# Refraction Seismic Investigation
# at the
# Bass Lake Road
# Full Improvements, Phase 1A Project Site
# El Dorado County, California

***GGSI Project No. 2013-04.01***

**Prepared by:**


**Gasch Geophysical Services, Inc.**
**Rancho Cordova, California 95742-6576**


**Submitted to:**

Mr. John Youngdahl
**Youngdahl Consulting Group, Inc.**
1234 Glenhaven Court
El Dorado Hills, California 95762

***February, 2013***

GASCH GEOPHYSICAL SERVICES, INC.
WWW.GEOGASCH.COM Since 1969

February 26, 2013

Mr. John Youngdahl
Youngdahl Consulting Group, Inc.
1234 Glenhaven Court
El Dorado Hills, California 95762

***Re: Refraction Seismic Investigation at the Bass Lake Road Full Improvements, Phase 1A Project Site near El Dorado Hills, El Dorado County, California. GGSI Project No. 2013-04.01***

Dear Mr. Youngdahl;

At your request and authorization, Gasch Geophysical Services, Inc. (GGSI) has completed a refraction seismic investigation to evaluate the excavatability characteristics of the sub-surface materials at the Bass Lake Road Full Improvements, Phase 1A Project Site near El Dorado Hills, El Dorado County, California (Figure 1).

**Purpose**

The purpose of this investigation was to determine the depth to higher velocity material and also define the rippability (excavatability) characteristics of the sub-surface materials. The refraction seismic (RS) method was used to evaluate the rock velocities on site, as seismic primary-wave travel times are used to quantify the rock velocities and as a result, can determine the general competency/rippability in areas of various rock types.

**Method, Instrumentation and Software**

The RS method measures the velocity at which a seismic wave propagates through a soil or rock medium. In this case, the primary (p-wave) or compressional seismic wave was measured. Higher seismic p-wave velocities (measured in feet per second, ft/s) indicate material of higher density, thus quantifying the competency, or strength of the soil or rock medium and providing an estimation of the rippability and/or excavatability of the sub-surface materials.

GGSI's seismic data acquisition system was a distributed, 24-bit digital instrument with data output to electronic media for subsequent processing. Digital grade geophones were used and the energy source was a twelve pound sledge hammer. All data were processed in house, on our data reduction and plotting workstation.

Our refraction seismic processing software utilizes Wavepath Eikonal Traveltime (WET) tomography which models multiple signal propagation paths contributing to one first break (the Fresnel volume approach), while conventional ray tracing tomography is limited to the modeling of just one ray path per first break. An Eikonal solver (Lecomte, Gjoystdal et al. Geophysical Prospecting May 2000) is used for traveltime field computation which models diffraction in addition to refraction and transmission of acoustic waves. As a result, the velocity anomaly imaging capability is enhanced with the WET tomographic inversion method compared to conventional ray tomography. This software is developed by Intelligent Resources, Inc. of Vancouver, British Colombia, Canada.

A color-coded seismic velocity cross-section of the subsurface has been generated for each RS line, where cool colors (blues) indicate lower seismic velocities and warm colors (reds) indicate higher velocities. Color scaling of these seismic velocity sections is based on the range of seismic velocity values calculated. Scaling has been normalized for all three RS velocity sections.

## Data Acquisition Parameters

A total of 3 RS lines were acquired during this investigation. RS Line locations were selected by Youngdahl personnel. Each RS line employed 15 active geophone stations spaced at 5-foot intervals for a total line length of 80 feet each. Energy source points were applied between every other geophone station and also included energy source points off the ends of each line for a total of 9 source points per line. A total of 240 lineal feet of data was acquired and the collection of the field data was carried out on February 26, 2013. The locations of the RS lines are presented on Figure 2.

## Rippability

Rippability is dependent on the physical condition of the rock masses to be excavated. In addition to rock type and degree of weathering, structural features in the rock such as bedding planes, cleavage planes, joints, fractures, consolidation and shear zones also influence rippability. Rock masses tend to be more easily ripped if they have well defined, closely spaced fractures, joints, or other planes of weakness. Massive rock bodies which lack discontinuities may allow for slow and difficult ripping or refusal, even where partially weathered, and may require blasting to break the rock for efficient removal.

The association between the seismic velocity of any given earth material and its rippability varies greatly from one type of earth-moving equipment to another. For example, although a large track laying dozer with a single ripper tooth can sometimes rip material with seismic velocities in excess of 10,000 ft/s. GGSI has experienced a limiting (refusal) velocity for large excavators to range from 3,500 ft/s to 4,500 ft/s, and a standard backhoe may meet refusal at seismic velocities as low as 2,000 ft/s. Ultimately, the relationship between seismic velocity and rippability is dependent on both: site conditions *and* equipment and/or operator ability.

Seismic p-wave velocities are related to both rock hardness and fracture density. Rippability has been empirically correlated to refraction seismic velocities by Caterpillar Inc., as displayed on Figure 7 for a CAT D10R (Caterpillar Performance Handbook, Edition 32, October 2001). According to this chart, metamorphic rock becomes marginally rippable near 7,800 ft/s; and non-rippable at about 9,500 ft/s for a D10R dozer. These estimations are based on the lowest values for metamorphic rocks on the CAT chart; however, site geology and topography may cause some variations of these values.

