APPENDIX 3.7-C: HSR GUIDEWAY ENCLOSURE FOR THE GRASSLANDS ECOLOGICAL AREA

Confidential/Internal Use

MEMORANDUM

Date: November 5, 2019

To: Gary Kennerley

From: Julian Bratina

CC: Dave Shpak

Subject: HSR Guideway Enclosure for the Grasslands Ecological Area

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Introduction

This memorandum summarizes the efforts by the Authority to develop, analyze and review conceptual design options for an acoustic guideway enclosure. An enclosure that surrounds the train operating envelope and OCS equipment would provide a greater reduction in noise, visual, and bird strike impacts than noise barriers and line markers where the alignment passes through an important complex of wetlands. The Authority Director of Environmental Services commissioned this analysis in response to a request from the Grassland Water District and other stakeholders in the Grasslands Ecological Area.

Background

During the program level route identification efforts, the Authority selected an alignment across the Grasslands Ecological Area (GEA), a complex of wetlands measuring approximately 95,000 hectares in the San Joaquin Valley, at the narrowest point to minimize the impact of high-speed rail (HSR) on the area. The results of these efforts were published in the Bay Area to Central Valley HST Final EIR/S 2008 environmental document. During this program environmental stage, CHSRA committed to place approximately 3.0 miles of guideway on an elevated structure centered on Mud Slough to minimize the impact on the GEA.

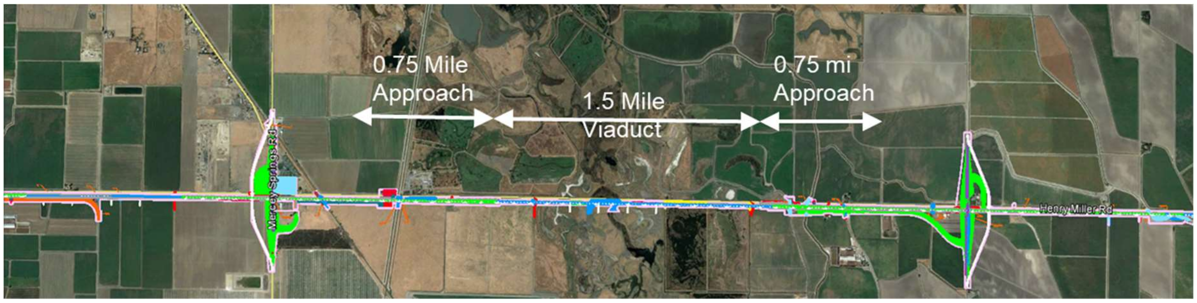


Figure 1: Extent of HSR guideway across Grasslands Ecological Area

The Authority has been working with stakeholders in the GEA to evaluate the environmental impact of this decision, and potential methods of mitigation. In December of 2018, the Authority received a letter from the GEA Working Group that requested consideration of an enclosure structure similar to that used in China's Shenzen-Maoming HSR program. This is a structure that would fully enclose the guideway and overhead contact system, to mitigate visual and acoustic impacts on waterfowl and shorebirds living in and moving across the adjacent habitat.

Figure 2: Chenzen-Maoming Guideway Enclosure

Coincidentally, preliminary results of the Authority's ongoing evaluation of impacts to waterfowl and shorebirds in the GEA Important Bird Area proximate to Mud Slough indicated potential for visual, noise, and bird-strike impacts. The Authority agreed to evaluate the enclosure concept, determine whether a similar structure would be suitable for the GEA crossing, and what the structure's potential impacts would be.

Analysis

1. Design Development

The Engineering team evaluated the tubular concept, and produced a similar design that would enclose the guideway and the full extents of the CHSRA operating envelope. The structure primarily consisted of steel w-flange beams rolled into a circular shape, bolted together with gusset plates, and supported on the concrete viaduct structure. A circular steel frame would support precast concrete panels mounted around the structure, with OCS brackets hung inside the structure, and longitudinally reinforced by steel struts. The design concepts were subjected to preliminary structural assessments, including wind loading, support of OCS equipment, the loading on the viaduct structure, and considered different material types for sound attenuation.

There were two primary objectives of the enclosure: (1) to avoid the visual and acoustic impacts on waterfowl and shorebirds, and (2) to prevent bird strikes. While a noise barrier would encourage birds to fly higher over the guideway, it would not prevent nesting, foraging, or roosting within the operating envelope of the train. Also, the OCS equipment would protrude above the noise barriers and attract perching, and create a deadly obstacle to avian flight paths. A permeable enclosure was explored to preclude avian access, but discarded due to its inability to reduce acoustic and visual impacts, and the unacceptable maintenance challenges.

After the design and performance analyses revealed considerable weight and cost, the engineering team designed an alternative concept with equivalent functionality that would minimize the structure's weight and complexity, and probable cost.

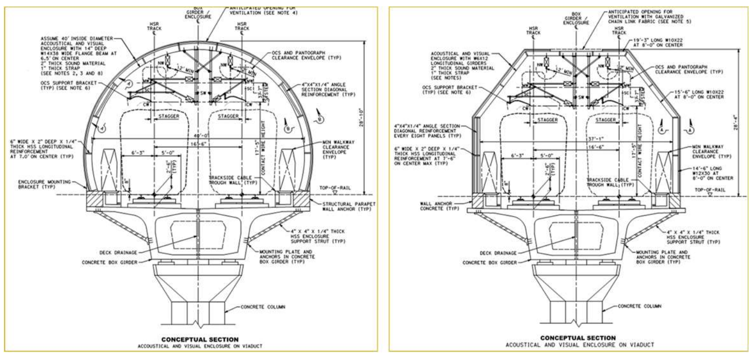


Figure 3: Tubular and Wall Panel Enclosure Concepts

2. Pressure Transient Analysis

A pressure transient (i.e. pneumatic) analysis was necessary to evaluate the impacts of the enclosure on HSR operations at full speed, the impacts to passenger comfort levels, and the impacts the train operation would have on the enclosure. In addition, the operation of a high-speed train within an enclosed space results in a pressure wave in front of and behind the train, that when exiting the enclosed space, would rapidly expand and could generate a loud percussive noise. To ensure the enclosure would not have a detrimental impact on the operation of the train and its surroundings, a preliminary pressure transient analysis was conducted.

The analysis looked at three scenarios: Two trains crossing in the enclosure, a single train passing through the enclosure, and the micro pressure waves at the exit portal. A one-dimensional analysis performed using the ThermoTun-Online software, commonly used for proof of concept, estimated the maximum pressure change to which train passengers and crew are subjected, the maximum/minimum pressures exerted on the enclosure structure, and the magnitude of the pressure wave at the enclosure portals.

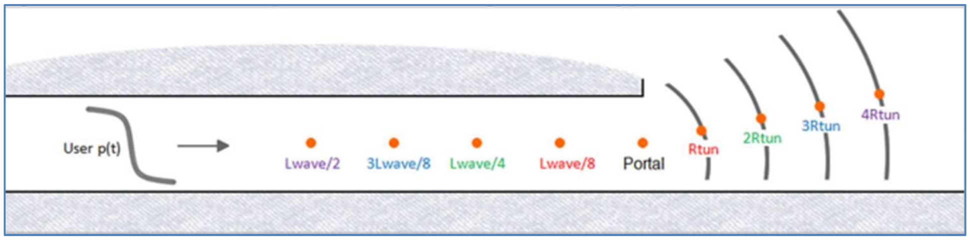


Figure 4: Illustration of the micro pressure waves analysis

To reduce the magnitude of the pressure wave within the enclosure, while minimizing the size of the structure, the designers proposed three openings to be located at the obvert of the enclosure. These openings, each 35% of the enclosure cross-sectional area and spaced out at quarter points along the length of the structure, reduced the estimated maximum pressure by 40% to stay within standard HSR operating parameters.

3. Noise Analysis

A noise analysis was necessary to evaluate the effectiveness of the structure and potential to attenuate noise impacts in the area. The analysis, using Cadna-A modeling software, also evaluated the performance of other structural noise mitigation options including; a noise barrier 14-ft above top of rail (TOR), a 17.5-ft noise barrier, and a 17.5-ft noise barrier with an angled cantilevered top edge (similar to the alternative enclosure concept) to provide a basis for functional comparison.

The acoustical model was used to evaluate the base condition and all four noise mitigation options to allow for direct comparison of results.

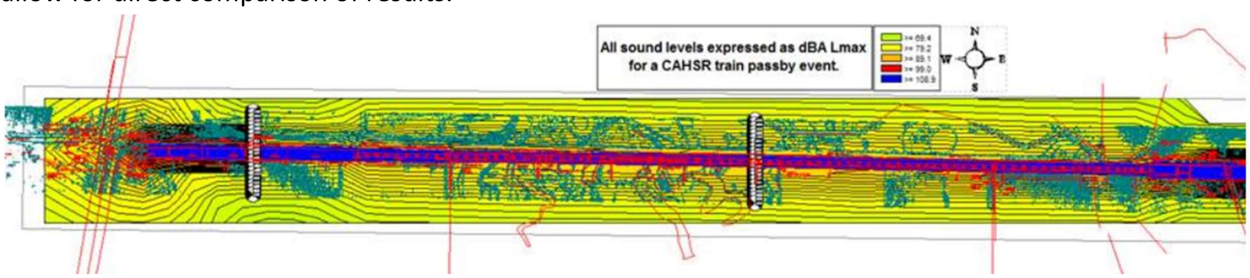


Figure 5: Isopleth Noise Contours

The level of noise reduction increases with the barrier height and extent of enclosure. However, higher levels of noise reduction provided by enclosure come at increasing costs of more complex structures. The results of the analysis showed that the permanent hearing damage criterion (140 dBA Lmax) would not be exceeded. However, temporary hearing damage, masking, and arousal criteria were exceeded and would require additional land based mitigation up to 300-ft from the track alignment.

4. Cost Estimates

A preliminary cost estimate was completed to evaluate the five options under review in the GEA: existing conditions (no mitigation), a noise barrier 14-ft above TOR, a noise barrier 17.5-ft above TOR, a tubular enclosure, and a wall panel enclosure. The cost estimates, supported by material quotes and reviewed by the Authority estimating department, included materials, labor, equipment, and viaduct structural and foundation improvements. In addition to the capital cost estimates, a rough order of magnitude operations and maintenance (O&M) cost was calculated for the two enclosures as their complexity would result in higher maintenance costs. Land based compensatory mitigation costs were also estimated for each of the structural options. The potential to stack mitigation (i.e. consolidated mitigation for more than a single impact type) enabled an estimated low to high (i.e. separated mitigation for each impact type) range of mitigation costs.

Table 1: Concept level cost estimate

<table>
<tr><th>Structure Options</th><th>Noise Reduction</th><th>Capital Cost</th><th>Compensatory Mitigation Cost*</th><th>Total ROM Net Cost</th><th>ROM Additional O&M Cost (average annual)</th></tr>
<tr><td>None</td><td>0 dBA</td><td>N/A</td><td>$20.5 to 33M</td><td>$20.5 to 33M</td><td>N/A</td></tr>
<tr><td>Noise Barrier 14-ft>TOR</td><td>8 dBA</td><td>$36M</td><td>$12 to 19M</td><td>$48 to 55M</td><td rowspan="2">< $60K for 3 miles</td></tr>
<tr><td>Noise Barrier 17.5ft>TOR</td><td>10 dBA</td><td>$46M</td><td>$9.5 to 15M</td><td>$55.5 to 61M</td></tr>
<tr><td>Wall Panel Enclosure</td><td>10+ dBA</td><td>$90M±</td><td>$9.5M to 15M</td><td>$100.5M to 106M</td><td rowspan="2">≈$60K ± for 3 miles</td></tr>
<tr><td>Tubular Enclosure</td><td>12 dBA</td><td>$119M</td><td>$7M to 11M</td><td>$126 to 130M</td></tr>
</table>

*Stacked to Unstacked Mitigation

Conclusions

The results of the analysis showed that the two enclosures would support HSR operations and provide visual and acoustic mitigation at a greater level than a standard noise barrier mitigation measure. In addition, noise barriers lacked the ability to prevent bird strikes, and were therefore eliminated from consideration. The enclosures were deemed conceptually feasible, and due to the sensitivity of resources and stringent regulatory requirements, the Authority is proposing an enclosure as a mitigation measure for regulatory assurance, and technical efficiency. This approach requires further detailed design analysis, and engineering validation that is beyond the scope of preliminary engineering. Language for a proposed mitigation measure has been drafted for the Draft EIR/EIS to assure concept-level feasibility, performance, and efficacy:

- Enclose HSR guideway and OCS continuously for 3.4 miles, centered approximately at Mud Slough. The final recommendation of 3.4 miles is the result of iterative design refinement between engineering and environmental science teams.

- Construct using opaque, nonglare materials that provide a minimum of 10 dBA attenuation of sound generated by HSR operations, as measured immediately outside the enclosure.

- Design in compliance with all HSR design, operations, and maintenance requirements.

- Build in conjunction with installation of track and OCS; completed before HSR train operations begin.

- Consult with CDFW, USFWS, GWD, the owner(s) of private properties affected by the 3.4-mile HSR project footprint, and other stakeholders as part of final design of the guideway enclosure.
- Implement in conjunction with compensatory mitigation, if quantitative modeling of final enclosure design demonstrates residual noise of 77 dBA or more, measured outside the HSR right-of-way.

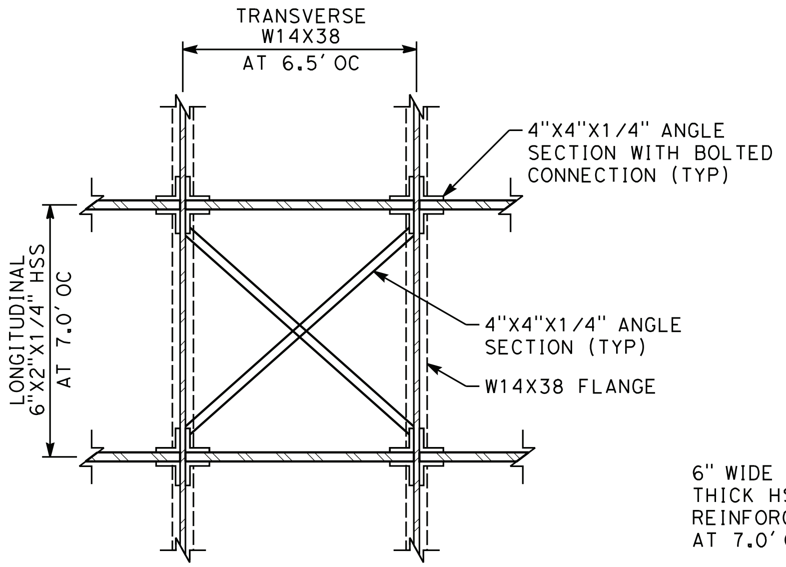
Appendices

1. Tubular Enclosure on Embankment
2. Tubular Enclosure on Viaduct
3. Wall Panel Enclosure on Viaduct
4. Pressure Transient Analysis Memo
5. Noise Analysis Memo
6. Cost Estimates

Appendix 1

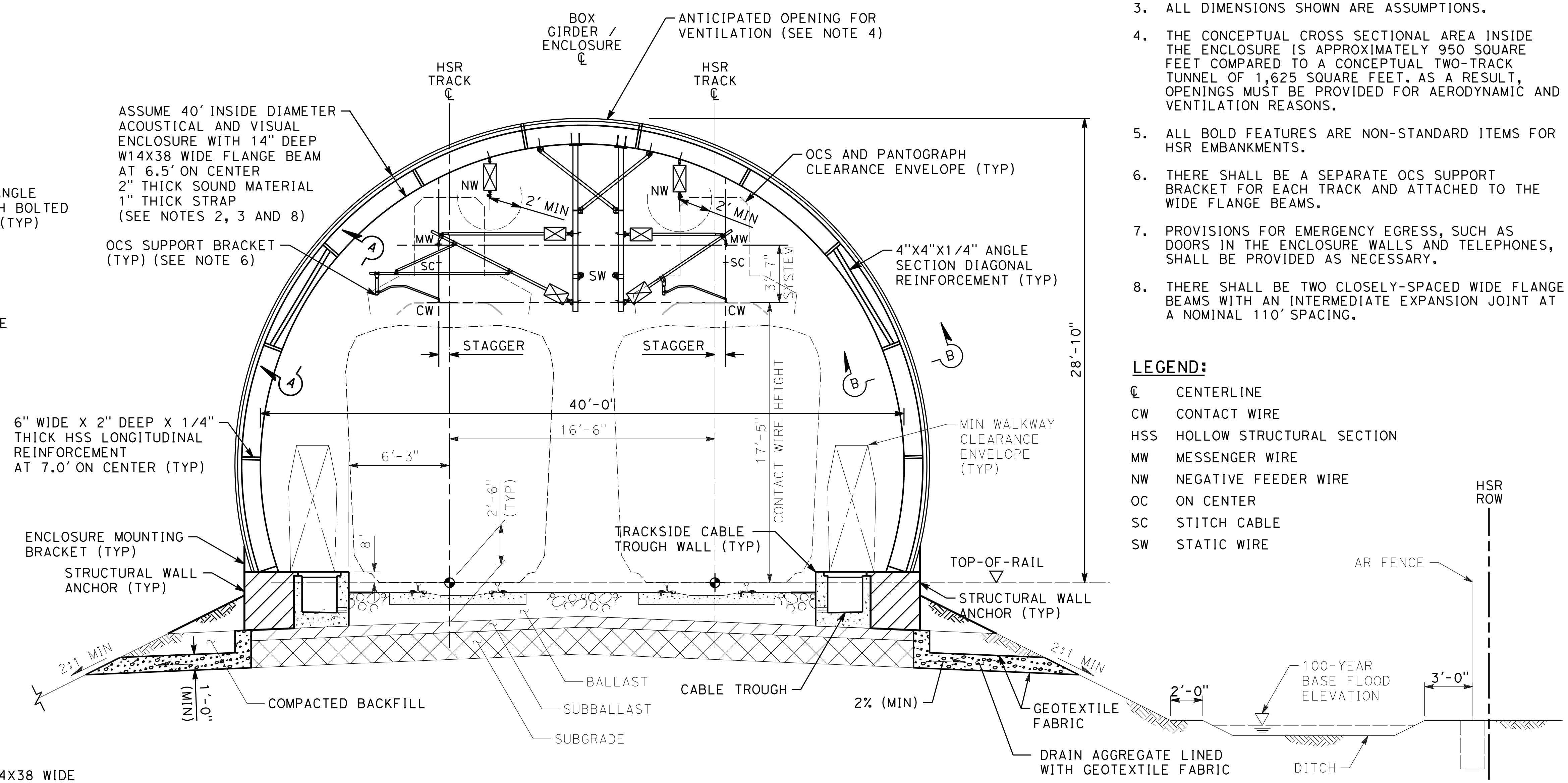
Tubular Enclosure on Embankment

CONCEPTUAL FOR DISCUSSION PURPOSES ONLY NOT FOR CONSTRUCTION



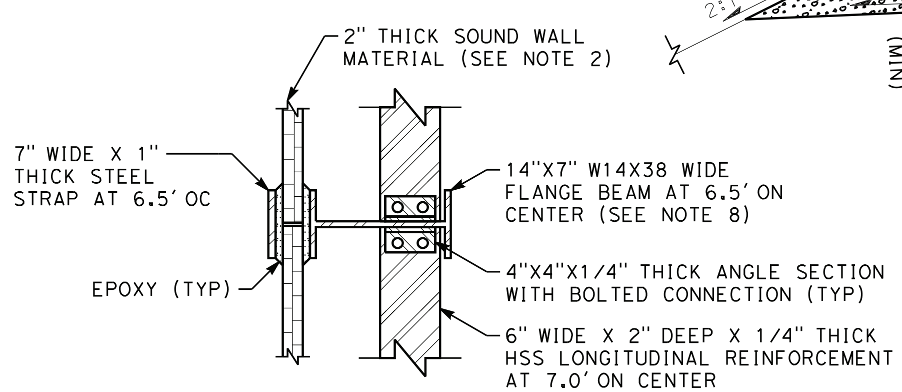
SECTION A-A

DIAGONAL REINFORCEMENT
ALL DIMENSIONS ARE ASSUMED
(SEE NOTES 2 AND 3)



CONCEPTUAL SECTION

ACOUSTICAL AND VISUAL ENCLOSURE ON EMBANKMENT



SECTION B-B

LONGITUDINAL SECTION
ALL DIMENSIONS ARE ASSUMED
(SEE NOTES 2 AND 3)

NOTES:

1. SEE TRACK, DRAINAGE AND OCS DIRECTIVE DRAWINGS FOR DETAILS NOT SHOWN.
2. ACOUSTICAL AND VISUAL ENCLOSURE MATERIALS TO BE DETERMINED.
3. ALL DIMENSIONS SHOWN ARE ASSUMPTIONS.
4. THE CONCEPTUAL CROSS SECTIONAL AREA INSIDE THE ENCLOSURE IS APPROXIMATELY 950 SQUARE FEET COMPARED TO A CONCEPTUAL TWO-TRACK TUNNEL OF 1,625 SQUARE FEET. AS A RESULT, OPENINGS MUST BE PROVIDED FOR AERODYNAMIC AND VENTILATION REASONS.
5. ALL BOLD FEATURES ARE NON-STANDARD ITEMS FOR HSR EMBANKMENTS.
6. THERE SHALL BE A SEPARATE OCS SUPPORT BRACKET FOR EACH TRACK AND ATTACHED TO THE WIDE FLANGE BEAMS.
7. PROVISIONS FOR EMERGENCY EGRESS, SUCH AS DOORS IN THE ENCLOSURE WALLS AND TELEPHONES, SHALL BE PROVIDED AS NECESSARY.
8. THERE SHALL BE TWO CLOSELY-SPACED WIDE FLANGE BEAMS WITH AN INTERMEDIATE EXPANSION JOINT AT A NOMINAL 110' SPACING.

