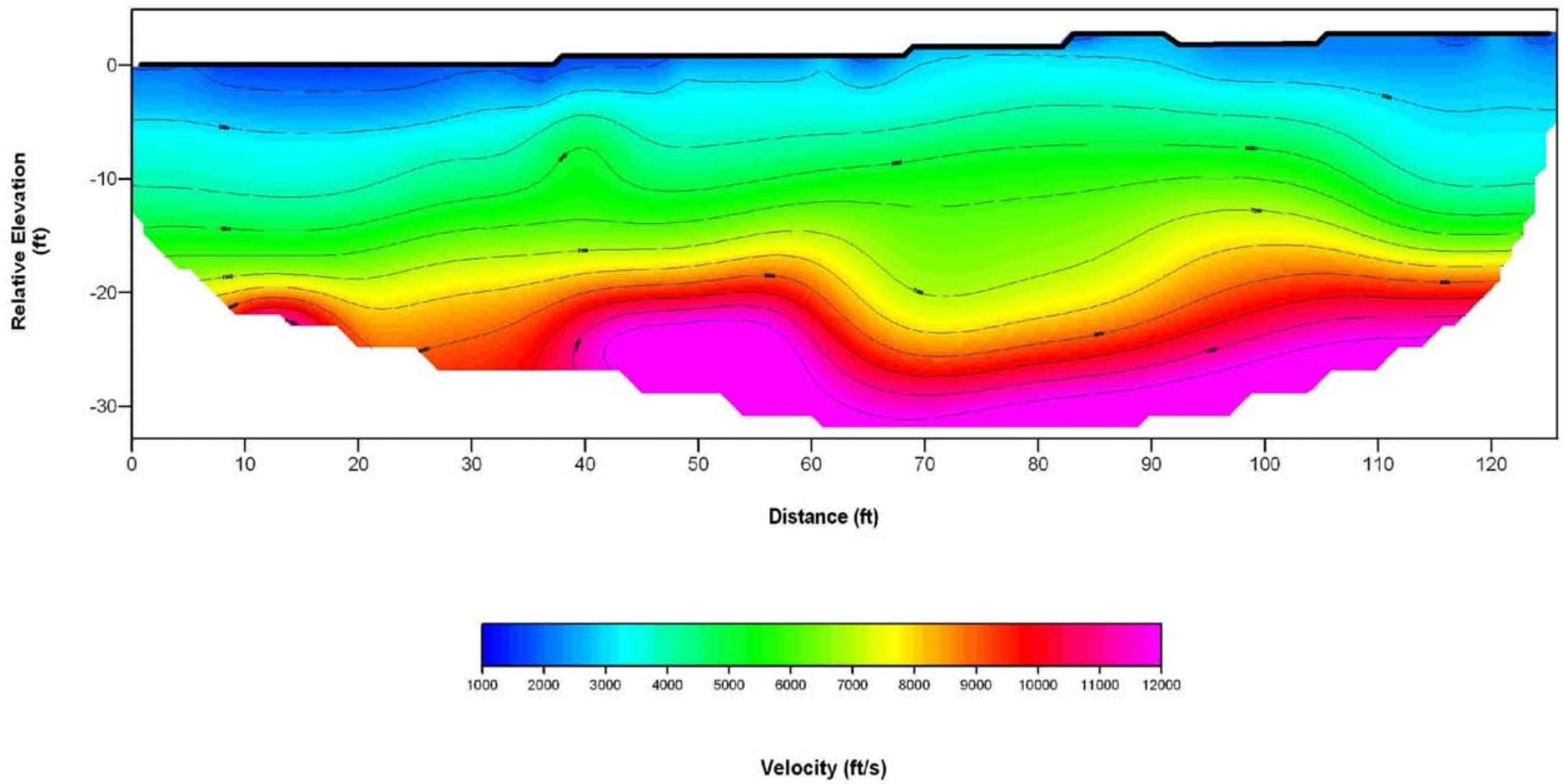
SL-6



SEISMIC PROFILE	Campus Pointe San Marcos, California Project No.: 114175 · Date: 05/14	SOUTHWEST GEOPHYSICS INC. Figure 4f	Note: Contour Interval = 1,000 feet per second

