APPENDIX 2-D: APPLICABLE DESIGN STANDARDS

California High Speed Rail Authority
San Jose to Merced Section: San Jose to Central Valley Wye

DESIGN CHECKLISTS
Draft PEPD
May 19, 2017

The discipline leads identified below attest that design for the Draft PEPD submittal for the San Jose to Central Valley Wye portion of the CAHSR San Jose to Merced Section has been performed in general compliance with the standards and guidance established in the attached Design Criteria Checklists, to the extent applicable to a 15% level of design.

Locations where compliance with standards has not been deemed feasible are documented in the Design Variance Log.

TRACK	Myat Ohn, PE	5/15/17 Date
ROADWAY	Lillie Lam, PE	5/15/17 Date
STATION	~~Tony Lee~~ Rosanna McGuire	5/16/17 Date
STRUCTURE	Erik Okada, PE, SE	5/15/17 Date
TUNNEL	Jimmy Thompson FOR	5/15/17 Date
HYDROLOGY	John Mountin, PE	5/15/17 Date
UTILITIES	Peter Anastos, PE	15 May 2017 Date
GENERAL	Myat Ohn, PE	5/15/17 Date
SYSTEMS	~~Sandro Pani~~	5/15/17 Date

HNTB

CAHSR JM
HORIZONTAL DESIGN CHECKLIST

<table>
<tr><th>DESIGN ELEMENT</th><th>CAHSR JM DEDICATED HST CRITERIA</th><th>HST REFERENCE</th><th>CALTRAIN (CHP 2)</th><th>UPRR (INDUSTRIAL TRACK CONSTRUCTION SPECS)</th></tr>
<tr><td>MAIN LINE TRACK CENTER</td><td>MINIMUM 16.5'</td><td>HST TM1.1.21_3.2.2 (Table 3.3)</td><td>Main track: 15 feet minimum
Yard track: 20 feet minimum</td><td>Industry track center minimums are as follows:
a) 15 feet preferred on tangent track.
b) 15 feet if spur is adjacent to a lead track or on a curve track.
c) 20 feet if spur is adjacent to a switching lead.
d) 25 feet if spur is adjacent to a main or branch line track.</td></tr>
<tr><td rowspan="3">SPEED</td><td>V (MPH) — Above 125 mph with an initial maximum operating speed of 220 mph. The design shall not unnecessarily preclude operation at higher speeds up to at least 250 mph.</td><td>HST TM 2.1.2_1.0</td><td rowspan="3">TABLE 2-4 DESIGN SPEEDS THROUGH CURVES
<table><tr><th rowspan="2">Track Type & Condition</th><th colspan="2">Curve Design Speed (MPH)</th></tr><tr><th>Preferred</th><th>Minimum</th></tr><tr><td>Main Track</td><td>90</td><td>Exceed MAS</td></tr><tr><td>Control Siding with #20 T.O.</td><td>50</td><td>NA</td></tr><tr><td>Control Siding with #14 T.O.</td><td>35</td><td>NA</td></tr><tr><td>Temporary Main Track</td><td>Existing MAS</td><td>(MAS – 15 MPH)</td></tr><tr><td>Yard Lead</td><td>25</td><td>15</td></tr><tr><td>Yard Track</td><td>15</td><td>10</td></tr></table></td><td rowspan="3">N/A</td></tr>
<tr><td>V (MPH) — For tunnel, maximum operating speed is 200 mph</td><td>HST NTD 10R1</td></tr>
<tr><td>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.</td><td>HST TM 2.1.2_4.0</td></tr>
<tr><td>CHANGES IN DIRECTION</td><td>Over four changes in direction per mile shall constitute an Exceptional condition.</td><td>HST TM 2.1.2_6.1</td><td>N/A</td><td>N/A</td></tr>
<tr><td>MINIMUM SEGMENT LENGTH</td><td>Attenuation time, based on the most conservative requirements, shall be:
For V < 186 MPH,
o Desirable attenuation time: not less than 2.4 seconds
o Minimum attenuation time: not less than 1.8 seconds
o Exceptional attenuation time: not less than 1.5 seconds.
o An attenuation time of 1.0 seconds on the diverging route in curves adjacent to or between turnouts
For V >= 186 mph
o Desirable attenuation time: not less than 3.1 seconds
o Minimum attenuation time: not less than 2.4 seconds
o Exceptional attenuation time: not less than 1.8 seconds.
Where alignment segments overlap, each change shall be treated as a separate alignment element for the purpose of calculating minimum segment lengths. Minimum segment length is calculated by the formula: Lfeet = Vmph x 44/30 x tsec</td><td>HST TM 2.1.2_6.1.1</td><td>TABLE 2-2 MINIMUM TANGENT LENGTH (MAIN TRACKS)
<table><tr><th rowspan="2">Tangent Location On Mainline Tracks</th><th colspan="2">Minimum Tangent Length (feet)</th></tr><tr><th>Preferred</th><th>Absolute Minimum</th></tr><tr><td>Between reverse curves</td><td>3V</td><td>100</td></tr><tr><td>Between Point of Switches of turnouts (TO's)</td><td>50</td><td>20*</td></tr><tr><td>Between PS and curve</td><td>100</td><td>15*</td></tr><tr><td>Between PS and platform</td><td>100</td><td>60</td></tr><tr><td>Between PS and grade crossing</td><td>100</td><td>50</td></tr><tr><td>Between PS and last long tie of T.O.</td><td>60</td><td>15*</td></tr><tr><td>Between curve and platform</td><td>60</td><td>30</td></tr><tr><td>Between curve and grade crossing</td><td>50</td><td>10</td></tr></table>* Tangent length shall not be less than the length of stock rail projection
V = design speed in the area, MPH
The minimum tangent length for yard and non-revenue tracks shall be established as per Table 2-3:
TABLE 2-3 MINIMUM TANGENT LENGTH (YARD AND NON-REVENUE TRACKS)
<table><tr><th rowspan="2">Tangent Location On Yard and Non-Revenue Tracks</th><th colspan="2">Minimum Tangent Length (feet)</th></tr><tr><th>Preferred</th><th>Absolute Minimum</th></tr><tr><td>Between reverse curves</td><td>60</td><td>N/A</td></tr><tr><td>Between PS of T.O.'s</td><td>40</td><td>15*</td></tr></table>* Tangent length shall not be less than the length of stock rail projection</td><td>The minimum tangent distance between curves greater than 07° 30' shall be at least one car length (60 feet to 100 feet). Use UP Standard Drawing No. 0018 for guidance for minimum distance between facing point turnouts. Use UP Standard Drawing No. 0017 for guidance for minimum distance between reverse curves.</td></tr>
<tr><td>MINIMUM RADII (BASED ON CHORD DEFINITION)</td><td><table><tr><th rowspan="2">Design Speed</th><th colspan="6">Minimum radius, Based on Superelevation Limits</th></tr><tr><th colspan="2">Desirable</th><th colspan="2">Minimum</th><th colspan="2">Exceptional</th></tr><tr><th>miles per hour</th><th>km/h</th><th>feet</th><th>meters (rounded)</th><th>feet</th><th>meters (rounded)</th><th>feet</th><th>meters (rounded)</th></tr><tr><td>250</td><td>400</td><td>45,000</td><td>13,700</td><td>28,000</td><td>8,500</td><td>25,000</td><td>7,600</td></tr><tr><td>220</td><td>355</td><td>35,000</td><td>10,700</td><td>22,000</td><td>6,700</td><td>19,500</td><td>6,000</td></tr><tr><td>200</td><td>320</td><td>30,000</td><td>9,200</td><td>18,000</td><td>5,500</td><td>16,000</td><td>4,900</td></tr><tr><td>186</td><td>300</td><td>25,000</td><td>7,600</td><td>16,600</td><td>4,700</td><td>14,000</td><td>4,250</td></tr><tr><td><186</td><td><300</td><td>25,000</td><td>7,600</td><td>16,600</td><td>4,700</td><td>12,600</td><td>3,850</td></tr><tr><td>175</td><td>280</td><td>22,000</td><td>6,700</td><td>14,000</td><td>4,200</td><td>11,200</td><td>3,400</td></tr><tr><td>150</td><td>240</td><td>16,000</td><td>4,900</td><td>10,000</td><td>3,100</td><td>8,200</td><td>2,500</td></tr><tr><td>125</td><td>200</td><td>10,500</td><td>3,200</td><td>7,000</td><td>2,100</td><td>5,700</td><td>1,750</td></tr></table></td><td>HST TM 2.1.2_6.1.2 (Table 6.1.3)</td><td rowspan="2">Based on 100' Chord Definition:
Radius, R = 50/sin(Dc/2)
Length of curve, Lc = 100 (D/Dc)
Tangent distance, T = R tan(D/2)
where D = central angle
The minimum length of circular curve shall be 100 feet for mainline tracks and 50
feet for yard and industry tracks.</td><td rowspan="2">Horizontal curves are defined using the 100-foot chord definition method. Horizontal curves shall be 10°0'0". Horizontal curves must not begin on the long ties of a turnout.</td></tr>
<tr><td>MINIMUM DEGREE OF CURVATURE</td><td><table><tr><th rowspan="2">Design Speed</th><th colspan="4">Minimum Curve in Degrees, degree, minutes, seconds</th></tr><tr><th>miles per hour</th><th>km/h</th><th>Desirable</th><th>Minimum</th><th>Exceptional</th></tr><tr><td>250</td><td>400</td><td>0d 07m 30s</td><td>0d 12m 15s</td><td>0d 13m 30s</td></tr><tr><td>220</td><td>355</td><td>0d 09m 45s</td><td>0d 15m 30s</td><td>0d 17m 30s</td></tr><tr><td>200</td><td>320</td><td>0d 11m 15s</td><td>0d 19m 00s</td><td>0d 21m 15s</td></tr><tr><td>186</td><td>300</td><td>0d 13m 45s</td><td>0d 21m 30s</td><td>0d 24m 30s</td></tr><tr><td><186</td><td><300</td><td>0d 13m 45s</td><td>0d 21m 30s</td><td>0d 27m 15s</td></tr><tr><td>175</td><td>280</td><td>0d 15m 30s</td><td>0d 24m 30s</td><td>0d 30m 30s</td></tr><tr><td>150</td><td>240</td><td>0d 21m 15s</td><td>0d 34m 15s</td><td>0d 41m 45s</td></tr><tr><td>125</td><td>200</td><td>0d 32m 30s</td><td>0d 49m 00s</td><td>1d 00m 00s</td></tr></table></td><td>HST TM 2.1.2_6.1.2 (Table 6.1.4)</td></tr>
<tr><td>TOTAL SUPERELEVATION</td><td>Balancing superelevation shall be calculated by one of the following formulae, depending upon how the curve is defined:
SE = 0.0007 V2 D (curvature in degrees, speed in mph and SE in inches)
Which when expressed with radius instead of degrees gives:
SE = 4.0 V2 / R (radius in feet, speed in mph and SE in inches)
<table><tr><th>Speed (mph)</th><th><186</th><th>>=186</th></tr><tr><td>Desirable (in)</td><td>6</td><td>6</td></tr><tr><td>Maximum (in)</td><td>9</td><td>9</td></tr><tr><td>Exceptional (in)</td><td>11</td><td>10</td></tr></table></td><td>HST TM 2.1.2_6.1.3 (Table 6.1.5)</td><td rowspan="3">Equilibrium superelevation shall be determined by the following equation:
e = 0.0007 DcV2
where:
e = total superelevation required for equilibrium, in inches.
V = maximum design speed through the curve, in miles per hour (MPH)
Dc = degree of curvature, in degree
The total superelevation e is expressed as follows:
e = Ea + Eu
where:
Ea = actual superelevation that is applied to the curve
Eu = unbalanced superelevation (amount of superelevation not applied to the curve) The actual superelevation shall be rounded to the nearest 1/4 inch by the formulas above. For any curve, a 1/2 inch minimum superelevation shall be specified.</td><td>No superelevation required</td></tr>
<tr><td>APPLIED SUPERELEVATION</td><td><table><tr><th>Speed (mph)</th><th><186</th><th>>=186</th></tr><tr><td>Desirable (in)</td><td>4</td><td>4</td></tr><tr><td>Maximum (in)</td><td>6</td><td>6</td></tr><tr><td>Exceptional (in)</td><td>7</td><td>7</td></tr></table></td><td>HST TM 2.1.2_6.1.3 (Table 6.1.6)</td><td>No superelevation required</td></tr>
<tr><td>UNBALANCED SUPERELEVATION</td><td><table><tr><th>Speed (mph)</th><th><186</th><th>>=186</th></tr><tr><td>Desirable (in)</td><td>2</td><td>2</td></tr><tr><td>Maximum (in)</td><td>3</td><td>3</td></tr><tr><td>Exceptional (in)</td><td>4</td><td>3</td></tr></table></td><td>HST TM 2.1.2_6.1.3 (Table 6.1.6)</td><td>No superelevation required</td></tr>
</table>

