Stantec

Memo

To:	Talia Flagan Cupertino, CA	From:	Jennifer Van Pelt, Paul Kos Walnut Creek, CA
File:	YY Seismic Conclusions	Date:	March 17, 2020

Reference: Summary of Yeager Yard Seismic Results

In November 2019, Stantec Consulting Services, Inc. (Stantec) prepared geotechnical recommendations for Lehigh Southwest Cement Company's (Lehigh) Permanente Quarry in a report entitled *West Materials Storage Area Geotechnical Evaluation*. The report included recommendations for achieving slope stability in an area of the quarry known as the "Yeager Yard" (YY) according to the standards set forth in the California Surface Mining and Reclamation Act (SMARA). An earlier version of these recommendations was contained in Stantec's *Permanente Quarry – WMSA Slope Instability Remediation Plan*, dated September 27, 2019.

Santa Clara County staff members have requested further data that confirms the presence of certain subsurface geologic features descried in Stantec's reports – specifically, a bedrock ridge of native material at the headscarp of the WMSA Slope Instability. To accommodate this data request, Lehigh proposed to perform a seismic refraction (SR) survey in lieu of a drilling investigation to demonstrate the presence of the bedrock ridge of native material and that the bedrock ridge has the strength as described and assumed in the Stantec's reports. The SR survey report prepared by NORCAL Geophycial Consultants, Inc. (NORCAL) is attached to this memorandum, and this memorandum compares the SR results to previous analyses and assumptions prepared by Stantec.

NORCAL determined that the fill-bedrock interface occurs at a velocity of approximately 6000 feet per second, which corresponds with the bedrock elevation identified in the adjacent borehole YY-VWP-02. Stantec selected line SR-01 specifically to correlate the SR data to this borehole and to demonstrate that the SR method is capable of identifying the top of bedrock and the ridgeline location identified from the interpretation of historical aerial photographs. The SR data documented the bedrock ridge in all three SR lines as discussed in the NORCAL report, and the SR method can be used to map the ridgeline present in the subsurface. The location of the bedrock ridge in all three SR lines match the locations Stantec previously mapped, which demonstrates the presence of the ridge near the northern and western extents of the Yeager Yard slide.

The geotechnical properties of the rock present at the Permanente Quarry have been evaluated several times by several companies as documented in the various Reclamation Plan Amendment submittals. Each investigation included drilling, laboratory testing, assessment of strength parameters for the various rock types encountered, and slope stability calculations. The rock strength parameters were based on laboratory data, rock mass rating (RMR) calculations, and back-analysis of landslide areas. The strength parameters for soil, greenstone overburden, and limestone have been consistent through the various geotechnical analyses. The strength parameters for greenstone vary significantly depending on the condition of the bedrock and particularly the amount of weathering and shearing. Lower-bound values are based on back-analysis of the Main Slide in the North Quarry, and upper bound values are based on laboratory data of in-place rock collected from core drilling operations. Considering the Yeager Yard area was mined and then backfilled, any near-surface and weathered material was removed, with the stronger greenstone left in place. The seismic data corroborate these strengths, and the NORCAL reports interprets the bedrock as "moderately to little weathered/fractured". The sharp increase in velocities from the SR data also confirm a significant change in material properties between the fill material and the bedrock.

Reference: Summary of Yeager Yard Seismic Results

Analysis of the drilling data, aerial photograph data, and SR data all provide corroborating data that the bedrock ridge is present in the location Stantec mapped and at the northern and western extents of the Yeager Yard slide area. These data also suggest that the bedrock is competent with the material strengths necessary to limit further extension of the Yeager Yard slide area. There is a distinct absence of data suggesting the contrary. Therefore, Stantec concludes that the Yeager Yard slide area is definitively bounded on the northern and lateral extents by the remaining bedrock ridge. Stantec further opines that additional studies into this subject are unwarranted due to the abundance of data already collected.

Stantec Consulting Services Inc.

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Attachment: NORCAL Seismic Report

NORCAL
GEOPHYSICAL CONSULTANTS INC.
A Terracon COMPANY

March 13, 2020

Lehigh Hanson, Inc.
24001 Stevens Creek Boulevard
Cupertino, California 95014

Subject: Seismic Refraction Survey
Permanente Quarry
Cupertino, California
NORCAL Job Number NS205004

Attention: Ms.Talia Flagan

This report presents the findings of a seismic refraction (SR) survey performed by NORCAL Geophysical Consultants, Inc. (NORCAL) for Lehigh Hanson, Inc. (Lehigh) at the subject site. The survey was authorized by Lehigh Purchase Order No. 3000006873 dated January 21, 2020. NORCAL Professional Geophysicist Hunter S. Philson (PGp No. 1094) and Staff Geophysicist Kristopher M. Powell conducted the survey on February 17-19, 2020. Tristan Rhodes of Stantec provided on-site logistical support and background information.

1.0 SITE DESCRIPTION AND OBJECTIVE

The Permanente Quarry is a limestone and aggregate mining operation located in the foothills west of Cupertino, as indicated by the Vicinity Map included on Plate 1. According to information provided by others, a landslide underlies mine tailings to the west of the main pit. A recent geotechnical evaluation by Stantec found that the upslope edge of the landslide may be constrained by a historic ridgeline that is partially buried beneath greenstone overburden. The suspected ridgeline and two adjacent drainages, shown on Plate 1, were located based on historic aerial photographs and topo maps.

