Drozd, Doug@HSR

From:	cindy bloom <cbloom571@gmail.com>
Sent:	Tuesday, April 17, 2018 8:13 AM
To:	Richard, Dan@HSR; Boehm, Michelle@HSR; Kelly, Brian@HSR; HSR Draft Business Plan 2018; HSR Southern California@HSR; HSR boardmembers@HSR; Arellano, Genoveva@HSR
Cc:	cindy bloom; Dave DePinto
Subject:	Video from United Southern California Communities as Official Comment to 2018 Business Plan

FROM UNITED NE SAN FERNADO VALLEY COMMUNITIES OF SYLMAR, KAGEL CANYON, RIVERWOOD RANCH, PACOIMA, SHADOW HILLS, SUNLAND- TUJUNGA, LA TUNA CANYON, LAKE VIEW TERRACE AND SUN VALLEY:

4-14-17 RALLY VIDEO (4 min.)

Here is link: https://vimeo.com/265158257

We are submitting this video as our official public comment regarding the 2018 Draft Business Plan to the California High Speed Rail Authority.

The SAFE Coalition

www.dontrailroad.us

Comments for the Record, California High-Speed Rail Board meeting – to be included into the official minutes of this session in Los Angeles on April 17, 2018, Los Angeles

Good morning, Alan Scott, Kings County once again coming before this Board asking "When will the Authority and the Board adhere to the stewardship requirements of honesty, integrity, and ethical standards. I firmly believe that this is a high-level expectation for all State of California regulatory and political environments, that the truth is paramount over political sheniagians?

The voids provided by this organization over the last decade have resulted in the harmful, abusive descriptive adjectives that only further obfuscate your empty public relations releases. In other words, you stretched the truth without saying why!

Stewardship is your priority to the taxpayers of this state and this country. The Authority, the Legislature, and the Govenor have failed miserably with unacceptable convoluted machinations with failed Business Plans from day one.

I take you back to May 15, 2012, Senate Transportation Hearing Chaired by Senator DeSaulnier and interrupted by Senate Pro Tempore Steinberg, who was on a full press pushing the governors' desires of what we know today as a failed political legacy. https://web.mail.comcast.net/zimbra/mail?app=mail#11

However, three Senators' rose from the Majority Party producing volumes of valid reasons why the 2012 BP; as well the 2016 BP plan. According to Director Rossi, it was wrong before it was released. This comment was made to those in attendance at the F & A committee session on Novemeber 15, 2107.

The same applies to flawed 2018 BP that is lacking corrective action solutions from the previous BP's a most troubling ommission.

I have attached a video from the derailhsr website specific to the section where Senator Simitian provided all the necessary data to negate the 2012 BP. He further proved Mr. Richard comments did absolutely nothing to eliminate these four individual concerns (to summarize) you stated would not occur.

Mr. Richard, again you were wrong, and in fact, it did happen 6-years later almost to a "T." A mazing, how precise the Senator outlined it.

Comments for the Record, California High-Speed Rail Board meeting – to be included into the official minutes of this session in Los Angeles on April 17, 2018, Los Angeles

Instead of 6-billion-dollar cost, it almost double to 10.8-billion-dollars and unfortunately climbing and has not stopped rising! The most significant component of this project is the lack of actual funding acumen from the onset of this debacle.

I have inserted below link from Mr. Vranich's testimony before an Assembly Transportation Hearing on October 25, 2008, about 2-weeks before the Proposition 1A vote.

Once again, 4-years after Mr. Vranich's presentation noted above, and I have provided a support link to validate Senator Simitian's 2012 admonition of impending HSR failure.

Not only was Mr. Vranich correct; moreover, Senators Lowenthal, Simitian, and DeSauliner predicted that failure would occur. Amazingly, it did, in fact, it happen with very minor adjustments from their statements 6-years previously. They were more exact than the Authority, with less information.

https://www.youtube.com/watch?v=SS0RD6dqpKY

What is more troubling is that you Mr. Chairman at that hearing, you took exception, while you gave some far-reaching postulations that principally held zero substance. However, once again, you were wrong again!

It is difficult to sell a pig in a poke but to spend 6-years negating every single expert, along with knowledgable citizens who were all on the receiving end of severe ridicule by you others is unacceptable.

In fact, Mr. Richard, you do owe all of them a public apology.

In closing, I am asking you Mr. Chairman and the entire board to resign immediately along with all senior executives!

Mr. Kelly, fundamentally speaking are speaking in cliche statements and not once did I, or others hear a definitive competent fiscal or operational plan. Hope and by God will not build this politicially induced debacle.

Comments for the Record, California High-Speed Rail Board meeting – to be included into the official minutes of this session in Los Angeles on April 17, 2018, Los Angeles

Additionally, once the above is completed, then the following adjustments must happen ASAP:

1. Stop all construction;
2. Safely secure the various construction sites in accordance with standard Risk Management requirements;
3. Ensure standard business practices are adhered to by clearing all outstanding invoices within 60-days;
4. Bring a vote before the Legislature to defund and eliminate all activity involving Proposition 1A in total, no exceptions.
5. Any future HSR project for the State of California must be fully funded with all funds deposited in a protected account. A comprehensive, validated Business Plan that eliminates all aspects that were absent from the previous politically machinated plans;
6. Immediately refrain from taking private property, businesses and their assoicated possessions, and their livelihoods until a proper certified routing has been established instead of the current wishey washey circuitous mickey mouse haphazard politically created disaster routing specifically to gain Mr. Costa's vote.

Thank you

Alan Scott

Comments for the Record, California High-Speed Rail Board meeting – to be included into the official minutes of this session in Los Angeles on April 17, 2018, Los Angeles

PS: The Chairmen's abundant usage of the word transformative and transparent caused me pause to go back to the definition of this adjective:

Adjective: pertaining to evolution or development!

Well, after my review of the dictionary and the thesaurus, I have determined that transformative and HSR project used in the same sentence to be an egregious error and must be changed to 'destructive.'

Adjective: Transparent If a substance or object is transparent, you can see through it very clearly.

Again, after reviewing, the first question arises, why did you wait so long to announce a 2.8-billion-dollar shortfall? That is just one of the many incomprehensible situations that CAHSRA failed to be transparent.

Drozd, Doug@HSR

From:	Kathy Gillies <kathygolfs@yahoo.com>
Sent:	Sunday, April 15, 2018 5:38 PM
To:	HSR boardmembers@HSR
Subject:	High Speed Rail Project
Follow Up Flag:	Follow up
Flag Status:	Flagged

Mr. Dan Richard
Chairman, Board of Directors
California High Speed Rail Authority
770 L Street, Suite 620
Sacramento, CA 95814

To whom it may concern. we oppose any alignment that is "not" underground. to the proposed high speed rail project in the Sand Canyon area... Vote No...
We live here in this canyon and feel that it will cause only harm to our beautiful sand canyon area..

Thank You

Kathy Gillies

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April 16, 2018

California High Speed Rail
Attn: Dan Richards and Board of Directors

Sent Via Email:
2018businessplancomments@hsr.ca.gov

Re: *Comments on DRAFT CHSRA 2018 Business Plan*

Dear California High Speed Rail:

I have the following comments about the CHSRA 2018 Business Plan:

1. Page 51 of the Business Plan, "Engineering and Environmental" states that there are unknowns about tunnels and mountain terrains and that CHSRA will conduct preliminary hazard analysis.

<u>COMMENT TO ITEM 1</u>

These "preliminary" reports have been concluded for the Angeles National Forest and are set forth in the 60 plus pages Geotechnical Tunnel Feasibility Evaluation for High Speed Rail Tunnels Beneath the Angeles National Forest (March 2017 Geotechnical Report) issued in March 2017 which is over a year ago. A copy is attached for your review since you apparently have not read it. In part, the Summary and Preliminary Conclusions in Section 8 of the March 2017 Geotechnical Report state in part as follows:

> "Based on the results from a limited field investigation, the geologic and hydrogeologic conditions along the tunnel alignments present significant design and construction challenges.
>
> Design and construction challenges within the ANF could be overcome with adequate site characterization and proper planning and design (at what cost?). Specifically, the major challenges are:
>
> - Squeezing ground will be encountered, affecting TBM

(tunnel boring machine) performance and possibly forcing TBM rescues. (Think Big Bertha at 2,600 feet)

- Active fault zones intersect the tunnel alignments resulting in the need for special designs for tunnel

- linings and enlarged tunnel sections to accommodate fault displacement for track realignment. (Think train tunnel in an earthquake and at what cost)

- High groundwater pressures on the tunnel lining system would require a thickened and high strength concrete lining system (Think guaranteed water leaking into tunnel and TMBs with closed-mode capability as required by CAL OSHA- Does this exist?)

- High groundwater flows and pressures will be encountered at faults and sheared rock zones. Release of pressures during construction may be necessary." (Think tunneling through a swimming pool or draining water all the way from the surface to tunnel depth)

The 2018 Business Plan states that studies are preliminary but Table 6.9 of the March 2017 Geotechnical Report summarizes the problem areas. Most of the summary is self explanatory but of particular note is that NO TUNNEL LINING DESIGN EXISTS THAT WILL WITHSTAND 25 BARS of water pressure. Both routes E-1 and E-2 have over 6.5 miles each of tunnel where the water pressure exceeds 25 bars. These tunnels are GUARANTEED TO LEAK. The corrosive water will ultimately compromise the integrity of the tunnel and the track.

This geotechnical work has already been completed. It shows real problems that likely make such tunneling technically infeasible and/or cost prohibitive. CHSRA has ignored its own March 2017 report.

This is not transparency, it is deception. The 2018 Business Plan should acknowledge the existence of the March 2017 Geotechnical Report and address those issues including the technical feasibility and additional costs of each route based on such report.

2. Page 18 of the 2018 Business Plan sites the tunnel through the Swiss Alps at 8,000 feet below the surface as proof (hope) that tunneling through the Angeles National Forest (ANF) can be completed.

COMMENT TO ITEM 2

The tunnel through the Alps was completed in 2016. The March 2017 Geotechnical Report, completed one year after the tunnel through the Alps was opened, makes no mention of the tunnel through the Alps because those granite rock formations have nothing to do with the geotechnical condition of the Additionally, the 2018 Business Plan failed to acknowledge that the proposed route E-3 was deleted in the last Supplemental Alternative Analysis because the 2,700 ft. "over burden" was too much. This compares with E-2's over burden of 2,650 ft. with no explanation as to why E-3 was eliminated but E-2 remains an alternative.

All references to a tunnel through the Alps should be eliminated from the 2018 Business Plan as being misleading and deceptive and the 2018 Business Plan should acknowledge that the almost identical E-3 was eliminated due to excess overburden.

3. This is supposed to be a business plan for the entire train. However, the Palmdale to Burbank section is fatally flawed which makes the entire business plan fatally flawed. This must be acknowledged and dealt with. This weakest link will derail the entire project.

4. The 2018 Business Plan does not state what happens if no more money is obtained to build the project. What is the exit strategy?

In conclusion, there are defects, omissions and misleading statements in the 2018 Business Plan which need to be corrected before the business plan is submitted to the legislature.

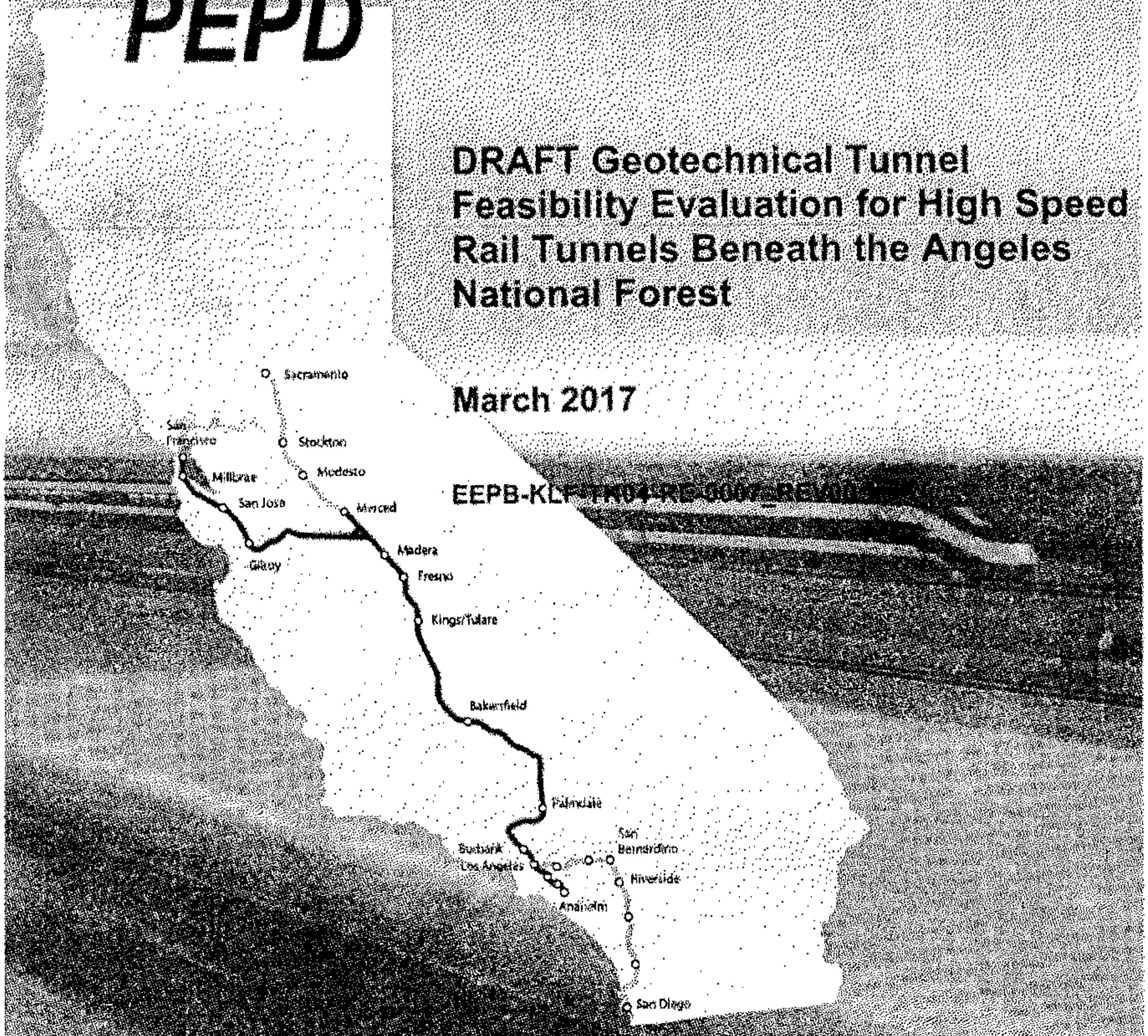
Very truly yours,

Will E Eick

William E. Eick
Attorney at law

California High-Speed Rail Authority

Palmdale to Burbank Project Section Draft PEPD



DRAFT Geotechnical Tunnel Feasibility Evaluation for High Speed Rail Tunnels Beneath the Angeles National Forest

March 2017

EEPB-KLF-TK04-RE-0007_REV00

CALIFORNIA High-Speed Rail Authority

U.S. Department of Transportation Federal Railroad Administration

	Name	Signature	Date
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Signature not needed if electronically approved by route

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00	Initial edition. Issued for Approval	03-02-2017

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Figures

ACRONYMS AND ABBREVIATIONS

σ1	Major Principal Stress
σ2	Intermediate Principal Stress
σ3	Minor Principal Stress
σc	Rock Mass Strength
σH	Maximum Horizontal Stress
σv	Vertical Stress
Authority	California High-Speed Rail Authority
BMP	Best Management Practice
Ca-HCO3	Calcium Bicarbonate
Ca-SO4	Calcium Sulfate
CAI	Cerchar abrasiveness index
Cal/OSHA	California Division of Safety and Health
Caltrans	California Department of Transportation
CGS	California Geological Survey
CCR	California Code of Regulations
cm/sec	centimeter per second
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
FRA	Federal Railroad Administration
GAMA	Groundwater Ambient Monitoring and Assessment
GSI	Geological Strength Index
HSR	High-Speed Rail
ISRM	International Society for Rock Mechanics
MWD	Metropolitan Water District of Southern California
PGDR	Preliminary Geotechnical Data Report
PMT	Program Management Team
RC	Regional Consultant
RMR	Rock Mass Rating
RQD	Rock Quality Designation
SGMNM	San Gabriel Mountains National Monument
SR	State Route
SST	Seismic Specialists Team
USBR	U.S. Department of the Interior Bureau of Reclamation
USFS	United States Forest Service
VWPT	Vibrating Wire Pressure Transducers

CONVERSIONS

1 inch (in.) = 2.54 centimeter (cm)

1 foot (ft) = 0.3048 meter (m)

1 mile (mi) = 1.61 kilometer (km)

1 ft3 = 28.3 liters (l)

1 acre-foot = 4.36E+04 ft3

1 pound force (lbf) = 4.45 Newtons (N)

1 metric ton = 2,205 lbf

1 ton / square foot (tsf) = 13.88 lbf / square inch (psi)

1 psi = 6.89E-03 megaPascal (MPa)

1 MPa = 145.14 psi

1 ksf = 6.94 psi

1 bar = 0.10 MPa

1 bar = 14.5 psi

1 bar = 34.5 foot-head-freshwater

62.4 lbf/cubic feet (pcf)= 0.43 psi/ft

1 pcf = 6.37E-03 N/m3

EXECUTIVE SUMMARY

The California High-Speed Rail (HSR) Authority (Authority) proposes to construct, operate, and maintain an electric-powered HSR system in California. When completed, it will run from San Francisco to the Los Angeles Basin in under 3 hours at speeds capable of exceeding 200 miles per hour. The system will eventually extend to Sacramento and San Diego, totaling 800 miles with up to 24 stations.

The Authority and FRA are now undertaking second-tier, project environmental evaluations for several sections of the statewide system. This report is for the Palmdale to Burbank Project Section. This project section is approximately 38- to 44-mile long, and has multiple alignment alternatives under study. The project section extends through a variety of land uses and ecoregions, including urban, rural, and mountainous terrain. Each alignment alternative would involve areas of tunneling beneath the Angeles National Forest (ANF), including portions within the San Gabriel Mountains National Monument (SGMNM). A complete General Project Description is included in other documents.

Each of the alternatives under analysis in the Palmdale to Burbank Project Section is divided in three subsections: Palmdale, Central and Burbank.

This report focuses on the geotechnical feasibility of proposed tunnels under the Angeles National Forest in the San Gabriel Mountains within the Central Subsection of the Palmdale to Burbank Section.

The data obtained for the HSR project by field investigations within the ANF in support of this geotechnical feasibility report are available in the following HSRA report:

"Preliminary Geotechnical Data Report for Tunnel Feasibility, Angeles National Forest" dated December 2016.

The data presented in the preliminary geotechnical data report (PGDR) were obtained specifically to identify and evaluate field conditions within the ANF that could present feasibility constraints for design and construction. Recognizing the history of challenging tunnel design and construction for deep tunnels beneath United States Forest Service (USFS) land in Southern California, the most challenging constraints with strong potential for influencing tunnel feasibility include the following:

- Rock quality and potential effects of squeezing ground;
- In-situ stresses;
- Intersections with faults and gouge zones;
- Groundwater pressures on the tunnel lining system;
- Water draining into the tunnel both during and after construction;
- Groundwater temperature;
- Potential impacts to USFS water resources due to tunneling activities.

The data available in the PGDR include results from the following studies:

- Continuous rock coring at six sites (FS-B1, E1-B1, E1-B2, ALT-B2, ALT-B3 and C-1) to depths as great at 2,700 feet;
- Geologic Logging of nearly 9,000 feet of cored rock;
- Photographic documentation of rock core;
- In-situ hydraulic conductivity testing using single or dual packer systems;
- In situ groundwater sampling;
- In-situ rock stress/strength testing;
- Geophysical logging including caliper, electric (spontaneous potential), temperature, conductivity, natural gamma, seismic velocity, and downhole televiewer surveys; and
- Installation of vibrating wire pressure transducers (VWPTs) within each hole for measuring in-situ pressures;
- Laboratory testing of rock core samples;

- Petrographic analyses of rock thin sections; and
- Analytical testing of water samples for chemistry and radioisotopes.

The results of the geotechnical investigations within the ANF are documented in the PGDR and should be referenced as background information for the geotechnical feasibility report. The PGDR field investigations were not conducted to investigate specific tunnel alignments, but were generally focused on the critical feasibility issues as stated previously. Once a preferred alternative is determined through the environmental screening process (EIR/EIS), a more detailed and focused investigation of the preferred tunnel alignment will need to be developed and implemented for preliminary design of the tunnel excavation methods (sequential excavation methods, tunnel boring machine, etc.), construction sequence and schedule, tunnel lining system, and mitigation measures for potential impacts from challenging geotechnical conditions.

1 INTRODUCTION

The Palmdale to Burbank Project Section would be a critical link in the Phase 1 HSR system connecting San Francisco and the Bay Area to Los Angeles and Anaheim. A complete General Project Description is included in other documents and is not repeated in this report.

This report documents geotechnical feasibility of tunnel alignments beneath the Angeles National Forest (ANF) based on the "Geotechnical Data Report for Tunnel Feasibility for the Angeles National Forest" within the Palmdale to Burbank Section of the California HSR System. This report includes the following:

- Description of site geotechnical conditions within the Angeles National Forest.
- An explanation of key conditions that affect overall tunnel design and construction.
- Interpretation of geotechnical data representing the in-situ conditions along tunnels in the ANF.
- Discussion of geotechnical conditions and potential impacts on the feasibility of proposed tunnel alignments.

2 PROJECT DESCRIPTION

The approximately 38- to 44-mile Palmdale to Burbank section has multiple alignment alternatives under study. The project section extends through a variety of land uses and ecoregions, including urban, rural, and mountainous terrain. Each alignment alternative would involve areas of tunneling beneath the ANF, including portions within the San Gabriel Mountains National Monument (SGMNM).

2.1 Alternatives

This section briefly describes the Palmdale to Burbank Project Section alternatives, as they relate to the proposed tunnels beneath the ANF. For a complete General Project Description refer to other documents.

The HSR Build Alternatives for the Palmdale to Burbank Project Section include three (SR14/E1/E2) end-to-end alternatives. Figure 2-1 shows the alignment alternatives and station options. Discussion of the HSR Build Alternatives is organized from north to south.

Within the ANF of the Central Subsection, the SR14 alignment is separate from the other two alignments but joins E2 south of the ANF boundary. The E1 and E2 alignments share a common course beneath the SGMNM and then diverge southward into separate alignments through the ANF.

Figure 2-1 Alignment Alternatives and Station Options of the Palmdale to Burbank Project Section

2.1.1 SR14 Alternative

The northern limit of the SR14 Central Subsection is near Lang Station at the northern edge of the SGMNM, Station 1320+00, where a portal is located on the Vulcan Mine property south of the Santa Clara River crossing. The alignment trends southwest and exits the National Monument briefly near Station 1470+00. It enters the ANF at Sand Canyon near Station 1530+00 and crosses beneath the mountains west of Bear Divide. The tunnel leaves the ANF at Station 1705+00 but continues underground where it joins the E1 alignment south of the ANF boundary. The length of the tunnel starting at the Vulcan Mine portal to the southern edge of the ANF is approximately 7.3 miles. The highest topographic relief is within the ANF where maximum cover over the tunnel invert is approximately 2,060 feet (Station 1626+00).

2.1.2 E1 Alternative

The northern limit of the E1 alternative enters the SGMNM near Station 680+00. It traverses by tunnel beneath the National Monument for approximately 3 miles emerging in Aliso Canyon from approximate Station 720+00 to 750+00, where it enters the National Monument again in tunnel. From Station 750+00 to 860+00, E1 continues in tunnel until Arrastre Canyon, where the alignment is above ground for approximately 1.1 miles. The alignment again enters a tunnel at the north edge of the National Monument at Station 920+00 and continues in in tunnel to the south side of the Angeles National Forest near Station 1620+00 a distance of 13.3 miles. Near Station 1110+00, the E1 alternative leaves the National Monument and transitions to the Angeles National Forest (ANF). The maximum depth of the tunnel invert is south of forest road 3N17, Santa Clara Divide where maximum cover over the tunnel invert is approximately 2,060 feet (Station 1166+00).

2.1.3 E2 Alternative

The E2 and E1 alternatives follow the same path in the SGMNM from Station 680+00 until Station 1020+00, where E2 takes a more easterly alignment passing beneath North Fork Station and continuing below Pacoima Canyon and then passing beneath Mendenhall Ridge. It continues south to the edge of the ANF at Station 1625+00. The maximum depth to the tunnel is at Mendenhall Ridge, where the cover over the tunnel invert is approximately 2,650 feet (Station 1338+00).

3 PURPOSE AND SCOPE

The purpose of this tunnel feasibility evaluation is to provide geotechnical information supported by preliminary geotechnical data for this project, geologic conditions and data from selected previous tunneling projects, and professional opinions that the Authority can use for assessing the feasibility of the ANF Tunnels. The three proposed alignments (Figure 2-1) include the SR14 that parallels the SR14 highway until the Santa Clara River, where it crosses the river and continues south beneath the SGMNM and the ANF. Two eastern alignments depart from the SR14 alignment immediately south of Palmdale and enter the SGMNM and ANF southwest of Acton.

The primary emphasis of this feasibility evaluation is to identify, describe, and quantify challenging technical constraints that may impact tunnel feasibility, such as extremely high groundwater pressures, high temperatures, or unavoidable impacts to water resources in the ANF. Other challenging conditions may include severely unfavorable geology, such as wide fault zones, squeezing ground and high groundwater inflows. Active faults intersecting the tunnel can also be a constraint, and are briefly addressed in this report based on data summarized from previous HSRA reports. Any one of these conditions or a combination of the conditions can represent design or construction challenges that need careful evaluation. The most challenging conditions related to groundwater pressures, high temperatures, squeezing ground and high groundwater flows are expected in the areas where the tunnels are deepest below the ground surface. Thus, the focus of the field investigations was in the high mountains within the ANF, where the feasibility of the tunnels at depth was evaluated.

This feasibility evaluation assimilates and interprets the available geotechnical data for tunnels passing beneath the ANF along three proposed alignments. The tunnel locations through the San Gabriel Mountains are shown on Figure 2-1. For this feasibility study, tunnel alignments were evaluated with respect to four feasibility categories, which comprise the main sections of this report, as follows:

- Geologic Conditions (rock mass conditions, weathering);
- Tunnel Design and Construction Conditions (hydraulic head and conductivity, temperature, and fault displacement);
- Hydrogeologic Conditions and USFS Concerns within ANF; and
- Construction Difficulties (Groundwater flow controls, Fault Zones, and state of rock stress).

The ANF feasibility evaluation team performed this evaluation by completing the following:

- Summarizing case histories of tunneling challenges in Southern California mountain ranges;
- Evaluating and interpreting available geotechnical data to develop a conceptual geological/geotechnical model of the ANF Tunnel Alignments (Geologic Profiles); and
- Interpreting field data collected from the geotechnical investigations and presented in the Authority report: "Geotechnical Data Report for Tunnel Feasibility, Angeles National Forest" for estimating groundwater pressures, ground temperatures, groundwater inflows to the tunnel, and other ground conditions.

The geotechnical investigation performed in 2016 provides the primary source of geotechnical data used for this feasibility evaluation. The geotechnical investigation included the following:

- Drilled six exploratory core holes to characterize the rock mass conditions and install groundwater monitoring instrumentation;
- Logged nearly 9,000 feet of rock core;
- Performed in-situ hydraulic conductivity testing;
- Conducted down-hole geophysical surveys;
- Conducted high-resolution acoustical televiewer surveys within stable intervals of the core holes;
- Conducted in-situ stress tests in two core holes;
- Performed geotechnical testing of samples from the anorthosite, syenite, gabbro, granite, granodiorite, shale and sandstone rock types along the alignments; and

- Compiled published geologic information for the study area.

The results of the 2016 geotechnical investigations are documented in the "Preliminary Geotechnical Data Report for Tunnel Feasibility, Angeles National Forest" (Authority, 2016).

4 BACKGROUND INFORMATION

4.1 Historical Tunnel Projects in National Forests

Historical tunnel projects in Southern California stand as examples of tunnel conditions that are typical and have served as the basis for many mitigation requirements for tunnel design, safety regulations, and construction methods in the industry. Significant case histories are summarized in Table 4-1 covering a long period of tunnel industry development, evolution of design and construction methods and general industry changes with respect to feasibility constraints. These tunnels include the San Jacinto Tunnel through the San Jacinto Mountains National Forest and State Park, the Tecolote Tunnel beneath the Santa Ynez Mountains Los Padres National Forest, Arrowhead Tunnels in the San Bernardino National Forest, and the Central Pool Augmentation Tunnel and the Irvine-Corona Expressway Tunnels in the Cleveland National Forest. Several characteristics for each of these tunnels and the accompanying impacts and mitigation methods are summarized in Table 4-1 as background information for tunnels in national forests of Southern California.

Table 4-1 Southern California Tunnel Case Histories in National Forests

Case History/ Owner / National Forest (NF)	Timeline	Length / Diameter / Overburden Depth	Host Rocks / Construction Method	Water Parameters H – Heading Flow P – Portal Flow Measured Water Pressures (bar)	Impacts and Mitigations	Historical Notes
#1 San Jacinto Tunnel / MWD / San Jacinto Mountains NF and State Park	Construction 1933-1939	13 Miles / 18 Feet / 2,600 Feet overburden	Predominantly granitic rock / Drill and blast with horsehoe and circular steel sets with gunite where needed.	H – Instantaneous Max. 16,000 gpm + 3,000 cy sand P – Max. 40,000 gpm P – 540 gpm after sealing cracks and concrete lining system. P – Sustained flow at 2,500 gpm long term. Max. Measured Pressures 43 bar with typical being 11 to 22 bar.	Tunnel flooding during construction; drove pioneer tunnels for drainage and injected cement into holes at pressures of 1,500 psi. Springs and seeps dried up in and around mountains. Grouted leaking cracks and lined the tunnel with concrete.	High groundwater flows were associated with 21 faults mapped after groundwater impacts manifested. Efforts to seal the leaks could achieve no less than 540 gpm.
#2 Tecolote Tunnel / Bureau of Reclamation / Los Padres NF	Construction 1950-1956	6.4 Miles / 7 Feet / 2,300 Feet overburden	Tertiary and Cretaceous marine sandstone and siltstone / Drill and Blast / 6-inch horseshoe H-Beam ribs with plating and lagging.	H – 1,200 to 2,800 gpm P – 9,100 gpm peak Max. Measured Pressures 26 bar.	Sustained drainage from tunnel required a combination of grouting with pressures up to 2,000 psi against 230 to 250 psi water pressures. Baseline monitoring of 125 springs and streams before construction. Reduced water flow observed at one of 125 monitored springs and spring fed streams	Monitored springs and streams. Increased flows due to Arvin-Tehachapi earthquake and after Refugio fire. Only one spring was documented to be influenced by drainage from tunnel construction.

Case History/ Owner / National Forest (NF)	Timeline	Length / Diameter / Overburden Depth	Host Rocks / Construction Method	Water Parameters H – Heading Flow P – Portal Flow Measured Water Pressures (bar)	Impacts and Mitigations	Historical Notes
#3 Arrowhead Tunnel East Phase I / MWD / San Bernardino NF	Construction Phase I City Creek Portal 1997-2000	1.5 Miles / 19 Feet / 1,100 to 2,070 Feet overburden	Gneiss, marble beds and mafic gneiss. TBM with grout ports at front of TBM; leaky segmented concrete lining.	780 million gallons of water drained from City Creek portal. P – Exceeded Permit Limits	Water levels declined 200-feet near City Creek and perennial streams dried up during construction. Grouting in advance of TBM not effective.	First contractor completed 8,000 feet of mining. Construction was shut down due to uncontrolled water inflows and concerns from USFS and San Manuel Bandof Indians.
#3 Arrowhead Tunnel East Phase II / MWD / San Bernardino NF	Construction Phase II Strawberry Creek Portal 2003-2008	4.2 Miles / 19 Feet / 1,100 to 2,070 Feet overburden	Quartz Monzonite, granodiorite and gneiss with marble. / TBM Open or closed face mode up to 10 bar pressure and operating at 3 bar. Gasketed, bolted, reinforced concrete segmental lining rated for 40 bar pressure.	520 million gallons of water loss from Strawberry Creek portal. P – ? Max. Measured Pressures 30 bar	Water resources Impacts from Phase I. Mitigation by custom designed Herrenknecht TBM with advanced grouting and dual mode operation. Pre-construction Grouting when one of 34 probe hole flows exceeded 0.3 gpm or if portal flow exceeded 520 gpm. Mitigation of surface water resources by artificial irrigation. Gasketed and bolted segmental concrete lining.	Contact grouting was carried out after erection of the segmental lining to fill the annular space and cut off flow along tunnel using inflatable collars for grouting. The final lining was a steel pipeline to carry the aqueduct water. For mitigation of water resources impacts, the spring and stream supplemental water distribution continued after tunnel construction. Results indicated that a standard procedure for control of groundwater in the tunnel did not apply to all conditions and the best approach was to adapt groundwater flow controls on a case-by-case basis.

Case History/ Owner / National Forest (NF)	Timeline	Length / Diameter / Overburden Depth	Host Rocks / Construction Method	Water Parameters H – Heading Flow P – Portal Flow Measured Water Pressures (bar)	Impacts and Mitigations	Historical Notes
#4 Central Pool Augmentation Tunnel / MWD / Cleveland NF	Not Constructed Feasibility Evaluation 2006-2008	10 Miles/ ~ 20 feet/ 2,200 to 2,500 Feet overburden	Meta-sandstone and meta-shale (Argillite, slate, and mudstone)/ Planned for TBM excavation. Developed RMR, Q and GSI for estimates of TBM performance	Hydraulic Conductivities ranged from 5x10-3 cm/sec to 5x10-5 cm/sec near surface; and 1x10-6 cm/sec to 5x10-8 cm/sec at tunnel envelope Maximum Measured Water Pressures from Vibrating Wire Piezometers (VWPT) in Core Holes 35 bar at 2,200 feet depth 42 bar at 2,500 feet depth	Recommended dual mode TBM with gasketed, and bolted segmental concrete lining.	Measured VWPT pressures indicated lower than estimated hydrostatic pressures at tunnel depths of 2,200 and 2,500 feet. Hydraulic conductivities decreased with greater depths. Lower pressures at depth suggest hydraulic separation (i.e. isolation) of deep water from shallow water.
# 5 Irvine Corona Expressway (ICE) Tunnels / Riverside County Transportation Commission / Cleveland NF	Not Constructed Feasibility Evaluation and Conceptual Design, TBM specifications and cost estimate. 2007-2010	11 Miles/ 52 feet vehicular and 26.5 feet rail tunnels / 1,500 feet overburden or greater to match 25 bar of water pressure. Ventilation shaft near middle of tunnel for Fire-Life Safety.	Meta-sandstone and meta-shale (Argillite, slate, and mudstone)/ Planned for TBM excavation. Developed RMR, Q and GSI for estimates of TBM performance	Hydraulic Conductivities ranged from 2x10-3 cm/sec to 6x10-8 cm/sec for shallower than 1,000 fee of overburdent; and 3x10-6 cm/sec to 3x10-8 cm/sec at tunnel envelope of about 1,500 feet. Maximum Measured Pressures from Vibrating Wire Piezometers (VWPT) in Core Holes 25 bar at 1,250 feet depth 30 bar at 1,500 feet depth	ICE mitigation measures were planned to establish pre-construction baseline spring and spring-fed stream flow monitoring followed by monitoring during and after tunnel construction. Recommended dual mode TBM. Lining system to be gasketed and bolted segmental high strength concrete lining. Pre-excavation grouting program. Controlled drainage would be needed for water pressures above 25 bar.	Recommended proposed tunnel profiles/depths corresponding to water pressures no greater than 25 bar (~350 psi). For tunnel sections in water pressures greater than 25 bar (i.e. deeper), it was assumed that water leakage would need to be controlled to maintain peak pressures no more than 25 bar.

4.2 Geotechnical Tunnel Feasibility Issues within National Forests

Based on past tunnel project case histories in southern California, the following issues are recognized as critical for evaluating feasibility of tunnels in certain environments with challenging conditions for design and construction of transportation tunnels:

- Effects of tunnel construction and impacts to groundwater and surface water resources.
- Balancing groundwater protection measures against practical design and construction requirements.
- Defining acceptable impacts (e.g., grading) at tunnel portal locations and, if needed, at intermediate accesses for construction and fire-life safety issues.
- State of the art tunnel lining design to minimize water leakage into the tunnels under anticipated high groundwater pressures.
- Addressing the potential for high water temperatures and the impacts on fire-life safety ventilation controls.
- General rock mass conditions combined with in-situ pressures and stresses controlling ground behavior during construction.
- Squeezing ground conditions affecting tunneling methods and rates of advancement.
- Displacements from large earthquakes along active (i.e., Hazardous) faults that intersect the tunnel below ground.

The geotechnical feasibility of the ANF tunnels are discussed in Section 7.0 of this report.

4.2.1 Other Geotechnical Feasibility Issues

Adits (i.e., shafts or galleries from the ground surface to the tunnel) will be necessary for ventilation and construction access; however, these are planned in areas outside the ANF. Similar to the tunnels, where adits penetrate groundwater, these will also need to implement groundwater inflow control measures during construction and operation to reduce the potential impacts to surface and groundwater resources within the ANF.

5 GEOLOGIC AND HYDROGEOLOGIC CONDITIONS

Conceptual geologic and hydrogeologic models have been developed from the available geotechnical data and results of field investigations for this feasibility evaluation to estimate the tunneling conditions with respect to the ANF tunnel alignments (Authority, 2016). The geologic units, and structures traversed by the ANF tunnel alignments are shown on Figure 5-1, Figure 5-2 provides an explanation of the map units and symbols for Figure 5-1 and the Geologic Profiles and Anticipated Tunnel Conditions drawings in Appendix A.

Figure 5-1 Geologic Map

Figure 5-2 Geologic Map Explanation

5.1 General Geology

5.1.1 Geologic Units

The three alternative tunnel alignments traverse the western San Gabriel Mountains beneath the ANF, the Study Area. The local geology of the project Study Area is complex due to multiple stages of metamorphism, igneous intrusion, rotation, and subsequent uplift and faulting of the area over the past 1.7 billion years. Previous mapping of the San Gabriel Mountains by the California Geological Survey (CGS; Campbell et al., 2014) and the United States Geological Survey (USGS; Yerkes and Campbell, 2005) provided the surface mapping of the Study Area's geology. To supplement this existing data and check site-specific geologic information, limited geologic mapping and a subsurface investigation were conducted within the Study Area. The subsurface investigation included drilling, collecting core and performing geophysical and hydrogeological downhole tests. Detailed descriptions of the field activities, including rock coring, are provided in Section 3 of the Draft Geotechnical Data Report for Tunnel Feasibility, Angeles National Forest (Authority, 2016).

The rocks within the project Study Area include a massif of Proterozoic- to Cretaceous-age metamorphic and igneous rocks that comprise the areas of greatest relief within the San Gabriel Mountains that are bordered to the northwest and south with a lower-lying mantling of Tertiary-age and younger sedimentary rocks and surficial deposits.

The metamorphic and igneous rocks include remnants of Proterozoic gneiss that have been intruded by a Proterozoic anorthosite-gabbro complex, the Mount Lowe Granodiorite (intrusive suite) of Permian-Triassic age, Mesozoic granitic (including the Mount Josephine granodiorite) and gneissic rocks. The oldest and one of the most distinctive rocks on the Study Area is the approximately 1.7 billion year old Mendenhall Gneiss. The Mendenhall Gneiss was described and named by Oakeshott (1958). This gneiss is exposed in the Study Area north of the San Gabriel fault and south of the anorthosite-gabbro complex (Authority, 2016). It was subjected to high temperature metamorphism 1.2 billion years ago and in many areas again during the Mesozoic (Silver, 1971; Ehlig, 1975b). The anorthosite-gabbro and related rocks are exposed over an area of about 80 square miles, mostly in the Study Area. The anorthosite-gabbro complex is described in detail by Carter (1980a, 1980b and 1982) and Oakeshott (1958). The blue-gray to white andesine anorthosite is the most abundant rock type in the anorthosite-gabbro complex (Carter, 1980a) with the gabbro the next most abundant followed by the syenite. This igneous complex was emplaced 1.22 billion years ago (Silver, 1971; and Carter, 1980a). Studies by Carter (1980a) indicate the complex was initially stratiform with prominent compositional layering produced by gravitational settling of mineral crystals. The structure has subsequently become geologically complex due to several episodes of deformation and faulting. These rocks are generally coarse grained and have unusual textures.

Northwest and south of the metamorphic and igneous rock outcrops are layers of Tertiary-age sedimentary rocks. The sedimentary deposits have been both faulted against and deposited over the metamorphic and igneous rocks. In the northwest part of the Study Area, the sedimentary layers belonging to the Vasquez, Tick and Mint Canyon Formations have been deposited. The Vasquez Formation is Oligocene to early Miocene in age and includes sandstone, mudstone, and conglomerate with interbedded andesite-basalt. The Vasquez Formation is greater than 12,000 feet thick and rests on crystalline bedrock. Overlaying the Vasquez formation is the Miocene Tick Canyon Formation, which is comprised of well-cemented conglomerate sandstone, claystone and siltstone of fluvial origin (Oakeshott, 1958). The Tick Canyon is early to middle Miocene in age. Deposited above the Tick Canyon Formation is the Mint Canyon Formation. The Mint Canyon Formation is middle to late Miocene in age (Campbell et.al. 2014) and includes semi-consolidated non-marine layers of arkosic and conglomerate sandstone, siltstone, mudstone, and an interbedded tuff near the top of the formation. The formation is fossiliferous and approximately 2,500 feet thick. In the southern part of the Study Area, the sedimentary layers belonging to the Modelo, Towsley and Saugus Formations are present. The Modelo Formation is middle to late Miocene in age and consists of layers of thinly-bedded mudstone, diatomaceous shale, siltstone with interbeds of sandstone. Its thickness varies by location, but overall can easily exceed 10,000 feet. Deposited above the Modelo Formation is the late Miocene to early Pliocene Towsley Formation. The Towsley Formation consists of interbedded marine siltstone, mudstone, sandstone and conglomerate layers. Fossils indicate the Towsley Formation was deposited in water in excess of 600 feet deep. The unit has a maximum thickness of approximately 4,000 feet, and is overlain by the Saugus Formation. The Saugus Formation is a non-marine unit that is Pliocene to Pleistocene in age. The Saugus Formation, which contains layers of sandstone, sandy conglomerate, and siltstone, may be up to 12,000 feet thick. The lithologies comprising Saugus Formation are predominantly weakly to moderately cemented.

Above the bedrock, units include surficial deposits of landslide debris and alluvium (old and young). In the Study Area, these deposits are generally found along canyon bottoms (alluvium) and along steep canyon walls (landslide debris). However, the proposed alignments within the ANF will be primarily in tunnel below the ground surface. These surficial deposits should not have an impact on tunnel design.

5.1.2 Geologic Structures and Faults

The San Andreas Fault System formed along the translational boundary between the North American and Pacific Plates during the Miocene. Convergent transform movements are responsible for the mountain building of the Transverse Ranges and the San Gabriel Mountains. The east-west oriented Transverse Ranges/San Gabriel Mountains present an anomaly in southern California where all the other mountain ranges are oriented northwest parallel to the strike of the San Andreas Fault System. Paleomagnetic data indicate that the Transverse Ranges were originally oriented north-south, with its southern and northern ends located near the latitude of present day San Diego and Anaheim, respectively (Atwater, 1998; Kamerling and Luyendyk, 1985). During the evolution of the Pacific-North America plate boundary, the Transverse Ranges broke off the North America plate and rotated as a cohesive block 80-110 degrees clockwise to its present position (Kamerling and Luyendyk, 1985). This process of rotation, which was associated with faulting, folding, and crustal upwelling in the Transverse Ranges, continued until about 5 million years ago. The development of the San Gabriel fault, generally regarded as an older strand of the San Andreas Fault System occurred during this time (Atwater, 1998). In addition to the San Gabriel fault, other active faults belonging to the San Andreas Fault System which have formed in the Project area the past few million years include the Sierra Madre (Sunland and San Fernando strands) bordering the south edge of the ANF(Figure 5-1). The San Gabriel Mountains owe their steep, youthful southern front to the uplift to the reverse faults belonging to the Sierra Madre fault. However, there are many faults within the San Gabriel Mountains, which affect the development of the geologic structure, stratigraphy and hydrogeology of the Project area, but are not considered active (i.e., experienced displacement in the past 11,000 years). These include, Agua Dulce, Pole Canyon, Oak Spring, Magic Mountain, Lonetree, Transmission Line, Laurel Canyon, Goose Berry Canyon, Bad Canyon, Mendenhall, and Slaughter Canyon faults (Figure 5-1). These inactive faults promote canyon development and erosion by juxtaposing differing lithologies/formations and promote and/or restrict groundwater movement within the interconnected fracture networks.

5.1.3 Hydrogeology

Information on the hydrogeologic conditions is limited to the data collected during the geotechnical field investigations (Authority, 2016). Although the San Gabriel Mountains are part of the Groundwater Ambient Monitoring and Assessment (GAMA) studies managed by the USGS, the data from this study located directly on any of the ANF tunnel alignments is limited.

