440

08-SBd-138-K.P. 0.00/22.53
Construct truck climbing lanes,
Truck descending lanes,
Median left turn lane, widen
Shoulders, realign roadway
And rehabilitate pavement.
In San Bernardino County
08-220-469700, 359700 & 340120
Program HB1, HA22 & HE13

GEOTECHNICAL INVESTIGATION

(PAVEMENT PEER REVIEW)

Memorandum

To : MR. MARK LANCASTER - D 08
Office of Design A

Attention: Mr. Du Lu
Office of Design A

Date : June 28, 2001

File No. : 08-220-469700
08-SBd-138-KP0/22.85

From : DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
Geotechnical Services - MS#5
Office of Geotechnical Design - South

Subject : Geotechnical Investigation

This report presents the results of an investigation conducted by the Office of Geotechnical Design-South, Branch B for proposed construction on State Route 138 from the Los Angeles San Bernardino County Line (KP 0.00) near Pinon Hills to the Southern Pacific Railroad (KP 22.85), approximately 1.69 kilometers east of the Cajon Junction on I-15 (Figure 1). The investigation was limited to the geotechnical study of surface materials as they pertain to the following improvements:

- Construct a truck climbing lane with 3.6 m median buffer
- Widen shoulders and acceleration lanes between Sheep Creek Road and SR 2 Junction
- Modify the right turn lane at Sheep Creek Road
- Modify the left turn pockets at Mountain Road, Phelan Road and Lone Pine Canyon Road
- Horizontal and vertical curve corrections
- Construct turnouts
- Drainage improvements, and
- Miscellaneous safety improvements

The purpose of this report is to document existing slope conditions and recommend cut slope design, evaluate the need for retaining walls and provide recommendations for retaining wall foundations, evaluate rippability and evaluate the need for blasting. The study included field reconnaissance, review of published material and related studies, geotechnical engineering analysis, and preparation of this report.

This report is intended for use by the project roadway design engineer, construction personnel, bidders and contractors. This report also presents a geotechnical baseline to be used in assessing the existence and scope of changed site conditions.

EXISTING FACILITIES

SR 138 in the project area is a two-lane highway with sparse turnouts and little shoulder space. The intersection where SR 2 joins SR 138 has recently been widened and improved with turn lanes. The existing structures found along the highway are Sheep Creek Bridge (BR No. 54-0810) at KP 5.82 (PM 3.62), Cajon Mountain UP (BR No. 54-0832) at KP 22.79 (PM 14.16), and numerous culverts. Culvert rehabilitation will be addressed in a subsequent report.

PHYSICAL SETTING

The project, located between SR 18 (Pearblossom Highway) and I-15, is the section of SR 138 (Antelope Highway) from Station 00+00 and Station 144+30, and from Station 171+00 to Station 227+00. Elevation ranges from 1184.7 m at the LA/SBd county line (Sta. 00+00) to 1464.2 m at the SR 2 junction (Sta. 108+75) and to 987.7 m at the south end of the project (Sta. 227+00). Proposed cut slopes are located from Sta. 85+50 to 140+80 and from Sta. 213+85 to 226+80. The remainder is on fill or original ground.

The site is a mountain and valley region with a semi-arid to arid climate. The major portion of precipitation (mostly rain with some snow) occurs during the period of November through April with average annual rainfall about 225 mm. Maximum temperatures of between 38°C and 55°C are common, while minimum temperatures range as low as -9°C to -12°C in the winter months. The average annual temperature range is between 25°C and 8°C.

GROUNDWATER AND LIQUEFACTION

Groundwater level was estimated from logs of borings performed at the two bridges listed above to be greater than 30 meters depth below any particular site area. Liquefaction potential is considered low. Perched water may be encountered during grading which may require mitigation.

GENERAL GEOLOGY

The project site lies in the central Transverse Range and the southwestern Mojave Desert Geomorphic Provinces of Southern California. Geology of the area is shown in Figures 2 and 3. The coarse-grained clastic rocks in the area range in age from middle Miocene to Holocene. Regional strike is northwest with shallow dipping upper (younger) units and steeper dipping lower units. The sequence from oldest to youngest is the "Punchbowl Formation" of Cajon Valley, Crowder Formation, Harold Formation and Shoemaker Gravel, Well Dissected Alluvial Fans, Older Alluvium and Recent Alluvium.

SITE GEOLOGY

Soils underlying the project site consist primarily of sand, gravel, and silty sand with trace amounts of silt and clay. The consistencies range from dense to very dense with some loose pockets and lenses. Bedrock from Stations 214+00 to 216+60 is highly indurated sandstone.

Station 0+00 to 69+15: The highway is underlain by undifferentiated sedimentary deposits including colluvium, older alluvium, terrace gravels and fanglomerate. These deposits consist of gravelly and silty sand with minor to trace cobbles, boulders and clay.

Station 69+15 to 98+00: The highway traverses well dissected (eroded), mature formational material in broad alluvial fans. This material consists of pale orange arkosic (rich in feldspar) coarse gravels with abundant granodiorite and Pelona schist clasts. At Station 98+00 to 104+00, deposits are finer and consist of grayish orange arkosic sandstone and siltstone. The erosion of the Cajon Valley has left steeper slopes on the northeast side of the highway. Several streams, like Sheep Creek and Horse Creek, have eroded through the composite ridge northward making a natural passage for the highway.

Station 104+00 (at the junction of SR 2) to 140+80: The highway descends from the Summit into the Cajon Valley. Formational materials consist of gently folded and faulted pinkish-gray to very pale orange arkosic sandstone with lenticular sand and gravel beds that is poorly to moderately well-indurated (hardened). Thin lenses of cemented sandstone occur sporadically, as do up to cobble size clasts of volcanic porphyry, schists and marble.

Station 140+80 to 214+00 and 216+80 to 227+00, The highway traverses across dissected alluvial fans and very coarse-grained semiconsolidated fanglomerate from the San Gabriel Mountains. These fans are composed of gravel, sand, silt and clay, and have been slightly uplifted and dissected to form isolated terrace deposits. On both sides of the highway from Stations 214+00 to 216+80, highly indurated, almost unfractured sandstone dips from 40° to 60° northeast. The sandstone is thickly to very thickly bedded buff white to locally pink medium to coarse-grained arkose, with granitic and metamorphic gravel and cobble with a few scattered boulders.

SITE SEISMICITY

According to the 1996 California Seismic Hazard Map (Figure 4), the San Andreas Fault south of the site is the nearest seismic source. In the north, the site is 8.4 km from the fault and in the south the site is 2.5 km from the fault. The Maximum Credible Earthquake (MCE) expected on this fault is Mw 8.0, producing in the south site area a Peak Acceleration (PA) of 0.7g and in the north site area 0.6g. Other faults in the area capable of producing large accelerations are the east-trending left-lateral Cleghorn Fault with a MCE of Mw 7.75 producing in the south (nearest) area a PA of 0.6g, and the northwest trending Llano Fault with a MCE of Mw 6.0 producing in the north (nearest) area of the highway a PA of 0.5g.

FIELD EXPLORATION AND LABORATORY TESTING

Test borings and lab testing were not performed by this office because of the overall consistency of the material and well-exposed existing cuts in the sandstone.

Rippability between Stations 214+00 and 215+00 (part of a larger group of rocks called the Mormon Rocks) was evaluated by seismic refraction, which was done on outcrops on the north side of the roadway (See Figure 5 and 6). The Seismic Refraction Report is summarized below and included in the Appendix.

GEOTECHNICAL ANALYSIS AND DESIGN

1. Cut Slope Design - A slope stability analysis was performed by this Office and summarized in a memo written May 2, 1996 from Mr. Les Whitmore, P.E. to Mr. Ngoc Huang of District 8 entitled "Slope Recommendations for Widening on Route 138". That analysis is summarized here. Geologic bedding and slope measurements between old Stations 465+30 to 466+30 (between new Stations 93+00 and 93+25) and between 490+17 to 498+69 (new Stations 96+00 and 103+00) were checked by this author and surface samples from old Station 496+00 (99+20) were taken to the TransLab for shear testing. Using XSTABL 3.22 computer program it was determined that a slope of 1(V) to 1.5(H) would be stable. However, due to surficial erosion and the possibility of rockfall, we recommended 1:2 slopes. All cut and fill slopes for the project are summarized in the Appendix as are paved brow ditches and slope drains that will need to be addressed on a site by site topographic basis.

   Because erosion may dislodge cobbles or boulders, all cuts should conform to the Ritchie Criteria (Figure 7). The 1:2 (V:H) cuts should be designed according the specifications in Figure 7, "Rock Slope 1:1" category where a minimum catchment area

(W) of 3 m (10 ft) is recommended for maintenance cleanout purposes. A rock fence on the shoulder is advisable in high rockfall areas. A mid-slope bench with paved drainage swales at toe of upper slope is acceptable if sloped 3° to 5° into the slope. Six meter wide benches should be considered at ten meter high intervals for stability and erosion control.

After grading, an engineering geologist should examine the new slopes for any unanticipated conditions.