The seismic refraction (SR) survey is part of the larger geotechnical investigation being conducted by Stantec to better characterize the historic ridgeline and adjacent landslide. Specifically, the objective of the SR survey is to obtain seismic P-wave velocity (Vp) data to determine the thickness of overburden and the depth and hardness of the underlying bedrock.

2.0 GLOSSARY OF GEOPHYSICAL TERMS

Seismic P-wave Velocity (Vp) – the velocity at which compressional, or "Primary", waves propagate through the earth.
Seismic Refraction (SR) – a technique for measuring P-wave velocities beneath a traverse (line) to produce a Vp cross-section (profile).
Geophone – a device that detects ground motion.
Spread – a collinear array of geophones and shot points
Line – a traverse along which SR data are acquired; may consist of one or more spreads
Profile – a cross-section depicting variations in P-wave velocities beneath a portion of a line
Shot Point – a point on the ground surface at which seismic energy is produced.

3.0 SEISMIC REFRACTION (SR) SURVEY

To achieve the objective stated above, we obtained SR data along three lines, as depicted by the red lines shown on the Site Location Map, Plate 1. The lines are labelled Line SR-01 through SR-03 from southwest to northeast. Each line is 735-ft in length as measured along the ground surface and consisted of three overlapping 375-ft long arrays (spreads). Each spread comprised 7-shot points and 24-geophones distributed in a collinear array. The geophones were spaced at 15-ft intervals and coupled to the ground surface by a metal spike affixed to the bottom of each geophone case. Shot points were located 15-ft to 97.5-ft beyond the first and last geophones in the spread, and at additional locations distributed within each spread. Seismic energy was produced at each shot point by multiple impacts on a metal plate with a 10-pound sledgehammer. The line lengths and positions, determined in consultation with Stantec, were chosen to optimize resolution and depth of investigation across the suspected historic ridgeline and adjacent landslide. A general "rule of thumb" for seismic refraction is that the length of a spread is about three to five times greater than the depth of investigation. For this survey, we selected a spread length of 375-ft in order to achieve a depth of investigation of about 75- to 125-ft.

Compressional wave velocities, also known as primary or "P-wave" velocities, are dependent on physical properties of subsurface materials such as hardness, compaction, and induration. However, other factors such as bedding, fracturing and saturation also affect P-wave velocity. Herein, we will use the terms "velocity" and "Vp" interchangeably to refer to P-wave velocity.

Detailed descriptions of the SR methodology, our data acquisition and analysis procedures, the instrumentation we used and general limitations of the method are provided in Appendix A.

3.1 PRESENTATION OF RESULTS (PLATES 2-4)

The results of the SR survey are illustrated by the seismic refraction profiles shown on Plates 2-4. On each profile, the vertical axis represents elevation above mean sea level (MSL) and the horizontal axis represents distance (Station) in feet along the line starting from the northwest end. The bold black line at the top each profile represents the ground surface. Variations in Vp are depicted by labeled contours and by color shading between contours, as indicated by the color scale shown at the bottom of each plate. The profiles indicate that Vp ranges from about 1,000-ft/s near the surface to as high as 15,000-ft/s at depths of up to 125-ft below ground surface (bgs).

3.2 LITHOLOGIC CORRELATION

Stantec provided the geologic logs for Boring No. YY-VWP-02 showing the subsurface lithology to a depth of 250-ft. The position and orientation of seismic refraction line SR-01 were selected specifically to intercept this boring in order to demonstrate the SR methodology at this site. The locations of YY-VWP-02 and line SR-01 are shown on Plate 1. According to the boring log, bedrock was encountered at a depth of about 53-ft. However, since the well was drilled at an angle of 30-degrees from vertical, the true depth to bedrock was about 46-ft bgs. Furthermore, considering the fact that the boring is 10-ft northeast of the line and about 5-ft higher in elevation, the depth to rock at the point of closest approach (Station 350-ft) on Line SR-01 is about 41-ft. This depth corresponds with the 6,000-ft/s contour on the profile for Line SR-01. This velocity is consistent with moderately weathered/fractured bedrock. The interpreted relationship between Vp and lithology is listed in Table 1. The correlation is based on the well record described above and our experience with previous seismic refraction surveys in the coast range near the Bay Area.

Table 1: *General P-wave Velocity (Vp) Lithology Correlation.*

Vp Range (ft/s)	Color Shading	Interpreted Lithology
1,000 – 6,000	tan, yellow, green	Colluvium, mine tailings, landslide material and severely weathered/fractured greenstone and metavolcanic bedrock
6,000 – 15,000	blue, magenta	Greenstone and metavolcanic bedrock; moderately to little weathered/fractured

3.3 DISCUSSION

Based on the velocity vs. lithology correlation listed above, the seismic profiles for the three lines depict a near-surface, low-velocity layer of colluvium, mine tailings and/or landslide material overlying bedrock of varying degrees of weathering/fracturing. The interpreted surface of the moderately weathered/fractured bedrock is depicted by the black dashed line the coincides with the 6,000-ft/s contour on the SR profiles (Plates 2-4). All three profiles depict a rise in this contour near the location of the mapped historic ridge. The upward deviation of the contours is consistent with a buried ridge of moderately to slightly weathered/fractured bedrock. The geographic location of the interpreted bedrock ridge is depicted with blue hachures on the Site Location Map, Plate 1, and at the top of the SR profiles on Plates 2-4.