As shown on Figure 5-2, the project area is a tectonically elevated terrain that extends from Soledad Canyon on the north to the Santa Clarita and San Fernando Valleys on the west, Tujunga Wash (i.e. Tujunga Valley) on the south and Big Tujunga Canyon to the east. The steep topographic relief of the San Gabriel Mountains is illustrated in Figure 5-3. The surface drainage pattern is governed by two approximately east-west trending drainage divides, the Santa Clara Divide and the Mendenhall Divide (Mendenhall Ridge Road) (Figure 5-3). The Santa Clara Divide extends from the Little Tujunga Canyon Road-Sand Canyon Road transition eastward to Mendenhall Ridge Road. The Mendenhall Divide extends from Little Tujunga Canyon Road at Pacoima Road north-northeasterly where it joins Santa Clara Divide. The Little Tujunga Canyon and Gold Creek drainage system captures the surface run off in the Study Area south of Mendenhall Divide. Big Tujunga Canyon is the next drainage system east of Little Tujunga Canyon-Gold Creek drainage that is south of Mendenhall Divide. Both Big Tujunga and Little Tujunga canyons drain southward into Tujunga Wash. Pacoima Canyon and its tributaries drain westward between the Santa Clara Divide and Mendenhall Divide to discharge along the northeast edge of San Fernando Valley. Numerous smaller canyons drain northward from the Santa Clara Divide into the Santa Clara River and Soledad Canyon. The smaller canyons include Sand Canyon, Iron Canyon, Pole Canyon, and Arrastre Canyon. The many small tributary canyons capture the mountain runoff and feed into the larger canyons, which discharge the majority of rainfall and snowmelt into the valleys flanking the mountains as surface runoff.

Figure 5-3 Hydrology Map

Stream flows within the local canyons vary depending on seasonal trends in precipitation, and with the topography, vegetation, and geology of the drainages. The flow of springs in the area appears to vary with seasonal precipitation; however, the current database is not sufficient to quantify the amount of water discharge from springs in the Study Area.

The groundwater table generally mimics the topography as a subdued expression of the ground surface; that is, the depth to groundwater is nearest the canyon bottoms and it is generally deeper beneath the ridgelines and mountain peaks. This is generally the case in all crystalline and metamorphic rock terrains, where steep hillsides facilitate rapid runoff of precipitation to canyon bottoms, where water is directed as runoff to larger tributaries. Infiltration is generally less on hillsides and more within canyons and valleys, where the flow gradients are lower and residence time is greater.

5.1.3.1 Hydrogeology of Rock Mass

The interaction between surface water and groundwater systems is governed largely by lithology, geologic structures (e.g., faults, joints, unconformities, etc.), weathering conditions, and in-situ stress. Conceptually, groundwater flow within rock mass occurs in two possible ways through the medium's void spaces: 1) Primary porosity, and 2) Secondary porosity. For hydrogeologic flow properties of rock masses, the terms porosity and permeability are not the appropriate terminology. The hydraulic conductivity (K) is the property that is applicable, and is highly dependent upon the connected void spaces where water flow is permissible. When the primary and secondary porosity are together or are not differentiated, this is simply referred to as the effective porosity (or effective hydraulic conductivity). In general, the effective hydraulic conductivity of rock mass tends to decrease with depth coinciding with reduction in weathering effects, fewer discontinuities and increasing lithostatic pressures.

Primary porosity is the connected void spaces of the intact rock, i.e. spaces between grains and cement or interlocking crystalline minerals comprising the rock. In poorly-cemented, granular sedimentary rock, the primary porosity can be comparable to that of unconsolidated sediments. Conversely, for well-cemented or fine-grained sedimentary, metamorphic, and crystalline igneous rock, the primary porosity is low and prevents water transmission. Weathering processes alter the primary porosity of all rocks. Where cement or crystalline minerals are removed, the primary porosity could increase. In most cases, it is assumed that weathering of crystalline rock tends to increase their primary porosity by altering rock chemically, accentuating defects in the rock (i.e. fractures) and general opening of discontinuities.

Secondary porosity is the connected void spaces formed from discontinuities (e.g., joints, shears, faults, fractures, bedding, etc.) and geologic structures. Rock mass with persistent discontinuity systems with wide apertures open or infilled with coarse material will have a high secondary porosity. In some cases, such conduits may be further enhanced over time as flow occurs, water pressures build acting to prop open the joint, finer-particles infilling the system are flushed away, and weathering of the surrounding intact rock walls increases their local primary porosity. The orientation of the discontinuities are also important. In general, near-vertical discontinuities often are better connected to the surface as the normal stress that reduces the joint opening tends to be lower in a gravitational stress field than the normal stress acting on near-horizontal discontinuities. At some critical depth, the state of stress becomes so great that joint openings are inhibited or eliminated altogether.

Depending on the style of faulting, lithology, net displacement and other factors, faults typically impose a high-degree of anisotropy to groundwater flow. In most cases, faults act as a barrier to flow across the fault, and as a conduit for flow parallel to the fault. These established relationships are suggested within the Study Area based on the geotechnical investigations completed to date and will be further investigated and developed in later phases of study.

With respect to the behavior of groundwater systems, a rock mass aquifer can behave much more complexly than sediment aquifers or other "Darcy porous mediums." This does not preclude the possibility for rock mass to behave as a Darcy porous medium, such as sedimentary rock or virtually any homogeneously fractured or weathered rock mass (i.e., at shallow depth). However, in fractured crystalline rock mass at depth, the fracture networks dominate the hydrogeologic conditions and define the aquifers or groundwater compartments within the rock mass. Some observations of groundwater aquifers and behavior are discussed in Section 6.3.1.

5.1.4 Faulted Ground

Faults can pose significant construction difficulties for tunnels by altering the conditions of the rock mass being mined and increasing water flows into the tunnel. Therefore, faults should be anticipated and accounted for when selecting the tunnel alignment, tunneling methods and tunnel lining design.

Geologic formations that once were intact and strong become mechanically sheared and brecciated, altered, decomposed, and weak after being subjected to faulting. The degradation of the rock mass may result in face instability during mining, higher lithostatic loads on the tunnel lining system, and facilitate higher groundwater pressures and flows in and adjacent to the faults.

Faults have the potential to act both as groundwater conduits and as barriers that often result in significant variations in groundwater pressures from one side of the fault to the other. These variations in groundwater pressures are especially critical when unexpectedly encountered during tunnel mining. Also, high temperature groundwater may be channeled upward along faults to shallower depths requiring special controls to enable workers to work in the hot tunnel environment.

Three of the six core holes were placed at inclined angles in order to investigate the width and general rock mass properties of mapped faults that would intersect the tunnel alignments. The faults investigated included the Transmission Line Fault and the San Gabriel fault. In both core holes drilled through the San Gabriel fault, the rock coring operation was slowed by squeezing ground conditions and general difficulty with keeping the core hole open after tripping out drill rods. Recovery of core through the fault zones also indicated extreme brecciation of the rock, abundant shearing and clay gouge zones for both the San Gabriel fault and the Transmission Line fault indicating that loss of core hole integrity could be attributed to either squeezing ground or swelling ground due to expansive clay properties. The width of the fault zones drilled in the core holes ranged from individual fault strands that are tens of feet wide to several hundred feet wide. The widest fault zone intersecting the alignments is the San Gabriel fault zone, whose width is greatest at the E2 alignment (e.g. composed of many fault strands). The many fault traces and shear zones at the E2 alignment are mapped as merging into a narrow zone both at the SR14 and E1 alignments. However, isolated, single fault branches are mapped up to 6,000 feet away from the merged zones at SR14 and E1alignment suggesting the total width is comparable at the fault intersections. For tunneling progress, the most important factors are maintaining tunnel advance rate and minimizing challenging mining conditions is the cumulative or net width of gouge zones and sheared and brecciated rock. Therefore the summed (net) width of faulted ground to be encountered by the tunnel is most important for comparison between alignments with respect to ease of advancing the tunnel mining. The general widths and number of mapped faults are illustrated on the geologic profiles referenced in Section 6 of this report.

Where faults intersect tunnel construction, more water flow and greater groundwater pressures (depending on the depth below ground) should be expected. The exploratory core holes and pressure readings at difference locations along the inclined core holes through faults indicated that water pressures were almost the same on either side of the faults explored. From the data collected it is unclear that the faults investigated create a groundwater barrier where explored. However, the general hydraulic conductivity measurements indicate higher conductivity potential in the rock surrounding the fault zone with very low conductivities closest to or within the fault gouge zone. The presence of the shears and more brecciated rock are indicators of higher groundwater flows along faults and into tunnels under construction.

5.2 Geologic Hazards

Potential hazards for construction and operation of the ANF Tunnel Alignments that are directly related to the geology include:

- Gassy ground;
- Corrosive groundwater; and
- Active fault displacement.

Several of these hazards are mainly applicable to the subsurface portions of the ANF Tunnels, while others, such as faulting, may be applicable to both underground and surface portions (e.g., portals) of the ANF Tunnels.

5.2.1 Gassy Ground

Gassy ground results from the migration of flammable, toxic, or asphyxiating gases into the tunnel during construction or operation. The gas emanates from geologic materials (e.g., from oxidation of minerals), groundwater containing dissolved gas flowing into the tunnel, or petroleum occurrence in formations. Tunnel Alignments have been successfully constructed through gassy ground in southern California with proper procedures as required by the California Division of Safety and Health (Cal/OSHA). A more detailed discussion of requirements for gassy ground is presented in the California Code of Regulations (CCR). Based on the limited data available at this time, the potential for gassy ground within the ANF may exist. The risk for gassy ground is higher for tunnel lengths within or overlying Modelo Formation, which is known as a source of gas, and oil within southern California.

5.2.2 Corrosive Groundwater

Corrosive groundwater can damage components of the TBM, and over time may deteriorate the concrete compromising the performance of the tunnel structure. Although relatively high sulfate concentration is the primary cause of corrosive groundwater, gases such as carbon dioxide and hydrogen sulfide that dissolve into groundwater form acids that may also damage construction materials. Based on the limited groundwater chemistry tests from samples of groundwater within the ANF, the potential for corrosive ground and groundwater exists.

5.2.3 Active Fault Displacement

Fault displacements result from differential movement across a fault during an earthquake due to tectonic forces shearing the Earth's crust. Depending on the size of the earthquake (i.e. magnitude representing energy release), the displacement sometimes propagates to the ground surface causing surface rupture and displacement of features straddling the fault such as geomorphic features (e.g. streams, flat surfaces) or man-made structures (e.g. roads, buildings, pipelines, etc.). Tunnels also are subject to fault displacement causing offset of the tunnel structure below ground due to relative displacement across a fault or fault zone. Restoration of a tunnel would require realignment or smoothing of the offset of the tunnel and repair of the lining system. For high-speed train projects, the track realignment would require track straightening or curvature restoration within the tunnel diameter to allow the train to maintain required speed for the project.

For the HSR project, criteria have been established to recognize and classify the potential risks of fault displacement for the railroad tunnels where they intersect Holocene-age faults. The Holocene age (activity within the past 11,700 years) applies to three faults intersected by the proposed tunnel alignments within ANF. All other faults that intersect the alignments within ANF have been inactive during the Holocene and are classified as Non-Hazardous. From north to south all three alignments intersect the same three Holocene- age faults but at different locations. The faults include San Gabriel fault, Sierra Madre fault (north), and Sierra Madre fault (south). The Sierra Madre (north and south) are Class A Hazardous faults (Holocene age with a geologic slip rate >1.0 mm/yr). The San Gabriel fault is currently classified as "Indeterminate" meaning that insufficient data exist for this fault to be assigned a classification according to the HSR criteria (California High Speed Rail Authority, 2016)).

The Seismic Specialists Team (SST) at The Authority is tasked with providing estimates of displacement for future fault activity.

6 ANTICIPATED TUNNEL CONDITIONS

We have interpreted anticipated tunnel conditions considering the tunnel configurations, geologic, hydrogeologic, and geomechanical conditions as these are relevant to the geotechnical feasibility. Our interpretations based on the limited data and available information are presented on several geologic profiles prepared for each of the ANF tunnel alignments (Appendix A – Geologic Profiles and Anticipated Tunneling Conditions).

The range of stationing considered in this feasibility summary is summarized in Table 6-1. In the summary of anticipated tunnel conditions, below-grade portions within these station limits are assumed to be tunnel. Where the alignment elevation is at-grade or where the tunnel conditions are not applicable to the material within the tunnel envelope, these lengths are not included in the summaries. When considering the tunnel alignments, a major difference that separates the SR14 alignment from the other two is it's significantly shorter length within the ANF.

Table 6-1 Stationing Limits Tabulated for Anticipated Tunnel Conditions

Alignment	Stationing		Length	
			feet	miles
SR14	1330+00	1750+00	42,000	7.95
E1	638+80	1750+00	111,120	21.04
E2	638+80	1750+00	111,120	21.04

6.1 Geologic Conditions

The interpretation of geologic conditions for the ANF tunnels is limited to the information available from six core holes completed within the Study Area, published maps and studies, and our previous project experience with some of these and similar lithologies. Considering the nearly 50 miles of tunnel that are being evaluated in this report, where the existing core holes are not located directly on an alignment (i.e., projected onto a profile), we have used these as analogs to represent the general conditions within the ANF. The geologic units, lithologies, geologic structures, geologic hazards and other key features are summarized in the geologic profiles and anticipated tunneling conditions (Appendix A).

6.2 Abrasivity

The abrasivity of the geologic units affects the amount of wear of the various pieces of mining equipment. Mining in abrasive materials requires more frequent tooling replacements to avoid overwearing vital components of the TBM cutterhead.

We have interpreted the abrasivity of the geologic units using limited testing from the ANF core holes, published information about the geologic formations, and published correlations between lithology and abrasivity. Figure 6-1 summarizes the descriptors and ranges of abrasivity and correlations used to interpret the anticipated abrasivity conditions for the ANF tunnels (Appendix A).

Figure 6-1 Abrasivity Correlations

Based on the abrasivity correlations and available data, the anticipated abrasivity conditions for the ANF tunnel alignments are summarized in Figure 6-2. From the interpreted abrasivity conditions, most of the geologic units traversed by the ANF tunnels are anticipated to exhibit high to extreme abrasivity.

Figure 6-2 Summary of Anticipated Abrasivity

6.3 Hydrogeologic Conditions

6.3.1 Preliminary Observations of Groundwater Behavior

Data collected during the ANF geotechnical investigations (HSR, 2016) help to demonstrate some trends believed to characterize the groundwater system(s) within the forest where the tunnels are proposed. These trends are relevant to the discussions of tunnel feasibility and the potential impacts on surface water resources within the forest. The characteristics are interpreted from both published data and field data reported in the Geotechnical Data Report for Tunnel Feasibility (HSR,2016). The data include: 1) Rock mass classifications base on geologic logging of rock core; 2) Measurements of hydraulic conductivity in exploratory core holes; 3) In-Situ measurements of hydraulic pressures at varying depths; 4) Water chemistry of shallow water and deep groundwater samples; 5) Observations of springs and seeps within the ANF; and 6) Age dating of surface water samples and deep groundwater.

The rock mass data summarized from the geologic logs of rock core and acoustical televiewer surveys of five exploratory holes in the crystalline rocks of the ANF indicate a highly variable occurrence of discontinuities in the overall rock mass. In general, the rock is much more weathered, oxidized, fragmented, sheared, and pulverized near fault zones reflecting the localized mechanical degradation of the native rock due to the tectonic forces of faults. Away from faults, the condition of the rock improves with fewer discontinuities representing the broader occurrence of in-tact rock. The patterns of discontinuities assume a consistency within the rock mass leaving telltale signs of stresses within the mountain that have generated consistency of predominant joints with fairly regular spacing and orientations. Numerous sets of intersecting joints have been identified in the core resulting in varying degrees of fracturing quantified as rock quality designation (RQD). Quantification of the discontinuity spacings within the core illustrates broadly differing zones of fracturing, some with high density of fractures and other zones with virtually no fracturing. As discussed above, in-tact crystalline rock is has essentially no ability to carry or transmit water, whereas the fractures in the rock allow water storage (limited) and movement along fractures. The wide variation of discontinuities and intersecting patterns of discontinuities governs the direction and quantity of groundwater that is able to flow through the rock mass adjacent to a fault. For example, faults are zones of dislocation that displace one side of the fault past the other causing shearing and brecciation of adjacent rock with a preferred orientation of closely spaced discontinuities roughly parallel to the fault trend. With greater and greater displacement along a fault, the rock adjacent to a fault becomes a preferred path of water flow. Away from faults, the rock quality improves but still the variations in RQD can either facilitate or inhibit groundwater flow. Zones of completely intact rock can prevent groundwater flow forming an impermeable barrier within the rock mass, whereas zones of low RQD are more fractured and facilitate storage and movement of groundwater.

The in-situ hydraulic conductivity of the rock mass explored during the geotechnical investigation was measured by use of inflatable packers to isolate fractured zones of rock within each core hole. A high capacity pump apparatus forced water flow into the fractures of the isolated rock zone. The rate of water flow into the fractures in the rock was converted to effective hydraulic conductivity. The results of the in-situ packer tests indicate very low rates of flow demonstrating only a very small quantity of water is able to flow through the rock mass at very slow rates. The rate of groundwater flow is expressed in centimeters per second, which ranged through five orders of magnitude ranging 5x10-3 cm/sec to 5x10-7 cm/sec. The wide range of recorded values represents the non-uniform nature of the aquifer characteristics of the rock resulting from. the variability of fracturing and interconnection between fractures. The low effective hydraulic conductivity values indicate that there is very little potential for the rock mass to yield large quantities of water. The rate of flow is also dependent on the locations and frequencies of discontinuities in the rock. The low flow potential also indicates that there is very little potential for draining wide-spread zones of water.

Hydraulic head or groundwater pressures at the tunnel depth are used as a parameter for design of the TBM and tunnel lining system. Design and construction of the tunnel and lining system will vary depending on the anticipated groundwater pressures at the tunnel depth. For example, the measured pressures will help the designer apply the optimum lining system that minimizes water losses into the tunnel. The pressure data are also necessary for planning grouting programs to shut off water flow into or along the tunnel. Direct water pressures were measured at various depths within each of the core holes drilled in the ANF. The pressures were measured using a calibrated vibrating wire pressure transducer (VWPT), which senses pressure within isolated zones of the bedrock at varying depths. The data indicate that there is a fairly constant rate of pressure increase that tracks very well with a constantly increasing direct head of water from the shallowest (first encountered water elevation) to the deepest VWPT for core holes that crossed faults. In contrast, two deep core holes within in-tact bedrock masses suggested several zones of isolated groundwater pressures that appear to unrelated (not connected) to adjacent zones. There was a very pronounced variance from constant head increase within the anorthosite and to a lesser degree within the granodiorite rock. The deviation in pressure data from a constant head increase indicates that there are several zones or compartments of isolated groundwater within the rock mass that have lower pressures than expected. These data indicate that water zones encountered within the bedrock are not interconnected and therefore draining water from one compartment would have minimal impact on the adjacent occurrence of water. The data imply that a tunnel driven through in-tact bedrock at depth may not have any influence on the shallow groundwater (i.e. sources of springs). In contrast, the constant hydraulic head increase with depth near the fault zones explored suggests that there is an open vertical path of water to flow from shallow to deeper zones demonstrating connectivity near faults.

Water resources monitoring was implemented in the vicinity of the three tunnel alternatives beneath the ANF. The monitoring program encompassed 20 known springs at various locations on USFS land. One monitoring cycle was completed during the end of the summer season on September 16, 2016 to assess access to the sites and make initial observations of the spring conditions. The first cycle of spring observations discovered that the long preceding dry years had resulted in most all of the springs being dry or evidenced only by wet soil or greener vegetation where the spring had been identified. From this first documentation of springs in the ANF, the conclusion is that protracted drought can result in the documented springs ceasing flows during late summer. This indicates that the springs are not fed by deep sustained water resources, but that the springs are dependent on seasonal wet cycles in order to maintain their flow.

Chemistry of deep water samples collected from the geotechnical core holes were analyzed for general chemistry, for radio-carbon age dating, and for radio nuclides to compare results to published water chemistry from the GAMA analytical test results. Many of the samples collected from deep within the core holes contained residual potable water used for rock core drilling indicating that the purging cycle to remove all potable water had not been long enough to draw in the native deep groundwater for sampling. The general chemistry of the water tested by the USFS GAMA program indicates a calcium bicarbonate ($Ca-HCO_3$) type of water, whereas the deep water from our field exploration indicates the uniquely different chemistry of a calcium sulfate ($Ca-SO_4$) type of water. These differences demonstrate that the water sources for GAMA program, which are from shallow wells are not connected to the deep groundwater sampled and tested for the geotechnical investigations. The results of the carbon-14 age dating also indicates that the water collected from deep in the mountain is at least 4,500 years old and has not been replenished or recharged by younger shallow rain water. So far, the results from water chemistry testing suggest that the deep water within bedrock units beneath the ANF has not been mixing with shallow water that supplies wells and springs with water.

6.3.2 Hydraulic Conductivity

The hydraulic conductivity of the various geologic units and the groundwater pressures anticipated within the tunnel envelope are interpreted from in-situ testing and instrumentation data obtained from the six core holes within the ANF, published information for similar geologic conditions, and our previous project experience.

The hydraulic conductivity of the geologic units interacting with the tunnels are important as these affect the potential for inflows during construction and operation, and the groutability of the geologic units.

Table 6-2 summarizes the descriptors used for the anticipated hydraulic conductivity conditions for the ANF tunnels (Appendix A). For the Proterozoic- and Mesozoic-age igneous and metamorphic rock lithologies tested within the ANF core holes, we have plotted the resulting ranges of hydraulic conductivity along with compiled published ranges of data from other rock lithologies (Figure 6-3). For locations where there are data gaps, we have interpreted the hydraulic conductivity considering the rock lithology and potential fracturing.

Figure 6-3 Hydraulic Conductivity Correlations

Table 6-2 Hydraulic Conductivity by Generalized Lithology

Descriptor	Hydraulic Conductivity (K) cm/sec	Lugeon	Generalized Lithology or Conditions
Very High	$10 - 10^{-1}$	>50	▪ Sediments comprised of gravel ▪ Intensely fractured (karstic) limestone or basalt ▪ Rock mass with many open joints
High	$10^{-1} - 10^{-3}$	5-50	▪ Sediments comprised of sand ▪ Intensely fractured igneous or sedimentary rock ▪ Rock mass with only some open joints
Moderate	10^{-3} - 10^{-5}	1-5	▪ Sediments comprised of fine sand, or interlayers of silt or clay ▪ Coarse- to medium-grained sedimentary rocks ▪ Fractured sedimentary, igneous, and metamorphic rocks ▪ Rock mass with small joint openings, openings with impervious infill, or few joints
Low	10^{-5} - 10^{-7}	0.01 – 1	▪ Sediments comprised predominantly of silt or clay ▪ Fine-grained sedimentary and igneous rock, metamorphic rock ▪ Rock mass with tight joints, openings with impervious infill, or few joints
Very Low	$<10^{-7}$	<0.01	▪ Sediments comprised of homogeneous clay ▪ Shale and evaporite ▪ Rock mass with tight joints, openings with impervious infill, or few joints

Sources: Isherwood, 1979; Goodman, 1981; Jaeger et al., 2007; Domenico and Schwartz, 1990; USBR, 1998; Fell et al., 2005; Freeze and Cherry, 1979.

Figure 6-4 summarizes the anticipated hydraulic conductivity for the rock types cored within the ANF. Based on the data collected for the feasibility study, the SR14 alignment is anticipated to have the longest portion of tunnel within geologic units anticipated to have high hydraulic conductivity.

Figure 6-4 Summary of Anticipated Hydraulic Conductivity

6.3.3 Groundwater Pressures

The groundwater pressures are one of the key features to consider when designing and constructing a watertight tunnel lining. The feasibility for watertight linings are generally limited to magnitudes of water pressure less than about 40 bar (580 psi), based on specifications for the Hallandsas Tunnel in Sweden. The Arrowhead Tunnels lining systems were proof tested up to the 27 bar (390 psi) to meet the anticipated design requirements (Swartz et al., 2002). During construction, potential inflows are proportional to groundwater pressure gradient.

The groundwater pressures are interpreted from instrumentation data available for the six core holes within the ANF, published data of groundwater resources within the ANF [i.e., as shown on Appendix A.9 in the Draft GDR (Authority, 2016)], and topographic and hydrogeologic trends. Table 6-3 summarizes the descriptors used for the anticipated groundwater pressure conditions for the ANF tunnels (Appendix A). The groundwater pressures within the tunnel envelopes will be governed by how the tunnels penetrate the rock mass aquifer(s). Based on the limited data from the six coreholes, where multi-point vibrating wire piezometers (VWP) were installed, the tunnel envelopes will likely penetrate zones where there is only a single rock mass aquifer overlying the tunnel (i.e., an unconfined aquifer) and zones where there are several rock mass aquifers overlying the tunnel and the tunnel only penetrates one of these at a time as it traverses along the alignment (i.e., a confined aquifer). In reality, there will likely be overlapping zones where the tunnel penetrates from one rock mass aquifer to another where these zones are merged to some degree (i.e., leaky aquifer).

Based on the depth versus groundwater pressure trends observed from the instruments monitored from five coreholes within the ANF, most of the locations (i.e., all except Core Hole E1-B1) appear to deviate only slightly from that exhibited from a single unconfined rock mass aquifer. Core Hole C-1 was only recently completed and monitoring data has not been evaluated to-date. The prevalence of unconfined rock mass aquifer systems observed from the core holes within the ANF are likely biased by the core hole locations, which in several core holes were intended to investigate faults. In other words, several of the core hole locations were specifically selected to penetrate faults and resulting fractured rock mass in order to represent worst-case scenarios of rock quality.

In our interpretations of groundwater pressure, we have assumed the following cases:

- A single unconfined rock mass aquifer for all geologic units penetrated by the SR14 and E2 tunnel envelopes, and the E1 tunnel envelope with the exception of where it penetrates anorthosite-gabbro complex at depths greater than 1,000 feet. The groundwater pressure is estimated from an assumed groundwater surface and the resulting hydrostatic pressure at the elevation of the tunnel envelope.
- Multiple rock mass aquifers for the E1 tunnel envelope, where the tunnel is deeper than 1,000 feet and penetrates anorthosite-gabbro complex, the multiple rock mass aquifer system and groundwater pressure trends exhibited in the Core Hole E1-B1 VWP are superimposed to estimate the groundwater pressure at the elevation of the tunnel envelope.

Table 6-3 Descriptors for Groundwater Pressures

Descriptor	Approx. Groundwater Pressures		
	feet-head	psi	bar
Low	<175	<75	<5
Moderate	175-350	75-150	5-10
High	350-850	150-370	10-25
Very High	850-1,175	370-510	25-35
Extremely High	>1,175	>510	>35

Figure 6-5 presents a summary of the anticipated groundwater pressures. Based on the limited data and our interpretations, the E1 and E2 alignments have three to five times the lengths of tunnel where the groundwater pressures are anticipated to be very high to extremely high, compared to the SR14 alignment,. The highest anticipated groundwater pressures for portions of the SR14, E1, and E2 alignments are anticipated to be as high as 50 bar (SR14 Station 1626+00), 50 bar (E1 Station 1278+00) and 60 bar (E2 Station 1328+00), respectively.

Figure 6-5 Summary of Anticipated Groundwater Pressures

6.4 Intact Rock Strength

The intact rock strength is a key feature to consider for tunnel mining and support. Where the intact rock is strong and the rock mass is unfractured, the advance rate of the TBM may be slower as it can take more time and effort to chip and digest this material at the excavation face. However, a strong and unfractured rock mass is less disturbed by the excavation process and may require less support. In zones of intact rock, grippers on the TBM can also be used to help provide thrust for the TBM. Intact rock strength will vary for the various geologic units with weathering grade and proximity to faults.

Intact rock strength data is obtained from the six core holes within the ANF, published information for similar geologic conditions, and our previous project experience. Table 6-4 summarizes the descriptors used for the anticipated intact rock strength conditions for the ANF tunnels (Appendix A). Figure 6-6 presents a summary of the anticipated intact rock strength conditions for the ANF tunnels. Based on our interpretations, the overall intact rock strength is greater for the E1 and E2 tunnels as these traverse more of the crystalline igneous and metamorphic rock of the San Gabriel Mountains. However, the E1 and E2 tunnels have longer reaches of tunnel in very soft to moderately soft rock.

Table 6-4 Descriptors for Intact Rock Strength

Rock Grade	ISRM Descriptor	Caltrans or USBR Descriptor	Unconfined Compressive Strength of Intact Rock (σ_c)
			MPa
R0	extremely weak	very soft	0.25-1.0
R1	very weak	soft	1.0-5.0
R2	weak	moderately soft	5.0-25
R3	medium strong	moderately hard	25-50
R4	strong	hard	50-100
R5	very strong	very hard	100-250
R6	extremely strong	extremely hard	>250

Source: Adapted from ISRM, 1978 and Caltrans, 2010.

Figure 6-6 Summary of Anticipated Intact Rock Strength

6.5 Rock Mass Conditions

The rock mass conditions are another key feature to consider for tunnel mining and. Rock mass conditions are used to predict ground conditions (i.e. how the ground behaves during and shortly following the excavation process), and to design the TBM and tunnel lining system. These conditions can also be used to estimate TBM advance rates, grouting characteristics, and to develop other rock mass properties for seismic engineering.

Rock mass data are obtained from the six core holes within the ANF, published information for similar geologic conditions, and our previous project experience. Table 6-5 and Table 6-6 summarize the descriptors developed by Bieniawski (1989), Hoek et al. (1995) and Barton et al. 1978) used for the anticipated rock mass conditions for the ANF tunnels (Appendix A). Rock Mass Rating (RMR) and Geological Strength Index (GSI) are closely related rock mass characterization/classification systems (Table 6-5). In treatment of the rock mass properties, the rock mass quality (Q) is not as closely related to RMR or GSI, but is roughly correlated using the following relation (Bieniawski, 1993):

$$RMR = 9 \ln Q + 44$$

Therefore, in interpreting rock mass conditions, we have considered RMR and then correlated these to Q using the descriptor ranges and the relation cited above.

Table 6-5 Descriptors for RMR and GSI

RMR or GSI	Rock Classes	Description
0-20	I	Very Poor
21-40	II	Poor
41-60	III	Fair
61-80	IV	Good
81-100	V	Very Good

Source: Bieniawski, 1989.

Table 6-6 Descriptors for Q

Q	Rock Classes	Description
0.001-0.004	G	Exceptionally Poor
0.004-0.1	F	Extremely Poor
0.1-1	E	Very Poor
1-4	D	Poor
4-10	C	Fair
10-40	B	Good
40-100	A	Very Good
100-400	A	Extremely Good
400-1000	A	Exceptionally Good

Source: Barton et al., 1994.

Figure 6-7 presents a summary of the anticipated rock mass conditions according to RMR for the ANF tunnels. Based on limited data and our interpretations, the overall rock mass conditions are only slightly more favorable for the E1 and E2 tunnels. However, the sum of tunnel sections in very poor to poor rock mass for E1 and E2 is longer than the sum of tunnel sections in very poor to poor rock mass for SR14 by over 10,000 feet.

Figure 6-7 Summary of Anticipated Rock Mass Conditions

6.6 In-Situ Stress

The in-situ stress conditions are important for feasibility as stresses affect tunnel mining and support requirements. Anisotropic stress fields may result in TBM steering difficulties, instabilities in short spans that are temporarily unsupported, or overstressing of tunnel support. In-situ stress is governed by the lithostatic stress, which is the overlying weight of the rock mass (i.e., the average unit weight including the intact rock, joints, groundwater and infill), and in some cases tectonic stresses caused by active faults or other geologic structures (e.g., antiforms, synforms, etc.)

As described in the Draft GDR (Authority, 2016), in-situ stress testing was performed in two core holes (Core Hole E1-B1 and ALT-B3) as part of the ANF investigation. The purpose for in-situ stress testing is to establish the magnitude and orientation of the principal stresses. Orienting the tunnel parallel to the maximum horizontal stress (σH) has advantages in terms of tunnel support as this stresses the lining axially (compression) instead of diametrically (e.g., both compression and tension). Conversely, orienting the tunnel parallel to σH may result in greater ground loads at the excavation face. However, this is still more desirable than having larger ground loads in the sidewalls. In a gravitational stress field, the vertical (σv) or lithostatic stress is the major principal stress ($\sigma 1$). Therefore, the intermediate ($\sigma 2$) and minor principal ($\sigma 3$) stresses are both oriented perpendicular to $\sigma 1$ and each other in the horizontal plane. In this scenario, the minimum horizontal stress (σh) is $\sigma 3$ and the maximum horizontal stress (σH) is $\sigma 2$.

The test results from Core Hole E1-B1 over several intervals indicate the stress field within the anorthosite-gabbro complex are likely gravitational. Therefore, $\sigma 1$ can be estimated from the thickness of overburden and the total unit weight of the rock mass. For hard to extremely hard, moderately fractured to unfractured, crystalline rock mass, we estimate the total unit weight of the rock mass to be on the order of 1.20 to 1.25 psi per foot. The lateral earth pressure coefficients (Ko,H and Ko,h) were estimated to range from 0.57 to 0.67. At Core Hole E1-B1, the orientation of the maximum horizontal stress (σH) is potentially northwest-southeast (approximately 136 to 316 degrees). At Core Hole ALT-B3, in-situ testing was only successful over a single interval of about 20 feet. From the tests within this interval, the σH was larger than the estimated lithostatic or vertical stress (σv). This indicates a non-gravitational or tectonic stress field. These results suggest $\sigma 1 = \sigma H$, $\sigma 2 = \sigma v$, and $\sigma 3 = \sigma h$. In terms of lateral earth pressure coefficients, which are defined as the ratio of the vertical to lateral stress (Ko,H or h = σv / σH or h), these were 1.23 and 0.93. The orientation of σH at Core Hole ALT-B3 is potentially northeast-southwest (approximately 50 to 230 degrees).

For defining in-situ stress conditions on the geologic profiles and anticipated tunnel conditions (Appendix A), we utilize the descriptors in Table 6-7 that are related to the thickness of overburden and a range of $\sigma 1$. Where the stress field is tectonic, $\sigma 1$ may not be vertical (i.e., the lithostatic stress), the stress field may be highly anisotropic, and stress conditions may change abruptly depending on lithology.

Table 6-7 Descriptors for In-Situ Stress

Descriptor	Cover	Major Principal Stress (σ_1)	Other
	feet	psi	
Low	<250	<300	▪ Gravitational stress fields with low cover ▪ Non-gravitational stress fields with low σ_1
Moderate	250-1,000	300-1,200	▪ Gravitational stress fields with moderate cover ▪ Non-gravitational stress fields with moderate σ_1
High	1,000-2,000	1,200-2,400	▪ Gravitational stress fields with high cover ▪ Non-gravitational stress fields with high σ_1
Very High	>2,000	>2,400	▪ Gravitational stress fields with very high cover ▪ Non-gravitational stress fields with very high σ_1
Tectonic	*Any	*Any	▪ Stress field is non-gravitational, anisotropic, and can change abruptly depending on the competency of the geologic units and their distribution

Figure 6-8 presents a summary of the anticipated in-situ stress conditions for the ANF tunnels. Based on limited data and our interpretations, E1 and E2 have the greatest length of tunnels where the in-situ stress is anticipated to be high to very high. The maximum overburdens for the SR14, E1 and E2 tunnels are approximately 2,100 feet (i.e., SR14 Station 1626+00 and E1 Station 1167+00) and 2,650 feet (i.e., E2 Station 1338+00).

Figure 6-8 Summary of Anticipated In-Situ Stress

6.7 Ground Conditions

In the tunnel industry, ground condition is a term used to describe how the ground responds during or shortly following excavation. The ground conditions affect the feasibility with respect to the mining and support requirements and are related to the geomechanical properties of the geologic units or rock mass conditions, the in-situ stress, groundwater conditions and the excavation method. There are different descriptors that are applied to soil (Tunnelman's Ground Classification) and rock (Squeezing Degree). In some conditions, e.g. where the rock mass is faulted or weathered, the rock mass may be reduced to intermediate geomaterials that behave more similar to soil. Therefore, we've adopted descriptive terms compiled by Singh and Goel (1999), which include terms that are commonly used for rock or soil (Table 6-8).

For the ANF tunnels, squeezing is likely an important factor in tunnel feasibility. Squeezing occurs where the rock mass strength (σc) is substantially less than the reconfiguration of the stress (i.e., post-excavation stress) around the openings at the excavation face and sidewalls, the rock surrounding the TBM or lining can deform inward elastically and plastically (i.e., tunnel closure) following excavation. If this deformation is not accounted for in the design, the TBM may become frozen in the ground, or the lining could become overstressed. Although the mechanisms are different, the ground response from swelling is similar to squeezing, as swelling can result in tunnel closure and TBM entrapment. In general, substantial lengths of tunnel with ground conditions that describe soil and intermediate geomaterials occur in areas of lower in-situ stress. Therefore, these are not considered as being as critical to the tunnel feasibility. These and other ground conditions used as descriptors for the ANF tunnels (Appendix A) are summarized in Table 6-8.

Our interpretations of the ground conditions, based on the limited data, are derived from the six ANF coreholes, published information regarding the geologic units, and previous project experience. Figure 6-9 presents a summary of the anticipated squeezing ground conditions for the ANF tunnels. Based on our interpretations, the E1 and E2 tunnels are anticipated to have longer lengths of tunnel within moderate to heavy squeezing ground than the SR14 tunnel.

Figure 6-9 Summary of Anticipated Ground Conditions

Table 6-8 Descriptors for Ground Conditions

Ground Condition Description	Potential Materials	Excavation Behavior	Design and Construction Considerations
Self supporting	Unfractured to slightly fractured, hard rock mass	▪ Adequate stand-up time to install support ▪ Does not require initial support	▪ Identify potential wedges, rock blocks in crown and walls requiring reinforcing as necessary during mining
Firm	Stiff, cohesive or strongly cemented soil or soil-like material	▪ Adequate stand-up time to install support ▪ Does not require initial support	▪ Identify potential zones where degree of cementation is less that have the potential to run or flow

Ground Condition Description	Potential Materials	Excavation Behavior	Design and Construction Considerations
Non squeezing	Slightly to moderately fractured, hard rock mass with a stress to strength ratio less than 1	▪ Adequate stand-up time to install support ▪ Does not require initial support	▪ Install tunnel support with delay necessary to allow release of strain-energy within rock mass
Ravelling	Intensely to very intensely fractured rock mass or stiff, cohesive or weakly to moderately cemented soil under moderate to high stress	▪ Blocks drop from the face, crown or walls shortly after excavation. ▪ Inadequate stand-up time to install support ▪ Requires initial support, limiting unsupported spans, and/or rapid installation of support	▪ Install initial support shortly after excavating to prevent overbreakage ▪ Heavy crown and wall pressures should be considered in design
Mild squeezing	Slightly to moderately fractured, soft to hard rock mass with a stress to strength ratio greater than 1 and less than 5	▪ Inadequate stand-up time to install support ▪ Excavation deforms plastically decreasing the tunnel diameter (closure) on the order of 1 to 3%.	▪ Install initial support shortly after excavating to prevent heaving in invert of tunnel ▪ Install tunnel support with little delay ▪ Side pressure should be considered in design
Moderate squeezing	Intensely to very intensely fractured, or soft rock mass with a stress to strength ratio greater than 1 and less than 5	▪ Inadequate stand-up time to install support ▪ Rate of closure is more rapid than mild squeezing ground with a closure magnitude on the order of 3 to 5%	▪ Initial support should be installed as early as possible to reduce the rate of closure or to limit closure ▪ Tunnel excavation diameter should be increased to allow for desired closure ▪ Wall pressure should be considered in design ▪ Instrumentation is essential
High (Heavy) squeezing	Rock mass or soil with a stress to strength ratio greater than 5	▪ Inadequate stand-up time to install support ▪ Rate of closure is more rapid than moderate squeezing ground with a closure magnitude > 5% ▪ Excavation deforms irregularly resulting in irregular cross-section	▪ Initial support should be installed as early as possible to reduce the rate of closure or to limit closure ▪ Tunnel excavation diameter should be increased to allow for acceptable closure ▪ Invert support should be installed as early as possible to mobilize support capacity ▪ TBM steering may be difficult ▪ Instrumentation is essential

Ground Condition Description	Potential Materials	Excavation Behavior	Design and Construction Considerations
Swelling	Rock mass or soil with expansive clay minerals that have natural moisture contents near or less than their liquid limit	▪ Expansive clays absorb water and expand volumetrically resulting in some degree of tunnel closure or swelling pressure where support is placed in advance of swelling	▪ Tunnel excavation diameter should be increased to allow for expected swelling ▪ Measures should be made to limit moisture being absorbed by swelling clay during and following construction ▪ Tunnel closure should be measured
Running	Decomposed to highly weathered, very intensely fractured to earthlike unsaturated rock mass or cohesionless soil or soil-like material	▪ Blocks, grains or particles fall or "run" into tunnel from the face, invert, crown or walls	▪ Forepoling, grouting or other ground improvements may be necessary to stabilize ground and reduce the risk of mining-in-place ▪ Excavated volumes and advance should be monitored closely
Flowing	Decomposed to highly weathered, very intensely fractured to earthlike saturated rock mass or cohesionless soil or soil-like material, usually under water pressure	▪ Mixture of rock or soil and water material flows into tunnel like a viscous fluid from the face, invert, crown or walls	▪ Forepoling, grouting or other ground improvements may be necessary to stabilize ground and reduce the risk of mining-in-place ▪ Dewatering ahead of excavation to reduce water pressure ▪ Excavated volumes and advance should be monitored closely
Rock bursting, Slabbing, Spalling	Unfractured to very slightly fractured, hard rock mass under moderate to high stress	▪ Portions of massive, unsupported rock explode, elastically deform rapidly, or pop from unsupported areas of the face, invert, crown or walls	▪ Rock anchors installed in portions of tunnel where slabbing is evident or where there is a delay before installing support ▪ Micro-seismic monitoring essential

Source: Singh et al., 1999.

6.8 Fault Zones

Three wide fault zones intersect the tunnel alignments as illustrated in the drawings in Appendix A. These wide fault zones are San Gabriel fault, Sierra Madre fault (north), and the Sierra Madre fault (south). The wide fault intersections consist of multiple smaller faults and several wide fault gouge zones consisting of clay and silt gouge, rock flour and crushed rock. Adjacent to the fault gouge are zones of crushed and sheared rock, weathered rock and highly fractured and jointed rock. Joint infillings may be clay and silt as well as crushed rock with some healed by carbonate. The degree of jointing and fractured rock usually decreases away from the fault gouge zone until the rock mass escapes the imprint of deformation and weathering associated with the fault zone. This is usually a few hundred feet of transition to intact rock mass. Other smaller faults also intersect the tunnel alignments to differing degrees as shown on the drawings (Appendix A). The smaller fault zones are similar to the wide fault zones in appearance with a narrower core of fault gouge and narrower zones of sheared and brecciated rock adjacent to the gouge zone. Primarily the difference between faults is the width of the fault zone in the rock mass as it intersects the tunnel. The width can appear wider than the actual fault width if the tunnel intersects the fault at a small angle. For evaluating feasibility of tunnel construction, three fault widths (I, II, and III) have been labeled on the drawings (Appendix A) to distinguish those faults to be considered for construction feasibility as follows.

I – Fault width that is <20 feet (<10 feet on either side of gouge zone). Fault width Category I is not expected to cause difficulties for mining or TBM operation except for limited wedge or block failures resulting from the fault and joint intersection geometries. Small increases of groundwater flow should be anticipated along the fault with the potential for the fault causing a groundwater barrier in the host rock.

II – Fault width that is approximately 20 to 100 feet (10 to 50 feet on either side of gouge zone), and is usually one fault strand of a named fault (e.g. Transmission Line fault and Lone Tree fault). Category II width faults will result in noticeable increases in groundwater flow and will likely result in a groundwater barrier in the host rock. Some convergence of the tunnel may be expected but will be of limited extent.

III – Fault width that is approximately 100 to 200 feet (50 to 100 feet on either side of gouge zone), and contains substantial gouge zone(s). A single named fault (e.g. San Gabriel fault) may have multiple fault strands in this category that when combined are an additive width. Fault width Category III will be most challenging for mining and for TBM operation. Tunnel wall convergence should be expected accompanied by high groundwater flows into an open tunnel adjacent to the fault zone. Depending on the depth below ground, high groundwater pressures may occur at the tunnel depth. Other likely ground conditions may include running ground and flowing ground. The anticipated ground conditions will be the most challenging of the three fault width categories.

6.9 Summary of Tunneling Conditions

A summary of the tunneling conditions for each of the proposed alternative alignments within ANF is presented in Table 6-9.