CAHSR JM
HORIZONTAL DESIGN CHECKLIST

<table>
<tr><th>DESIGN ELEMENT</th><th>CAHSR JM DEDICATED HST CRITERIA</th><th>HST REFERENCE</th><th>CALTRAIN (CHP 2)</th><th>UPRR (INDUSTRIAL TRACK CONSTRUCTION SPECS)</th></tr>
<tr><td>SPIRAL TYPE</td><td>HALF-SINE SPIRALS (variable rate transitions) shall be used on all tracks designed for:
1) Ballasted tracks: Curves having design maximum speeds of 80 mph or more
2) Non-ballasted tracks: Curves having design maximum speeds of 60 mph or more
3) Curves associated with turnouts having design maximum speeds of 110 mph or more
CLOTHOID SPIRALS (constant rate transitions) shall be used on all lower speed tracks. Clothoid spirals may also be used on very large radius curves that require small amounts or no superelevation and have very small unbalanced superelevations</td><td>HST TM 2.1.2_6.1.5</td><td>The clothoid spiral is commonly used in most CADD design software. Since Caltrain adopted AutoCAD and its associated Civil Design Software in the design of track alignment, the clothoid spiral shall be used. Spirals are not required for curves less than 30 minutes for MAS under 20 MPH or on curve that is part of a turnout, however, a minimum of curve length of 100 feet shall be implemented. Additionally, all curves including such curves shall have a minimum 1/2 inch actual superelevation.</td><td>N/A</td></tr>
<tr><td>SPIRAL LENGTH</td><td>Spiral Lengths: The length of the spiral shall be the longest length determined by calculating the
various length requirements, which are:
- Length needed to achieve Attenuation Time
- Length determined by allowed rate of change in superelevation
- Length determined by allowed rate of change in unbalanced superelevation
- Length determined by limitation on twisting over vehicle and truck spacing length

Half-Sine (Variable Change) Spirals *
<table><tr><th>Spiral Design Factor</th><th>Desirable</th><th>Minimum</th><th>Exceptional</th></tr><tr><td>Superelevation</td><td>1.63 Ea V</td><td>1.30 Ea V</td><td>1.09 Ea V</td></tr><tr><td>Unbalance</td><td>2.10 Eu V</td><td>1.57 Eu V</td><td>1.26 Eu V</td></tr><tr><td>Twist **</td><td>140 Ea</td><td>118 Ea</td><td>98 Ea</td></tr><tr><td>Minimum Segment</td><td>2.64 V</td><td>2.20 V</td><td>1.47 V</td></tr><tr><td colspan="4">Clothoid (Linear Change) Spirals</td></tr><tr><td>Spiral Design Factor</td><td>Desirable (0.03 g)</td><td>Minimum (0.04 g)</td><td>Exceptional (0.05 g)</td></tr><tr><td>Superelevation</td><td>1.47 Ea V</td><td>1.17 Ea V</td><td>0.98 Ea V</td></tr><tr><td>Unbalance</td><td>1.63 Eu V</td><td>1.22 Eu V</td><td>0.98 Eu V</td></tr><tr><td>Twist</td><td>90 Ea</td><td>75 Ea</td><td>62 Ea</td></tr><tr><td>Minimum Segment</td><td>2.64 V</td><td>2.20 V</td><td>1.47 V</td></tr></table>The length is given in feet with:
- Ea = Actual elevation in inches
- Eu = Unbalanced elevation in inches
- V = maximum speed of the train in mph
* Longer lengths of half-sine spirals are due to the variability in the ramp rate.
** Provides maximum twist rates identical to clothoids. As a practical matter, this limitation never governs due to use of this type spiral only on high-speed tracks.</td><td>TM 2.1.2_6.1.5.3
(Table 6.1.7)</td><td>The superelevation differential between rail car truck centers should not exceed one (1) inch. The minimum length of spiral between compound curves shall be 62 feet.