Note, the seismic velocity of mine tailings, landslide materials, and highly weathered/fractured bedrock tend to have overlapping velocity ranges (<6,000-ft/s) Therefore, the lateral limits of landslide are not well defined by the SR profiles.

4.0 CONCLUSIONS

Correlation of the boring log from Boring YY-WVP-02 with Seismic Line SR-01 indicates that the 6,000-ft/sec contour (heavy dashed line) depicted on the seismic velocity profile (Plate 2) closely matches the depth to rock indicated by the boring log. Furthermore, the 6,000-ft/sec velocity is consistent with what we would expect for moderately weathered rock in this area. In addition, ridge-like features in the 6,000-ft/sec contour (interpreted bedrock ridge) correlate with the known location of the historic ridge line. All of these factors lend confidence to the results of the seismic refraction survey.

5.0 STANDARD CARE

The scope of services for this project consisted of using geophysical methods to characterize the shallow 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 level of skill 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.

We appreciate the opportunity to provide our services to Lehigh Hanson for this project. Should you require additional geophysical services or have questions regarding this survey, please do not hesitate to call.

Respectfully,

NORCAL Geophysical Consultants, Inc.

PROFESSIONAL GEOPHYSICIST
Hunter S. Philson
No. 1094
3-13-2020
STATE OF CALIFORNIA

Hunter S. Philson
Professional Geophysicist, PGp No. 1094

Donald J. Kirker
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PROFESSIONAL GEOPHYSICIST
DONALD KIRKER
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HSP/DJK

Enclosures: Plates 1 through 4
Appendix A – Seismic Refraction Surveys

NORCAL
GEOPHYSICAL CONSULTANTS INC.
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Appendix A

SEISMIC REFRACTION SURVEYS

Appendix A

SEISMIC REFRACTION SURVEYS

1.0 METHODOLOGY

The seismic refraction (SR) method is used to measure variations in compressional (P-) wave velocities versus depth and distance beneath the length of a transect (line). Herein, we will refer to P-wave velocity as Vp, or simply “velocity”.

The velocity of 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 velocity. Typically, low velocities are indicative of loose soil, poorly to semi-consolidated sediments, and deeply weathered and highly fractured rock. Moderate velocities are usually indicative of dense and highly compacted sediments, and/or moderately weathered and moderately fractured rock. High velocities are indicative of slightly weathered to unweathered rock with little fracturing.

An impulsive (mechanical) source is used to produce P-wave energy. The P-waves propagate into the earth and are refracted along interfaces representing a pronounced downward 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 multichannel 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.

2.0 DATA ACQUISITION AND INSTRUMENTATION

We collected SR data along three lines at the Permanente Quarry, as shown on the Site Location Map, Plate 1. Details on the data acquisition procedures are provided in the body of the report.

The seismic waveforms produced at each shot point were recorded using a Geometrics ***Geode*** 24-channel engineering distributed array seismograph and Oyo ***Geospace*** geophones with a natural frequency of 8-Hz. The seismic waveforms were digitized, processed and amplified by the Geode and transmitted via a ruggedized Ethernet cable to a field computer. There the data were archived for subsequent processing and displayed on the computer screen in the form of seismograms. These were subsequently used to determine the time required for P-waves to travel from each shot point to each geophone in each spread.

Following data acquisition, we used a Trimble ***Geo 7x*** global positioning system (GPS) with sub-foot precision to measure the geographical coordinates of the end points and several intermediate points along each line. These positions were differentially corrected and exported for data analysis. Additionally, relative elevations between geophones were acquired using a hand level and stadia rod along Line SR-01. The relative elevations were converted to actual elevations in feet above mean sea level (msl) by correlating them with the GPS data. Steep slopes along Lines SR-02 and SR-03 precluded the use of a hand level and stadia rod. Therefore, we extrapolated between GPS data points to obtain the geophone elevations.

3.0 DATA ANALYSIS

Prior to the computer analysis, we determined the elevation profile along each SR line using the correlated elevation data. Preliminary seismic refraction models were computed using the software package ***SeisImager***, written by Oyo Corporation (Japan) and distributed by Geometrics Inc. The first stage of seismic processing included compilation and identification of first arriving P-wave energy at each geophone from each shot point. This process was conducted using ***Pickwin, Version 5.2.1.3*** (2016), which is part of the ***SeisImager*** package. A second interactive program ***Plotrefa, Version 3.1.0.5*** (2016) was used to assign surface elevations to each geophone and Vp layer assignments to the measured travel times. We then used ***SeisImager's*** time-term routine to compute a 2D seismic velocity model based on these inputs. Actual examples from this survey are presented in the following figures:

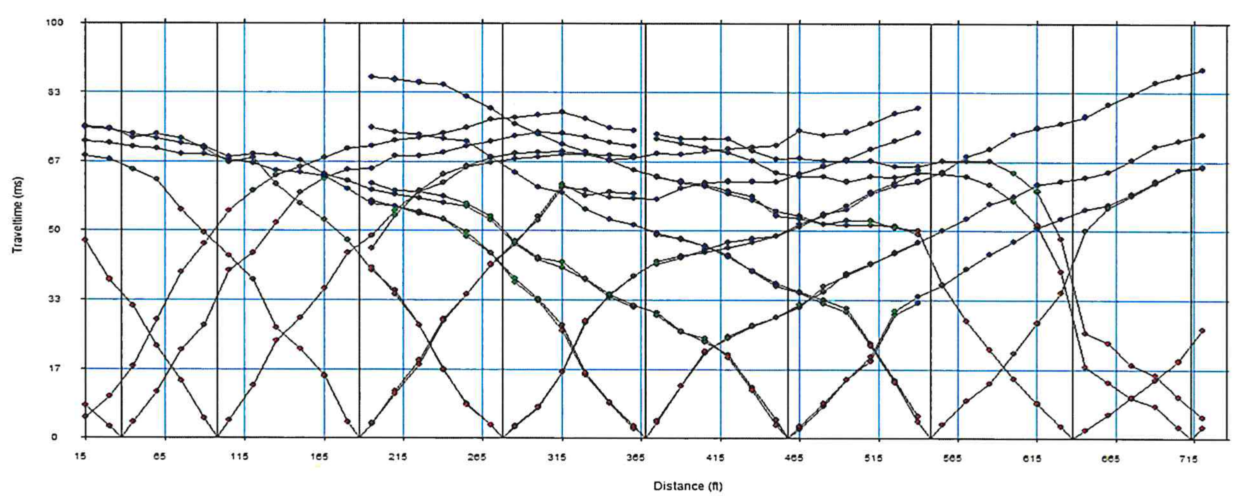


Figure 1: *Line SR-01 time-distance graph with 48 geophone locations and 21 shot points.*

