March 30, 2016

Ms. Ann Borgonovo, P.E.
Vice President
ESA | Environmental Hydrology
550 Kearny Street, Suite 800
San Francisco, CA 94108
ABorgonovo@esassoc.com

RE: Sites 2C and 2D Seismic Refraction Investigation
Dry Creek Habitat Enhancement Phase III, Mile Three Project
Sonoma County Water Agency
Sonoma County, California

Dear Ms. Borgonovo:

This report presents the results of the seismic refraction investigation performed at Sites 2C and 2D for the Dry Creek Habitat Enhancement Phase III, Mile Three project in Sonoma County, California. Sites 2C and 2D are located immediately south of the Westside Road Bridge near Healdsburg, California (Figure 1). Additional geotechnical and geologic information relevant to the project can be found in the Draft Geotechnical Report dated June 29, 2015 which was prepared by A3GEO. A3GEO's services during this phase of the project were authorized under the ESA Subconsultant Amendment No. 2 of our Agreement for Subconsultant Services (#D130163.00) which references our November 5, 2015 proposal.

Purpose and Scope of Services

The purpose of our investigation was to evaluate subsurface conditions and estimate the depth to bedrock using seismic refraction. Borings and/or test pits were not authorized. Our November 5, 2015 proposal outlined a scope of services that consisted of the following:

- Conducting a site reconnaissance to select survey locations;
- Exploring subsurface conditions at Sites 2C and 2D by conducting 6 seismic refraction surveys; and
- Preparing a report summarizing the results.

Seismic Refraction Investigation

On February 12 and 13, 2016, NORCAL Geophysical Consultants, Inc., (a subconsultant to A3GEO) explored subsurface conditions by performing a seismic refraction investigation at Sites 2C and 2D. The investigation consisted of conducting a total of six seismic refraction surveys. Three surveys (designated 2C-1, 2C-2 and 2C-3) were conducted at Site 2C at the locations shown on the Site 2C Site Plan, Figure 2. Three surveys (designated 2D-1, 2D-2 and 2D-3) were conducted on Site 2D at the locations shown on the Site 2D Site Plan, Figure 3. The profiles surveyed ranged in length from 150 feet to 250 feet long and extended to depths between 30 and 50 feet below the ground surface. All of the surveys, except two, were conducted near the creek channel close to Elevation +80 feet. Survey lines 2C-2 and 2C-3 at Site 2C were conducted at the top of bank close to Elevation +95 feet due to inaccessibility near the channel.

Seismic refraction is a non-invasive, surficial, geophysical method used to determine primary wave (p-wave) velocities of near-surface materials. The p-wave velocities are then used to interpret the physical properties (e.g., density and hardness) of the materials. The survey method involves placing a continuous line of geophones on the ground surface and recording the arrival of p-waves, which are induced into the ground by a hammer striking a steel plate. More information regarding the methodology and procedures used can be found in NORCAL's report which follows this letter.

Results Summary

The results of the investigation are presented in Sections 4.0 and 5.0 of NORCAL's seismic refraction investigation report (attached) and include the interpreted pressure wave (P-wave) velocity profiles for the six surveys performed (Plates 2 through 5). In general, low to moderate velocities (i.e., < 5,000 feet/second) were measured in materials above an approximate Elevation of +70 feet, and higher velocities (i.e., 5,000 to 6,500 feet/second) were measured in materials below an approximate Elevation of +70 feet, with the exception of the north end of Line 2D-3. The north end of Line 2D-3 encountered 5,000 feet/second at about Elevation +77 feet. Low to moderate velocities are interpreted to represent loose to more consolidated sedimentary formations (i.e., sands, gravels, silts and clays), and higher velocities (5,000 to 6,500 feet/second) are interpreted to represent either saturated sedimentary deposits or highly weathered bedrock.

Correlation to Previous Investigations and Construction

We have been informed by the Sonoma County Water Agency (SCWA) that bedrock was encountered near the ground surface at river Station 380+00 during construction of the Demonstration Reach in September 2012. The bedrock apparently prevented installing elements to their full depth and design modifications were required. Prior to construction, a seismic refraction survey had been performed by NORCAL in the same general area by another consultant team. We reviewed the report and noted that P-wave velocities measured were about 7,000 feet/second very close to the ground surface. The maximum p-wave velocity measured at Sites 2C and 2D is about 6,500 feet/second and this occurs at depths greater than 10 feet, except at the north end of Line 2D-3 where relatively high velocities were measured at 2 feet below the ground surface.

Limitations

This report has been prepared for the exclusive use of the Sonoma County Water Agency and their consultants for specific application to the proposed Dry Creek Habitat Enhancement project. We performed our services in a manner consistent with the standard of care ordinarily exercised by members of the profession currently employing similar methods. No other warranty, expressed or implied, is made. Our scope was limited to geophysical services and did not include drilling borings, excavating test pits or conducting an environmental assessment or investigation of the site for the presence of hazardous, toxic or corrosive materials.

The findings of this report are valid as of the present date. However, the passing of time will likely change the conditions of the existing property due to natural processes or the works of man. In addition, due to legislation or the broadening of knowledge, changes in applicable or appropriate standards may occur. Accordingly, the findings of this report may be invalidated, wholly or partly, by changes beyond our control. Therefore, this report should not be relied upon after a period of three years without being reviewed by this office.

If you have any questions concerning this report, please do not hesitate to call us.

Very truly yours,

Dona K Mann

REGISTERED PROFESSIONAL ENGINEER
DONA KELLY MANN
No 2901
Exp. 12/31/16
GEOTECHNICAL
STATE OF CALIFORNIA

Dona K. Mann, P.E., G.E.
Principal Engineer
(415) 425-0247

Attachments: A3GEO Figures 1-3
NORCAL Seismic Refraction Investigation Report – Sites 2C and 2D