Table 6-9 Angeles National Forest Tunneling Conditions Summary

Tunneling Condition Description	SR14 Alignment	E1 Alignment	E2 Alignment
Total All Tunnel Lengths for Entire Project (mi)	24.27	23.32	22.6
Number of All Portals	Ten	Four	Six
ANF Tunnel Lengths (mi)	7.22	18.75	18.79
Number of Narrow-Width Faults (I) / Net Width (ANF)*	Nine / 180 Feet Net Width	Three / 60 Feet Net Width	Six / 120 Feet Net Width
Number of Medium-Width Faults (II) / Net Width (ANF)*	Two / 200 Feet Net Width	None / 00 Feet Net Width	One / 100 Feet Net Width
Number of Wide Faults (III) / Net Width (ANF)*	Four / 800 Feet Net Width	Four / 800 Feet Net Width	Thirteen / 2,600 Feet Net Width

tunnels guaranteed to leak

Tunneling Condition Description	SR14 Alignment	E1 Alignment	E2 Alignment
Total Width of Gouge, Crushed and Sheared Rock Zones (ANF)	1,180 Feet	860 Feet	2,820 Feet
Maximum Distance between Sierra Madre fault zone traces (north and south segments)	2.85 Miles	2.75 Miles	1.45 Miles
Maximum Distance between San Gabriel fault zone traces	1.2 Miles	0.4 Miles	1.2 Miles
Approximate Overburden at San Gabriel Fault	1,600 Feet	700 Feet	1,700 Feet
Maximum Overburden	2,060 Feet	2,060 Feet	2,650 Feet
Tunnel Length with pressures above 25 Bar and less than 35 bar	0.6 Miles	2.6 Miles	2.1 Miles
Tunnel Length with pressures above 35 Bar	1.0 Mile	4.3 Miles	4.5 Miles
Known Springs, Wells in ANF, and HSRA Monitoring Points Within One Mile	Two Inactive Wells No Springs ALT-B2 and ALT-B3	One Active Well Three Springs E1-B1, E1-B2, and FS-B1	Three Inactive Wells One Active Well Nine Springs FS-B1 and C-1

*Narrow-Width Faults assumed to be less than 20 feet of gouge, sheared and crushed rock (Category I); Medium-Width Faults assumed to be 20 to 100 feet of gouge, sheared and crushed rock (Category II); Wide Faults assumed to be 100 to 200 feet of gouge, sheared and crushed rock (Category III). Net width is the sum of widths of individual fault widths.

7 TUNNEL FEASIBILITY EVALUATION

During the selection and evaluation of potential tunnel alignments through the Angeles National Forest, major conditions affecting tunnel feasibility were identified and discussed between the Regional Consultant (RC) and HSRA (Authority). Many of the conditions have been documented to varying degrees in historical southern California projects that have encountered adverse conditions affecting tunnel design and construction methods, and impacts to groundwater, surface water and habitats. All of the concepts and criteria discussed in this study are preliminary and for feasibility level assessments. More detailed geotechnical investigations and engineering evaluations will be required to establish design parameters, construction methodology, and mitigation measures for the selected alignment.

7.1 ANF Feasibility Assumptions

During the initial stages of the feasibility evaluation, the Authority developed several design guidelines as Technical Memoranda (TM) to be used in the feasibility evaluations. These TMs provided guidelines concerning the location of the ANF tunnel alignment and profile, intersections with Hazardous faults, potential water pressures, avoidance of environmental constraints, and adverse ground conditions.

The key criteria and assumptions considered in the ANF tunnel alignments feasibility evaluation include the following:

- Watertight tunnel linings designs have been successfully constructed to withstand 25 bar of sustained groundwater pressure (approximately 360 psi or 850 feet of hydraulic head);
- Both drained and undrained tunnel lining designs are possible;
- Unless the lining design and construction technology can be improved, it is likely that groundwater leakage cannot be prevented along the entire reach of any of the ANF tunnels; and
- Fault displacements can be accommodated by design for specified displacement magnitude and slip direction.

7.2 Tunnel Design and Construction Constraints

The feasibility of tunnel design, excavation and support is largely governed by the ground conditions, and groundwater pressures and inflows during tunnel construction and/or operation. Typically, in long tunnels, using TBM and a pre-cast concrete lining system is the most economical because of cost and schedule. However, in most tunneling projects, appurtenant tunnel components (i.e., cross passages, utility chambers, etc.) are constructed using a variety of methods (e.g., drill and blast, mechanized mining using a shield and roadheader, etc.) and support systems (e.g., shotcrete and rockbolts, steel sets, truss systems, etc.).

7.2.1 Ground Conditions

The ANF tunnels will encounter a wide spectrum of ground conditions ranging from soft ground to hard rock conditions. The ground conditions are governed by the geologic units (i.e., lithology or alluvial sediments), geologic structures, in-situ stress, groundwater conditions, rock mass conditions, and excavation methods. With respect to the feasibility of the ANF tunnels, the most adverse ground conditions are likely zones of heavy (high) squeezing in proximity to faults where the rock mass surrounding the tunnel "squeezes" causing tunnel closure (convergence) of 5 percent or more. In such conditions, it may be necessary to install temporary reinforcing to maintain safety and control the rate of closure, and allow some degree of deformation to occur before installing the final support. The excavation diameter within these zones should carefully consider the ground load and tolerable deformation for the tunnel lining system.

The ground conditions should be carefully considered in the TBM selection and design. Based on the anticipated ground conditions, the more adverse ground conditions (i.e., squeezing, high groundwater pressure) will likely require a TBM that can operate in closed-mode [e.g., an Earth Pressure Balance (EPB) TBM, Slurry TBM, or Crossover TBM]. Such TBM technologies have been successfully used to mine tunnels subjected to groundwater pressures as high as 11 to 15 bar (Hallandsas Tunnel, Sweden and Lake Mead Tunnel, Nevada). To avoid the risks of the TBM becoming frozen (entrapped), the TBM and lining system should be designed such that the thrust necessary to overcome shield friction from squeezing ground can be accommodated.

7.2.2 Groundwater Pressures

The maximum groundwater head (pressure) of about 850 feet (25 bar) assumed for the conceptual tunnel lining is considered state-of-the-art for a watertight, precast, segmental lining for the proposed tunnel diameter. Therefore, development and testing of lining systems for pressures greater than 25 bar (360 psi) and a watertight lining requirement is needed to mitigate groundwater impacts. Based on conceptual design considerations, the TBM-excavated tunnels would be lined with a one-pass system, consisting of bolted and gasketed precast concrete segments with the capability to resist approximately 25 bar of groundwater pressure; the concrete segments would have an effective hydraulic conductivity of approximately 1x10-8 centimeter per second (cm/sec). As a result, where the external groundwater pressure is 25 bar or less, inflows into the completed tunnel are considered negligible.

Where groundwater pressure exceeds 25 bar, it is assumed that the lining would leak, or be designed to leak, to the extent that the maximum external water pressure would be limited to 25 bar or less.

7.2.3 Groundwater Flow Potential

Drainage of groundwater from the rock mass into the tunnels can occur during construction, and also after the tunnels are completed if the lining is not watertight. The amount of drainage that occurs during construction will be dependent on the hydraulic conductivity of the rock mass, depth of the tunnel relative to the groundwater level (i.e. pressure) above the tunnel, and the construction methods used. The extent to which water drains from the rock mass following construction will be dependent on the ability of the tunnel's final lining system to resist the hydrostatic pressure. However, a small amount of leakage is inevitable for most lining systems.

At tunnel depths within the ANF, the rock mass generally has a low to very low hydraulic conductivity. The shallow zones have moderate to low hydraulic conductivity. Therefore, groundwater flow through the rock mass is generally expected to occur at a slower rate at depth than near the ground surface. This condition could be favorable in terms of limiting the potential effects that tunnel construction could have on water resources in the vicinity of the project. However, locally, more intensely fractured zones may have higher hydraulic conductivity and allow more rapid water flows through the affected rock. This is assumed to occur in association with fault zones.

Fault, shear, or fracture zones that are present in the rock mass typically have higher conductivity than the general rock mass. Where crossed by the tunnels, such fracture zones could introduce relatively high water flows into the tunnels, causing significant hazards and/or difficulty during construction. Under the assumption that a TBM will be used to excavate the tunnels, inflows may come from the heading area (the zone around the TBM ahead of where the tunnel lining is installed) and through the completed tunnel lining.

The main method for mitigating tunnel flooding is through probing and pre-excavation grouting. According to the Tunnel Safety Orders of the CCR, Cal-OSHA requires a minimum of 20 feet of tested ground ahead of the excavation face in tunnels where there is a likelihood for dangerous accumulations of water, gas or mud within 200 feet of the working area. If the ANF Tunnel Alignments are constructed using TBMs that apply a positive face pressure, tunnel flooding is prevented so long as the TBM operating pressure is greater than the groundwater pressure in the vicinity of the excavation. Additional precautions may be necessary (e.g., using compressed air) during TBM intervention (mandatory access to the TBM cutterhead) or maintenance when the tunnel is not being advanced for prolonged periods of time and groundwater pressures begin to recover. Once the tunnel is completed, the cast in place or gasketed tunnel lining system is designed to prevent leakage through the lining system.

7.2.4 Gassy Ground Mitigation

Once a preferred tunnel alignment has been selected and a preliminary investigation is completed, the CCR Subchapter 20 Article 8 require a tunnel classification be obtained from Cal/OSHA with respect to flammable gas or vapors. Depending upon the Cal/OSHA classification, various gas monitoring and ventilation methods may be required during tunnel construction and operation. Based on the limited data available at this time, the potential for gassy ground within the ANF may exist. The risk for gassy ground is higher for tunnel lengths within or overlying Modelo Formation, which is known as a source of gas, and oil within southern California. However, conventional tunneling methods and ventilation systems appear to be feasible to mitigate gas and ventilate the tunnels during construction and operations.

7.2.5 Corrosive Groundwater Mitigation

Based on the limited groundwater chemistry tests from samples of groundwater within the ANF, the potential for corrosive ground and groundwater exists. Corrosive ground and groundwater can be mitigated by the use of corrosion resistant concrete mix and admixtures. As more information and data is collected for the selected tunnel alignment, project-specific designs would need to consider the effects of corrosion on the tunnel structures and components.

8 SUMMARY AND PRELIMINARY CONCLUSIONS

Following is a summary of the geotechnical feasibility evaluation of the ANF Tunnel Alignments through the San Gabriel Mountains, preliminary findings, and conclusions. The significant tunneling and ground conditions are summarized in Table 6-9 (Section 6.9 of this report).

Based on the results from a limited field investigation, the geologic and hydrogeologic conditions along the tunnel alignments present significant design and construction challenges.

Design and construction challenges within the ANF could be overcome with adequate site characterization and proper planning and design. Specifically, the major challenges are:

- Squeezing ground will be encountered, affecting TBM performance and possibly forcing TBM rescues.
- Active fault zones intersect the tunnel alignments resulting in the need for special designs for tunnel linings and enlarged tunnel sections to accommodate fault displacement for track realignment.
- High groundwater pressures on the tunnel lining system would require a thickened and high strength concrete lining system and TBMs with closed-mode capability.
- High groundwater flows and pressures will be encountered at faults and sheared rock zones. Release of pressures during construction may be necessary.

8.1 Ground Conditions

Squeezing ground conditions are expected to occur in the deeper sections of tunnel and in proximity to wide fault zones that are intersected by tunnel. In order to overcome the squeezing ground conditions, geologic investigations must thoroughly evaluate ground conditions within lengths of tunnel with high overburdens and at major fault zone crossings (e.g., width Category III). An enlarged bore and/or construction methods may need to be compatible with or capable of overcoming or avoiding squeezing pressures. In some cases, ground improvement may be feasible to stabilize squeezing ground ahead of tunnel excavation. It is not expected that squeezing ground poses a feasibility risk if anticipated and planned for in advance. Future design and construction planning should include contingencies for conducting TBM rescues in the event that one becomes frozen (entrapped).

Tunnels crossing active faults are subject to fault displacement causing offset of the tunnel structure below ground due to relative displacement across a fault or fault zone. Fault displacements can be accommodated by design for specified displacement magnitude and slip direction. These include use of enlarged tunnel sections and/or fault chambers. Restoration of a tunnel would require realignment or smoothing of the offset of the tunnel and repair of the lining system. For high-speed train projects, the track realignment would require track straightening or curvature restoration within the tunnel diameter (or chamber) to allow the train to maintain required speed for the project.

8.2 Hydrologic and Hydrogeologic Conditions

The hydrologic and hydrogeologic conditions along and adjacent to the tunnel corridor pose two major feasibility challenges as follows: 1) impacts on the groundwater and surface water resources are undesirable and would require mitigation; and 2) groundwater pressures greater than 25 bar pose challenges to tunnel excavation and support.

Tunneling will tend to provide a conduit for groundwater to drain into the excavation as the advancing tunnel intersects fractures and faults within the crystalline rock terrain below the ANF. Based on the general understanding of the groundwater system within the crystalline bedrock from the limited geotechnical investigation, the near surface water resources appear to respond more rapidly to annual precipitation and will likely respond to tunnel construction within the shallow groundwater zones along the tunnel alignments. The magnitude of potential impacts to shallow groundwater resources and surface water would depend upon the total volume of groundwater that flows into the tunnel during construction and the potential rate of recharge due to precipitation. Since the deeper rock zones generally exhibit lower hydraulic conductivity than shallower zones, recharge from shallow zones vertically downward will likely exceed the rate of drainage/leakage from rock mass surrounding the tunnel lining.

The groundwater encountered at the deeper tunnel profiles (e.g., below 1,000 ft depth) tends to respond slower to water drainage due to the generally tighter rock fractures and resultant lower hydraulic conductivities. It also appears that rock at greater depths contains confined zones of groundwater that occur in pockets or zones (compartmentalized) of more fractured rock separated by less fractured rock. This results in confined aquifers being isolated from the shallow resources by zones of very low hydraulic conductivity rock. Tunneling in these deeper sections are not expected to influence the shallower groundwater systems or surface water resources.

In portions of tunnels where groundwater pressure is less than 25 bar, tunnel lining designs could eliminate water leakage into the tunnel once tunnel construction is completed. Thus the shallow groundwater, which is most susceptible to impacts of water draining into the tunnel, would be isolated from the tunnel effects by design of the tunnel lining. The tunnel lining would be watertight and the groundwater system would begin to recover rapidly to pre-tunnel conditions.

In zones of tunnels where the groundwater pressure is greater than the assumed limit of 25 bar, the tunnel lining system will need to be designed to reduce the external hydrostatic pressures by allowing controlled drainage of water from around the tunnel lining. The continuous drainage of water will need to be controlled to balance the maximum pressure on the tunnel lining system versus the minimum amount of water drainage needed to maintain the design pressure. The amount of water drainage for pressure relief purposes will need to be evaluated along all tunnel sections affected by groundwater pressures over 25 bar. The rate of groundwater losses can be minimized by grouting the native rock to lower its hydraulic conductivity immediately around the tunnel lining. This will accomplish two objectives: 1) Will maintain a lower recharge rate in the grouted zone in contact with the tunnel lining while allowing a higher recharge rate outside the grouted zone; and 2) Will minimize losses of water into the tunnel with minimal impact on the bedrock groundwater system.

Although a groundwater pressure of 25 bar is the current state-of-the-art for a watertight tunnel lining, development and testing of a lining system that can withstand higher pressures is possible and the actual maximum design pressure is unknown. Specific design concepts may be developed to increase the maximum design pressure applicable to this project including the use of new gasket technologies and/or double gasket tunnel lining segments. Alternatively, the use of a two-pass lining system incorporating an impermeable membrane between the interim and final lining is an option for preventing water entry into the tunnel and increasing the tunnel lining strength. Some tunnel sections may need the use of two-pass lining systems especially for enlarged fault chamber sections and at tunnel crossovers.

In summary, anticipated hydrologic and hydrogeologic conditions may be mitigated by use of special design and construction considerations as follows:

- Pre-excavation grouting of the rock ahead of the tunnel excavation can reduce or prevent groundwater drainage into the tunnel. Reducing inflow into the tunnel during construction will reduce the hydrologic and hydrogeologic impacts to the ANF.
- A segmental, precast, concrete lining with bolted and gasketed joints could control groundwater inflows to the tunnel during and after excavation up to certain pressures, as discussed above.
- Although less effective in protecting groundwater and surface water resources, a lining system that allows enough leakage to reduce groundwater pressures on the lining system may be considered as an alternative in specific areas of a final tunnel alignment provided that impacts to water resources do not occur or can be mitigated.

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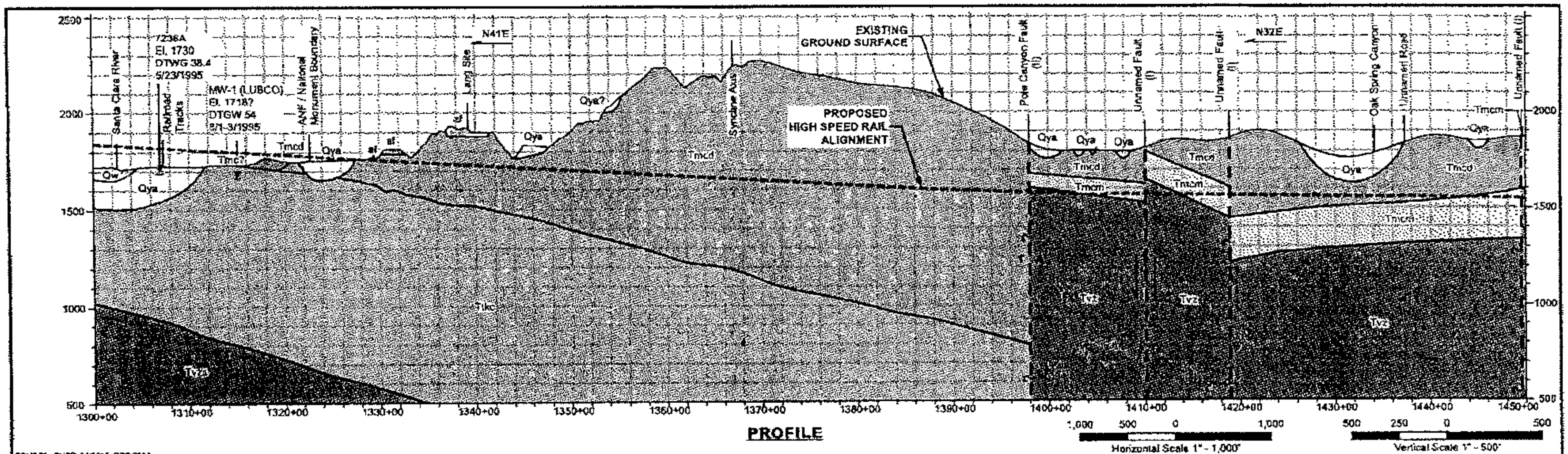
APPENDIX A
GEOLOGIC PROFILES AND ANTICIPATED TUNNEL CONDITIONS



SOURCE: CHSR, 04/2014; CGS 2014.

Tunnel Information		TBM 28' ID				
Formation		Mint Canyon Formation (Tmcd)		Mint Canyon Formation (Tmcro)	Mint Canyon Formation (Tmcd)	Mint Canyon Formation (Tmcro)
Lithology		arkosic sandstone, with conglomeratic sandstone and interbedded siltstone and claystone; tuffaceous and marly		lacustrine/fluvial arkosic sandstone and conglomeratic sandstone with siltstone	arkosic sandstone, with conglomeratic sandstone and interbedded siltstone and claystone; tuffaceous and marly	[illegible]
Fracturing / Bedding / Structure		interbedded, cross bedded		thickly bedded to massive, interbedded, thin beds of limestone in mudstone	interbedded, cross bedded	[illegible]
Key Features / Geologic Hazards		conglomeratic, medium to high abrasiveness		poorly cemented, medium to high abrasiveness	conglomeratic, medium to high abrasiveness	[illegible]
Hydraulic Conductivity (Lugeon)		Low to Moderate (0.01-5)		Low to High (0.01-50)	Low to Moderate (0.01-5)	
Groundwater Head (bar)		Low (<5)	Moderate (5-10)	Low (<5)		Moderate (5-10)
Intact Rock Strength (MPa)		Soft to Hard (1-100)		Very Soft to Mod. Hard (<1-50)		
RMR, GSI		Fair (41-60)		Very Poor to Fair (0-60)		
Q		Very Poor to Fair (0.1-10)		Ext. Poor to Fair (0.004-10)		
In-Situ Stress		Low	Low to Moderate			Moderate
Ground Condition		Ravelling, Running/Flowing	Mild to Mod Squeezing, Swelling, Ravelling, Flowing			

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CALIFORNIA HIGH-SPEED RAIL AUTHORITY
PALMDALE TO BURBANK PROJECT SECTION
SR14 GEOLOGIC PROFILE AND
ANTICIPATED TUNNEL CONDITIONS
STATION 1300+00 TO 1450+00

A1

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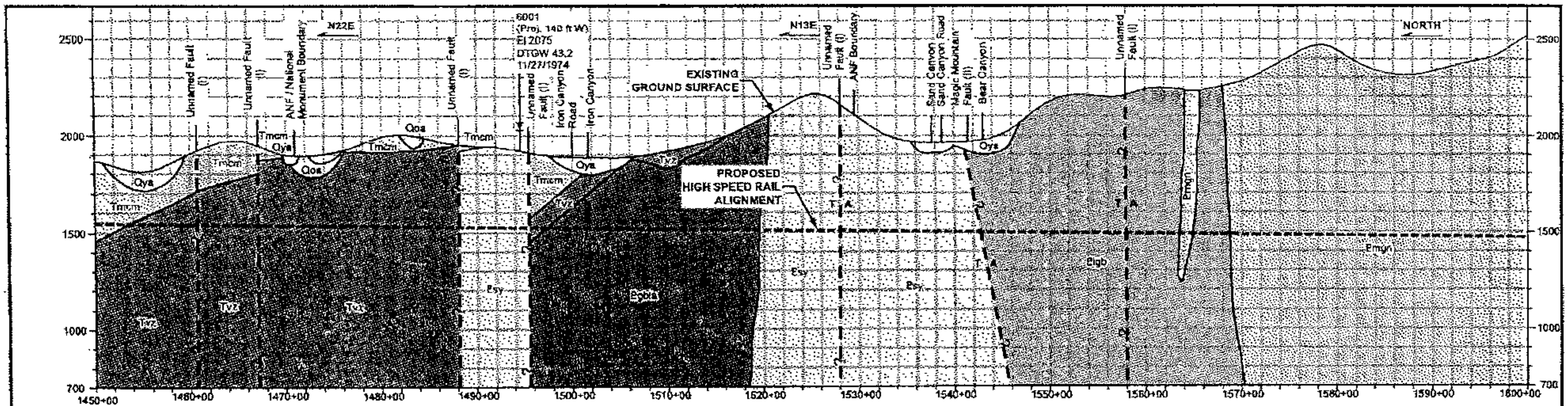

PROFILE

Horizontal Scale 1" - 1,000'

Vertical Scale 1" - 500'

SOURCE: CHSR, 04/2016, CGS 2014.

Tunnel Information		TBM 28' ID				TBM ETD 31.5' ID	
Formation		Vasquez Formation (Tvz)	Anorthosite-gabbro complex - syenite (Psy)	Anorthosite-gabbro complex - anorthosite inclusion-rich gabbro (Pgbla)	Anorthosite-gabbro complex - syenite (Psy)	Anorthosite-gabbro complex - jotunitic gabbro (Pjgb)	Mendenhall gneiss (Pmgn)
Lithology		coarse sandstone, conglomerate and interbedded andesite-basalt	plagioclase feldspar with 10-40% ferro-magnesian minerals	gabbro with numerous inclusions of anorthosite	plagioclase feldspar with 10-40% ferromagnesian minerals.	jotunitic gabbro with antiperthitic andesine	layered migmatitic felsic gneiss and mafic granulite
Fracturing / Bedding / Structure		thickly bedded breccia, interbedded	generally homogenous, however contains some FeMg-rich compositional layering	strongly layered	generally homogenous, however contains some FeMg-rich compositional layering	compositionally layered	compositionally layered, large scale foliations, fracturing and jointing
Key Features / Geologic Hazards		conglomeratic, mega-breccia, high abrasiveness	trace magnetite, high abrasiveness	high abrasiveness	trace magnetite, high abrasiveness	high abrasiveness	extreme abrasiveness
Hydraulic Conductivity (Lugeon)	Low to High (0.01-50)		Very Low to Moderate (<0.01-5)				Low to Moderate (0.01-5)
Groundwater Head (bar)	Moderate (5-10)			High (10-25)			Very High (25-35)
Intact Rock Strength (MPa)	Soft to Hard (1-100)		Mod. Soft to Hard (5-100)				Mod. Soft to Very Hard (5-250)
RMR, GSI	Very Poor to Fair (0-60)		Poor to Good (21-80)				Fair to Good (41-80)
Q	Ext. Poor to Fair (0.004-10)		Very Poor to Good (0.1-40)				
In-Situ Stress	Moderate						Moderate to High
Ground Condition		Moderate Squeezing, Swelling	Mild to Mod. Squeezing				Non to Mild Squeezing

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PALMDALE TO BURBANK PROJECT SECTION
SR14 GEOLOGIC PROFILE AND
ANTICIPATED TUNNEL CONDITIONS
STATION 1450+00 TO 1600+00

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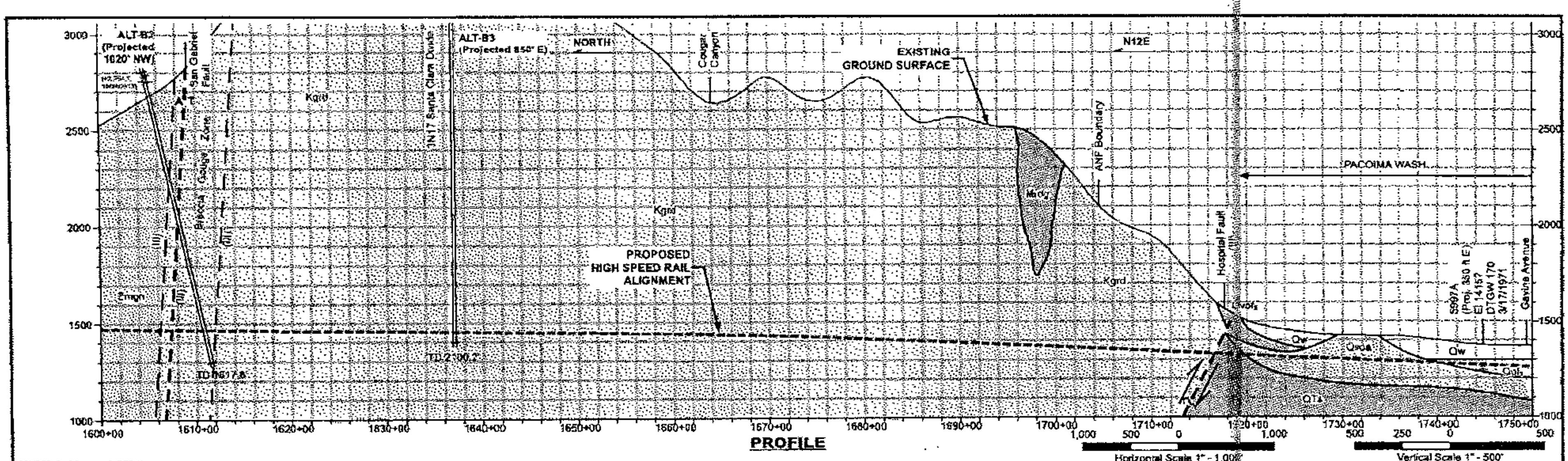

SOURCE: CHSR, 04/2016, CGS/CT 14.

Tunnel Information	TBM ETD 31.5' ID					
Formation		Granodiorite (Kgrd)			[illegible] Formation undivided (QTs)	Very old alluvium, undivided (Qvoa) and old fan deposits (Qof)
Lithology		granodiorite with quartz diorite and granite			[illegible]	silt, sand and gravel
Fracturing / Bedding / Structure		mostly massive, gneissoid near contacts with older rocks			[illegible]	N/A
Key Features / Geologic Hazards		large inclusions and pendants of gneiss and Placerita metasediments, extreme abrasiveness			[illegible]	slightly to moderately consolidated, medium to high abrasiveness
Hydraulic Conductivity (Lugeon)	Very Low to Low (<0.01-1)	Low to Moderate (0.01-5)				Moderate to Very High (5->50)
Groundwater Head (bar)	Very High (25-30)	Ext. High (>35)	Very High (25-35)	High (10-25)	Moderate (5-10)	Low (<5)
Intact Rock Strength (MPa)	Soft to Hard (1-100)	Mod. Soft to Ext. Hard (5->250)			Very Soft to Mod. Hard (<1-50)	N/A
RMR, GSI	Very Poor to Fair (0-60)	Poor to Good (21-80)			Very Poor to Poor (0-40)	N/A
Q	Ext. Poor to Good (0.004-40)	Ext. Poor to Fair (0.004-10)			Ext. Poor to Very Poor (0.004-1)	N/A
In-Situ Stress	High to Very High (Tectonic)	High			Moderate to High (Tectonic)	Low
Ground Condition	Heavy Squeezing, Swelling	Mod. to Heavy Squeezing, Spalling, Slabbing, Rock Bursting	Mild to Mod. Squeezing, Spalling, Slabbing, Rock Bursting			Ravelling, Running/Flowing

IN-PROGRESS SUBMITTAL FOR INTERNAL USE ONLY

NOT FOR CONSTRUCTION

CALIFORNIA High-Speed Rail Authority

CALIFORNIA HIGH-SPEED RAIL AUTHORITY
PALMDALE TO BURBANK PROJECT SECTION
SR14 GEOLOGIC PROFILE AND ANTICIPATED TUNNEL CONDITIONS
STATION 1600+00 TO 1750+00

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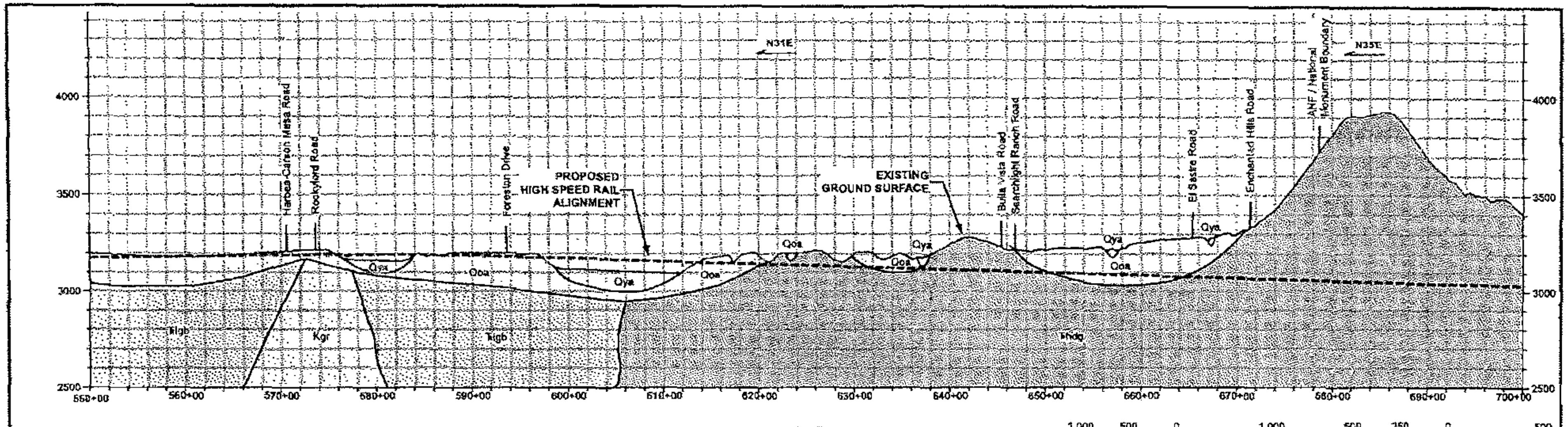

PROFILE

Horizontal Scale 1" - 1,000'

Vertical Scale 1" - 500'

SOURCE: CHSR, 04/2014, CGS 2014.

Tunnel Information								Mined 28' ID		
Formation	Old alluvium, undivided (Qoa)		Old alluvium, undivided (Qoa)		Old alluvium, undivided (Qoa)	Mount Lowe intrusive suite - hornblende diorite gabbro (TRhdg)	Old alluvium, undivided (Qoa)	Mount Lowe intrusive suite - hornblende diorite gabbro (TRhdg)	Old alluvium, undivided (Qoa)	Mount Lowe intrusive suite - hornblende diorite gabbro (TRhdg)
Lithology	silt, sand, gravel, cobbles and boulders		silt, sand, gravel, cobbles and boulders		silt, sand, gravel, cobbles and boulders	hornblende diorite gabbro	silt, sand, gravel, cobbles and boulders	hornblende diorite gabbro	silt, sand, gravel, cobbles and boulders	hornblende diorite gabbro
Fracturing / Bedding / Structure	N/A		N/A		N/A	massive to locally foliated	N/A	massive to locally foliated	N/A	massive to locally foliated
Key Features / Geologic Hazards	unconsolidated to moderately indurated, conglomeratic (some boulders), medium to high abrasiveness		unconsolidated to moderately indurated, conglomeratic (some boulders), medium to high abrasiveness		unconsolidated to moderately indurated, conglomeratic (some boulders), medium to high abrasiveness	high abrasiveness	unconsolidated to moderately indurated, conglomeratic (some boulders), medium to high abrasiveness	high abrasiveness	unconsolidated to moderately indurated, conglomeratic (some boulders), medium to high abrasiveness	high abrasiveness
Hydraulic Conductivity (Lugeon)	Very Low to High (<0.01->50)									Very Low to Moderate (<0.01-5)
Groundwater Head (bar)	Low (<5)									Moderate (5-10)
Intact Rock Strength (MPa)	N/A					Mod. Soft to Hard (5-100)	N/A	Mod. Soft to Hard (5-100)	N/A	Mod. Soft to Hard (5-100)
RMR, GSI	N/A					Poor to Fair (21-60)	N/A	Poor to Fair (21-60)	N/A	Poor to Fair (21-60)
Q	N/A					Very Poor to Poor (0.1-4)	N/A	Very Poor to Poor (0.1-4)	N/A	Very Poor to Poor (0.1-4)
In-Situ Stress	Low									Low to Moderate
Ground Condition	Running					Running/Flowing, Non-Squeezing			Flowing	Non to Mild Squeezing

IN-PROGRESS SUBMITTAL FOR INTERNAL USE ONLY

NOT FOR CONSTRUCTION

CALIFORNIA High-Speed Rail Authority

CALIFORNIA HIGH-SPEED RAIL AUTHORITY
PALMDALE TO BURBANK PROJECT SECTION
E1 GEOLOGIC PROFILE AND
ANTICIPATED TUNNEL CONDITIONS
STATION 550+00 TO 700+00

A2

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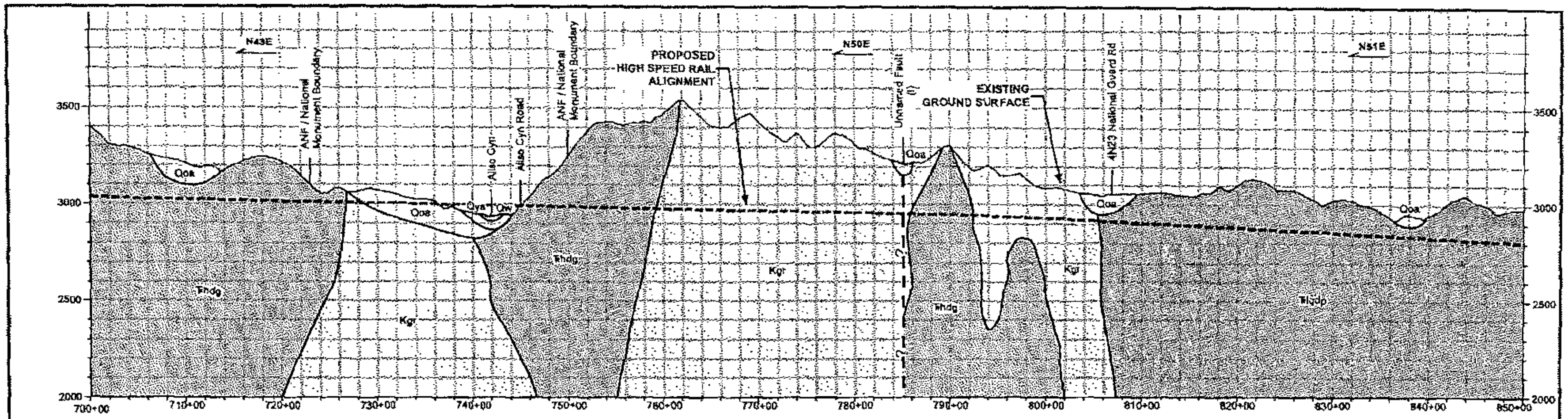

PROFILE

1,000 500 0 1,000
Horizontal Scale 1" - 1,000'

500 250 0 500
Vertical Scale 1" - 500'

SOURCE: CHSR, 04/2016; CGS 2014.

Tunnel Information	Mined 28' ID			Mined 28' ID					
Formation	Mount Lowe intrusive suite - hornblende diorite gabbro (TRhdg)	[illegible]	Old alluvium, undivided (Qoa)		Mount Lowe intrusive suite - hornblende diorite gabbro (TRhdg)	Granitic Rocks (Kgr)	Mount Lowe intrusive suite - hornblende diorite gabbro (TRhdg)	Granitic Rocks (Kgr)	Mount Lowe intrusive suite - porphyritic facies (TRgdp)
Lithology	hornblende diorite gabbro	[illegible]	silt, sand, gravel, cobbles and boulders		hornblende diorite gabbro	quartz monzonite, granodiorite, tonalite, quartz diorite and diorite	hornblende diorite gabbro	quartz monzonite, granodiorite, tonalite, quartz diorite and diorite	Orthoclase phenocrysts in matrix of plagioclase and subordinate quartz; localized garnet
Fracturing / Bedding / Structure	massive to locally foliated	---	---		massive to locally foliated	N/A	massive to locally foliated	N/A	N/A
Key Features / Geologic Hazards	high abrasiveness	[illegible]	[illegible]		high abrasiveness	high to extreme abrasiveness	high abrasiveness	high to extreme abrasiveness	localized garnet, high to extreme abrasiveness
Hydraulic Conductivity (Lugeon)	Very Low to Moderate (<0.01-5)	Low to Very High (0.01->50)	N/A	Very Low to Moderate (<0.01-5)					
Groundwater Head (bar)	Moderate (5-10)	Low (<5)	N/A	Low (<5)	Moderate (5-10)	Low (<5)			
Intact Rock Strength (MPa)	Mod. Soft to Hard (5-100)	N/A	Mod. Soft to Very Hard (5-250)						
RMR, GSI	Poor to Good (21-80)	N/A	Poor to Good (21-85)						
Q	Very Poor to Good (0.1-40)	N/A	Very Poor to Good (0.1-40)						
In-Situ Stress	Low to Moderate	Low	N/A	Low to Moderate					
Ground Condition	Non to Mild Squeezing	Running	N/A	Non to Mild Squeezing	Non Squeezing				

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PALMDALE TO BURBANK PROJECT SECTION
E1 GEOLOGIC PROFILE AND
ANTICIPATED TUNNEL CONDITIONS
STATION 700+00 TO 850+00

A2

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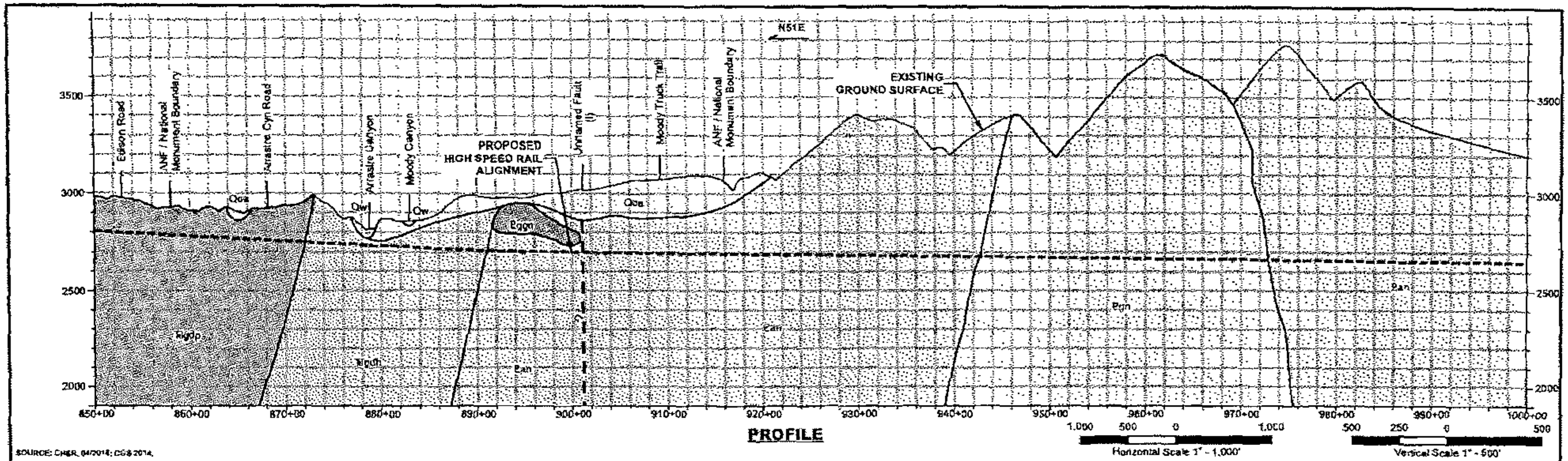

PROFILE

SOURCE: CHSR, 04/2014; CGS 2014.

Tunnel Information	Mined 28' ID	TBM 28' ID			
Formation	Mount Lowe intrusive suite - porphyritic facies (TRigdp)	Mount Lowe intrusive suite - orthoclase-hornblende facies (TRigdh)	Anorthosite-gabbro complex - anorthosite (Pan)	Gneiss (Pgn)	Anorthosite-gabbro complex – anorthosite (Pan)
Lithology	Orthoclase phenocrysts in matrix of plagioclase and subordinate quartz; localized garnet	hornblende diorite	anorthosite, more than 90% plagioclase, less than 10% mafic minerals, occasional quartz dikes	gneiss, biotite-rich and quartz-feldspar-rich lenses	anorthosite, more than 90% plagioclase, less than 10% mafic minerals, occasional quartz dikes
Fracturing / Bedding / Structure	---	---	massive, pervasively sheared, shattered, brecciated. Layering rare, but sparse layering is present	foliated, banded layers generally ~1in thick, sheared	massive, pervasively sheared, shattered, brecciated. Layering rare, but sparse layering is present
Key Features / Geologic Hazards	localized garnet, high to extreme abrasiveness	high abrasiveness	quartz dikes, high to extreme abrasiveness	foliation and banding, extreme abrasiveness	quartz dikes, high to extreme abrasiveness
Hydraulic Conductivity (Lugeon)	Very Low to Moderate (<0.01-5)				
Groundwater Head (bar)	Low (<5)	Moderate (5-10)	High (10-25)		
Intact Rock Strength (MPa)	Mod. Soft to Very Hard (5-250)	Mod. Hard to Ext. Hard (25->250)			
RMR, GSI	Poor to Good (21-80)	Fair to Good (41-80)			
Q	Very Poor to Good (0.1-40)	Poor to Good (1-40)			
In-Situ Stress	Low to Moderate	Moderate	Moderate to High	Moderate	
Ground Condition	Non Squeezing	Non to Mild Squeezing			

IN-PROGRESS SUBMITTAL FOR INTERNAL USE ONLY

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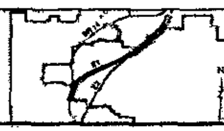

CALIFORNIA High-Speed Rail Authority

CALIFORNIA HIGH-SPEED RAIL AUTHORITY
PALMDALE TO BURBANK PROJECT SECTION
E1 GEOLOGIC PROFILE AND
ANTICIPATED TUNNEL CONDITIONS
STATION 850+00 TO 1000+00

A2

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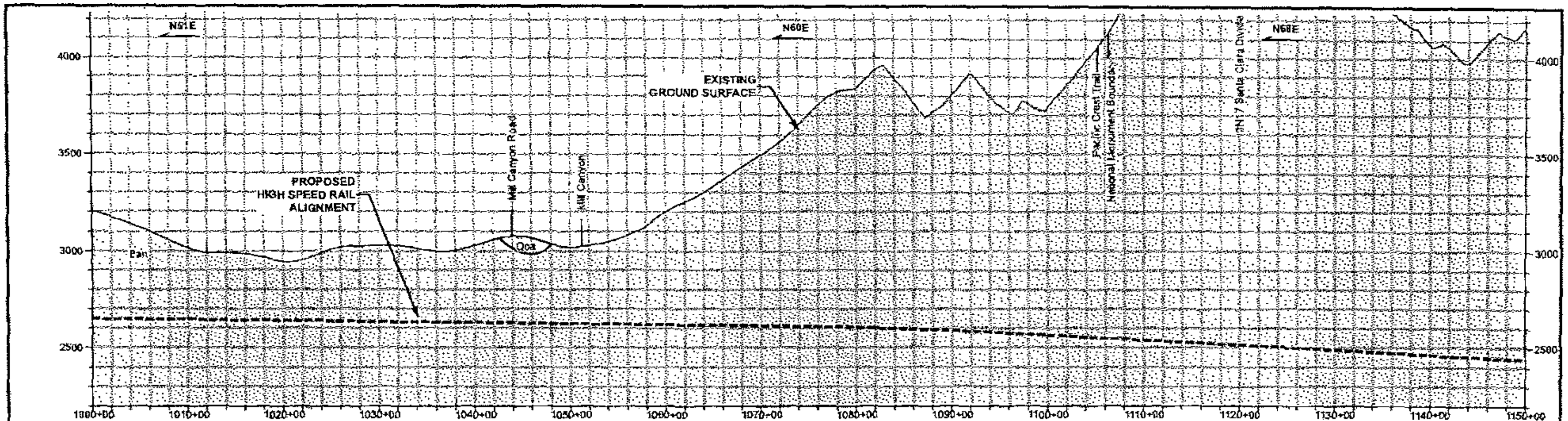

PROFILE

1,000 500 0 1,000
Horizontal Scale 1" - 1,000'

500 250 0 500
Vertical Scale 1" - 500'

SOURCE: CHSR, 04/2014, CGS 2014.