Spiral Length Requirements

Based on sections AREMA Chapter 5, Section 3.1, the length of spiral shall be longest as determined from formulas:

1. $L_s = 1.63E_aV$; or $L_s = 1.22E_uV$ * Desirable
2. $L_s = 1.2E_aV$ Minimum (upto 60 mph)
3. $L_s = 62E_a$ Absolute Minimum (or Exception) upto 50 mph

* Use of Spiral length $L_s = 1.22E_uV$ requires the approval of Caltrain Deputy Director of Engineering

where, E_a = actual superelevation that is applied to the curve
E_u = unbalanced superelevation (amount of superelevation not applied to the curve)
V = design speed, MPH

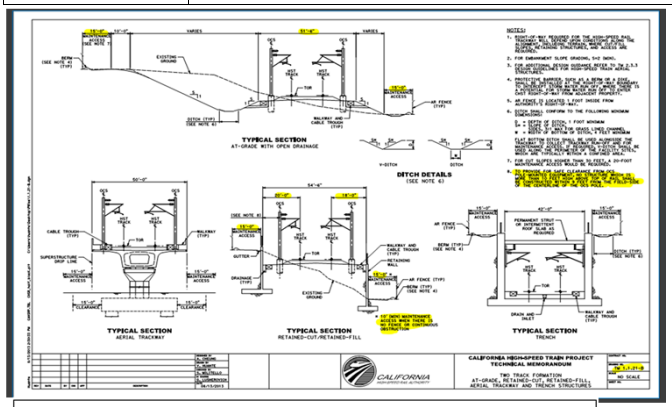
The spiral length shall generally be rounded to the nearest 5 feet.</td><td>N/A</td></tr>
<tr><td>SPIRALS ON LARGE RADIUS CURVES</td><td>Clothoid spirals may be used instead of half-sine spirals regardless of track type or design speed if the following conditions are met: The required superelevation and unbalanced superelevation are both under 1.0 inches at the maximum design speed; and the “Minimum Segment” length for the spiral is more than twice the length required by any other factor. Spirals may be omitted if the following conditions are met: The required superelevation is zero (balancing superelevation for the maximum speed less than 0.75 inches); and the calculated offset of the curve due to application of the spiral is less than 0.05 feet in ballasted track or less than 0.02 feet in non-ballasted track. (These values are subject to revision.)</td><td>HST TM 2.1.2_6.1.5.4</td><td>SEE SD-2101 Track Geometry - Curve Marking Details</td><td>N/A</td></tr>
<tr><td>REVERSE CURVES</td><td>If there is insufficient distance between curves to provide the minimum required length tangent segment, the spirals shall be extended to provide a reversing curve. If beneficial to design and construction, a straight distance between curves that would be run in less than 0.2 seconds at the normal operating speed may be left between spiral ends.</td><td>HST TM 2.1.2_6.1.5.4</td><td>SEE SD-2102 Track Geometry - Reversing curves Layout and Calculations</td><td>N/A</td></tr>
<tr><td>COMPOUND CIRCULAR CURVES</td><td>If there is insufficient distance between curves to provide the minimum required length tangent segment, the spirals shall be extended to provide a reversing curve. If beneficial to design and construction, a straight distance between curves that would be run in less than 0.2 seconds at the normal operating speed may be left between spiral ends.</td><td>HST TM 2.1.2_6.1.5.4</td><td>The minimum length of spiral between compound curves shall be 62 feet</td><td>N/A</td></tr>
<tr><td>CLEARANCE</td><td>See Typical Section design checlist</td><td></td><td>See CPUC requirements</td><td>See CPUC requirements</td></tr>
</table>

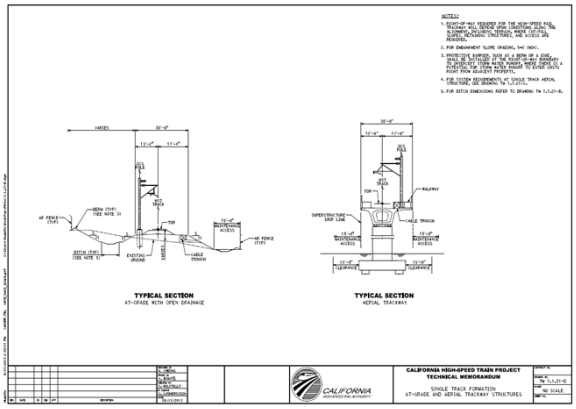
CAHSR JM
VERTICAL DESIGN CHECKLIST

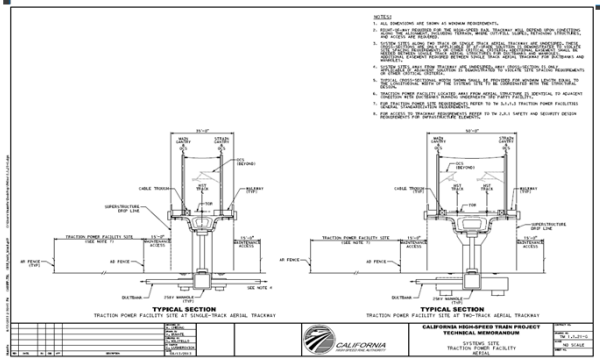
DESIGN ELEMENT	CAHSR JM DEDICATED HST CRITERIA	HST REFERENCE	CALTRAIN (CHP 2)	UPRR (INDUSTRIAL TRACK CONSTRUCTION SPECS)
MINIMUM SEGMENT LENGTH	Attenuation time, based on the most conservative requirements, shall be: For V < 186 MPH, o Desirable attenuation time: not less than 2.4 seconds o Minimum attenuation time: not less than 1.8 seconds o Exceptional attenuation time: not less than 1.5 seconds. o An attenuation time of 1.0 seconds on the diverging route in curves adjacent to or between turnouts For V >= 186 mph o Desirable attenuation time: not less than 3.1 seconds o Minimum attenuation time: not less than 2.4 seconds o Exceptional attenuation time: not less than 1.8 seconds. Where alignment segments overlap, each change shall be treated as a separate alignment element for the purpose of calculating minimum segment lengths. Minimum segment length is calculated by the formula: Lfeet = Vmph x 44/30 x tsec.	HST TM 2.1.2_6.1.1	For mainline track, the desired length of constant profile grade between vertical curves shall be determined by the following formula (but not less than 100 feet): L = 3V where, L = minimum tangent length, feet V = design speed in the area, mph	Minimum length of 100 feet and be designed for the longest curve practical, with a V/L not to exceed 1.2 for Sags and 2.00 for ummits, in which V = (Grade 1) minus (Grade 2) and L = Length of Curve in Stations. Rate of change V/L = Algebraic difference in grades divided by the length of the vertical curve in 100 foot stations
CHANGES IN DIRECTION	Over four changes in direction per mile shall constitute an Exceptional condition.	HST TM 2.1.2_6.1	N/A	The track should be designed to minimize the number of grade changes and use the smallest V/L as practical (See Union Pacific (UP) Standard Drawing No. 0016)
MAXIMUM GRADE LIMITS	Maximum Grade Limits: - Desirable grades: as low as reasonably practical, with a limit of 1.25% - Maximum grades: above 1.25% and shall be as low as practical up to 2.50% - Exceptional grades: above 2.50% and shall be as low as practical up to 3.50% Minimum Grades: Without a separate drainage system, grades in cuts or tunnels (included cut and-cover) shall not be less than 0.25%.	HST TM 2.1.2_6.1.6.1	The maximum continuous main line grade along the Caltrain commuter corridor is one (1)%. The preferred maximum design gradient for long continuous grade shall be one (1)%. Maximum design gradient, with curve compensation at 0.04 percent per degree of curve if applicable, for grades up to two (2)% may be implemented for new construction projects with the approval of the Caltrain Deputy Director of Engineering. The resulting maximum gradient Gc is generally expressed as follows: Gc = G – 0.04D Where G is the Gradient before, and D is the degree of curve, in decimal.	Shall be designed for the least grade practical, but shall not exceed 2.00%. Grades on track at location used for spotting rail cars are not to exceed 0.4%. Vertical curves must not begin on the long ties of a turnout. The grade from the point of switch through the long switch ties must be the same as the existing track that the turnout is coming out of.
LENGTH OF STEEP GRADES	Where terrain permits, long grades steeper than the following shall not be used due to limits of breaking capability of some of the proposed train sets: - The average grade for any 3.7 mi long section of the line shall be under 3.5% - The average grade for any 6.2 mi long section of the line shall be under 2.5%	HST TM 2.1.2_6.1.6.1	N/A	N/A
LIMITATIONS OF SPEED ON GRADES	In European practice, speed on downgrades is constrained by train set braking limitations. The restriction is based on the average grade over any continuous length of 17,100ft along the line. The following speed limits for different grades are as determined in accordance with French standards: - Grade between 3.0% and 3.5%: Vmax = 143 mph - Grade between 2.2% and 3.0%: Vmax = 168 mph - Grade between 1.6% and 2.2%: Vmax = 186 mph - Grade between 0.0% and 1.6%: Vmax = 217 mph	HST TM 2.1.2_6.1.6.1	N/A	N/A
VERTICAL CURVES	The radius of the curve at the crest or sag is determined in accordance with the vertical acceleration permitted for passenger comfort and the maximum speed of the line. The formula in US Customary units would be: Rmin >= (V*44/30)2 / av, where R is in feet, V in mph, Vertical acceleration (av) in feet/sec2 and the 44/30 is necessary for the mph to ft/sec conversion. Vertical Curve Type Shall be Parabolic	HST TM 2.1.2_6.1.6.2	Vertical curves shall be designed per the requirements for high-speed main tracks and shooflies as recommended in AREMA	N/A
VERTICAL CURVES ACCELERATION RATES	The acceleration values to be used for vertical curves shall be: - Desirable: 0.60 ft/sec/sec (1.86 percent of gravity) – AREMA recommended practice for passenger railroads. - Minimum: 0.90 ft/sec/sec (2.80 percent of gravity) - Exceptional: 1.40 ft/sec/sec (4.35 percent of gravity)	HST TM 2.1.2_6.1.6.2	Passenger Train 0.60 (0.02 g) Freight Train 0.10	N/A
VERTICAL CURVE LENGTH	Vertical curve lengths on lines carrying high-speed trains only shall be: - Desirable VC Length: The longer of LVCfeet = 4.55 V (for 3.1 seconds) or LVCfeet = 2.15 V2 (Δ% / 100) / 0.60 ft/sec2, but not less than 400 Δ% - Minimum VC Length: The longer of LVCfeet = 3.52 V (for 2.4 seconds) or LVCfeet = 2.15 V2 (Δ % / 100) / 0.80 ft/ sec2, but not less than 200 Δ% - Exceptional VC Length: The longer of LVCfeet = 2.64 V (for 1.8 seconds) or LVCfeet = 2.15 V2 (Δ % / 100) / 1.20 ft/ sec2, but not less than 100 Δ% - The speed used in the preceding formulae shall be no less than 250 mph, except where other alignment factors such as speed limiting curves exist. In those locations, a lower speed equal to or higher than the maximum anticipated achievable train speed may be used to calculate the required vertical curve lengths. At 250 mph, these formulae give: o Desirable VC Length: LVCfeet = 2250 Δ% o Minimum VC Length: LVCfeet = 1500 Δ% o Exceptional VC Length: LVCfeet = 970 Δ% The 2.15 factor is a constant necessary to unit conversions within the US Customary measuring system.	HST TM 2.1.2_6.1.6.2	L = (D V²K) /A where, A = vertical acceleration, in ft/sec² D = absolute value of the difference in rates of grades expressed in decimal K = 2.15 conversion factor to give L, in feet L = length of vertical curve, in feet V = speed of train, in miles per hour Under no circumstances shall the length of vertical curve be less than 100 feet.	N/A
VERTICAL CURVE AND HORIZONTAL SPIRAL CLEARANCE	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 with a minimum limit of 100 feet. 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.	HST TM 2.1.2_6.1.7	N/A	N/A
CLEARANCE	See Typical Section design checklist		N/A	Top of Rail to Existing track - minimum of 200 feet in prior to the proposed point of switch and 200 feet from the last long switch tie. The minimum clearance shall be 23 feet from top of rail to nearest overhead obstruction (See UP Standard Drawing No. 0038 & 0035).