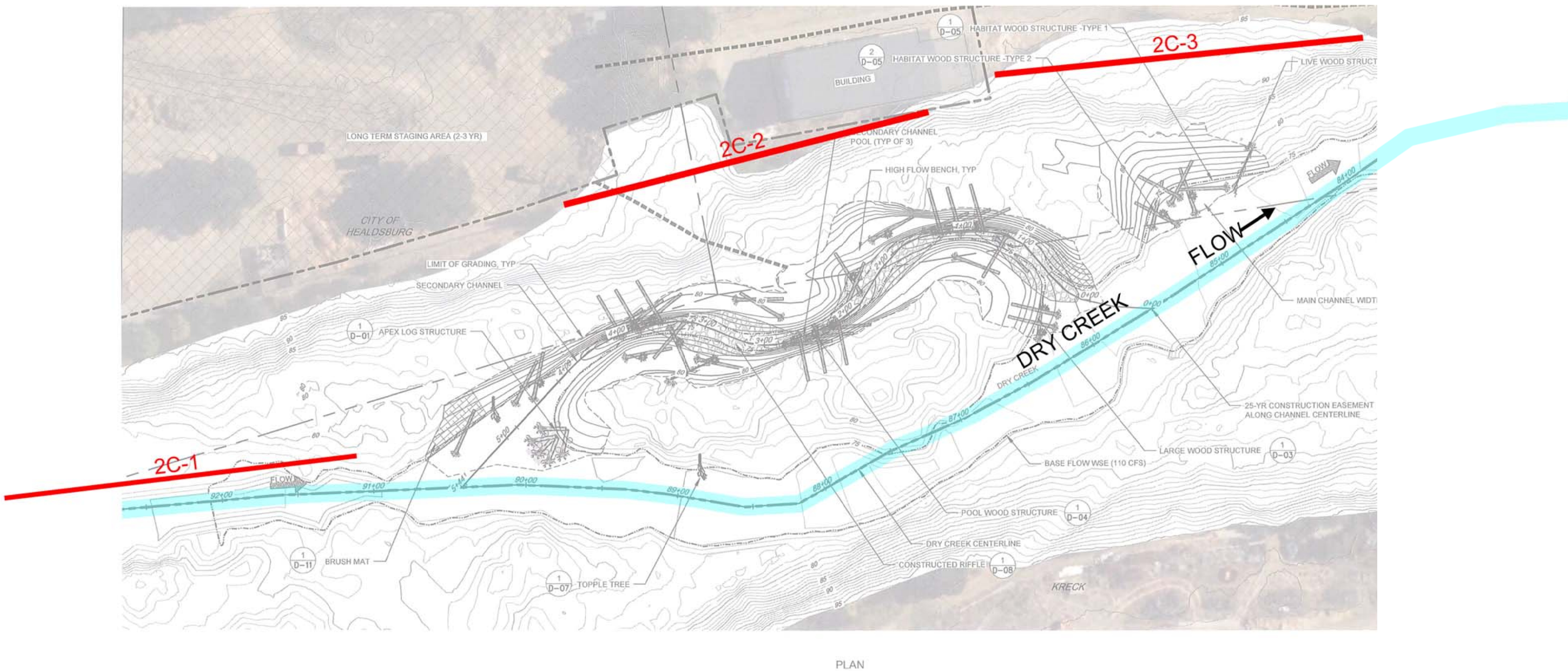
Source: Google Earth® (imagery date 4/20/2013)

DRY CREEK ENHANCEMENT
SITES 2C and 2D SEISMIC REFRACTION INVESTIGATION

FIGURE 1
VICINITY MAP

A3GEO, Inc.
PROJECT No. 1110-4E
Sites 2C & 2D Seismic Refraction

A3GEO



SCALE:
0 75 FEET 150

NORTH

LEGEND

Approximate Location of Seismic Refraction Line

Notes

1. Base Map: Dry Creek Habitat Enhancement Phase III, Mile Three : 2C&2D : Site 2C Enhancement Plan Drawing Number C-02 by ESA