LEGEND:

℄	CENTERLINE
CW	CONTACT WIRE
HSS	HOLLOW STRUCTURAL SECTION
MW	MESSENGER WIRE
NW	NEGATIVE FEEDER WIRE
OC	ON CENTER
SC	STITCH CABLE
SW	STATIC WIRE

CONCEPTUAL FOR DISCUSSION PURPOSES ONLY NOT FOR CONSTRUCTION

REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY A. GURA
DRAWN BY A. GURA
CHECKED BY J. BRATINA
IN CHARGE J. BRATINA
DATE 2/01/2019

CONCEPTUAL FOR DISCUSSION PURPOSES ONLY NOT FOR CONSTRUCTION

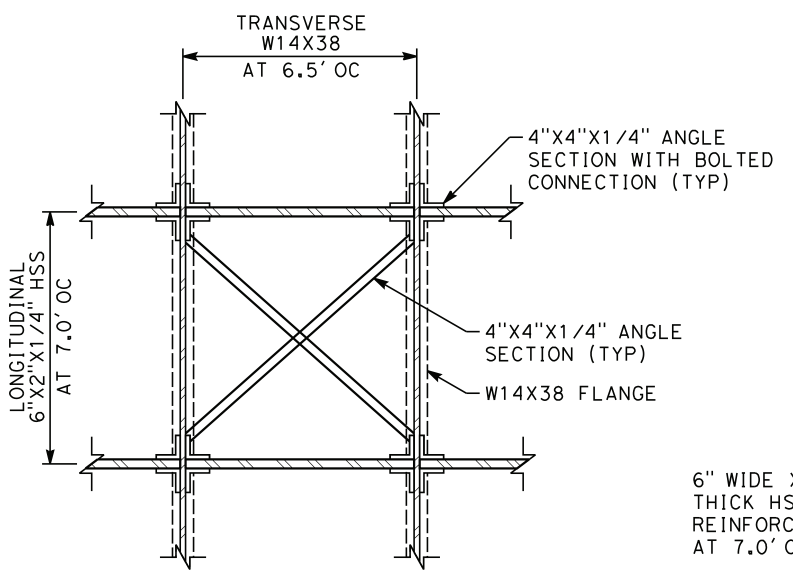
CALIFORNIA HIGH-SPEED RAIL PROJECT
STRUCTURAL DIRECTIVE
TYPICAL CROSS SECTION
AT-GRADE EMBANKMENT
TWO TRACK BALLASTED
WITH ACOUSTICAL AND VISUAL ENCLOSURE

CONTRACT NO.
DRAWING NO. ENCLOSURE 2
SCALE NO SCALE
SHEET NO.

Appendix 2

Tubular Enclosure on Viaduct

CONCEPTUAL FOR DISCUSSION PURPOSES ONLY NOT FOR CONSTRUCTION



SECTION A-A

DIAGONAL REINFORCEMENT
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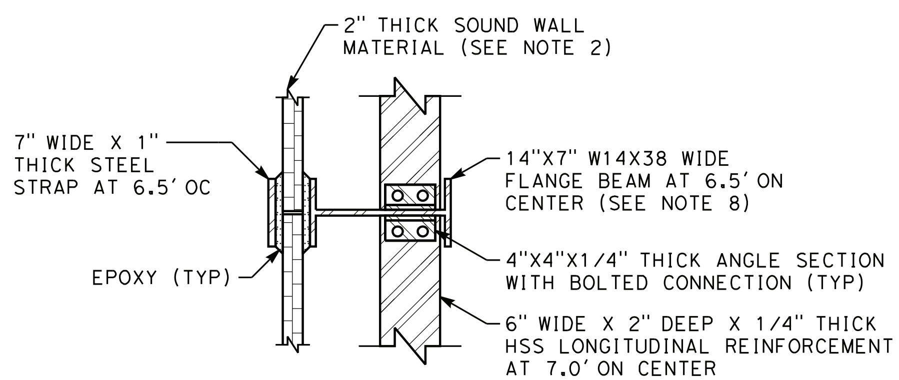
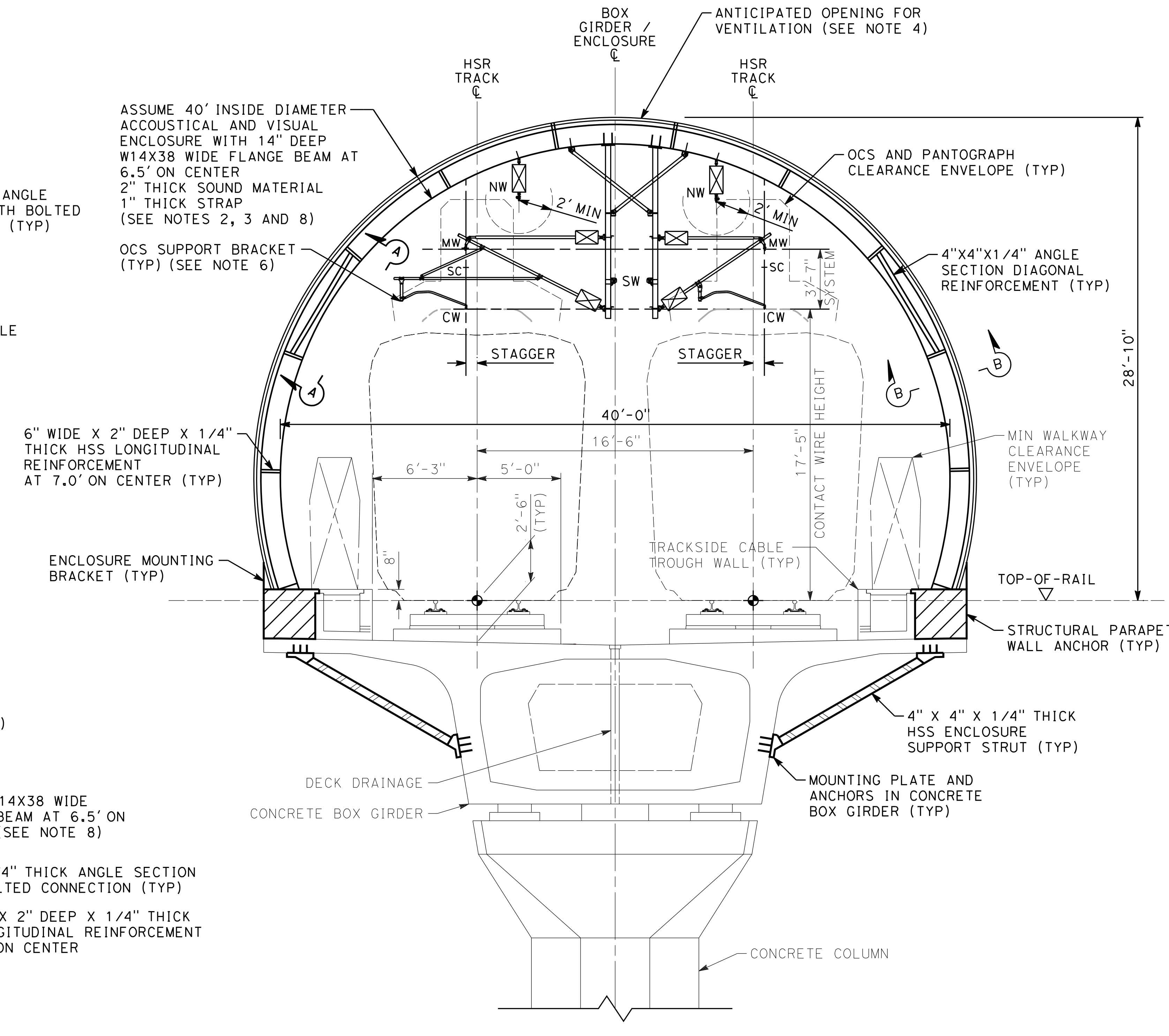
(SEE NOTES 2 AND 3)



SECTION B-B

LONGITUDINAL SECTION
ALL DIMENSIONS ARE ASSUMED
(SEE NOTES 2 AND 3)



CONCEPTUAL SECTION

ACCOUSTICAL AND VISUAL ENCLOSURE ON VIADUCT

NOTES:

1. SEE STRUCTURE AND OCS DIRECTIVE DRAWINGS FOR DETAILS NOT SHOWN.
2. ACCOUSTICAL AND VISUAL ENCLOSURE MATERIALS TO BE DETERMINED.
3. ALL DIMENSIONS SHOWN ARE ASSUMPTIONS.
4. THE CONCEPTUAL CROSS SECTIONAL AREA INSIDE THE ENCLOSURE IS APPROXIMATELY 950 SQUARE FEET COMPARED TO A CONCEPTUAL TWO-TRACK TUNNEL OF 1,625 SQUARE FEET. AS A RESULT, OPENINGS MUST BE PROVIDED FOR AERODYNAMIC AND VENTILATION REASONS.
5. ALL BOLD FEATURES ARE NON-STANDARD ITEMS FOR HSR STRUCTURES.
6. THERE SHALL BE A SEPARATE OCS SUPPORT BRACKET FOR EACH TRACK AND ATTACHED TO THE WIDE FLANGE BEAMS.
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LEGEND:

℄	CENTERLINE
CW	CONTACT WIRE
HSS	HOLLOW STRUCTURAL SECTION
MW	MESSENGER WIRE
NW	NEGATIVE FEEDER WIRE
OC	ON CENTER
SC	STITCH CABLE
SW	STATIC WIRE

CONCEPTUAL FOR DISCUSSION PURPOSES ONLY NOT FOR CONSTRUCTION

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GuraA

REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY A. GURA
DRAWN BY A. GURA
CHECKED BY J. BRATINA
IN CHARGE J. BRATINA
DATE 2/01/2019

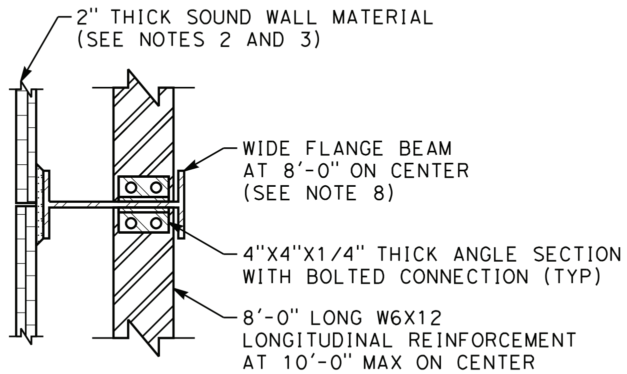
CONCEPTUAL FOR DISCUSSION PURPOSES ONLY NOT FOR CONSTRUCTION

CALIFORNIA HIGH-SPEED RAIL PROJECT
STRUCTURAL DIRECTIVE
TYPICAL CROSS SECTION
AERIAL STRUCTURE
TWO TRACK NON-BALLASTED
WITH ACCOUSTICAL AND VISUAL ENCLOSURE

CONTRACT NO.
DRAWING NO. ENCLOSURE 1
SCALE NO SCALE
SHEET NO.

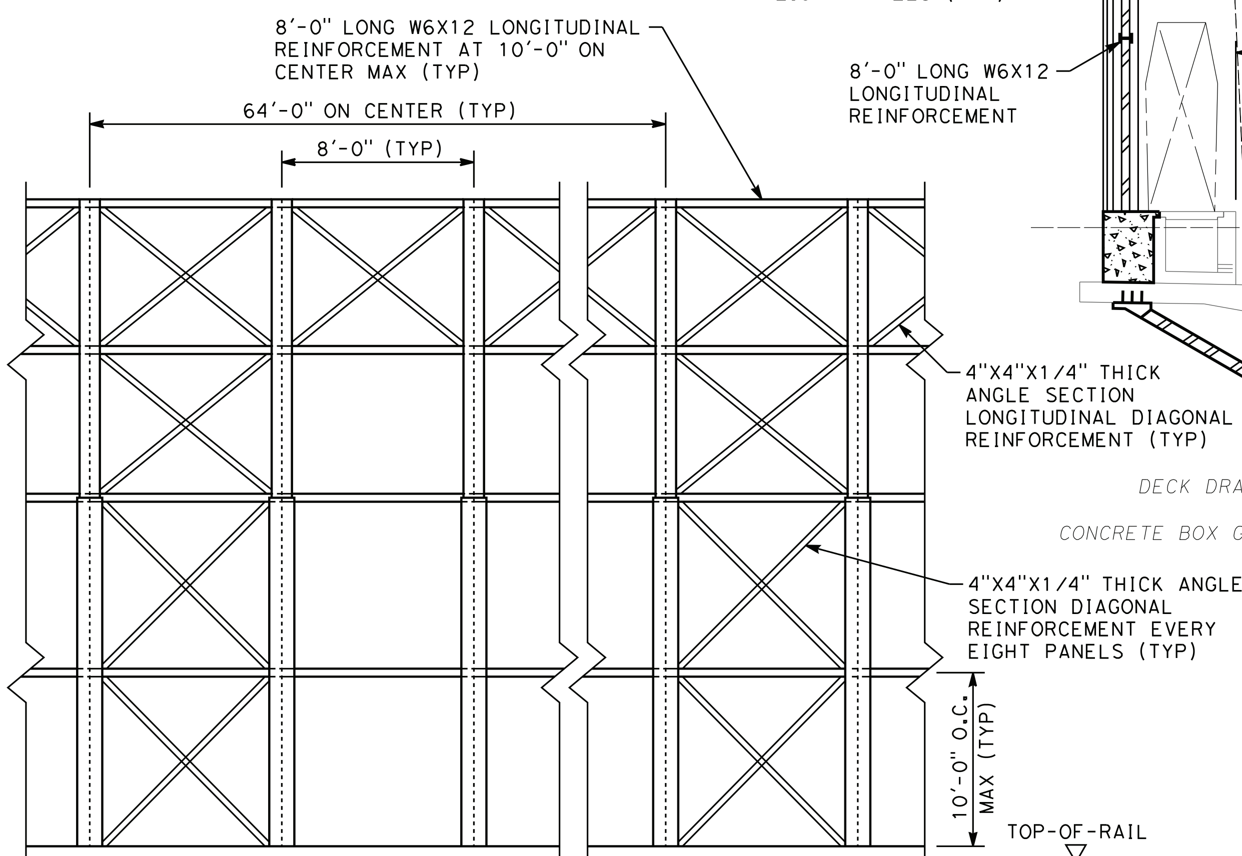
Appendix 3

Wall Panel Enclosure on Viaduct

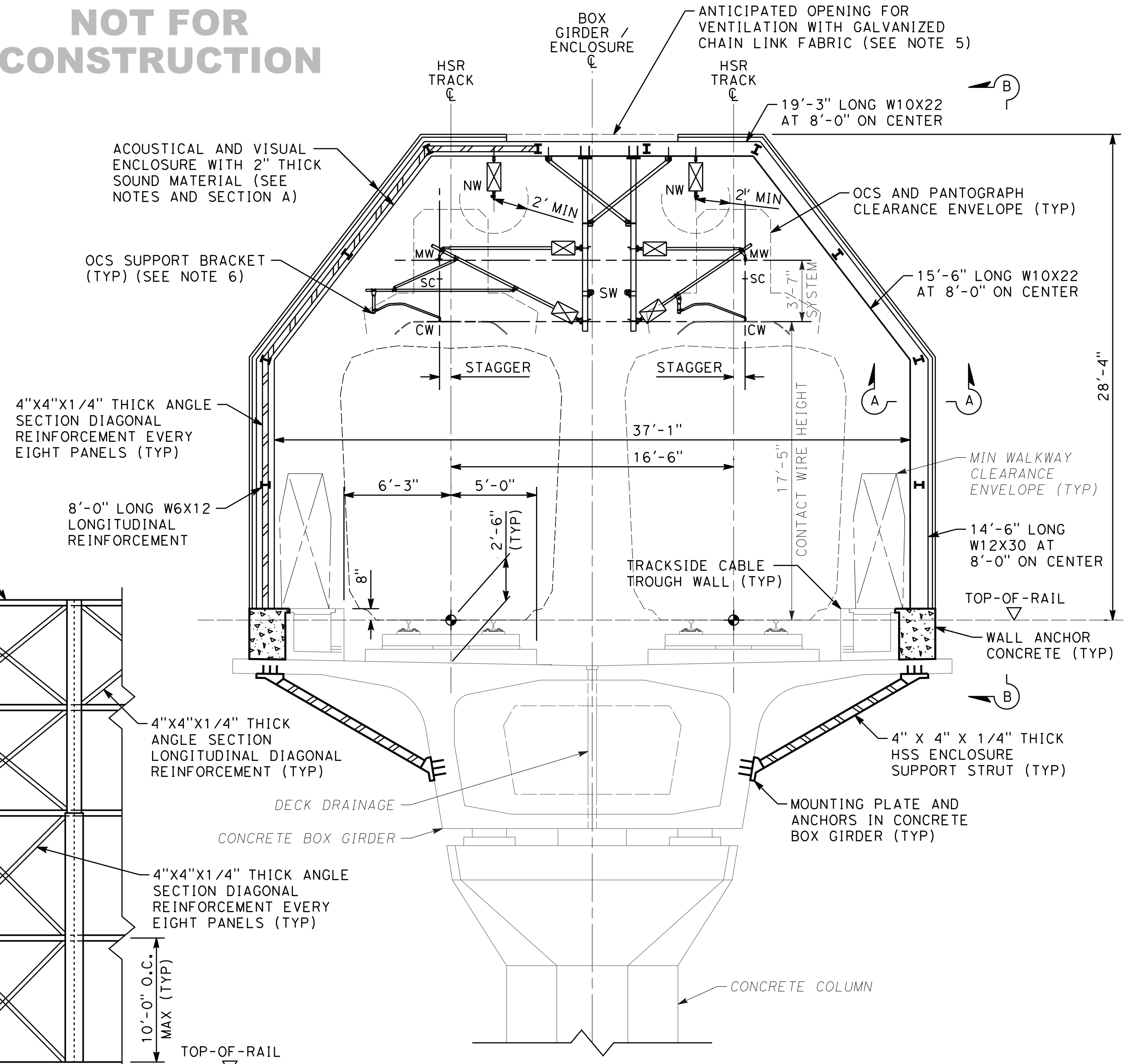


SECTION A-A

LONGITUDINAL SECTION



LONGITUDINAL ELEVATION B-B



CONCEPTUAL SECTION

ACOUSTICAL AND VISUAL ENCLOSURE ON VIADUCT

NOTES:

1. SEE STRUCTURE, TRACK, DRAINAGE AND OCS DIRECTIVE DRAWINGS FOR DETAILS NOT SHOWN.
2. ACOUSTICAL AND VISUAL ENCLOSURE MATERIALS WITH WEIGHT OF NO MORE THAN FIVE POUNDS PER SQUARE FOOT TO BE DETERMINED.
3. ALL DIMENSIONS SHOWN ARE ASSUMPTIONS AND NOT BASED ON DETAILED DESIGN.
4. ALL BOLD FEATURES ARE NON-STANDARD ITEMS FOR HSR STRUCTURES.
5. THE CONCEPTUAL CROSS SECTIONAL AREA INSIDE THE ENCLOSURE IS APPROXIMATELY 930 SQUARE FEET COMPARED TO A CONCEPTUAL TWO-TRACK TUNNEL OF 1,625 SQUARE FEET. AS A RESULT, OPENINGS MUST BE PROVIDED FOR AERODYNAMIC AND VENTILATION REASONS.
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HSR	HIGH-SPEED RAIL
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MW	MESSENGER WIRE
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CONCEPTUAL
FOR DISCUSSION
PURPOSES ONLY
NOT FOR
CONSTRUCTION

REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY K. PUGASAP
DRAWN BY A. GURA
CHECKED BY J. BRATINA
IN CHARGE J. BRATINA
DATE 8/26/2019

CONCEPTUAL
FOR DISCUSSION
PURPOSES ONLY
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CALIFORNIA HIGH-SPEED RAIL PROJECT
STRUCTURAL DIRECTIVE
TYPICAL CROSS SECTION
AERIAL STRUCTURE
TWO TRACK NON-BALLASTED
WITH GUIDEWAY ENCLOSURE

CONTRACT NO.
DRAWING NO. ENCLOSURE 1
SCALE NO SCALE
SHEET NO.