TOMOGRAPHY MODEL

SL-7

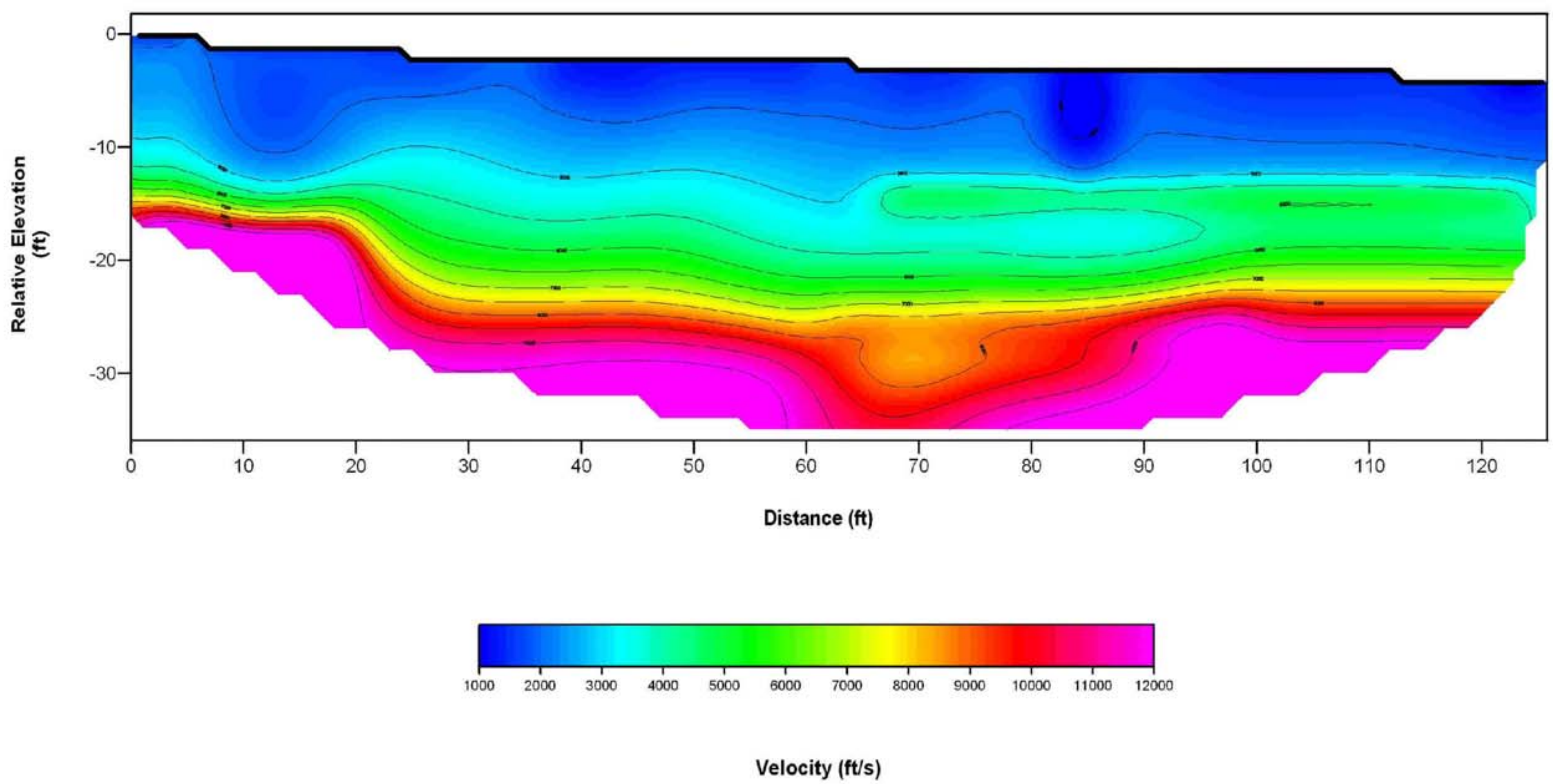


SEISMIC PROFILE	Campus Pointe San Marcos, California	SOUTHWEST GEOPHYSICS INC. Figure 4g
	Project No.: 114175 / Date: 05/14	