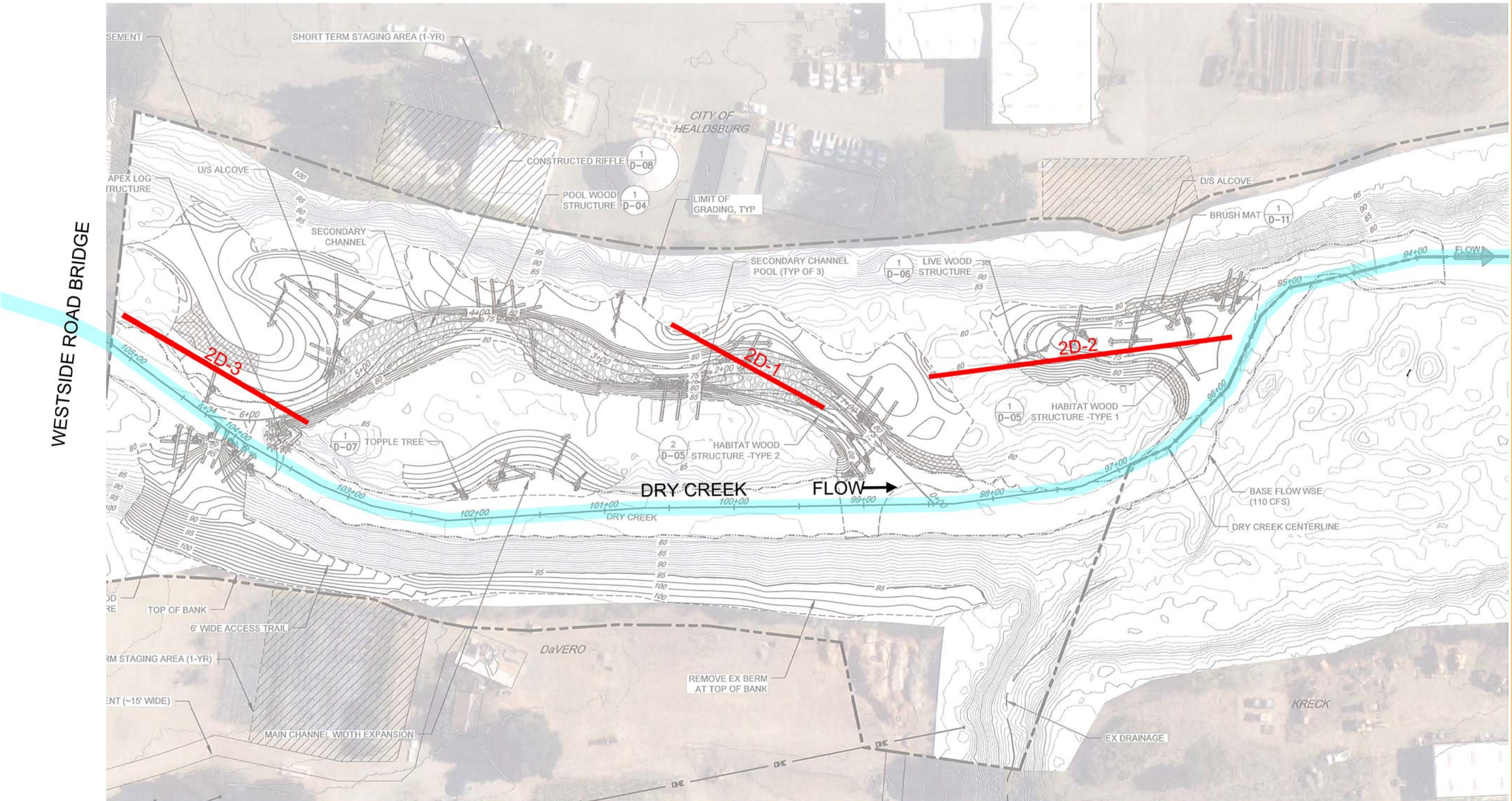
FIGURE 2

SITE PLAN - SITE 2C

3/30/2016 11:30 PM A:\A3GEO Projects\1110 - ESA-PWA\1110-4E Sites 2C& 2D Seismic Refraction\A3GEO Figures\Site Plan.dwg

A3GEO, Inc.
PROJECT No. 1110-4E
Sites 2C & 2D Seismic Refraction

A3GEO



SCALE:
0 75 FEET 150

NORTH

LEGEND

Approximate Location of Seismic Refraction Line

Notes

1. Base Map: Dry Creek Habitat Enhancement Phase III, Mile Three : 2C&2D : Site 2D Enhancement Plan Drawing Number C-08 by ESA

FIGURE 3

SITE PLAN - SITE 2D

3/30/2016 11:30 PM A:\A3GEO Projects\1110 - ESA-PWA\1110-4E Sites 2C& 2D Seismic Refraction\A3GEO Figures\Site Plan.dwg

March 28, 2016

Ms. Dona Mann
A3GEO, Inc.
1331 Seventh Street, Unit E
Berkeley, CA 94710

Subject: Seismic Refraction Investigation
Dry Creek at Westside Rd., Healdsburg, CA
Restoration Sites 2C and 2D

NORCAL Job # 16-1080.03-NS165006

Dear Ms. Mann:

This report presents the findings of a seismic refraction (SR) investigation performed by NORCAL Geophysical Consultants at the subject site in Sonoma County, west of the city of Healdsburg. The survey was performed on February 11th and 12th, 2016 by NORCAL Professional Geophysicist David T. Hagin PGp 1033 and Staff Geophysicist Hunter S. Philson. Logistical support was provided onsite by Mr. Flint Olsen of A3GEO.

1.0 SITE DESCRIPTION

The area of investigation lies along the left bank (east side) of Dry Creek, south of the Westside Road Bridge over Dry Creek (Plate 1). The area is typical of riparian terrain, with dense brush, small trees and wood debris in most locations; sparse gravel bars provide a few relatively accessible areas suitable for data acquisition; some brush clearing was required. To the east of the streambed channel we noted a steep slope beneath the adjacent terrace; the slope contained numerous large chunks of concrete emerging from the ground surface, potentially indicating the presence of artificial fill beneath the terrace.

The scope of the overall project is the restoration of fish habitat along many sections of the creek, involving excavation and construction in some areas. To this end it is desired to estimate the thickness of overburden and the depth to competent rock prior to construction.

The purpose of our investigation is to evaluate the shallow sub-surface conditions by measuring the seismic p-wave velocity values. These data will be used by A3GEO to aid in delineating subsurface stratigraphy and estimating the hardness of the underlying materials.

2.0 METHODOLOGY

The SR method is used to determine the compressional acoustic primary wave (p-wave) velocity (seismic velocity) of subsurface materials. The seismic velocity of fill, sediments, and rock are dependent on physical properties such as compaction, density, hardness, and induration.

However, other factors such as bedding, fracturing, and saturation also affect seismic velocity. Typically, low velocities are indicative of loose, dry soils, poorly compacted fill material or poorly to semi-consolidated sediments. Moderate velocities usually indicate dense and highly compacted or saturated sedimentary deposits or fill, and/or weathered and fractured rock. High velocities typically represent slightly weathered to unweathered (fresh) rock with little fracturing. A more detailed description of the SR methodology is provided in Appendix A.

3.0 SURVEY, INSTRUMENTATION AND PROCESSING

3.1 Data Acquisition

The geophysical survey entailed the acquisition of six SR lines distributed along the left bank of Dry Creek (Plate 1); four were in the streambed near the creek (Lines 2C-1, 2D-1, 2D-2 and 2D-3). Due to inaccessible conditions near the creek two lines were placed on top of the creek bank approximately 15 feet higher in elevation (Lines 2C-2 and 2C-3). The placement of the lines was determined by A3GEO personnel, and designed to evaluate the thickness of overburden as well as the depth and hardness of shallow bedrock.

Each SR line consisted of a single geophone spread comprised of 24 geophones coupled to the ground surface at six to ten foot intervals with five shot points distributed in a linear array. The two end shot points were located one or more stations beyond each end of the geophone spreads and the remaining shot points were evenly spaced within the spreads, yielding total line lengths ranging from 150 to 250 feet.

3.2 Instrumentation

The SR data were recorded using a ***Geometrics Geode***, 24-bit digital seismic recording system and ***Oyo Geospace*** digital-grade geophones with a natural frequency of 10 Hz. We produced seismic energy at each shot point by striking an aluminum plate placed on the ground surface with a 16-pound sledge hammer. An accelerometer attached to the hammer transmitted a triggering pulse to the seismograph to begin recording each time the plate was struck. Several strikes were performed and the data stacked at each shot point to ensure an acceptable signal to noise ratio.

3.3 Data Processing

The refraction data were processed in-house using ***SeisImager***, specialized software developed by Geometrics, Inc. of San Jose, California. We then used the program ***Surfer 13*** by Golden Software to graphically illustrate the subsurface distribution of seismic velocity values. This consisted of generating a color-contoured seismic velocity cross-section (profile) for each SR Line.

4.0 RESULTS AND INTERPRETATIONS

The results of the seismic refraction survey are illustrated by the seismic velocity profiles shown on Plates 2 through 5. The vertical axes represent elevation (above mean sea level) and the horizontal axes represent survey stationing (distance along the line). The profiles show the ground surface and color contours representing the distribution of seismic velocity values according to the color scale shown at the bottom of each plate; the scales have been normalized for ease of comparison.