Tunnel Information	TBM 28' ID				
Formation	Anorthosite-gabbro complex - anorthosite (Pan)				
Lithology	anorthosite, more than 90% plagioclase, less than 10% mafic minerals. occasional quartz dikes				
Fracturing / Bedding / Structure	massive, pervasively sheared, shattered, brecciated. Layering rare, but sparse layering is present				
Key Features / Geologic Hazards	quartz dikes, high to extreme abrasiveness				
Hydraulic Conductivity (Lugeon)	Very Low to Moderate (<0.01-5)				
Groundwater Head (bar)	High (10-25)	Moderate (5-10)	High (10-25)	Very High (25-35)	Ext. High (>35)
Intact Rock Strength (MPa)	Mod. Hard to Ext. Hard (25->250)				
RMR, GSI	Fair to Good (41-80)	Poor to Good (21-80)			
Q	Poor to Good (1-40)	Very Poor to Good (0.1-40)			
In-Situ Stress	Moderate	High	High to Very High		
Ground Condition	Non to Mild Squeezing	Non Squeezing	Non to Mild Squeezing	Mild to Moderate Squeezing, Spalling, Slabbing, Rock Bursting	

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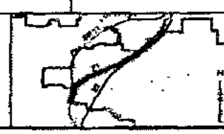

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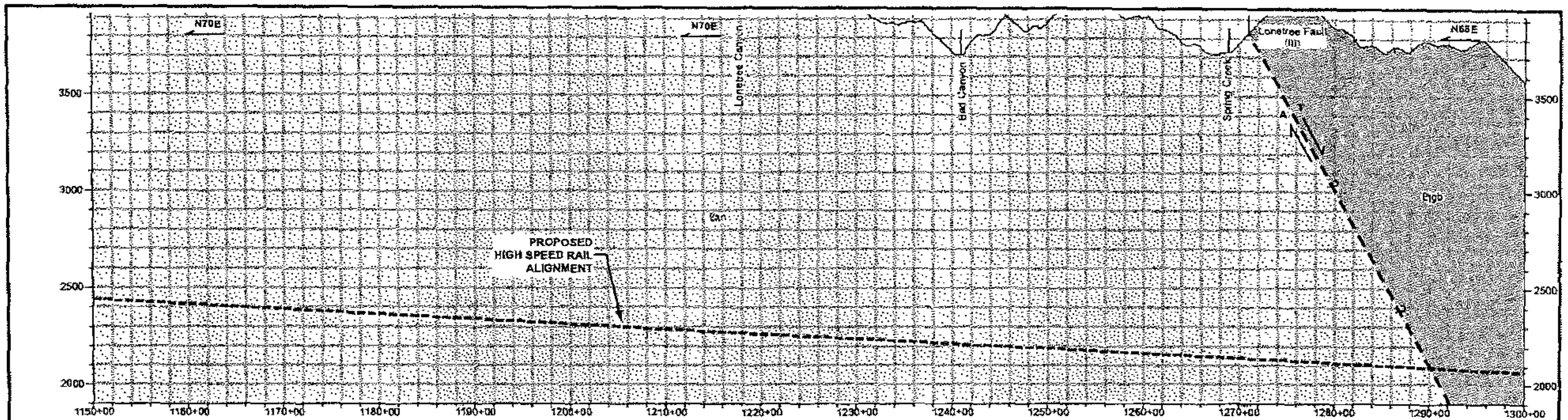
PALMDALE TO BURBANK PROJECT SECTION
E1 GEOLOGIC PROFILE AND
ANTICIPATED TUNNEL CONDITIONS
STATION 1000+00 TO 1150+00

AZ

4 of 8



PROFILE

1,000 500 0 1,000 — Horizontal Scale 1" = 1,000'

500 250 0 500 — Vertical Scale 1" = 500'

SOURCE: CHSR, 04/2016; C/16/2014.

Tunnel Information	TBM 28' ID	
Formation	Anorthosite-gabbro complex - anorthosite (Pan)	Anorthosite-gabbro complex - jotunitic gabbro (Pjgb)
Lithology	anorthosite, more than 90% plagioclase, less than 10% mafic minerals. occasional quartz dikes.	jotunitic gabbro with antiperthitic andesine
Fracturing / Bedding / Structure	massive, pervasively sheared, shattered, brecciated. Layering rare, but sparse layering is present	compositionally layered
Key Features / Geologic Hazards	quartz dikes, high to extreme abrasiveness	high abrasiveness
Hydraulic Conductivity (Lugeon)	Very Low to Moderate (<0.01-5)	
Groundwater Head (bar)	Ext. High (>35)	
Intact Rock Strength (MPa)	Mod. Hard to Ext. Hard (25->250)	Soft to Very Hard (1-250)
RMR, GSI	Poor to Good (21-80)	Poor to Fair (21-60)
Q	Very Poor to Good (0.1-40)	Very Poor to Poor (0.1-4)
In-Situ Stress	High to Very High	High to Very High (Tectonic)
Ground Condition	Mild to Moderate Squeezing, Spalling, Slabbing, Rock Bursting	Moderate to Heavy Squeezing, Spalling, Slabbing, Rock Bursting

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CALIFORNIA High-Speed Rail Authority

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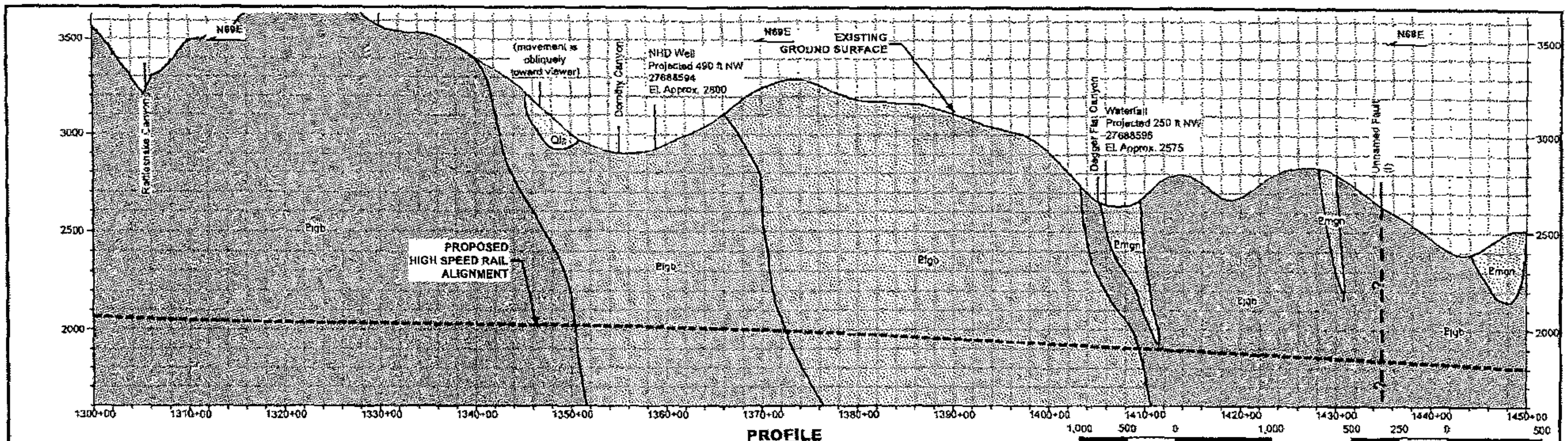
PALMDALE TO BURBANK PROJECT SECTION
E1 GEOLOGIC PROFILE AND
ANTICIPATED TUNNEL CONDITIONS
STATION 1150+00 TO 1300+00

AZ



PROFILE

SOURCE: CHSR, 04/2016, CGS 2014.

Tunnel Information	TBM 28' ID			Mined ETD 32' ID
Formation	Anorthosite-gabbro complex - jotunitic gabbro (Pjgb)	Anorthosite-gabbro complex - leucogabbro (Plgb)	Anorthosite-gabbro complex - ferro-gabbro (Pfgb)	Anorthosite-gabbro complex - jotunitic gabbro (Pjgb)
Lithology	jotunitic gabbro with antiperthitic andesine	gabbro, leucogabbro and anorthosite	ferro-gabbro, mostly ferro-magnesian minerals with lesser feldspars	jotunitic gabbro with antiperthitic andesine
Fracturing / Bedding / Structure	compositionally layered	heterogenous layering, 1 cm-10m layers, differing only in Plag:FeMg composition	- - -	compositionally layered
Key Features / Geologic Hazards	high abrasiveness	high to extreme abrasiveness	contains magnetite-titanite, high abrasiveness	high abrasiveness
Hydraulic Conductivity (Lugeon)	Very Low to Moderate (<0.01-5)			
Groundwater Head (bar)	Ext. High (>35)	Very High (25-35)	High (10-25)	
Intact Rock Strength (MPa)	Soft to Very Hard (1-250)	Mod. Soft to Very Hard (5-250)		
RMR, GSI	Poor to Fair (21-60)	Poor to Good (21-80)		
Q	Very Poor to Poor (0.1-4)	Very Poor to Good (0.1-40)		
In-Situ Stress	High to Very High (Tectonic)	High	Moderate to High	
Ground Condition	[illegible]	Moderate Squeezing, Spalling, Slabbing, Rock Bursting	Mild to Moderate Squeezing	

IN-PROGRESS SUBMITTAL FOR INTERNAL USE ONLY

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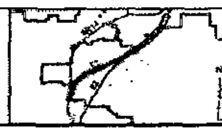

CALIFORNIA High-Speed Rail Authority

CALIFORNIA HIGH-SPEED RAIL AUTHORITY
PALMDALE TO BURBANK PROJECT SECTION
E1 GEOLOGIC PROFILE AND
ANTICIPATED TUNNEL CONDITIONS
STATION 1300+00 TO 1450+00

A2

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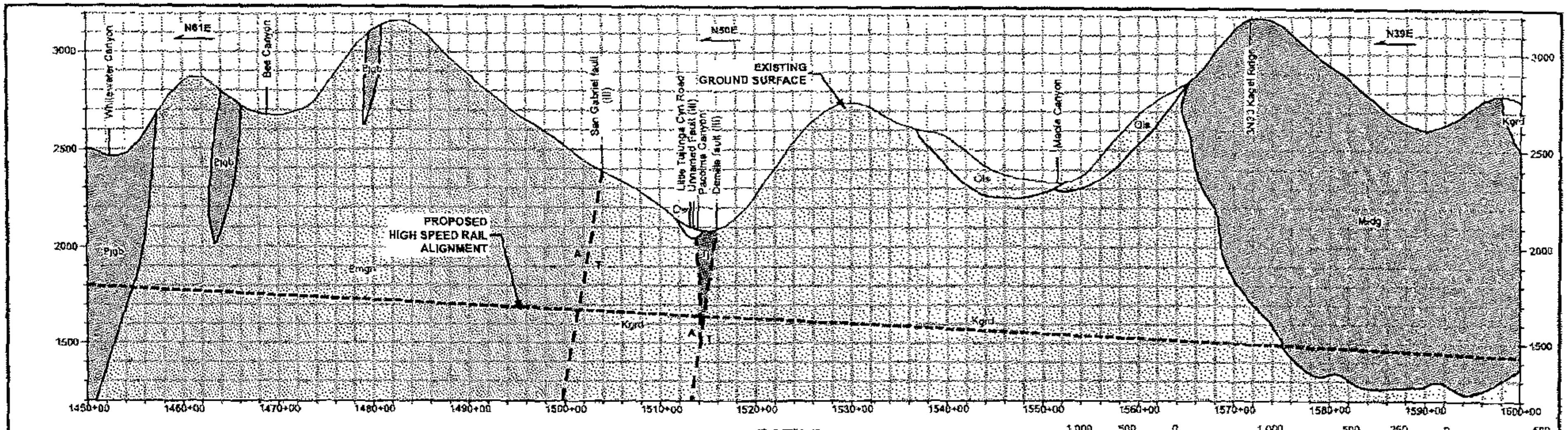

PROFILE

SOURCE: CH2M, 04/2016; CGS 2014.

Tunnel Information	Mined ETD 32' ID	TBM ETD 36' ID					
Formation	Mendenhall gneiss (Pmgn)	Granodiorite (Kgrd)	Diorite gneiss (Mzdg)				
Lithology	layered migmatitic felsic gneiss and mafic granulite	granodiorite with quartz diorite and granite	gneiss, including metadiorites, hornblende diorite and amphibolite and biotite schists.				
Fracturing / Bedding / Structure	compositionally layered, large scale foliations, fracturing and jointing	mostly massive, gneissoid near contacts with older rocks	foliated gneiss, hornblende diorites are massive				
Key Features / Geologic Hazards	extreme abrasiveness	large inclusions and pendants of gneiss and Placerita metasediments, extreme abrasiveness	high abrasiveness				
Hydraulic Conductivity (Lugeon)	Very Low to Moderate (<0.01-5)						
Groundwater Head (bar)	High (10-25)	Very High (25-35)	High (10-25)	Very High (25-35)	Ext. High (>35)	Very High (25-35)	High (10-25)
Intact Rock Strength (MPa)	Mod. Soft to Very Hard (5-250)	Soft to Hard (1-100)	Soft to Very Hard (1-250)				
RMR, GSI	Poor to Good (21-80)	Very Poor to Fair (0-60)	Poor to Good (21-80)				
Q	Very Poor to Good (0.1-40)	Ext. Poor to Poor (0.004-4)	Very Poor to Good (0.1-40)				
In-Situ Stress	Moderate to High	High	Moderate to High (Tectonic)	Moderate to High			
Ground Condition	Mild to Moderate Squeezing	Moderate to Heavy Squeezing, Spalling, Slabbing, Rock Bursting	Mild to Moderate Squeezing, Spalling, Slabbing, Rock Bursting				

IN-PROGRESS SUBMITTAL FOR INTERNAL USE ONLY

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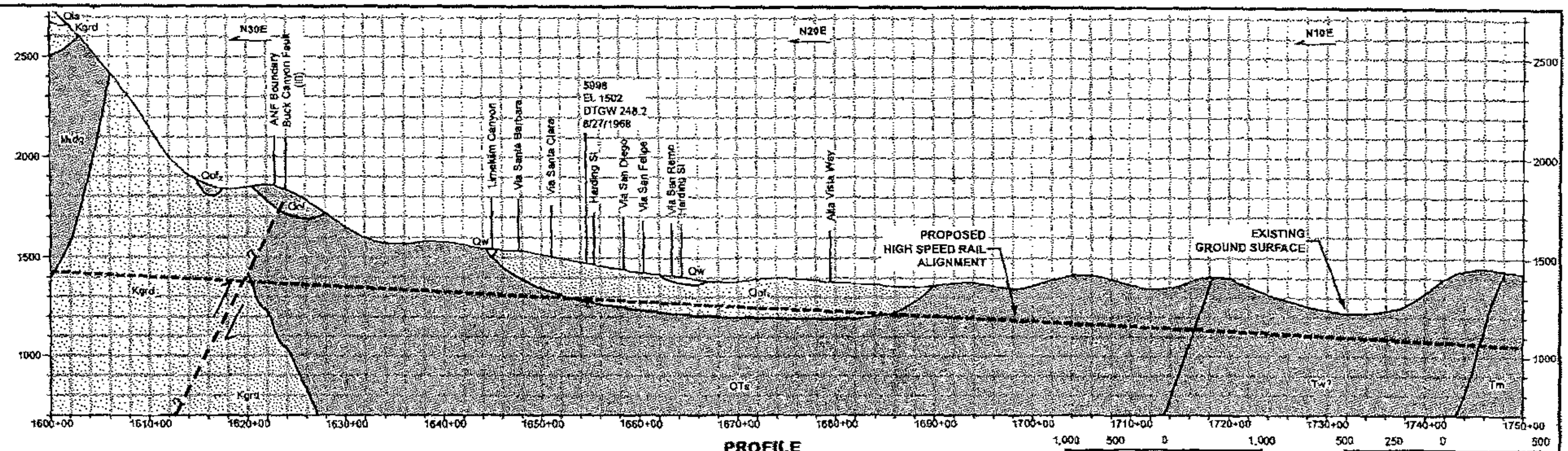
CALIFORNIA High-Speed Rail Authority

CALIFORNIA HIGH-SPEED RAIL AUTHORITY
PALMDALE TO BURBANK PROJECT SECTION
E1 GEOLOGIC PROFILE AND
ANTICIPATED TUNNEL CONDITIONS
STATION 1450+00 TO 1600+00

A2



PROFILE

SOURCE: CHSR, 09/2016; CGS 2014.

Tunnel Information	TBM ETD 36' ID					
Formation	Granodiorite (Kgrd)	Saugus Formation, undivided (QTs)	Old fan deposits, Unit 1 (Qof1)	Saugus Formation, undivided (QTs)	Towsley Formation, undivided (Tw?)	[illegible] (Tm)
Lithology	granodiorite with quartz diorite and granite	medium to coarse-grained sandstone and pebble conglomerate	silt, sand, and gravel	medium to coarse-grained sandstone and pebble conglomerate	interbedded sandstone, conglomerate, sandy siltstone and mudstone	[illegible]
Fracturing / Bedding / Structure	mostly massive, gneissoid near contacts with older rocks	poorly bedded, cross-bedded, channeled and lenticular beds common	---	poorly bedded, cross-bedded, channeled and lenticular beds common	interbedded, lenticular beds, poorly-bedded to massive, local clay seams	[illegible]
Key Features / Geologic Hazards	large inclusions and pendants of gneiss and Placerita metasediments, extreme abrasiveness	weakly to moderately cemented, conglomeratic (some boulders), high abrasiveness	slightly to moderately consolidated, medium to high abrasiveness	weakly to moderately cemented, conglomeratic (some boulders), high abrasiveness	cemented sandstone and siltstone, conglomeratic (some boulders), medium to high abrasiveness	[illegible]
Hydraulic Conductivity (Lugeon)	Very Low to Moderate (<0.01-5)	Very Low to High (<0.01->50)				[illegible]
Groundwater Head (bar)	High (10-25)	Moderate (5-10)	Low (<3)			
Intact Rock Strength (MPa)	Soft to Very Hard (1-250)	Very Soft to Mod. Hard (<1-50)	N/A	Very Soft to Mod. Hard (<1-50)	Soft to Very Hard (1-250)	[illegible]
RMR, GSI	Poor to Good (21-80)	Very Poor to Fair (0-80)	Poor to Good (21-80)	N/A	Poor to Good (21-80)	
Q	Very Poor to Good (0.1-40)	Ext. Poor to Poor (0.004-4)	Very Poor to Good (0.1-40)	N/A	Very Poor to Good (0.1-40)	
In-Situ Stress	Moderate to High	Moderate (Tectonic)	Moderate	Low to Moderate		
Ground Condition	Mild to Moderate Squeezing, Spalling, Slabbing, Rock Bursting	Moderate Squeezing, Swelling	Non to Moderate Squeezing, Raveling, Running/Flowing			[illegible]

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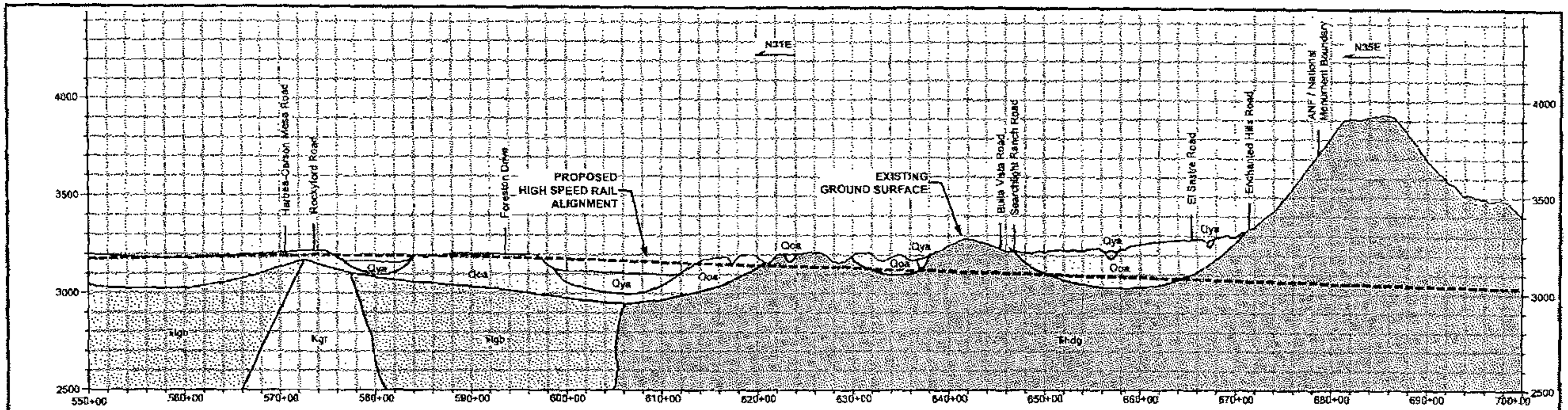
CALIFORNIA HIGH-SPEED RAIL AUTHORITY
PALMDALE TO BURBANK PROJECT SECTION
E1 GEOLOGIC PROFILE AND
ANTICIPATED TUNNEL CONDITIONS
STATION 1600+00 TO 1750+00

A2



PROFILE

Horizontal Scale 1" - 1,000'

Vertical Scale 1" - 500'

SOURCE: CHSR, 04/2016; CGS 2014.

Tunnel Information								Mined 28' ID		
Formation	Old alluvium, undivided (Qoa)		Old alluvium, undivided (Qoa)		Old alluvium, undivided (Qoa)	Mount Lowe intrusive suite - hornblende diorite gabbro (TRhdg)	Old alluvium, undivided (Qoa)	Mount Lowe intrusive suite - hornblende diorite gabbro (TRhdg)	Old alluvium, undivided (Qoa)	Mount Lowe intrusive suite - hornblende diorite gabbro (TRhdg)
Lithology	silt, sand, gravel, cobbles and boulders		silt, sand, gravel, cobbles and boulders		silt, sand, gravel, cobbles and boulders	hornblende diorite gabbro	silt, sand, gravel, cobbles and boulders	hornblende diorite gabbro	silt, sand, gravel, cobbles and boulders	hornblende diorite gabbro
Fracturing / Bedding / Structure	N/A		N/A		N/A	massive to locally foliated	N/A	massive to locally foliated	---	massive to locally foliated
Key Features / Geologic Hazards	unconsolidated to moderately indurated, conglomeratic (some boulders), medium to high abrasiveness		unconsolidated to moderately indurated, conglomeratic (some boulders), medium to high abrasiveness		[illegible]	high abrasiveness	[illegible]	high abrasiveness	unconsolidated to moderately indurated, conglomeratic (some boulders), medium to high abrasiveness	high abrasiveness
Hydraulic Conductivity (Lugeon)	Very Low to High (<0.01->50)									Very Low to Moderate (<0.01-5)
Groundwater Head (bar)	Low (<5)									Moderate (5-10)
Intact Rock Strength (MPa)	N/A					Mod. Soft to Hard (5-100)	N/A	Mod. Soft to Hard (5-100)	N/A	Mod. Soft to Hard (5-100)
RMR, GSI	N/A					Poor to Fair (21-60)	N/A	Poor to Fair (21-60)	N/A	Poor to Good (21-80)
Q	N/A					Very Poor to Poor (0.1-4)	N/A	Very Poor to Poor (0.1-4)	N/A	Very Poor to Good (0.1-40)
In-Situ Stress	Low									Low to Moderate
Ground Condition	Running					Running/Flowing, Non-Squeezing			Flowing	Non to Mild Squeezing

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CALIFORNIA HIGH-SPEED RAIL AUTHORITY
PALMDALE TO BURBANK PROJECT SECTION
E2 GEOLOGIC PROFILE AND
ANTICIPATED TUNNEL CONDITIONS
STATION 550+00 TO 700+00

A3

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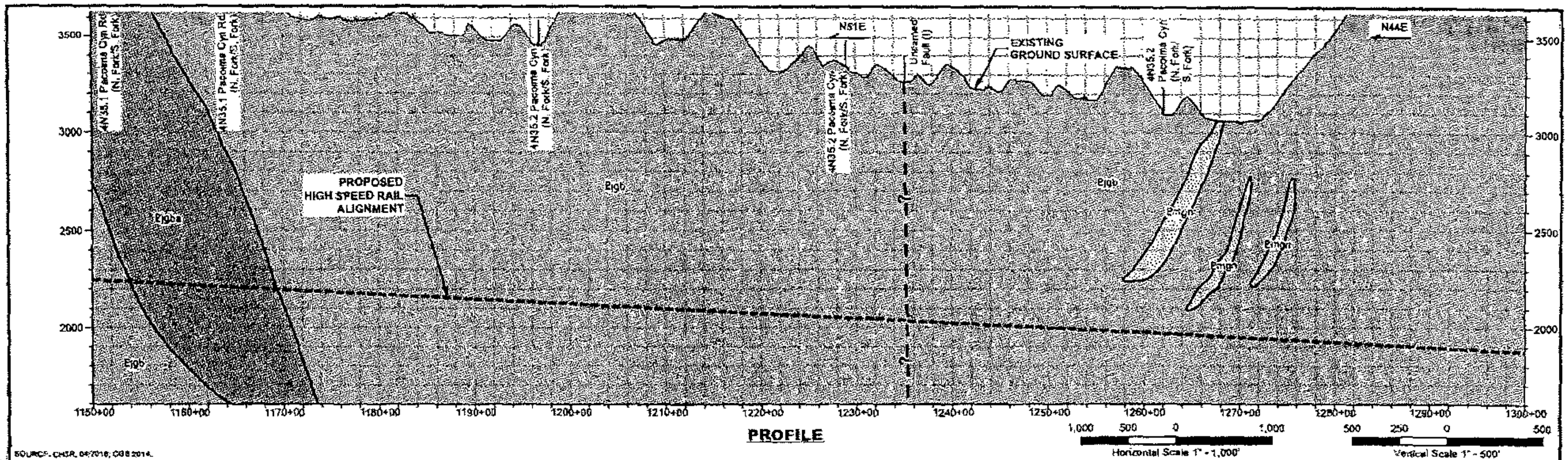

PROFILE

SOURCE: CHSR, 04/2016; CGS 2014.

Tunnel Information	TBM 28' ID		TBM ETD 32' ID	
Formation		Anorthosite-gabbro complex - jotunite-norite-gabbro-diorite (Pjgba)	Anorthosite-gabbro complex - jotunitic gabbro (Pjgb)	
Lithology		composed of hornblende, chlorite, biotite, actinolite and limonite-magnetite	jotunitic gabbro with antiperthitic andesine	
Fracturing / Bedding / Structure		compositionally layered	compositionally layered	
Key Features / Geologic Hazards		contains actinolite and limonite-magnetite, high abrasiveness	high abrasiveness	
Hydraulic Conductivity (Lugeon)	Very Low to Moderate (<0.01-5)			
Groundwater Head (bar)	Ext. High (>35)	Very High (25-35)	Ext. High (>35)	
Intact Rock Strength (MPa)	Mod. Soft to Very Hard (5-250)			
RMR, GSI	Poor to Good (21-80)			
Q	Very Poor to Good (0.1-40)			
In-Situ Stress	High	High to Very High (Tectonic)		
Ground Condition	Mild to Moderate Squeezing			

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PALMDALE TO BURBANK PROJECT SECTION
E2 GEOLOGIC PROFILE AND
ANTICIPATED TUNNEL CONDITIONS
STATION 1150+00 TO 1300+00

A3

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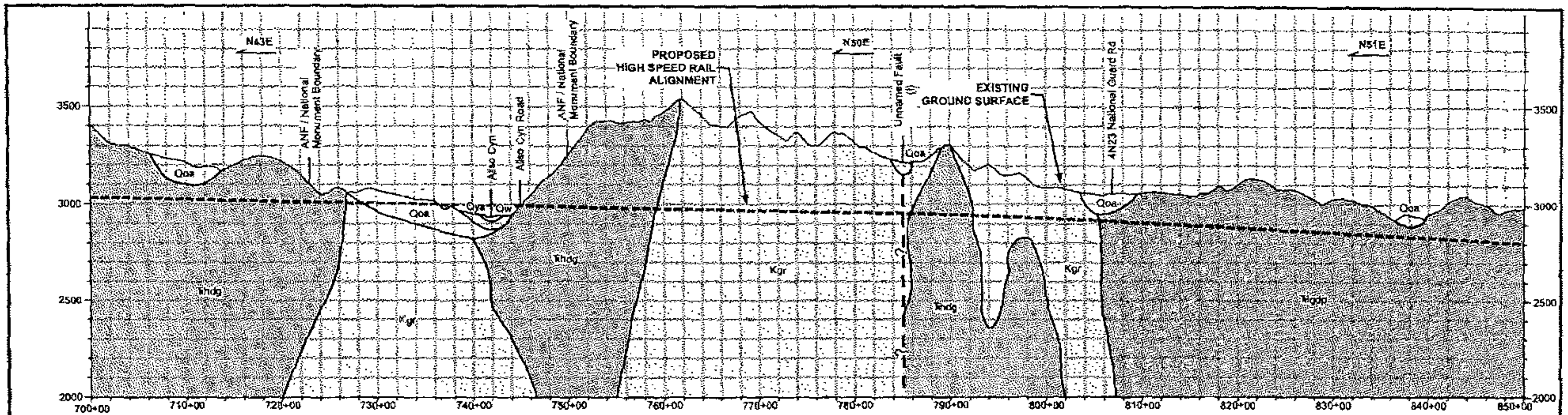

PROFILE

1,000 500 0 1,000
Horizontal Scale 1" - 1,000'

500 250 0 500
Vertical Scale 1" - 500'

SOURCE: CHSR, 04/2016, CGS 2014.

Tunnel Information	Mined 28' ID								Mined 28' ID
Formation	Mount Lowe intrusive suite - hornblende diorite gabbro (TRhdg)	[illegible]	Old alluvium, undivided (Qoa)		Mount Lowe intrusive suite - hornblende diorite gabbro (TRhdg)	Granitic Rocks (Kgr)	Mount Lowe intrusive suite - hornblende diorite gabbro (TRhdg)	Granitic Rocks (Kgr)	Mount Lowe intrusive suite - porphyritic facies (TRgdp)
Lithology	hornblende diorite gabbro	[illegible]	silt, sand, gravel, cobbles and boulders		hornblende diorite gabbro	quartz monzonite, granodiorite, tonalite, quartz diorite and diorite	hornblende diorite gabbro	quartz monzonite, granodiorite, tonalite, quartz diorite and diorite	Orthoclase phenocrysts in matrix of plagioclase and subordinate quartz; localized garnet
Fracturing / Bedding / Structure	massive to locally foliated	---	---		massive to locally foliated	---	massive to locally foliated	---	---
Key Features / Geologic Hazards	high abrasiveness	[illegible]	[illegible]		high abrasiveness	high to extreme abrasiveness	high abrasiveness	high to extreme abrasiveness	localized garnet, high to extreme abrasiveness
Hydraulic Conductivity (Lugeon)	Very Low to Moderate (<0.01-5)	Low to Very High (0.01->50)	N/A	Very Low to Moderate (<0.01-5)					
Groundwater Head (bar)	Moderate (5-10)	Low (<5)	N/A	Low (<5)	Moderate (5-10)	Low (<5)			
Intact Rock Strength (MPa)	Mod. Soft to Hard (5-100)	N/A	Mod. Soft to Very Hard (5-250)						
RMR, GSI	Poor to Good (21-80)	N/A	Poor to Good (21-80)						
Q	Very Poor to Good (0.1-40)	N/A	Very Poor to Good (0.1-40)						
In-Situ Stress	Low to Moderate	Low	N/A	Low to Moderate					
Ground Condition	Non to Mild Squeezing	Running	N/A	Non to Mild Squeezing	Non Squeezing				

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E2 GEOLOGIC PROFILE AND
ANTICIPATED TUNNEL CONDITIONS
STATION 700+00 TO 850+00

A3

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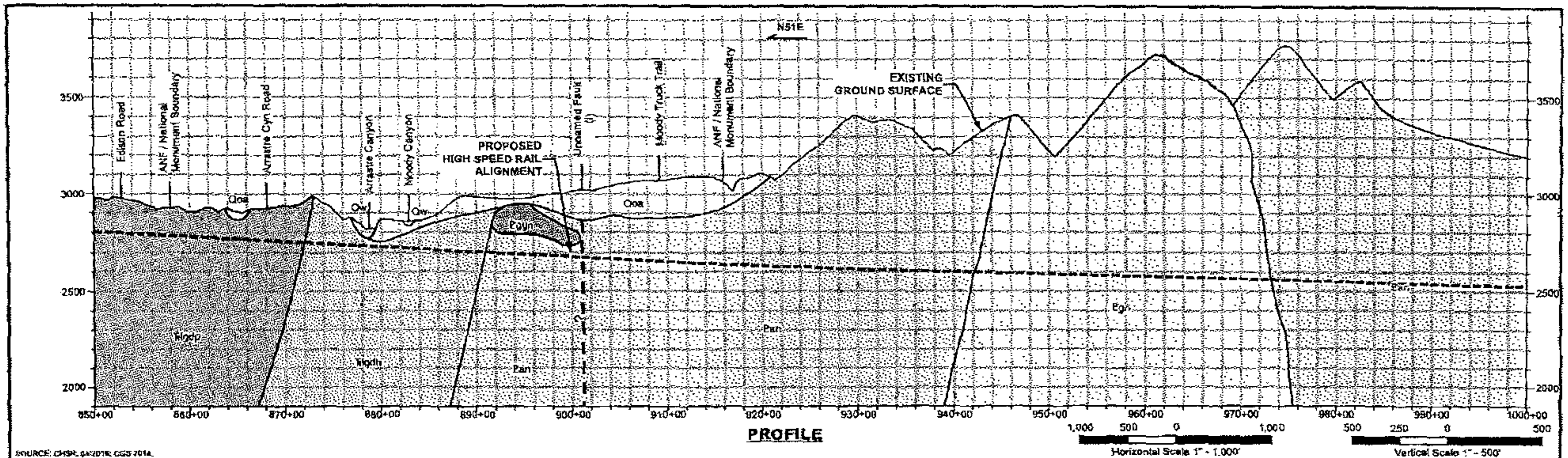

SOURCE: CHSR, 04/2016; CGS 2014.

Tunnel Information	Mined 28' ID	TBM 28' ID			
Formation	Mount Lowe intrusive suite - porphyritic facies (TRlgdp)	Mount Lowe intrusive suite - orthoclase-hornblende facies (TRlgdh)	Anorthosite-gabbro complex - anorthosite (Pan)	Gneiss (Pgn)	Anorthosite-gabbro complex - anorthosite (Pan)
Lithology	Orthoclase phenocrysts in matrix of plagioclase and subordinate quartz; localized garnet	hornblende diorite	anorthosite, more than 90% plagioclase, less than 10% mafic minerals. occasional quartz dikes	gneiss, biotite-rich and quartz-feldspar-rich lenses	anorthosite, more than 90% plagioclase, less than 10% mafic minerals. occasional quartz dikes
Fracturing / Bedding / Structure	---	---	massive, pervasively sheared, shattered, brecciated. Layering rare, but sparse layering is present	foliated, banded layers generally ~1in thick, sheared	massive, pervasively sheared, shattered, brecciated. Layering rare, but sparse layering is present
Key Features / Geologic Hazards	localized garnet, high to extreme abrasiveness	high abrasiveness	quartz dikes, high to extreme abrasiveness	foliation and banding, extreme abrasiveness	quartz dikes, high to extreme abrasiveness
Hydraulic Conductivity (Lugeon)	Very Low to Moderate (<0.01-5)				
Groundwater Head (bar)	Low (<5)	Moderate (5-10)	High (10-25)		
Intact Rock Strength (MPa)	Mod. Soft to Very Hard (5-250)	Mod. Hard to Ext. Hard (25->250)			
RMR, GSI	Poor to Good (21-80)	Fair to Good (41-80)			
Q	Very Poor to Good (0.1-40)	Poor to Good (1-40)			
In-Situ Stress	Low to Moderate	Moderate	Moderate to High	Moderate	
Ground Condition	Non Squeezing	Non to Mild Squeezing			

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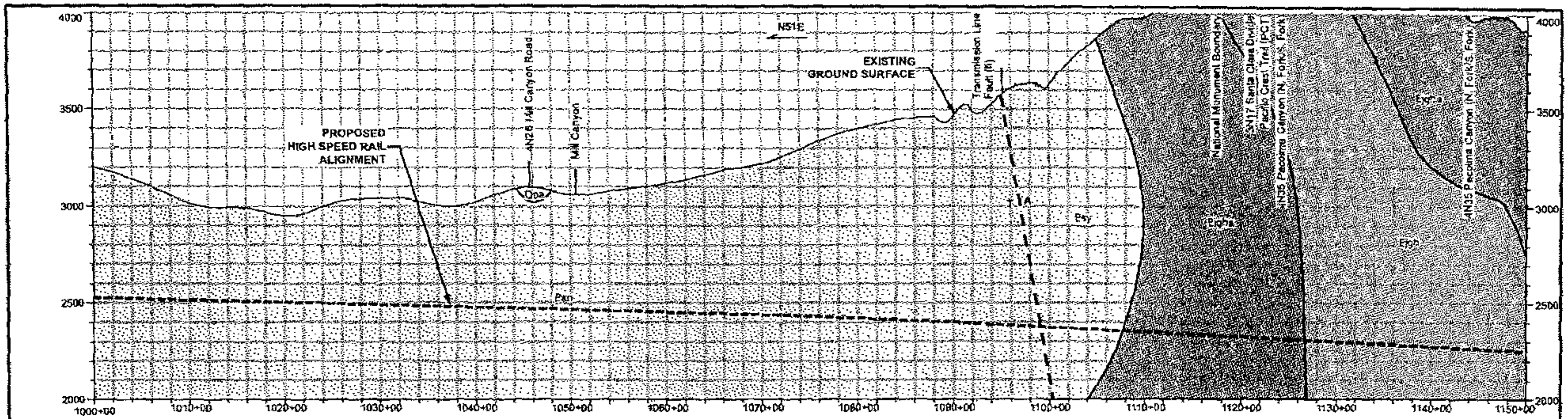
A3



PROFILE

1,000 500 0 1,000 — Horizontal Scale 1" = 1,000'

500 250 0 500 — Vertical Scale 1" = 500'

SOURCE: CHSR, 04/2014; CGS 2014.

Tunnel Information	TBM 28' ID			
Formation	Anorthosite-gabbro complex - anorthosite (Pan)	Anorthosite-gabbro complex - syenite (Psy)	Anorthosite-gabbro complex - jotunite-norite-gabbro-diorite (Pjgba)	Anorthosite-gabbro complex - jotunitic gabbro (Pjgb)
Lithology	anorthosite, more than 90% plagioclase, less than 10% mafic minerals, occasional quartz dikes	plagioclase feldspar with 10-40% ferro-magnesian minerals.	composed of hornblende, chlorite biotite, actinolite and limonite-magnetite	jotunitic gabbro with antiperthitic andesine
Fracturing / Bedding / Structure	massive, pervasively sheared, shattered, brecciated. Layering rare, but sparse layering is present	generally homogenous, however contains some Fe/Mg-rich compositional layering	compositionally layered	compositionally layered
Key Features / Geologic Hazards	quartz dikes, high to extreme abrasiveness	trace magnetite, high abrasiveness	contains actinolite and limonite-magnetite, high abrasiveness	high abrasiveness
Hydraulic Conductivity (Lugeon)	Very Low to Moderate (<0.01-5)			
Groundwater Head (bar)	High (10-25)	Very High (25-35)	Ext. High (>35)	
Intact Rock Strength (MPa)	Mod. Hard to Ext. Hard (25->250)	Soft to Very Hard (1-250)	Mod. Soft to Very Hard (5-250)	
RMR, GSI	Fair to Good (41-80)	Poor to Good (21-80)		
Q	Poor to Good (1-40)	Very Poor to Good (0.1-40)		
In-Situ Stress	Moderate	High (Tectonic)	High	
Ground Condition	Non to Mild Squeezing	Mild to Moderate Squeezing		

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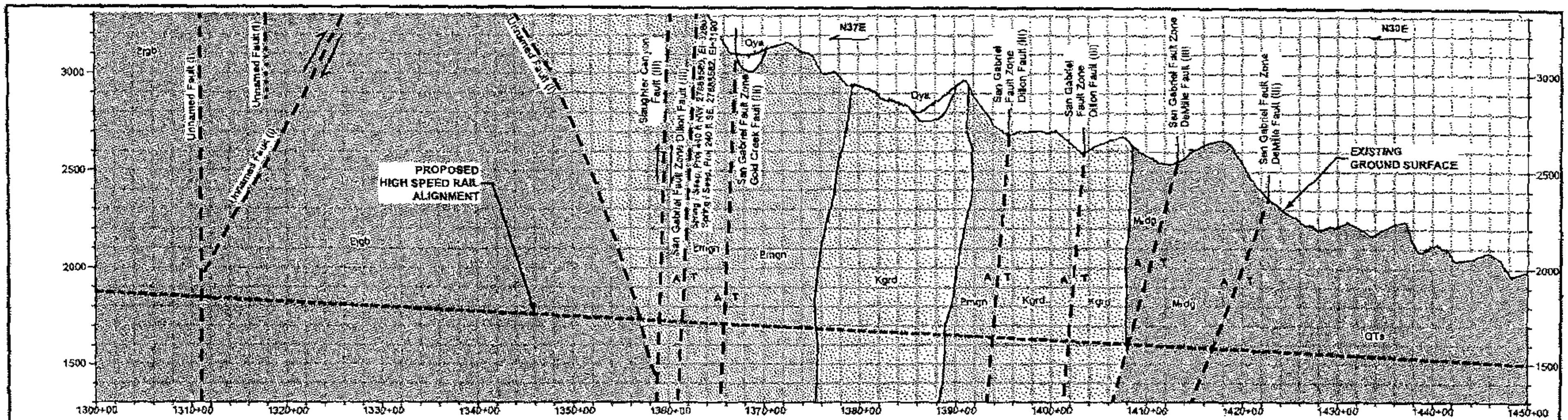

PROFILE

1,000 500 0 1,000
Horizontal Scale 1" - 1,000'

500 250 0 500
Vertical Scale 1" - 500'

SOURCE: CHSR, 04/2016; CGS 2014.