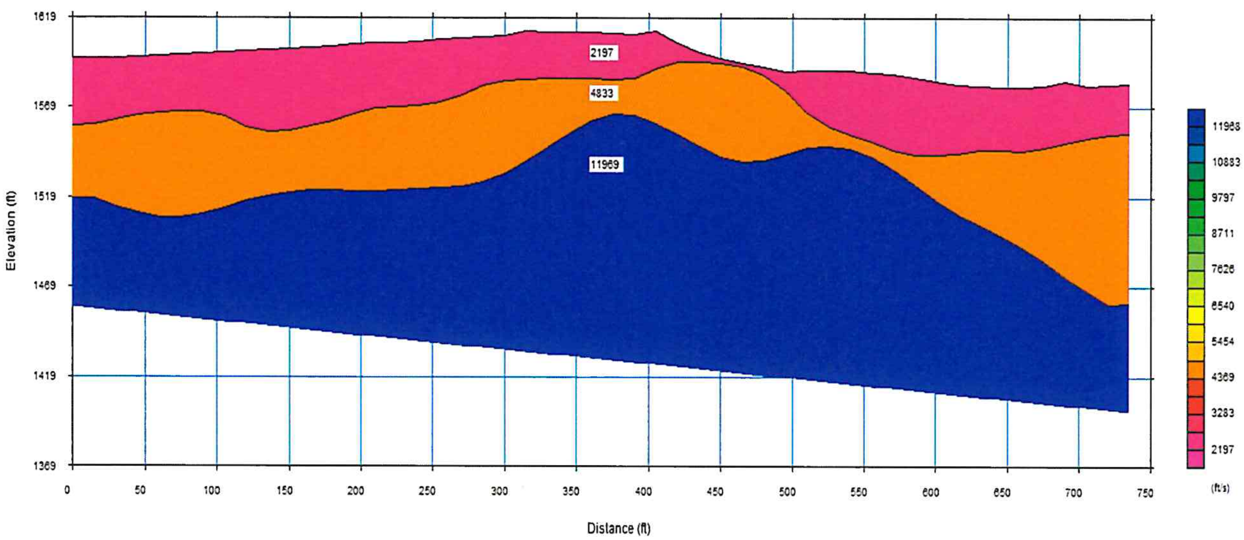
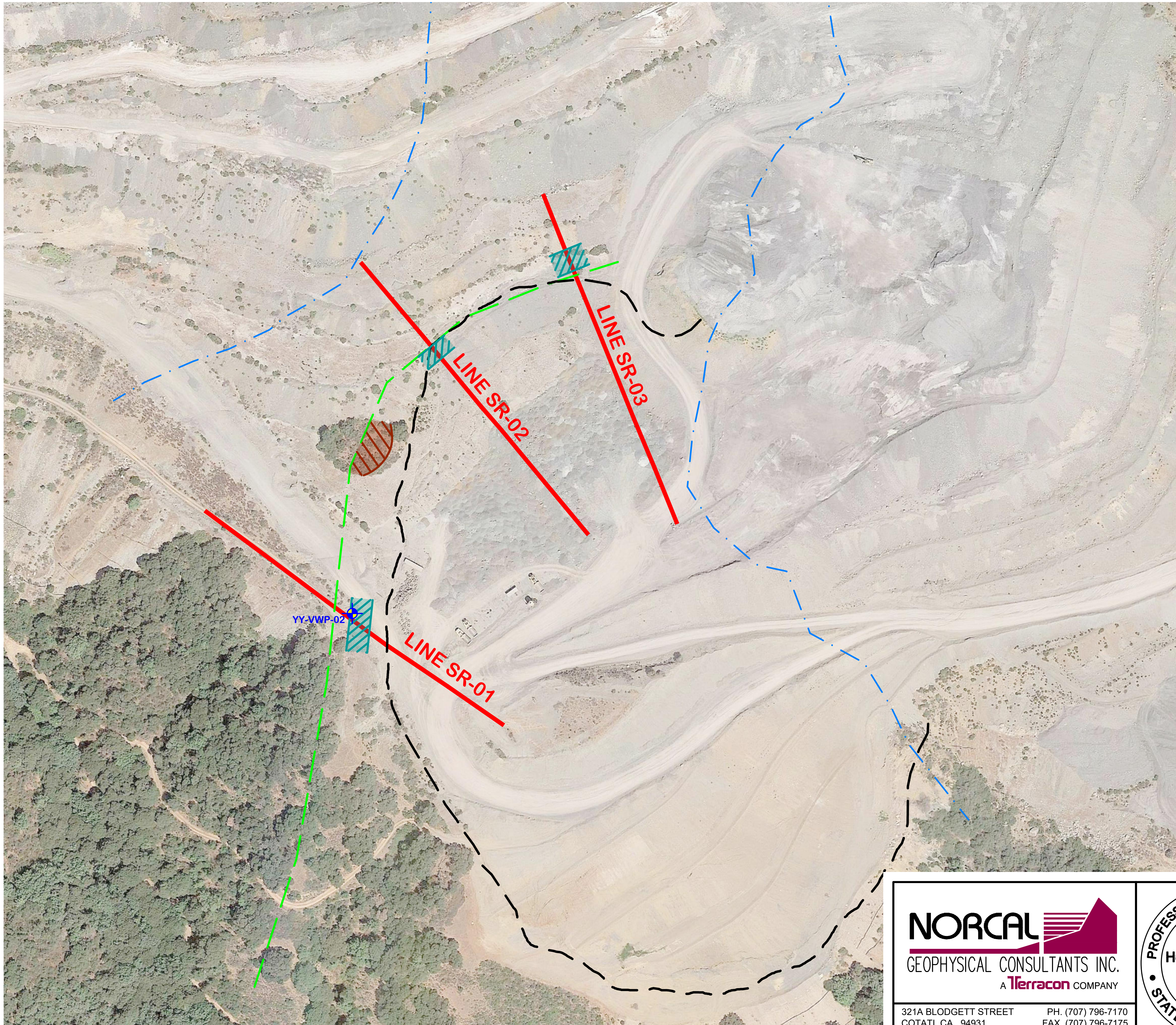


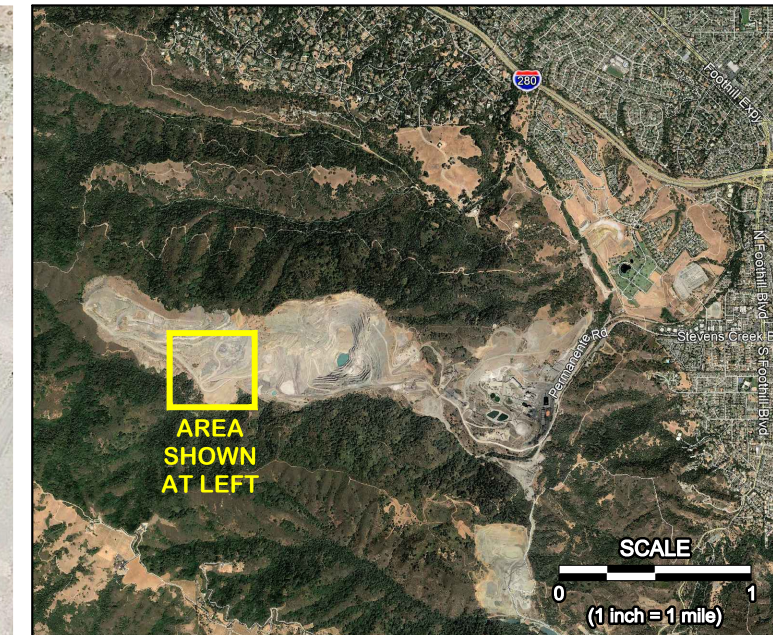
Figure 2: *Line SR-01 time-term inverted seismic velocity model.*