CAHSR JM
TYPICAL SECTION DESIGN CHECKLIST

DESIGN ELEMENT	CAHSR JM DEDICATED HST CRITERIA				CALTRAIN (DWG SD-2151, 2152, 2154)	UPRR (INDUSTRIAL TRACK CONSTRUCTION SPECS)
	AT GRADE (HST TM 1.1.21-B)	PLATFORM (HST TM2.2.4-6.1.3)	MSE WALL (HST TM1.1.21-B)	AERIAL STRUCTURE (HST TM 2.3.3) (HST TM DIRECTIVE DWG 1.1.21-D) (HST TM3.2.1-C) (HST TM DIRECTIVE DWG 1.1.2-G)		
Center of track to Center of OCS Pole	10.67'	n/a	10.67'	10.67'	n/a	n/a
Center of track to Face of OCS Pole	n/a	n/a	n/a	n/a	n/a	n/a
Pole Width	n/a	n/a	n/a	n/a	n/a	n/a
Face of OCS to Structure Clearance	n/a	n/a	n/a	n/a	n/a	n/a
Centerline of OCS to Structure Clearance	9'	n/a	n/a	n/a	n/a	n/a
Face of OCS to Vegetation Clearance	n/a	n/a	n/a	n/a	n/a	n/a
Embankment Slope	2:1	n/a	n/a	n/a	2:1	See UP Standard. Drawing No. 0003 and UP Exhibit 'E' Drawing
Excavation Slope	2:1	n/a	n/a	n/a	2:1	See UP Standard. Drawing No. 0003 and UP Exhibit 'E' Drawing
OCS Pole Foundation Width (TM 1.1.21 3.2.6)	3'	n/a	3'	3'	n/a	n/a
Walkway Width	Desirable 3' Minimum 3' Exceptional 2.5'	n/a	Desirable 3' Minimum 3' Exceptional 2.5'	Desirable 3' Minimum 3' Exceptional 2.5'	2' minimum CPUC	Provide typical cross-sections showing proposed track sections, any side ditches and all areas requiring a walkway (see UP Exhibit 'E' Drawing
Edge of OCS Pole Foundation to Ditch	3'	n/a	n/a	n/a	n/a	n/a
Ditch Width	V-Ditch 6' Ditch 10'	n/a	n/a	n/a	V 2', H 12"	See UP Standard. Drawing No. 0003 and UP Exhibit 'E' Drawing
Fence Foundation Width	n/a	n/a	n/a	n/a	n/a	n/a
Utility Easement	n/a	n/a	n/a	n/a	n/a	n/a
Centerline of Fence to Proposed ROW	1'	n/a	n/a	n/a	n/a	n/a
Proposed ROW to TCE	n/a	n/a	n/a	n/a	n/a	n/a
Center of track to edge of platform	n/a	5.75'	n/a	n/a	5'-4"	n/a
Platform Width	n/a	**Center island platform** Minimum 30' Exceptional 25' **Outboard platform** Minimum 20' Exceptional 18'	n/a	n/a	n/a	n/a
Vertical Circulation (Stairs)	n/a	n/a	n/a	n/a	n/a	n/a
Edge of MSE Wall to Proposed ROW	n/a	n/a	n/a	n/a	n/a	n/a
Centerline of track to face of MSE Wall	n/a	n/a	Wall in Cut 20' Wall in Fill 18'	n/a	n/a	n/a
Edge of Structure to Proposed ROW	n/a	n/a	n/a	n/a	n/a	n/a
Tunnel Cross Section Reduction (NTD 10R1)	a. Reduce operating maximum speed in Tunnels from 220 mph to 200 mph. b. Reduce nominal tunnel diameter from 29.5ft ID to 28ft ID.				n/a	n/a