<table>
<tr><td>Tunnel Information</td><td colspan="12">TBM ETD 32' ID</td></tr>
<tr><td>Formation</td><td colspan="2">Anorthosite-gabbro complex - jotunitic gabbro (Pjgb)</td><td>Mendenhall gneiss (Pmgn)</td><td colspan="3">Granodiorite (Kgrd)</td><td>Mendenhall gneiss (Pmgn)</td><td>Granodiorite (Kgrd)</td><td colspan="2">Diorite gneiss (Mzdg)</td><td colspan="2">Saugus Formation, undivided (QTs)</td></tr>
<tr><td>Lithology</td><td colspan="2">jotunitic gabbro with antiperthitic andesine</td><td>layered migmatitic felsic gneiss and mafic granulite</td><td colspan="3">granodiorite with quartz diorite and granite</td><td>layered migmatitic felsic gneiss and mafic granulite</td><td>granodiorite with quartz diorite and granite</td><td colspan="2">gneiss, including meta-diorites, hornblende diorite and amphibolite and biotite schists.</td><td colspan="2">medium to coarse-grained sandstone and pebble conglomerate</td></tr>
<tr><td>Fracturing / Bedding / Structure</td><td colspan="2">compositionally layered</td><td>compositionally layered, large scale foliations, fracturing and jointing</td><td colspan="3">mostly massive, gneissoid near contacts with older rocks</td><td>compositionally layered, large scale foliations, fracturing and jointing</td><td>mostly massive, gneissoid near contacts with older rocks</td><td colspan="2">foliated gneiss, hornblende diorites are massive</td><td colspan="2">poorly bedded, cross-bedded, channeled and lenticular beds common</td></tr>
<tr><td>Key Features / Geologic Hazards</td><td colspan="2">high abrasiveness</td><td>extreme abrasiveness</td><td colspan="3">large inclusions and pendants of gneiss and Placerita metasediments, extreme abrasiveness</td><td>extreme abrasiveness</td><td>large inclusions and pendants of gneiss and Placerita metasediments, extreme abrasiveness</td><td colspan="2">high abrasiveness</td><td colspan="2">weakly to moderately cemented, conglomeratic (some boulders), high abrasiveness</td></tr>
<tr><td>Hydraulic Conductivity (Lugeon)</td><td colspan="10">Very Low to Moderate (<0.01-5)</td><td colspan="2">Very Low to High (<0.01->50)</td></tr>
<tr><td>Groundwater Head (bar)</td><td colspan="5">Ext. High (>35)</td><td colspan="4">Very High (25-35)</td><td colspan="3">High (10-25)</td></tr>
<tr><td>Intact Rock Strength (MPa)</td><td>Mod. Soft to Very Hard (5-250)</td><td colspan="9">Very Soft to Hard (1<100)</td><td colspan="2">Very Soft to Mod. Hard (1<50)</td></tr>
<tr><td>RMR, GSI</td><td>Poor to Good (21-60)</td><td colspan="9">Poor to Fair (21-60)</td><td colspan="2">Very Poor to Fair (0-60)</td></tr>
<tr><td>Q</td><td>Very Poor to Good (0.1-40)</td><td colspan="9">Ext. Poor to Fair (0.004-10)</td><td colspan="2">Ext. Poor to Poor (0.004-4)</td></tr>
<tr><td>In-Situ Stress</td><td colspan="12">High to Very High (Tectonic)</td></tr>
<tr><td>Ground Condition</td><td>Mild to Moderate Squeezing</td><td>Mod. to Heavy Squeezing, Rock Bursting, Spalling Slabbing</td><td colspan="2">Mod. to Heavy Squeezing, Swelling, Rock Bursting, Spalling, Slabbing</td><td colspan="7">Mod. Squeezing, Swelling, Rock Bursting, Spalling, Slabbing</td><td>Mild to Mod. Squeezing, Ravelling, Flowing</td></tr>
</table>

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STATION 1300+00 TO 1450+00

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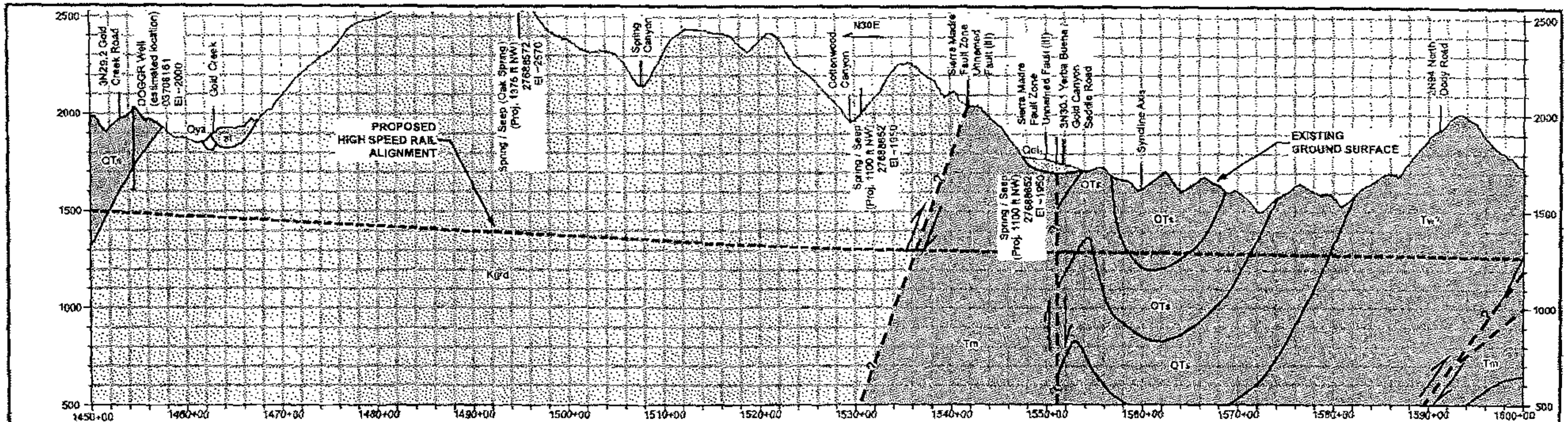

PROFILE

1,000 500 0 1,000
Horizontal Scale 1" - 1,000'

500 250 0 500
Vertical Scale 1" - 500'

SOURCE: CHSR, 0/2014; CGS 2014,

Tunnel Information	TBM ETD 32' ID				
Formation	Granodiorite (Kgrd)	Modelo Formation, undivided (Tm)	Saugus Formation, undivided (QTs)	Towsley Formation, undivided (Tw?)	
Lithology	granodiorite with quartz diorite and granite	mudstone, diatomaceous clay shale or siltstone with very fine to coarse-grained sandstone	medium to coarse-grained sandstone and pebble conglomerate	interbedded sandstone, conglomerate, sandy siltstone and mudstone	
Fracturing / Bedding / Structure	mostly massive, gneissoid near contacts with older rocks	thin bedded, interbedded, sheared along bedding	poorly bedded, cross-bedded, channeled and lenticular beds common	interbedded, lenticular beds, poorly-bedded to massive, local clay seams	
Key Features / Geologic Hazards	large inclusions and pendants of gneiss and Placerita metasediments, extreme abrasiveness	sheared along bedding, potential gassy ground, low to medium abrasiveness	weakly to moderately cemented, conglomeratic (some boulders), high abrasiveness	cemented sandstone and siltstone, conglomeratic (some boulders), medium to high abrasiveness	
Hydraulic Conductivity (Lugeon)	Very Low to Moderate (<0.01-5)	Very Low to High (<0.01->50)			
Groundwater Head (bar)	High (10-25)	Very High (25-35)	High (10-25)	Moderate (5-10)	
Intact Rock Strength (MPa)	Mod. Soft to Very Hard (5-250)	Very Soft to Mod. Hard (1<-50)	Soft to Very Hard (1-250)		
RMR, GSI	Poor to Good (21-80)	Very Poor to Fair (0-60)	Poor to Good (21-80)	Very Poor to Fair (0-60)	
Q	Very Poor to Good (0.1-40)	Ext. Poor to Poor (0.004-4)	Very Poor to Good (0.1-40)	Very Poor to Good (0.1-40)	
In-Situ Stress	Moderate (Tectonic)	High	Moderate (Tectonic)		
Ground Condition	Non to Mild Squeezing	Mild to Moderate Squeezing	Moderate to Heavy Squeezing	Mild to Mod. Squeezing, Ravelling, Flowing	

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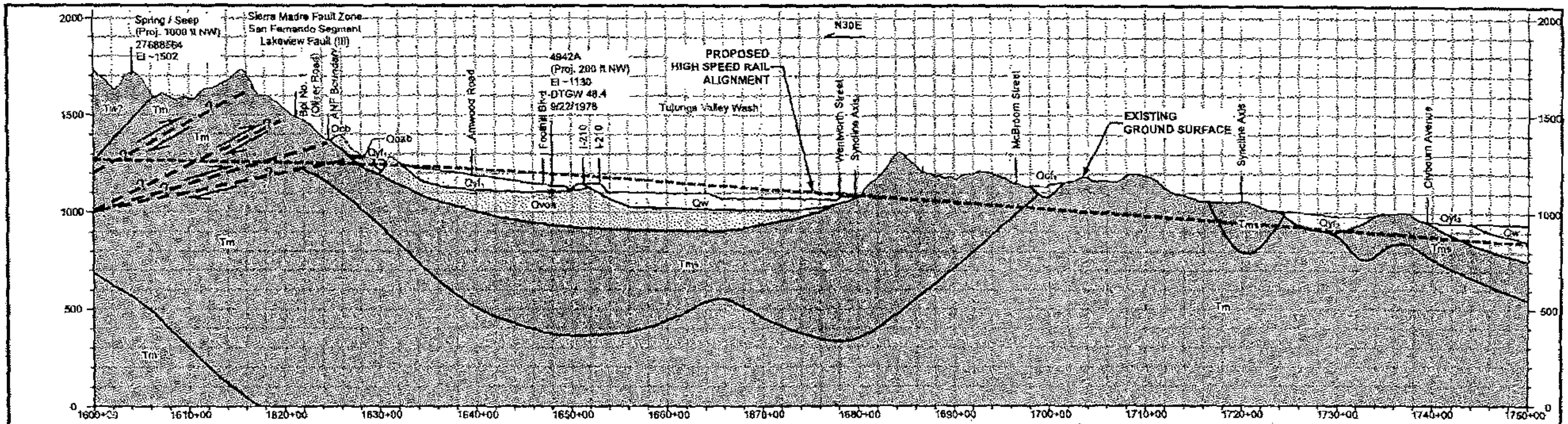
A3



PROFILE

1,000 500 0 1,000
Horizontal Scale 1" - 1,000'

500 250 0 500
Vertical Scale 1" - 500'

SOURCE: CHSR, 04/2016; CGS 2014.

Tunnel Information	TBM ETD 32' ID		SEM ETD 33.5' ID					
Formation	Modelo Formation, undivided (Tm)	Modelo Formation, sandstone (Tms)	Modelo Formation, sandstone (Tms)	Modelo Formation, undivided (Tm)	Modelo Formation sandstone (Tms)	Modelo Formation, undivided (Tm)	Modelo Formation, sandstone (Tms)	Young alluvial fan (Qyf_2)
Lithology	mudstone, diatomaceous clay shale or siltstone with very fine to coarse-grained sandstone	sandstone and conglomerate	sandstone and conglomerate	mudstone, diatomaceous clay shale or siltstone with very fine to coarse-grained sandstone	sandstone and conglomerate	[illegible]	sandstone and conglomerate	silt, sand and gravel
Fracturing / Bedding / Structure	thin bedded, interbedded, sheared along bedding	---	---	thin bedded, interbedded, sheared along bedding	---	thin bedded, interbedded, sheared along bedding	---	---
Key Features / Geologic Hazards	sheared along bedding, potential gassy ground, low to medium abrasiveness	[illegible]	potential gassy ground, conglomeratic, low to high abrasiveness	sheared along bedding, potential gassy ground, low to medium abrasiveness	potential gassy ground, conglomeratic, low to high abrasiveness	[illegible]	potential gassy ground, conglomeratic, low to high abrasiveness	unconsolidated, boulders and cobbles, medium to high abrasiveness
Hydraulic Conductivity (Lugeon)	Very Low to Moderate (<0.01-5)	Very Low to Very High (<0.01->50)	Very Low to Moderate (<0.01-5)	Very Low to Very High (<0.01->50)				
Groundwater Head (bar)	Moderate (5-10)	Low (<5)	Low (<5)					
Intact Rock Strength (MPa)	Very Soft to Mod. Hard (1<-50)	N/A	Very Soft to Mod. Hard (1<-50)	N/A	Very Soft to Mod. Hard (1<-50)	N/A		
RMR, GSI	Very Poor to Fair (0-60)	N/A	Poor to Good (21-80)	N/A	Poor to Good (21-80)	N/A		
Q	Ext. Poor to Poor (0.004-4)	N/A	Very Poor to Good (0.1-40)	N/A	Very Poor to Good (0.1-40)	N/A		
In-Situ Stress	Moderate (Tectonic)	Low	Low					
Ground Condition	Firm, Ravelling, Swelling	Running/ Flowing	Firm, Ravelling, Swelling	Firm, Ravelling, Flowing				

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FIGURES

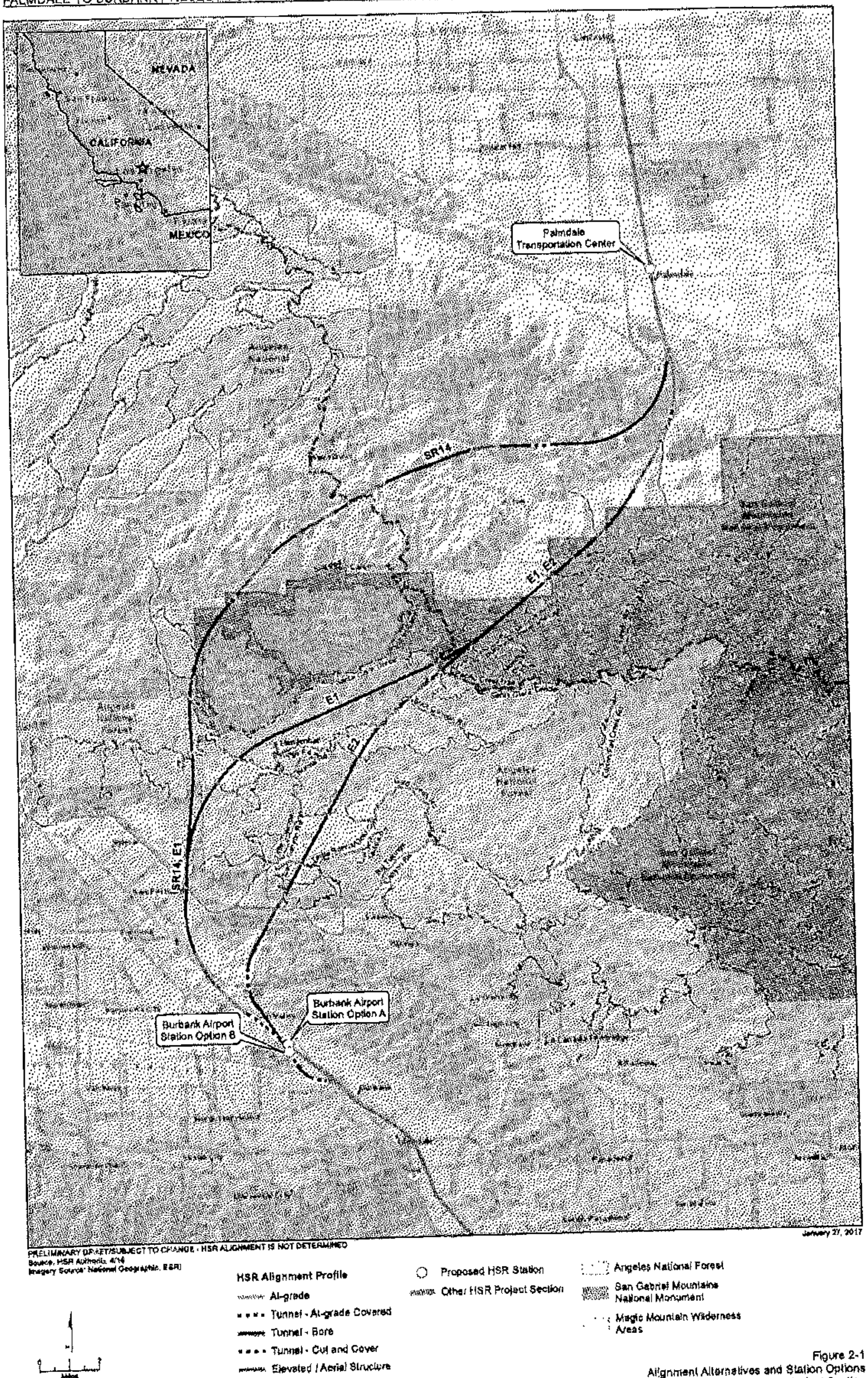
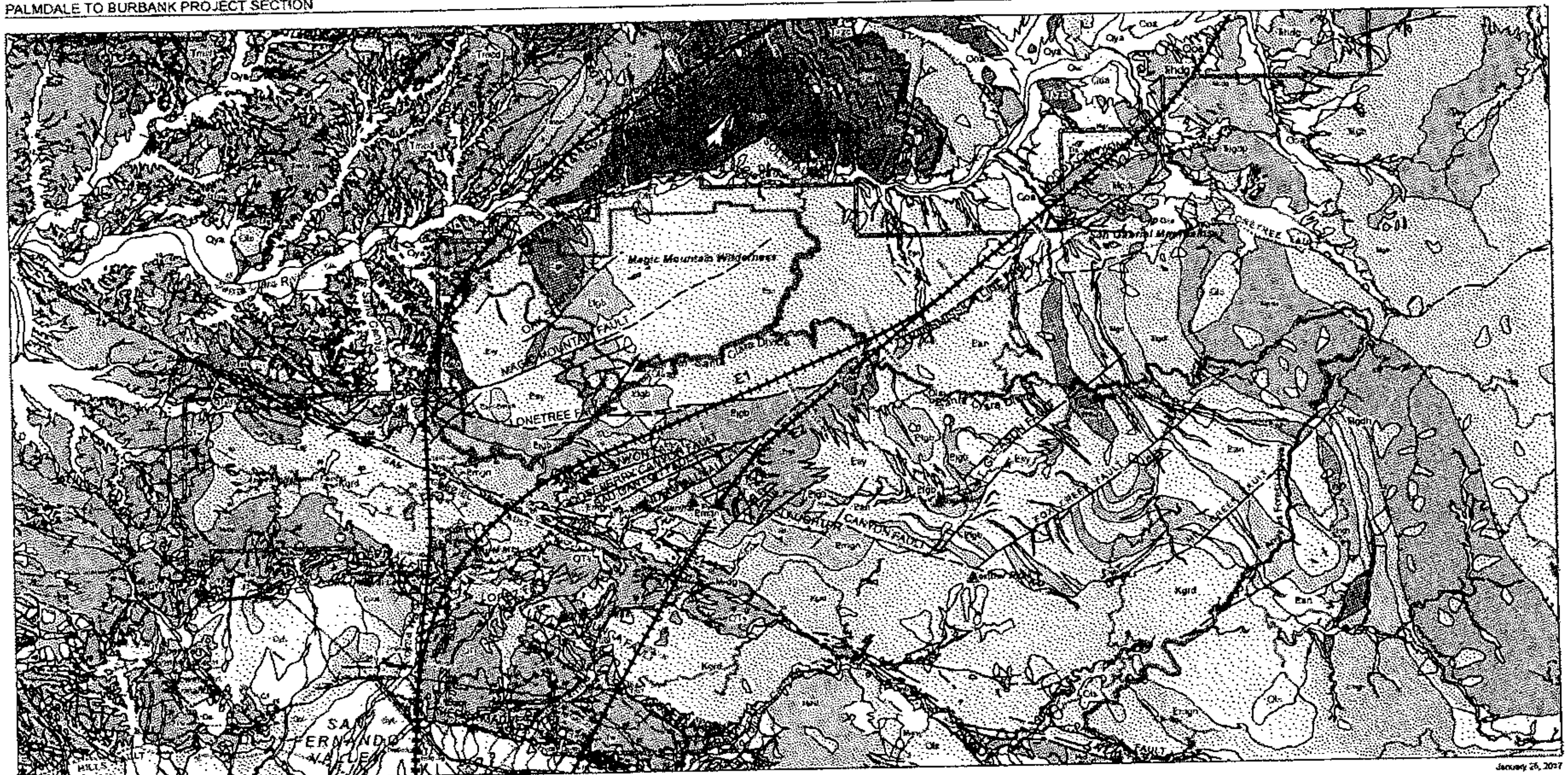


Figure 2-1
Alignment Alternatives and Station Options of the Palmdale to Burbank Project Section



PRELIMINARY DRAFT/SUBJECT TO CHANGE - HSR ALIGNMENT IS NOT DETERMINED
Source: CHSR, 04/2016; CGS 2014.

January 26, 2017

Figure 5-1 Geologic Map

af — Artificial fill (Holocene)

Qw — Wash deposits (Holocene)

Qls — Landslide deposits (Only selected, larger landslides shown) (Holocene)

Qya — Young alluvium, undivided (Holocene)

Qyf2 — Young alluvial fan deposits, Unit 2 (Holocene and late Pleistocene)

Qoa — Old alluvium, undivided (late to middle Pleistocene)

Qof2 — Old alluvial fan deposits, Unit 2 (late Pleistocene)

Qof1 — Old alluvial fan deposits, Unit 1 (late Pleistocene)

Qvof2 — Very old alluvial fan deposits, Unit 2 (late Pleistocene)

Qvoa — Very old alluvium, undivided (middle to early Pleistocene)

Qvof — Very old alluvial fan deposits, undivided (middle to early Pleistocene)

Pacoima Formation (Ventura Basin)

Qpa — Fanglomerate or sedimentary breccia (middle Pleistocene)

Saugus Formation (Ventura Basin)
Predominantly non-marine sandstone, conglomerate and siltstone (late Pleistocene)

QTs Qs — Undivided

Towsley Formation
Turbidity current deposits of interbedded sandstone, conglomerate, sandy siltstone and mudstone (early Pliocene to late Miocene)

Tw — Undivided

Modelo Formation
Mudstone, diatomaceous clay shale or siltstone with interbeds of sandstone (late to middle Miocene)

Tm — Undivided

Mint Canyon Formation
Non-marine fluvial and lacustrine sedimentary breccia, conglomerate, sandstone, siltstone and mudstone (late to middle Miocene)

Tmc — Undivided

Tmcd — Lacustrine deltaic (foreset) facies

Tmcm — Lacustrine and lake-marginal fluvial facies

Tick Canyon Formation
Fluvial and lacustrine sedimentary sandstone, siltstone, claystone and conglomerates (middle to early Miocene)

Ttkc — Conglomerate

Vasquez Formation (Soledad basin and San Andreas fault zone)
Sandstone, conglomerate and interbedded andesite-basalt. Includes numerous beds and lenses of megabreccia.

Tvz — Undivided (early Miocene to Oligocene)

Tvza — Andesitic volcanic rocks (early Miocene to late Oligocene)

Tvzs — Sedimentary rocks (early Miocene to late Oligocene)

San Gabriel Mountains and Eastern Santa Monica Mountains

Tj — Juncal Formation. Turbidity current and submarine fan deposits, including sandstone, conglomeratic sandstone, conglomerate and siltstone (late early Eocene)

Kgr — Granitic Rocks. Includes a variety of plutonic rocks, chiefly quartz diorite (late Cretaceous)

Kgrd — Granodiorite with quartz diorite and granite, commonly gneissoid near contacts with older rocks. Locally carries large inclusions and pendants of gneiss and Placerita metasediments (Cretaceous)

Mzdg — Diorite gneiss (early to middle Mesozoic)

Mount Lowe Instrusive Suite
A compositionally layered pluton (Triassic)

TRlgb — Biotite-orthoclase facies

TRlgdp — Porphyritic facies

TRlgdn — Orthoclase-hornblende facies

TRhdg — Hornblende diorite gabbro

Anorthosite-gabbro complex of Oakeshott (1958) (Proterozoic)
Unit is composed of sub-units mapped and described by Carter (1980a) including:

Pan — Anorthosite

Psy — Syenite

Pfgb — Ferro-gabbro

Plgb — Leucogabbro

Pjgb — Jotunitic gabbro

Pjgba — Jotunite-norite-gabbro-diorite

Pggn — Gabbroic to anorthositic gneiss

Pgb — Gabbro

Pgbla — Anorthosite inclusion-rich gabbro

Pgn — Gneiss (Proterozoic)

Pmgn — Mendenhall Gneiss. Layered migmatic felsic and mafic granulite, having rare interlayered augen gneiss and aluminous gneiss. Age predates the anorthosite-gabbro complex (Proterozoic)

Contact, approximate, dashed where inferred, queried where uncertain

U
D

Fault, long dashed where approximate, short dashed where inferred, dotted where concealed, queried where uncertain
Plan view: Arrows indicated relative strike-slip movement of fault blocks, U (up) and D (down) show relative dip-slip or vertical movment.

T A

Cross section view: Arrows show relative dip-slip or vertical movement. T (toward) and A (away) show relative strike-slip movement of fault blocks

Thrust fault, dashed where approximate, dotted where concealed

Anticline, dashed where approximate, dotted where concealed

Syncline, dashed where approximate, dotted where concealed

Proposed CHSR Alignment, stationing tick marks every 1,000 feet

35 — Inclined bedding, number indicated dip angle in degrees

Vertical bedding

75 — Overturned bedding, number indicates dip angle in degrees

35 — Inclined foliation, number indicates dip angle in degrees

National Forest / Other Federal Land

Magic Mountain Wilderness

San Gabriel Mountains National Monument

U. S. Forest Service Road

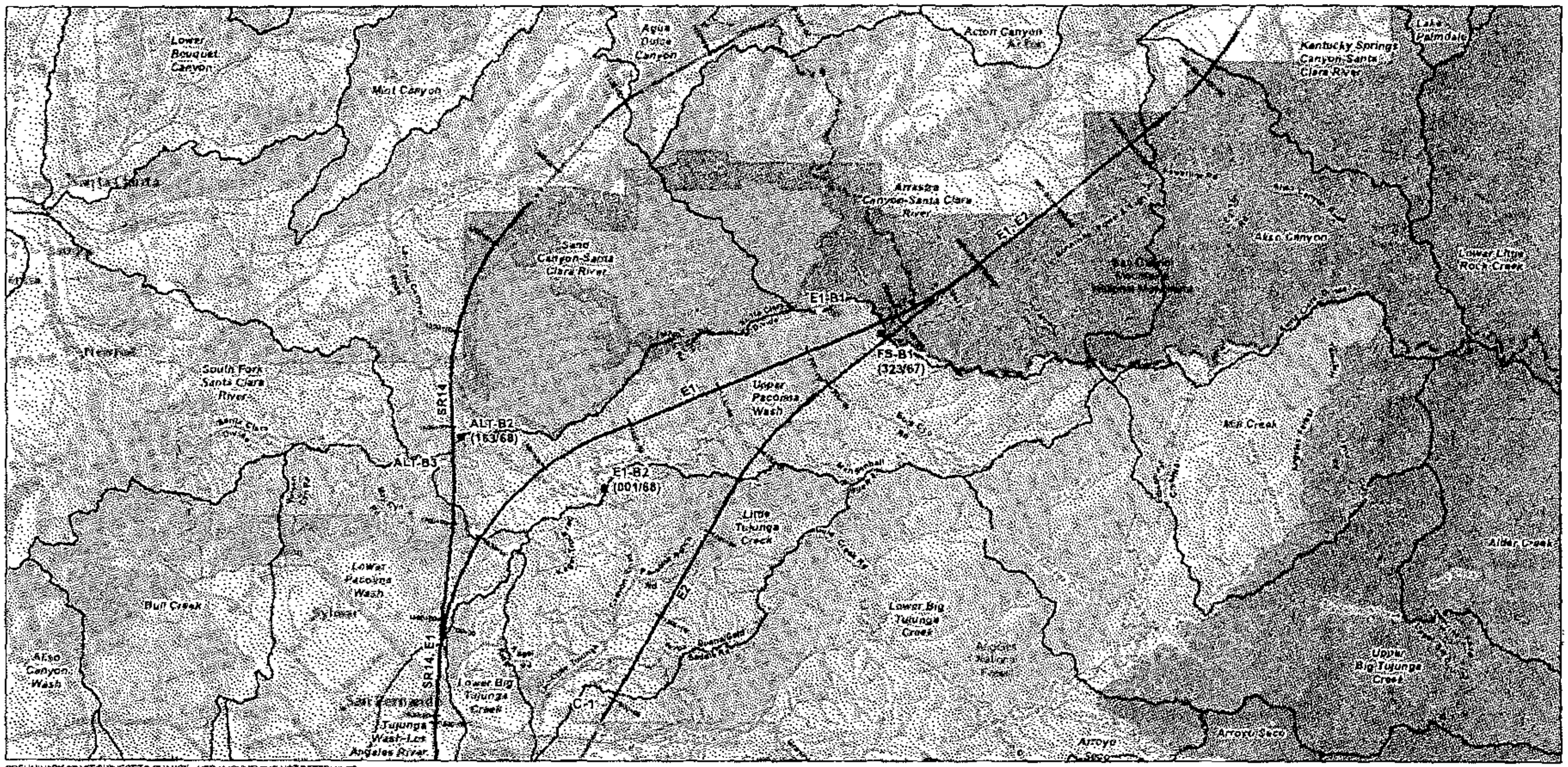
Mountain / Peak

Elevation of shallowest groundwater measured from shallowest core hole vibrating wire piezometer (Elev.; Date Measured)

Source: CHSR, 04/2018, CGS 2014, Weinfeiser 2016.

CALIFORNIA High-Speed Rail Authority — U.S. Department of Transportation Federal Railroad Administration

Figure 5-2 Geologic Map Explanation



PRELIMINARY DRAFT/SUBJECT TO CHANGE - HSR ALIGNMENT IS NOT DETERMINED
Source: Alignment - HSR Authority, 4/16; Kleinfelder; USFS.
Basemap: National Geographic, ESRI

January 27, 2017

HSR Alignment Profile
- At-grade
- Tunnel - At-grade Covered
- Tunnel - Bore
- Elevated / Aerial Structure

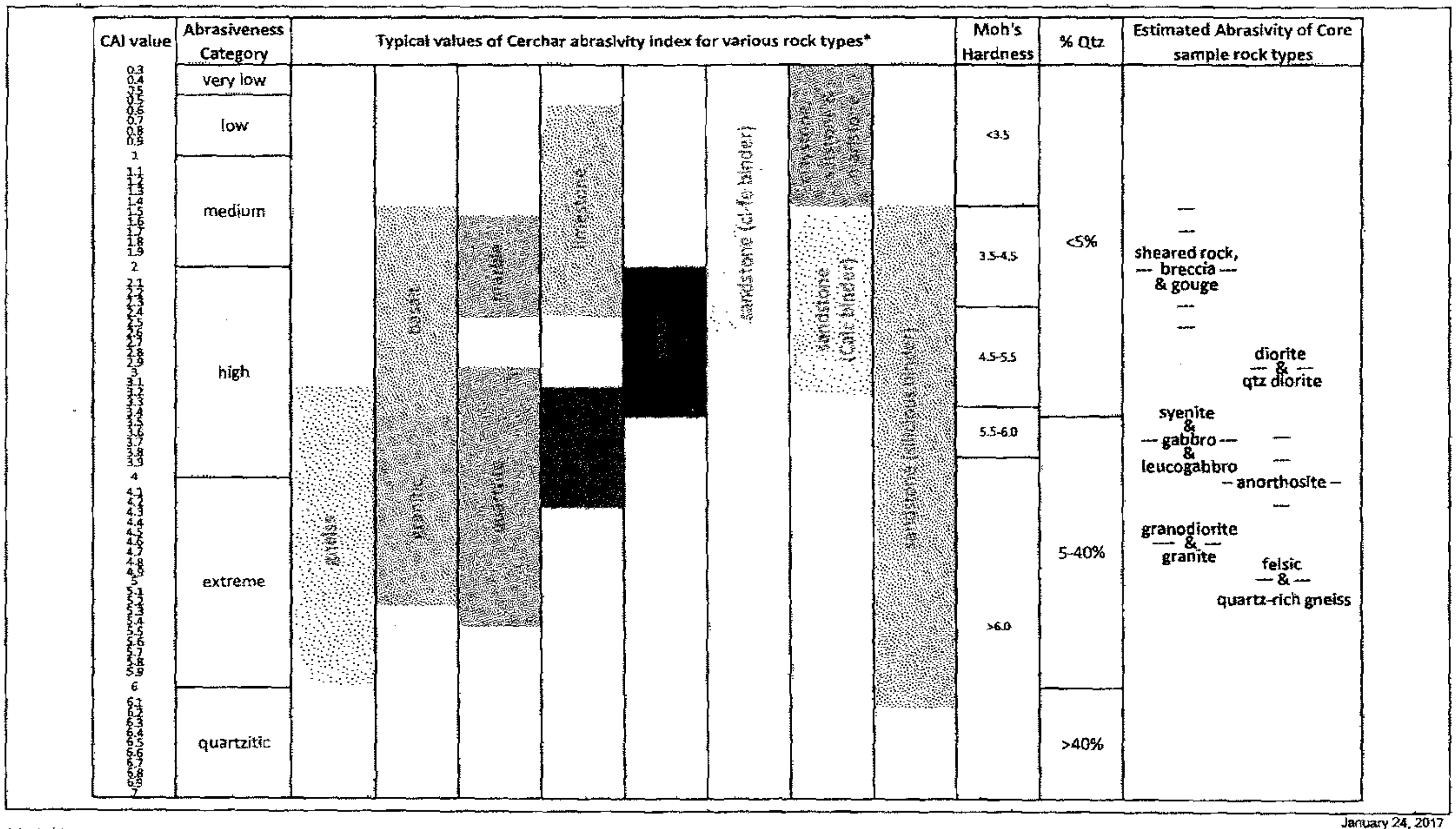
- Vertical Core
- Inclined Core (trend/plunge)

- Stream
- USFS Road
- Pacific Crest Trail
- Subwatershed Hydrologic Unit (12)

- Magic Mountain Wilderness Areas
- San Gabriel Mountains National Monument
- Angeles National Forest

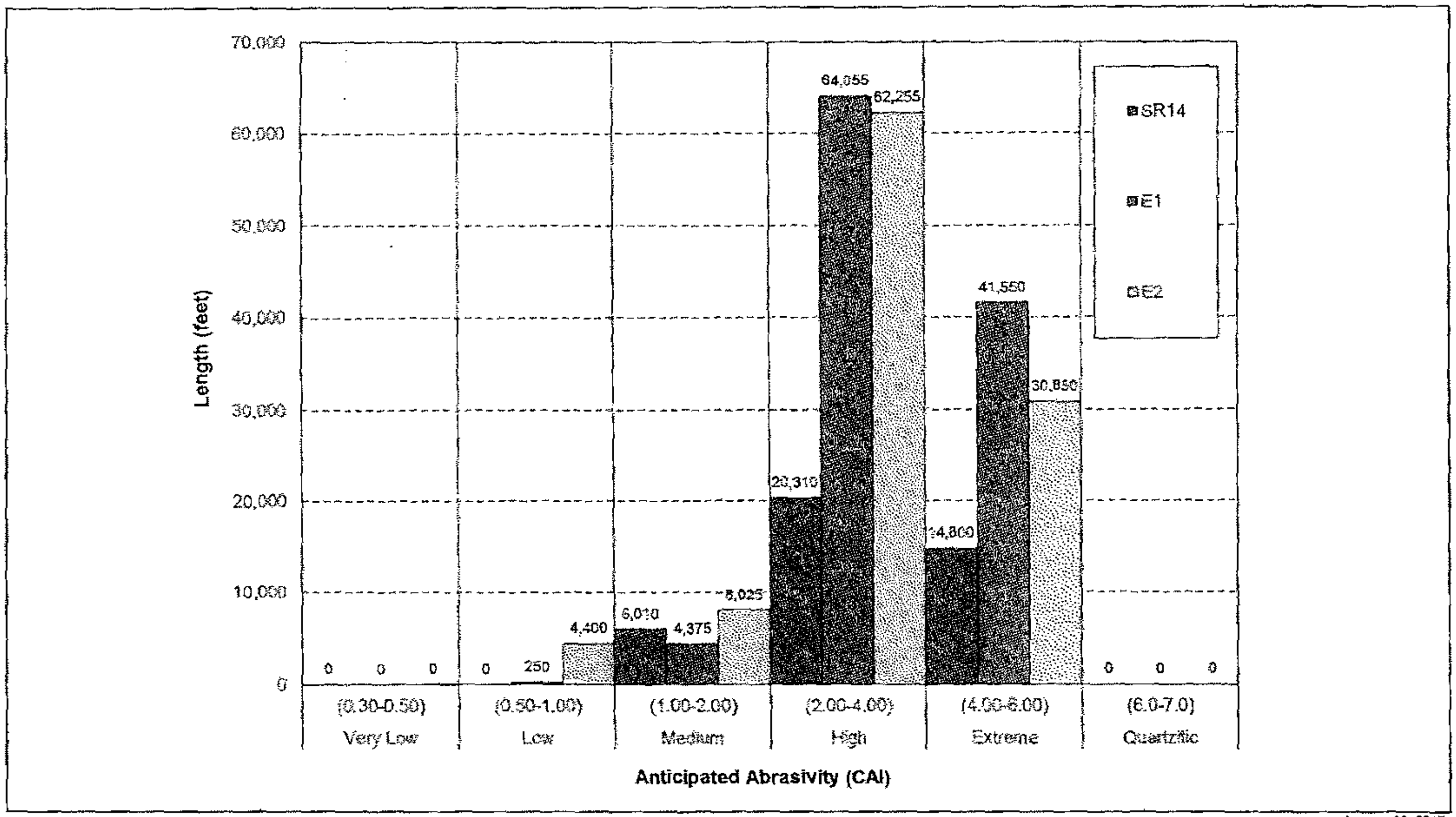
Miles
Kilometers

Figure 5-3 Hydrology Map



Adapted from:
Zhang, 2016; and
Plinninger et al., 2003.

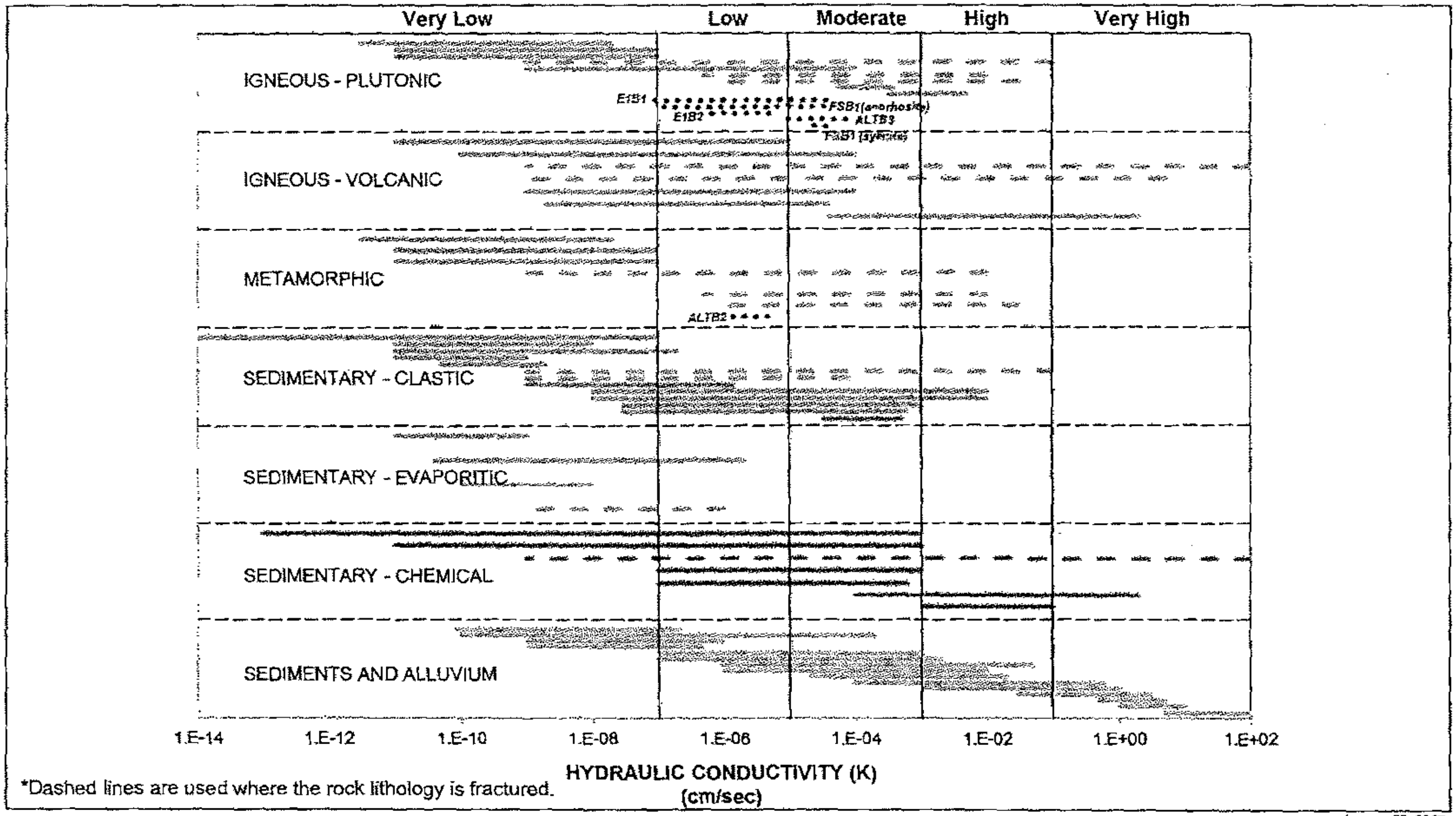
Figure 6-1
Abrasivity correlations



January 23, 2017

Tunnel Alignment	Stationing		Length feet	Very Low Length feet	Very Low Length %	Low Length feet	Low Length %	Medium Length feet	Medium Length %	High Length feet	High Length %	Extreme Length feet	Extreme Length %	Quartzitic Length feet	Quartzitic Length %
SR14	1330+00	1750+00	41,120	0	0.0	0	0.0	6,010	14.6	20,310	49.4	14,800	36.0	0	0.0
E1	638+80	1750+00	110,230	0	0.0	250	0.2	4,375	4.0	64,055	58.1	41,550	37.7	0	0.0
E2	638+80	1750+00	105,530	0	0.0	4,400	4.2	8,025	7.6	62,255	59.0	30,850	29.2	0	0.0

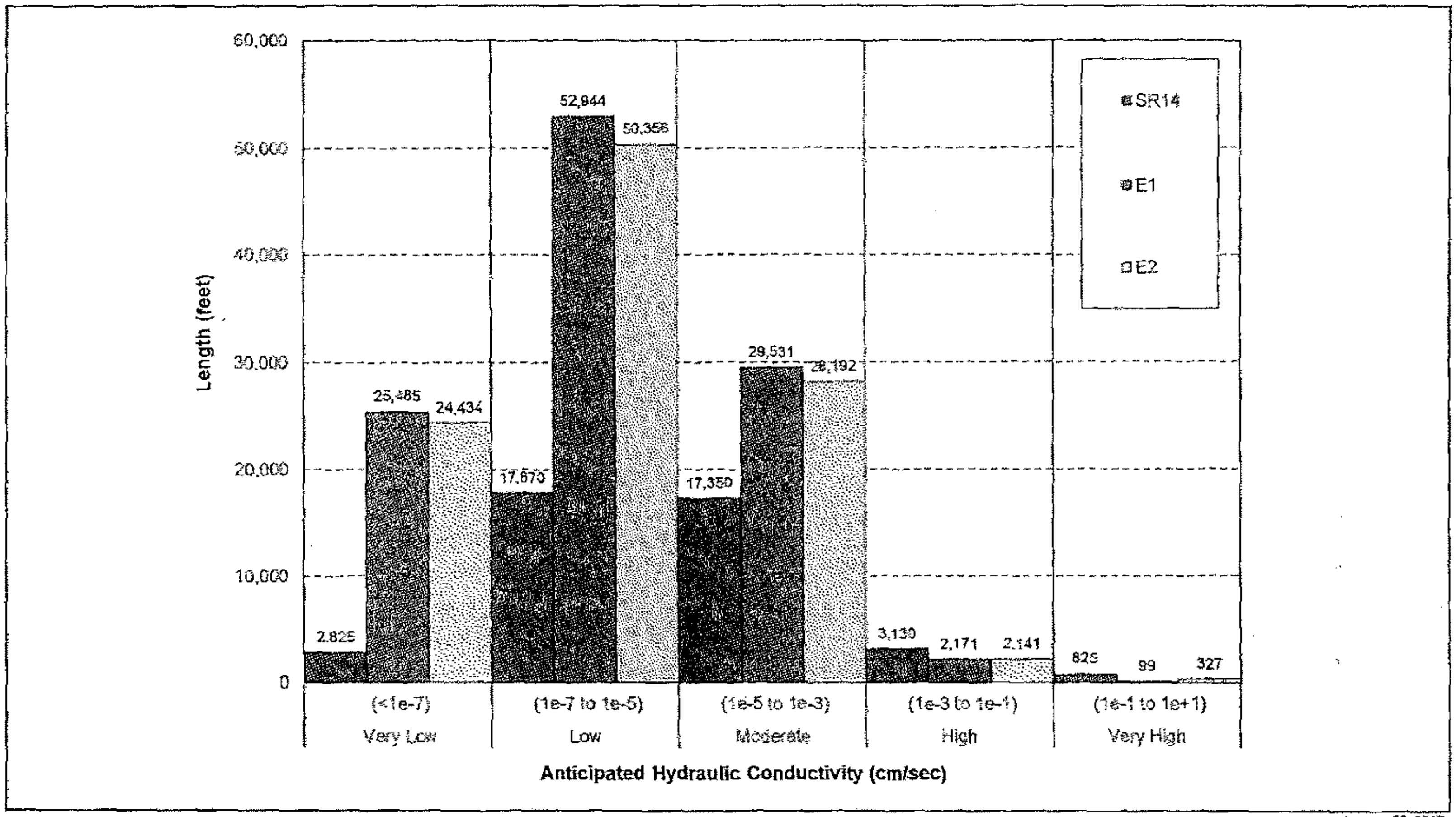
Figure 6-2
Summary of
anticipated abrasivity



January 20, 2017

Sources:
Domenico and Schwartz, 1990;
Freeze and Cherry, 1979;
Goodman, 1989;
Isherwood, 1979;
Jaeger and Cook, 2007; and
USBR, 1998.