4.1 Seismic Velocities

Lower seismic velocity values of less than 3,500 feet per second (ft/s) are shown in tan to yellow colors and are interpreted to represent relatively loose unsaturated stream deposits, likely sands and gravels. Moderate seismic velocity values between 3,500 ft/s and 5,000 ft/s are shown in green and blue and are likely representative of more consolidated or cemented sedimentary formations, or possibly highly weathered and/or fractured rock. Higher seismic velocity values range from 5,000 ft/s to 6,500 ft/s and are shown in varying shades of maroon; these are the highest values measured for this investigation, and are relatively low for rock. As this range of velocity values may be characteristic of both saturated sands/gravels and weathered rock it is uncertain whether these values indicate the presence of saturated sediments or bedrock. Additionally, no borehole or other subsurface data (ground truth) is available for correlation with the seismic profiles.

4.2 Seismic Refraction Profiles

4.2.1 SR Lines 2C-1, 2D-1, 2D-2 and 2D-3

These seismic refraction profiles are all within the streambed and show a high degree of similarity. They show a generally thin and uniform layer of surficial lower velocity values varying from three to eight feet in thickness. This layer is notably thin at the northeast end of Line 2D-3 and it thickens slightly near the northwest end of Line 2D-2 and the southwest end of Line 2D-3. Beneath this lower velocity layer we note a thin layer of moderate values generally ranging from three to six feet thick. Higher seismic velocity values are relatively shallow, generally about six to ten feet in depth, and extend to the bottom of the profiles. The higher velocity interface appears to be at a relatively constant elevation of about 70 to 75 feet, suggesting that it may represent the groundwater table with saturated sedimentary deposits below. However, it is also possible that a portion of these higher velocity values may represent highly weathered bedrock. Below ten to twelve feet in depth seismic velocities are relatively unvarying to the maximum depth of exploration (30 to 50 feet), ranging from 5,500 ft/s to 6,500 ft/s. The fact that we do not see an increase in velocity with depth below 30 feet is another indication that these seismic velocity values are likely representative of saturated sediments; bedrock velocities tend to increase with depth due to a lesser degree of weathering.

4.2.2 SR Lines 2C-2 and 2C-3

SR Profile 2C-2 and 2C-3 are both on the terrace adjacent to the streambed and approximately 15 feet higher in elevation. They are very similar in nature and can be described as follows: The seismic profiles indicate a relatively thick and uniform surficial layer of lower velocity values ranging from 10 to 15 feet in thickness. Based on field observations, much of this layer may be comprised of artificial fill placed during construction of the adjacent vineyard. The underlying layer of moderate values is thicker on these profiles, ranging from 8 to 12 feet thick. Higher seismic velocity values are found at 25 to 35 feet in depth here. It is unknown whether these higher velocity values represent highly weathered bedrock or if they may indicate saturated and/or indurated sedimentary formations. The maximum seismic velocity values measured on these lines were less than 6,500 ft/s.

5.0 ROCK RIPPABILITY

We can use seismic velocity to assess the excavatibility (rippability) of rock materials based on empirical data. Charts relating seismic velocity to excavation characteristics have been developed from field tests by others. These charts list the seismic velocity of various types of rock and their relative ease of excavation using different types of ripping equipment. Caterpillar Tractor Company publishes a performance manual that lists ripper performance charts for the D8R, D9R, D10T and D11T tractors. Although the equipment to be used may vary from the models listed, the charts may still provide a relative guide to aid in characterizing rock properties.

The ripper performance charts show that all of the equipment tested encounters rippable to marginally rippable conditions for seismic velocity values less than 6,500 ft/s for all rock types. Thus, if the highest velocity materials shown on the profiles represent rock, these velocity values suggest a high degree of weathering and/or fracturing and generally rippable conditions.

6.0 LIMITATIONS

This information should only be used as a general guide to rippability as many other factors also contribute to the evaluation of rock rippability. These factors include rock jointing and fracture patterns, the experience of the equipment operator, and the equipment and excavation methods selected. Also, the computed velocities measured along each line are an average; therefore, there may be localized zones where the velocities may be higher or lower than indicated. Since the accuracy of our findings is subject to these limitations, it should be noted that subsurface conditions may vary from those depicted in the final results. A more detailed discussion of the limitations with regard to the seismic refraction method is presented in Appendix A.

It should also be noted that the seismic refraction technique is based on the assumption that seismic velocity increases with depth. Any layers representing a decrease in velocity with depth, otherwise known as a velocity inversion, will not be defined and will result in the over-estimation of the depth of deeper, higher velocity layers. In addition, relatively thin layers might not be individually resolved and might, instead, be lumped together with other layers. Hard and soft zones within a given seismic layer will tend to be averaged into the velocity of that layer. Finally, there is not necessarily a one-to-one relationship between lithologic layers and seismic layers. It is entirely possible that two different types of material could have the same seismic velocity. Alternatively, a change in velocity can occur within a single lithologic unit.

7.0 STANDARD OF CARE

The scope of NORCAL's services for this project consisted of using geophysical methods to characterize the subsurface. The accuracy of our findings is subject to specific site conditions and limitations inherent to the techniques used. We performed our services in a manner consistent with the standard of care ordinarily exercised by members of the profession currently employing similar methods. No warranty, with respect to the performance of services or products delivered under this agreement, expressed or implied, is made by NORCAL.

Thank you for the opportunity to participate on this project.

Sincerely,

NORCAL Geophysical Consultants, Inc.

David Hagin

David T. Hagin
Professional Geophysicist PGp 1033

DTH/KGB/tt
Enclosures: Plates 1 through 5
Appendix A - Seismic Refraction Survey

Appendix A

SEISMIC REFRACTION SURVEY

Appendix A

SEISMIC REFRACTION (SR)

METHODOLOGY

The seismic refraction method provides information regarding the seismic velocity structure of the subsurface. An impulsive (mechanical or explosive) source is used to produce compressional (P) wave seismic energy. The P-waves propagate into the earth and are refracted along interfaces caused by an increase in velocity. A portion of the P-wave energy is refracted back to the surface where it is detected by sensors (geophones) that are coupled to the ground surface in a collinear array (spread). The detected signals are recorded on a multi-channel seismograph and are analyzed to determine the shot point-to-geophone travel times. These data can be used along with the corresponding shot point-to-geophone distances to determine the depth, thickness, and velocity of subsurface seismic layers.

The seismic refraction technique is based on several assumptions. Paramount among these are:

- seismic velocity increases with depth, and,
- the velocity of each seismic layer is uniform over the length of the given spread.