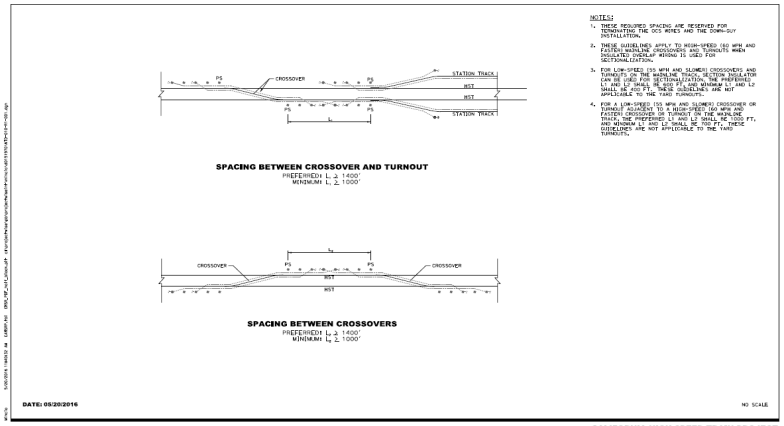


CAHSR JM
TURNOUT AND STATION TRACKS DESIGN CHECKLIST

DESIGN ELEMENT	CAHSR JM DEDICATED HST CRITERIA	HST REFERENCE	CALTRAIN (CHP 2)	UPRR (INDUSTRIAL TRACK CONSTRUCTION SPECS)
GENERAL	Use curved frogs. The high-speed turnouts will normally be built on some form of concrete based track, not on ties and ballast.	HST TM 2.1.3_6.1	a. Lateral turnouts numbers 8 and 9 for yards b. Lateral turnouts number 10, 14, and 20 for main line. Number 20 sha l be used where there are no real estate constraints. c. Number 9 double slip sw tches may be used in terminals. d. Turnouts w th Hollow Steel Ties (HST) per Standard Drawings SD-2000 series shall be used for new constructions. SEE DWG SD-2401-2901	n/a
SUPERELEVATION	Unbalanced Superelevation not to exceed 3 inches Superelevation in curve off of a turnout ≤ 1.25"	HST TM 2.1.3_6.1	N/A	N/A
MINIMUM TIME	Minimum time over any turnout segment or curve connected to a turnout, including spirals on the frog end of turnouts and spirals into a curve on the diverging track that is adjacent to the turnout 1 sec	HST TM 2.1.3_6.1	N/A	N/A
MAXIMUM VIRTUAL TRANSITION RATE AT SWITCH POINT	5.0 inches/second	HST TM 2.1.3_6.1	N/A	N/A
KEEP SPIRALS OUT OF FROGS	Minimum/Exceptional In order to avoid a special design swing nose frog, the frog end spiral shall begin at or beyond the point where track centerline spacing exceeds 5.85 feet, even if this means that the transition length in a crossover will have a run time of less than 1.0 seconds. Desirable Start frog end spiral beyond the point where the track centerline spacing exceeds 7.00 feet, if spiral is to a tangent or followed by a reversing curve. If the spiral is to a compound curve, it shall start beyond the point where the track center ine spacing exceeds 8.00 feet.	HST TM 2.1.3_6.1		
HIGH SPEED TURNOUTS GEOMETRY	See Table 6.1.1	HST TM 2.1.3_6.1.1	N/A	N/A
CROSSOVER BETWEEN MAIN TRACKS	See Table 6.1.2 for 16.50 feet track centers. Use of highspeed crossovers in tracks with centers of under 16.50 feet shall be an Exceptional condition.	HST TM 2.1.3_6.1.2		
STATION CONNECTION TRACKS WITH SPIRAL POINT TURNOUTS	See Table 6.1.3 for 25 feet track centers	HST TM 2.1.3_6.1.3	N/A	N/A
LOW AND MEDIAN SPEED TURNOUTS GEOMETRY	See Table 6.1.4	HST TM 2.1.3_6.1.4	Turnouts and crossovers shall be located on tangent tracks and shall meet the following requirements a. 100 feet minimum from point of switch (PS) to horizontal or vertical curves b. Less than 100 feet from horizontal curves without superelevation with approval from the Ca train Deputy Director of Engineering. c. 100 feet minimum from point of switch to the edge of road crossings (including sidewalks) d. 50 feet minimum from PS to Insulated Joint e. 50 feet minimum from PS to opposing point of switch f. Crossovers sha l be located in parallel tracks only g. Standard crossovers shall be of 15 feet track center SEE SD-2103 TRACK TURNOUTS AND DERAILS - STANDARD TURNOUT AND CROSSOVER DATA	Show a l existing turnouts (within 1500' of the limits of the construction area) and proposed turnouts, including size (No. 11, No. 15, etc). Show the Engineering Station (ES) of each point of switch. **UP Standard Drawing No. 345000 345003** - No. 15 turnouts will be required for all unit train operations and at other locations required by the UP. Installation may or may not require power operation. Main line turnouts are to be made of 136# rail unless specified and/or approved by UP's AVP Engineering – Design/Construction or a designated representative. **UP Standard Drawing 343000 343003**- No. 11 turnouts (minimum) are required out of all main tracks and located not closer than 300 ft. to a main line curve or bridge. Main line turnouts are to be made of 136# rail unless specified and/or approved by UP's AVP Engineering – Design/Construction or a designated representative **UP Standard Drawing 341000 341003** - No. 9 turnouts are recommended for industrial lead and spur track installation other than main track. Turnouts maintained by UP are to be 136# rail unless specified and/or approved by UP's AVP Engineering – Design/Construction or a designated representative. No. 7, No. 8, No. 8-1/2 or No. 10 turnouts will be considered where site conditions warrant in lieu of No. 9 turnouts on privately owned and maintained trackage, they must meet the latest edition of the AREMA Manual. UP w ll not own or maintain turnouts of these sizes.
	a. Reduce size of Turnouts from 110 mph to 60 mph. b. Reducing the speed of the station turnouts is in conjunctic;m w th the recommendation to reduce the speed of the universal crossovers and increase their spacing. c. The station platform track between entry turnout and the exit turnout along the main track shall have a 3,350 foot minimum length centered symmetrically on the midpoint of the station platform.	HST NTD 13		
STORAGE AND REFUGE TRACKS AT HIGH SPEED STATIONS	Turnouts smaller than the number 11 shall not be used. See Table 6.1.5 for 22 feet track offset the turnout - return curve selections.	HST TM 2.1.3_6.1.5	N/A	N/A
	Modify refuge track or storage track length from 1650' to 900' clear length	HST NTD 13	N/A	N/A
Spacing Between Facing Adjacent Points of Switch on Main Tracks	The distance between two facing points of switch of adjacent crossovers and the distance between the point of switch of a turnout facing an adjacent point of switch of a crossover shall adhere to the following spacing requirements • Desirable distance between two high-speed (60 mph or faster) points of switch 1400' • Minimum distance between two high-speed (60 mph or faster) points of switch 1000' • Desirable distance between two low-speed (55 mph or slower) points of switch 600' • Minimum distance between two low-speed (55 mph or slower) points of switch 400' • Desirable distance between high-speed and low-speed points of switch 1000' • Minimum distance between high-speed and low-speed points of switch 700'	HST NTD 10R1	N/A	For the minimum distance between facing point turnouts use UP Standard Drawing No. 0017 for guidance
Crossover Spacing	a. Increase nominal spacing of the interlockings from 20 miles to 40 miles throughout the program. b. Change universal interlocking from 110 mph to 80 mph.	HST NTD 10R1	Maximum authorized speeds (MAS) through turnouts and crossover for passenger and freight trains are as fo lows a. 10/10 MPH for turnouts number 9 for both passenger and freight b. 25/15 (passenger/freight) MPH for turnout number 10 c. 35/25 (passenger/freight) MPH for turnout number 14 d. 50/40 (passenger/freight) MPH for turnout number 20	N/A

CAHSR JM
TURNOUT AND STATION TRACKS DESIGN CHECKLIST

DESIGN ELEMENT	CAHSR JM DEDICATED HST CRITERIA	HST REFERENCE	CALTRAIN (CHP 2)	UPRR (INDUSTRIAL TRACK CONSTRUCTION SPECS)



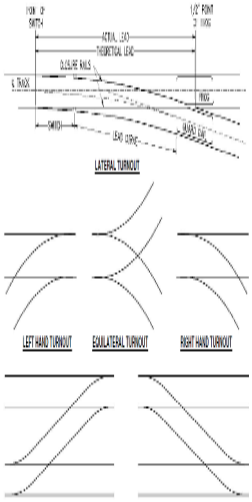
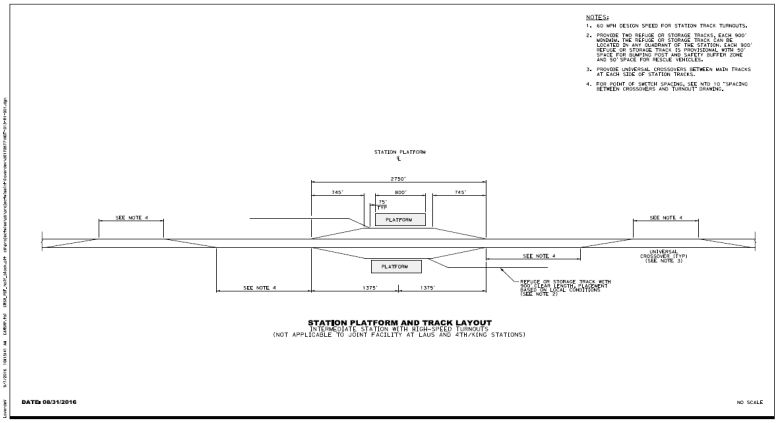
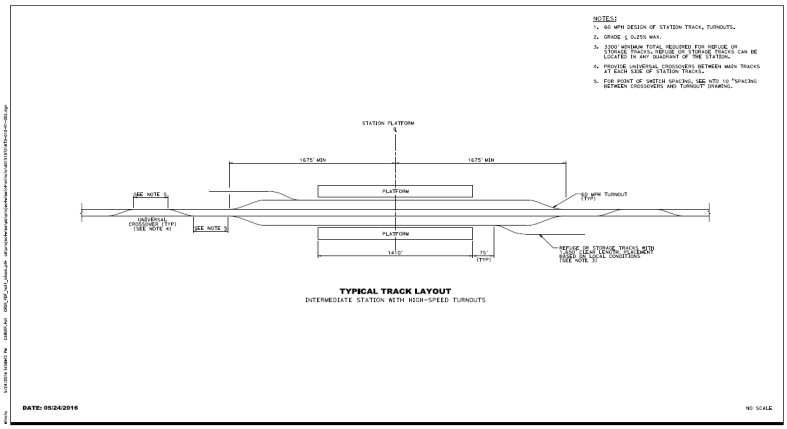