The Caterpillar Chart of Ripper Performance should be considered as being only one indicator of rippability. Ripper tooth penetration is the key to successful ripping, regardless of seismic velocity. This is particularly true in finer-grained, homogeneous materials and in tightly cemented formations. Ripping success may ultimately be determined by the operator finding the proper combination of factors, such as: number of shanks used, length and depth of shank, tooth angle, direction of travel, and use of throttle. Although low seismic velocities in any rock type indicate probable rippability; if the fractures, bedding and/or joints do not allow tooth penetration, the material still may not be ripped efficiently. In some cases, drilling and blasting may be required to induce sufficient fracturing to allow for excavation.

## Seismic Velocities

Generally, seismic p-wave velocities less than 3,000 ft/s indicate native soil, fill material or heavily weathered and/or decomposed rock, while velocities in excess of 10,000 ft/s indicate fresh (essentially non-weathered) rock. Seismic velocities between these two values typically indicate rock with varying degrees of weathering and/or fracturing. Consolidation and cementation, as well as, fracture spacing and density also affect the measured seismic velocities. Moderate velocities may indicate compacted soil, moderately weathered rock or loosely consolidated sediment such as gravel, sand and silt. Saturated sediment below the water table characteristically displays seismic velocities near or slightly above 5,000 ft/s.

Extremes in seismic velocities may range from below 1,000 ft/s to over 20,000 ft/s. Very low seismic velocities usually indicate highly weathered or poorly compacted material, either natural or man-made. Extremely high velocities are rare in the near-surface, and only possible in certain types of rock. Rock velocities are dependent on the physical condition of the rock masses evaluated. Seismic p-wave velocities are related to rock hardness, fracture density and sediment consolidation, saturation and cementation.

## Findings

The results of this refraction seismic investigation are summarized by Figures 3 through 5. These seismic velocity sections, which were created through the inversion process, have very low error and provide a high degree of lateral definition of the seismic velocity horizons found beneath each line. The seismic velocity sections have been scaled from 1,000 ft/s to 10,000 ft/s for the velocity window. The horizontal and vertical axis are scaled 1-inch equals 10-feet.

To provide a visual tool for evaluating the velocities of the area of excavation beneath each RS Line, a transparency of the planned box culvert has been overlaid on each seismic velocity section at the planned project depth. Examination of these sections provides a visual depiction of the variation in seismic velocities beneath each RS line.

<u>RS Line 1</u>

RS Line 1 was located on the western edge of Bass Lake Road, just off of the existing asphalt and was centered over the existing culvert (see Figure 3). The velocities measured at this location show a moderate to high gradation from the low to moderate velocities (1,500 ft/s to 4,000 ft/s) at the surface to greater than 6,000 ft/s (feet per second) at a depth around 5 feet bgs (below ground surface) on the southern portion of the line . The velocities at the maximum excavation depth of the planned box culvert range from 3,000 ft/s to 4,000 ft/s. These velocities at this depth are at the maximum capability of a large track type excavator, depending on the amount and degree of fracturing of the rock encountered. Excavation beyond the capability of conventional track type excavators may require a hydraulic hammer or blasting to break and excavate the rock.

<u>RS Line 2</u>

This line was acquired on the eastern side of Bass Lake Road, just off the asphalt and centered over the existing culvert (see Figure 4). Velocities grade moderately to over 6,000 ft/s at a depth of around 10 feet bgs. In the top 8 feet, velocities range from less than 1,500 ft/s up to about 4,000 ft/s. At the depth of the planned box culvert, velocities measured are between 2,500 ft/s to 3,000 ft/s. These velocity values are generally within the capability of a large track type excavator, depending on the amount and degree of fracturing of the rock encountered.

<u>RS Line 3</u>

RS Line 3 was located approximately 1-foot east of the centerline of Bass Lake Road (see Figure 5). Velocities on this line show a moderate gradation from lower velocities at the surface to over 8,000 ft/s at a depth of around 22 feet bgs. The top 8 feet of this section measured velocities from 2,000 ft/s to 3,500 ft/s. At the maximum depth of the planned box culvert, excavation with a large track type excavator should not be problematic; however, progress may be slower as the higher velocity material is encountered, again, depending on the amount and degree of fracturing of the rock encountered.

Figure 6 presents the extrapolated velocity horizons over the box culvert profile (EDDOT Sheet L-1). This is a simple diagram showing the velocities horizons from each RS Line and the associated depth, relative to the profile. While there is likely more character than the “straight-line” velocity horizons shown on this figure, it clearly shows the relationship of the subsurface velocities and the box culvert.

**Summary**

This refraction seismic investigation revealed a high degree of variation in the calculated seismic velocities of the subsurface materials, with maximum seismic velocity values greater than 8,000 ft/s found on RS Line 3. The low to moderate velocity material encountered in the near surface material suggests moderately weathered rock and soil and/or fill. Moderate velocities were measured in the near surface on Line 1; however, lower velocities dominated the near surface material of RS lines 2 and 3. RS Line 1 shows a non-continuous and very thin section of low velocity material followed by higher velocity material at the box culvert grade.

Since it is assumed that a large track type excavator will be used for excavation on this project, which generally meets refusal at a seismic velocity around 4,000 ft/s ±, it should be anticipated that some areas in the excavation will encounter slower progress and possibly refusal before reaching the maximum depth of the cut. Depending on the degree of weathering and/or fracturing of the rock, some locations of the planned alignment may require a hydraulic hammer or blasting to efficiently break the rock for excavation.