2. Need for Retaining Walls - No retaining walls are recommended for this project.

3. Rippability - All materials from Stations 0+00 to 214+00 and 216+80 to 227+00 are rippable. The indurated sandstone (Mormon Rocks) between Stations 214+00 to 216+80 are only slightly rippable on the surface. The lack of fracturing would make ripping difficult, even on the weathered surface. Blasting would still be required to complete the majority of work.

4. Blasting - The District has proposed cutting of the Mormon Rocks for future widening, curve realignment and lowering of the roadway several meters for safety reasons. Blasting of the right (south) side of the outcrop is probably not necessary since the highway will be moved to the north providing room for an edge ditch.

This proposed work will remove at least two of the three outcrops on the north side of the highway (Figure 6). Quantities estimated for blasting from the existing right shoulder 43 m north between Stations 214+30 and 215+50 are 20,125 cubic meters (26,321 cubic yards or 711,131 cubic feet) including cutting two meters below the roadway at Station 214+30 to zero meters at Station 215+50. Blasting specifications are included in the Appendix.

Possible alternatives to blasting include realignment of the roadway to the north of the rocks in the flat area and slope-armoring the north side of the roadway, or splitting the roadway around the rocks to the north and south.

RECOMMENDATIONS AND CONSTRUCTION CONSIDERATIONS

1) All cuts and fills are recommended to be 1(V):2(H). Brow ditches for cuts are recommended for certain slopes listed in the Appendix. Erosion protective planting should be placed before the first rainy season after the slopes are constructed. Materials should conform to the requirements in Section 19-5 and 19-7 of the Caltrans Standard Specifications (1999). Construction of Embankments shall conform to the requirements of Section 19-6 of the Standard Specifications. If groundwater or perched water is encountered during construction, it should be controlled in accordance with Section 19-3.04 of the Standard Specifications. A Ritchie Criteria ditch should be installed at the edge of roadway for all cuts to control rockfall and facilitate maintenance cleanup. Drainage terraces on cut and fill slopes should be avoided. Due to the unconsolidated nature of the material, we recommend that slopes not be cut to step benches for the benefit of erosion control. Erosion control should be addressed by landscaping, hydroseeding, straw wattles and/or a mid-slope bench with paved drainage swales at toe sloped 3° to 5° into the slope. Additionally, six meter wide benches should be considered at ten meter high intervals for stability and erosion control.

2) No retaining walls are recommended for this project.

3) All slopes from Stations 0+00 to 214+00 and 216+80 to 227+00 are rippable. Sandstone between Stations 214+00 and 216+80 is slightly rippable at the surface only.

4) Blasting would be necessary along the currently proposed alignment from Stations 214+00 to 216+80. The following procedures should be followed for blasting. Loading of explosives can be done a minimum of 15 m from live traffic. During blasting operations, traffic is to be stopped either directly or with rolling traffic breaks with the CHP. Typically, the blasters load the holes at night and shoot at dawn, or when traffic is lightest.

If you have any questions or comments, please contact me at (916) 227-7238 or CalNet 498-7238.

CHRIS HOADLEY, R.G., No.7068
Associate Engineering Geologist
Geotechnical Branch B

MARTHA MERRIAM, C.E.G., No.1957
Senior Engineering Geologist
Geotechnical Branch B

Attachment(s)

c: BKeen-08
RGES.02

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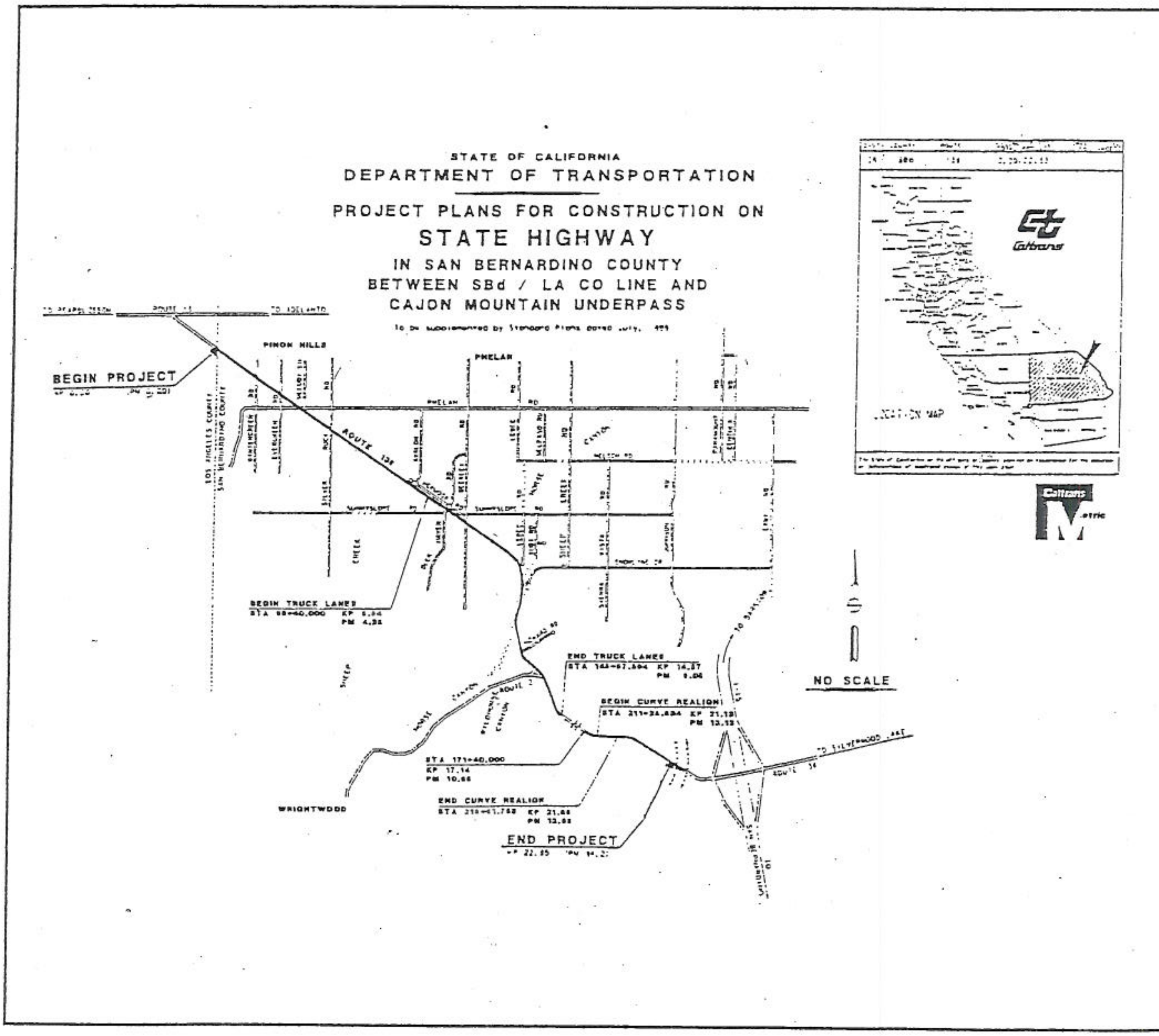
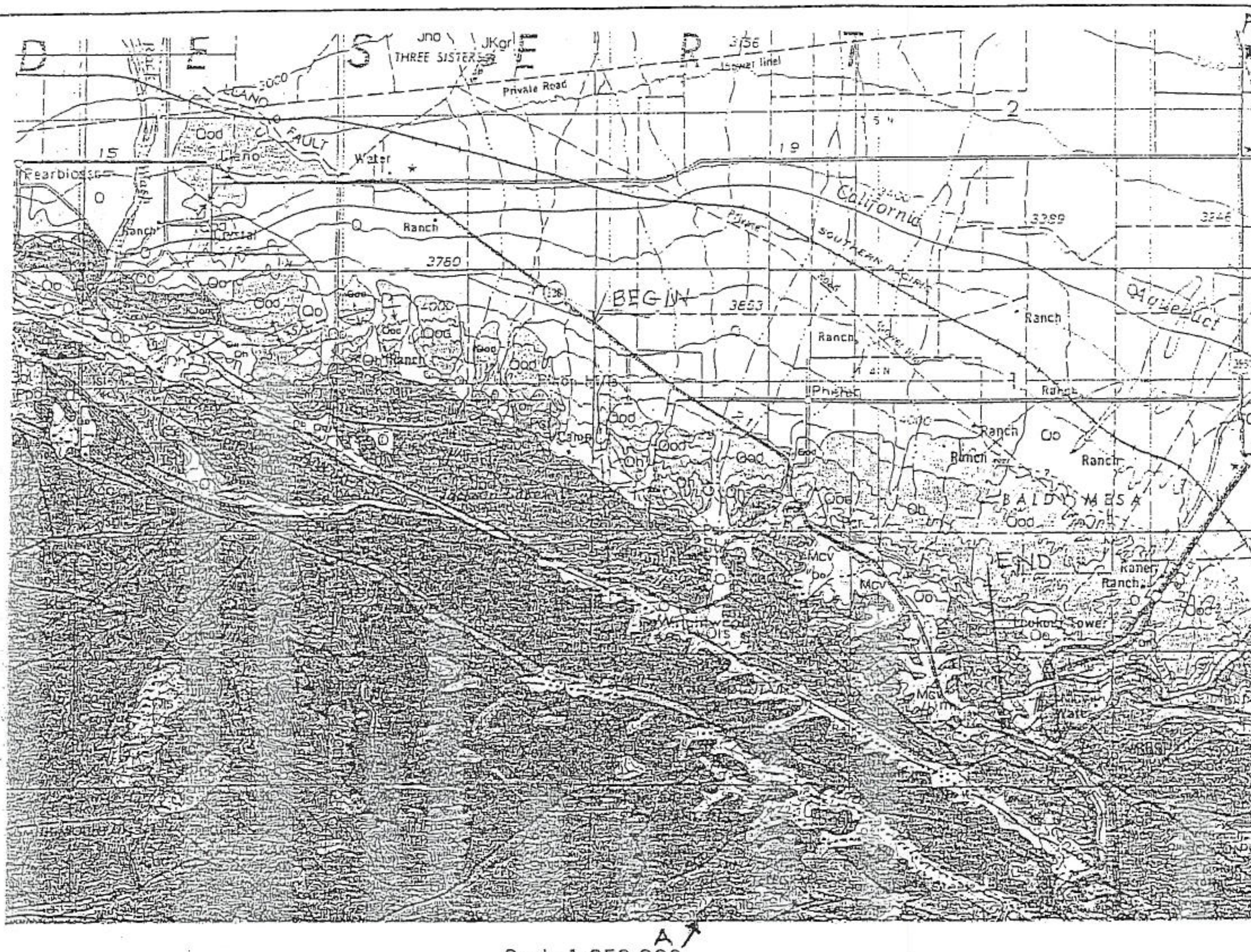
08-SBd-138-KP0.0/22.85