In cases where these assumptions do not hold, the accuracy of the technique decreases. For example, if a low velocity layer occurs between two layers of higher velocity, the low velocity layer will not be detected and the depth to the underlying high velocity layer will be erroneously large. Also, if the velocity of a seismic layer varies laterally within a spread, those variations will be interpreted as fluctuations in the elevation of the underlying seismic layer.

It should be noted that apparent velocities can be affected by the orientation of bedding planes with respect to the direction of the seismic profile. Apparent velocities of rock are typically slower when measured along lines oriented perpendicular to bedding planes of steeply dipping rock than those measured along lines oriented parallel.

INSTRUMENTATION

Data acquisition is initiated along each SR line by producing seismic energy using a mechanical source. Mechanical sources produce energy by impacting a metal strike plate on the ground surface with either a 12-16 pound sledge hammer or an elastic-band driven weight drop. The resulting seismic wave forms are recorded using a Geometrics 24-channel engineering seismograph and Mark Products geophones with a natural frequency of 10 Hz. The data are recorded on hard copy records (seismograms) as well as on computer disks for future processing. The seismograms display the amount of time it takes for a compression (P) wave to travel from a given shot point to each geophone in a spread.

DATA ANALYSIS

The seismic data are downloaded to a computer and processed using the software ***Seisimager*** by Geometrics, Inc. This is an interactive program that is used to determine the shot point to geophone travel times, and to compute a 2D model based on those times. Once the travel times for a given line are determined, the programs time-term algorithm is used to compute a preliminary 2D seismic model. This model is then used as input for the programs tomographic routine. Using this procedure, the program divides the starting model into a network of cells and assigns velocities to those cells based on the starting model. The program then traces the refracted seismic travel paths through those cells and computes the associated travel times. It then compares the computed travel times with the measured times and adjusts the velocities of the appropriate cells to improve the fit. The software is programmed to continue this procedure for twenty iterations. Typically, at the end of the twenty iterations the travel times associated with the computed model match the observed travel times to an accuracy of one milli-second (mS) or better. Once a satisfactory model is computed, the software contours the model velocities to produce seismic velocity vs. depth and distance cross-sections (profiles).

LIMITATIONS

In general, there are limitations unique to the SR method. These limitations are primarily based on assumptions that are made by the data analysis routine. First, the data analysis routine assumes that the velocities along the length of each spread are uniform. If there are localized zones within each layer where the velocities are higher or lower than indicated, the analysis routine will interpret these zones as changes in the surface topography of the underlying layer. A zone of higher velocity material would be interpreted as a low in the surface of the underlying layer. Zones of lower velocity material would be interpreted as a high in the underlying layer.

Second, the data analysis routine assumes that the velocity of subsurface materials increase with depth. Therefore, if a layer exhibits velocities that are slower than those of the material above it, the slower layer will not be resolved. Also, a velocity layer may simply be too thin to be detected. Due to these and other limitations inherent to the SR method, the results of the SR survey should be considered only as approximations of the subsurface conditions. The actual conditions may vary locally.

SCALE

0 150 300

(1 inch = 150 feet)

LEGEND	
	SEISMIC REFRACTION LINE

NOTE: TOPOGRAPHIC MAP AND AERIAL PHOTO PROVIDED BY ENVIRONMENTAL SCIENCE ASSOCIATES

SITE LOCATION MAP
DRY CREEK - WESTSIDE ROAD
SEISMIC REFRACTION SURVEY

LOCATION: HEALDSBURG, CALIFORNIA

CLIENT: A3GEO

NORCAL

JOB #: 16-1080.03

NORCAL GEOPHYSICAL CONSULTANTS INC.