**Warranty and Limitations**

Gasch Geophysical Services, Inc. has performed these services in a manner which is consistent with standards of the profession. Site conditions can cause some variations of the calculated seismic velocities. Refraction seismic velocities assume that velocities increase with depth; therefore, a lower seismic velocity layer beneath a higher seismic velocity layer will not be resolved. No guarantee, with respect to the results and performance of services or products delivered for this project, is implied or expressed by Gasch Geophysical Services, Inc.

We trust that this is the information you require; however, should you have comments or questions, please contact our Rancho Cordova office at your convenience. Thank you for this opportunity to again be of service.

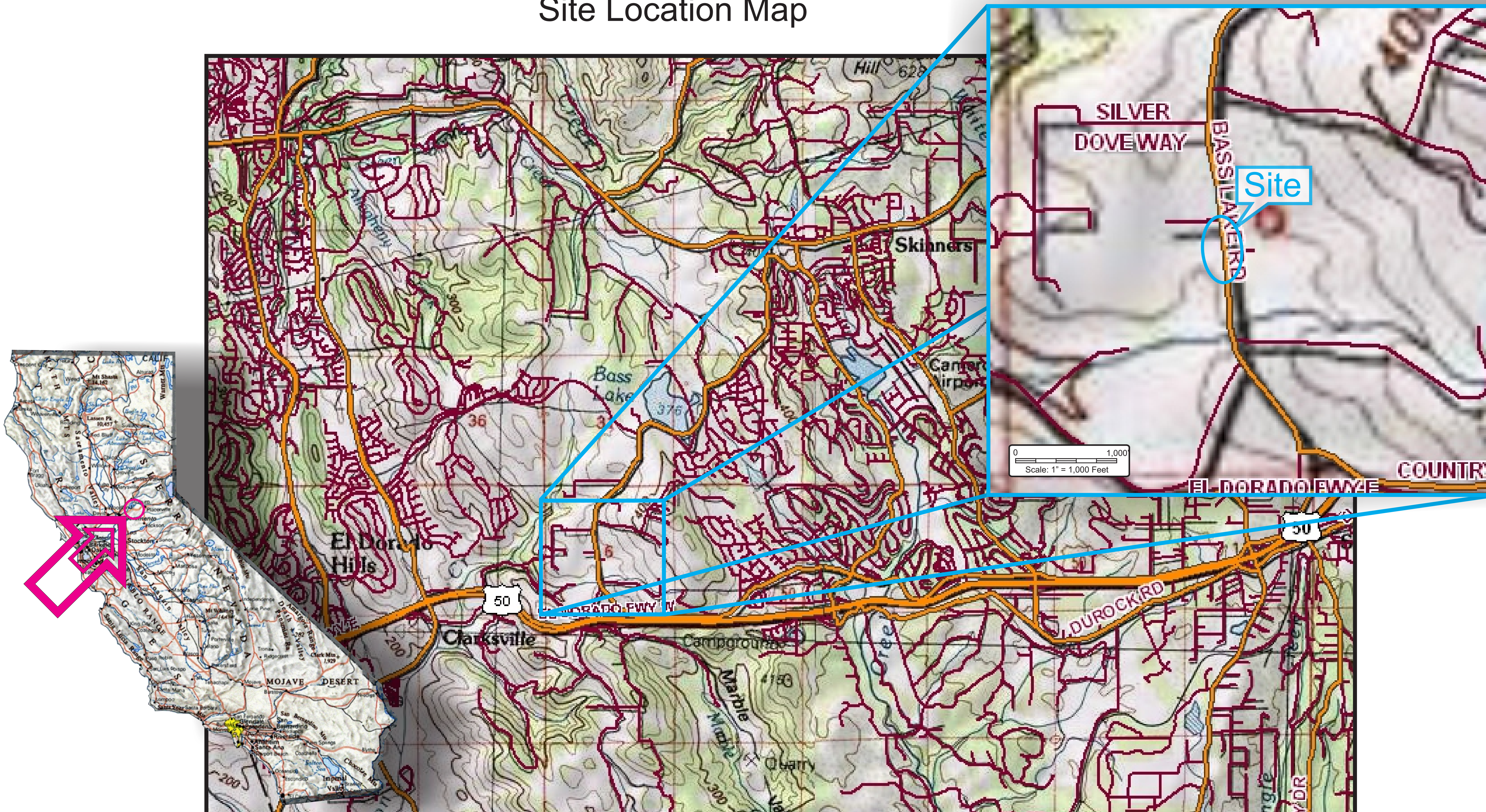
Sincerely,

GASCH GEOPHYSICAL SERVICES, INC.