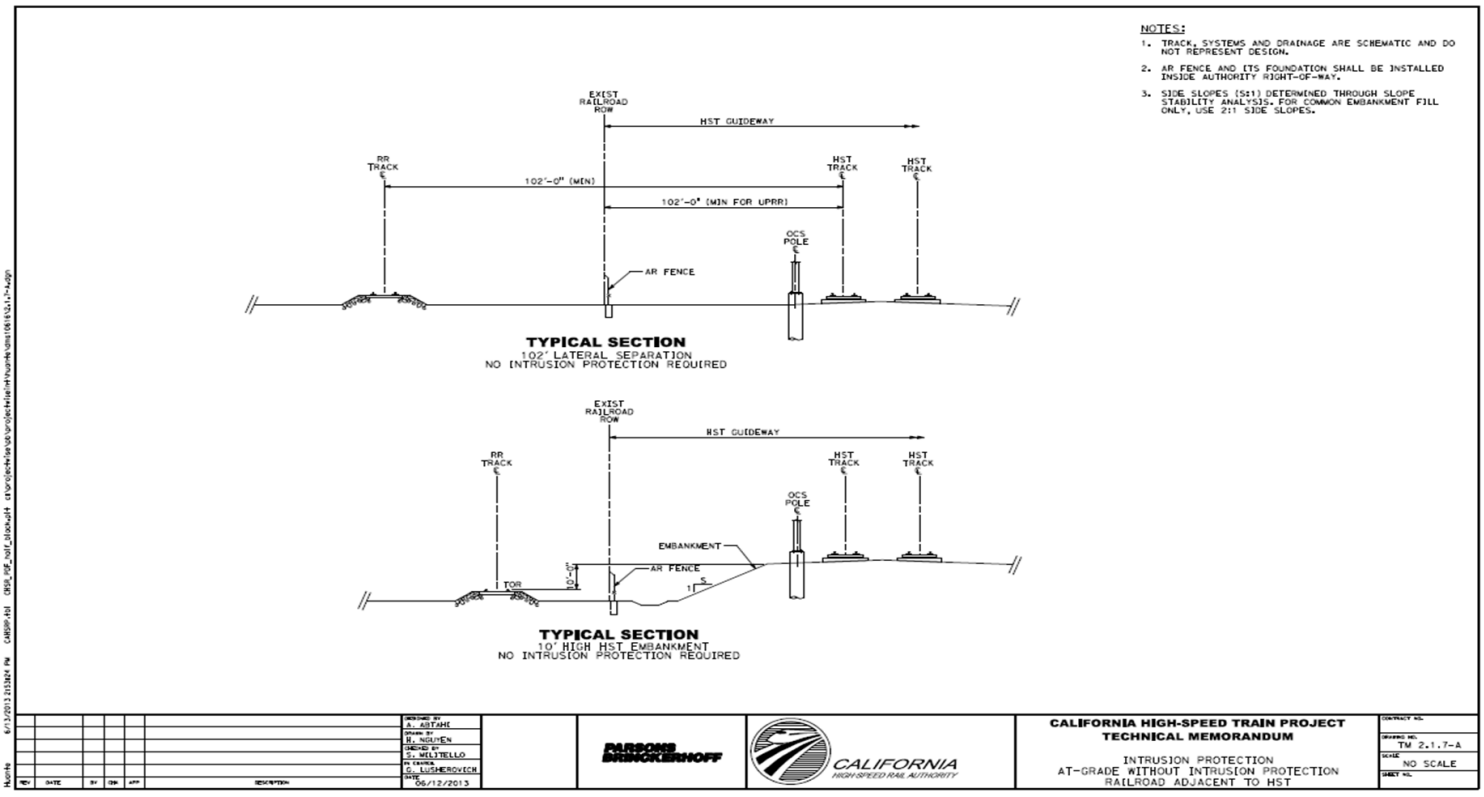
FIGURE 3-4 TURNOUTS AND CROSSOVERS



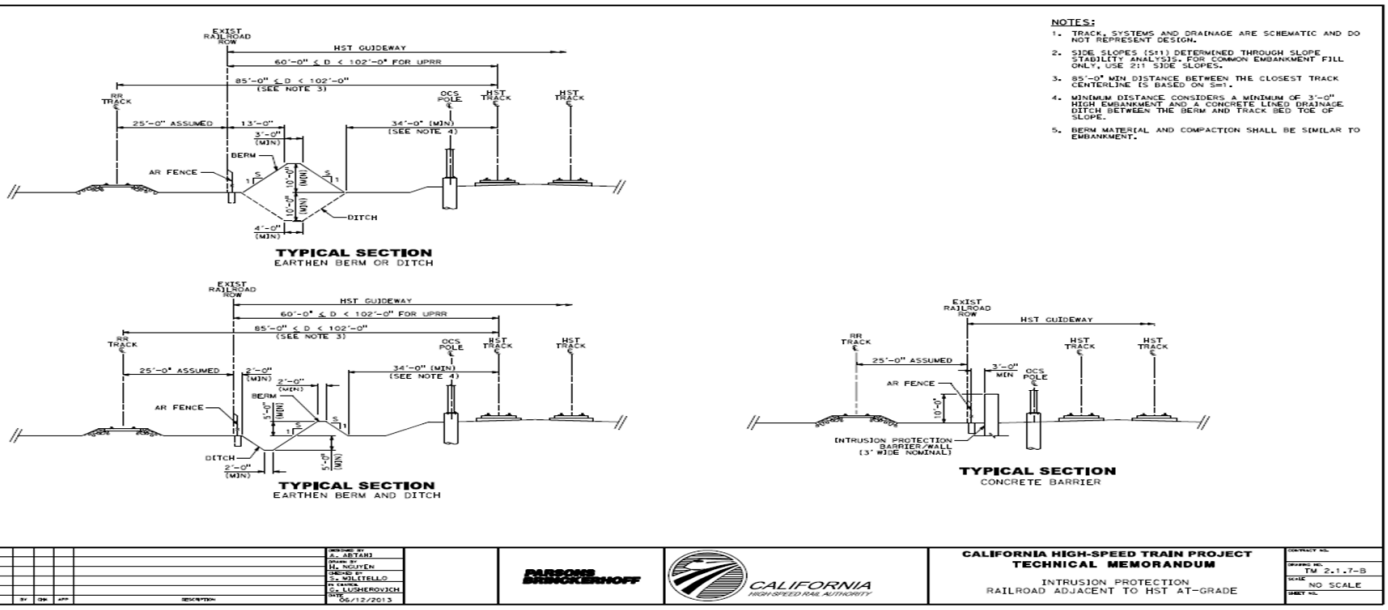


CAHSR JM
ROLLING STOCK AND VEHICLE INTRUSION PROTECTION FROM ADJACENT TRANSPORTATION SYSTEMS DESIGN CHECKLIST

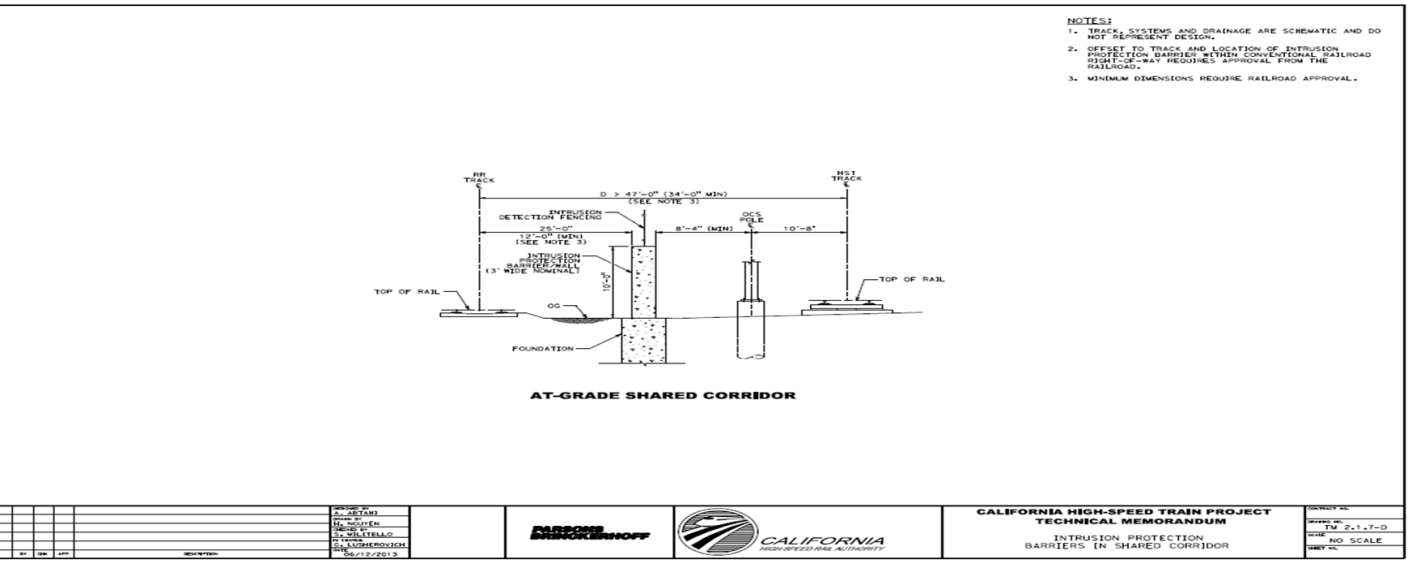
DESIGN ELEMENT	CAHSR JM DEDICATED HST CRITERIA	REFERENCE
SEPARATION DISTANCE FROM ADJACENT RAILROAD SYSTEMS	1. No intrusion protection is required for tracks with centerlines separated horizontally by 102 feet or greater. 2. No intrusion protection is required where the closest HST track elevation is 10 feet or higher than the rail elevation of the closest conventional track. This can be accomplished when the HST is on aerial structure, on an embankment or on a retained fill. However, protective structures may be required for piers, abutments or retaining walls if the side clearance is less than 25 feet. 3. Where intrusion protection is required, the minimum total height shall be 10 feet and may be comprised of a ditch and berm, concrete wall plus screen, or only concrete wall. 4. Use of only berms or ditches as intrusion protection requires centerline separation of 76 feet or more where half of the berm is in the HST right-of-way and the other half in adjacent railroad right-of-way, as shown on drawing TM 2.1.7-A, and 85 feet or greater where the entire berm is in HST right-of-way or 76 feet or more where the entire ditch is within HST right-of-way, as shown on drawing TM 2.1.7- E in Appendix A. 5. A physical intrusion barrier/crash wall is required when the separation between centerlines of the nearest HST and adjacent conventional railroad track is less than 76 feet, as shown on drawing TM 2.1.7-D in Appendix A. The minimum separation between the closest conventional railroad track centerline and HST track centerline is 50 feet (37 feet with railroad approval) for at grade section and 27.5 feet on a common aerial structure as shown on drawing TM 2.1.7-B. These guidelines consider physical separation and do not include right-of-way considerations, which may introduce additional separation requirements. Additionally, separation requirements of other owners and operators must be considered in establishing separation requirements.	HST TM 2.1.7_6.1.4
MINIMUM OFFSET BETWEEN PIER FOR GRADE SEPERATION PROJECTS AND THE CLOSEST TRACK	25 FEET	HST TM 2.1.7_6.1.5