Location Map

Figure 1



Scale 1:250,000

5 0 5 10 15 20 Statute Miles

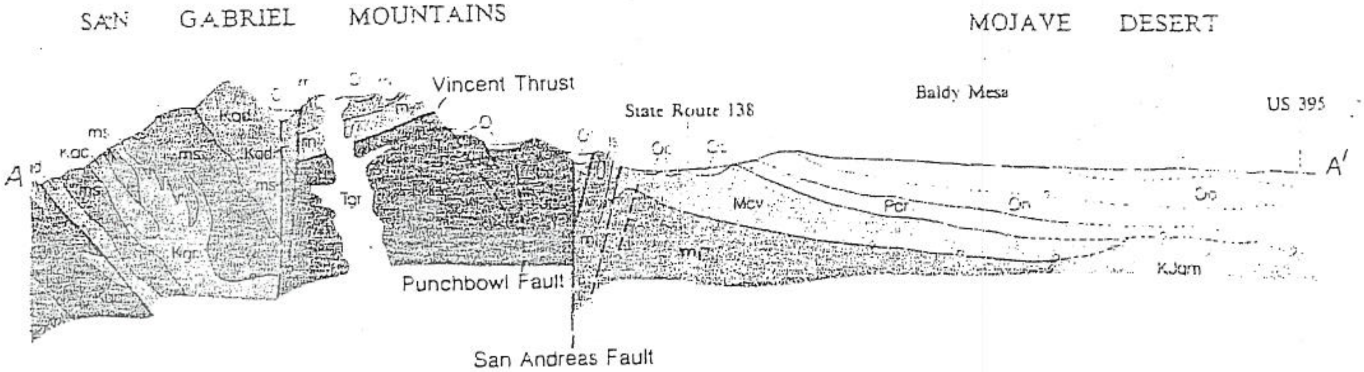
5 0 5 10 15 20 25 30 Kilometers

5 0 5 10 15 Nautical Miles

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS

CROSS SECTION

Vertical Exaggeration = Approximately 2X Horizontal



DIVISION OF MINES AND GEOLOGY

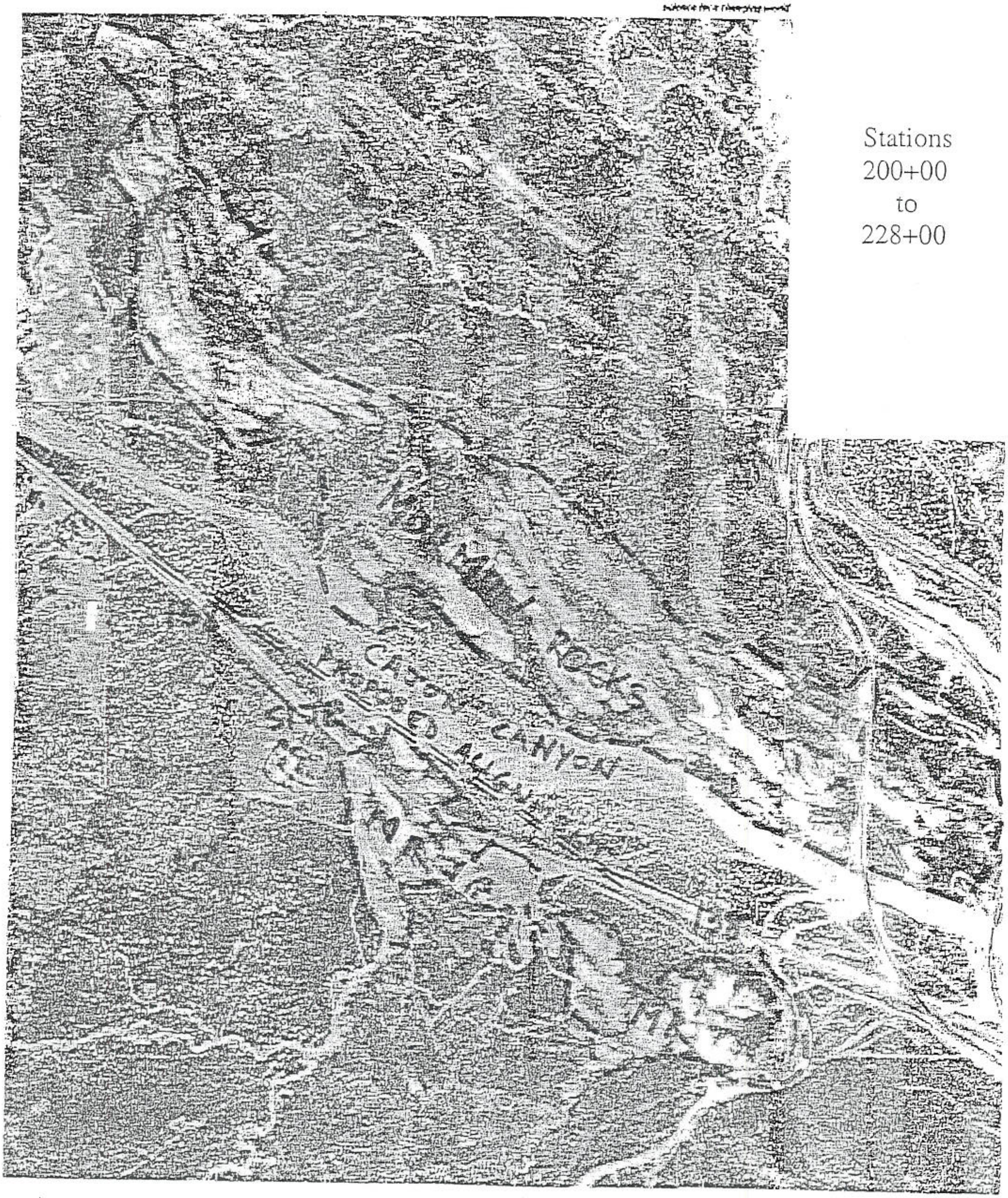
SEE FIGURE 3 FOR LEGEND

Geologic Map

Figure 2

08-469700
08-SBd-138-0.0/22.85

75 km NE of Los Angeles, California, United States 28 May 1994



Stations
200+00
to
228+00

0 .5Km

Mormon Rocks Area Air Photo

Figure 5

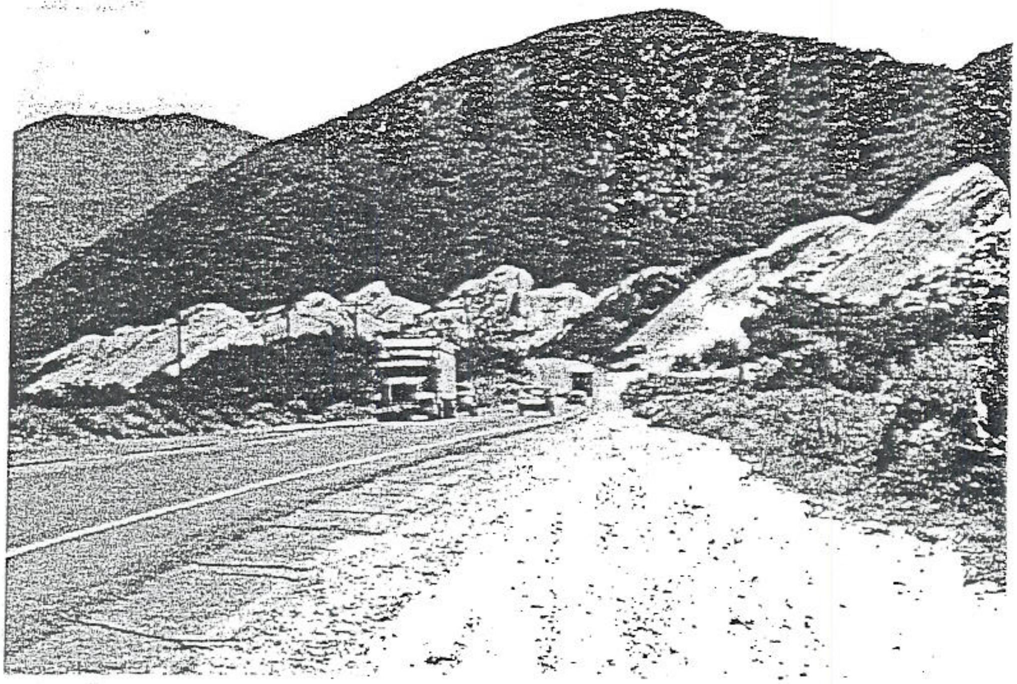


Photo 1. Mormon Rocks, "Punchbowl" sandstone of Cajon Valley inclined 45° to the northeast. View is looking southeast along strike.

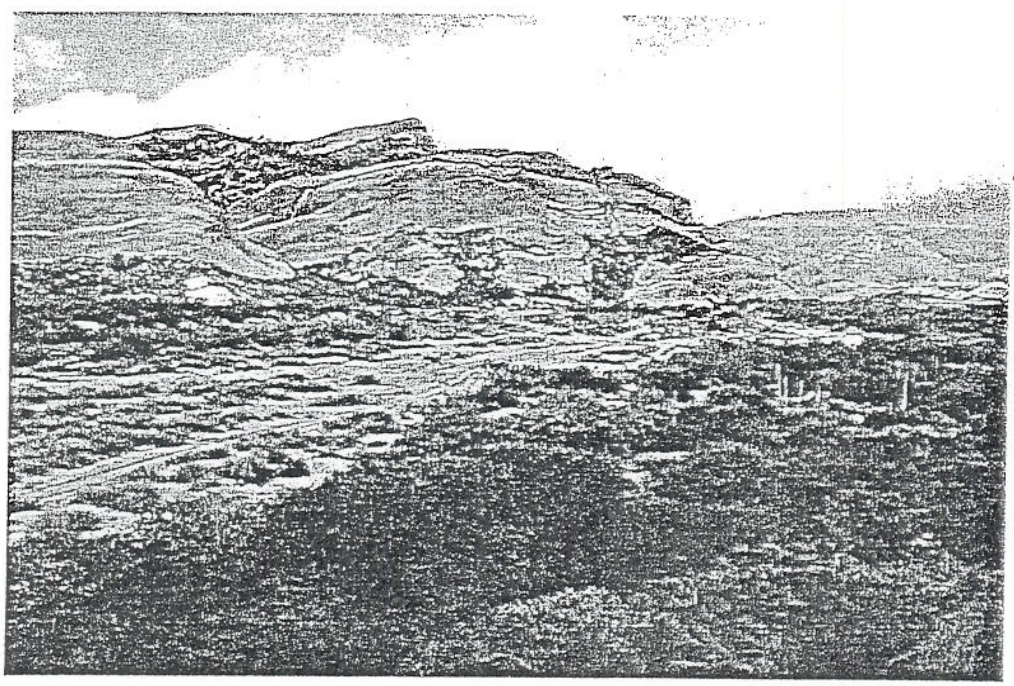
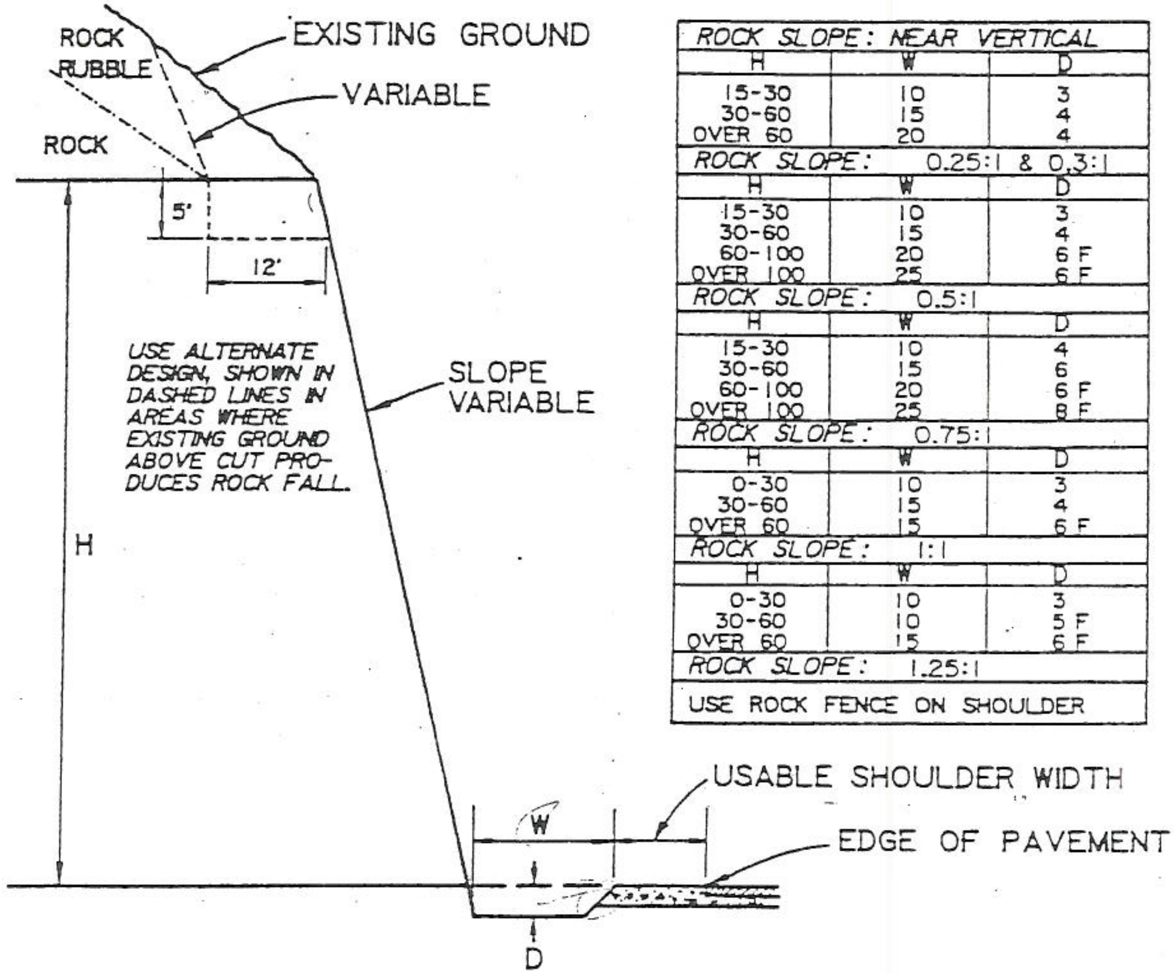


Photo 2. Looking eastnortheast at Cajon Canyon wash area. Outcrop is in lower right corner. Note vegetation difference. Channel is against rocks on left.