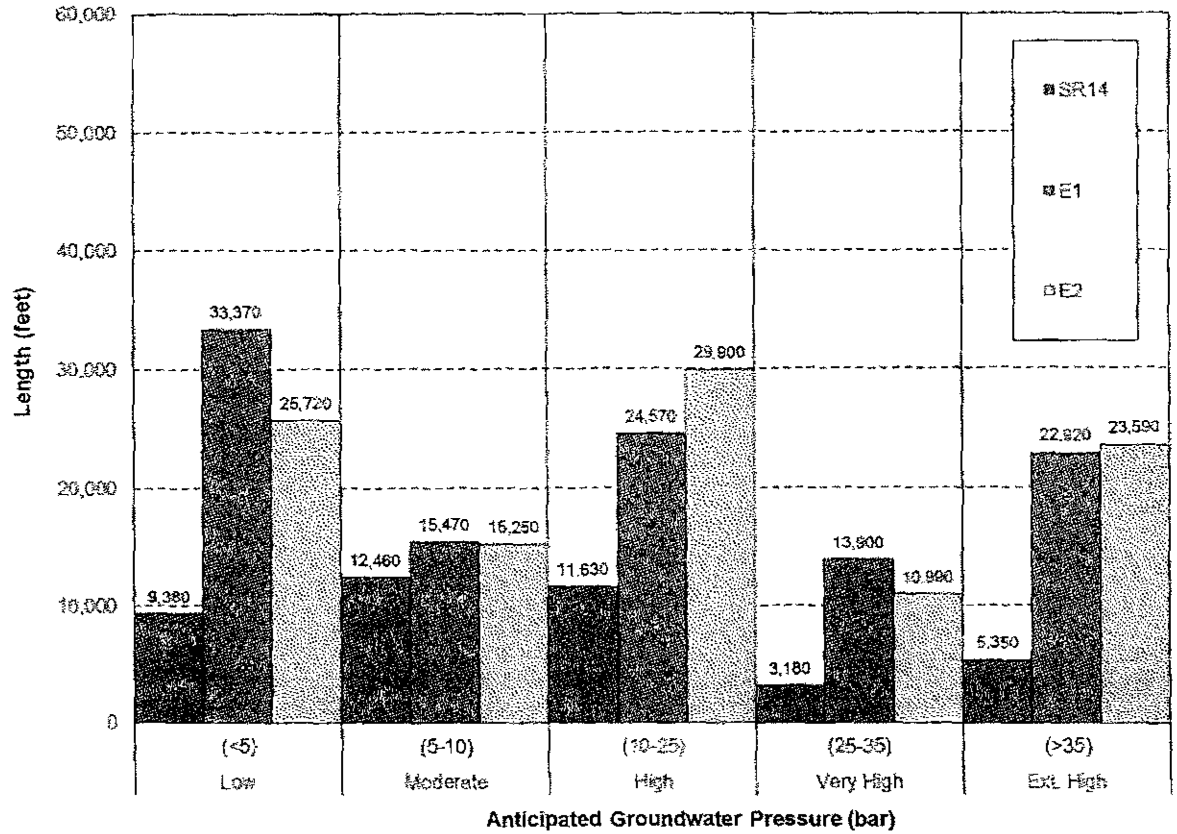
Figure 6-3
Hydraulic conductivity
correlations



January 23, 2017

Tunnel Alignment	Stationing		Length feet	Very Low Length feet	Very Low Length %	Low Length feet	Low Length %	Moderate Length feet	Moderate Length %	High Length feet	High Length %	Very High Length feet	Very High Length %
SR14	1330+00	1750+00	42,000	2,825	6.7	17,870	42.5	17,350	41.3	3,130	7.5	825	2.0
E1	638+80	1750+00	110,230	25,485	23.1	52,944	48.0	29,531	26.8	2,171	2.0	99	0.1
E2	638+80	1750+00	105,450	24,434	23.2	50,356	47.8	28,192	26.7	2,141	2.0	327	0.3

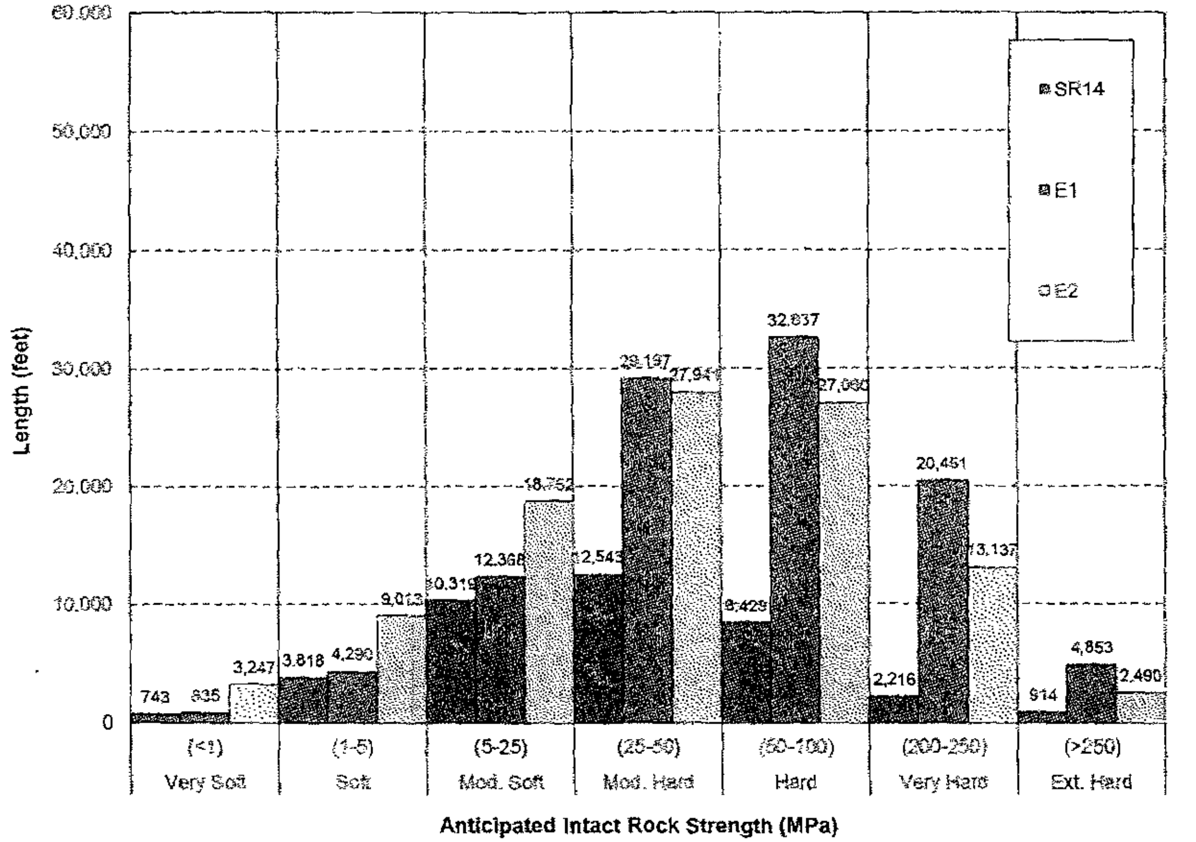
Figure 6-4
Summary of anticipated
hydraulic conductivity



January 23, 2017

Tunnel Alignment	Stationing		Length	Low Length		Moderate Length		High Length		Very High Length		Ext. High Length	
			feet	feet	%	feet	%	feet	%	feet	%	feet	%
SR14	1330+00	1750+00	42,000	9,380	22.3	12,460	29.7	11,630	27.7	3,180	7.6	5,350	12.7
E1	638+80	1750+00	110,230	33,370	30.3	15,470	14.0	24,570	22.3	13,900	12.6	22,920	20.8
E2	638+80	1750+00	105,450	25,720	24.4	15,250	14.5	29,900	28.4	10,990	10.4	23,590	22.4

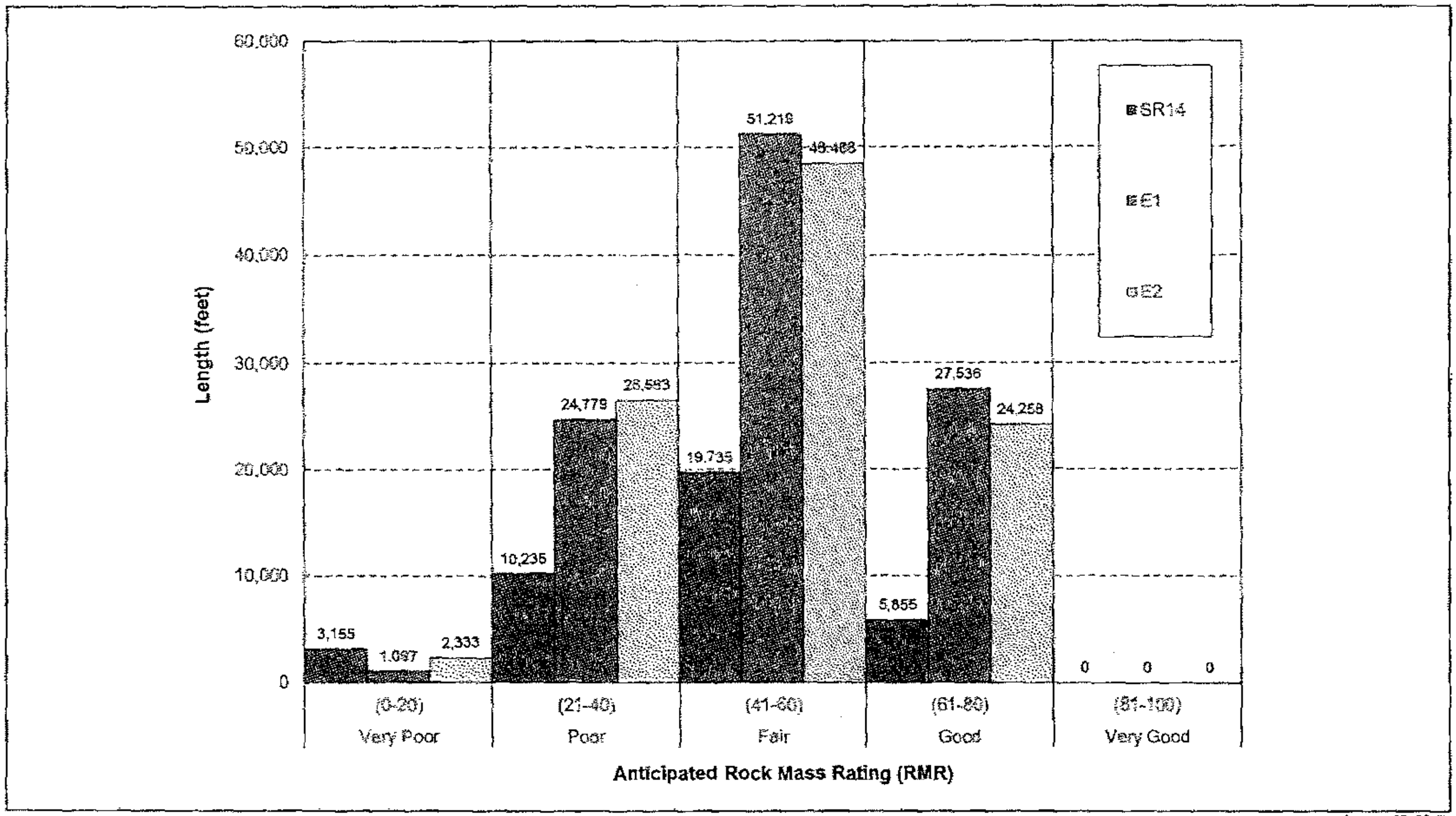
Figure 6-5
Summary of anticipated groundwater pressure



January 23, 2017

Tunnel Alignment	Stationing		Length feet	Very Soft Length feet	Very Soft %	Soft Length feet	Soft %	Mod. Soft Length feet	Mod. Soft %	Mod. Hard Length feet	Mod. Hard %	Hard Length feet	Hard %	Very Hard Length feet	Very Hard %	Ext. Hard Length feet	Ext. Hard %
SR14	1330+00	1750+00	38,980	743	1.9	3,818	9.8	10,319	26.5	12,543	32.2	8,429	21.6	2,216	5.7	914	2.3
E1	638+80	1750+00	104,630	835	0.8	4,290	4.1	12,368	11.8	29,197	27.9	32,637	31.2	20,451	19.5	4,853	4.6
E2	638+80	1750+00	101,640	3,247	3.2	9,013	8.9	18,752	18.4	27,941	27.5	27,060	26.6	13,137	12.9	2,490	2.4

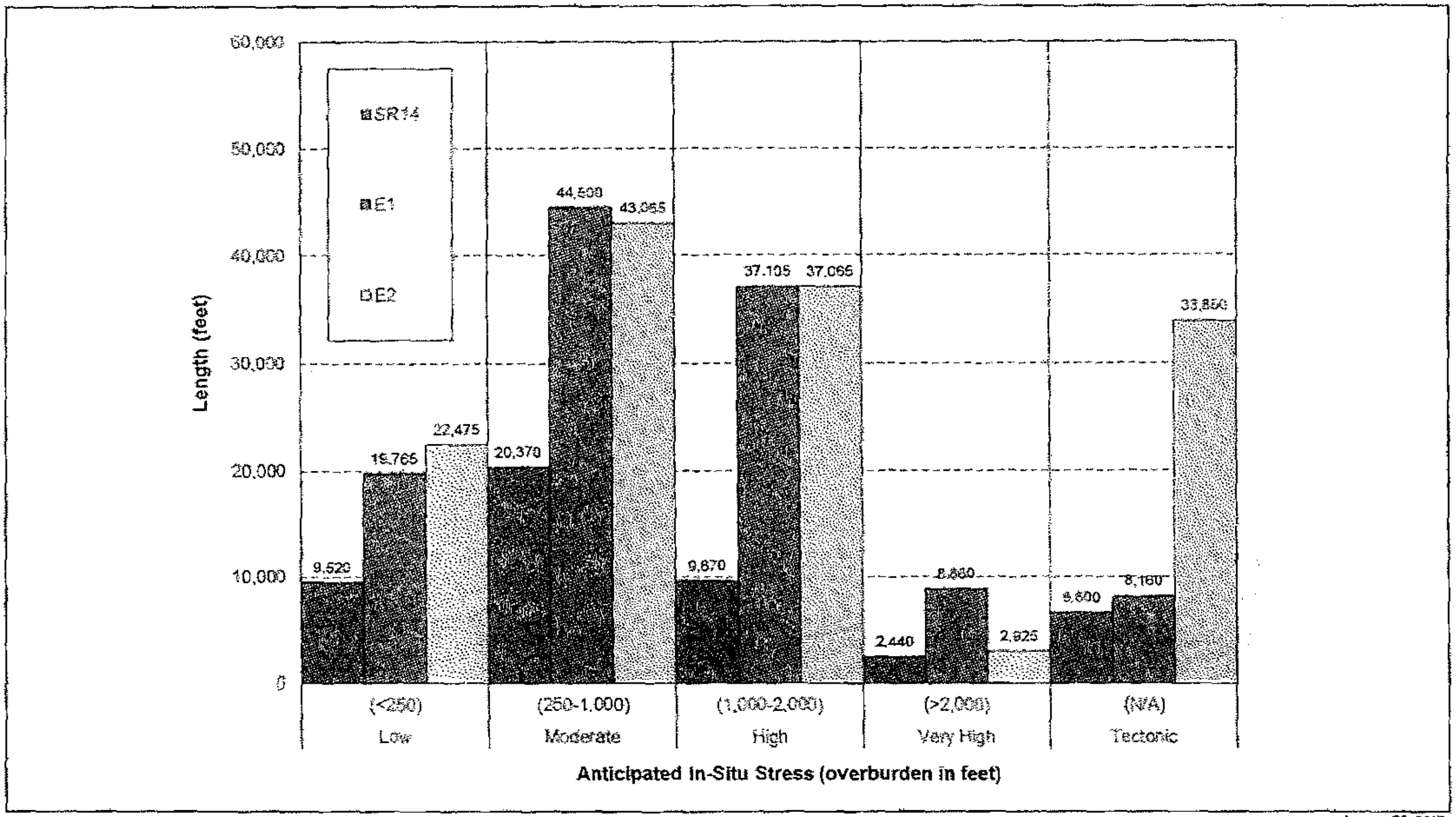
Figure 6-6
Summary of anticipated intact rock strength



January 23, 2017

Tunnel Alignment	Stationing		Length feet	Very Poor Length feet	Very Poor Length %	Poor Length feet	Poor Length %	Fair Length feet	Fair Length %	Good Length feet	Good Length %	Very Good Length feet	Very Good Length %
SR14	1330+00	1750+00	38,980	3,155	8.1	10,235	26.3	19,735	50.6	5,855	15.0	0	0.0
E1	638+80	1750+00	104,630	1,097	1.0	24,779	23.7	51,219	49.0	27,536	26.3	0	0.0
E2	638+80	1750+00	101,640	2,333	2.3	26,563	26.1	48,488	47.7	24,258	23.9	0	0.0

Figure 6-7
Summary of anticipated
rock mass conditions

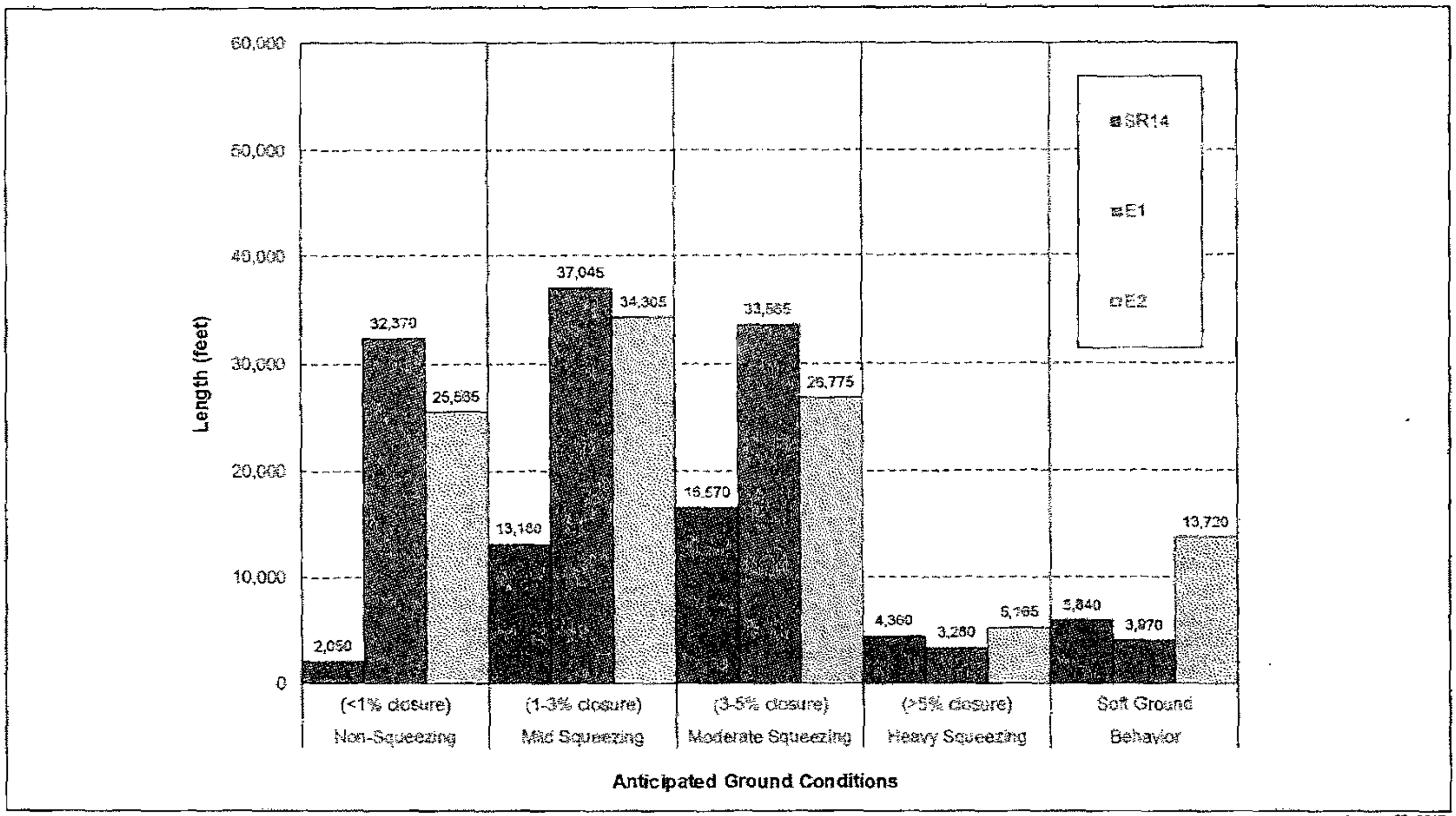


January 23, 2017

Tunnel Alignment	Stationing		Length feet	Low Length feet	Low %	Moderate Length feet	Moderate %	High Length feet	High %	Very High Length feet	Very High %	Tectonic Length feet	Tectonic %
SR14	1330+00	1750+00	42,000	9,520	22.7	20,370	48.5	9,670	23.0	2,440	5.8	6,600	15.7
E1	638+80	1750+00	110,230	19,765	17.9	44,500	40.4	37,105	33.7	8,860	8.0	8,160	7.4
E2	638+80	1750+00	105,530	22,475	21.3	43,065	40.8	37,065	35.1	2,925	2.8	33,850	32.1

*Tectonic stress is not exclusive to a single range or magnitude of in-situ stress.

Figure 6-8
Summary of anticipated in-situ stress



January 23, 2017

Tunnel Alignment	Stationing		Length feet	Non-Squeezing Length feet	%	Mild Squeezing Length feet	%	Moderate Squeezing Length feet	%	Heavy Squeezing Length feet	%	Soft Ground Length feet	%
SR14	1330+00	1750+00	42,000	2,050	4.9	13,180	31.4	16,570	39.5	4,360	10.4	5,840	13.9
E1	638+80	1750+00	110,230	32,370	29.4	37,045	33.6	33,565	30.4	3,280	3.0	3,970	3.6
E2	638+80	1750+00	105,530	25,565	24.2	34,305	32.5	26,775	25.4	5,165	4.9	13,720	13.0

*Soft Ground Behavior includes: Firm, Ravelling, Running, or Flowing Ground

Figure 6-9
Summary of anticipated ground conditions

[redacted]

SANTA CLARITA VALLEY
Chamber of Commerce

April 16, 2018

Mr. Dan Richard, Chairman
Board of Directors
California High-Speed Rail Authority
770 L Street, Suite 800
Sacramento, CA 95814

CALIFORNIA HIGH-SPEED RAIL AUTHORITY (CHSRA) DRAFT 2016 BUSINESS PLAN - COMMENT

Dear Chairman Richard:

The Santa Clarita Chamber of Commerce is supporting the City of Santa Clarita, and several other local communities, in support of two key issues from the CHSR Business Plan: undergrounding and the commitment to provide funding to local rail systems under the MOU.

We represent 900 businesses in the community and are opposed to any above ground project which will create a damaging economic and environmental impact on our community which cannot be mitigated. The Chamber is appreciative of CHSRA's continuing efforts to identify potential routes for the Palmdale to Burbank Project Section, and want to make sure you understand that we only support the fully underground alignments in order minimize negative impacts to the communities located within this Project Section.

Additionally, several years ago the California High-Speed Rail Authority entered into a Memorandum of Understanding with the Southern California Association of Governments and other entities that promised the investment of one billion dollars in Southern California regional rail improvements. That money has not yet materialized in any meaningful way within the Palmdale to Burbank segment and needs to be added.

We hope that you will continue to work with the City of Santa Clarita, other local impacted communities and SCAG to ensure the undergrounding of this segment and to facilitate early investment in the region's rail infrastructure to increase interregional connectivity, speed, capacity, and safety.

Sincerely,

Troy Hooper
Chairman, Santa Clarita Valley Chamber of Commerce

An Open Letter to the California High Speed Rail Authority : April 17th, 2018

It is my hope that you, the California Legislature, and the California High Speed Rail Authority are successful in constructing and operating the California Bullet Train from San Francisco to Los Angeles.

The primary difficulty in achieving this is the segment from Bakersfield to Los Angeles. Much has been written regarding the cost & time required to traverse and tunnel through the Tehachapi & San Gabriel Mountains, to the point where many feel that Bakersfield may ultimately be the final southern terminus.

To insure that Los Angeles is, in fact, in play, it's time for the Authority to "Think Outside the Box". From a geological, geographical, logistical, and financial standpoint, there is an alignment that will enable the completion of the project SOONER THAN EXPECTED & UNDER BUDGET. Upon study, it is likely that the most logical alignment to Los Angeles is the following SOUTHWEST ROUTE:

Depart Bakersfield to the Southwest through Maricopa and Ventucopa, to the junction of SR33 and Lockwood Valley Road. From here tunnel under the Los Padres National Forest all the way to the SR33 Freeway between Ojai & Ventura (Casitas Springs), parallel the freeway into Ventura, then head south along the established right-of-way all the way to Los Angeles Union Station. The tunneling distance will be approximately 17-20 miles (compared to total of 36 miles of tunnels along the Tehachapi route, one measuring 17 miles in length). With lower elevation gain to deal with than the Tehachapi route, the tunnel (and tracks) under the Los Padres will have decreased percent grade (2.5%) ,allowing for maximum train speeds of 220 mph. Thus, it will take the HSR only about 7 minutes to travel under the Los Padres from Lockwood Valley Road to Casitas Springs. Because the train will travel under the forest, it will have no effect on the natural ecosystem above ground (out of sight-out of mind).

The tunnels can be bored under a direct line of canyons running north to south, not under ridges and summits. This means shallower tunnels that enable construction of escape routes at reasonable depth along its entirety. The biggest difference & advantage of this route is the geology. The Los Padres consists of Monterey shale, marine sandstone, chalk, limestone, pebbly conglomerate, and sedimentary rock. This makeup is much more suitable for boring tunnels. Through the Shattered Granite & Fault Zones of the Tehachapi- San Gabriel's, the boring rate is only 10-20 feet/day vs. the boring rate of 100-200 feet/day through the Sedimentary Los Padres. This represents a tenfold reduction in the time to bore the tunnel, not to mention that the southwest route requires ½ the number of tunnel miles and as few as 1/10th the number of actual tunnels. The result being, greatly reduced construction cost, and decreased construction time. To build the tunnel(s) running the entire 17-20 mile length under the Los Padres is very doable, considering the Gotthard Base Tunnel was completed in Switzerland last year with a length of 35 miles.

As described above, the Southwest Route provides definite economic, logistical, and safety advantages to HSR construction. A fourth advantage is the elimination of the Public Outcry and Opposition being voiced from residents in Acton, Agua Dulce, Lakeview Terrace, Sunland-Tujunga, and San Fernando. As stated, the bullet-train alignment from Ventura all the way through Oxnard, Simi Valley, Van Nuys, and Burbank to Union Station will run along an already established Right of Way. Not only will this curtail the Public Outcry and Litigation from the above mentioned communities, this route will save countless millions by eliminating the need to have Subterranean Tracks from Santa Clarita to Burbank.

The fifth major advantage is that this route will be much more appealing to the public. Travelers, Commuters, and Tourists will be attracted to the Coastal Route. Residents of the Central Valley will use HSR to travel to the coast with their families to enjoy the beaches during the summer months. The result being increased ridership and greater revenues, which in turn will attract & generate Outside Investment In the System.

The overall mileage from Bakersfield to Los Angeles via the Tehachapi/ San Gabriel route is approximately 168 miles, via the southwest Los Padres route it is roughly 170 miles. The difference is negligible.

I realize that the current plan sends the alignment through Palmdale so that, perhaps, sometime in the long distant future, an eventual junction can route the HSR to both Los Angeles and Las Vegas. This idea is putting the cart before the horse. We need to first fulfill the original objective, and build HSR from San Francisco to Los Angeles. Considering the perspective I have presented, it is time that the HSR Authority order a full DEIR and EIR to prove the merits of the Los Padres Coastal Alignment.

This inquiry may, in fact, lead us to believe that
the Los Padres is the Coloma of the 21st century for High Speed Rail,
and the Coastal Route is the Mother Lode.

Sincerely,

Charles R. Follette,
2103 Idaho Avenue, #A
Santa Monica, Calif. 90403
americanbotanical@verizon.net
310-963-9952

SWITZERLAND

Longest rail tunnel is finished

Just like Hannibal in ancient times, Swiss engineers have conquered the Alps.

More than 2,200 years after the commander from the ancient North African civilization of Carthage led his army of elephants and troops over Europe's highest mountain chain, the Swiss have burrowed the world's longest railway tunnel under the Swiss Alps to improve European trade and travel.

European dignitaries inaugurated the 35-mile Gotthard Base Tunnel, a major engineering achievement deep under the Alps. It took 17 years to build at a cost of $12 billion — but workers kept to a key Swiss tradition and brought the massive project in on time and on budget.

The Gotthard Base Tunnel is a record-setter — it also bores deeper than any other tunnel, running about 1.4 miles underground at its maximum depth. It is part of a broader, multi-tunnel project to shift the haulage of goods from roads to rails amid concerns that heavy trucks are destroying the pristine Alpine landscape.

Drozd, Doug@HSR

From:	Vivian Zinn <Rebel-Zinn@socal.rr.com>
Sent:	Thursday, April 12, 2018 1:34 PM
To:	HSR boardmembers@HSR
Subject:	Palmdale to Burbank Alignment
Follow Up Flag:	Follow up
Flag Status:	Flagged

Mr. Dan Richard
Chairman, Board of Directors
California High Speed Rail Authority
770 L Street, Suite 620
Sacramento, CA 95814

Dear Mr. Richard,

I am sorry I am unable to attend the California High-Speed Rail Authority (CHSRA) Board of Directors meeting on April 17, 2018 to address my concerns to the CHSRA Board of Directors. I am writing to express my opposition to any alignment between these cities that is not totally underground. Anything above ground is unacceptable and has a serious negative impact not only my community of Sand Canyon but other affected communities as well. Several years ago, the California High-Speed Rail Authority entered into a Memorandum of Understanding with Southern California Association of Governments and other entities and promised the investment of one billion dollars in Southern California regional rail improvements.To date, there has been no indication that that commitment has been fulfilled or even acted upon. It is my, and the community's expectation that the CHSRA will fulfill the commitment and keep the project underground in these areas.

Respectfully,

Vivian Zinn

26961 Tannahill Ave
Santa Clarita, CA 91387

Drozd, Doug@HSR

From: Eric <lindvall@earthlink.net>
Sent: Thursday, April 12, 2018 2:58 PM
To: HSR boardmembers@HSR
Subject: High speed rail project

Follow Up Flag: Follow up
Flag Status: Flagged

Please drop the High speed rail project!! It is a project California does not need and certainly will never be able to afford without further bankrupting the state !!!

C Eric Lindvall,
CA Registered Geologiet # 891

Drozd, Doug@HSR

From: janandskip <janandskip@earthlink.net>
Sent: Thursday, April 12, 2018 4:48 PM
To: HSR boardmembers@HSR
Subject: Santa Clarita alignment

Follow Up Flag: Follow up
Flag Status: Flagged

We are very definitely OPPOSED to any alignment that is not underground!!!

Sent from my T-Mobile 4G LTE Device

Drozd, Doug@HSR

From:	Susan MacAdams <susan.macadams@gmail.com>
Sent:	Wednesday, April 11, 2018 3:25 PM
To:	HSR boardmembers@HSR; HSR Central Valley Wye@HSR; HSR fresno_bakersfield@HSR; HSR san.jose_merced@HSR
Cc:	tsheehan@fresnobee.com; cgallegos@cityofmadera.com; jrodriguez@cityofmadera.com; woliver@cityofmadera.com; drobinson@cityofmadera.com; crigby@cityofmadera.com; dholley@cityofmadera.com; jeaguilar@cityofmadera.com; cboyle@cityofmadera.com; District5@co.fresno.ca.us; District2@co.fresno.ca.us; District3@co.fresno.ca.us; District1@co.fresno.ca.us; District4 @co.fresno.ca.us
Subject:	REQUEST FOR IMMEDIATE STOP WORK ORDER FOR MERCED TO FRESNO SECTION
Attachments:	Attach 1 CHSRA Merced to Fresno Section.pdf; Attach 2 HSR Structure over UPRR.pdf; Attach 3 Structure over UPRR.pdf; Attach 4 Aerial Structure.pdf; Attach 5 Aerial Deck.pdf; Attach 6 Horizontal Curve.pdf; Attach 7 Vertical Curve.pdf; Attach 8 Superelevation.pdf; Attach 9 Curve on bridge deck.pdf; Attach 10 HSR Curve Criteria.pdf; Attach 11 Temp Extremes Fresno 1.pdf; Add Attach Curve Criteria Highway.pdf; Stop Work Order.pdf; Article HSR Derailment.pdf; Request for Stop Work Order CHSRA.pdf

April 11, 2018

To: Brian P. Kelly
Chief Executive Officer
California High Speed Rail Authority
770 L Street, Suite 620
Sacramento, CA 95814

RE: REQUEST FOR IMMEDIATE STOP WORK ORDER FOR MERCED TO FRESNO SECTION

Public Safety should be paramount in any track design for High Speed Rail (HSR), but the design for the track curves across the Herndon Overpass structure north of Fresno is a public safety hazard and poses a serious threat to derailment.

Background

Building straight tracks along the UPRR corridor from Merced to Fresno was the shortest route for HSR.

In 2012, the track route called the Hybrid was chosen by the Authority. This route veers from the UPRR corridor and zig-zags across open farmland. The sixty mile straight route now contains nearly 25 miles of high speed curves and horizontal super-elevated spirals with an additional ten miles of track. Trains will travel over the curves and spirals on ballasted track built on alluvial soil at 220 mph. The California High Speed Rail Authority (CHSRA) officials continue to state that this route between Merced and Fresno is the backbone of the high speed rail system, yet this backbone has developed scoliosis, or curvature of the spine; the area in question will need a spinal brace.

(See Attachments 1A and 1B for Merced to Fresno Section alignment.)

This is a request for an immediate Stop Work Order for the Fresno to Merced section to reevaluate the curve designs. This report focuses only on the curve north of Fresno between Herndon Drive and the San Joaquin River. However, similar alignment flaws are shown on the Authority's construction drawings in Madera County for the Chowchilla Boulevard/UPRR Bridge, the Fresno River Bridge, the two single track crossovers between Avenue 10 and 12, and the entire Wye complex surrounding the storage facility site. Each of these high speed rail curves should be re-evaluated, realigned and reconfigured as they each contain similar alignment problems that will lead to future operational and maintenance hazards and derailments.

Dangerous Design

North of Herndon Drive in Fresno, near the San Joaquin River, there is a wide support structure for high speed rail currently being constructed over a single UPRR track. (See Attachments 2 and 3.) As the HSR tracks curve northwards, this wide track support structure transitions into tall support columns. (See Attachments 4 and 5.) The trains will travel at 220 mph on top of these 60 to 100 foot tall structures. Near the transitional area between the wide deck and the support columns, the track design calls for a combination of overlapping horizontal and vertical curves. This combination violates the Authority's own Criteria for safe track design. The track design is extremely dangerous; this track design cannot be easily built or safely maintained, thereby creating a significant risk of derailment.

The Draft Environmental Report, the Final Environmental Report and the Construction Documents all use the same curve design for this track; the two sets of environmental documents are identical. This is non-standard practice for good curve design. Usually, in critical locations such as this, between the draft, final and construction documents, multiple track designs are evaluated in order to determine the best and safest fit. For this alignment, there was only one proposal. A single drawing from the Final EIR will be used for ease of argument.

For five years, I was the Manager of Metro's Green Line track contracts in Los Angeles. This included the Aviation Wye, which is located on the southern boundary of the Los Angeles International Airport (LAX). The size and type of the structures near LAX are similar to the size and type structures from Herndon Drive to the San Joaquin River. On the Los Angeles project, there were many track alternatives studied before the trackway was built. There is not any evidence of any other track design proposed for this critical structure near the San Joaquin River.

At the overlap of vertical and horizontal curves, the tracks begin to curve away from the large structure; three mathematical models are needed to construct the tracks, an unsafe track engineering practice. (See Attachments 6, 7 and 8.) A horizontal spiral curving outwards is built on top of a vertical curve going downwards. (See Attachment 9.) The tracks will be super-elevated from zero to six inches on one side, while the trains are spiraling downwards on a maximum grade slope across the top of a vertical curve. Normal track design does not allow this combination except in amusement parks and coal mines; this is not Disneyland and all of the curvature for HSR should be seriously investigated. The northbound train has the greatest potential for derailment when traveling across the peak of the vertical curve. Maintaining a slower speed may actually make things worse.

This combination of curves is avoided in rail and roadway design criteria, including the CHSRA Criteria. (See Attachment 10A, 10B, 10C and 10D.)

For high speed rail, due to the large radius and length of curves, there can be some overlap at the edges. But in this case, the horizontal spiral and the vertical curve are on top of one another. It will be impossible to build, maintain and operate trains safely over this combination.

Fresno suffers from extreme heat and cold. This will result in extremes in the expansion and contraction of the rail and the structures. Rail and concrete expand and contract at different rates. Has this been taken into account in the curve designs that are built on the structures? (See Attachment 11.)

Summary: Combining a horizontal spiral that increases from zero to six inches of super-elevation with a maximum grade vertical curve built on top of a transitional structural support system in a geographical area that experiences extreme temperature range is very dangerous for trains traveling at any speed. This is a request to immediately issue a Stop Work Order to the Contractor for all structures on the Merced to Fresno segment of California High Speed Rail.

Please see additional attachments for further information.

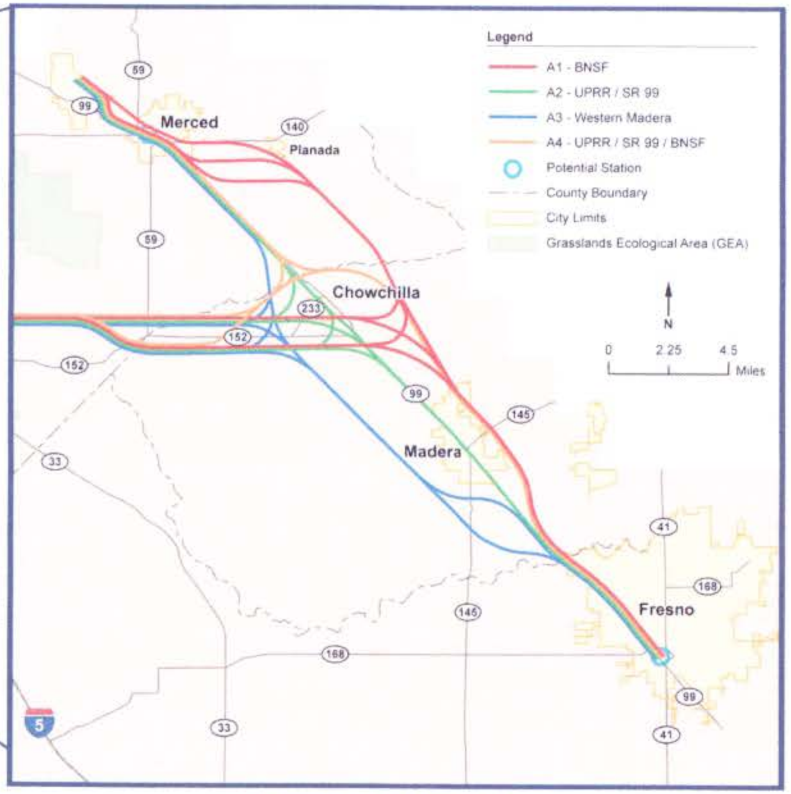
Thank you for your cooperation in this matter.

Susan MacAdams
Track and Alignment Expert
Former High Speed Rail Planning Manager,
Los Angeles County Metropolitan Transportation Authority (Metro)
Metro Red, Blue and Green Lines, Los Angeles
Light and Heavy Rail Track Design and Construction: Baltimore, Boston, & Washington DC
susan.macadams@gmail.com

ATTACHMENT 1

Merced-to-Fresno Section

Statewide Map



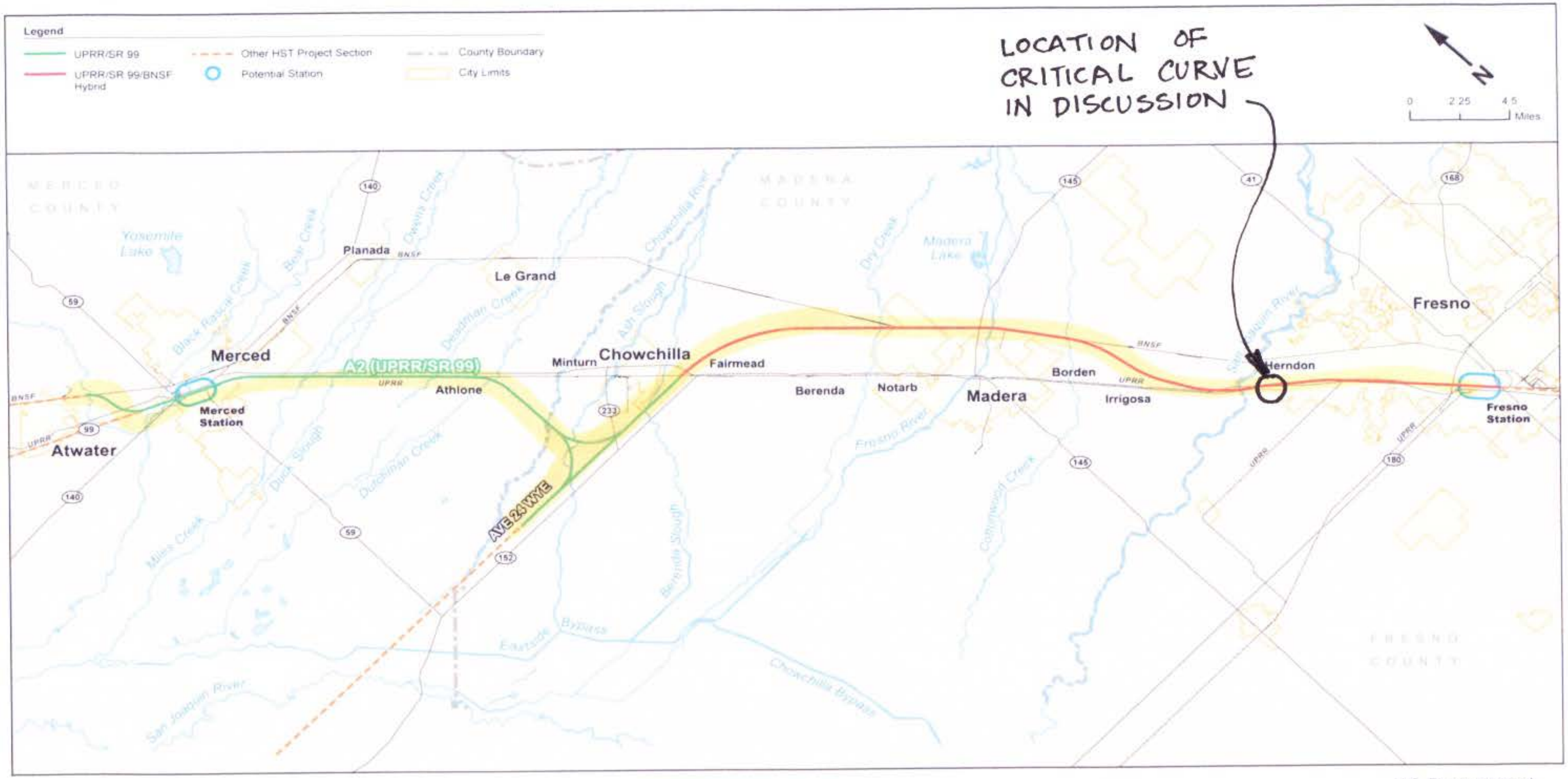
Project Vicinity

CALIFORNIA HIGH-SPEED RAIL AUTHORITY

U.S. Department of Transportation
Federal Railroad Administration

ATTACHMENT 1B

A2 (UPRR) / A1 (BNSF) – Ave 24 Wye
West Chowchilla Design Option



CALIFORNIA HIGH-SPEED RAIL AUTHORITY

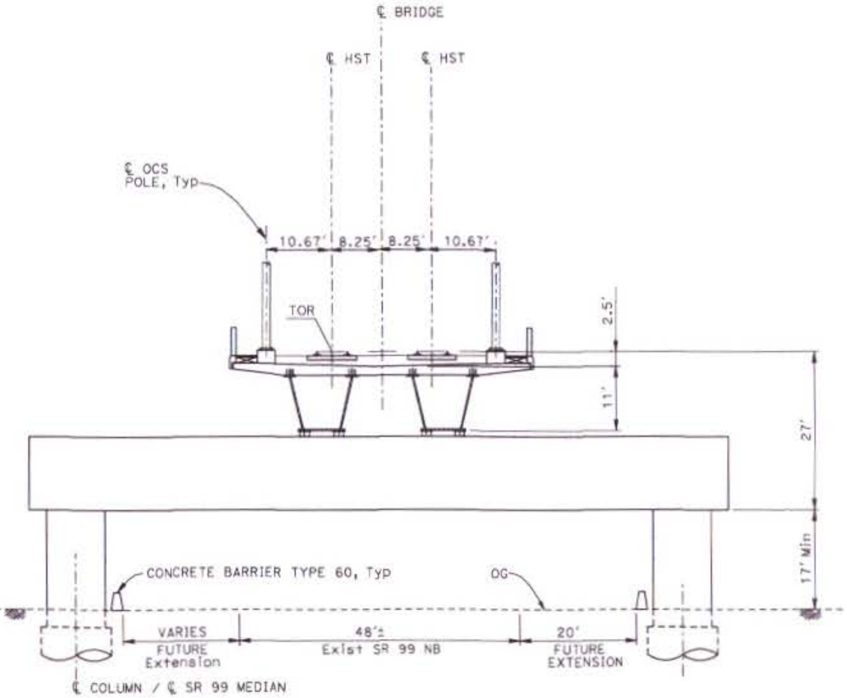
U.S. Department of Transportation
Federal Railroad Administration

ATTACHMENT 2

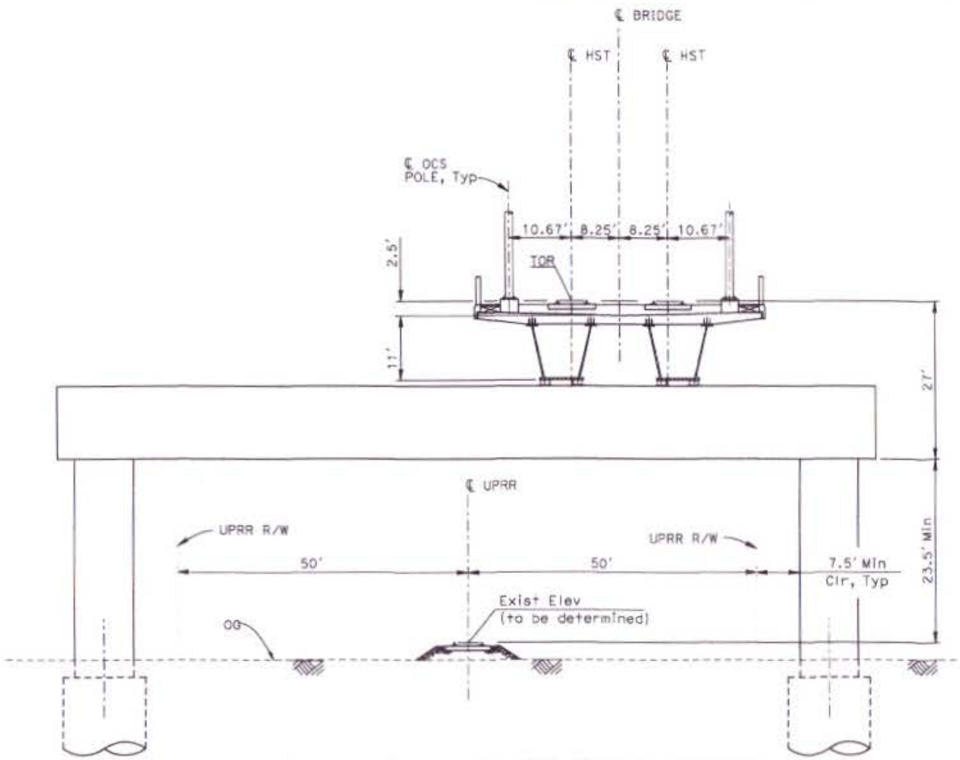
HSR STRUCTURE OVER UPRR TRACKS NEAR HERNDON DRIVE, FRESNO
LOOKING NORTHWEST

CHANGE IN TRACK STRUCTURE

ATTACHMENT 3



EL4 - DOUBLE TRACK ELEVATED CROSSING SR99



EL5 - DOUBLE TRACK ELEVATED CROSSING UPRR/BNSF

LOOKING NORTHWEST

NOTES:

1. TRACK, OCS POLES AND FOUNDATIONS, CABLE DUCTS AND DRAINAGE ARE SCHEMATIC AND DO NOT REPRESENT DESIGN.
2. RIGHT-OF-WAY REQUIRED FOR THE HIGH-SPEED RAIL GUIDEWAY WILL DEPEND UPON CONDITIONS ALONG THE ALIGNMENT, INCLUDING TERRAIN, WHERE CUT/FILL SLOPES, RETAINING STRUCTURES, AND ACCESS ARE REQUIRED.
3. POTENTIAL SOUND BARRIERS NOT SHOWN IN CROSS SECTIONS. FOR THE EXTENT OF POTENTIAL SOUND BARRIERS, SEE ALIGNMENT PLAN AND PROFILE SHEETS.

REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY A. SHIELDS
DRAWN BY C. VALADAO
CHECKED BY A. BOONE
IN CHARGE A. BOONE
DATE 07/20/2011

RECORD SET 15% DESIGN SUBMITTAL

NOT FOR CONSTRUCTION

AECOM Technical Services, Inc.

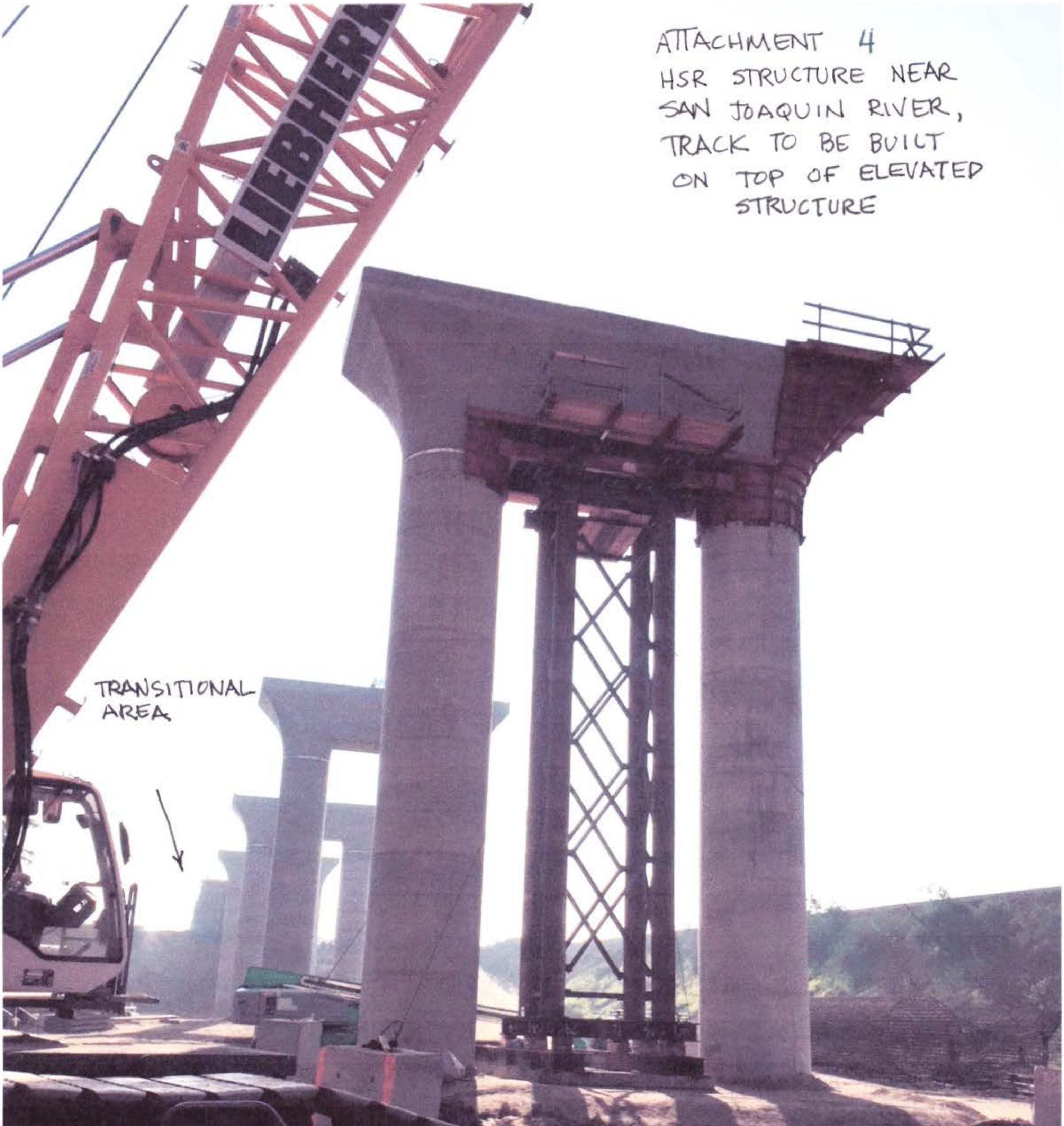
CH2M HILL

CALIFORNIA HIGH-SPEED RAIL AUTHORITY

CALIFORNIA HIGH-SPEED TRAIN PROJECT
MERCED TO FRESNO

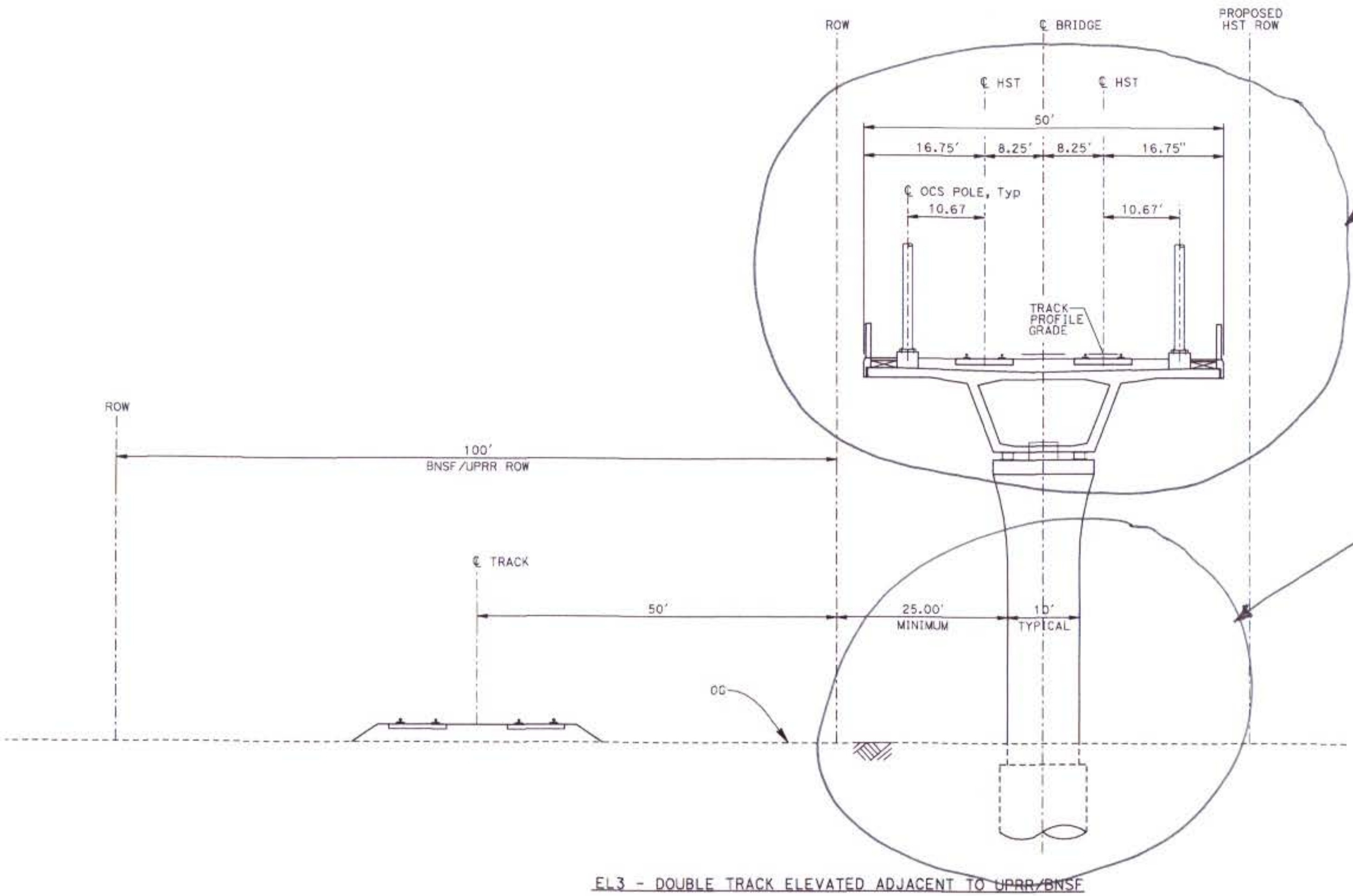
TYPICAL SECTIONS
SHEET 6 OF 17

CONTRACT NO. HSR06-007
DRAWING NO. T3006-A
SCALE NO SCALE
SHEET NO. OF ###


ATTACHMENT 4
HSR STRUCTURE NEAR
SAN JOAQUIN RIVER,
TRACK TO BE BUILT
ON TOP OF ELEVATED
STRUCTURE
TRANSITIONAL
AREA

CHANGE IN TRACK STRUCTURE

ATTACHMENT 5



EL3 - DOUBLE TRACK ELEVATED ADJACENT TO UPRR/BNSF

THE AERIAL DECK WILL NEED TO BE RE-DESIGNED TO ACCOMODATE ACCEPTABLE CURVATURE

THE COLUMN FOOTINGS MAY REQUIRE RE-LOCATION

NOTES:
1. TRACK, OCS POLES AND FOUNDATIONS, CABLE DUCTS AND DRAINAGE ARE SCHEMATIC AND DO NOT REPRESENT DESIGN.
2. RIGHT-OF-WAY REQUIRED FOR THE HIGH-SPEED RAIL GUIDEWAY WILL DEPEND UPON CONDITIONS ALONG THE ALIGNMENT, INCLUDING TERRAIN, WHERE CUT/FILL SLOPES, RETAINING STRUCTURES, AND ACCESS ARE REQUIRED.
3. POTENTIAL SOUND BARRIERS NOT SHOWN IN CROSS SECTIONS. FOR THE EXTENT OF POTENTIAL SOUND BARRIERS, SEE ALIGNMENT PLAN AND PROFILE SHEETS.

REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY A. SHIELDS
DRAWN BY C. VALADAO
CHECKED BY A. BOONE
IN CHARGE A. BOONE
DATE 07/20/2011

RECORD SET 15% DESIGN SUBMITTAL

NOT FOR CONSTRUCTION

AECOM Technical Services, Inc.
2020 L Street, Suite 300 Sacramento, CA 95811

CH2M HILL

CALIFORNIA HIGH-SPEED RAIL AUTHORITY

CALIFORNIA HIGH-SPEED TRAIN PROJECT
MERCED TO FRESNO

TYPICAL SECTIONS
SHEET 5 OF 17

CONTRACT NO. HSR06-007
DRAWING NO. T3005-A
SCALE NO SCALE
SHEET NO. OF ###

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Shieldsa

ATTACHMENT 6

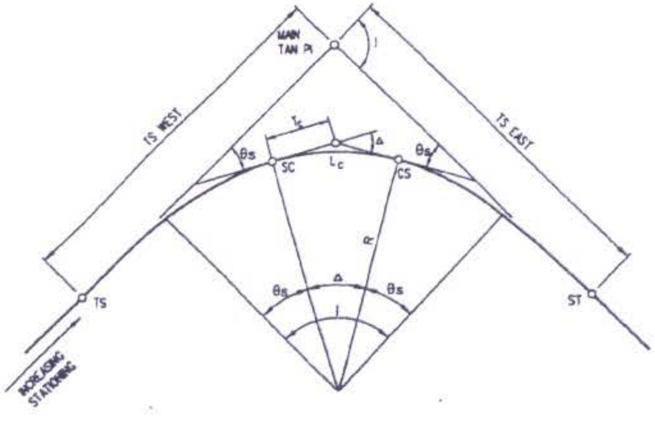

FIGURE A
CIRCULAR CURVES
WITH SPIRAL TRANSITION

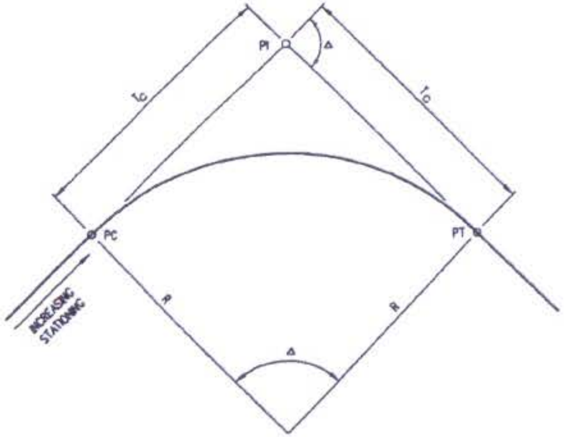

FIGURE B
SIMPLE CIRCULAR CURVE

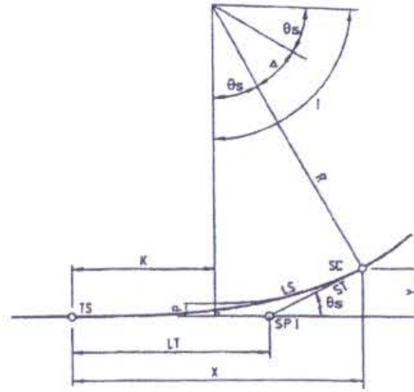

FIGURE C
SPIRAL TRANSITION CURVE

I - TOTAL INTERSECTION ANGLE

θs - SPIRAL ANGLE $= \frac{LS\ Dc}{200}$

Δ - CENTRAL ANGLE OF CIRCULAR CURVE $= I - 2\ \theta s$

R - RADIUS OF CIRCULAR CURVE

T - TANGENT LENGTH OF CIRCULAR CURVE $= R \tan \frac{\Delta}{2}$

L_c - LENGTH OF CIRCULAR CURVE $= \frac{\Delta}{180} \pi R$

TS - TANGENT TO SPIRAL

SC - SPIRAL TO CURVE

CS - CURVE TO SPIRAL

ST - SPIRAL TO TANGENT

MAIN TAN PI - POINT OF INTERSECTION OF MAIN TANGENTS

(TS WEST)
(TS EAST) - TANGENT LENGTH OF COMPLETE CURVE

Ds, θs, Δ, and I are in degrees.
all other dimensions are in feet.
if conditions permit: the degree of curve chosen should be an integral number of degrees and/or minutes incremented by 10 minutes.

Circular curves are defined by the arc definition of curvature and specified by their degree.

R - RADIUS OF CIRCULAR CURVE

Δ - CENTRAL ANGLE OF CIRCULAR CURVE

$Tc = R \tan \frac{\Delta}{2}$

$L_c = \frac{\Delta}{180} \pi R$

$D_c = \frac{5{,}729.58}{R}$

TC - TANGENT TO SIMPLE CURVE

CC - COMPOUND CURVE TO CURVE

CT - SIMPLE CURVE TO TANGENT

To be used in new construction, reconstruction, and whenever alignment is surveyed in the field.
Refer to es2302 for proper length and use of spirals.
computer calculations: the linear (clothoid) spiral shall be used.
manual calculations: the 10 cord spiral may be used if d<=8° and d<=15°.
refer to es2302.

LS = LENGTH OF SPIRAL (TS TO SC)

$\theta s = \frac{LS\ Dc}{200}$

$ST = \frac{Y}{\sin \theta s}$

$LT = X - \frac{Y}{\tan \theta s}$

HORIZONTAL SPIRAL DESIGN

ATTACHMENTS 6, 7, & 8 TO BE APPLIED SIMULTANEOUSLY WHERE TRAINS TRAVEL AT 220mph

REV	DATE	BY	SUB	APP	DESCRIPTION
	3/10/03				35% DESIGN SUBMITTAL
	1/10/03				25% DESIGN SUBMITTAL

DESIGNED BY MW
DRAWN BY JYM
CHECKED BY KR
IN CHARGE
DATE MAR 10, 2003

AMTRAK NATIONAL RAILROAD PASSENGER CORPORATION

STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

HDR Engineering, Inc.

SUBMITTED
APPROVED

LOS ANGELES UNION STATION
RUN-THROUGH TRACKS

HORIZONTAL
CURVE GEOMETRY

CONTRACT NO.
DRAWING NO. HC-1
REV
SCALE N/A
SHEET NO. 10

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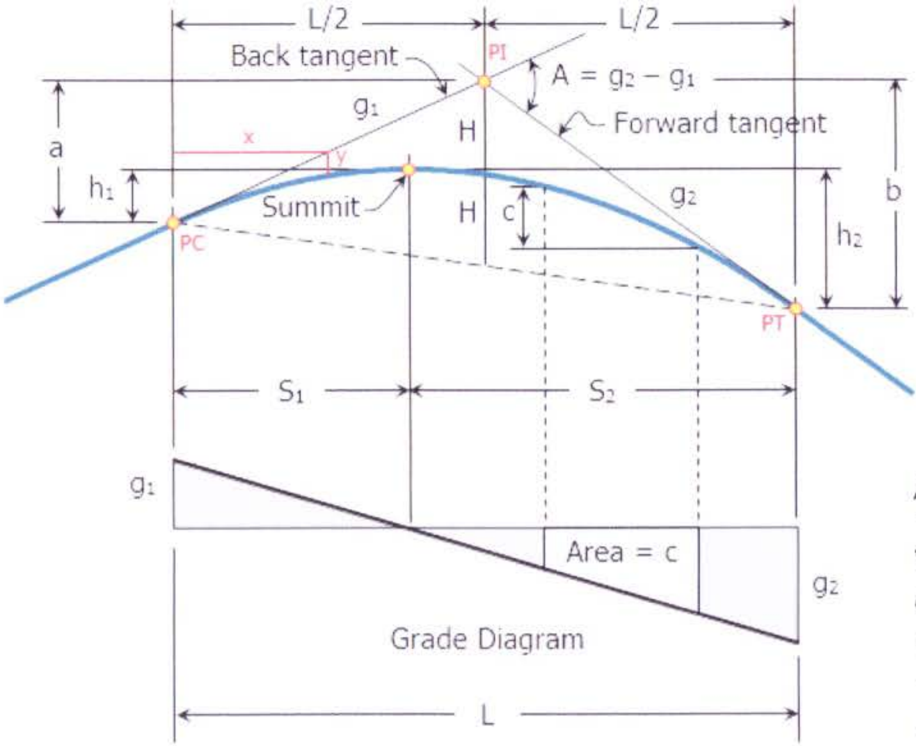


ATTACHMENT 7
VERTICAL CURVE
DESIGN

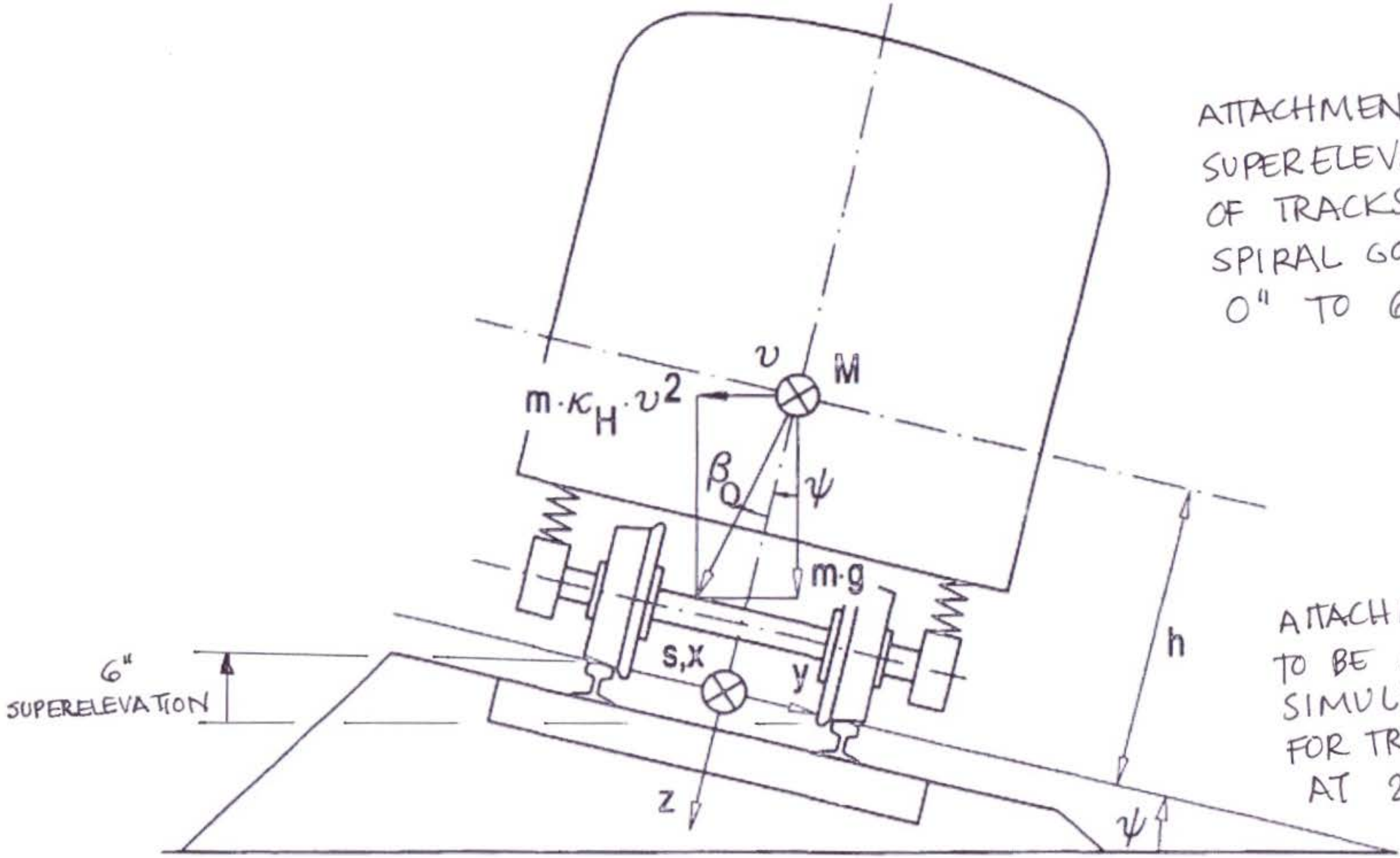
ATTACHMENTS 6, 7, & 8
TO BE APPLIED SIMULTANEOUSLY,
VERTICAL CURVE IS
COMBINED WITH
HORIZONTAL SPIRAL
WHILE TRACKS ARE
SUPERELEVATED FROM
0" TO 6"
WHERE TRAINS TRAVEL
AT 220 mph

Properties of Parabolic Curve and its Grade Diagram

1. The length of parabolic curve L is the horizontal distance between PI and PT.
2. PI is midway between PC and PT.
3. The curve is midway between PI and the midpoint of the chord from PC to PT.
4. The vertical distance between any two points on the curve is equal to area under the grade diagram. The vertical distance c = Area.
5. The grade of the curve at a specific point is equal to the offset distance in the grade diagram under that point. The grade at point Q is equal to g_Q.

Formulas for Symmetrical Parabolic Curve

The figure shown above illustrates the following geometric properties of parabolic curve. Note that the principles and formulas can be applied to both summit and sag curves.

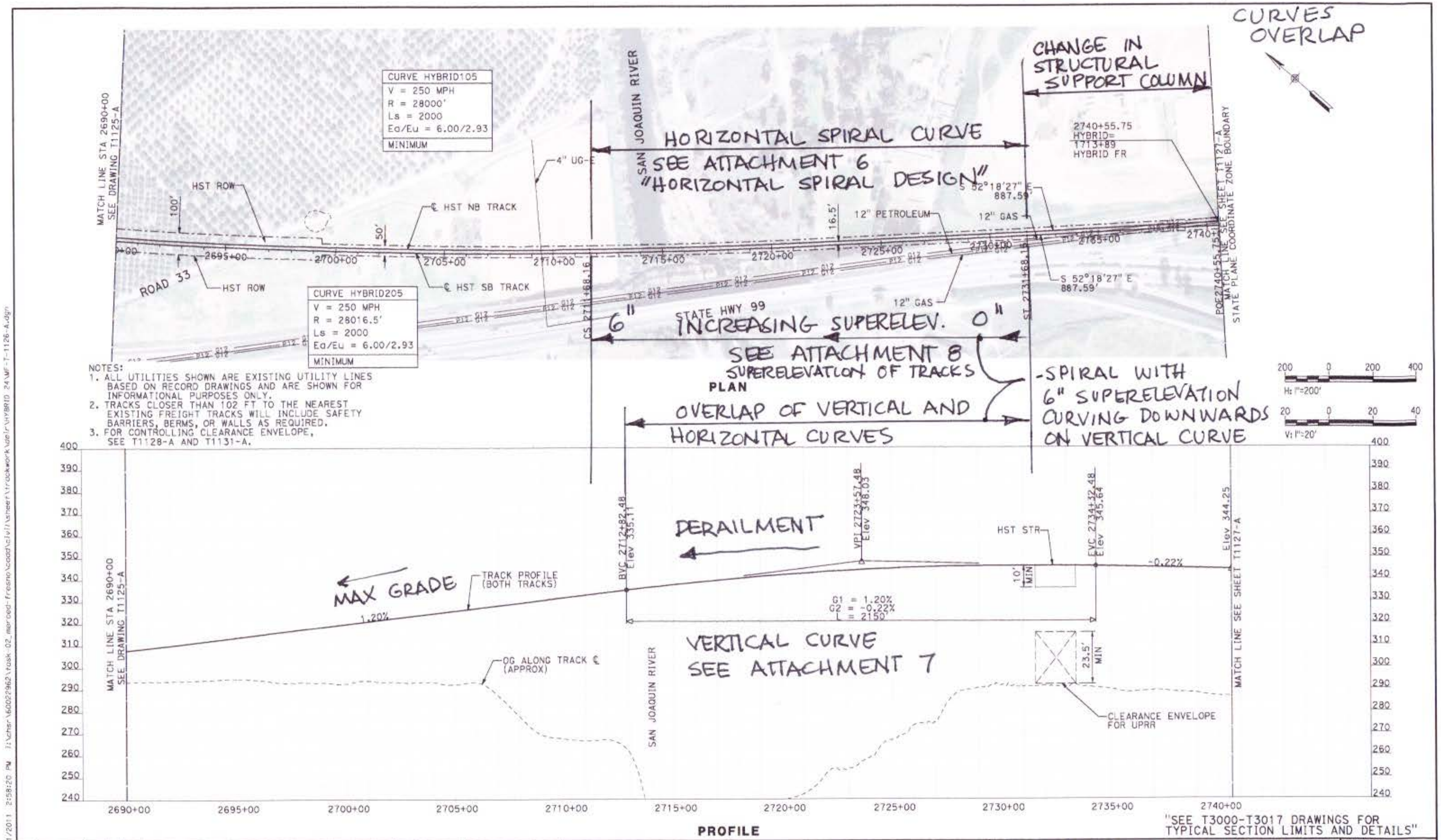


ATTACHMENT 8
SUPERELEVATION
OF TRACKS THRU
SPIRAL GOES FROM
0" TO 6" MAX

ATTACHMENTS 6, 7, & 8
TO BE APPLIED
SIMULTANEOUSLY
FOR TRAINS TRAVELING
AT 220 mph.

$$\kappa_H(s) = \frac{\kappa_C}{\psi_C} \cdot \psi(s) - h \cdot \frac{d^2\psi}{ds^2} \qquad (I)$$

ATTACHMENT 9 VERTICAL & HORIZONTAL CURVES OVERLAP



REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY A. SHIELDS
DRAWN BY H. SULLIVAN
CHECKED BY A. BOONE
IN CHARGE A. BOONE
DATE 07/20/2011

RECORD SET 15% DESIGN SUBMITTAL
NOT FOR CONSTRUCTION

AECOM Technical Services, Inc. 2020 L Street, Suite 300 Sacramento, CA 95811
CH2M HILL

CALIFORNIA HIGH-SPEED RAIL AUTHORITY

CALIFORNIA HIGH-SPEED TRAIN PROJECT
MERCED TO FRESNO
HYBRID
PLAN AND PROFILE
STA 2690+00 TO STA 2740+55.75

CONTRACT NO. HSR06-007
DRAWING NO. T1126-A
SCALE AS SHOWN
SHEET NO. ### OF ###

ATTACHMENT 10 A

HSR CRITERIA

SIX CHANGES IN ONE HALF MILE:
(1) SUPERELEVATION: 0" TO 6" VARIES
(2) BVC: Begin vertical curve (5) CS: Curve to Spiral
(3) EVC: End vertical curve Curve radius
(4) ST: SPIRAL TO TANGENT 28,000'

3.0 ASSESSMENT/ANALYSIS

3.1 ALIGNMENT CRITERIA

The alignment of the railroad shall be as smooth as practical with minimal changes in both the horizontal and vertical direction. Appearance, ease of maintenance, and ride quality are all enhanced by a smooth alignment with infrequent and gentle changes in direction. Over four changes in direction per mile shall constitute an Exceptional condition. (6) MAXIMUM VERTICAL GRADE

All alignment element segments (vertical curves, lengths of grade between vertical curves, horizontal curves, spirals) shall have a minimum length sufficient to attenuate changes in the motion of the rolling stock. This length is defined by the time elapsed over the segment, and therefore varies directly with design speed. Not all systems have the same time requirements. This attenuation time varies from 1.0 to 2.4 seconds, and on the SNCF, up to 3.1 seconds at higher speeds. Segment length requirements will govern only where design considerations for the various elements do not require longer segment lengths.

Vertical and horizontal alignment sections may overlap. Overlap of horizontal spirals and vertical curves shall be an Exceptional condition. Based on European high-speed rail standards, the Minimum distance between the end of a spiral and the beginning of a vertical curve or the end of a vertical curve and the beginning of a spiral is 50 meters (160 feet) with an Exceptional limit of 30 meters (100 feet).

3.1.1 Minimum Segment Length due to Attenuation Time

Attenuation time, based on the most conservative requirements, shall be:

- For V < 300 km/h (Under 186 mph)
  - Desirable attenuation time: not less than 2.4 seconds
  - Minimum attenuation time: not less than 1.8 seconds
  - Exceptional attenuation time: not less than 1.5 seconds
  - An attenuation time of 1.0 seconds on the diverging route in curves adjacent to or between turnouts
- For 300 km/h ≤ V (Over 186 mph)
  - Desirable attenuation time: not less than 3.1 seconds
  - Minimum attenuation time: not less than 2.4 seconds
  - Exceptional attenuation time: not less than 1.8 seconds

Minimum segment length is calculated by the formula: $L_{feet} = V_{mph} \times 44/30 \times t_{sec}$ and $L_m = V_{km/h} / 3.6 \times t_{sec}$. Sample minimum segment lengths are presented in Tables 3.1.1 and 3.1.2.

Table 3.1.1: Minimum Segment Lengths at Various Speeds of 300 km/h (186 mph) and higher

Design Speed		Minimum Segment Lengths for times of							
		3.1 seconds		2.4 seconds		1.8 seconds		1.5 seconds	
miles per hour	km/h	feet	meters	feet	meters	feet	meters	feet	meters
250	400	1137	346	880	268	660	201	550	168
220	355	1000	305	774	236	581	177	484	148
200	320	909	277	704	215	528	161	440	134
186	300	846	258	655	200	491	150	409	125
175	280	796	243	616	188	462	141	385	117
150	240	682	208	528	161	396	121	330	101

ATTACHMENT 10B

HSR CRITERIA

4.0 SUMMARY AND RECOMENDATIONS

The primary objective in setting alignment is to develop the smoothest practical alignment within the limitations imposed by location of stations, urban areas, mountain crossings and major stream crossings as well as environmental and political constraints. It is also important to consider the optimization of earthworks movement, tunnel length, drainage and structures. The radii of horizontal curves, in particular, should be larger than "Desirable" values wherever it is practical to do so. Going below "Desirable" values for the various portions of the alignment should not be treated lightly. Very seldom will an alignment as finally designed and built be better than that set out initially. Quite frequently points will be "locked in" very early in the study process. This is particularly true for the horizontal component of alignment.

Use of Minimum and Exceptional values should be held back to the greatest extent practical for use in the adjustments due to unanticipated constraints that will always occur.

It is very easy to get into a "can't see the forest for the trees" situation. At frequent intervals the designer should step back and look at things globally. This, in particular, means plotting condensed profiles, and looking at the layout over long segments. When transitioning from low speed areas to high-speed areas, consider the operating characteristics of both presently available trains and characteristics of trains with anticipated improvements in power, acceleration and braking. Sudden jumps in speed do not happen with trains.

There should be a relationship between horizontal and vertical alignment standards. For example, there is no point in using vertical curves designed for 250 mph which are adjacent to curves or other constraining elements that permanently restrict speeds to a much lower value. However, the speed used in developing vertical curves should never be lower than that possible under "Exceptional" conditions on adjacent horizontal curves.

It is not possible for this document to anticipate all eventualities, nor to be a textbook in alignment design practices, nor is it intended to be used as a substitute for good engineering judgment.

ATTACHMENT 10C
HSR CRITERIA

Table 3.3.2-2: *Minimum* Vertical Curves –
Rates of Change and Equivalent Radii (0.90 ft/s^2 = 2.80% g)

Speed mph	Speed km/h	% change per 100 feet	feet per % of change	Radius feet	Radius meters
300	480	0.045%	2150	215,000	66,000
250	400	0.065%	1500	150,000	46,000
220	355	0.085%	1160	116,000	36,000
200	320	0.100%	960	96,000	30,000
175	280	0.130%	740	74,000	22,500
150	240	0.180%	540	54,000	16,500
125	200	0.260%	375	37,500	11,500

Table 3.3.2-3: Exceptional Vertical Curves –
Rates of Change and Equivalent Radii (1.4 ft/s^2 = 4.35% g)

Speed mph	Speed km/h	% change per 100 feet	feet per % of change	Radius feet	Radius meters
300	480	0.070%	1400	140,000	43,000
250	400	0.100%	970	97,000	30,000
220	355	0.130%	750	75,000	23,000
200	320	0.150%	620	62,000	19,000
175	280	0.200%	480	48,000	15,000
150	240	0.250%	350	35,000	11,000
125	200	0.400%	250	25,000	7,500

The lengths developed in the preceding tables and formulae are the shortest allowed lengths for each scenario. Vertical curve lengths shall always be rounded up, usually to an even 100 feet multiple. Rate of change and other parameters shall then be derived from that length.

Where the difference between gradients is small, the minimum segment length requirements described in Section 3.1.1 shall determine the minimum length of vertical curve. Rate of change, radius and other parameters of the vertical curve shall then be derived from the length.

3.3.3 Vertical Curve / Horizontal Curve Combinations

Vertical and horizontal curves can overlap. Crest vertical curves result in a downward acceleration of the vehicle, thereby reducing the gravitational effect. This reduction is small but not insignificant for the vertical curve rates of change permitted in this document. A reduction of 0.25 inches for limiting and 0.50 inches for exceptional unbalanced is sufficient to allow for this effect.

3.3.4 Other Vertical Curve Restrictions

It is neither practical nor possible to provide a set of rules that cover all situations. It is anticipated that the information in this document will be applied with good engineering judgment.

Vertical Curves in Spirals: Due to potential maintenance difficulties, it is desirable to avoid use of vertical curves in spirals. The desirable distance between end of spiral and beginning of vertical curve or end of vertical curve and beginning of spiral is 160 feet (50 m) with a minimum limit of 100 feet (30m). Overlap between vertical curves and spirals may be permitted as an Exceptional condition, but only where it can be shown that practical alternatives have been exhausted.

NO OTHER PRACTICAL ALTERNATIVES SUBMITTED IN DEIR OR FEIR EXCEPT FOR UPRR ALIGNMENT.

ATTACHMENT 10 D
HSR CRITERIA

6.1.7 Horizontal Curves in Vertical Curves

Unbalanced Superelevation Limits: Horizontal and vertical curves can overlap. Crest vertical curves result in a downward acceleration of the vehicle, thereby reducing the gravitational effect. This reduction is small but not insignificant for the vertical curve rates of change permitted in this document. A reduction of 0.25 inches for limiting and 0.50 inches for exceptional unbalanced superelevation is sufficient to allow for this effect.

Vertical Curves in Spirals: Due to potential maintenance difficulties, it is desirable to avoid use of vertical curves in spirals. The desirable distance between end of spiral and beginning of vertical curve or end of vertical curve and beginning of spiral is 160 feet (50 m) with a minimum limit of 100 feet (30m). Overlap between vertical curves and spirals may be permitted as an Exceptional condition, but only where it can be shown that practical alternatives have been exhausted.

ATTACHMENT 11
TEMPERATURE EXTREMES
FRESNO

Table 1-3: Weather Conditions by Segment

	Record Extreme Maximum Temperature (°F)	Record Extreme Minimum Temperature (°F)	Mean Number of Days with Freezing Temperatures	Mean Maximum Daily Precipitation (inches)	Annual Record Total Snowfall (inches)	Mean Maximum Daily Snowfall (inches)	Annual Fastest Mile of Wind (mph)	Annual Mean Occurrence of Gust >50 mph	Annual Mean Number of Days with Heavy Fog
San Francisco – San Jose	106–110°	11–20°	0.5–30.4	2.01–2.50"	2.1–6.0"	0.1–3.0"	**41–45**	**2.5–3.4**	15.5–20.4
San Jose –Merced	111–115°	11–20°	30.5–60.4	2.01–2.50"	6.1–12.0"	3.1–6.0"	**41–45**	0.5–1.4	25.5–30.4
Merced – Fresno	**116–120°**	11–20°	30.5–60.4	1.00–1.50"	2.1–6.0"	0.1–3.0"	**41–45**	0.5–1.4	**30.5–35.4**
Fresno –Bakersfield	111–115°	11–20°	30.5–60.4	1.00–1.50"	0.1–2.0"	0.1–3.0"	**41–45**	0.5–1.4	**30.5–35.4**
Bakersfield –Palmdale	111–115°	**-9–0°**	**90.5–120.4**	1.51–2.00"	**48.1–72.0"**	**12.1–15.0"**	**41–45**	0.5–1.4	20.5–25.4
Palmdale – Los Angeles	111–115°	1–10°	30.5–60.4	**3.01–3.50"**	12.1–24.0"	6.1–9.0"	**41–45**	0.5–1.4	15.5–20.4
Los Angeles –Anaheim	111–115°	21–32°	0.5–30.4	2.01–2.50"	0.0"	0.0"	**41–45**	0.5–1.4	20.5–25.4
Los Angeles –San Diego	111–115°	11–20°	30.5–60.4	2.51–3.00"	0.1–2.0"	0.1–3.0"	**41–45**	0.5–1.4	**30.5–35.4**
Sacramento –Merced	111–115°	11–20°	30.5–60.4	1.51–2.00"	0.1–2.0"	0.1–3.0"	**41–45**	1.5–2.4	**30.5–35.4**
Altamont	111–115°	11–20°	30.5–60.4	1.51–2.00"	0.1–2.0"	0.1–3.0"	**41–45**	1.5–2.4	25.5–30.4

This data is included as general information and not for use in application of these design criteria.

Source: National Climatic Data Center (NCDC), National Oceanic and Atmospheric Administration (NOAA). Climate Atlas of the United States: Data Documentation. April 2010. http://www.ncdc.noaa.gov/oa/about/cdrom/climatls2/datadoc.html

Weather Condition Definitions:

Record Extreme Maximum Temperature – Highest temperature recorded in the segment

Record Extreme Minimum Temperature – Lowest temperature recorded in the segment

Mean Number of Days with Freezing Temperatures – Number of days per year on average that temperatures in the segment are below 32°F (maximum value for the segment)

Mean Maximum Daily Precipitation – Maximum precipitation in one day during an average year (maximum value for the segment)

Annual Record Total Snowfall – Maximum amount of snowfall recorded over one year in the segment (maximum value for the segment)

Mean Maximum Daily Snowfall – Maximum snowfall in one day during an average year (maximum value for the segment)

Annual Fastest Mile of Wind – Average speed obtained during the passage of one mile of wind (maximum value for the segment)

Annual Mean Occurrence of a Gust > 50 mph – Frequency of gusts of over 50 mph in 1 year during an average year(maximum value for the segment)

Annual Mean Number of Days with Heavy Fog – Frequency of days with fog resulting in visibility of less than 0.25 miles in an average year(maximum value for the segment)

Notes:

1. Data is provided in ranges consistent with the source data. Specific values will fall within the range provided by more discrete information is not provided.
2. Numbers in bold represent system-wide extreme (maximum/minimum)
3. NCDC archives weather data from the National Weather Service, Military Services, Federal Aviation Administration, the Coast Guard, and volunteer observers. NCDC has a database of U.S. climate data and maps that portray the climate of the U.S. by such elements as temperature, precipitation, snow, wind, and pressure. The period of record for most of this data is 1961 to 1990.
   National Climatic Data Center, National Oceanic and Atmospheric Administration. Climate Maps of the United States. http://cdo.ncdc.noaa.gov/cgi-bin/climaps/climaps.pl

HSR 13-06 - EXECUTION VERSION

ADDITIONAL ATTACHMENT
AASHTO CRITERIA

inside lane and the midpoint of the sight line is from 0.5 to 1.5 m [1.5 to 4.5 ft] greater than that for stopping sight distance. It is obvious that for many cut sections, design for passing sight distance should, for practical reasons, be limited to tangents and very flat curves. Even in level terrain, provision of passing sight distance would need a clear area inside each curve that would, in some instances, extend beyond the normal right-of-way line.

In general, the designer should use graphical methods to check sight distance on horizontal curves. This method is presented in Exhibit 3-8 and described in the accompanying discussion.

General Controls for Horizontal Alignment

In addition to the specific design elements for horizontal alignment discussed under previous headings, a number of general controls are recognized in practice. These controls are not subject to theoretical derivation, but they are important for efficient and smooth-flowing highways. Excessive curvature or poor combinations of curvature limit capacity, cause economic losses because of increased travel time and operating costs, and detract from a pleasing appearance. To avoid such poor design practices, the general controls that follow should be used where practical:

- Alignment should be as directional as practical, but should be consistent with the topography and with preserving developed properties and community values. A flowing line that conforms generally to the natural contours is preferable to one with long tangents that slashes through the terrain. With curvilinear alignment, construction scars can be kept to a minimum and natural slopes and growth can be preserved. Such design is desirable from a construction and maintenance standpoint. In general, the number of short curves should be kept to a minimum. Winding alignment composed of short curves should be avoided because it usually leads to erratic operation. Although the aesthetic qualities of curving alignment are important, long tangents are needed on two-lane highways so that sufficient passing sight distance is available on as great a percentage of the highway length as practical.
- In alignment developed for a given design speed, the minimum radius of curvature for that speed should be avoided wherever practical. The designer should attempt to use generally flat curves, saving the minimum radius for the most critical conditions. In general, the central angle of each curve should be as small as the physical conditions permit, so that the highway will be as directional as practical. This central angle should be absorbed in the longest practical curve, but on two-lane highways the exception noted in the preceding paragraph applies.
- Consistent alignment should always be sought. Sharp curves should not be introduced at the ends of long tangents. Sudden changes from areas of flat curvature to areas of sharp curvature should be avoided. Where sharp curvature is introduced, it should be approached, where practical, by a series of successively sharper curves.