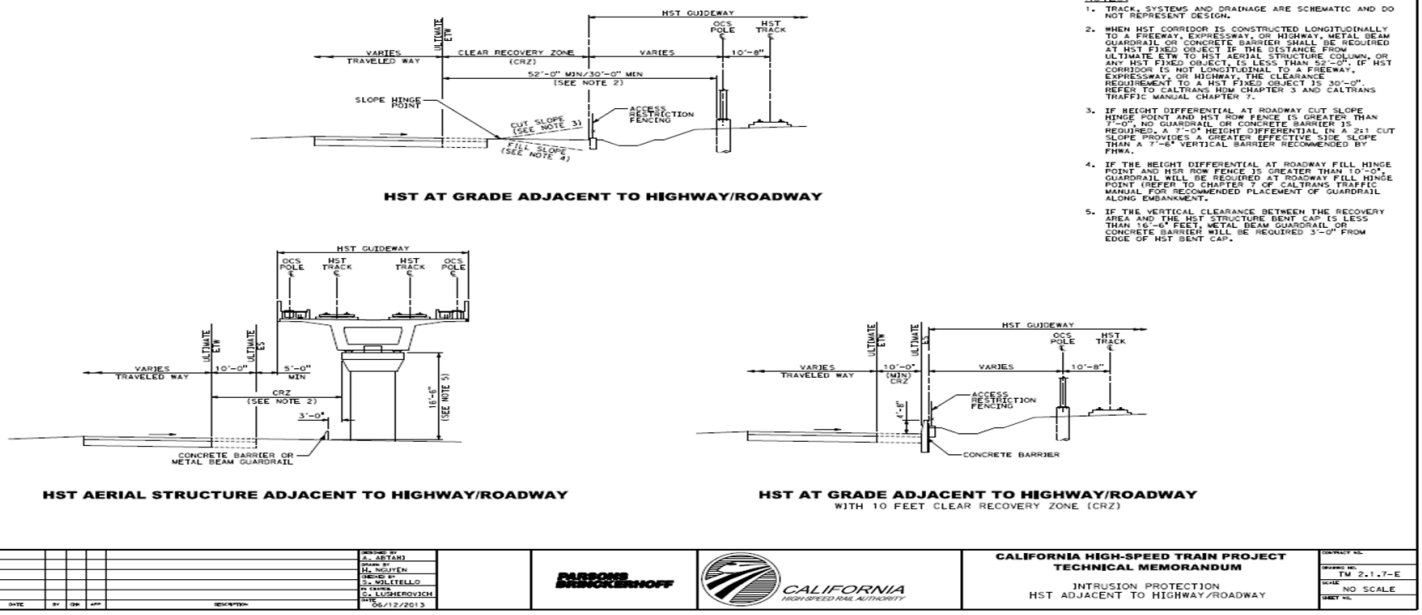
CAHSR JM
ROLLING STOCK AND VEHICLE INTRUSION PROTECTION FROM ADJACENT TRANSPORTATION SYSTEMS DESIGN CHECKLIST



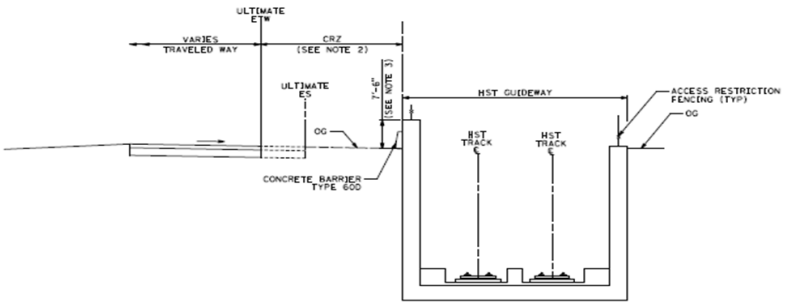
CALIFORNIA HIGH-SPEED TRAIN PROJECT
TECHNICAL MEMORANDUM
INTRUSION PROTECTION
RAILROAD ADJACENT TO HST AT-GRADE
TM 2.1.7-B
NO SCALE



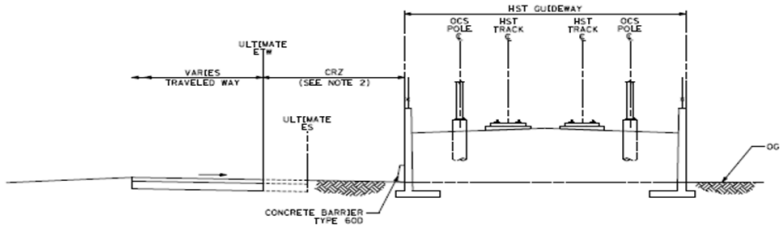
CALIFORNIA HIGH-SPEED TRAIN PROJECT
TECHNICAL MEMORANDUM
INTRUSION PROTECTION
BARRIERS IN SHARED CORRIDOR
TM 2.1.7-D
NO SCALE



CALIFORNIA HIGH-SPEED TRAIN PROJECT
TECHNICAL MEMORANDUM
INTRUSION PROTECTION
HST ADJACENT TO HIGHWAY/ROADWAY
TM 2.1.7-E
NO SCALE



HIGHWAY/ROADWAY AT GRADE ADJACENT TO HST TRENCH



HIGHWAY/ROADWAY AT GRADE ADJACENT TO HST RETAINED FILL

NOTES:

1. TRACK, SYSTEMS AND DRAINAGE ARE SCHEMATIC AND DO NOT REPRESENT DESIGN.
2. IF THE DISTANCE BETWEEN HST WALL AND THE ULTIMATE ETW IS LESS THAN 52'-0", THE WALL HEIGHT SHALL BE 7'-6" ABOVE THE GROUND SURFACE AND CALTRANS CONCRETE BARRIER TYPE 60D SHALL BE INCLUDED IN CONSTRUCTION OF THE WALL.
3. FHWA RECOMMENDS 7'-6" FEET VERTICAL BARRIER TO CONTAIN HIGH CENTER OF GRAVITY CARGO TRUCKS WITHIN HIGHWAY RIGHT-OF-WAY.

REV	DATE	BY	CHK	APP	DESCRIPTION

DESIGNED BY: A. ABTAHI
DRAWN BY: H. NGUYEN
CHECKED BY: S.s WILLITELLO
IN CHARGE: G.s LUGHEROVICH
DATE: 06/12/2013

PARSONS BRINCKERHOFF

CALIFORNIA HIGH-SPEED RAIL AUTHORITY

CALIFORNIA HIGH-SPEED TRAIN PROJECT
TECHNICAL MEMORANDUM

INTRUSION PROTECTION
HST TRENCH AND RETAINING WALL PROTECTION

CONTRACT NO.
DRAWING NO. TM 2.1.7-F
SCALE NO SCALE
SHEET NO.