Appendix 4

Pressure Transient Analysis Memo

CALIFORNIA High-Speed Rail Authority

RDP Rail Delivery Partner

DRAFT

Memorandum

DRAFT FOR INTERNAL DISCUSSION ONLY

DATE: April 12, 2019

TO: Julian Bratina

FROM: Silas Li

CC: Brian Sutliff, Steve Klein

SUBJECT: Pressure Transient Analysis for An Acoustic Enclosure

Introduction

This memorandum summarizes the pressure transient analysis at conceptual design level for a 3-mile long acoustic enclosure. There is an 0.75 mile approach embankment, then 1.5 mile viaduct over a wetland area, and then another 0.75 mile embankment section that would support the acoustic enclosure structure. The objective of the conceptual design is to verify the cross sectional area of the structure, the size of the proposed obvert openings, and the resulting magnitude of the pressure waves generated by high speed operations. Based on the results of the pressure transient analysis, information will be forwarded to the noise analysis team.

Three scenarios were identified for pressure transient analysis and are discussed below:

1. Two crossing trains in the acoustic enclosure
2. Single train in the acoustic enclosure
3. Micro pressure waves at the exit portal

A 1-dimensional (1D) analysis was performed using the ThermoTun-Online software [1] which is commonly used for proof of concept. The benefit of using 1D model is shorter simulation time. Performing 3D CFD (Computational Fluid Dynamics) analysis would take a few months, and exceed the project schedule of 4 weeks for proof of concept.

The ThermoTun-Online has some limitations. In particular, it cannot simulate 3-dimensional (3D) phenomena in detail and the effects of ceiling openings. It averages values over the tunnel cross-section and estimate these averages vary along the tunnel. The software cannot address multiple ceiling openings. Simulations were performed without ceiling openings. The quantity of openings and size were estimated based on a literature search and engineering judgement.

Assumptions

The following assumptions were made for the pressure transient analysis:

- Cross sections of the acoustic enclosure (tunnel) on viaduct and on embankment (Figures 1 and 2 below).
- Tunnel length = 4,828 m (3 miles)
- Cross-sectional area of tunnel = 88.2 m^2 (950 ft^2)
- Tunnel radius = 4.7 m (15.4 ft)
- Length of train = 400 m (1312 ft)
- Cross-sectional area of train = 11 m^2 (118 ft^2)
- Fanning friction coefficient = 0.008
- Loss coefficient, flow from open tunnel into annulus around train = 0.1
- Shape factor, flow from annulus around train into open tunnel = 0.5
- Speed of train = 354 kph (220 mph)
- Sealing time constant for leakage through coach bodies = 1 second
- Time of nose entry = 0 second (both trains)
- The medical health criteria is taken from TM 2.4.2 for basic high-speed train tunnel configuration.

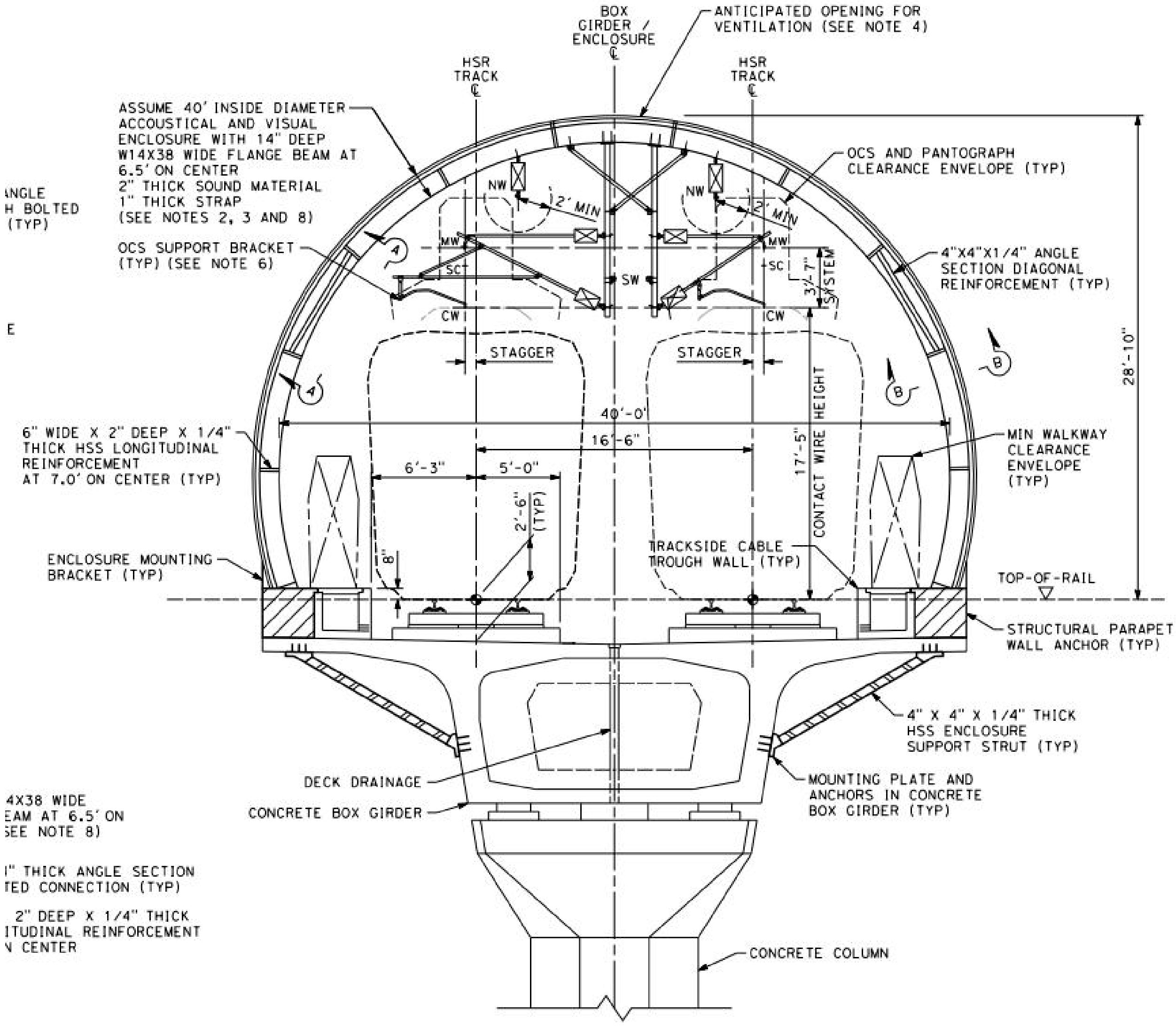

Figure 1: Acoustic Enclosure on Viaduct

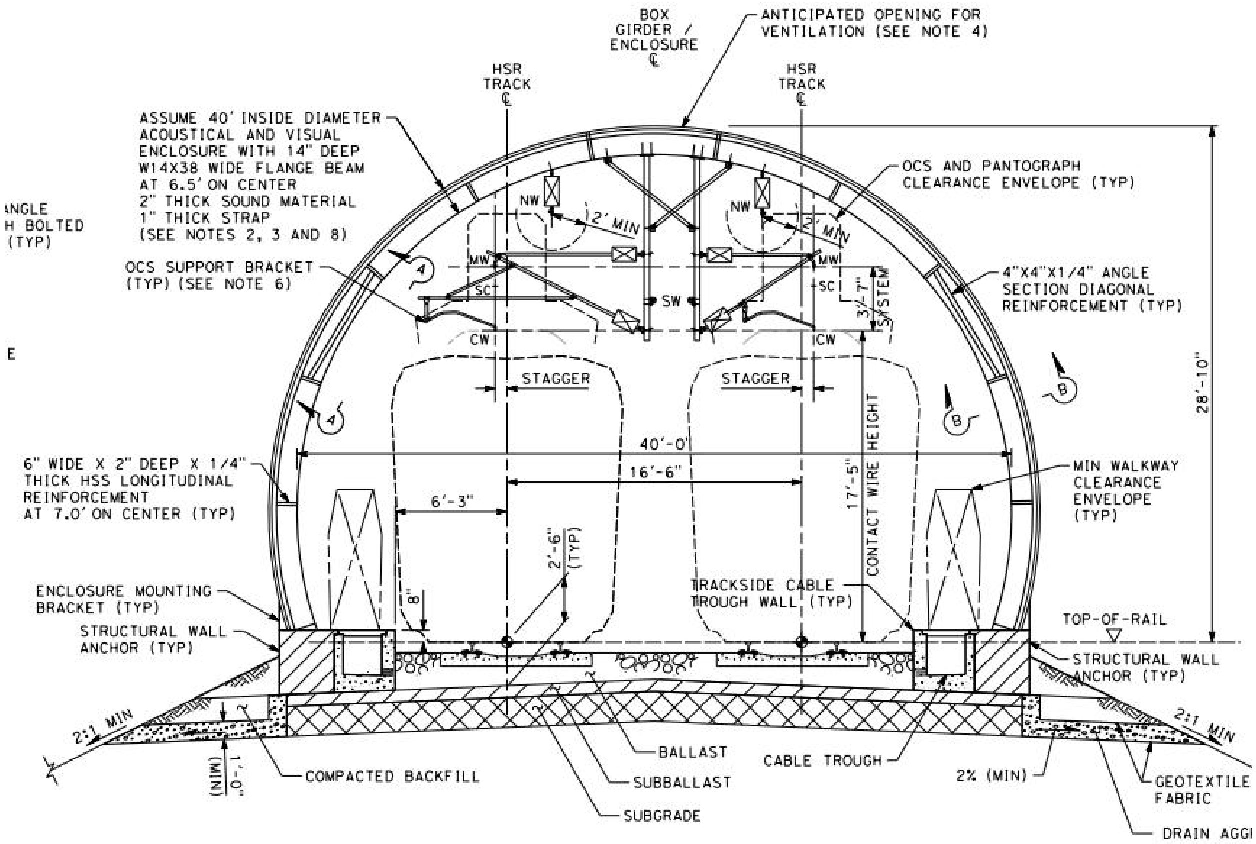

Figure 2: Acoustic Enclosure on Viaduct

Crossing Trains in Tunnel

Figure 3 below shows the output locations used in Figures 4 and 5 showing pressure results.

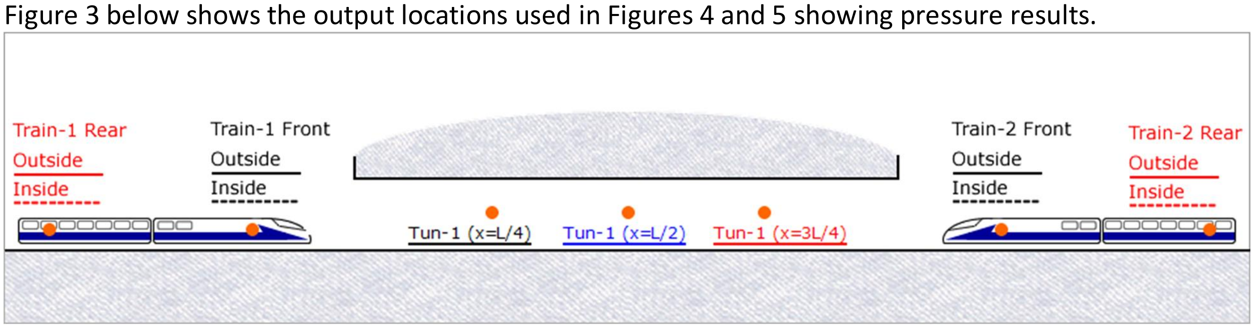

Figure 3: Crossing Trains in Tunnel

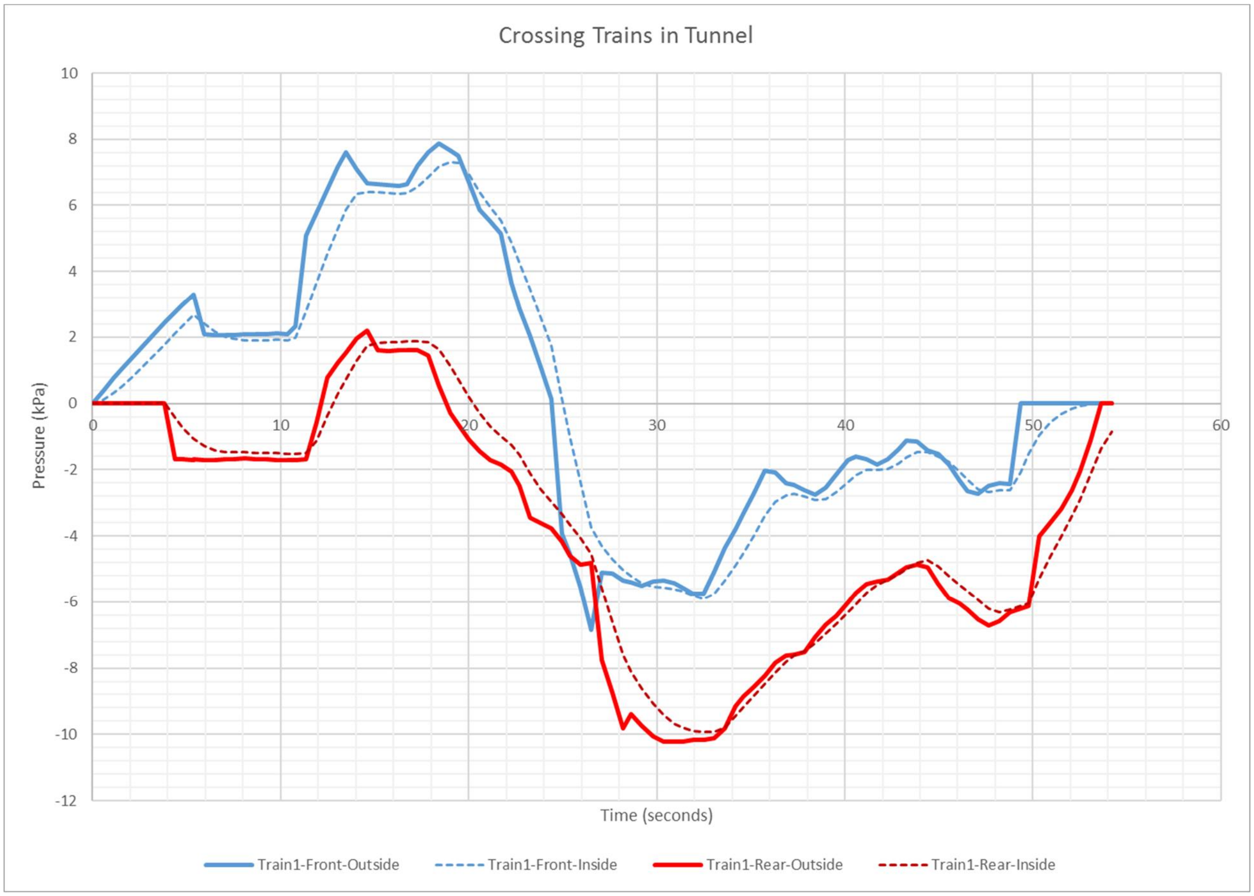

Figure 4: Pressure at the moving train

Figure 5: Pressure in the Tunnel

Single Train in Tunnel

Figure 6 below shows the output locations used in Figure 7 showing pressure results.