Note: Contour Interval = 1,000 feet per second

TOMOGRAPHY MODEL

SL-8

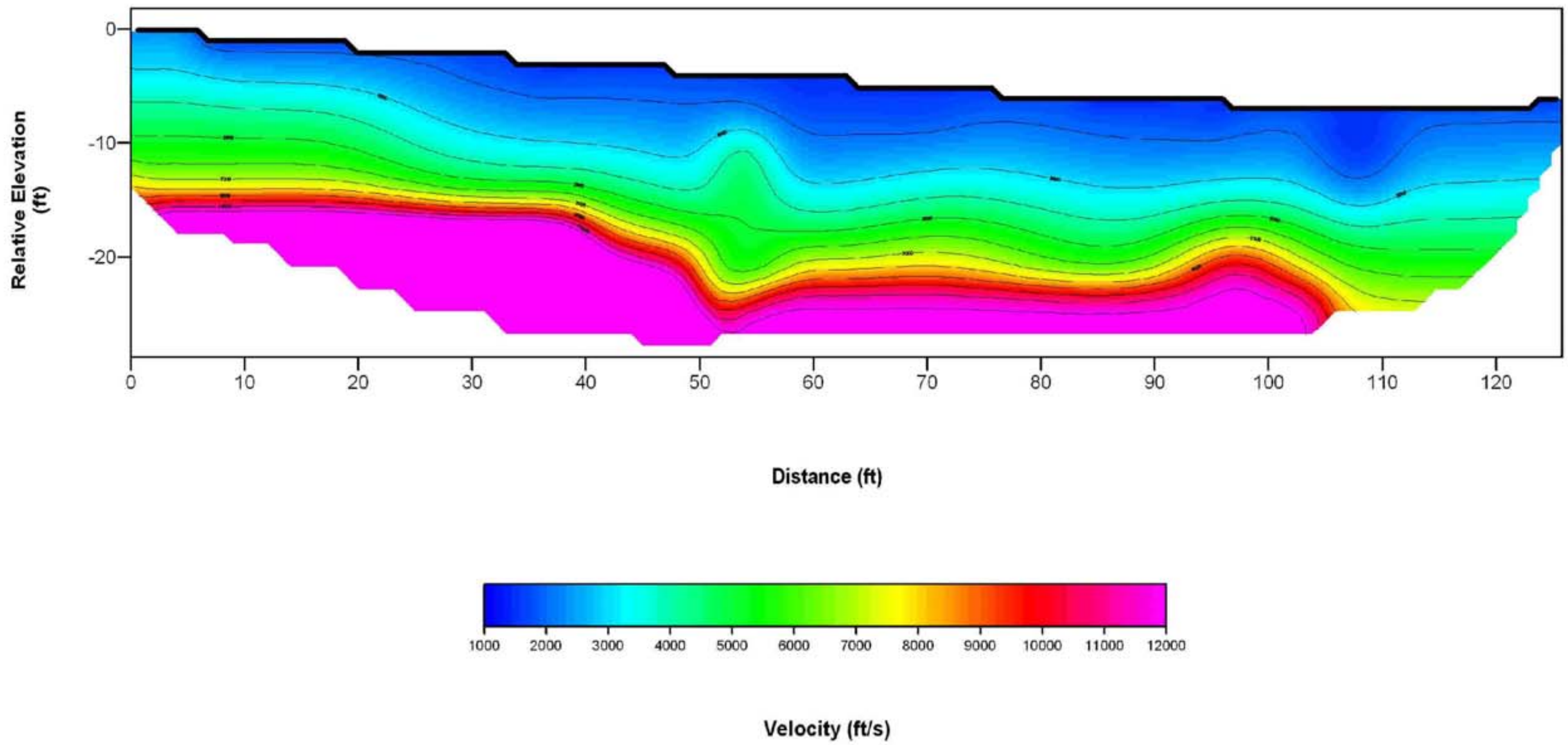


SEISMIC PROFILE	Campus Pointe San Marcos, California Project No.: 114175 — Date: 05/14	SOUTHWEST GEOPHYSICS INC. Figure 4h