Figure 6



H	W	D
ROCK SLOPE: NEAR VERTICAL		
H	W	D
15-30	10	3
30-60	15	4
OVER 60	20	4
ROCK SLOPE: 0.25:1 & 0.3:1		
H	W	D
15-30	10	3
30-60	15	4
60-100	20	6 F
OVER 100	25	6 F
ROCK SLOPE: 0.5:1		
H	W	D
15-30	10	4
30-60	15	6
60-100	20	6 F
OVER 100	25	8 F
ROCK SLOPE: 0.75:1		
H	W	D
0-30	10	3
30-60	15	4
OVER 60	15	6 F
ROCK SLOPE: 1:1		
H	W	D
0-30	10	3
30-60	10	5 F
OVER 60	15	6 F
ROCK SLOPE: 1.25:1		
USE ROCK FENCE ON SHOULDER		

When required for slope stability, the use of benches is satisfactory; however, they do not alter the design and values shown. Ordinarily, their use will be a result of the soils study and be on the recommendation of the Materials Engineer.

Where the existing ground above the top of cut is on a slope approximating that of the cut slope, the height (H) shall include the existing slope or that portion of it that can logically be considered a part of the rock cut.

Ordinarily, guardrail shall be provided where D is greater than 3. F permits diminishing D to 4 if fence is also used.