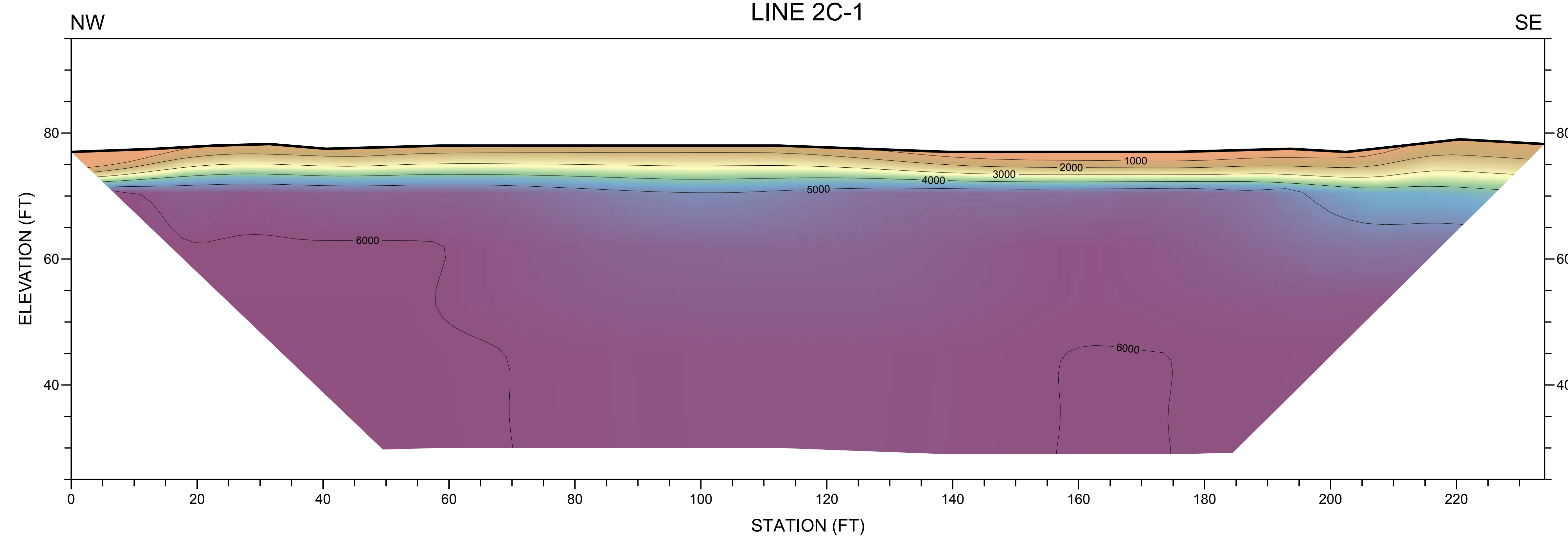
DATE: MAR. 2016

DRAWN BY: G.RANDALL

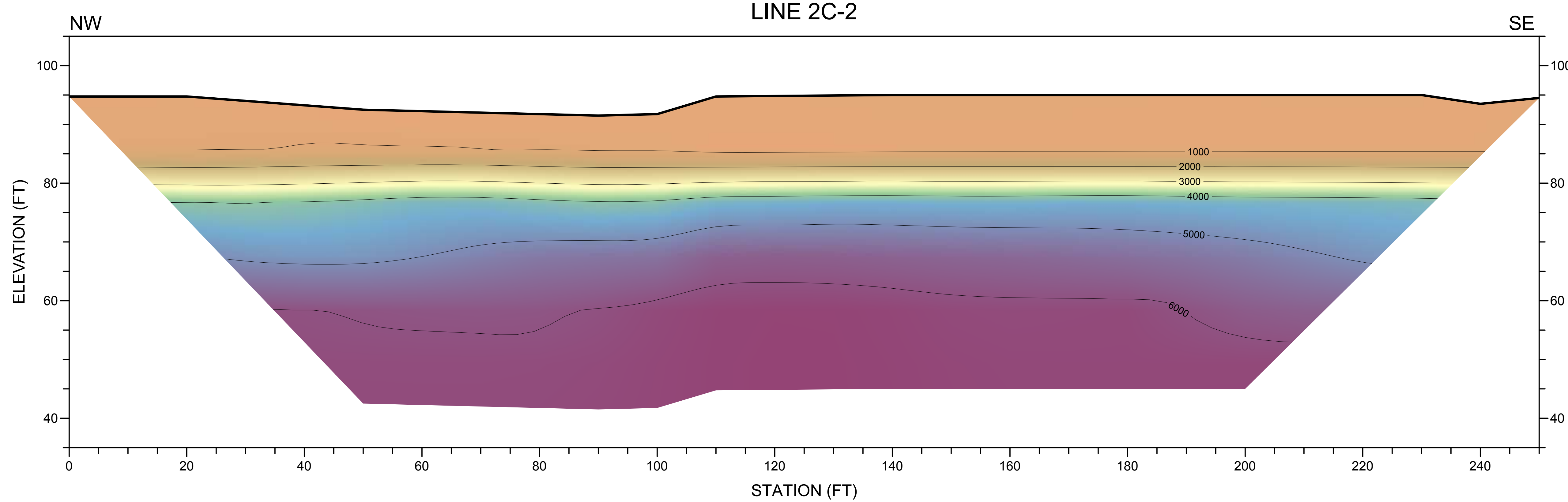
APPROVED BY: DTH

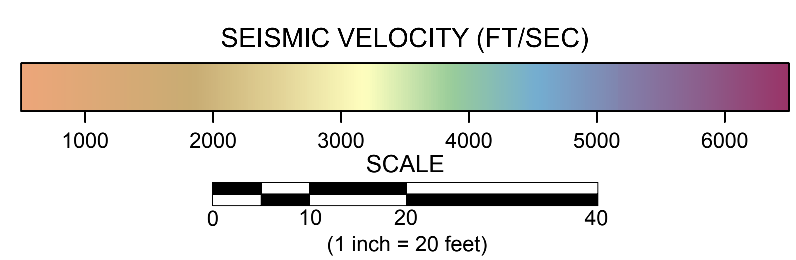
PLATE 1

LINE 2C-1



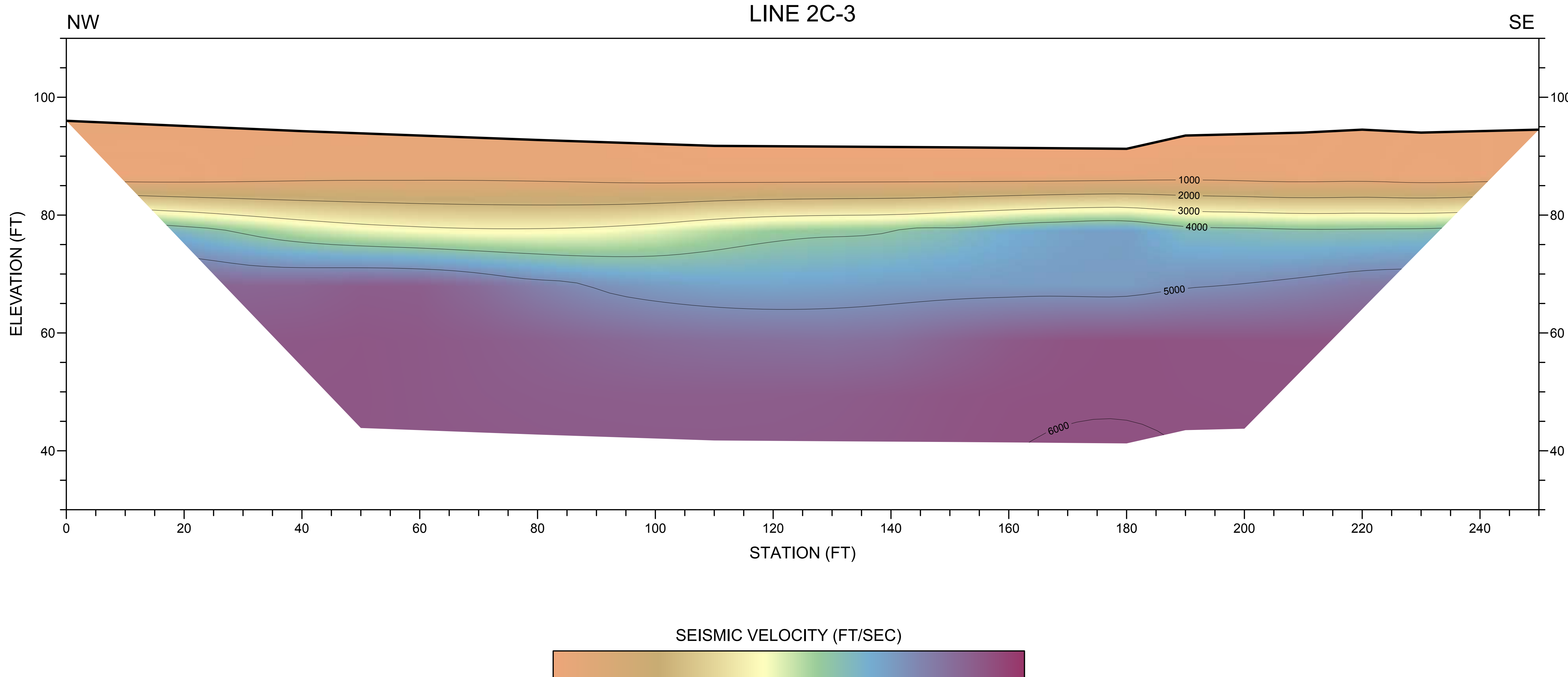
LINE 2C-2