We used the resulting 2D seismic velocity model as input to the computer program ***Rayfract*** by Intelligent Resources, Lt. ***Rayfract*** uses wave path eikonal travel time (WET) tomography to model multiple signal propagation paths contributing to one first break, based on the Fresnel volume approach (conventional ray tracing tomography is limited to the modeling of just one ray per first break). ***Rayfract*** also uses an eikonal solver (Lecomte, Gjoystdal et al. Geophysical Prospecting May 2000) for travel time field computation to explicitly model diffraction besides refraction and transmission of acoustic waves. As a result, the velocity anomaly imaging capability is enhanced with the WET tomographic inversion compared to conventional ray-tracing tomography. ***Rayfract*** also includes a smooth inversion tomographic method that is based on physically realistic modeling of first break propagation, for P-wave and S-wave surveys. It forward model's refraction, transmission and diffraction (Lecomte, 2000) and back-projects travel time residuals along wave-paths, also known as Fresnel volumes (Watanabe, 1999) instead of conventional rays. This increases the numerical robustness of the inversion. A smooth minimum-structure and artifact-free 1D starting model is determined automatically, directly from the seismic travel time data, by horizontally averaging DeltaV (Wiechert-Herglotz) method 1D velocity-depth profiles along the seismic line. The starting model is then refined with 2D WET inversion (Schuster, 1993). ***Rayfract*** uses an adapted SIRT algorithm for velocity update of grid cells, when back-projecting travel time residuals along wave paths (Schuster, 1993) and (Watanabe, 1999). The result of these data processing features is a seismic velocity model that is geologically reasonable even in cases involving rugged topography and strong lateral velocity variations.

4.0 LIMITATIONS

The seismic refraction method provides a 2-D cross-section (profile) depicting the distribution of compressional (P) wave velocities versus distance and depth beneath a seismic line. These variations in velocity can be related to lithologic variations by correlating the seismic data with other subsurface information such as borehole geological and/or geophysical logs. In the absence of ground truth, certain assumptions can be made according to the interpreter's knowledge of the local geology and experience in similar surveys. In either case, the resulting seismic velocity profile represents a model of the subsurface, not an exact depiction.





VICINITY MAP

SCALE

0 100 200 400

(1 inch = 200 feet)

LEGEND	
(solid red line)	SEISMIC REFRACTION LINE
(cyan hatched box)	INTERPRETED BEDROCK RIDGE
(brown hatched oval)	OBSERVED BEDROCK RIDGE
(green dashed line)	HISTORIC RIDGELINE (STANTEC, 2020)
(blue dash-dot line)	HISTORIC DRAINAGE (STANTEC, 2020)
(black dashed line)	LIMITS OF LANDSLIDE (STANTEC, 2020)
(well symbol)	WELL

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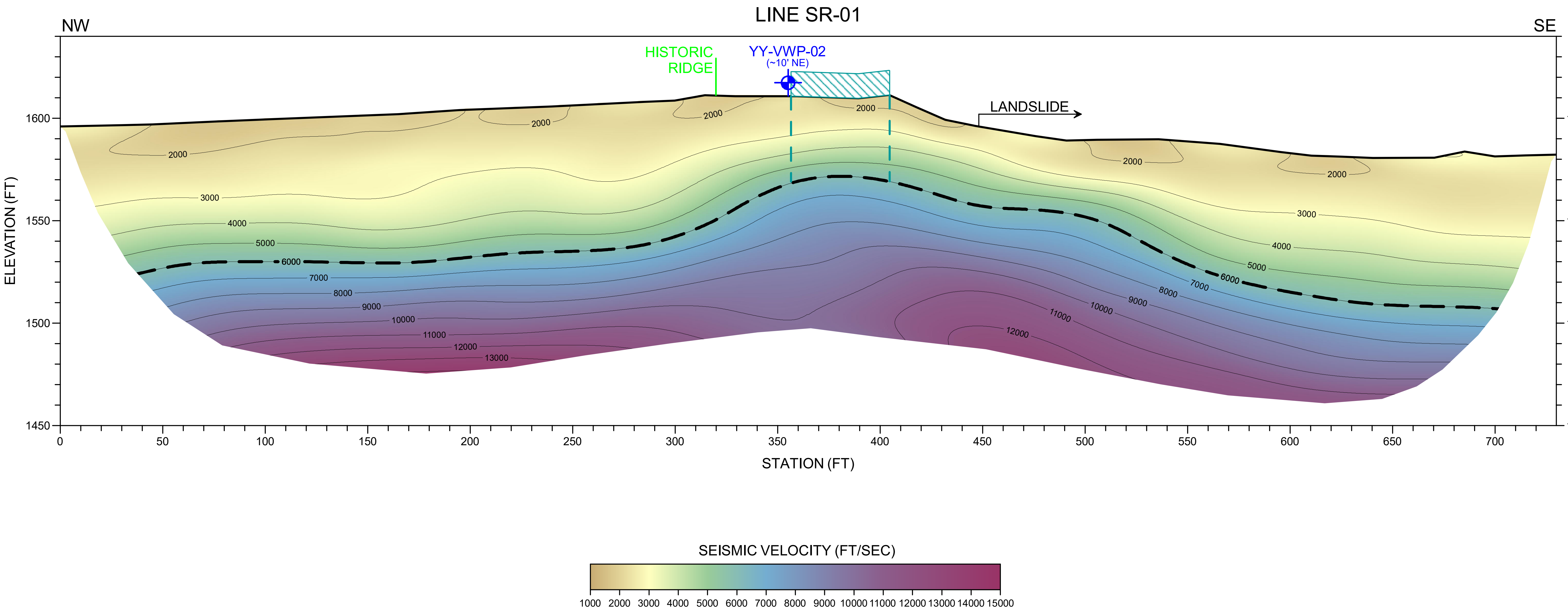
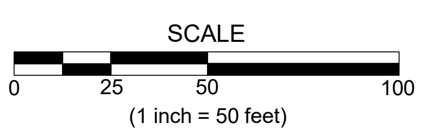
SITE LOCATION MAP
SEISMIC REFRACTION SURVEY
PERMANENTE QUARRY