GENERAL DESIGN CRITERIA FOR SHAPED DITCHES (After Ritchie, 1963)

Figure 7

Memorandum

To : MR. MARK WILLIAN, SR. ENG. GEOLOGIST
OFFICE OF GEOTECHNICAL DESIGN SOUTH

Date : June 13, 2001

File : 08-SBd-138-13.8
PM 13.8
EA 08-469700

Attention: Mr. Chris Hoadley

From : DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
Office of Geotechnical Support

Subject : Seismic Refraction Survey for to determine rippibility of outcrop at Mormon Rocks, Highway138, San Bernadino, County

Introduction

This report documents results of a seismic refraction survey undertaken along the proposed improvements for Highway 138 at M.P.13.8. The purpose of this survey was to determine the seismic velocity of the sandstone outcrop in question for determination of its rippibility.

Data Acquisition and Processing

Interpretation of the survey results used the Generalized Reciprocal Method of refraction interpretation (GRM; Palmer [1980]). The method can accommodate variation in refractor velocity and depth along the seismic line, is relatively insensitive to refractor dip (up to 20 degrees), and can accommodate hidden layer conditions (where supporting borehole data exist). Data analysis used Viewseis, a commercially available computer program.

Seismic refraction data were recorded from 2 profiles. Data were acquired using a Geometrics Smartseis 24 channel seismograph with 14 Hz geophones. Geophone spacings for profile 1 was .5 meters (1.64 feet), and 1 meter (3.28 feet) for profile 2.

The seismic source for the survey was a hammer and striker plate. Geophones were adapted to allow the survey to be directly on the rock surface. During data acquisition, profile geometry (shot and geophone locations) was recorded and stored in seismograph memory. Refraction data from each shot were also stored in the seismograph's memory. Both profile geometry and refraction data were backed-up to paper and floppy disk upon completion of the survey.

The Viewseis computer program was used to interpret the refraction data. This is a commercially developed program that uses the GRM method for interpretation and presentation of refraction data. This method calculates refractor depths for each geophone location, using overlapping refraction arrival times from both forward and reverse shots. Accuracy of the GRM method relies on data from both forward and reverse shots, and on the selection of an optimum XY value. XY is defined as the distance of separation, measured at the surface, where forward and reverse seismic waves originate from the same point on the refractor. Where incomplete refractor coverage exists, the refractor can be modeled using the standard intercept-time method of interpretation (ITM), but with comparatively reduced accuracy.

In addition to the intercept-time method of interpretation, two methods of GRM interpretation can be used: the approximate velocity and the average velocity method. The approximate velocity method is relatively insensitive to selection of the optimum XY. However, this method requires that every refractor above the target be defined. The average velocity method is very sensitive to optimum XY selection and is, therefore, normally used only where supporting borehole information exists. However, the average velocity method does not require that every refractor above the target be known. The type of line drawn for the refractor represents the method used for interpretation. ITM interpretations are shown as a solid line, GRM interpretations are drawn as a series of arcs—the envelope formed by the locus of interconnecting points at the base of these arcs represents the "best fit" model for the refractor.

The refraction data were transferred from the seismograph to the Viewseis program via floppy disks. There, profile geometry (shot point and geophone locations), first P-wave arrival times and ground surface elevations were assigned for each profile. These data were used to produce the final interpretation.

Profiles in this report are presented in terms of velocity units. A velocity unit is a three-dimensional unit, which due to its elastic properties and density, propagates seismic waves at a characteristic velocity or within a characteristic velocity range. Velocities denoted in this report and in the seismic refraction sections are expressed in meters per second. At least one velocity is present within a geological rock unit. In addition, each zone of weathering, or fracturing within that geological unit can constitute its own velocity unit. Conversely, when two rock units such as water saturated gravel and moderately weathered rock propagate seismic waves at the same velocity and are adjacent to each other, both units would be part of the same velocity unit. Lastly, discontinuous velocities might result from variation in the degree of alteration in the form of physical and chemical weathering and should be considered in the interpretation of the data.

Results

The refraction profiles were recorded on an outcrop of sandstone lying within one of the proposed alignments for Highway 138. Locations of the seismic lines are shown on the attached map. Outcrops of sandstone were observed throughout the site. According to project geologists the sandstone unit is well cemented. Each profile is discussed individually below. A water table refractor is not evident on any of the field records. Elevations for the profiles in this report are based on topographic maps.

Profile 1

Profile 1 was 11.5 meters (37.7 feet) long. Based on examination of field records and rock outcrops, refraction data were modeled using three velocity units or "zones". The uppermost zone is .2 meters (.66 feet) thick and has a seismic velocity of 335 m/sec. (easily ripped). Zone 2 has a seismic velocity of 1140 m/sec. (moderately difficult ripping). It is 1.5 meters (4.9 feet) thick. Zone 3 is below 1.7 meters (5.6 feet) and has an average seismic velocity of 2517 m/sec. [(blasting required) (see table 1)]. The thickness of zone 3 is beyond the scope of this investigation.

Profile 2

This profile was12 meters (39.3 feet) long. Based on the examination of field records and rock outcrops, refraction data were modeled using three zones. The upper zone is only .3 meters (.98 feet) thick and has a seismic velocity of 268 m/sec.(easily ripped). The second zone has a seismic velocity of 1275 m/sec. (moderately difficult ripping), and is 2 meters (6.6 feet) thick. Zone three has a seismic velocity of 3322 m/sec. (blasting required) and is thicker than the depth of investigation. This profile was shot perpendicular to profile 1 and slightly down slope.

Because rippability was the main concern on this project, the intercept time method of interpretation (ITM) was used to present the most conservative estimate of depth to unrippable material.

Estimated rippability is summarized in Table 1. The velocity models indicate all sites may require some degree of light blasting for excavation. Ripping ability is based on unpublished Caltrans data for a Caterpillar D9G series bulldozer with a single-tooth ripper. These values are as follows:

Velocity (m/s)	Rippability
<1050	Easily Ripped
1050-1500	Moderately Difficult
1500-2000	Difficult Ripping/Light Blasting
>2000	Blasting Required

Different equipment may experience different results. Penetration of the ripping tooth into the soil or rock is often more important to ripping success than seismic velocity. If fracture or bed orientation does not allow tooth penetration, the soil or rock may not be rippable without blasting or other means of mechanical fracturing, despite having a low seismic velocity. Undetected blocks or lenses of high-velocity material may also be present within rippable layers, requiring blasting for excavation.

CONCLUSION

The outcrop contains a weathered horizon that appears rippible to a depth of approximately 2 meters. At a depth greater than 2 meters the material is unrippible. Removal of the outcrop via blasting to a subgrade elevation appears impractical and other alternatives would be recommended.

Line Number	Layer	Average Thickness (m)	Estimated Investigation Depth (m)	Average Velocity (m/s)	Inferred Material	Rippability[1]
1	1	.2	N/A	335	Weathered Sandstone	ER
1	2	1.5	2.7	1140	Weathered Sandstone	MD
1	3	N/A	N/A	2517	Sandstone	BR
2	1	.3	N/A	268	Weathered Sandstone	ER
2	2	2	2.7	1275	Weathered Sandstone	MD
2	3	N/A	N/A	3322	Sandstone	BR

NA=Not Applicable. [1]ER=Easily Ripped DR/LB=Difficult Ripping / Light Blasting BL=Blasting Required

Table 1: Summary of refraction interpretation results for the proposed Highway 138 improvements.

Thank you for the opportunity to work on this project. If you have any questions or need additional assistance, please call me at (916) 227-5849.

References

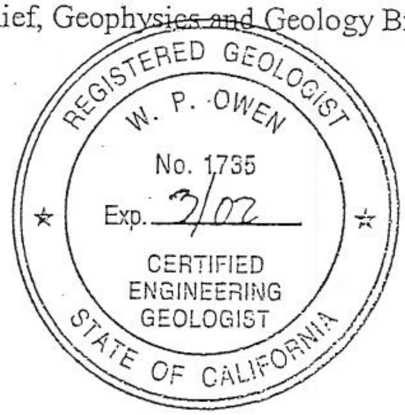
Palmer, D., 1980, The generalized reciprocal method of seismic refraction interpretation, Society of Exploration Geophysicists, Tulsa, Oklahoma, 104 p.