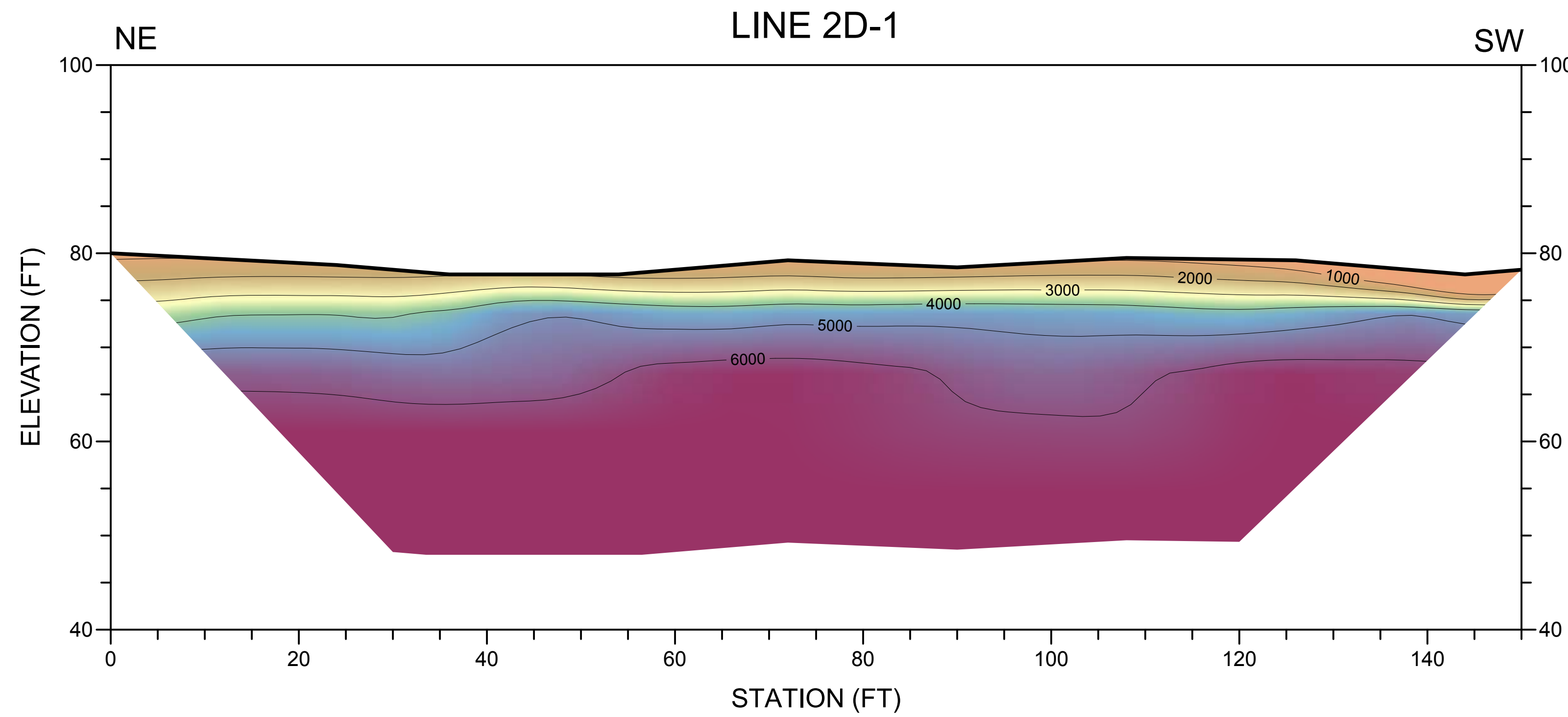
NORCAL	SEISMIC REFRACTION PROFILES LINES 2C-1 & 2C-2 DRY CREEK - WESTSIDE ROAD
	LOCATION: HEALDSBURG, CALIFORNIA
	CLIENT: A3GEO
JOB #: 16-1080.03	NORCAL GEOPHYSICAL CONSULTANTS INC.
DATE: MAR. 2016	DRAWN BY: G.RANDALL / APPROVED BY: DTH