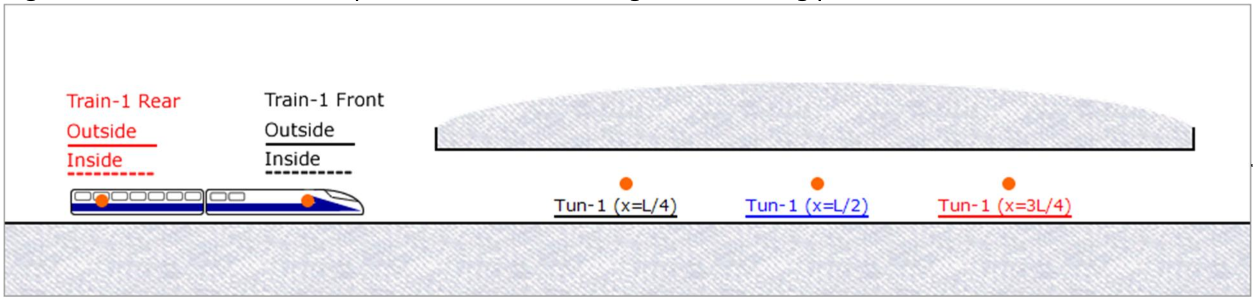

Figure 6: Single Train in Tunnel

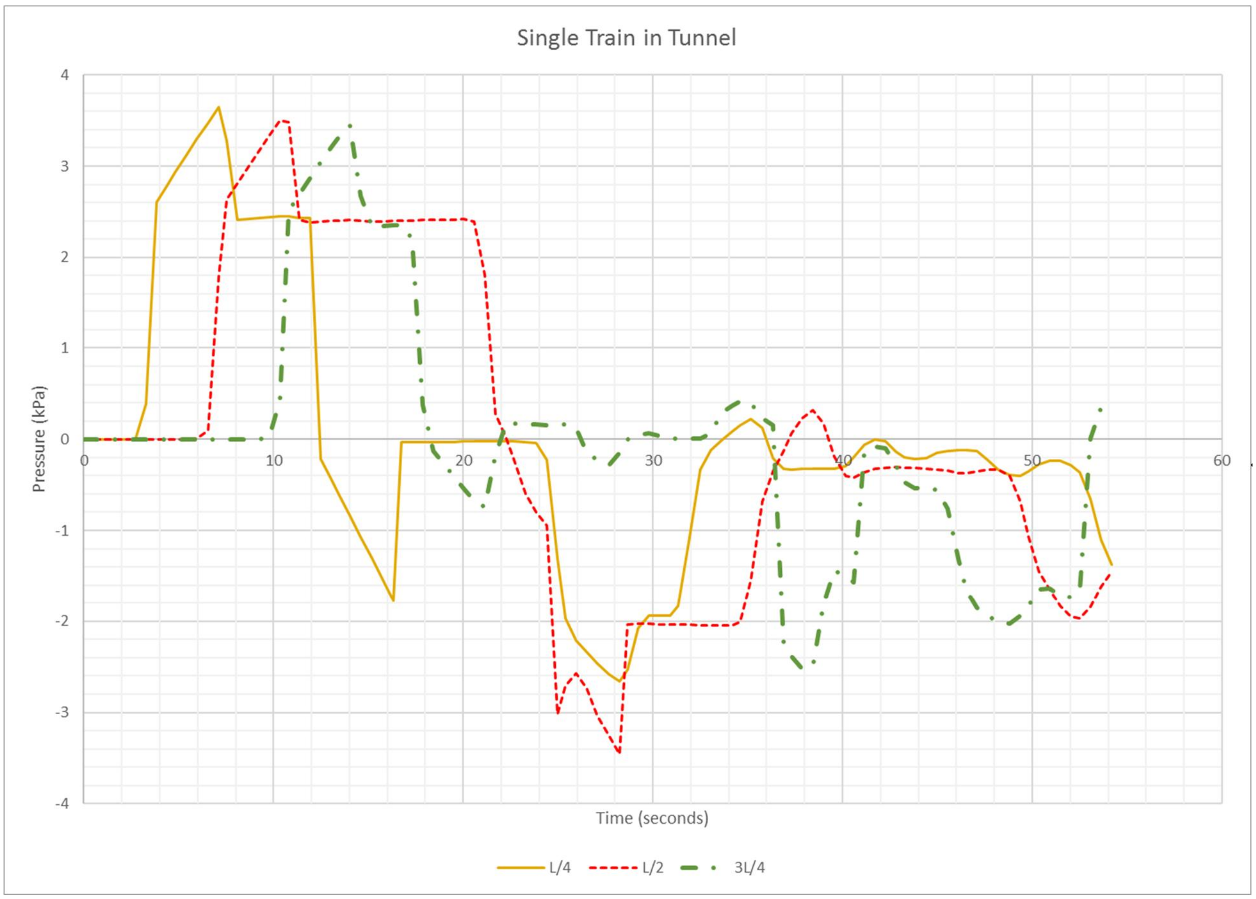

Figure 7: Pressure in the Tunnel

Micro Pressure Waves

Figure 8 below shows the output locations used in Figure 9 showing pressure results.

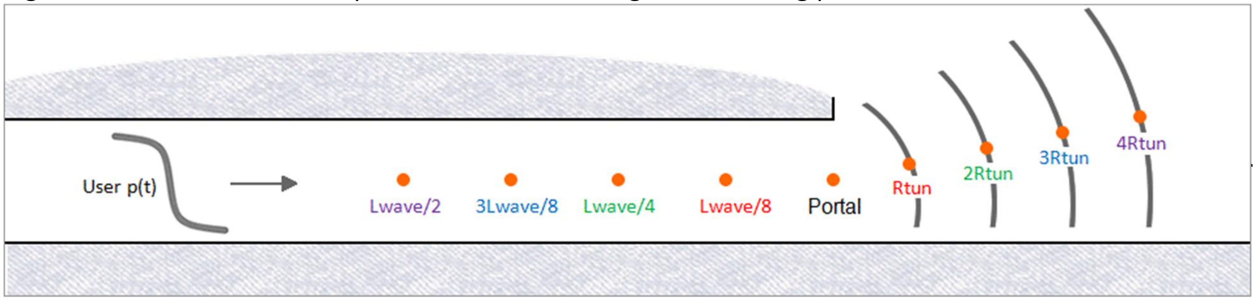

Figure 8: Micro Pressure Waves

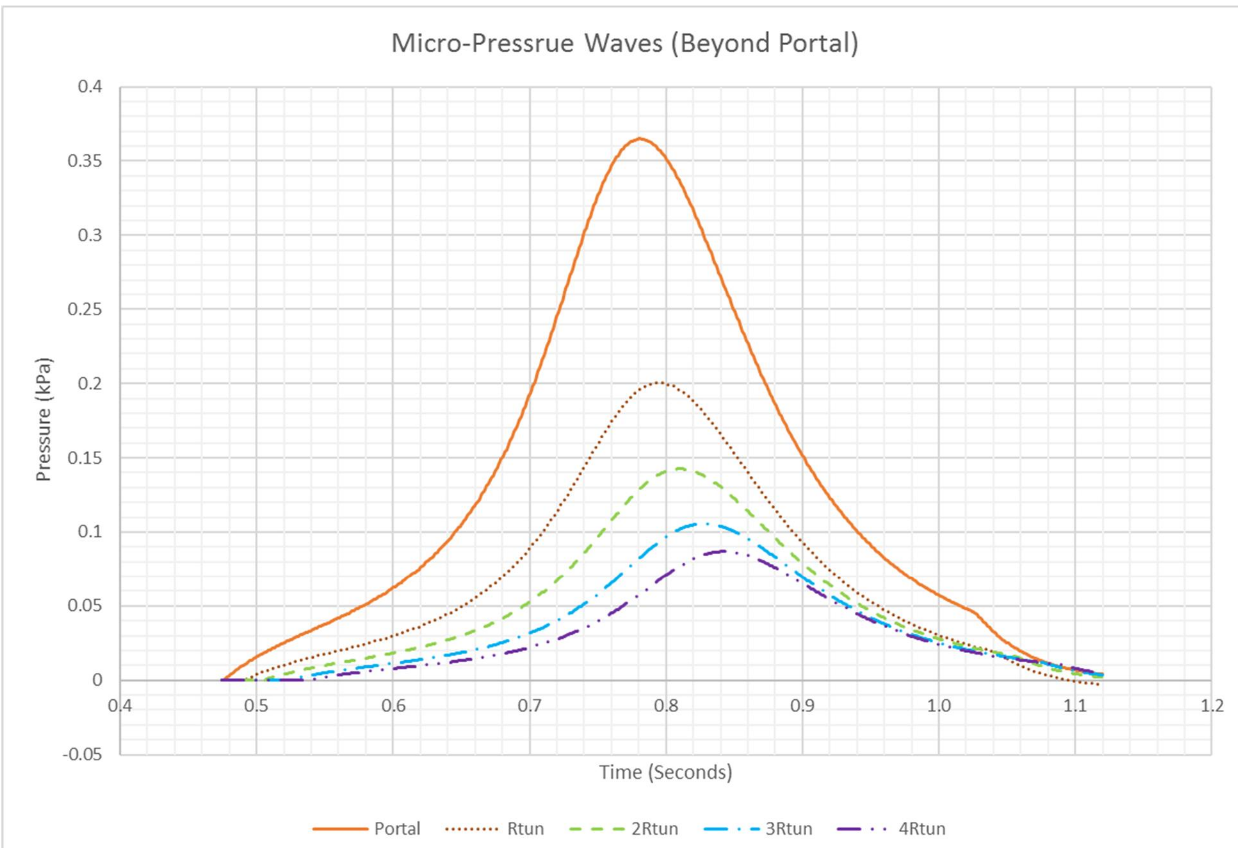

Figure 9: Micro Pressure Waves (Beyond Portal)

Discussions and Conclusions

Preliminary results for Crossing Trains in Tunnel (without Openings):

- Medical health criterion = 10 kPa (peak to peak pressure, Technical Memo TM 2.4.2)
- The maximum pressure change (peak to peak), to which train passengers and crews are subjected, would exceed 14.7 kPa for two trains passing at 354 kph.
- The maximum/minimum pressures on the tunnel structure would exceed +11.0 kPa / -9.8 kPa.

Preliminary results for Single Train in Tunnel (without Openings):

- The maximum pressure change (peak to peak) in the tunnel would be approximately 7.1 kPa.
- The pressure rise when the train entering the tunnel portal is 2.6 kPa.

Preliminary results for Micro-Pressure Waves (without Openings):

- The pressure at the portal is 365 Pa.

Pressure simulations were performed without ceiling openings. The quantity and size of ceiling openings were estimated based on literature search and engineering judgement. Reference [2] suggests that there was little benefit in increasing the number of shafts/openings above three. The cross-sectional area of air shafts/openings in tunnels should be around 10 to 35% of the area of the main tunnel. A total of 3 openings, spaced at approximately 0.75 miles apart could reduce the pressure by up to 40%.

For initial noise analysis, three openings are assumed at 1/4, 1/2 and 3/4 points of the tunnel length. Each opening is assumed to be 35% of the tunnel area or 31 m^2 (334 ft^2). The presence of openings is assumed to reduce the maximum pressure by 40%. This is an estimate for proof of concept at this stage. The tunnels referenced in the literatures are based on particular tunnel configurations, tunnel length, train area and speeds. The initial noise analysis should include two scenarios: 1) higher pressure without openings; and 2) with 3 ceiling openings and 40% reduction in pressure. Detailed analysis, such as CFD and passenger comfort analysis, should be performed for the acoustic enclosure with ceiling openings during next phase of design.

References

[1] ThermoTun Manual, www.thermotun-online.com

[2] "High-Speed Rail Aerodynamic Assessment and Mitigation Report", Final Report Dec 2015, U.S. Department of Transportation, Federal Railroad Administration, Office of Research, Development and Technology, Washington, DC 20590,

Appendix 5

Noise Analysis Memo

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MEMORANDUM

To:	Julian Bratina
From:	Erich Thalheimer
Date:	June 25, 2019
Project Name:	California High-Speed Rail Project
Project Number:	189229H
Subject:	**CAHSR Grasslands Noise Barrier Alternatives Comparison Tech Memo**

Study Overview

This memo summarizes the technical analysis process and results of an acoustical mitigation assessment performed to determine the potential impact of the California High-Speed Rail Project on the Grasslands Ecological Area, and mitigation of such impact. The Grasslands Ecological Area (Grasslands) is home to several species of waterfowl that could be adversely affected by high-speed train noise. Thus, consideration is being given towards reducing the train noise footprint through the rail corridor within the Grasslands.

The proposed alignment runs east and west through the middle of the Grasslands for about 3 miles, from approximately Station 4930 to Station 5085. Parallel noise mitigation barriers on both sides of the tracks have been suggested as an appropriate mitigation technique. Four train noise barrier mitigation designs are considered in this assessment: (1) 14-ft noise barriers, (2) 17.5-ft noise barriers, (3) 17.5-ft noise barriers with a slanted cantilever top edge, and (4) a nearly-complete tunnel enclosure.

The Cadna-A® acoustical model, developed by DataKustik GmbH, was used to perform this study. Cadna-A is a general purpose, three dimensional, ray tracing acoustical model that implements ISO Standard 9613 for outdoor sound prediction and propagation. All four noise barrier alternatives were evaluated using the same Cadna-A model, thus allowing for direct comparison of the results.

This study was not scoped to recommend a preferred alternative. Rather, this study presents an evaluation of the acoustical benefits and consequences of the candidate noise barrier alternatives.

Noise Criteria Thresholds

Several noise criteria thresholds were previously established (by others) for this study to avoid disturbing, upsetting or harming waterfowl residing in the Grasslands area. The noise metric of choice for this study was the maximum sound level (Lmax) measured in A-weighted decibels (dBA) using an RMS 'slow' response time. The justification for this criterion is the desire to avoid startling the waterfowl by the quick onset of noise due to trains moving through the area. Use of the Lmax dBA 'slow' noise metric is consistent with recommendations in the Federal Railroad Administration (FRA) High-Speed Ground Transportation Noise and Vibration Impact Assessment Manual (2012).

The four noise criteria considered and evaluated through this study included the following:

- Permanent hearing damage (Lmax < 140 dBA)
- Temporary hearing damage (Lmax < 93 dBA)
- Avoidance of masking (Lmax < 84 dBA)
- Avoidance of arousal (Lmax < 77 dBA)

As Planned Condition

The current As Planned condition is shown in **Figure 1.** Trains passing through this section would involve CAHSR electric multiple unit (EMU) consists of approximately 660 feet in length, including their locomotives and cars, traveling at about 220 mph. This section of tracks within the Grasslands is relatively straight (east and west) but has a portion of elevated track on a 25-ft high top-of-rail viaduct from Station 4955 to Station 5051. The remainder of the tracks are at grade supported by embankment stone ballast, ranging in top-of-rail heights from 8-ft in the western end to 17-ft in the eastern end. The terrain and topography within 500 feet of both sides of the tracks is quite flat, with elevation changes of less than 10 feet.

Figure 1. Aerial View of CAHSR Grasslands Section

Cadna-A Noise Model

As previously noted, CAHSR train noise levels affecting the adjacent Grasslands were estimated using the Cadna-A® noise model developed by DataKustik GmbH. Cadna-A is a powerful, three dimensional, ray tracing acoustical model that implements ISO Standard 9613 for the prediction and propagation of outdoor sound.

Noise sources are input to the Cadna-A model as point, line and/or area components. Each source is characterized as emitting sound power levels (PWL) in octave bands or broadband A-weighted format. Attenuation due to distance, terrain and elevation differences, ground absorption, wind effects, foliage, building shielding, and attenuation from barriers and berms are computed in the model. The resulting sound pressure levels (SPL) are predicted at any receptor location(s) of interest.

The first step in configuring the Cadna-A model was to import geoshape project design files to serve as a base map of the area. In this manner, the exact alignment of the proposed CAHSR rail corridor could be modeled to a high degree of accuracy, including the topography data inherent in the geoshape files.

The two parallel tracks were then entered into the model at their respective elevations above grade. Cadna-A's optional FRA/FTA module was used in this case to simulate the methods and calculations described in FRA's High-Speed Ground Transportation Noise and Vibration Impact Assessment Manual (2012). The portion of tracks elevated on the viaduct section was assigned to be self-shielding due to the concrete guideway deck, and an adjustment of +3 dB was assigned to the elevated track sections consistent with FRA guidelines. The rest of the surrounding grounds were considered to be moderately acoustically absorptive (G = 0.5) for hard dirt/sand surfaces.

The four noise barrier alternatives were then entered into the Cadna-A model, including: (1) 14-ft noise barriers, (2) 17.5-ft noise barriers, (3) 17.5-ft noise barriers with a slanted cantilever top edge, and (4) a nearly complete tunnel enclose. The surfaces of the barriers facing the trains were assumed to be covered with a material with an average acoustical absorption coefficient of 0.85 NRC in order to reduce the performance degradation effect caused by reflective parallel barriers.

Noise receptors were entered into the model in traverse patterns at three locations, representative of each of the three different track conditions. One location was the approximate center of the track on ballast section towards the west near Station 4942; another location was the approximate middle of the elevated viaduct track near Station 5003; and the final location was the approximate center of the track on ballast section towards the east near Station 5067. The receptors were modeled as being 5 feet above the ground and were positioned in the traverse arrays every 50 feet out to a distance of 500 feet from the tracks (topographical data was not available beyond 500 feet).

Lastly, the noise model computed isopleth contours, or lines of equal loudness, for each of the four noise criteria thresholds (i.e. Lmax = 140, 93, 84 and 77 dBA). In doing so, the results could be presented so that the four respective noise impact zones (or noise criteria exceedance zones) can be clearly seen relative to one another.

Noise Barrier Results

The noise impact zones, or isopleth contour lines, for the As Planned (i.e. without barriers) and for the four noise barrier alternatives are shown in **Figures 2 thru 11**. Two figures, a western half and an eastern half, are provided for each scenario.

The results indicate that concern for permanent hearing damage (i.e. Lmax = 140 dBA) was unwarranted. The impact zone for 140 dBA would occur too close to the train itself to warrant any further concern. Therefore, each of the figures only shows isopleth lines for Lmax = 93, 84 and 77 dBA, respectively.

To be effective, a noise barrier must, at a minimum, break the line-of-sight between the noise source and the receptor. Noise barriers need to be very long relative to their height to avoid noise from flanking around the endpoints. In this manner, the height of the barrier becomes the most important aspect in determining its noise reduction effectiveness. The taller a noise barrier, the more noise reduction it will provide for receptors on the other side. The position of the barriers, relative to the noise source, was limited in this case to being erected along the CAHSR right-of-way (ROW).

As expected, the size of the noise impact zones gets smaller with each more substantial noise barrier alternative. Thus, the noise reduction provided by the 14-ft barrier is greater than the As Planned condition; the noise reduction provided by the 17.5-ft barrier is greater than the 14-ft barrier; the noise reduction provided by the 17.5-ft cantilever barrier is greater than the 17.5-ft barrier; and the noise reduction provided by the tunnel barrier is greater than the 17.5-ft cantilever barrier.

Table 1 summarizes the Cadna-A noise model results for the three traverse lines of discrete receptors (i.e. Western, Middle and Eastern). While the impact zone distances vary somewhat from point to point, the results in the table give an overview of the noise reduction benefits associated with each barrier alternative. The results in the table are approximations, rounded to nearest 50-ft increment. More exact definition of the noise impacts zones should be taken from the isopleth contour lines in **Figures 2 thru 11**.

Table 1. CAHSR Grasslands Noise Impact Zones and Noise Barrier Effectiveness

Design Scenario	**Approximate Noise Impact Zones (Feet From Tracks)**											
Track Segment	**Western**				**Middle**				**Eastern**			
Stations	Sta. 4930 to Sta. 4955				Sta. 4955 to Sta. 5051				Sta. 5051 to Sta. 5085			
Track Condition	Ballast TOR = 8 ft				Elevated TOR = 25 ft				Ballast TOR = 17 ft			
Noise Criteria	Perm	Temp	Mask	Arouse	Perm	Temp	Mask	Arouse	Perm	Temp	Mask	Arouse
As Planned	0	250	>500	>500	0	50	>500	>500	0	200	>500	>500
14 ft Barriers	0	<100	150	>500	0	<50	150	>500	0	<100	100	500
17.5 ft Barriers	0	<100	100	450	0	<50	150	>500	0	<100	100	400
17.5 ft Cantilever Barriers	0	<100	100	400	0	<50	150	500	0	<100	100	400
Tunnel Barriers	0	<100	100	300	0	<50	150	450	0	<100	100	300

Notes: Perm = Permanent hearing damage (Lmax < 140 dBA)
Temp = Temporary hearing damage (Lmax < 93 dBA)
Mask = Avoidance of masking (Lmax < 84 dBA)
Arouse = Avoidance of arousal (Lmax < 77 dBA)

As can be seen in the table, the provision of even a 14 ft tall barrier will provide significant noise reduction compared to the As Planned condition. The installation of taller or more comprehensive barriers would further reduce noise levels affecting the Grasslands, but at a less significant incremental rate, meaning there are diminishing returns for the additional costs involved with building larger barriers.

It is hoped that this study will aid CAHSR officials in considering these noise barrier alternatives from a quantitative perspective. Refinements to these noise barrier alternatives, or additional noise analyses are available upon request.

Disclaimer – This study only examined the acoustical aspects of the subject noise barriers. No attempt was made to estimate the costs of the barriers, or the structural requirements to build the barriers.