Professional Geophysicist
Kent L. Gasch
No. 1061
State of California

Kent L. Gasch
Professional Geophysicist No. 1061

# Site Location Map




Base Maps Courtesy of: USGS

0 0.5 1.0 1.5 2.0 miles
0 1 2 3 kilometers

North

**Figure 1**

Refraction Seismic Investigation:
Bass Lake Road
Full Improvements, Phase 1A

***Prepared for: Youngdahl Consulting Group***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***Project Number:*** 2013-04.01 ***Date:*** February, 2013

# DEPARTMENT OF TRANSPORTATION
# COUNTY OF EL DORADO, CA

PROJECT PLANS FOR THE CONSTRUCTION OF

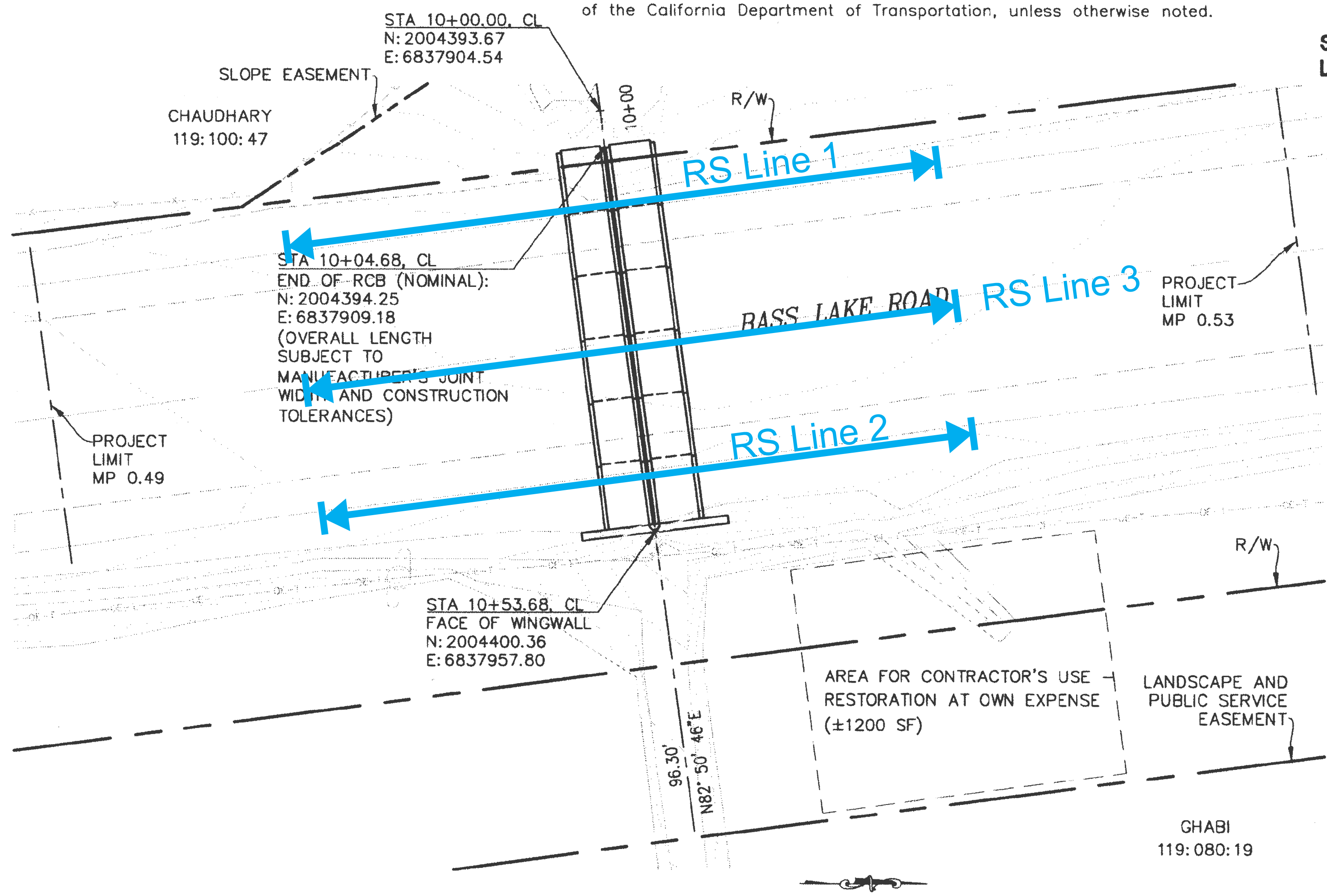
## *BASS LAKE ROAD FULL IMPROVEMENTS – PHASE 1A*

IN THE COUNTY OF EL DORADO, DISTRICT I
NEAR EL DORADO HILLS, CA

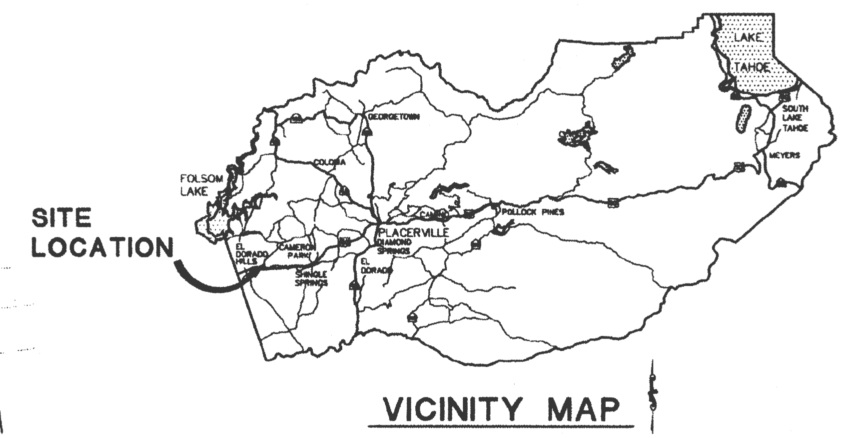
To be supplemented with Standard Plans and Specifications dated May 2006, including the amendments to the May 2006 Standard Specifications, of the California Department of Transportation, unless otherwise noted.