LOCATION: CUPERTINO, CALIFORNIA		
CLIENT: LEHIGH HANSON, INC.		
JOB #. NS205004	DATE: MARCH 2020	PLATE
DRAWN BY: G.RANDALL	APPROVED BY: HSP	1
Hunter Philson 3/13/2020		





LEGEND

— —	INTERPRETED BEDROCK SURFACE
(hatched)	INTERPRETED BEDROCK RIDGE
(symbol)	WELL

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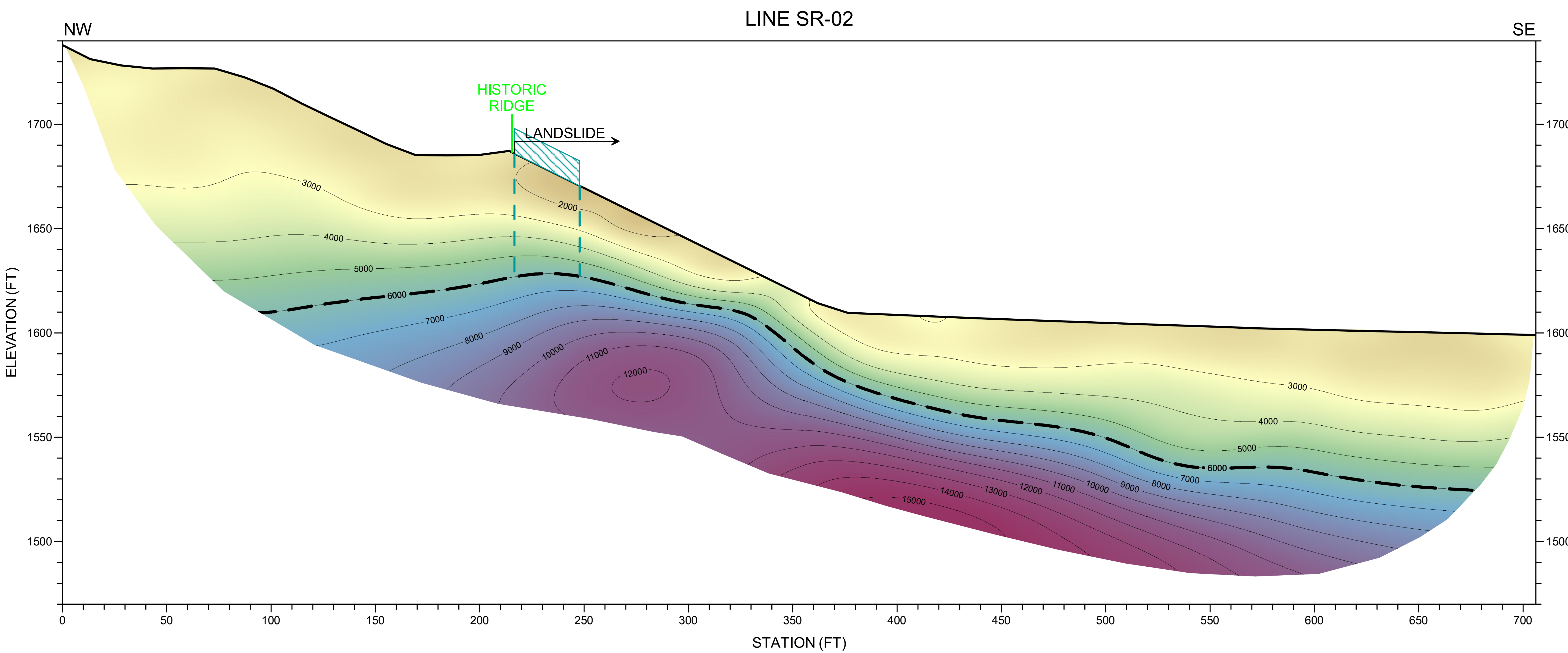
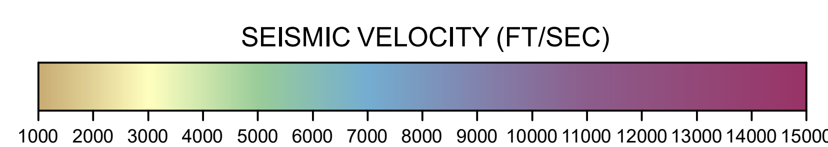
SEISMIC REFRACTION PROFILE
LINE SR-01
PERMANENTE QUARRY