Report By:

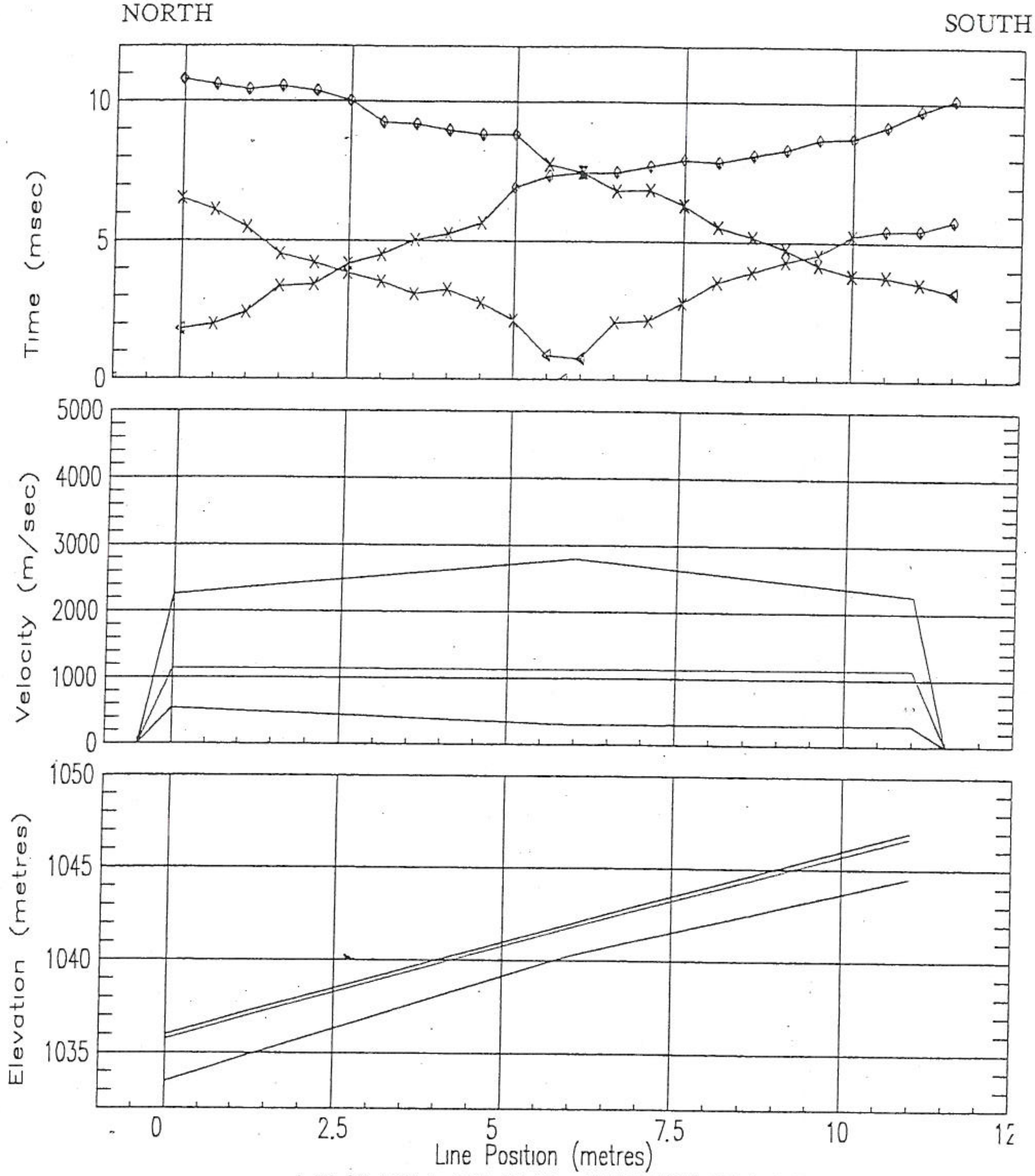
Dennison K. Leeds
Egineering Geologist
Geophysics and Geology Branch

Reviewed By:

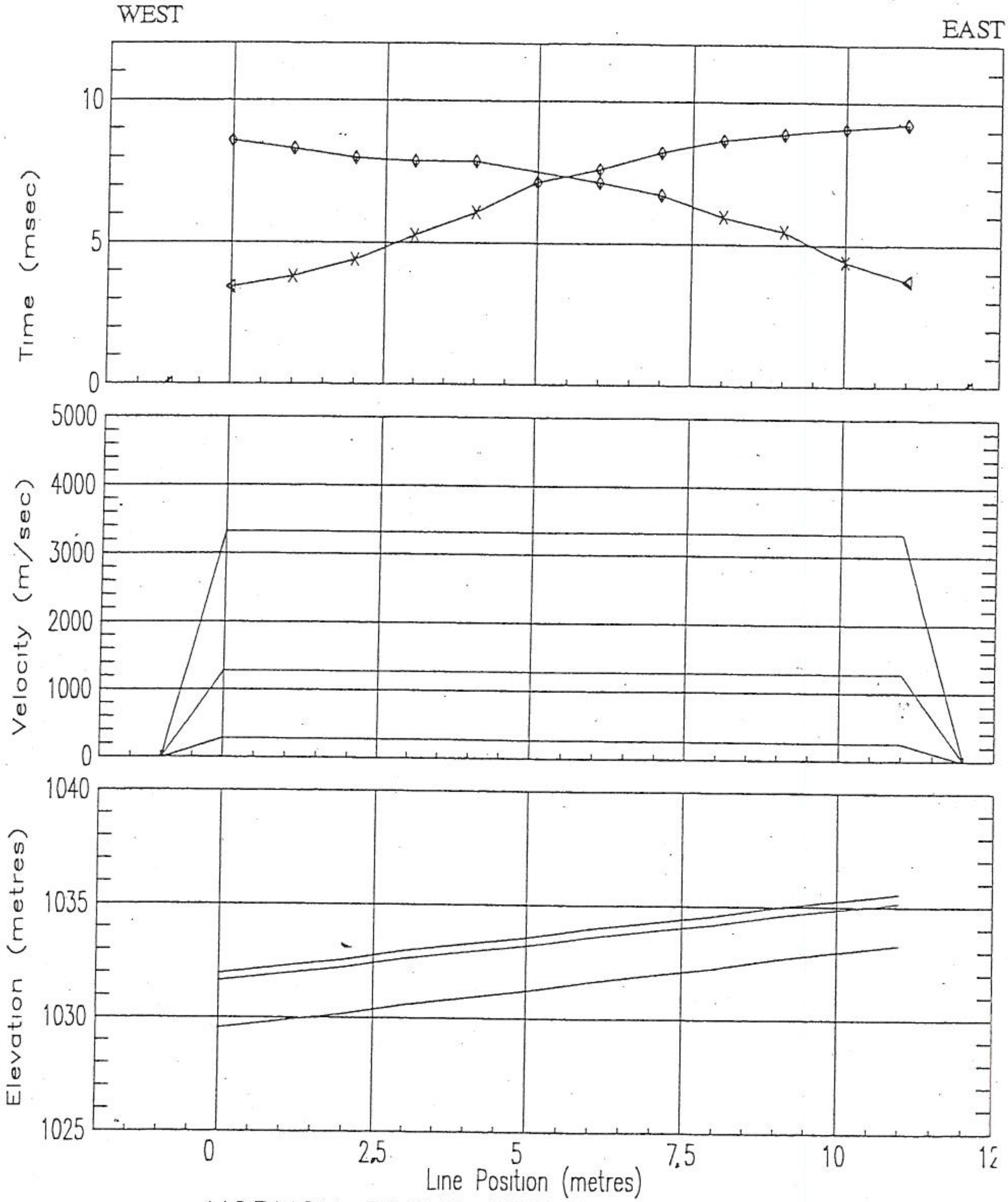
William Owen, CEG 1735
Chief, Geophysics and Geology Branch



Attachments
cc: GSB File



MORMON ROCKS RIPPIBILITY LINE 1



MORMON ROCKS RIPPIBILITY LINE 2

08-469700
08-SBd-138-KP0.0/22.85

Location Map

Figure 1

Blasting shall conform to Sections 7-1.10, "Use of Explosives," and 19-2.03, "Blasting," of the Standard Specifications, and to these special provisions.

The Contractor shall control blasting so that vibration, flyrock, ground/vibration motion, and air noise levels do not cause damage to nearby buildings and bridges including highway sign posts, light fixtures and parked vehicles, undue annoyance to nearby residents, or danger to employees on the project. The Contractor shall use controlled blasting techniques and designs and shall coordinate traffic control during blasting operations. The Contractor shall be responsible for any damage resulting from blasting.

When blasting near buildings, structures, or utilities that may be subject to damage from blast-induced ground vibrations, the Contractor shall control ground vibrations by the use of properly designed delay sequences and allowable charge weights per delay. Allowable charge weights per delay shall be based on vibration levels that will not cause damage. The Contractor shall perform trail blasts to select allowable charge weights per day by measuring vibration levels. The Contractor shall select proper control methods to limit overbreak. The trail blasts shall be carried out in conformance with the blasting test section requirements, modified as required to limit ground vibrations to a level which will not cause damage.

The blasting test section requirements require that two seismographs be used, one placed on the end of the blast and one placed at 90 degrees behind the blast to establish vibration levels and their relation to the measurement location. The Contractor shall have the final responsibility to control overbreak.

Whenever vibration damage to adjacent buildings and bridges is possible, the Contractor shall monitor each blast with an approved seismograph located, as approved, between the blast area and the closest structure subject to blast damage. The seismograph used shall be capable of recording particle velocities for three mutually perpendicular components of vibration in the range generally found with controlled blasting.

Peak particle velocity of each component shall not exceed 50.8 millimeters per second. The Contractor shall employ a qualified vibration specialist to establish safe vibration limits. The vibration specialist shall also interpret the seismograph records to ensure that the seismograph data are utilized effectively in the control of the blasting operations with respect to the existing structures. The vibration specialist used shall be subject to the Engineer's approval.