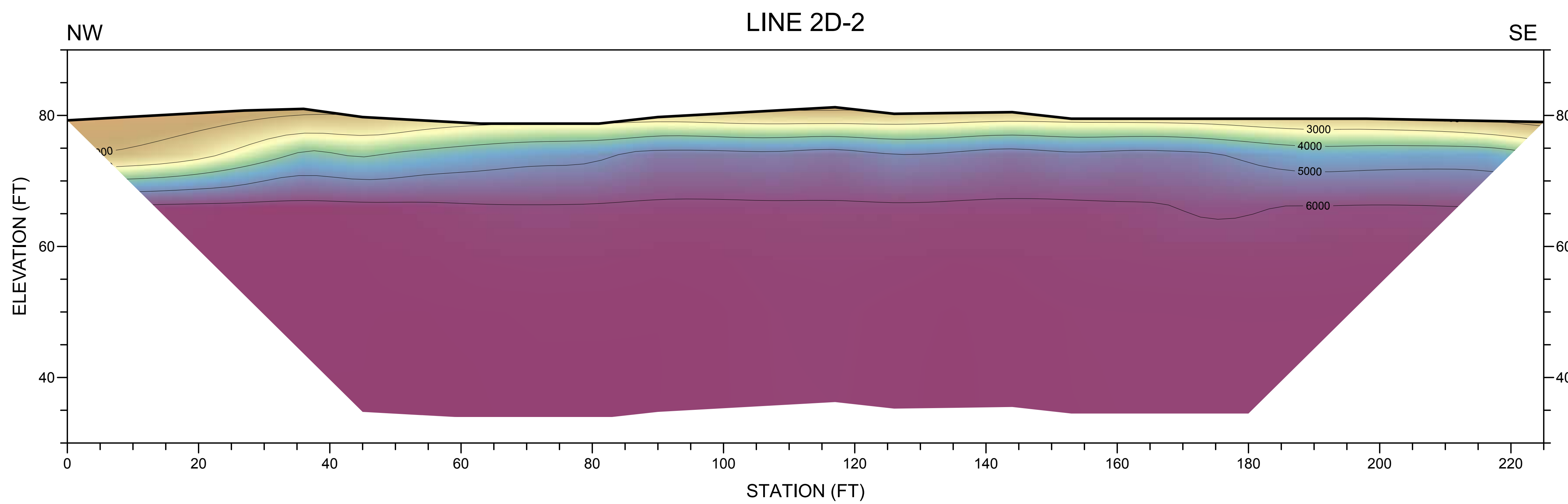
PLATE 2

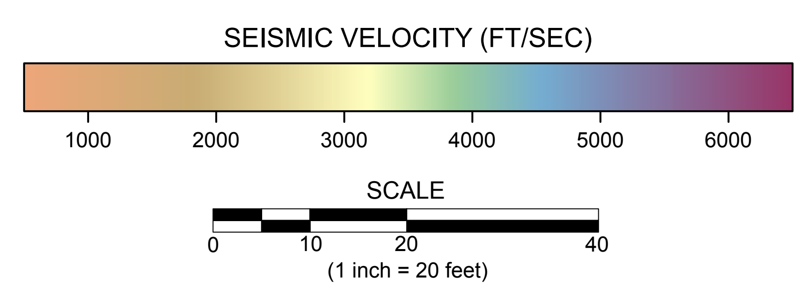


SCALE
0 10 20 40
(1 inch = 20 feet)

SEISMIC REFRACTION PROFILE LINE 2C-3 DRY CREEK - WESTSIDE ROAD		
LOCATION: HEALDSBURG, CALIFORNIA		
CLIENT: A3GEO		PLATE 3
JOB #: 16-1080.03	NORCAL GEOPHYSICAL CONSULTANTS INC.	
DATE: MAR. 2016	DRAWN BY: G.RANDALL	APPROVED BY: DTH



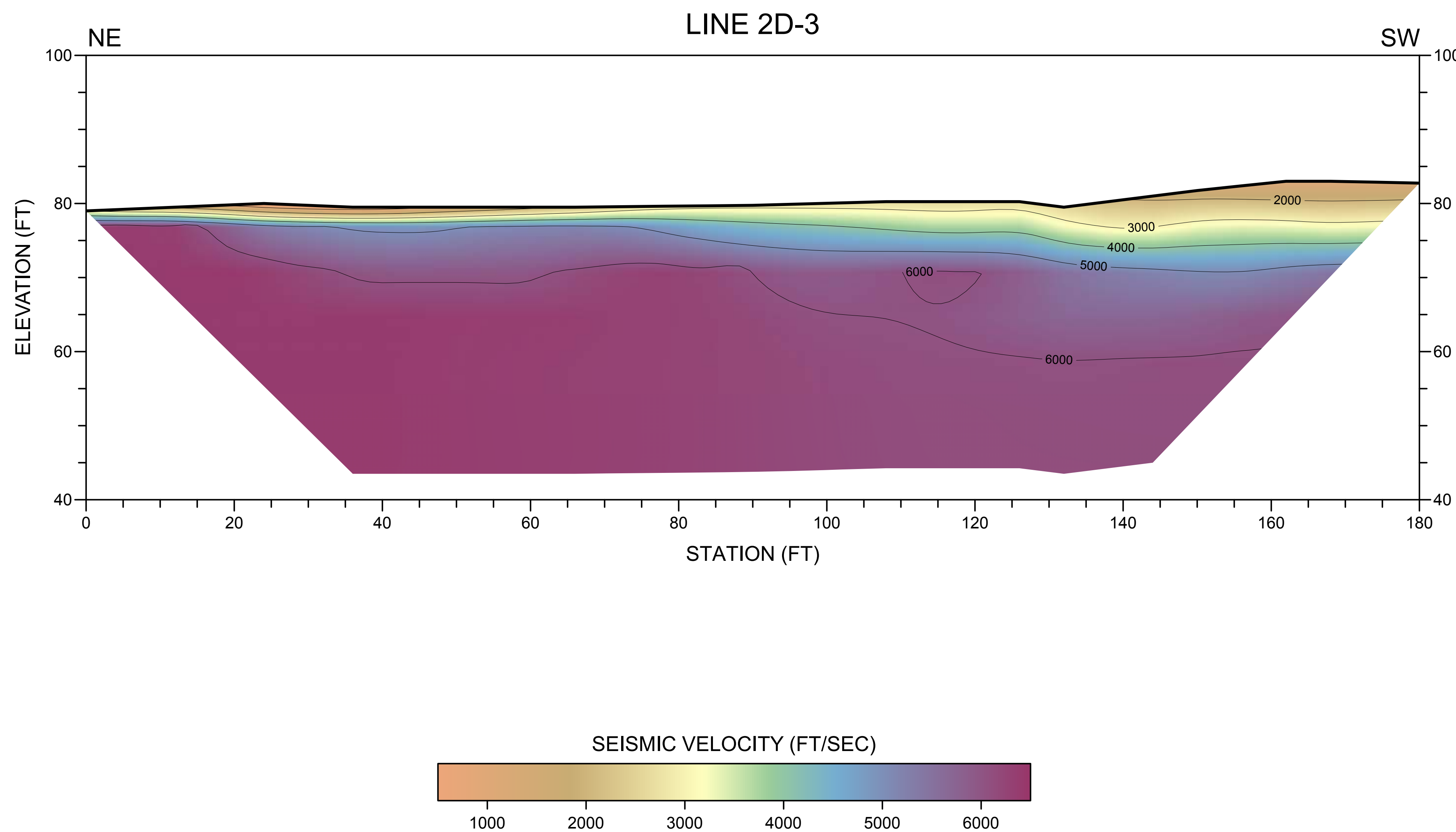




NORCAL

SEISMIC REFRACTION PROFILES
LINES 2D-1 & 2D-2
DRY CREEK - WESTSIDE ROAD

LOCATION: HEALDSBURG, CALIFORNIA		
CLIENT: A3GEO		PLATE 4
JOB #: 16-1080.03	NORCAL GEOPHYSICAL CONSULTANTS INC.	
DATE: MAR. 2016	DRAWN BY: G.RANDALL	APPROVED BY: DTH



SCALE
0 10 20 40
(1 inch = 20 feet)

NORCAL

SEISMIC REFRACTION PROFILE LINE 2D-3 DRY CREEK - WESTSIDE ROAD		
LOCATION: HEALDSBURG, CALIFORNIA		
CLIENT: A3GEO		PLATE 5
JOB #: 16-1080.03	NORCAL GEOPHYSICAL CONSULTANTS INC.	
DATE: MAR. 2016	DRAWN BY: G.RANDALL	APPROVED BY: DTH