Figure 2. CAHSR Grasslands Noise Impact Zones
As Planned Condition (Part 1 of 2)

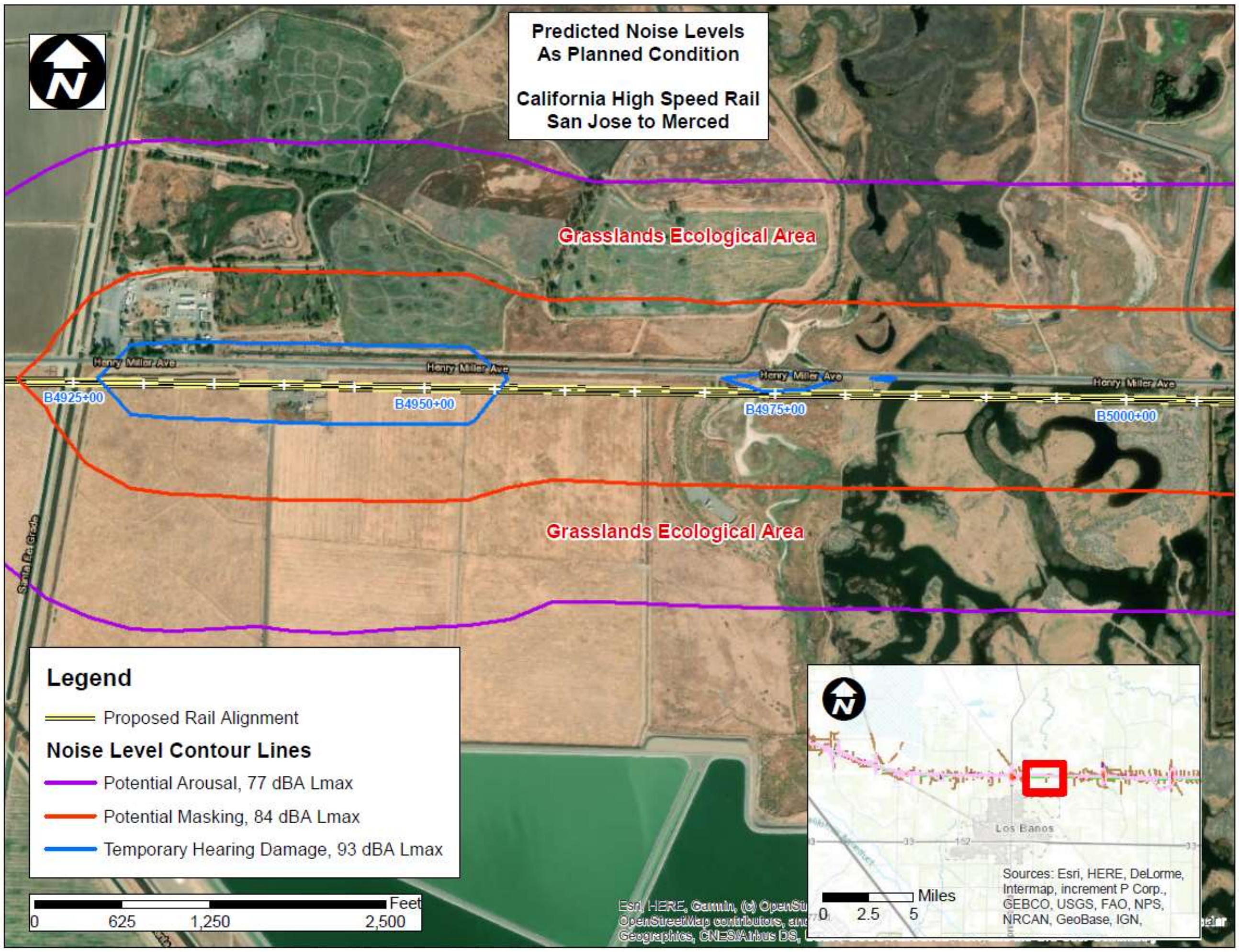


Figure 3. CAHSR Grasslands Noise Impact Zones
As Planned Condition (Part 2 of 2)

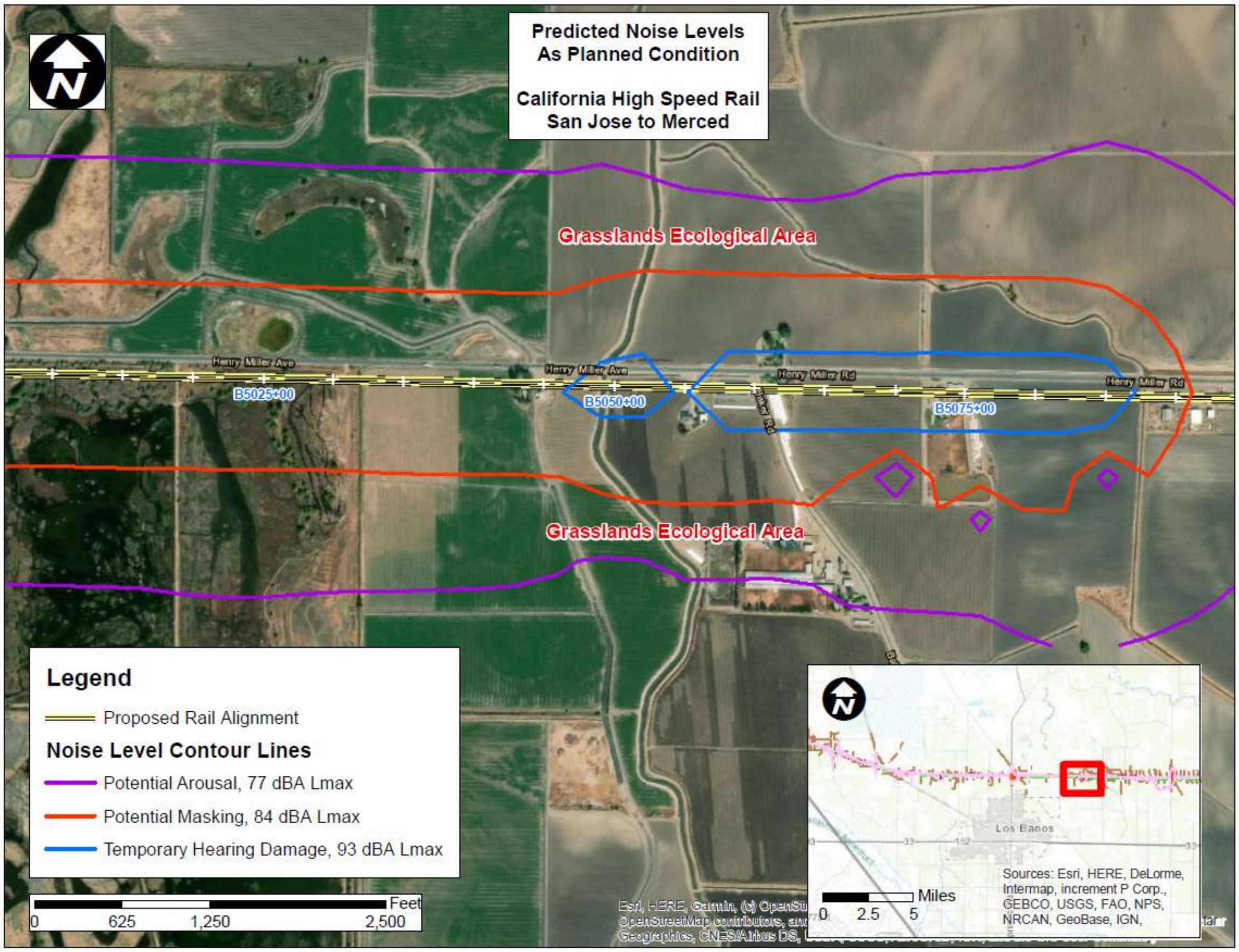


Figure 4. CAHSR Grasslands Noise Impact Zones With 14-ft Noise Barriers (Part 1 of 2)

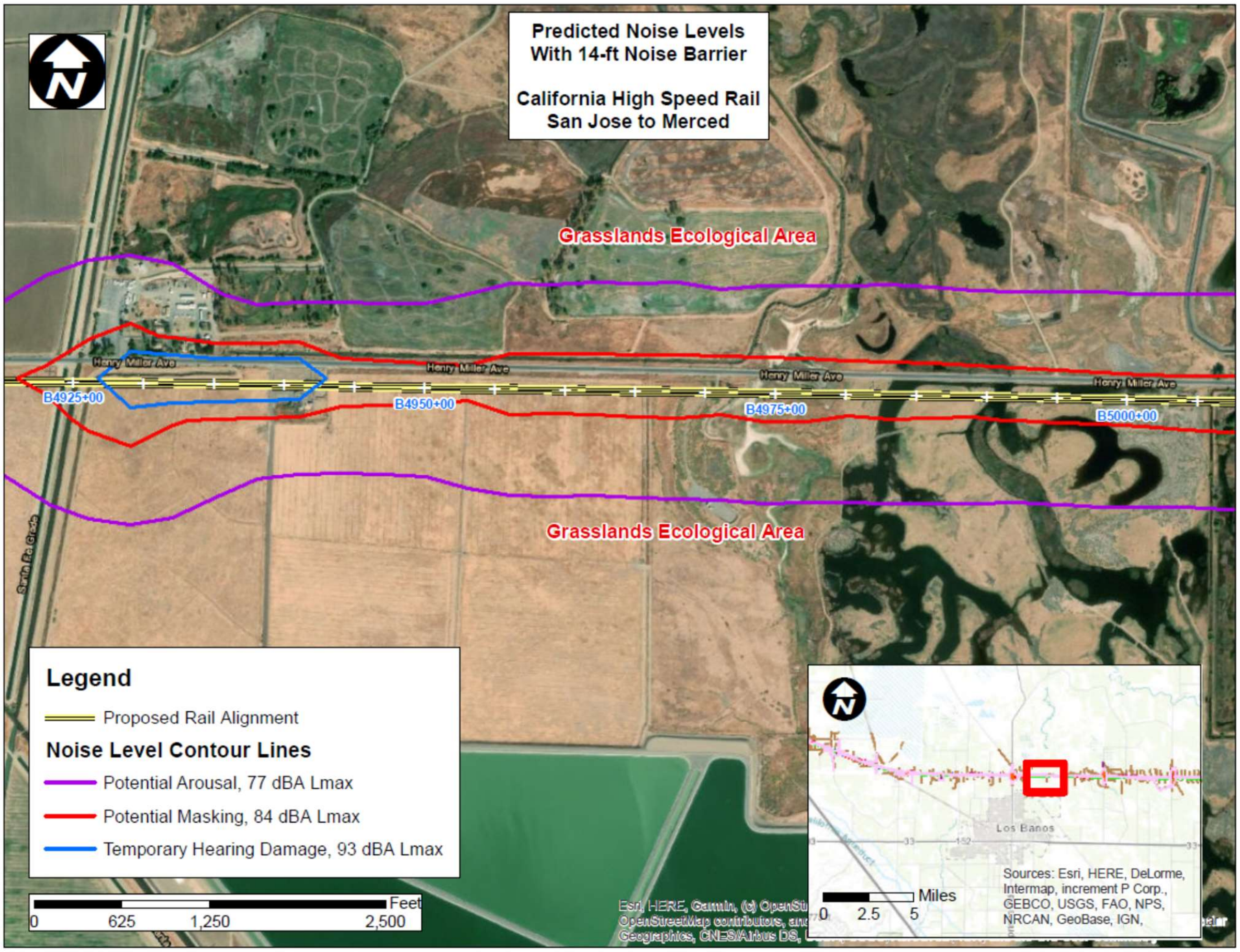


Figure 5. CAHSR Grasslands Noise Impact Zones With 14-ft Noise Barriers (Part 2 of 2)

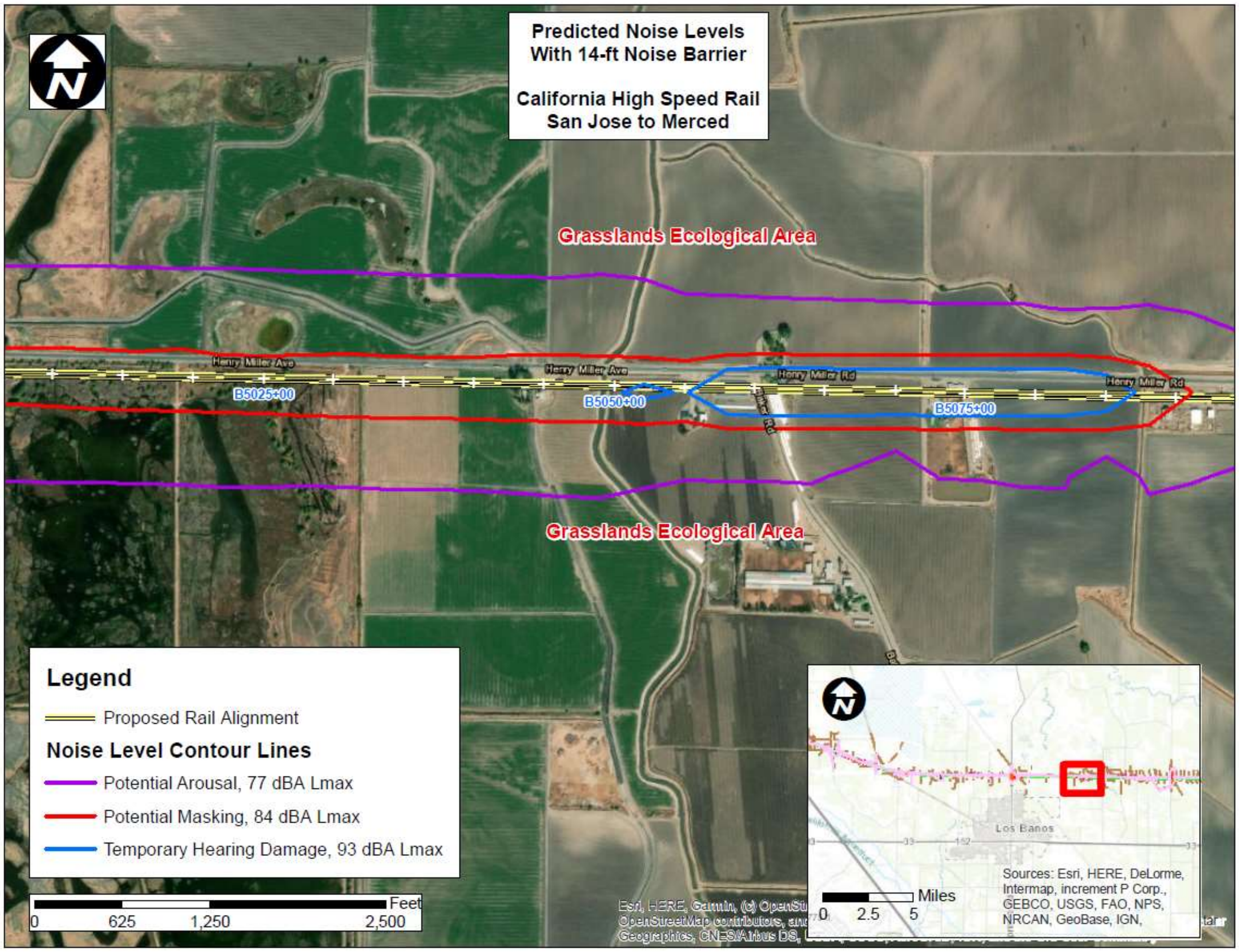


Figure 6. CAHSR Grasslands Noise Impact Zones With 17.5-ft Noise Barriers (Part 1 of 2)

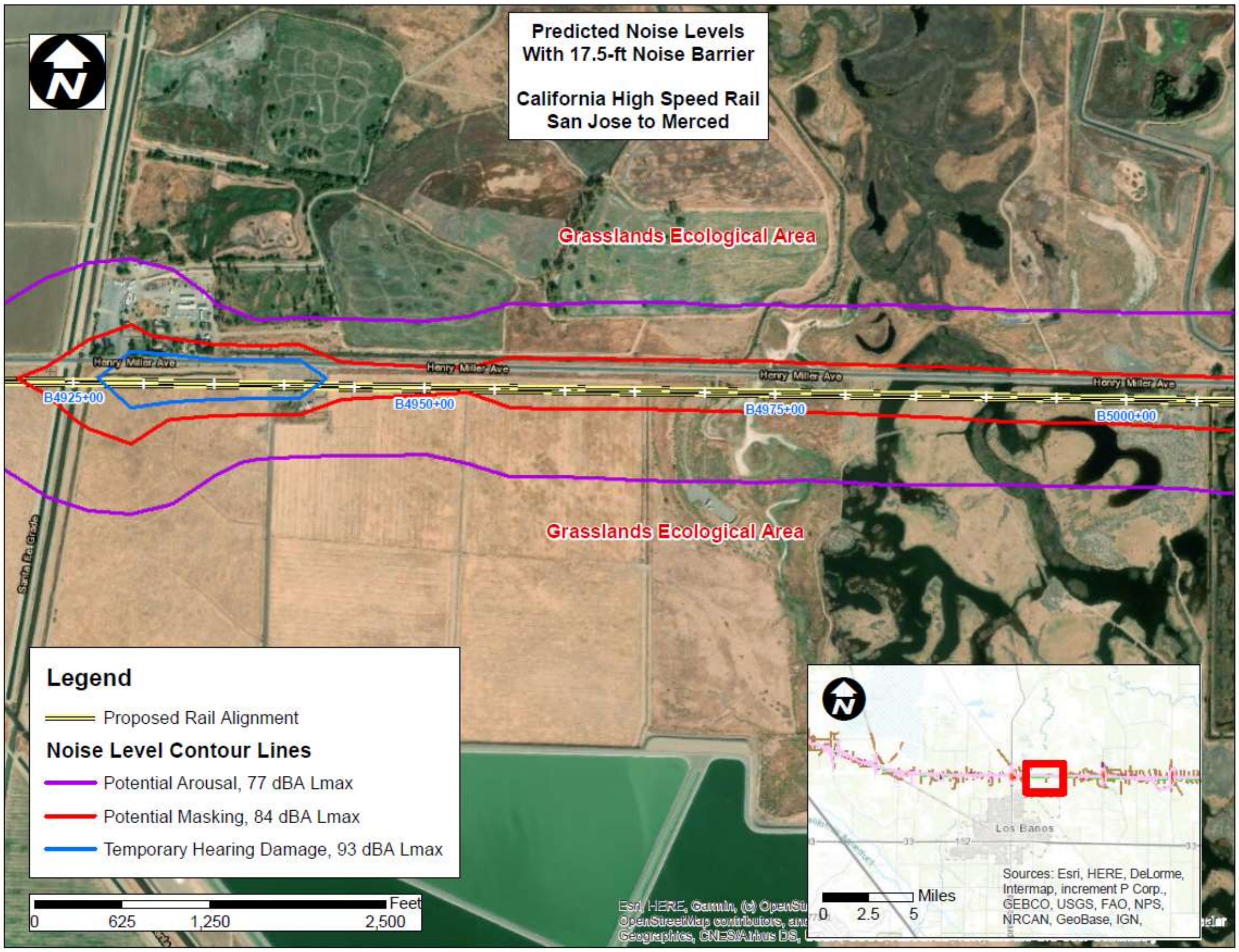


Figure 7. CAHSR Grasslands Noise Impact Zones With 17.5-ft Noise Barriers (Part 2 of 2)