**Refraction Seismic Line Location Map**

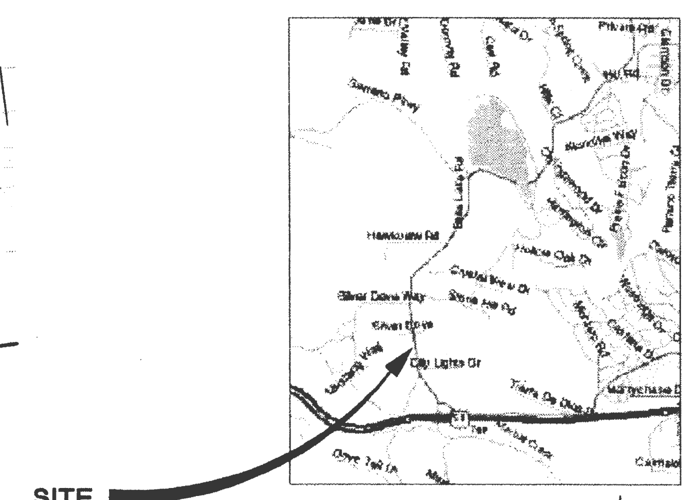
Base Map Courtesy of El Dorado County DOT
Title Sheet 1 of 5




**SITE PLAN**
SCALE: 1"=20'




**VICINITY MAP**
**COUNTY OF EL DORADO**
NO SCALE




**LOCATION MAP**
NO SCALE

North

# Figure 2

Refraction Seismic Investigation:
Bas Lake Road
Full Improvements, Phase 1A

***Prepared for: Youngdahl Consulting Group***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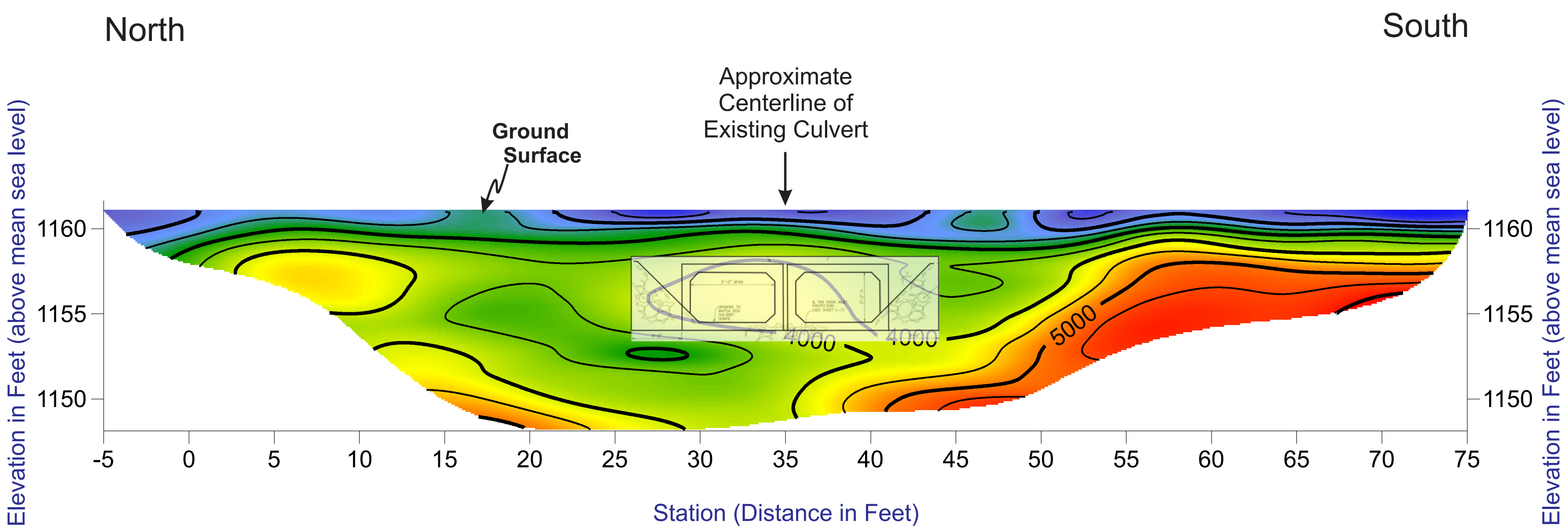
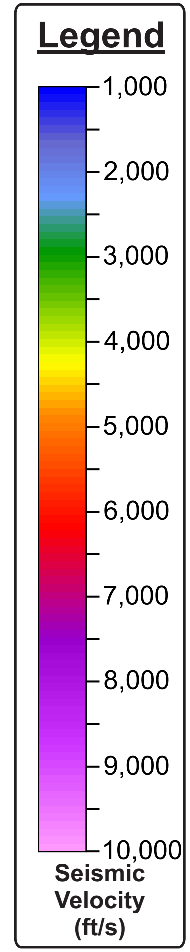
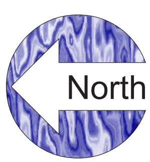
# Seismic Velocity Section • RS Line 1