LOCATION: CUPERTINO, CALIFORNIA
CLIENT: LEHIGH HANSON, INC.
JOB #: NS205004
DATE: MARCH 2020
DRAWN BY: G.RANDALL
APPROVED BY: HSP
PLATE 2
Hunter Philson 3/2/2020





SCALE

0 25 50 100

(1 inch = 50 feet)

LEGEND	
— — —	INTERPRETED BEDROCK SURFACE
(hatched)	INTERPRETED BEDROCK RIDGE

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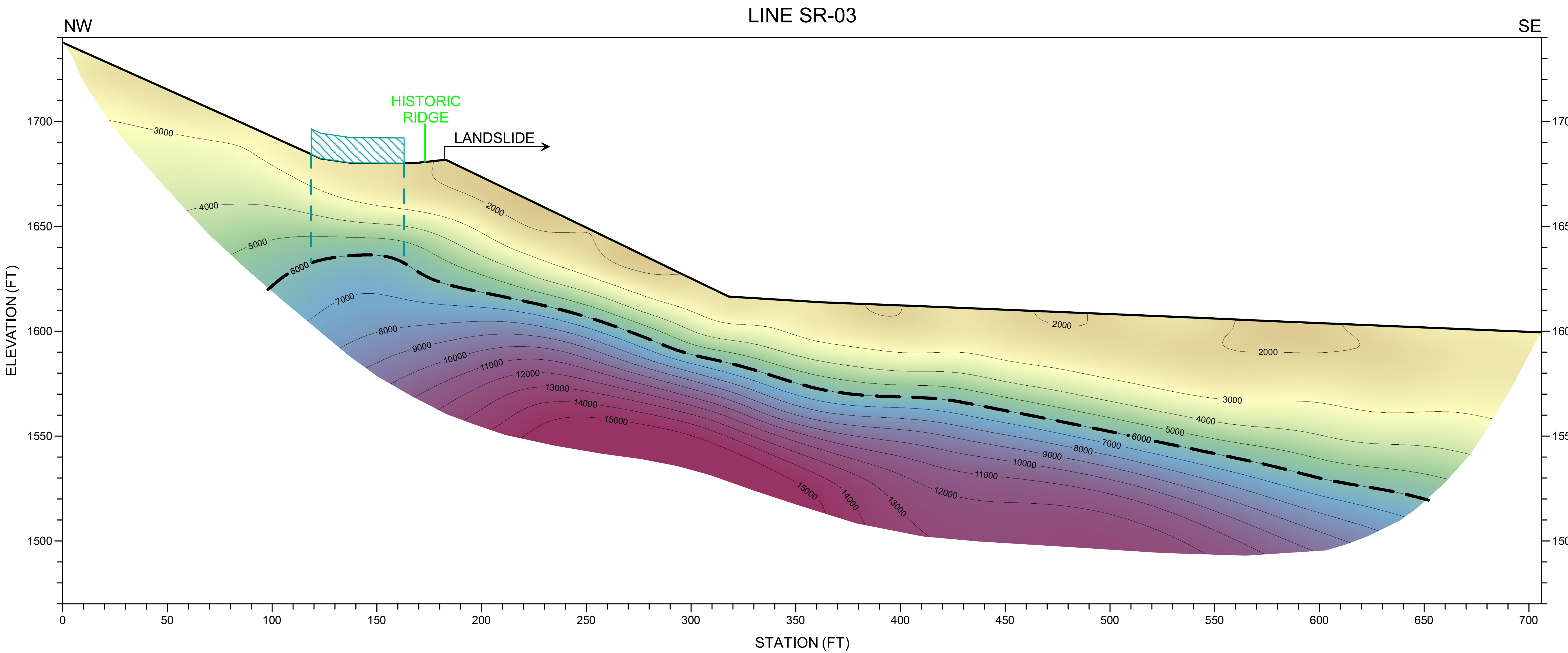
SEISMIC REFRACTION PROFILE
LINE SR-02
PERMANENTE QUARRY

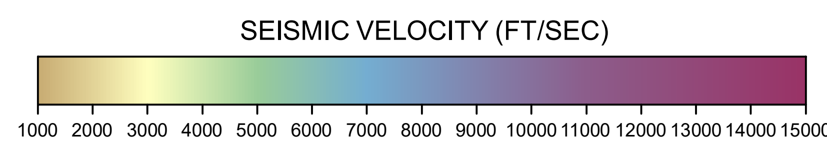
LOCATION: CUPERTINO, CALIFORNIA

CLIENT: LEHIGH HANSON, INC.

JOB #: NS205004	DATE: MARCH 2020	PLATE
DRAWN BY: G.RANDALL	APPROVED BY: HSP	3

Hunter Philson 3/2/2020





SCALE

0 25 50 100

(1 inch = 50 feet)

LEGEND	
— — —	INTERPRETED BEDROCK SURFACE
(hatched box)	INTERPRETED BEDROCK RIDGE

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SEISMIC REFRACTION PROFILE
LINE SR-03
PERMANENTE QUARRY

LOCATION: CUPERTINO, CALIFORNIA		
CLIENT: LEHIGH HANSON, INC.		
JOB #: NS205004	DATE: MARCH 2020	PLATE 4
DRAWN BY: G.RANDALL	APPROVED BY: HSP	
3/2/2020		