Data recorded for each blast shall be furnished to the Engineer prior to the next blast and shall include the following information:

A. Identification of instrument used.
B. Name of qualified observer and interpreter.
C. Type of ground at recording station and material on which instrument is sitting.
D. Maximum particle velocity on each component.
E. A dated and signed copy of seismograph readings records.

At the option of the Contractor, blast designs may be based upon scaled distance following the chart below. The scaled distance is the ratio of distance in meters from the blast site to the site to be protected to the square root of the maximum explosive weight used for each delay of 9 milliseconds or more.

Blast Design Table

Distance to site to be protected	Scaled distance factor
0 to 91 meters	22.57 $m/kg^{1/2}$
91 to 1,524 meters	24.94 $m/kg^{1/2}$
1,524 meters	29.4 $m/kg^{1/2}$

The Contractor shall install an air blast monitoring system between the main blasting area and the nearest structure subject to blast damage or annoyance. The equipment used to make the air blast measurements shall be the type specifically manufactured for that purpose. Noise levels shall be held below 125 decibels at the nearest building, bridge or designated location. The Contractor shall use appropriate blast patterns, detonation systems, and stemming to prevent venting of blasts and to minimize air blast and noise levels produced by the blasting operations. The decibels shall be lowered if it proves too high based on damage or complaints. The Contractor shall furnish a permanent, signed and dated record of the noise level measurement to the Engineer immediately after each blast.

Before the firing of any blast in areas where flying rock may result in personnel injury or unacceptable damage to property, parked vehicles or the work, the Contractor shall cover the rock to be blasted with approved blasting mats, soil, or other equally serviceable material, to prevent flyrock.

If flyrock leaves the construction site and lands on private property all blasting operations will cease until a qualified consultant, hired by the Contractor, reviews the site and determines the cause and solution to the flyrock problem. Before blasting proceeds, a written report detailing the cause and solution to the flyrock problem shall be submitted by the Contractor to the Engineer for approval.

Videotape recordings will be taken of each blast. The tapes or sections of tapes will be indexed in a manner to properly identify each blast. At the option of the Engineer, copies of videotapes of blasts will be furnished on a weekly basis.

The Contractor shall submit a plan to the Engineer detailing how blasting will be controlled. No blasting operation, including drilling, shall start until the Engineer has reviewed and approved this Blasting Control Plan in accordance with the provisions in Section 5-1.02, "Plans and Working Drawings," of the Standard Specifications. The Contractor shall allow not less than 2 weeks for the Engineer to complete the review of the Plan. In the event that additional Blasting Control Plans are required, the Contractor shall provide at least 2 weeks for the review of each additional plan. Should the Engineer fail to complete his review within the provided time allowed, and if, in the opinion of the Engineer, the Contractor's operation is delayed or interfered with by reason of this delay, an extension of time commensurate with the delay will be granted as provided in Section 8-1.07, "Liquidated Damages", of the Standard Specifications. Approval of the Contractor's Blasting Control Plan or blasting procedures shall not relieve the Contractor of any of his responsibility under the contract for assuring the complete safety of his operations or for the successful completion of the work in conformity with the requirements of the plans and specifications.

The Contractor shall keep accurate records of each blast. Blasting records shall be made available to the Engineer at all times and shall contain the following data as a minimum.

A. Blast identification by numerical and chronological sequence.
B. Location (referenced to stationing), date and time of blast.
C. Type of material blasted.
D. Number of holes.
E. Diameter, spacing and depth of holes
F. Height or length of stemming.
G. Types of explosives used.
H. Type of caps used and delay periods used.
I. Total amount of explosives used.
J. Maximum amount of explosives per delay period of 9 milliseconds or greater.
K. Powder factor (grams of explosive per cubic meter of material blasted).
L. Method of firing and type of circuit.
M. Weather conditions (including wind direction).
N. Direction and distance to nearest structure of concern.
O. Type and method of instrumentation.
P. Location and placement of instruments.
Q. Instrumentation records and calculations for determination of ground motion particle velocity or for charge size based on scaled distance.

R. Measures taken to limit air noise and fly rock.
S. Any unusual circumstances or occurrences during blast.
T. Name of contractor.
U. Name and signature of responsible blaster.
V. Measures to limit overbreak.

Blasting guards in sufficient numbers to assure that people and improvements will not be endangered shall be stationed around the blasting area during blasting operations.

Blasting operations may be suspended by the Engineer for any of the following:

A. Safety precautions, monitoring equipment and traffic control measures taken are inadequate.
B. Ground motion particle velocity or air noise exceeds the limits specified.
C. Blasting Control Plans have not been approved.
D. Required records are not being kept.
E. Excessive outbreak as determined by the Engineer.

Suspension of blasting operations shall in no way relieve the contractor of his responsibilities under the terms of this contract. Blasting operations shall not resume until modifications have been made to correct the conditions that resulted in the suspension.

Blasting complaints shall be accurately recorded by the Contractor as to complainant, address, date, time, nature of the complaint, name of person receiving the complaint, the complaint investigation conducted, and the disposition of the complaint. Complaint records shall be available to the Engineer at all times.

Full compensation for blasting shall be considered as included in the contract unit price paid for roadway excavation and no additional compensation will be allowed.

6/27/01

State Route 138 Widening

Left Side

Slope	Post Mile	Station #	Proposed Height	Length	Surface Material	Existing Cut slope ratio	Recommendation
Cut 30L	7.72 to 7.77	124 + 20 to 125 + 10	26 m 85 ft	90 m 295 ft	Gravely Silty SAND, with trace cobbles		cut at 1:2
Cut 31L	7.84 to 7.87	126 + 10 to 126 + 60	13 m 43 ft	50 m 164 ft	Gravely Silty SAND, with trace cobbles		cut at 1:2
Cut 32L	7.87 to 7.88	126 + 70 to 126 + 80	5 m 16 ft	10 m 33 ft	Gravely Silty SAND, with trace cobbles		cut at 1:2
Cut 33L	7.88 to 7.93	126 + 80 to 127 + 60	20 m 66 ft	80 m 262 ft	Gravely Silty SAND, with trace cobbles		cut at 1:2
Cut 34L	7.93 to 8.00	127 + 60 to 128 + 80	24 m 79 ft	120 m 394 ft	Gravely Silty SAND, with trace cobbles		cut at 1:2, Install brow ditch in wedge
Cut 35L	8.09 to 8.13	130 + 20 to 130 + 80	12 m 39 ft	60 m 197 ft	Gravely Silty SAND, with trace cobbles	1 : 1.0	Cut at 1:2, Install brow ditch between St. 130+50 to 131+90
Cut 36L	8.19 to 8.23	131 + 80 to 132 + 40	10 m 33 ft	60 m 197 ft	Gravely Silty SAND, with trace cobbles		Cut at 1:2, Install brow ditch between St. 132+10 to 132+80
Cut 37L	8.25 to 8.27	132 + 80 to 133 + 10	2.5 m 8 ft	30 m 98 ft	Gravely Silty SAND, with trace cobbles		Cut at 1:2
Cut 38L	8.28 to 8.39	133 + 25 to 135 + 10	20 m 66 ft	185 m 607 ft	Gravely Silty SAND, with trace cobbles	1 : 1.0	Cut at 1:2, Install brow ditch between St. 133+10 to 133+80
Cut 39L	13.32 to 13.38	214 + 40 to 215 + 30	8 m 26 ft	90 m 295 ft	V. Hard Sandstone/ Fanglomerate, gray white, bedded, med to coarse grained, contains lenses of conglomerate	Close to vertical	Blasting will be required, re-alignment preferred

Fill

Slope	Post Mile	Station #	Proposed Height	Length	Surface Material	Existing Cut slope ratio	Recommendation
Fill 1L	3.32 to 3.53	53 + 38 to 56 + 80	Sliver fill for Sheep Creek bridge approach embankment				
Fill 2L	3.56 to 3.61	57 + 25 to 58 + 10	Sliver fill for Sheep Creek bridge approach embankment				
Fill 3L	5.41 to 5.48	87 + 10 to 88 + 20	9 m 30 ft	110 m 361 ft			
Fill 4L	7.57 to 7.56	121 + 80 to 121 + 70	6 m 20 ft	90 m 295 ft			
Fill 14L	6.69 to 6.74	107 + 60 to 108 + 50	12 m 39 ft	90 m 295 ft			
Fill 15L	6.76 to 6.79	108 80 to 109 20	12 m 39 ft	40 m 131 ft			
Fill 16L	6.80 to 6.83	109 40 to 109 90	11 m 36 ft	50 m 164 ft			
Fill 17L	6.85 to 6.87	110 + 20 to 110 + 60	6.5 m 21 ft	40 m 131 ft			

General Notes
The overall foundation material appears to be stable but erodable.
Stability of the slopes is good for the existing cut ratio.
The bedding dips NE so daylighting will occur on cuts on the Right side of the roadway

Height and Length are calculated from the layout sheet line
Existing cut slope ratio is estimated from layout sheet (V:H)

General Recommendations
Due of the erodable material a catchment area should be included at the toe of each cut. This should stop most of the material before it can make its way onto the travelway.
Brow ditches should be installed at cuts where there is a slope above the cut.
Benching of the larger cuts my be necessi ssary.
Ritchie Criteria should be followed for cut slopes.