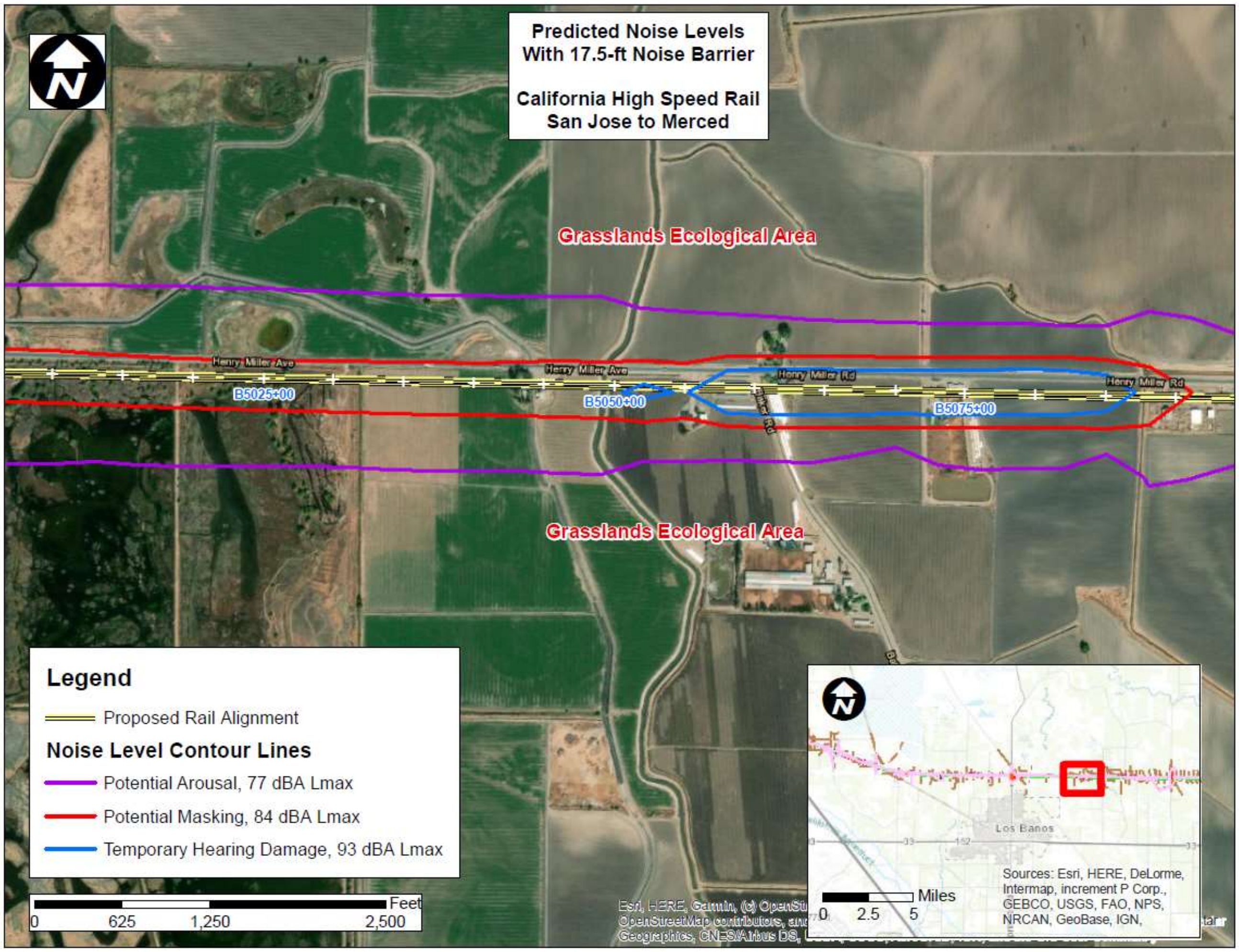


Figure 8. CAHSR Grasslands Noise Impact Zones With 17.5-ft Cantilever Noise Barriers (Part 1 of 2)

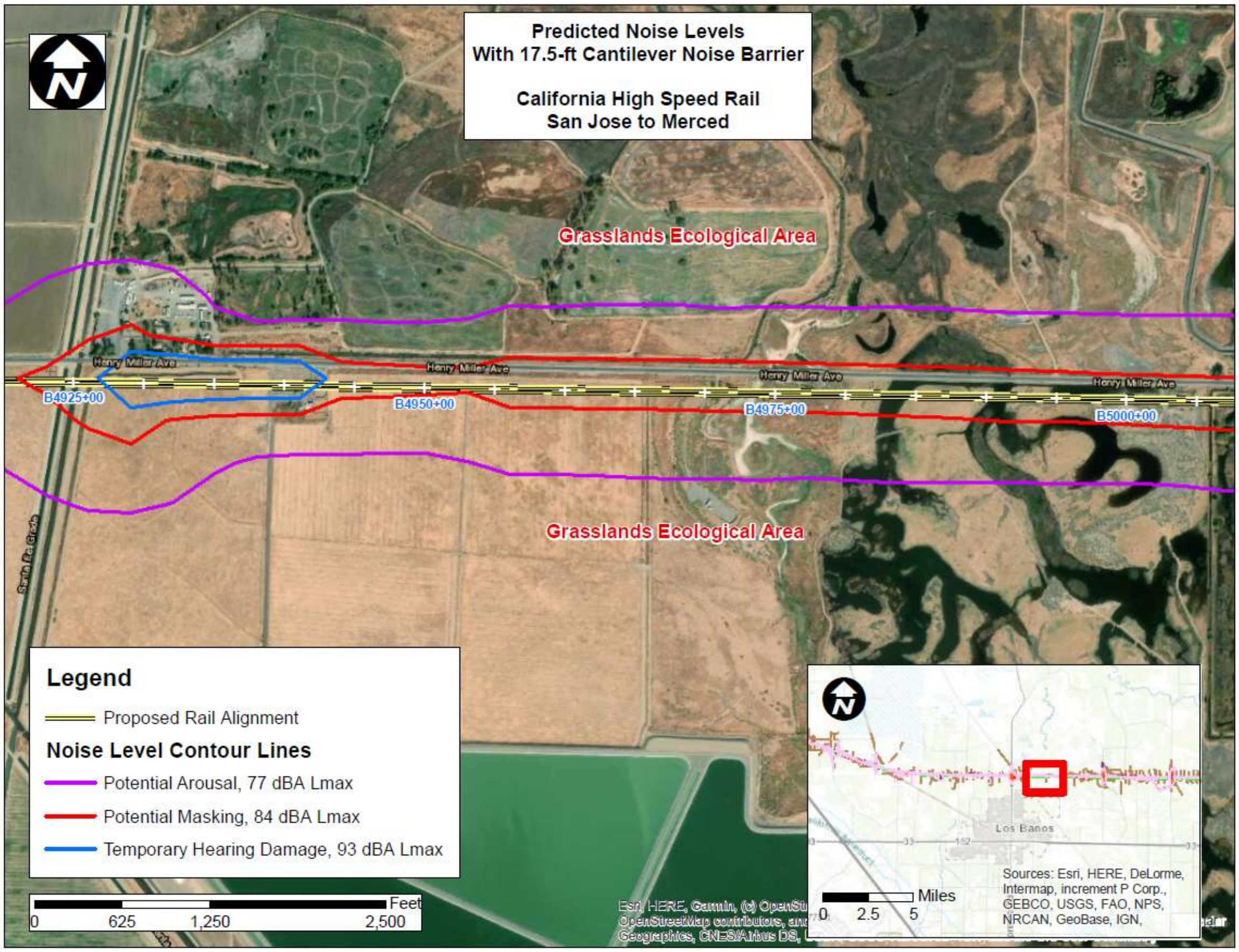


Figure 9. CAHSR Grasslands Noise Impact Zones
With 17.5-ft Cantilever Noise Barriers (Part 2 of 2)

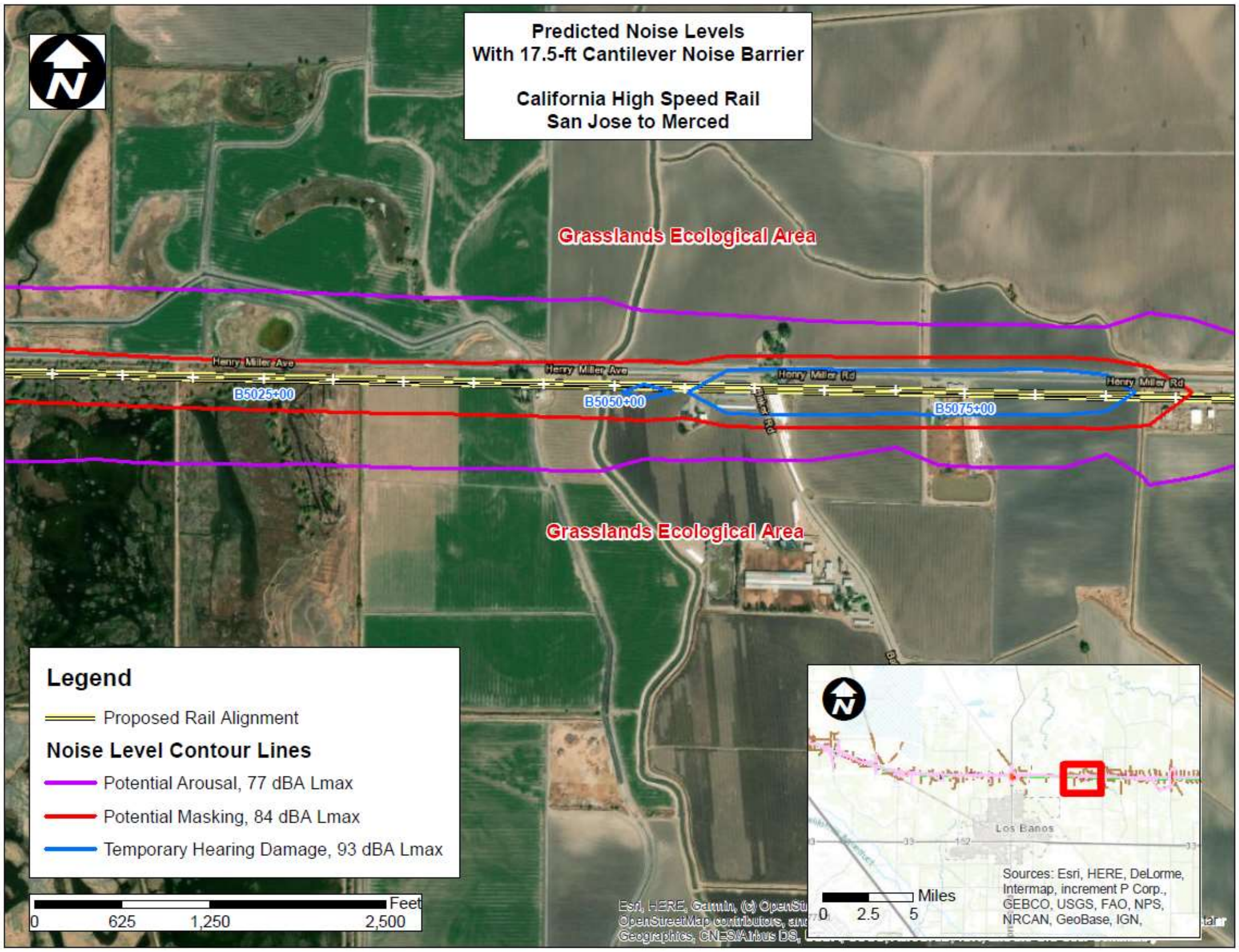


Figure 10. CAHSR Grasslands Noise Impact Zones
With Tunnel Noise Barriers (Part 1 of 2)

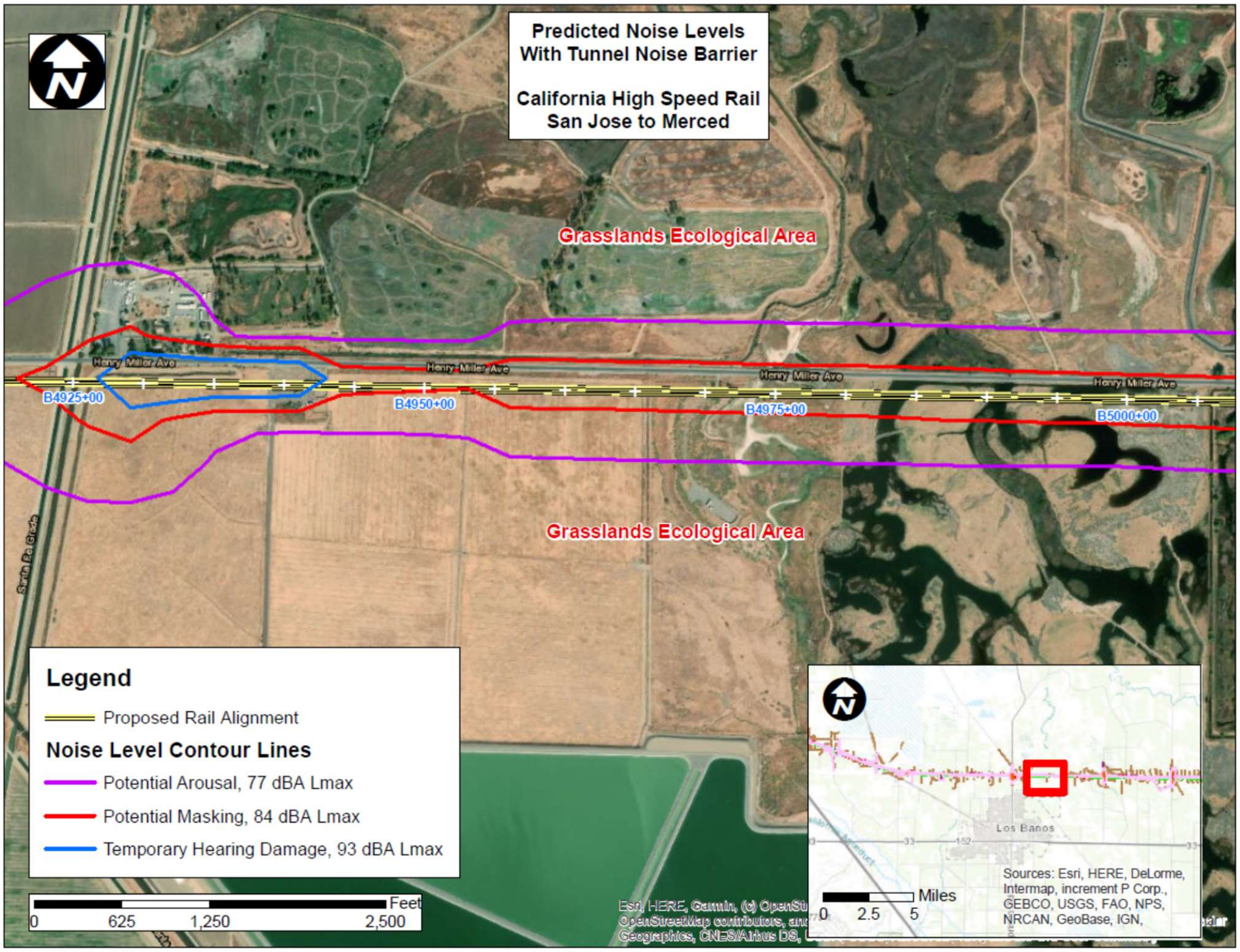
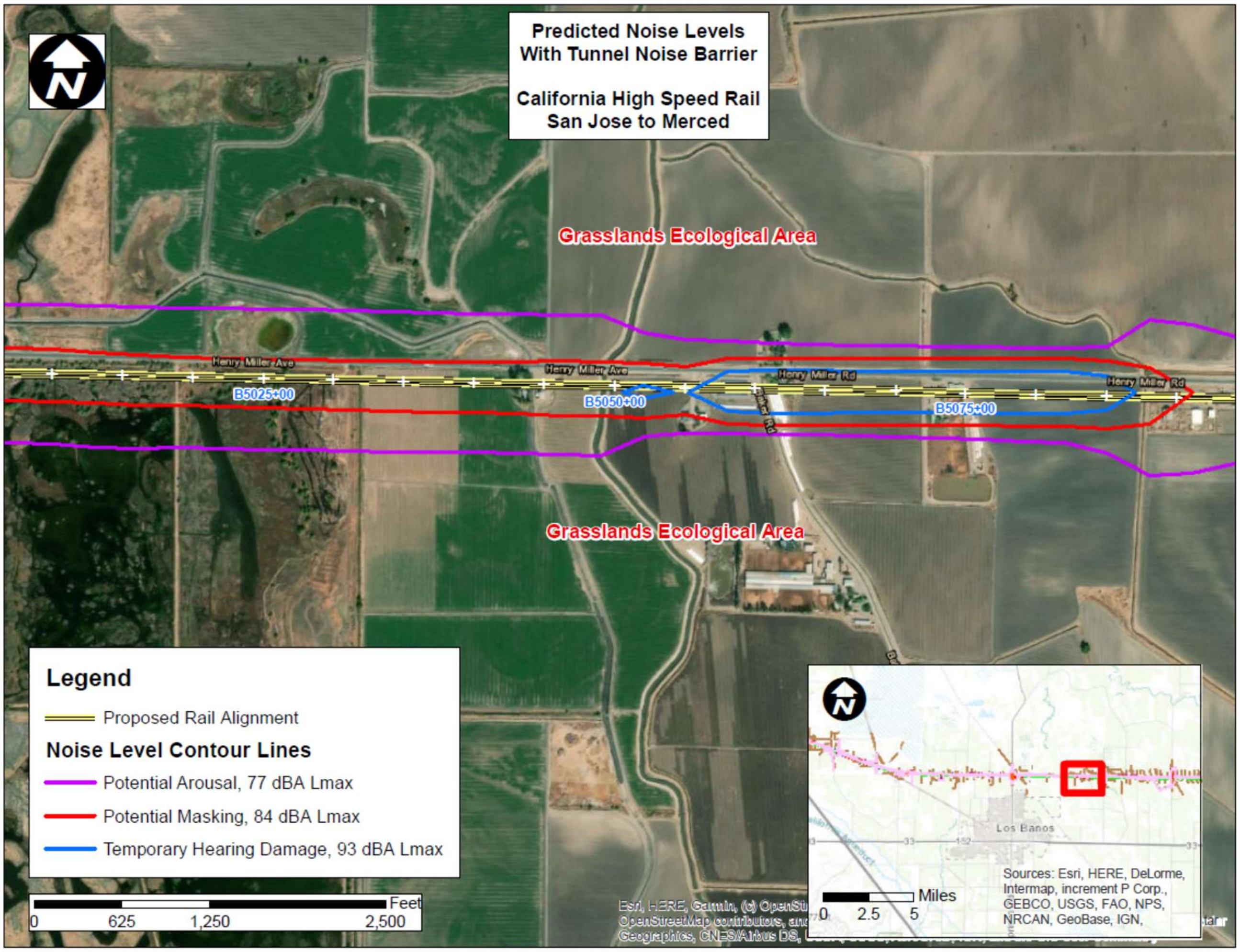


Figure 11. CAHSR Grasslands Noise Impact Zones With Tunnel Noise Barriers (Part 2 of 2)



Appendix 6

Cost Estimates

Noise Mitigation Options Estimate:

1.5 mi Viaduct & 1.5 mi Embankment:

Engineer's Estimate

9/16/2019 R.3

WBS Item	Description	Quant.	Unit	MHRS	Total Labor	Total Eq.Rent	Total Perm.Matl.	Total Subc.	**Direct Cost**	OH&P 15%	Subtotal Cost	Contingency 15%	**Total Direct Cost**	Unit Cost
10.10	Standard Soundwall along 1.5 mi Viaduct:	15,840	LF	17,058	$1,392,312	$697,447	$15,672,419	$0	**$17,762,178**	$2,664,327	$20,426,505	$3,063,976	**$23,490,481**	$1,482.98
10.20	Standard Soundwall along 1.5 mi Embankment:	15,840	LF	14,622	$1,187,781	$279,223	$11,630,203	$3,863,006	**$16,960,213**	$2,544,032	$19,504,244	$2,925,637	**$22,429,881**	$1,416.03
10.30	F&I Line Markers along 3.0 mi of Track:	1,056	EA	1,320	$78,207	$42,124	$12,143	$0	**$132,475**	$19,871	$152,346	$22,852	**$175,198**	$165.91
	MEASURE #1 Total Construction Cost	31,680	LF	33,000	2,658,300	1,018,794	27,314,766	3,863,006	**$34,854,865**	$5,228,230	$40,083,095	$6,012,464	**$46,095,560**	$1,455.04
20	Tubular Enclosure along 1.5mi Viaduct:	7,920	LF	115,674	$8,791,563	$3,099,518	$32,276,150	$5,195,520	**$49,362,751**	$7,404,413	$56,767,164	$8,515,075	**$65,282,239**	$8,242.71
30	Tubular Enclosure along 1.5 mi Embankment:	7,920	LF	115,674	$8,791,563	$3,099,518	$22,170,609	$6,893,723	**$40,955,414**	$6,143,312	$47,098,726	$7,064,809	**$54,163,535**	$6,838.83
	MEASURE #2 Total Construction Cost:	**15,840**	**LF**	**231,348**	**$17,583,127**	**$6,199,036**	**$54,446,759**	**$12,089,243**	**$90,318,165**	$13,547,725	$103,865,890	$15,579,883	**$119,445,773**	$7,540.77
40	Wall Panel Enclosure along 1.5mi Viaduct:	7,920	LF	64,385	$4,893,416	$1,854,376	$22,128,605	$5,195,520	**$34,071,917**	$5,110,788	$39,182,704	$5,877,406	**$45,060,110**	$5,689.41
50	Wall Panel Enclosure along 1.5 mi Embankment:	7,920	LF	61,148	$4,647,413	$1,777,795	$16,586,552	$6,893,723	**$29,905,483**	$4,485,822	$34,391,306	$5,158,696	**$39,550,001**	$4,993.69
	MEASURE #3 Total Construction Cost:	**15,840**	**LF**	**125,532**	**$9,540,829**	**$3,632,171**	**$38,715,158**	**$12,089,243**	**$63,977,400**	$9,596,610	$73,574,010	$11,036,101	**$84,610,111**	$5,341.55

Noise Mitigation Options Estimate: Engineer's Estimate

1.5 mi Viaduct & 1.5 mi Embankment: 9/16/2019 R.3

Item	Description	Quant.	Unit	Prod. Unit/Hr	Crew Hours	Days 8HR/Day	Man Hrs	Equip. Hrs	Labor Rate	Equip. Rent/Hr	Perm.Matl. Rate	Const.Matl. Rate	Subc. Rate	Total Labor	Total Eq.Rent	Total Perm.Matl.	Total Const.Matl.	Total Subc.	Direct Cost
10	**Standard Sound Wall:**					Days													
10.10	**Standard Soundwall along 1.5 mi Viaduct:**	**15,840**	**LF**	6.5	2,437	305													
	Acrylite Sound Wall System , (Quote by Armtec Company), Assume 4 Bays/Day = 2 Hrs/Bay = 2Hr/13LF=6.5'/HR	269,280	SF								$43.19					$11,630,203			$11,630,203
	90 TN RT Crane (Caltrans pg. 12 HCESP/GROVE/4760)	1	EA					2,437		$173.95					$423,903				$423,903
	Aerial Boom Manlift 60' (Caltrans pg. 15 HYLFT/BOOM/50-74)	1	EA					2,437		$47.31					$115,291				$115,291
	Flatbed Truck (Caltrans pg.34 TRUCK/T&TT/28-36)	1	EA					2,437		$39.96					$97,379				$97,379
	Pickup Truck (Caltrans pg.34 TRUCK/T&TT/06-12)	1	EA					2,437		$24.98					$60,874				$60,874
	Carpenter Foreman	1	EA				2,437		$86.27					$210,233					$210,233
	Carpenter Journeyman	4	EA				9,748		$83.93					$818,124					$818,124
	Flatbed Teamster - GR 2	1	EA				2,437		$64.23					$156,524					$156,524
	Crane Operator - GR 2-A	1	EA				2,437		$85.12					$207,431					$207,431
	Viaduct Structural Upgrade for 17ft high soundwall - Current Assumption is 2% of Viaduct cost															$4,042,216			$4,042,216
	Subtotal:						**17,058**							**$1,392,312**	**$697,447**	**$15,672,419**	**$0**	**$0**	**$17,762,178**
	Unit Cost:						0.9							$87.90	$44.03	$989.42	$0.00	$0.00	$1,121.35
						Days													
10.20	**Standard Soundwall along 1.5 mi Embankment:**	**15,840**	**LF**	6.5	2,437	305													
	16" CIDH Pile, 10 FT Long at 13' Spacing, (QTY = 15,840 LF @ 13' O.C. = 1218 EA @ 10 FT/EA = 12,184 LF), Quote Caltrans	12,184	LF										$68.31					$832,289	$832,289
	4,000 Psi Pile Cap & Reinforcement, (QTY = 1.5' W x 3.5' H x 15,840 LF = 3,080 CY)	3,080	CY										$984.00					$3,030,717	$3,030,717
	Acrylite Sound Wall System , (Quote by Armtec Company), Assume 4 Bays/Day = 0.5 Bay/HR = 6.5 LF/HR	269,280	SF								$43.19					$11,630,203			$11,630,203
	CAT446 Backhoe (Caltrans pg. 17 LDRRT/CAT/1868)	1	EA					2,437		$49.64					$120,969				$120,969
	Flatbed Truck (Caltrans pg.34 TRUCK/T&TT/28-36)	1	EA					2,437		$39.96					$97,379				$97,379
	Pickup Truck (Caltrans pg.34 TRUCK/T&TT/06-12)	1	EA					2,437		$24.98					$60,874				$60,874
	Carpenter Foreman	1	EA				2,437		$86.27					$210,233					$210,233
	Carpenter Journeyman	3	EA				7,311		$83.93					$613,593					$613,593
	Flatbed Teamster - GR 2	1	EA				2,437		$64.23					$156,524					$156,524
	Crane Operator - GR 2-A	1	EA				2,437		$85.12					$207,431					$207,431
	Embankment Sound wall Structural Upgrade for 17ft height - Current Assumption is 12% of soundwall cost															$1,859,185.11			$1,859,185
	Subtotal:						**14,622**							**$1,187,781**	**$279,223**	**$11,630,203**	**$0**	**$3,863,006**	**$16,960,213**
	Unit Cost:						1.1							$74.99	$17.63	$734.23	$0.00	$243.88	$1,070.72
						Days													
10.30	**F&I Line Markers along 3.0 mi of Track:**	**1,056**	**EA**	4	264	33													
	Aerial Marker Balls, Model JX (Quote by Flight Light)	83	EA								$151.17					$12,547			
	Bird-Flight Diverters, (Quote by Preformed Line Products)	1,056	EA								$11.50					$12,143			$12,143
	Aerial Boom Manlift 60' (Caltrans pg. 15 HYLFT/BOOM/50-74)	2	EA					528		$47.31					$24,980				$24,980
	Flatbed Truck (Caltrans pg.34 TRUCK/T&TT/28-36)	1	EA					264		$39.96					$10,549				$10,549
	Pickup Truck (Caltrans pg.34 TRUCK/T&TT/06-12)	1	EA					264		$24.98					$6,595				$6,595
	Labor Foreman	1	EA				264		$60.59					$15,996					$15,996
	Laborer - GR 3	3	EA				792		$57.14					$45,255					$45,255
	Flatbed Teamster - GR 2	1	EA				264		$64.23					$16,957					$16,957
	Subtotal:						**1,320**							**$78,207**	**$42,124**	**$12,143**	**$0**	**$0**	**$132,475**
	Unit Cost:						1.3							$74.06	$39.89	$11.50	$0.00	$0.00	$125.45
10	**Total Typical Mitigation on 3mi of track**	**31,680**	**LF**				**33,000**							**$2,658,300**	**$1,018,794**	**$27,314,766**	**$0**	**$3,863,006**	**$34,854,865**
20	**Tubular Enclosure along 1.5mi Viaduct:**	**7,920**	**LF**																
20.10	**4,000 Psi Concrete Anchor Wall:**	**5,280**	**CY**										$984.00					$5,195,520	**$5,195,520**
	(QTY = 3' W x 3' H x 7,920 LF = 2,640 CY x 2 EA = 5,280 CY)																		
						Days													
20.20	**Furnish & Install Steel:**	**8,902,241**	**LB**	1,000	8,902	1,113													
	(QTY = 8,902,241 LB = 4,451.12 TN @ 20 MH/TN = 89,022.4 MHs @ 10 men Crew = 8,902.24 CH = 1,000 LB/CH)																		
	Steel Rib - W14x38 Beam, (Quote by Durisol)	3,902,357	LB								$1.51					$5,898,998			$5,898,998
	Steel Straps - 1"x7"	2,552,774	LB								$1.51					$3,858,901			$3,858,901
	Struts 4" x 4" x 1/4" HSS	323,675	LB								$1.51					$489,283			$489,283
	Interior Cross Struts 4" x 4" x 1/4" Angle	521,580	LB								$1.51					$788,446			$788,446
	Longitudinal Braces 6" x 2" x 1/4" HSS	1,142,381	LB								$1.51					$1,726,880			$1,726,880
	Fasteners 4" x 4" x 1/4"	96,941	LB								$3.24					$314,015			$314,015
	Structural Plates 12" x 12" x 1/2"	224,726	LB								$1.51					$339,708			$339,708
	Cable Tray 4" x 3" x 1/4"	137,808	LB								$1.51					$208,317			$208,317
	Man Scissor Lift (Caltrans Pg.15, HYLFT/SCIS/31-50)	2	EA					17,804		$26.58					$473,243				$473,243
	Welding Machine (Caltrans Pg.34, WELD/AWM/250-500)	1	EA					8,902		$9.49					$84,482				$84,482
	Crane 90 Ton Grove RT-990 (Caltrans pg.12 HCESP/GROV/RT-990) - Unload Steel	1	EA					8,902		$173.95					$1,548,545				$1,548,545
	Crane Operator 2-A	1	EA				8,902		$85.12					$757,759					$757,759
	Iron Worker Foremen	1	EA				8,902		$78.83					$701,764					$701,764
	Iron Worker	8	EA				71,218		$74.51					$5,306,448					$5,306,448
	Subtotal:						**89,022**							**$6,765,970**	**$2,106,270**	**$13,624,548**	**$0**	**$0**	**$22,496,789**
	Unit Cost:						100.00							$0.76	$0.24	$1.53	$0.00	$0.00	$2.53
						Days													
20.30	**Furnish & Install Aluminum Panels:**	**688,248**	**SF**	258	2,665	333													
	(QTY = 688,248 SF @ 10.76SF/Panel = 63,973 Panels @ 24 Panels/HR = 2,665.54 HRs = 258.24 SF/HR)																		

Noise Mitigation Options Estimate: **Engineer's Estimate**

1.5 mi Viaduct & 1.5 mi Embankment: **9/16/2019** R.3

Item	Description	Quant.	Unit	Prod.	Crew	Days	Man	Equip.	Labor	Equip.	Perm.Matl.	Const.Matl.	Subc.	Total	Total	Total	Total	Total	Direct
				Unit/Hr	Hours	8HR/Day	Hrs	Hrs	Rate	Rent/Hr	Rate	Rate	Rate	Labor	Eq.Rent	Perm.Matl.	Const.Matl.	Subc.	Cost
	2" Aluminum Panel 1.64'W x 6.56'L, (Quote by Durisol)	688,248	SF								$12.42					$8,546,061			$8,546,061
	Aerial Boom Manlift 60' (Caltrans pg. 15 HYLFT/BOOM/50-74)	4	EA					10,661		$47.31					$504,353				$504,353
	Welding Machine (Caltrans Pg.34, WELD/AWM/250-500)	1	EA					2,665		$9.49					$25,292				$25,292
	Crane 90 Ton Grove RT-990 (Caltrans pg.12 HCESP/GROV/RT-990) - Unload Steel	1	EA					2,665		$173.95					$463,603				$463,603
	Crane Operator 2-A	1	EA				2,665		$85.12					$226,857					$226,857
	Iron Worker Foremen	1	EA				2,665		$78.83					$210,094					$210,094
	Iron Worker	8	EA				21,321		$74.51					$1,588,642					$1,588,642
20.4	**Structural Modifications** Viaduct Structural Upgrade for supporting enclosure - Assume 5% of viaduct structure cost ($134,740,541/mi)															$10,105,541			$10,105,541
	Subtotal:						**26,651**							**$2,025,593**	**$993,248**	**$18,651,602**	**$0**	**$0**	**$21,670,443**
	Unit Cost:						25.82							$2.94	$1.44	$27.10	$0.00	$0.00	$31.49
20	**Total Tubular Enclosure along 1.5 mi Viaduct**	**7,920**	**LF**				**115,674**							**$8,791,563**	**$3,099,518**	**$32,276,150**	**$0**	**$5,195,520**	**$49,362,751**
	Unit Cost:													$1,110.05	$391.35	$4,075.27	$0.00	$656.00	$6,232.67
30	**Tubular Enclosure along 1.5 mi Embankment:**	**7,920**	**LF**			Days													
30.10	**4,000 Psi Concrete Anchor Wall:**																		
	16" CIDH Pile, 10 FT Long at 13' Spacing, (QTY = 15,840 LF @ 13' O.C. = 1218 EA @ 10 FT/EA = 12,184 LF), Quote Caltrans	12,184	LF										$68.31					$832,289	
	(QTY = 3' W x 3.5' H x 7,920 LF = 3,080 CY x 2 EA = 6,160 CY)	**6,160**	**CY**										$984.00					$6,061,434	**$6,893,723**
30.20	**Furnish & Install Steel:**	**8,902,241**	**LB**	1,000	8,902	1,113													
	(QTY = 5,719,044 LB = 2,859.52 TN @ 20 MH/TN = 57,190.4 MHs @ 10 men Crew = 5,719 CH = 1,000 LB/CH)																		
	Steel Rib - W14x38 Beam, (Quote by Durisol)	3,902,357	LB								$1.51					$5,898,998			$5,898,998
	Steel Straps - 1"x7"	2,552,774	LB								$1.51					$3,858,901			$3,858,901
	Struts 4" x 4" x 1/4" HSS	323,675	LB								$1.51					$489,283			$489,283
	Interior Cross Struts 4" x 4" x 1/4" Angle	521,580	LB								$1.51					$788,446			$788,446
	Longitudinal Braces 6" x 2" x 1/4" HSS	1,142,381	LB								$1.51					$1,726,880			$1,726,880
	Fasteners 4" x 1/4"	96,941	LB								$3.24					$314,015			$314,015
	Structural Plates 12" x 12" x 1/2"	224,726	LB								$1.51					$339,708			$339,708
	Cable Tray 4" x 3" x 1/4"	137,808	LB								$1.51					$208,317			$208,317
	Man Scissor Lift (Caltrans Pg.15, HYLFT/SCIS/31-50)	2	EA					17,804		$26.58					$473,243				$473,243
	Welding Machine (Caltrans Pg.34, WELD/AWM/250-500)	1	EA					8,902		$9.49					$84,482				$84,482
	Crane 90 Ton Grove RT-990 (Caltrans pg.12 HCESP/GROV/RT-990) - Unload Steel	1	EA					8,902		$173.95					$1,548,545				$1,548,545
	Crane Operator 2-A	1	EA				8,902		$85.12					$757,759					$757,759
	Iron Worker Foremen	1	EA				8,902		$78.83					$701,764					$701,764
	Iron Worker	8	EA				71,218		$74.51					$5,306,448					$5,306,448
	Subtotal:						**89,022**							**$6,765,970**	**$2,106,270**	**$13,624,548**	**$0**	**$0**	**$22,496,789**
	Unit Cost:						100.00							$0.76	$0.24	$1.53	$0.00	$0.00	$2.53
	Furnish & Install Aluminum Panels:					Days													
30.30		**688,248**	**SF**	258	2,665	333													
	(QTY = 688,248 SF @ 10.76SF/Panel = 63,973 Panels @ 24 Panels/HR = 2,665.54 HRs = 258.24 SF/HR)																		
	2" Aluminum Panel 1.64'W x 6.56'L, (Quote by Durisol)	688,248	SF								$12.42					$8,546,061			$8,546,061
	Aerial Boom Manlift 60' (Caltrans pg. 15 HYLFT/BOOM/50-74)	4	EA					10,661		$47.31					$504,353				$504,353
	Welding Machine (Caltrans Pg.34, WELD/AWM/250-500)	1	EA					2,665		$9.49					$25,292				$25,292
	Crane 90 Ton Grove RT-990 (Caltrans pg.12 HCESP/GROV/RT-990) - Unload Steel	1	EA					2,665		$173.95					$463,603				$463,603
	Crane Operator 2-A	1	EA				2,665		$85.12					$226,857					$226,857
	Iron Worker Foremen	1	EA				2,665		$78.83					$210,094					$210,094
	Iron Worker	8	EA				21,321		$74.51					$1,588,642					$1,588,642
	Subtotal:						**26,651**							**$2,025,593**	**$993,248**	**$8,546,061**	**$0**	**$0**	**$11,564,902**
	Unit Cost:						25.82							$2.94	$1.44	$12.42	$0.00	$0.00	$16.80
30	**Total Tubular Enclosure along 1.5 mi Embankment**	**7,920**	**LF**				**115,674**							**$8,791,563**	**$3,099,518**	**$22,170,609**	**$0**	**$6,893,723**	**$40,955,414**
	Unit Cost:													$1,110.05	$391.35	$2,799.32	$0.00	$870.42	$5,171.14
20+30	**Total of 1.5 mi Tubular Enclosure on Embankment and 1.5 mi Tubular Enclosure on Viaduct**	**15,840**	**LF**				**231,348**							**$17,583,127**	**$6,199,036**	**$54,446,759**	**$0**	**$12,089,243**	**$90,318,165**
40	**Wall Panel Enclosure along 1.5mi Viaduct:**	**7,920**	**LF**																
40.10	**4,000 Psi Concrete Anchor Wall:**	**5,280**	**CY**										$984.00					$5,195,520	**$5,195,520**
	(QTY = 3' W x 3' H x 7,920 LF = 2,640 CY x 2 EA = 5,280 CY)																		