## Figure 3

**Scale:**
**Horizontal: 1" = 10'**
**Vertical: 1" = 10'**
**Geophone Station Interval = 5 feet**

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Full Improvements, Phase 1A

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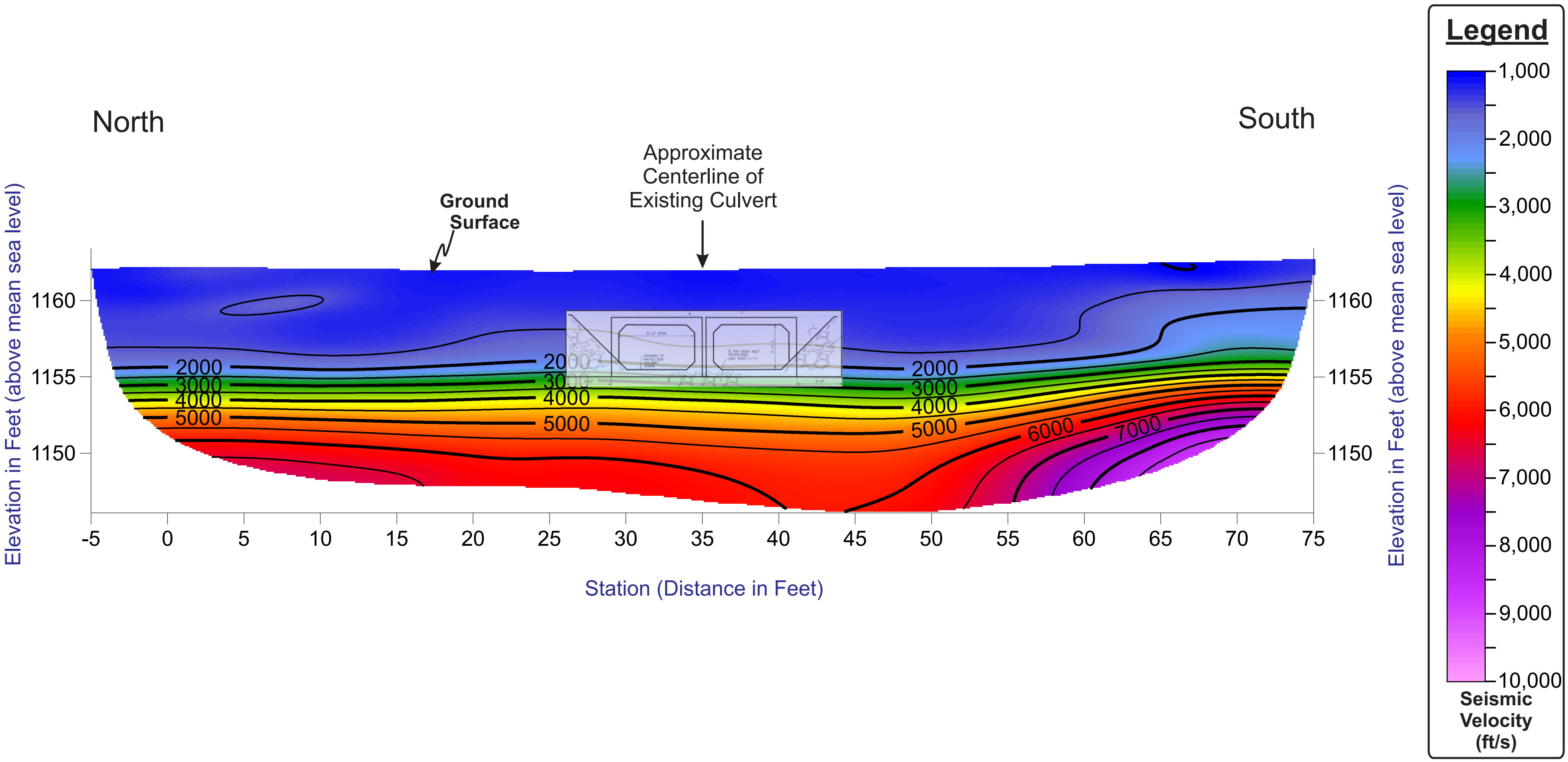
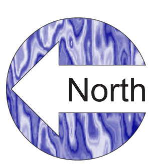
# Seismic Velocity Section • RS Line 2