Note: Contour Interval = 1,000 feet per second

TOMOGRAPHY MODEL

SL-9

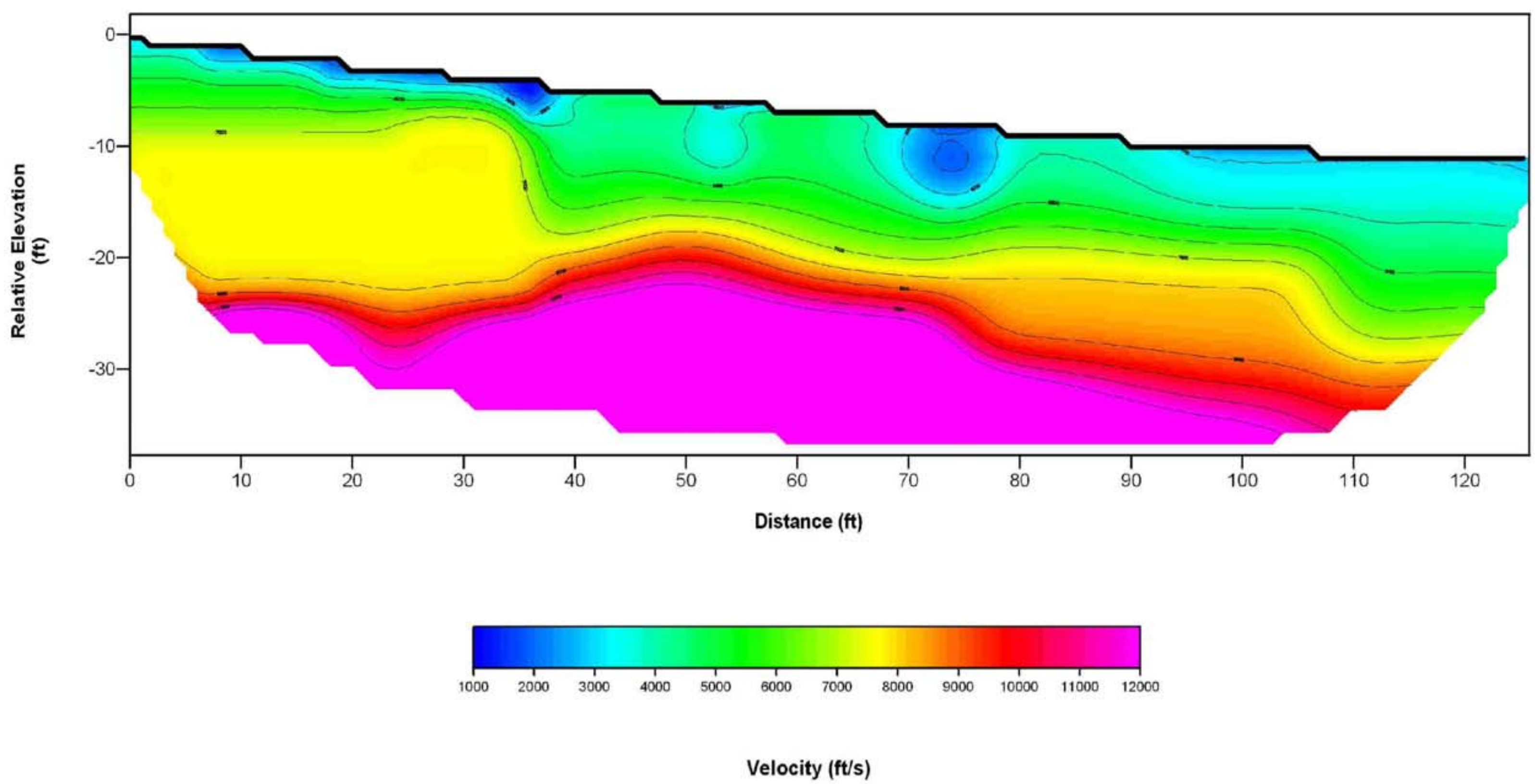


SEISMIC PROFILE	Campus Pointe San Marcos, California Project No.: 114175 / Date: 05/14	SOUTHWEST GEOPHYSICS INC. Figure 4i

Note: Contour Interval = 1,000 feet per second

TOMOGRAPHY MODEL

SL-10



SEISMIC PROFILE	Campus Pointe San Marcos, California	SOUTHWEST GEOPHYSICS INC.
	Project No.: 114175 / Date: 05/14	Figure 4j

Note: Contour Interval = 1,000 feet per second