WYE

- For small deflection angles, curves should be sufficiently long to avoid the appearance of a kink. Curves should be at least 150 m [500 ft] long for a central angle of 5 degrees, and the minimum length should be increased 30 m [100 ft] for each 1-degree decrease in the central angle. The minimum length for horizontal curves on main highways, $L_{c\,min}$, should be about three times the design speed expressed in km/h [15 times the

ADDITIONAL ATTACHMENT
HIGHWAY DESIGN MANUAL
page 1 of 2

radius of curvature and minimum sight distance for that design speed, Figure 201.6 gives the clear distance (*m*) from centerline of inside lane to the obstruction.

See Index 1003.1(12) for bikeway stopping sight distance on horizontal curve guidance.

When the radius of curvature and the clear distance to a fixed obstruction are known, Figure 201.6 also gives the sight distance for these conditions.

See Index 101.1 for technical reductions in design speed caused by partial or momentary horizontal sight distance restrictions. See Index 203.2 for additional comments on glare screens.

Cuts may be widened where vegetation restricting horizontal sight distance is expected to grow on finished slopes. Widening is an economic trade-off that must be evaluated along with other options. See Index 902.2 for sight distance requirements on landscape projects.

201.7 Decision Sight Distance

At certain locations, sight distance greater than stopping sight distance is desirable to allow drivers time for decisions without making last minute erratic maneuvers (see Chapter III of AASHTO, A Policy on Geometric Design of Highways and Streets, for a thorough discussion of the derivation of decision sight distance.)

On freeways and expressways the decision sight distance values in Table 201.7 should be used at lane drops and at off-ramp noses to interchanges, branch connections, roadside rests, vista points, and inspection stations. When determining decision sight distance on horizontal and vertical curves, Figures 201.4, 201.5, and 201.6 can be used. Figure 201.7 is an expanded version of Figure 201.4 and gives the relationship among length of crest vertical curve, design speed, and algebraic difference in grades for much longer vertical curves than Figure 201.4.

Decision sight distance is measured using the 3 ½-foot eye height and ½-foot object height. See Index 504.2 for sight distance at secondary exits on a collector-distributor road.

Table 201.7
Decision Sight Distance

Design Speed (mph)	Decision Sight Distance (ft)
30	450
35	525
40	600
45	675
50	750
55	865
60	990
65	1,050
70	1,105
75	1,180
80	1,260

Topic 202 - Superelevation

202.1 Basic Criteria

When a vehicle moves in a circular path, it undergoes a centripetal acceleration that acts toward the center of curvature. This force is countered by the perceived centrifugal force experienced by the motorist.

On a superelevated highway, this force is resisted by the vehicle weight component parallel to the superelevated surface and by the side friction developed between the tires and pavement. It is impractical to balance centrifugal force by superelevation alone, because for any given curve radius a certain superelevation rate is exactly correct for only one driving speed. At all other speeds there will be a side thrust either outward or inward, relative to the curve center, which must be offset by side friction.

If the vehicle is not skidding, these forces are in equilibrium as represented by the following simplified curve equation, which is used to design a curve for a comfortable operation at a particular speed:

ADDITIONAL ATTACHMENT
HIGHWAY DESIGN
page 2 of 2

wide. See Chapter 7 of the Traffic Manual for glare screen criteria.

203.3 Alignment Consistency

Sudden reductions in alignment standards should be avoided. Where physical restrictions on curve radius cannot be overcome and it becomes necessary to introduce curvature of lower standard than the design speed for the project, the design speed between successive curves should change not more than 10 miles per hour. Introduction of curves with lower design speeds should be avoided at the end of long tangents, steep downgrades, or at other locations where high approach speeds may be anticipated.

The horizontal and vertical alignments should be coordinated such that horizontal curves are not hidden behind crest vertical curves. Sharp horizontal curves should not follow long tangents because some drivers tend to develop higher speeds on the tangent and could over drive the curve.

See "Combination of Horizontal and Vertical Alignment" in Chapter 3 of AASHTO, A Policy on Geometric Design of Highways and Streets, for further guidance on alignment consistency.

203.4 Curve Length and Central Angle

The minimum curve length for central angles less than 10 degrees should be 800 feet to avoid the appearance of a kink. For central angles larger than 30 minutes, a curve is required without exception. Above a 20,000-foot radius, a parabolic curve may be used. Sight distance or other safety considerations are not to be sacrificed to meet the above requirements.

On 2-lane roads a curve should not exceed a length of one-half mile and should be no shorter than 500 feet.

203.5 Compound Curves

Compound curves should be avoided because drivers who have adjusted to the first curve could over drive the second curve if the second curve has a smaller radius than the first. Exceptions can occur in mountainous terrain or other situations where use of a simple curve would result in excessive cost. Where compound curves are necessary, the shorter radius should be at least two-thirds the longer radius when the shorter radius is 1,000 feet or less. On one-way roads, the larger radius should follow the smaller radius.

The total arc length of a compound curve should be not less than 500 feet.

203.6 Reversing Curves

When horizontal curves reverse direction the connecting tangents should be long enough to accommodate the standard superelevation runoffs given on Figure 202.5. If this is not possible, the 6 percent per 100 feet rate of change should govern (see Index 202.5(3)). When feasible, a minimum of 400 feet of tangent should be considered.

203.7 Broken Back Curves

A broken back curve consists of two curves in the same direction joined by a short tangent. Broken back curves are unsightly and undesirable.

203.8 Spiral Transition

Spiral transitions are used to transition from a tangent alignment to a circular curve and between circular curves of unequal radius. Spiral transitions may be used whenever the traffic lane width is less than 12 feet, the posted speed is greater than 45 miles per hour, and the superelevation rate exceeds 8 percent. The length of spiral should be the same as the Superelevation Runoff Length shown in Figure 202.5A. In the typical design, full superelevation occurs where the spiral curve meets the circular curve, with crown runoff being handled per Figure 202.5A. For a general discussion of spiral transitions see AASHTO *A Policy on the Geometric Design of Streets and Highways*. When used, spirals transitions should conform to the Clothoid definition.

203.9 Alignment at Bridges

Due to the difficulty in constructing bridges with superelevation rates greater than 10 percent, the curve radii on bridges should be designed to accommodate superelevation rates of 10 percent or less. See Index 202.2 for standard superelevation rates.

Superelevation transitions on bridges are difficult to construct and almost always result in an unsightly appearance of the bridge and the bridge railing. Therefore, if possible, horizontal curves should begin and end a sufficient distance from the bridge so that no part of the superelevation transition extends onto the bridge.

THE NEW YORKER

ADDITIONAL ATTACHMENT
HSR TRAIN DERAILMENT
pg. 1 of 3

THE PHYSICS OF HIGH-SPEED TRAINS

By Patrick Di Justo July 25, 2013

On Wednesday evening, a train travelling from Madrid to Ferrol, in northwestern Spain, derailed just as it was about to enter the Santiago de Compostela station. At least seventy-eight people were killed, and dozens were injured. Video of the accident shows the train entering the curve at what seems to be a high speed; the passenger cars detach from the engine and derail, while the engine stays on the tracks for a few more seconds before it, too, leaves the rails and hits a wall. Unofficial reports claim that the train was going as fast as a hundred and twenty miles per hour on track rated for only fifty m.p.h.

Unlike Japan's Shinkansen or France's T.G.V., which run on dedicated tracks, the Madrid-Ferrol route is a hybrid line, much like Amtrak's Acela Express. Only part of the track is configured for high-speed travel; the rest is shared with slower trains, and can handle only their more restricted speeds.

High-speed rail is a catchall term with several definitions. The Federal Railroad Administration says it starts at a hundred and ten m.p.h., while the International Union of Railways says a hundred and fifty-five. But whichever definition one favors, the rails themselves must be carefully designed to handle the physical forces imposed upon them by multi-ton trains moving at high velocity.

One of those forces is centrifugal ("to flee from the center") force, the inertia that makes a body on a curved path want to continue outward in a straight line. It's what keeps passengers in their seats on a looping roller coaster and throws unsecured kids off carousels. Centrifugal force is a function of the square of the train's velocity divided by the radius of the curve; the smaller and tighter the curve, or the faster the train, the greater the centrifugal force. As it increases, more and more of the weight of the train is transferred to the wheels on the outermost edge of the track, something even the best-built trains have trouble coping with. That's where the concepts of minimum curve radius and super-elevation, or banking, come in.

Banked curves, in which the outer edge of the track is higher than the inner edge, balance the load on the train's suspension. Since gravity pulls a train downward and centrifugal force pulls it outward, a track banked at just the right angle can spread the forces more evenly between a train's inner and outer wheels, and help to keep it on the track.

But banking the tracks isn't a cure-all—a passenger train can tilt only so far before people fall out of their seats. So the minimum curve radius comes into play. Imagine that a curved portion of track is actually running along the outer edge of a large circle. How big must that circle be to insure that a train's centrifugal force can be managed with only a reasonable amount of banking?

It's relatively easy to calculate these forces and the ways to counteract them, so it's relatively easy to set a safe maximum speed for a certain kind of track. Yes, badly maintained tracks, trains, or signals can sometimes contribute to a derailment. Historically, however, many of the world's worst train accidents on sharp curves—the 1918 Malbone Street wreck in the New York City subway system, which killed at least ninety-three people (figures vary), or the Metro page 3 of 3

derailment in Valencia, Spain, in 2006, which killed forty-three—were simply caused by the trains going too fast.

That seems to be the case in the Santiago de Compostela accident: tracks rated for fifty miles per hour need almost no banking and can have a curve radius of fifteen hundred feet, while a train traveling at a hundred and twenty miles per hour needs a track with significant banking, and a minimum curve radius of more than a mile and a half. The laws of physics all but insured that in this particular battle between gravity and centrifugal force, the latter would win.

ADDITIONAL ATTACHMENT
STOP WORK ORDER

48 CFR 42.1303 - Stop-work orders.

42.1303 Stop-work orders.

(a) Stop-work orders may be used, when appropriate, in any negotiated fixed-price or cost-reimbursement supply, research and development, or service contract if work stoppage may be required for reasons such as advancement in the state-of-the-art, production or engineering breakthroughs, or realignment of programs.

(b) Generally, a stop-work order will be issued only if it is advisable to suspend work pending a decision by the Government and a supplemental agreement providing for the suspension is not feasible. Issuance of a stop-work order shall be approved at a level higher than the contracting officer. Stop-work orders shall not be used in place of a termination notice after a decision to terminate has been made.

(c) Stop-work orders should include -

(1) A description of the work to be suspended;

(2) Instructions concerning the contractor's issuance of further orders for materials or services;

(3) Guidance to the contractor on action to be taken on any subcontracts; and

(4) Other suggestions to the contractor for minimizing costs.

(d) Promptly after issuing the stop-work order, the contracting officer should discuss the stop-work order with the contractor and modify the order, if necessary, in light of the discussion.

(e) As soon as feasible after a stop-work order is issued, but before its expiration, the contracting officer shall take appropriate action to -

(1) Terminate the contract;

(2) Cancel the stop-work order (any cancellation of a stop-work order shall be subject to the same approvals as were required for its issuance); or

(3) Extend the period of the stop-work order if it is necessary and if the contractor agrees (any extension of the stop-work order shall be by a supplemental agreement).

April 11, 2018

To: Brian P. Kelly
Chief Executive Officer
California High Speed Rail Authority
770 L Street, Suite 620
Sacramento, CA 95814

RE: REQUEST FOR IMMEDIATE STOP WORK ORDER FOR MERCED TO FRESNO SECTION

Public Safety should be paramount in any track design for High Speed Rail (HSR), but the design for the track curves across the Herndon Overpass structure north of Fresno is a public safety hazard and poses a serious threat to derailment.

Background

Building straight tracks along the UPRR corridor from Merced to Fresno for HSR was the shortest route.

In 2012, the track route called the Hybrid was chosen by the Authority. This route veers from the UPRR corridor and zig-zags across open farmland. The sixty mile straight route now contains nearly 25 miles of high speed curves and horizontal super-elevated spirals with an additional ten miles of track. Trains will travel over the curves and spirals on ballasted track built on alluvial soil at 220 mph. The California High Speed Rail Authority (CHSRA) officials continue to state that this route between Merced and Fresno is the backbone of the high speed rail system, yet this backbone has developed scoliosis, or curvature of the spine; the area in question will need a spinal brace.

(See Attachments 1A and 1B for Merced to Fresno Section alignment.)

This is a request for an immediate Stop Work Order for the Fresno to Merced section to reevaluate the curve designs. This report focuses only on the curve north of Fresno between Herndon Drive and the San Joaquin River. However, similar alignment flaws are shown on the Authority's construction drawings in Madera County for the Chowchilla Boulevard/UPRR Bridge, the Fresno River Bridge, the two single track crossovers between Avenue 10 and 12, and the entire Wye complex surrounding the storage facility site. Each of these high speed rail curves should be re-evaluated, realigned and reconfigured as they each contain similar alignment problems that will lead to future operational and maintenance hazards and derailments.

Dangerous Design

North of Herndon Drive in Fresno, near the San Joaquin River, there is a wide support structure for high speed rail currently being constructed over a single UPRR track. (See Attachments 2 and 3.) As the HSR tracks curve northwards, this wide track support structure transitions into tall support columns. (See attachments 4 and 5.) The trains will travel at 220 mph on top of these 60 to 100 foot tall structures. Near the transitional area between the wide deck and the support columns, the track design calls for a combination of overlapping horizontal and vertical curves. This combination violates the Authority's own Criteria for safe track design. The track design is extremely dangerous; this track design cannot be easily built or safely maintained, thereby creating a significant risk of derailment.

The Draft Environmental Report, the Final Environmental Report and the Construction Documents all use the same curve design for this track; the two sets of environmental documents are identical. This is non-standard practice for good curve design. Usually, in critical locations such as this, between the draft, final and construction documents, multiple track designs are evaluated in order to determine the best and safest fit. For this alignment, there was only one proposal. A single drawing from the Final EIR will be used for ease of argument.

For five years, I was the Manager of Metro's Green Line track contracts in Los Angeles. This included the Aviation Wye, which is located on the southern boundary of the Los Angeles International Airport (LAX). The size and type of the structures near LAX are similar to the size and type structures from Herndon Drive to the San Joaquin River. On the Los Angeles project, there were many track alternatives studied before the trackway was built. There is not any evidence of any other track design proposed for this critical structure near the San Joaquin River.

At the overlap of vertical and horizontal curves, the tracks begin to curve away from the large structure; three mathematical models are needed to construct the tracks, an unsafe track engineering practice. (See Attachments 6, 7 and 8.) A horizontal spiral curving outwards is built on top of a vertical curve going downwards. (See Attachment 9.) The tracks will be super-elevated from zero to six inches on one side, while the trains are spiraling downwards on a maximum grade slope across the top of a vertical curve. Normal track design does not allow this combination except in amusement parks and coal mines; this is not Disneyland and all of the curvature for HSR should be seriously investigated. The northbound train has the greatest potential for derailment when traveling across the peak of the vertical curve. Maintaining a slower speed may actually make things worse.

This combination of curves is avoided in rail and roadway design criteria, including the CHSRA Criteria. (See Attachment 10A, 10B, 10C and 10D.)

For high speed rail, due to the large radius and length of curves, there can be some overlap at the edges. But in this case, the horizontal spiral and the vertical curve are on top of one another. It will be impossible to build, maintain and operate trains safely over this combination.

Fresno suffers from extreme heat and cold. This will result in extremes in the expansion and contraction of the rail and the structures. Rail and concrete expand and contract at a different rate. Has this been taken into account in the curve designs that are built on the structures? (See Attachment 11.)

Summary: Combining a horizontal spiral that increases from zero to six inches of super-elevation with a maximum grade vertical curve built on top of a transitional structural support system in a geographical area that experiences extreme temperature range is very dangerous for trains traveling at any speed. This is a request to immediately issue a Stop Work Order to the Contractor for all structures on the Merced to Fresno segment of California High Speed Rail.

Please see additional attachments for further information.

Thank you for your cooperation in this matter.

Susan MacAdams
Track and Alignment Expert
Former High Speed Rail Planning Manager,
Los Angeles County Metropolitan Transportation Authority (Metro)
Metro Red, Blue and Green Lines, Los Angeles
Light and Heavy Rail Track Design and Construction: Baltimore, Boston, & Washington DC
susan.macadams@gmail.com

Drozd, Doug@HSR

From: Parker, Annie@HSR on behalf of HSR info@HSR
Sent: Tuesday, April 10, 2018 1:41 PM
To: HSR boardmembers@HSR
Subject: FW: California High-Speed Rail Authority Board of Directors Meeting April 17, 2018

From: Thor Schlibodnik [mailto:schlibodnik@yahoo.com]
Sent: Tuesday, April 10, 2018 10:49 AM
To: HSR info@HSR
Subject: Re: California High-Speed Rail Authority Board of Directors Meeting April 17, 2018

Please stop this insanity now. It will drain whatever resources the state has and ridership will be far less than predictions. California needs water. If you must build something, build desalination plants. Quit now!

On Monday, April 9, 2018, 7:32:22 PM PDT, California High-Speed Rail <info@hsr.ca.gov> wrote:

To view this email as a web page, go here.

BOARD AGENDA

BOARD MEETING DETAILS

APRIL 17, 2018
10:00 A.M.

Meeting Location
Metropolitan Water District Board Room
700 N. Alameda Street
Los Angeles, CA 90012

PUBLIC COMMENT - SESSION I (ACTION ITEMS)

For this meeting, an opportunity for public comment on only the ACTION items listed as

Drozd, Doug@HSR

From:	Roland Lebrun <ccss@msn.com>
Sent:	Tuesday, April 10, 2018 1:33 PM
To:	Aaron.Peskin@sfgov.org
Cc:	SFCTA Board Secretary; SFCTA CAC; SFMTA Municipal Transportation Agency; CAC@TJPA.org; board@tjpa.org; Caltrain Board; Caltrain CAC Secretary; Caltrain BAC; MTC Commission; HSR boardmembers@HSR; VTA Board Secretary; Caltrain, Bac (@caltrain.com)
Subject:	Platform Height compatibility Peer Review
Attachments:	Platform height compatibility.pdf

Dear Supervisor Peskin,

Thank you for your kind comments about the effectiveness of peer review panels.

It is in this context that I would like to attract your attention to the California High Speed Rail Peer Review Group (CAHSRPRG) letter dated February 7th 2017 (http://www.cahsrprg.com/files/PRG-letter-of-7-Feb-2017-Reduced.pdf) which advised the Legislature as follows (3rd paragraph on page 3):

"An alternative potential response would be to use bi-level trains at the outset for HSRA service. ***We have recommended in past letters that the Authority consider adopting bi-level trains from the outset because the loading platform level would be consistent with the lower level used by Caltrain and Metrolink (and ACE if there are joint operations in future)****. In our discussions, the Authority indicated that they will consider inputs from the new system operator (discussed below).* ***We recommend that this issue be addressed carefully before HSRA commits itself to a rolling stock fleet design."***

I am attaching a copy of a document I recently forwarded to the Authority's staff for your consideration. This document outlines the specifics of a solution adopted by a majority of countries in the European Union and Russia.

I hope that you find this information useful and that you will direct the High Speed Rail Authority to follow the recommendations of its own peer review panel.

Sincerely,

Roland Lebrun

cc:
SFCTA Board of Directors
SFCTA CAC
SFMTA Board of Directors
TJPA Board of Directors
TJPA CAC
Caltrain Board
Caltrain CAC
Caltrain BAC

Here is a follow up on the platform height compatibility issue

1) **The problem** (bi-level door at a North East Corridor (NEC) high platform)

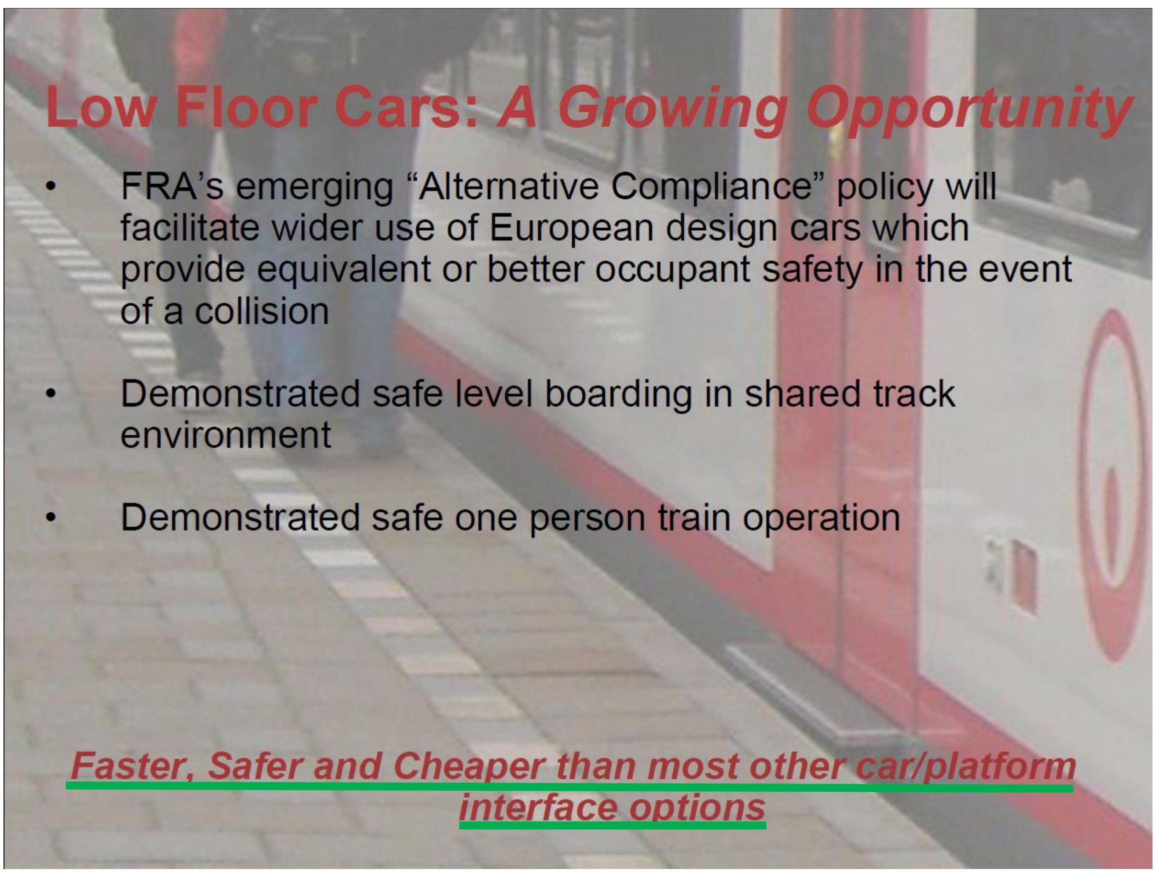
2) **The solution** (California High Speed Rail Peer Review Group February 7th 2017 letter to the Legislature)

"<u>We have recommended in past letters that the Authority consider adopting bi-level trains from the outset because the loading platform level would be consistent with the lower level used by Caltrain and Metrolink (and ACE if there are joint operations in future</u>). In our discussions, the Authority indicated that they will consider inputs from the new system operator (discussed below). <u>We recommend that this issue be addressed carefully before HSRA commits itself to a rolling stock fleet design.</u>"
http://www.cahsrprg.com/files/PRG-letter-of-7-Feb-2017-Reduced.pdf)

Legislation establishing the Peer Review Group

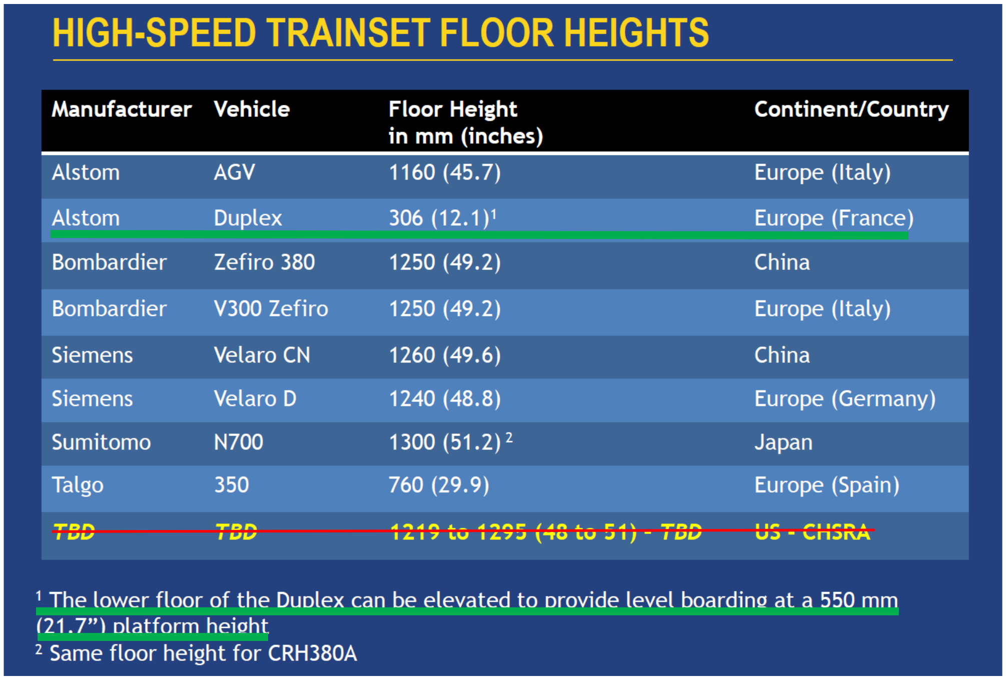
"<u>The authority shall establish an independent peer review group for the purpose of reviewing the planning, engineering, financing, and other elements of the authority's plans</u> and issuing an analysis of the appropriateness and accuracy of the authority's assumptions"
http://www.leginfo.ca.gov/pub/13-14/bill/asm/ab_0351-0400/ab_383_bill_20130422_amended_sen_v98.html

Recommended solution (June 5 2012 APTA Rail Conference)



http://www.apta.com/mc/rail/previous/2012/presentations/Presentations/Nelson-D-Rebalancing-Commuter-Rail-Level-Boarding.pdf

Low-level boarding compatibility between HSR and UTDC bi-levels



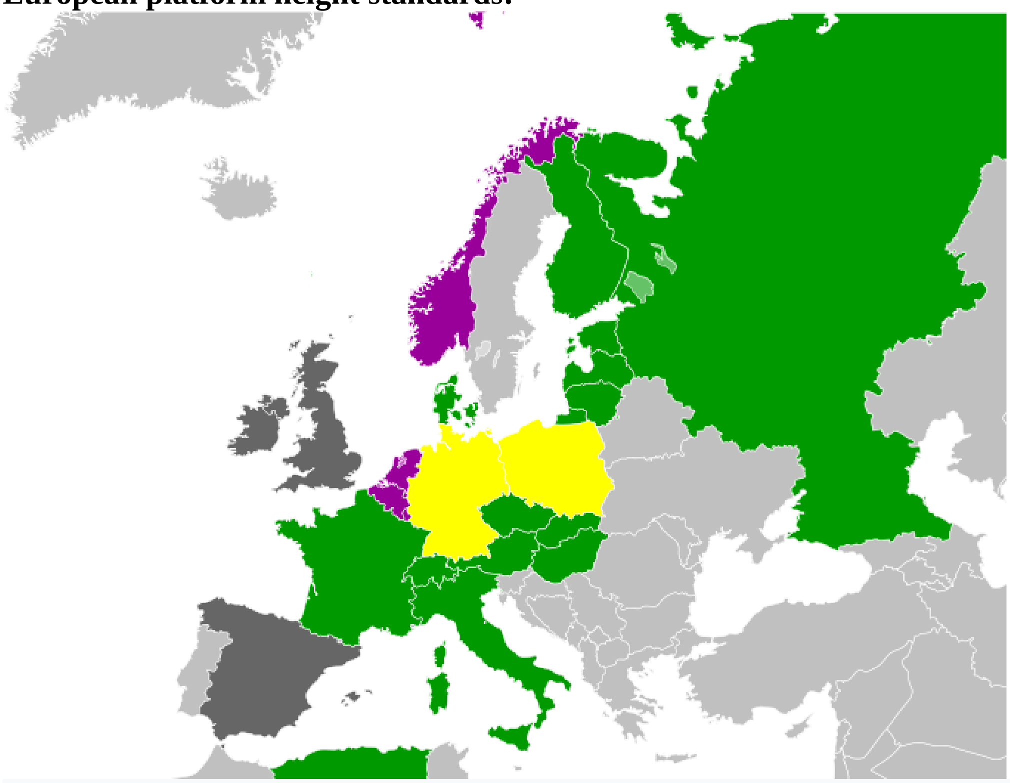
HIGH-SPEED TRAINSET FLOOR HEIGHTS

Manufacturer	Vehicle	Floor Height in mm (inches)	Continent/Country
Alstom	AGV	1160 (45.7)	Europe (Italy)
Alstom	Duplex	306 (12.1)[1]	Europe (France)
Bombardier	Zefiro 380	1250 (49.2)	China
Bombardier	V300 Zefiro	1250 (49.2)	Europe (Italy)
Siemens	Velaro CN	1260 (49.6)	China
Siemens	Velaro D	1240 (48.8)	Europe (Germany)
Sumitomo	N700	1300 (51.2)[2]	Japan
Talgo	350	760 (29.9)	Europe (Spain)
~~TBD~~	~~TBD~~	~~1219 to 1295 (48 to 51) - TBD~~	~~US - CHSRA~~

[1] The lower floor of the Duplex can be elevated to provide level boarding at a 550 mm (21.7") platform height
[2] Same floor height for CRH380A

http://www.caltrain.com/Assets/__Agendas+and+Minutes/JPB/Board+of+Directors/Presentations/2015/2015-05-20+JPB+BOD+CHSRA+Trainsets.pdf

European platform height standards:



Application of the EU standard heights for new construction; Green = 550 mm, Pink = 760 mm, Yellow = both, dark gray = New builds in other heights than the EU standards

"1,100 mm (43.3 in) high platforms are gradually changing to 550 mm (21.7 in) platform height.[17]"

https://en.wikipedia.org/wiki/Railway_platform_height#Russia

"TRAC proposes that the State work towards a universal platform height of 24", and not follow the example of the Northeast Corridor, which has very expensive-to-implement 48" platforms."
http://www.calrailnews.org/wp-content/uploads/2017/12/TRACCommentsStateRailPlan2017.pdf

Roland.

Drozd, Doug@HSR

From:	Gerald Upham <4jerry22@gmail.com>
Sent:	Monday, April 09, 2018 1:01 PM
To:	HSR boardmembers@HSR
Subject:	Stop the madness of this project

--

Best regards,
Jerry Upham
760 749-3074

Drozd, Doug@HSR

From: Brill Brill <ebrill@mac.com>
Sent: Friday, March 30, 2018 12:05 PM
To: HSR boardmembers@HSR
Subject: Self-driving Cars and High-speed Rail

Follow Up Flag: Follow up
Flag Status: Flagged

Dear Board Members:

I am a rail fan and in favor of all real progress, but I urge you to abandon the high speed rail project in California.

— with the advent of self-driving cars, almost no one (certainly not me) will want to take a train;

— the costs are astronomical and growing by the day;

— it is potentially a huge seismic liability, especially since it runs in the same north-south direction that the San Andreas fault does;

— it's always going to be three to four times slower than a jet airplane, and much slower than that if it has to share freight train tracks

There is so much that California could do with this money — including trying to get all the dangerous soot from large trucks and other diesel vehicles out of the air.

Sincerely,

Eric Brill
Palos Verdes

Drozd, Doug@HSR

From:	Morris Brown <mbrown5@pacbell.net>
Sent:	Thursday, March 29, 2018 10:51 AM
To:	HSR boardmembers@HSR
Subject:	Fox and Hounds: The High Speed Rail 2018 Business Plan – A Classic Model Of Deception
Follow Up Flag:	Follow up
Flag Status:	Flagged

http://www.foxandhoundsdaily.com/2018/03/high-speed-rail-2018-business-plan-classic-model-deception/

The High Speed Rail 2018 Business Plan – A Classic Model Of Deception

By Morris Brown
Founder of DERAIL, The original Grass Roots group opposing the High Speed Rail project.
Thursday, March 29th, 2018

The California High Speed Rail Authority has released its 2018 Business Plan. It portends to finally reveal the true cost for construction of Phase I of the project. The new cost estimate is at a base of $77.3 billion to a possible $98.1 billion dollars. Completion of Phase I is now projected for year 2032. Please remember the old promise to the voters was the project would be running by 2020 and the cost to California voters would be $10 billion (the rest of the $32 billions needed to build Phase I would come from Federal and private sources).

Looking a bit beneath the headlines, we find many questions that are not explained. Phase I as defined in the 2008 Prop 1A ballot measure, runs from the Trans Bay Terminal (TBT) in San Francisco to LA Union Station and Anaheim. This new business plan suddenly truncates the route to start at the 4th and King Street station in San Francisco, not at the TBT. Estimated costs for the needed tunnel from 4th and King to TBT are at $3.9 billion. This cost should have been included in the business plan but was omitted.

Furthermore, $400 million in Federal Funds for the needed "train box" to service the HSR trains at the TBT has already been spent, and is not included in Phase I projected costs.

Adding in these costs drives up projected cost estimates for Phase I to a range of $81.6 to $102.4 Billions.

Looking further, we now find, due to the lack of funding for a complete Phase I, the new plan essentially is building commuter lines in the Central Valley (Madera to Bakersfield) and Gilroy to San Francisco (using existing Caltrain tracks on the Peninsula).

The citizens of Southern California are being short-changed, and will have to be satisfied with funding of a couple hundred million dollars, to upgrade a rail intersection, and maybe an upgrade of LA Union station.

The published example train schedule shows no mention of a trip from San Francisco to LA in 2 hours 40 minutes; a trip time mandated in Prop 1A. No indeed. We are now on notice that such a trip would be 3 hr 30 minutes at best and many travel times on some runs are up to 5 hours in length.

The new plan delays construction of the needed tunnel to connect the Central Valley to the Bay Area and needed tunnels to connect Bakersfield going south to Los Angeles. These tunnels must wait for funding which is nowhere to be found.

The dream of the Authority and Governor Brown to construct a High Speed Rail line in California is indeed dead. What is now to be built are disconnected tracks claimed to improve commuter / passenger routes, mostly in the Central Valley and Silicon Valley. And by the way, a guarantee of Prop 1A, was no operating subsidies would ever be required to run the train. What commuter service do you know, that doesn't require a subsidy?

The new business plan is not a plan for a State wide High Speed Rail project. No one should be deceived by the colorful pictures and non-existent funding which is so artfully displayed in the plan.

Now is the time to stop this project!

Drozd, Doug@HSR

From:	V FORESTIERE <vforestiere@msn.com>
Sent:	Thursday, March 22, 2018 5:16 PM
To:	HSR boardmembers@HSR
Subject:	FW: Construction affecting Forestiere Underground Gardens
Follow Up Flag:	Follow up
Flag Status:	Flagged

From: V FORESTIERE
Sent: Thursday, March 22, 2018 6:14 PM
To: 'boardmembers@hsr.ca.gov.' <boardmembers@hsr.ca.gov.>; 'esmeralda.soria@fresno.gov' <esmeralda.soria@fresno.gov>; 'lee.brand@fresno.gov' <lee.brand@fresno.gov>; 'leager@fresnoedc.com' <leager@fresnoedc.com>; Scott Mozier <Scott.Mozier@fresno.gov>; 'dgomez@hsr.ca.gov' <dgomez@hsr.ca.gov>; Karana Hattersley-Drayton <Karana.Hattersley-Drayton@fresno.gov>; 'Mark.Standriff@fresno.gov' <Mark.Standriff@fresno.gov>
Cc: Lyn - Gardens <gardensllc@yahoo.com>; Courtney - Gardens <info@undergroundgardens.com>; Shera - Gardens <tours@undergroundgardens.com>; Jamie - Gardens <calendarllc@yahoo.com>; Marc <fccforestiere@yahoo.com>
Subject: Construction affecting Forestiere Underground Gardens

So it has begun just as we feared. We just became aware of the general notice that lanes of Shaw Ave will be closed off and on through April 6th (Thank you Councilwoman Soria). As Fresno County's most highly visited historic landmark, we were given assurances that we would be notified in plenty of time of any construction around our area that could impact tourism to the Gardens. Yet, once again, here we are.

In all those meetings over the past few years, we were assured that we would be kept informed so we could be pro-active and not have this type of public relations debacle. So, really, no one knew weeks ago (when work was scheduled) of the construction timeframe who could have contacted us as promised? Luckily most of the Cornelia Ave construction (of which we were also NOT pre-notified) occurred mainly during our off season.

Fresno and the Gardens has had increased exposure since the Fox channel show Strange Inheritance aired last week. We have had thousands of website hits just this week. We have scheduled school and tour bus bookings, not to mention the hundreds of visitors who have called to confirm that we are open around Easter. Many of resident visitors access the Gardens via Shaw Ave, not to mention those coming to/from Yosemite via Hwy 41.

And now, what are we supposed to do at such short notice? We are going to mitigate this mess as best we can on our website and contact those booked groups to recommend alternate routes and warn of traffic delays that may impact their scheduled visit. As for others who will be caught in the Shaw Ave SNAFU, if and when they make it to the Gardens, we will apologize on behalf of the City and HSR.

We hope that this lack of communication is not indicative of things to come.

Sincerely,
Valery L Forestiere
Forestiere Underground Gardens
California Historic Landmark #916

Drozd, Doug@HSR

From: donotreply@pbcommentsense.com
Sent: Wednesday, March 21, 2018 6:25 PM
To: HSR boardmembers@HSR
Subject: California High-Speed Train Comment

Follow Up Flag: Follow up
Flag Status: Flagged

Submission via California High-Speed Authority's Contact Form:

First Name: Craig
Last Name: Tacconi
Contact Category: Board of Directors
Interest As: Individual
Organization:
Title:
Email Address: ctactime@aol.com
Telephone:
City:
State: CA
County:
Zip Code: 94553

Message:
This needs to be stopped! The costs are going through the roof and they don't seem to ever slow down. We should be able to vote again on this project, because it's not what was promised to us originally. We don't need any legacy projects in this state.

==
Please note this record is also saved in PBCommentSense Board Corridor as record #436.
https://cahsr.pbcommentsense.com/pbcs/submission/edit.aspx?id=30916&projectID=28

Drozd, Doug@HSR

From:	donotreply@pbcommentsense.com
Sent:	Wednesday, March 21, 2018 4:30 PM
To:	HSR boardmembers@HSR
Subject:	California High-Speed Train Comment
Follow Up Flag:	Follow up
Flag Status:	Flagged

Submission via California High-Speed Authority's Contact Form:

First Name: Lynne
Last Name: Cheney
Contact Category: Board of Directors
Interest As: Individual
Organization:
Title:
Email Address: lynne_cheney@comcast.net
Telephone: 9259399049
City: Walnut Creek
State: CA
County:
Zip Code: 94598

Message:
To whom it may concern;

We need to stop the high speed rail project now! The cost has gotten too prohibitive and it isn't completed or in service yet. It will not pay for itself in the long run and taxpayers can not afford to cover all of the expenses.
Thank you.

Sincerely,

Lynne Cheney

==
Please note this record is also saved in PBCommentSense Board Corridor as record #435.
https://cahsr.pbcommentsense.com/pbcs/submission/edit.aspx?id=30912&projectID=28

Drozd, Doug@HSR

From: donotreply@pbcommentsense.com
Sent: Wednesday, March 21, 2018 1:11 PM
To: HSR boardmembers@HSR
Subject: California High-Speed Train Comment

Follow Up Flag: Follow up
Flag Status: Flagged

Submission via California High-Speed Authority's Contact Form:

First Name: Anne
Last Name: Wilson
Contact Category: Board of Directors
Interest As: State Agency
Organization: individual
Title: Mrs.
Email Address: beanie51@gmail.com
Telephone:
City: Martinez
State: CA
County: Contra Costa
Zip Code: 94553

Message:
The high speed train in CA is a joke, an embarrassment, and a complete waste of money. It is way over budget and way behind schedule. And, will continue to be so. We were lied to from the beginning about cost and completion.
It's future needs to go to the voters.

======================================
Please note this record is also saved in PBCommentSense Board Corridor as record #434.
https://cahsr.pbcommentsense.com/pbcs/submission/edit.aspx?id=30907&projectID=28

Drozd, Doug@HSR

From:	donotreply@pbcommentsense.com
Sent:	Wednesday, March 21, 2018 12:29 PM
To:	HSR boardmembers@HSR
Subject:	California High-Speed Train Comment
Follow Up Flag:	Follow up
Flag Status:	Flagged

Submission via California High-Speed Authority's Contact Form:

First Name: j
Last Name: duke
Contact Category: Board of Directors
Interest As: Individual
Organization: Mr.
Title:
Email Address: glenjo@sbcglobal.net
Telephone: 9255169493
City: brentwood
State: CA
County: CA
Zip Code: 94513

Message:
Kill the project. There is little need for the system. The most significant argument for the system is to provide for commutes from the central valley to San Jose so that employees of the tech industry can afford housing. A very expensive solution to that problem. Better for the tech industry to locate fewer offices in San Jose, and more into the central valley.

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Please note this record is also saved in PBCommentSense Board Corridor as record #433.
https://cahsr.pbcommentsense.com/pbcs/submission/edit.aspx?id=30904&projectID=28

Drozd, Doug@HSR

From: donotreply@pbcommentsense.com
Sent: Wednesday, March 21, 2018 8:42 AM
To: HSR boardmembers@HSR
Subject: California High-Speed Train Comment

Follow Up Flag: Follow up
Flag Status: Flagged

Submission via California High-Speed Authority's Contact Form:

First Name: Neil
Last Name: Joeck
Contact Category: Board of Directors
Interest As: Individual
Organization: UC Berkeley
Title: Research Scholar
Email Address: Njoeck@berkeley.edu
Telephone: 510-642-8749
City: Berkeley
State: CA
County: Alameda
Zip Code: 94551

Message:
HSR is failing to live up to its promises. It's initial expected cost was grossly under-estimated and the adjusted projected cost is almost certainly the same. Assumptions about affordibility and convenience are deeply flawed. You have an obligation to admit past errors and stop repeating them. Californians do not want HSR and do not want to waste any more money on this mistake.
Stop HSR now!

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Please note this record is also saved in PBCommentSense Board Corridor as record #430.
https://cahsr.pbcommentsense.com/pbcs/submission/edit.aspx?id=30897&projectID=28

Drozd, Doug@HSR

From: donotreply@pbcommentsense.com
Sent: Wednesday, March 21, 2018 8:16 AM
To: HSR boardmembers@HSR
Subject: California High-Speed Train Comment

Follow Up Flag: Follow up
Flag Status: Flagged

Submission via California High-Speed Authority's Contact Form:

First Name: Robert
Last Name: Mull
Contact Category: Board of Directors
Interest As: Individual
Organization:
Title:
Email Address: mullski777@gmail.com
Telephone: 9258789578
City: Lafayette
State: CA
County: California
Zip Code: 94549

Message:
This project is a joke on all of us who pay taxes. It is a boondoggle of the highest degree so our governor can have a legacy. Stop the madness and use the money for something useful.

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Please note this record is also saved in PBCommentSense Board Corridor as record #429.
https://cahsr.pbcommentsense.com/pbcs/submission/edit.aspx?id=30894&projectID=28

Drozd, Doug@HSR

From: donotreply@pbcommentsense.com
Sent: Wednesday, March 21, 2018 8:04 AM
To: HSR boardmembers@HSR
Subject: California High-Speed Train Comment

Follow Up Flag: Follow up
Flag Status: Flagged

Submission via California High-Speed Authority's Contact Form:

First Name: Rolland
Last Name: Pruner
Contact Category: Board of Directors
Interest As: Individual
Organization:
Title:
Email Address: expert-one@comcast.net
Telephone:
City: Livermore
State: CA
County:
Zip Code: 94551

Message:
Please stop the train, this will break us!!!!

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Please note this record is also saved in PBCommentSense Board Corridor as record #428.
https://cahsr.pbcommentsense.com/pbcs/submission/edit.aspx?id=30893&projectID=28

Drozd, Doug@HSR

From: donotreply@pbcommentsense.com
Sent: Tuesday, March 20, 2018 9:47 PM
To: HSR boardmembers@HSR
Subject: California High-Speed Train Comment

Follow Up Flag: Follow up
Flag Status: Flagged

Submission via California High-Speed Authority's Contact Form:

First Name: Craig
Last Name: Ash
Contact Category: Board of Directors
Interest As: Individual
Organization: Personal
Title:
Email Address: Craig.ash@msn.com
Telephone: 4082027355
City: San Jose
State: CA
County: Santa Clara
Zip Code: 95136

Message:
I am fed up with the waste of this high speed (??) rail project. We live in San Jose and travel often to sed family in Fresno. Pkease know that we will never rude this train. We enjoy the drive and stoppibg in Los Banos for meals and at Casa de Friuta. HSR is the biggest waste of taxpayer $$. It is time to terminate this project!!! Time for Califirnia to go on a spendibg diet.

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Please note this record is also saved in PBCommentSense Board Corridor as record #427.
https://cahsr.pbcommentsense.com/pbcs/submission/edit.aspx?id=30889&projectID=28