**Scale:**
**Horizontal: 1" = 10'**
**Vertical: 1" = 10'**
**Geophone Station Interval = 5 feet**

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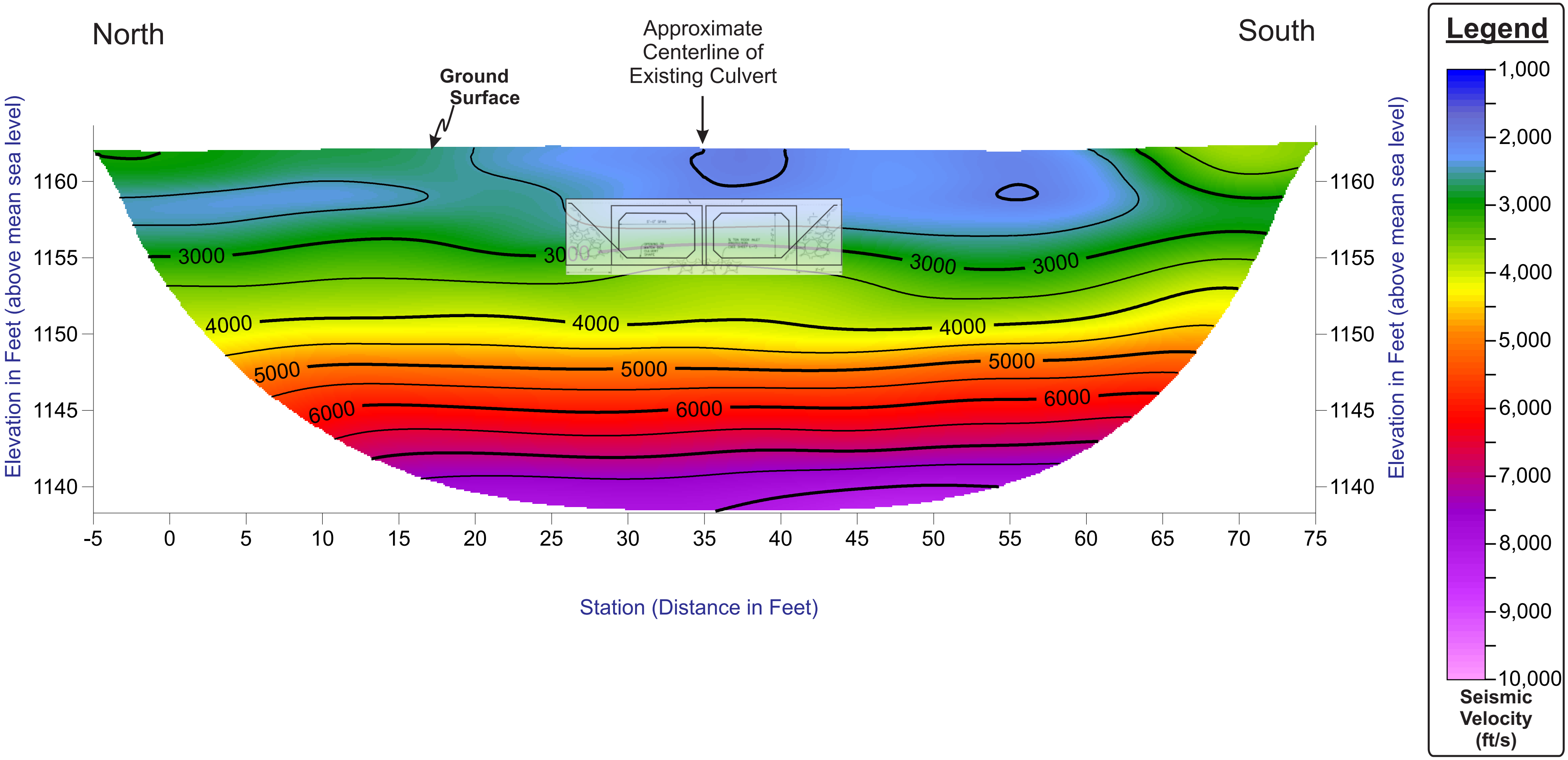
## Figure 4

Refraction Seismic Investigation:
Bas Lake Road
Full Improvements, Phase 1A

***Prepared for: Youngdahl Consulting Group***

***Project Number:*** 2013-04.01 ***Date:*** February, 2013

# Seismic Velocity Section • RS Line 3




**Scale:**
**Horizontal: 1" = 10'**
**Vertical: 1" = 10'**
**Geophone Station Interval = 5 feet**

North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## Figure 5

Refraction Seismic Investigation:
Bas Lake Road
Full Improvements, Phase 1A

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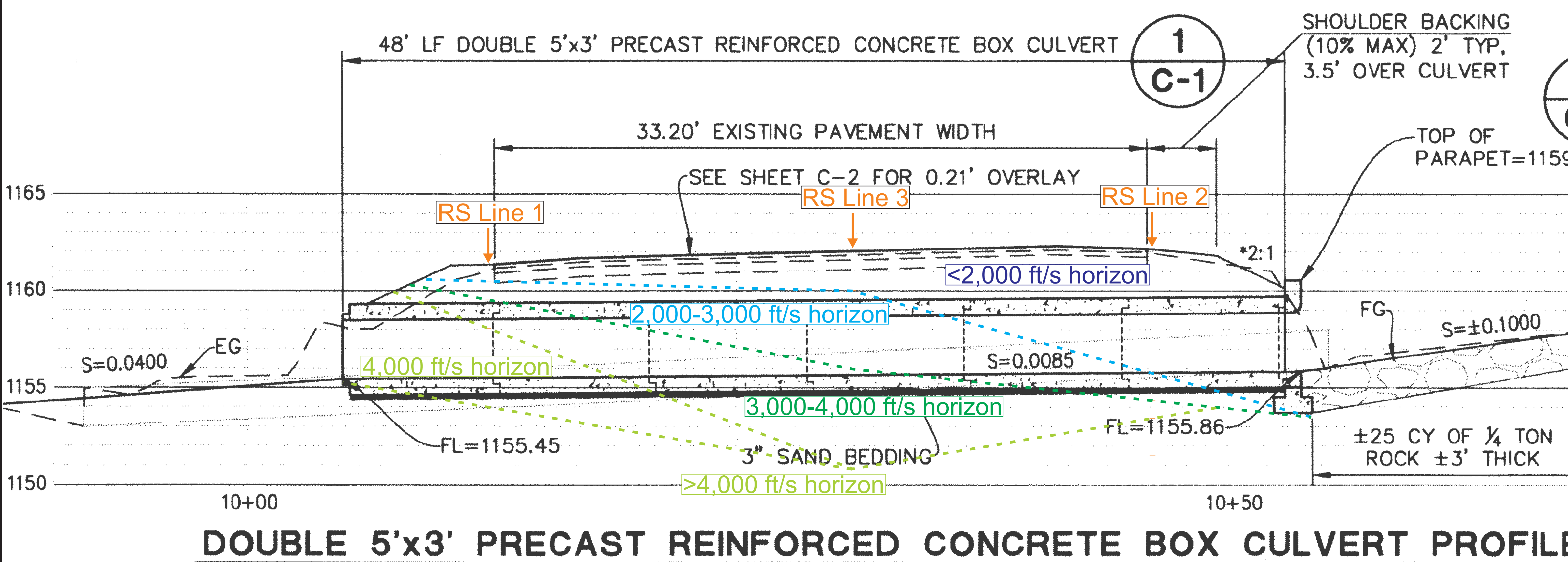
# Culvert Profile with Seismic Velocity Horizons