Noise Mitigation Options Estimate: **Engineer's Estimate**

1.5 mi Viaduct & 1.5 mi Embankment: **9/16/2019** R.3

Item	Description	Quant.	Unit	Prod.	Crew	Days	Man	Equip.	Labor	Equip.	Perm.Matl.	Const.Matl.	Subc.	Total	Total	Total	Total	Total	Direct
				Unit/Hr	Hours	8HR/Day	Hrs	Hrs	Rate	Rent/Hr	Rate	Rate	Rate	Labor	Eq.Rent	Perm.Matl.	Const.Matl.	Subc.	Cost
						Days													
40.20	**Furnish & Install Steel:**	**4,005,774**	**LB**	1,000	4,006	501													
	(QTY = 4,639,993 LB = 2320 TN @ 20 MH/TN = 46,400 MHs @ 10 men Crew = 4640 CH = 1,000 LB/CH)																		
	Steel Rib - W12x30 Beam	863,082	LB								$1.51					$1,304,678			$1,304,678
	Steel Rib upper and top - W10x22 Beam	1,094,663	LB								$1.51					$1,654,747			$1,654,747
	Struts 4" x 4" x 1/4" HSS	323,675	LB								$1.51					$489,283			$489,283
	Long - Interior Cross Struts 4" x 4" x 1/4" Angle	291,416	LB								$1.51					$440,520			$440,520
	Lat - Interior Cross Struts 4" x 4" x 1/4" Angle	207,397	LB								$1.51					$313,512			$313,512
	Longitudinal Braces W6x12	950,400	LB								$1.51					$1,436,672			$1,436,672
	Fasteners 4" x 4" x 1/4"	96,941	LB								$3.24					$314,015			$314,015
	Structural Plates 12" x 12" x 1/2"	40,392	LB								$1.51					$61,059			$61,059
	Cable Tray 4" x 3" x 1/4"	137,808	LB								$1.51					$208,317			$208,317
	Man Scissor Lift (Caltrans Pg.15, HYLFT/SCIS/31-50)	2	EA					8,012		$26.58					$212,947				$212,947
	Welding Machine (Caltrans Pg.34, WELD/AWM/250-500)	1	EA					4,006		$9.49					$38,015				$38,015
	Crane 90 Ton Grove RT-990 (Caltrans pg.12 HCESP/GROV/RT-990) - Unload Steel	1	EA					4,006		$173.95					$696,804				$696,804
	Crane Operator 2-A	1	EA				4,006		$85.12					$340,971					$340,971
	Iron Worker Foremen	1	EA				4,006		$78.83					$315,775					$315,775
	Iron Worker	8	EA				32,046		$74.51					$2,387,762					$2,387,762
	Subtotal:						**40,058**							**$3,044,508**	**$947,766**	**$6,222,803**	**$0**	**$0**	**$10,215,077**
	Unit Cost:						100.00							$0.76	$0.24	$1.55	$0.00	$0.00	$2.55
						Days													
40.30	**Furnish & Install Fiberglass Panels:**	**628,214**	**SF**	258	2,433	304													
	(QTY = 628,214 SF @ 10.76SF/Panel = 63,973 Panels @ 24 Panels/HR = 2,665.54 HRs = 258.24 SF/HR)																		
	x" Fiberglass Panel , (perSF Quote by SoundFighter)	628,214	SF								$17.28					$10,853,032			$10,853,032
	Aerial Boom Manlift 60' (Caltrans pg. 15 HYLFT/BOOM/50-74)	4	EA					9,731		$47.31					$460,360				$460,360
	Welding Machine (Caltrans Pg.34, WELD/AWM/250-500)	1	EA					2,433		$9.49					$23,086				$23,086
	Crane 90 Ton Grove RT-990 (Caltrans pg.12 HCESP/GROV/RT-990) - Unload Steel	1	EA					2,433		$173.95					$423,164				$423,164
	Crane Operator 2-A	1	EA				2,433		$85.12					$207,069					$207,069
	Iron Worker Foremen	1	EA				2,433		$78.83					$191,768					$191,768
	Iron Worker	8	EA				19,461		$74.51					$1,450,070					$1,450,070
40.4	**Structural Modifications** Viaduct Structural Upgrade for supporting enclosure - Assume 2.5% of viaduct structure cost ($134,740,541/mi)															$5,052,770			$5,052,770
	Subtotal:						**24,327**							**$1,848,907**	**$906,610**	**$15,905,802**	**$0**	**$0**	**$18,661,319**
	Unit Cost:						25.82							$2.94	$1.44	$25.32	$0.00	$0.00	$29.71
40	**Total Wall Panel Enclosure along 1.5 mi Viaduct**	**7,920**	**LF**				**64,385**							**$4,893,416**	**$1,854,376**	**$22,128,605**	**$0**	**$5,195,520**	**$34,071,917**
	Unit Cost:													$617.86	$234.14	$2,794.02	$0.00	$656.00	$4,302.01
50	**Wall Panel Enclosure along 1.5 mi Embankment:**	**7,920**	**LF**			Days													
50.10	**4,000 Psi Concrete Anchor Wall:**																		
	16" CIDH Pile, 10 FT Long at 13' Spacing, (QTY = 15,840 LF @ 13' O.C. = 1218 EA @ 10 FT/EA = 12,184 LF), Quote Caltrans	12,184	LF										$68.31					$832,289	
	(QTY = 3' W x 3.5' H x 7,920 LF = 3,080 CY x 2 EA = 6,160 CY)	**6,160**	**CY**										$984.00					$6,061,434	**$6,893,723**
50.20	**Furnish & Install Steel:**	**3,682,099**	**LB**	1,000	3,682	460													
	(QTY = 4,639,993 LB = 2320 TN @ 20 MH/TN = 46,400 MHs @ 10 men Crew = 4640 CH = 1,000 LB/CH)																		
	Steel Rib - W12x30 Beam	863,082	LB								$1.51					$1,304,678			$1,304,678
	Steel Rib upper and top - W10x22 Beam	1,094,663	LB								$1.51					$1,654,747			$1,654,747
	Long - Interior Cross Struts 4" x 4" x 1/4" Angle	291,416	LB								$1.51					$440,520			$440,520
	Lat - Interior Cross Struts 4" x 4" x 1/4" Angle	207,397	LB								$1.51					$313,512			$313,512
	Longitudinal Braces W6x12	950,400	LB								$1.51					$1,436,672			$1,436,672
	Fasteners 4" x 4" x 1/4"	96,941	LB								$3.24					$314,015			$314,015
	Structural Plates 12" x 12" x 1/2"	40,392	LB								$1.51					$61,059			$61,059
	Cable Tray 4" x 3" x 1/4"	137,808	LB								$1.51					$208,317			$208,317
	Man Scissor Lift (Caltrans Pg.15, HYLFT/SCIS/31-50)	2	EA					7,364		$26.58					$195,740				$195,740
	Welding Machine (Caltrans Pg.34, WELD/AWM/250-500)	1	EA					3,682		$9.49					$34,943				$34,943
	Crane 90 Ton Grove RT-990 (Caltrans pg.12 HCESP/GROV/RT-990) - Unload Steel	1	EA					3,682		$173.95					$640,501				$640,501
	Crane Operator 2-A	1	EA				3,682		$85.12					$313,420					$313,420
	Iron Worker Foremen	1	EA				3,682		$78.83					$290,260					$290,260
	Iron Worker	8	EA				29,457		$74.51					$2,194,826					$2,194,826
	Subtotal:						**36,821**							**$2,798,506**	**$871,185**	**$5,733,520**	**$0**	**$0**	**$9,403,211**
	Unit Cost:						100.00							$0.76	$0.24	$1.56	$0.00	$0.00	$2.55
	Furnish & Install Fiberglass Panels:					Days													
50.30		**628,214**	**SF**	258	2,433	304													
	(QTY = 628,214 SF @ 10.76SF/Panel = 63,973 Panels @ 24 Panels/HR = 2,665.54 HRs = 258.24 SF/HR)																		
	x" Fiberglass Panel , (perSF Quote by SoundFighter)	628,214	SF								$17.28					$10,853,032			$10,853,032
	Aerial Boom Manlift 60' (Caltrans pg. 15 HYLFT/BOOM/50-74)	4	EA					9,731		$47.31					$460,360				$460,360
	Welding Machine (Caltrans Pg.34, WELD/AWM/250-500)	1	EA					2,433		$9.49					$23,086				$23,086
	Crane 90 Ton Grove RT-990 (Caltrans pg.12 HCESP/GROV/RT-990) - Unload Steel	1	EA					2,433		$173.95					$423,164				$423,164

Noise Mitigation Options Estimate:

1.5 mi Viaduct & 1.5 mi Embankment:

Engineer's Estimate

9/16/2019 R.3

Item	Description	Quant.	Unit	Prod.	Crew	Days	Man	Equip.	Labor	Equip.	Perm.Matl.	Const.Matl.	Subc.	Total	Total	Total	Total	Total	Direct
				Unit/Hr	Hours	8HR/Day	Hrs	Hrs	Rate	Rent/Hr	Rate	Rate	Rate	Labor	Eq.Rent	Perm.Matl.	Const.Matl.	Subc.	Cost
	Crane Operator 2-A	1	EA				2,433		$85.12					$207,069					$207,069
	Iron Worker Foremen	1	EA				2,433		$78.83					$191,768					$191,768
	Iron Worker	8	EA				19,461		$74.51					$1,450,070					$1,450,070
	Subtotal:						**24,327**							**$1,848,907**	**$906,610**	**$10,853,032**	**$0**	**$0**	**$13,608,549**
	Unit Cost:						25.82							$2.94	$1.44	$17.28	$0.00	$0.00	$21.66
50	**Total Wall Panel Enclosure along 1.5 mi Embankment**	**7,920**	**LF**				**61,148**							**$4,647,413**	**$1,777,795**	**$16,586,552**	**$0**	**$6,893,723**	**$29,905,483**
	Unit Cost:													$586.79	$224.47	$2,094.26	$0.00	$870.42	$3,775.94
40+50	**Total of 1.5 mi Wall Panel Enclosure on Embankment and 1.5 mi Wall Panel Enclosure on Viaduct**	**15,840**	**LF**				**125,532**							**$9,540,829**	**$3,632,171**	**$38,715,158**	**$0**	**$12,089,243**	**$63,977,400**

California High Speed Rail: **Engineer's Estimate**
Conceptual Enclosure Structural Steel Estimate: **9/16/2019** R.2

Guideway Tubular Enclosure							
Item	Item Description	Quantity	Length/EA	Total Length	Weight/LF	Weight/EA	Total Weight
	Tubular Enclosure along 1.5mi viaduct	EA	FT	FT	LB	LB	LB
1	Steel Rib - W14x38 beam	1,224	83.90	102,693.60	38	3,188.20	3,902,356.80
2	Steel Straps - 1"x7"	1,224	86.9	106,365.60	24	2,085.60	2,552,774.40
3	Struts 4" x 4" x 1/4" HSS	2,448	11	26,928.00	12.02	132.22	323,674.56
4	Interior Cross Struts 4" x 4" x 1/4" Angle	8,064	9.8	79,027.20	6.6	64.68	521,579.52
5	Longitudinal Braces 6" x 2" x 1/4" HSS	13,824	6.875	95,040.00	12.02	82.64	1,142,380.80
6	Fasteners 4" x 4" x 1/4"	29,376	0.5	14,688.00	6.6	3.30	96,940.80
7	Structural Plates 12" x 12" x 1/2"	11,016				20.4	224,726.40
8	Cable Tray 4" x 3" x 1/4"	3	7,920	23,760	5.8	45,936.00	137,808.00
							8,902,241.28
9	Noise Mitigation Panels, 2" Thick	688,248	SF				
	(Acrylic, Wood Pulp Comp., or Concrete)						

Item	Item Description	Quantity	Length/EA	Total Length	Weight/LF	Weight/EA	Total Weight
	Enclosure along 1.5mi embankment	EA	FT	FT	LB	LB	LB
1	Steel Rib - W14x38 beam	1,224	83.90	102,693.60	38	3,188.20	3,902,356.80
2	Steel Straps - 1"x7"	1,224	86.9	106,365.60	24	2,085.60	2,552,774.40
3	Concreter Parapet	2	7,920	15,840.00			
4	Interior Cross Struts 4" x 4" x 1/4" Angle	8,064	9.8	79,027.20	6.6	64.68	521,579.52
5	Longitudinal Braces 6" x 2" x 1/4" HSS	13,824	6.875	95,040.00	12.02	82.64	1,142,380.80
6	Fasteners 4" x 4" x 1/4"	29,376	0.5	14,688.00	6.6	3.30	96,940.80
7	Structural Plates 12" x 12" x 1/2"	11,016				20.4	224,726.40
8	Cable Tray 4" x 3" x 1/4"	3	7,920	23,760	5.8	45,936.00	137,808.00
							8,578,566.72
9	Noise Mitigation Panels, 2" Thick	688,248	SF				
	(Acrylic, Wood Pulp Comp., or Concrete)						

Guideway Wall Panel Enclosure							
Item	Item Description	Quantity	Length/EA	Total Length	Weight/LF	Weight/EA	Total Weight
	Wall Panel Enclosure along 1.5mi viaduct	EA	FT	FT	LB	LB	LB
1	Steel Rib - W12x30 beam	990	29.06	28,769.40	30	871.80	863,082.00
2	Steel Rib upper - W10x22 beam	990	50.26	49,757.40	22	1,105.72	1,094,662.80
3	Struts 4" x 4" x 1/4" HSS	2,448	11	26,928.00	12.02	132.22	323,674.56
4	Long - Interior Cross Struts 4" x 4" x 1/4" Angle	990	44.6	44,154.00	6.6	294.36	291,416.40
5	Belt - Interior Cross Struts 4" x 4" x 1/4" Angle	124	253.9	31,423.84	6.6	1,675.94	207,397.33
6	Longitudinal Braces W6x12	9,900	8.000	79,200.00	12	96.00	950,400.00
7	Fasteners 4" x 4" x 1/4"	29,376	0.5	14,688.00	6.6	3.30	96,940.80
8	Structural Plates 12" x 12" x 1/2"	1,980				20.4	40,392.00
9	Cable Tray 4" x 3" x 1/4"	3	7,920	23,760	5.8	45,936.00	137,808.00
							4,005,773.89
10	Noise Mitigation Panels, 2" Thick	628,214	SF				
	Fiberglass, apprx. 5psf						

Item	Item Description	Quantity	Length/EA	Total Length	Weight/LF	Weight/EA	Total Weight
	Enclosure along 1.5mi embankment	EA	FT	FT	LB	LB	LB
1	Steel Rib - W14x38 beam	1,224	83.90	102,693.60	38	3,188.20	3,902,356.80
2	Steel Straps - 1"x7"	1,224	86.9	106,365.60	24	2,085.60	2,552,774.40
3	Concreter Parapet	2	7,920	15,840.00			
4	Interior Cross Struts 4" x 4" x 1/4" Angle	8,064	9.8	79,027.20	6.6	64.68	521,579.52
5	Longitudinal Braces 6" x 2" x 1/4" HSS	13,824	6.875	95,040.00	12.02	82.64	1,142,380.80
6	Fasteners 4" x 4" x 1/4"	29,376	0.5	14,688.00	6.6	3.30	96,940.80
7	Structural Plates 12" x 12" x 1/2"	11,016				20.4	224,726.40
8	Cable Tray 4" x 3" x 1/4"	3	7,920	23,760	5.8	45,936.00	137,808.00
							8,578,566.72
9	Noise Mitigation Panels, 2" Thick	688,248	SF				
	(Acrylic, Wood Pulp Comp., or Concrete)						

Concrete Estimate:

Engineer's Estimate
9/16/2019 R.1

Activity	Description	Quant.	Unit	Prod. Unit/Hr	Crew Hours	Durations 8HR/Day	Man Hrs	Equip. Hrs	Labor Rate	Equip. Rent/Hr	Perm.Matl. Rate	Const.Matl. Rate	Subc. Rate	Total Labor	Total Eq.Rent	Total Perm.Matl.	Total Const.Matl.	Total Subc.	Total Cost
	4,000 Psi Pile Cap (Standard Sound Wall 1.5 mi Embankment):	**15,840**	**LF**			Days													
10	**Fabricate Wall Forms:**	**4,200**	**SF**	49.00	86	10.7													
	Pre-Fab Supplies Flat	4,200	SF									$0.49					$2,046		$2,046
	5/8" Plywood	5,460	SF									$1.62					$8,866		$8,866
	Form Lumber	14,700	BF									$0.54					$7,956		$7,956
	185 CFM Diesel Comp. (Pg.1, AIRCP/PORT/016-025)	1	EA					86		$16.81					$1,441				$1,441
	Generator 10 KW (pg.6, ELGEN/GEN/008-015)	1	EA					86		$7.50					$643				$643
	Carpenter Foreman	1	EA				86		$86.27					$7,395					$7,395
	Carpenter Prefab	3	EA				257		$83.93					$21,582					$21,582
	Total Fabricate Forms						**343**							**$28,977**	**$2,084**	**$0**	**$18,868**	**$0**	**$49,928**
	Unit Cost:						12.25							$6.90	$0.50		$4.49	$0.00	$11.89
						Days													
20	**Erect & Strip Wall Forms:**	**93,139**	**SF**	70.40	1,323	165													
	Surface Form Oil	93,139	SF									$0.04					$4,033		$4,033
	Set/Strip Wood Form Supplies	121,081	SF									$1.35					$163,838		$163,838
	Pickup Truck (Caltrans pg.34 TRUCK/T&TT/06-12)	2	EA					2,646		$24.98					$66,097				$66,097
	185 CFM Diesel Comp. (Pg.1, AIRCP/PORT/016-025)	2	EA					2,646		$16.81					$44,479				$44,479
	Generator 10 KW (pg.6, ELGEN/GEN/008-015)	2	EA					2,646		$7.50					$19,845				$19,845
	Carpenter Foreman	2	EA				2,646		$86.27					$228,270					$228,270
	Carpenter Prefab	6	EA				7938		$83.93					$666,236					$666,236
	Total Erect & Strip Wall Forms						**10,584**							**$894,507**	**$130,421**	**$0**	**$167,871**	**$0**	**$1,192,799**
	Unit Cost:						8.80							$9.60	$1.40		$1.80	$0.00	$12.81
30	**Rebar - Furnish/Install (Black):**	**647,010**	**LBS**										$0.97					$627,599.70	**$627,600**
						Days													
40	**Place Concrete:**	**2,588.04**	**CY**	14.70	176	22													
	4000 psi Concrete	2,588.04	CY								$118.00					$305,389			$305,389
	Conc. Vib/Place Supply	2,588.04	CY									$1.52					$3,922		$3,922
	Pickup Truck (Caltrans pg.34 TRUCK/T&TT/06-12)	1	EA					176		$24.98					$4,398				$4,398
	Conc. Pump 36 M (Pg.5, CONPM/SHWG/1058)	1	EA					176		$107.63					$18,949				$18,949
	185 CFM Diesel Comp. (Pg.1, AIRCP/PORT/016-025)	1	EA					176		$16.81					$2,960				$2,960
	Generator 10 KW (pg.6, ELGEN/GEN/008-015)	1	EA					176		$7.50					$1,320				$1,320
	Conc. Pump Operator GR 5	1	EA				176		$79.53					$14,002					$14,002
	Laborer Foreman	1	EA				176		$60.59					$10,667					$10,667
	Concrete Vibratorman - GR 2	1	EA				176		$57.26					$10,081					$10,081
	Concrete Laborer - GR 2	3	EA				528		$57.26					$30,243					$30,243
	Total Place Concrete						**1,056**							**$64,993**	**$27,627**	**$305,389**	**$3,922**	**$0**	**$401,931**
	Unit Cost:						2.45							$25.11	$10.67	$118.00	$1.52	$0.00	$155.30
						Days													
50	**Wet Finish:**	**19,958**	**SF**	107.34	185.9	23													
	Wood float Supplies	19,958	SF									$0.09					$1,728		$1,728
	Screed Supplies	19,958	SF									$0.09					$1,728		$1,728
	Cement Mason Foreman	1	EA				185.9		$68.01					$12,646					$12,646
	Cement Mason/Conc. Finisher	1	EA				185.9		$65.67					$12,210					$12,210
	Subtotal:						**372**							**$24,856**	**$0**	**$0**	**$3,457**	**$0**	**$28,313**
	Unit Cost:						53.7							$1.25	$0.00		$0.17	$0.00	$1.42
						Days													
60	**Dry Finish:**	**93,139**	**SF**	138.36	673	84.1													
	Conc. Finish Supplies	93,139	SF									$0.03					$3,025		$3,025
	Point/Patch Supplies	93,139	SF									$0.10					$9,074		$9,074
	Cement Mason Foreman	1	EA				673		$68.01					$45,782					$45,782

	Cement Mason/Conc. Finisher	3	EA				2019		$65.67					$132,620					$132,620
	Subtotal:						**2693**							**$178,402**	**$0**	**$0**	**$12,099**	**$0**	**$190,501**
	Unit Cost:						34.6							$1.92	$0.00		$0.13	$0.00	$2.05
						Days													
70	**Water Cure:**	**113,098**	**SF**	224.50	504	63.0													
	Water Cure	113,098	SF									$0.04					$4,920		$4,920
	Concrete Finish Laborer - GR 2	2	EA				1008		$57.26					$57,692					$57,692
	Subtotal:						**1008**							**$57,692**	**$0**	**$0**	**$4,920**	**$0**	**$62,612**
	Unit Cost:						112.25							$0.51	$0.00	$0.00	$0.04	$0.00	$0.55
	Total 4,000 Psi Pile Cap (Standard Sound Wall 1.5 mi Embankment):						**16,055**							**$1,249,427**	**$160,132**	**$305,389**	**$211,136**	**$627,600**	**$2,553,684**
	Unit Cost:	**15,840**	**LF**																$161.22
	Unit Cost:	**2,588.04**	**CY**																**$986.72**