State Route 138 Widening

Right Side

Slope	Post Mile	Station #	Proposed Height	Length:	Existing Material Type	Existing Cut slope ratio	Recommendation
CUT							
Cut 1R	5.31 to 5.37	85 + 45 to 86 + 45	9.5 m 31 ft	100 m 328 ft	Gravely Silty SAND, with trace cobbles	1 : 2.0	Cut at 1:2
Cut 2R	5.41 to 5.48	87 + 0 to 88 + 25	24 m 79 ft	125 m 410 ft	Gravely Silty SAND, with trace cobbles	1 : 1.5	Cut at 1:2
Cut 3R	6.67 to 6.72	107 + 40 to 108 + 15	15 m 48 ft	60 m 197 ft	Gravely Silty SAND, with trace cobbles	1 : 2.3	Cut at 1:2
Cut 4R	6.72 to 6.77	108 + 15 to 109 + 0	10 m 33 ft	85 m 279 ft	Gravely Silty SAND, with trace cobbles	1 : 2.0	Cut at 1:2
Cut 5R	6.78 to 6.81	109 + 10 to 109 + 60	8.5 m 28 ft	50 m 164 ft	Gravely Silty SAND, with trace cobbles	1 : 2.0	Cut at 1:2
Cut 6aR	6.84 to 7.03	110 + 0 to 113 + 10	18 m 57 ft	310 m 1017 ft	Gravely Silty SAND, with trace cobbles	1 : 1.6	Cut at 1:2, possibly 1:1.5, Install erosion mat, Install culvert between 6aR & 6bR
Cut 6bR	6.84 to 7.03	110 + 0 to 113 + 10	25 m 80 ft	310 m 1017 ft	Gravely Silty SAND, with trace cobbles	1 : 1.75	Cut at 1:2, possibly 1:1.5, Install erosion mat, Install culvert between 6bR & 6cR, Install brow ditch between St. 111+00 to 111+60
Cut 6cR	6.84 to 7.03	110 + 0 to 113 + 10	37 m 120 ft	310 m 1017 ft	Gravely Silty SAND, with trace cobbles	1 : 1.0	Cut at 1:2, possibly 1:1.5, Install erosion mat
Cut 7R	7.65 to 7.67	123 + 10 to 123 + 40	3 m 10 ft	30 m 98 ft	Gravely Silty SAND, with trace cobbles	1 : 1.0	cut at 1:2
Cut 8R	7.69 to 7.72	123 + 70 to 124 + 20	6 m 20 ft	50 m 164 ft	Gravely Silty SAND, with trace cobbles	1 : 1.3	cut at 1:2
Cut 9R	7.72 to 7.79	124 + 20 to 125 + 30	10 m 33 ft	110 m 361 ft	Gravely Silty SAND, with trace cobbles	1 : 1.3	cut at 1:2
Cut 10R	7.89 to 7.93	127 + 5 to 127 + 60	5 m 16 ft	55 m 180 ft	Gravely Silty SAND, with trace cobbles	1 : 1.3	cut at 1:2
Cut 11R	7.97 to 8.00	128 + 20 to 128 + 70	7 m 23 ft	50 m 164 ft	Gravely Silty SAND, with trace cobbles	1 : 1.0	cut at 1:2
Cut 12R	8.30 to 8.35	133 + 50 to 134 + 30	6 m 20 ft	80 m 262 ft	Gravely Silty SAND, with trace cobbles	1 : 1.0	cut at 1:2
Cut 13R	8.35 to 8.42	134 + 30 to 135 + 50	18 m 59 ft	120 m 394 ft	Gravely Silty SAND, with trace cobbles	1 : 1	cut at 1:2
Cut 14R	8.64 to 8.71	139 + 0 to 140 + 20	24 m 79 ft	120 m 394 ft	Gravely Silty SAND, with trace cobbles	1:1 at toe 1:2 natural slope	cut at 1: 2, Install brow ditch
Cut 15R	8.71 to 8.76	140 + 20 to 140 + 90	22 m 72 ft	70 m 230 ft	Gravely Silty SAND, with trace cobbles	1:1 at toe 1:2 natural slope	cut at 1: 2, Install brow ditch
Cut 16R	13.30 to 13.35	214 + 0 to 214 + 80	22 m 72 ft	80 m 262 ft	V. Hard Sandstone/ Fanglomerate, gray white, bedded, med to coarse grained, contains lenses of pebble-cobble conglomerate, needs blasting or realignment	Bedding dips at 1:1.2 to 1:0.5	Blasting will be required, realignment preferred
Cut 17R	13.35 to 13.38	214 + 80 to 215 + 40	26 m 85 ft	60 m 197 ft		Bedding dips at 1:1.2 to 1:0.5	Blasting will be required, realignment preferred
Cut 18R	13.43 to 13.46	216 + 20 to 216 + 60	6 m 20 ft	40 m 131 ft		Bedding dips at 1:1.2 to 1:0.5	Blasting will be required, realignment preferred
Cut 19R	13.91 to 14.11	223 + 90 to 227 + 0	10 m 33 ft	310 m 1017 ft	Gravely Silty SAND, with trace cobbles	1 : 1	cut at 1:2
Fill							
Fill 1R	3.32 to 3.53	53 + 38 to 56 + 80	Sliver fill for Sheep Creek bridge approach embankment				
Fill 2R	3.56 to 3.61	57 + 25 to 58 + 10	Sliver fill for Sheep Creek bridge approach embankment				
Fill 3R	7.03 to 7.08	113 + 10 to 114 + 0	16 m 52 ft	90 m 295 ft	Gravely Silty SAND, with trace cobbles, 1:1.5 slope or steeper, Mod Vegetation		

State Route 138 Widening

Right Side

Slope	Post Mile	Station #	Proposed Height	Length:	Existing Material Type	Existing Cut slope ratio	Recommendation
Fill 4R	7.11 to 7.16	114 + 40 to 115 + 30	14 m 44 ft	90 m 295 ft	Gravely Silty SAND, with trace cobbles, 1:1.5 slope or steeper, Mod Vegetation		
Fill 5R	7.18 to 7.21	115 + 50 to 116 + 0	14 m 44 ft	50 m 164 ft	Gravely Silty SAND, with trace cobbles, 1:1.5 slope or steeper, Mod Vegetation		
Fill 6R	7.30 to 7.31	117 + 40 to 117 + 60	20 m 66 ft	20 m 66 ft	Gravely Silty SAND, with trace cobbles, 1:1.5 slope or steeper, Mod Vegetation		
Fill 7R	7.32 to 7.39	117 + 80 to 119 + 0	15 m 49 ft	120 m 394 ft	Gravely Silty SAND, with trace cobbles, 1:1.5 slope or steeper, Mod Vegetation		
Fill 8R	7.46 to 7.47	120 + 0 to 120 + 20	8 m 26 ft	20 m 66 ft	Gravely Silty SAND, with trace cobbles, 1:1.5 slope or steeper, Mod Vegetation		
Fill 9R	7.81 to 7.82	125 + 70 to 125 + 90	5 m 16 ft	20 m 66 ft	Gravely Silty SAND, with trace cobbles, 1:1.5 slope or steeper, Mod Vegetation		
Fill 10R	8.00 to 8.03	128 + 70 to 129 + 20	7 m 23 ft	50 m 164 ft	Gravely Silty SAND, with trace cobbles, 1:1.5 slope or steeper, Mod Vegetation		
Fill 11R	8.13 to 8.15	130 + 90 to 131 + 20	9 m 30 ft	30 m 98 ft	Gravely Silty SAND, with trace cobbles, 1:1.5 slope or steeper, Mod Vegetation		
Fill 12R	8.15 to 8.17	131 + 20 to 131 + 50	7 m 23 ft	30 m 98 ft	Gravely Silty SAND, with trace cobbles, 1:1.5 slope or steeper, Mod Vegetation		
Fill 13R	8.17 to 8.19	131 + 50 to 131 + 80	5 m 16 ft	30 m 98 ft	Gravely Silty SAND, with trace cobbles, 1:1.5 slope or steeper, Mod Vegetation		
Fill 14R	8.23 to 8.25	132 + 40 to 132 + 80	5.5 m 18 ft	40 m 131 ft	Gravely Silty SAND, with trace cobbles, 1:1.5 slope or steeper, Mod Vegetation		

General Notes

The overall foundation material appears to be stable but erodable.
Stability of the slopes is good for the existing cut ratio.
The bedding dips NE so daylighting of bedding planes will occur on cuts on the Right side of the roadway

Height and Length are calculated from the layout sheet line and contours
Existing cut slope ratio is estimated from layout sheet (V:H)

General Recommendations

A catchme ent area shou ld be incl. uded at th e toe of each slope e.
Brow ditches should be installed at cuts where there is a slope above the cut.
Benching of the larger cuts is may be necess ary.
Ritchie Criteria should be used for cut slopes.