Base Map Courtesy of El Dorado County DOT
Sheet L-1




DOUBLE 5'x3' PRECAST REINFORCED CONCRETE BOX CULVERT PROFILE

Scale: 1" = 5'

North

## Figure 6

Refraction Seismic Investigation:
Bas Lake Road
Full Improvements, Phase 1A

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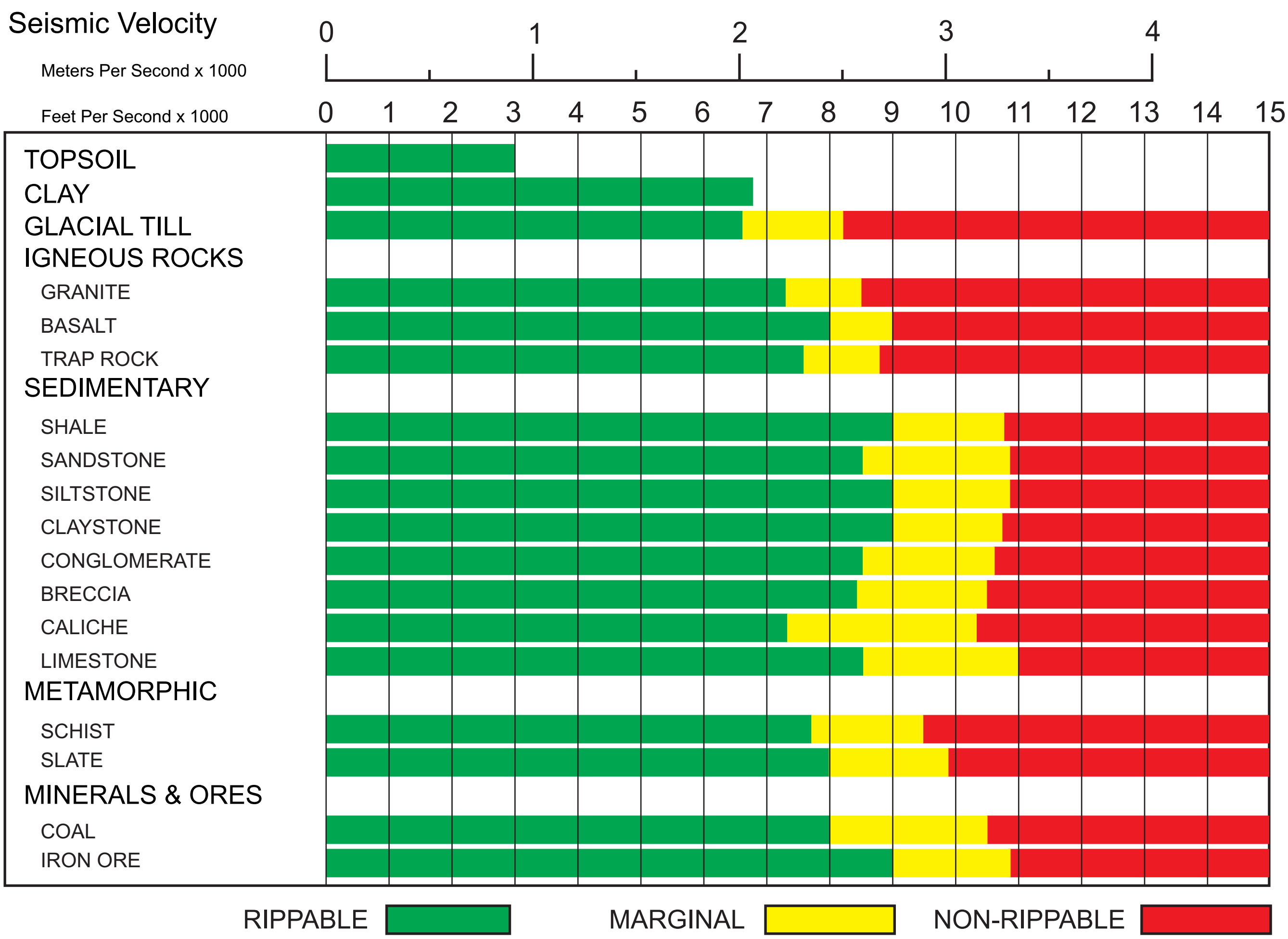
# Caterpillar D10R Ripper Performance Chart*

## D10R

**Multi or Single Shank No. 10 Ripper**
**Estimated by Seismic Wave Velocities**




## Figure 7

* Based on the Caterpillar Performance Handbook Edition 32 - October, 2001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