CAHSR JM
STRUCTURE GAUGE AND TRACK CENTER DESIGN CHECKLIST

DESIGN ELEMENT	CAHSR JM DEDICATED HST CRITERIA 1.1.10	REFERENCE
MAIN LINE TRACK CENTER	Track Centers – Straight Tracks Where space permits and the cost of doing so is not excessive, the track centers for main tracks shall be set at 20.00 feet. Where placing track at twenty feet track centers is not practical or is excessively costly, the following track center dimensions shall be used. **Speeds above 125 mph:** - Desirable: 16.50 feet - Minimum: 15.75 feet - Exceptional: 15.00 feet – do not use above 175 mph **Speeds of 125 mph and under:** - Desirable: 16.50 feet – Use 15.75 feet where 16.50 feet is not practical - Minimum: 15.00 feet - Exceptional: 14.75 feet – do not use above 90 mph **Yard, Yard Lead and Station and other tracks with speeds under 50 mph:** - Desirable: Yard Lead and Station Tracks: 16.50 feet, Yard Tracks: 15.00 feet - Minimum: 15.00 feet - Exceptional: 14.00 feet **Tracks with Catenary Poles between them:** - Desirable: 25.00 feet - Minimum: 22.00 feet, without walkway - Exceptional: 22.00 feet, without walkway	HST TM 1.1.10_6.2.1
INCREASE IN TRACK CENTERS DUE TO SMALL RADIUS	**Desirable**: Not needed for track centers greater than 16.50 feet. **Minimum**: Adding the value determined by the following formula to 14.25 feet. Track Center Increase (in feet) = 1,100 / R (in feet).	HST TM 1.1.10_6.2.2
EFFECTS OF SUPERELEVATION ON TRACK CENTERS	1) **Desirable** Track Centers: No need. 2) In the case of curves under 3,000 feet radius and the inside track having less superelevation than the outside track, additional space is required between tracks with track centers set to Minimum and Exceptional track center distances. This widening shall be 2.0 times the difference in superelevation.	HST TM 1.1.10_6.2.3
WALKWAY REQUIREMENTS	1) Minimum width: 3 feet. 2) The vertical walkway space shall be no less than 7.50 feet above the walkway surface or top of rail elevation, whichever is higher. 3) The walking surface shall be no less than 6 inches wider than the walkway envelope.	HST TM 1.1.10_6.3.4
WALKWAY ENVELOPE	Figure 6.3.1 Figure 6.3.2	HST TM 1.1.10_6.3.5
STRUCTURE GAUGE OUTLINE REQUIREMENTS	Figure 6.3.3 Figure 6.3.4 **Desirable and Minimum** Widening of Structure Gauge for Effects of Radius of Cuve: EO (in inches) =550 / R (feet)	HST TM 1.1.10_6.3.6-6.3.7.1
ROTATION OF STRUCTURE GAUGE FOR EFFECTS OF SUPERELEVATION	Table 6.3.3, Figure 6.3.7, 6.3.8, 6.3.9, 6.3.10	HST TM 1.1.10__6.3.7.2

Table 3.4.2: Widening for Curvature Effect

	Desirable & Minimum 550 / R(feet)		Exceptional 500 / R (feet)	
Radius (feet(	Widening per side (feet)	Full section max. width (feet)	Widening per side (feet)	Full section max. width (feet)
50,000	0.011	12.94	0.010	12.93
10,000	0.055	13.02	0.050	13.01
5,000	0.110	13.13	0.100	13.11
1,000	0.550	14.01	0.500	13.91
750	0.733	14.38	0.667	14.25
500	1.100	15.11	1.000	14.91

Widening under 0.05 feet may be neglected. The widening applicable to all points on the outline is shown in Table 3.2.3.

Table 3.4.2: Dynamic Envelope – For 500 feet Radius Curve

Desirable/Minimum (feet)		Exceptional (feet)	
X (from centerline)	Y (above top of rail)	X (from centerline)	Y (above top of rail)
0.00	0.21	0.00	0.21
6.43	0.21	6.33	0.21
7.02	2.18	6.92	2.18
7.56	13.35	7.46	13.35
7.28	14.61	7.18	14.61
6.15*	15.42*	6.05*	15.42*
5.01	15.82	4.91	15.82
0.00	15.49	0.00	15.49

- Corner of TSI GC Kinematic Outline

CAHSR JM
ROADWAY WORK (GRADE SEPARATION) DESIGN CHECKLIST

Note: Without knowing exactly which roads will be impacted, all criteria are assumed applicable except for rolling/mountainous rural roadways.

	DESIGN ELEMENTS	REFERENCES							COMMENTS
		CAHSR	AASHTO	Caltrans (HDM)	City of San Jose	City of Morgan Hill	City of Gilroy	City of Los Banos	
1	**VEH CLASSIFICATION**	WB50		WB50	20'/WB50				
	Curb Radius, Arterial				R=65'				
	Curb Radius, Collector				R=65'				
2	**DESIGN SPEED***				(5-10 abv SL)				Design Speed to be confirmed by local jurisdiction
	Design Speed, Arterial (4-6 lanes)				45 mph		1090'		
	Design Speed, Collector (2-4 lanes)				40-45 mph		610'		
	Design Speed, Residential/local (2 lanes)				30 - 40 mph		290' max		
	Design Speed, Level (Access Rd)	30 mph							
	Design Speed, Roll/Mtn (Access Rd)	20 mph							
	*SL = posted Speed Limit								
3	**ROADWAY GRADES, G**								
	Level Terrain, Urban/Local Road, Gmax			6.0%					
	Level Terrain, Rural, Gmax			4.0%					
	Level Terrain, Expw/Fwy, Gmax			3.0%					
	Level Terrain, Urban/Local/Expyw/Fwy, Gmin			0.3%					
	Rolling Terrain, Urban/Local Road, Gmax			7.0%					
	Rolling Terrain, Rural Road, Gmax			5.0%					
	Rolling Terrain, Expwy/Fwy, Gmax			4.0%					
	Rolling Terrain, Urban/Rural/Expwy/Fwy, Gmin			0.3%					
	Mtn Terrain, Urban/Local Road, Gmax			9.0%					
	Mtn Terrain,Rural Road, Gmax			7.0%					
	Mtn Terrain, Expwy/Fwy, Gmax			6.0%					
	Mtn Terrain, Urban/Rural/Expwy/Fwy, Gmin			0.3%					
	Fwy/Expwy Ramp, Gmax			8.0%					
	HST Access Rd, Gmax	6.0%							
	HST Access Rd, Gmin	0.50%							
	HST Access Rd, Reccm G	5% max, 1% min							
4	**ROADWAY X-SLOPES**								
	Road X-slope	2.0%		2.0%				2.50%	
	Road lane same dir X-slope, Algebraic diff, A, max			4%					
	Road lane/shldr same dir X-slope, Algebraic diff, A, max			8%					
5	**GRADE DIFFERENTIAL, A**								
	Crest Vert Curve (local road)							K=20-320	
	Sag Vert Curve (local road)							K=30-155	
	Crest Vert Curve (HST Road/Access Rd)	9.0%							
	Sag Vert Curve (HST Road/Access Rd)	6.5%							

CAHSR JM
ROADWAY WORK (GRADE SEPARATION) DESIGN CHECKLIST

Note: Without knowing exactly which roads will be impacted, all criteria are assumed applicable except for rolling/mountainous rural roadways.

	DESIGN ELEMENTS	REFERENCES							COMMENTS
		CAHSR	AASHTO	Caltrans (HDM)	City of San Jose	City of Morgan Hill	City of Gilroy	City of Los Banos	
6	**ROADWAY WIDTH***								
	Local								roadway widths to be confirmed by local jurisdiction.
	Arterial				106' - 130'	92'-110'	36'	62'-80'	
	Collector				60' - 90'	72'	86'-130'	40'-50'	
	Residential				52' - 56'	48'-52'	48'	32'	
	Rural					52'			
	Non-residential						48'		
	Roadway Width (Access Rd)	22 ft (incl. Shldr)							
	Roadway Width W/FH (Access Rd)	26 ft (incl. Shldr)					20'		
	Overcrossing 2-lane, Min			32' curb-curb					
7	**CUT/FILL SLOPES**								
	Cut slope	2h:1v		4h:1v			2:1		
	Fill slope	2h:1v		4h:1v					
8	**VERTICAL CLEARANCES**								
	Vertical Clr (from HST TOR to New Struct)	27 ft min							
	Vertical Clr (from HST TOR to ex Struct) >125 mph	27 ft min							
	Vertical Clr (from HST TOR to ex Struct) ≤125 mph	24 ft min							
	Vertical Clr (HST Access Rd)	14.5 ft min							
	*up to 25 ft laterally fr CL of outside HST track								
	Vertical Clr (fr Expwy/Fwy FG)			16.5 ft min					
	Vertical Clr (fr local roads FG)			15.0 ft min					
9	**HORIZONTAL CLEARANCES**								
	To Permanent Structure	25 ft fr Trk CL							
	To Fixed Equipment/Object	10 ft fr Trk CL		52' to edge of traveled way					
	Clear Recvry Zone, rd w/posted speed>40 mph			20 ft					
	Clear Recvry Zone, rd w/posted speed≤40 mph&curb			N/A					
	Horiz Clr fr Edge of Shldr, Foc, pole, wall	2.5 ft min							
	Horiz Clr fr edge of traveled way to rail,conc barrier, mbgr			shldr width, or 4 ft min for shldr<4'					
	Ramps - Horiz Clr fr edge of Traveled way to abutwalls, Retwall in cutslope			10' min					
	Local Rds - Horiz Clr fr edge of Traveled way to abutwalls, Retwall in cutslope			shldr width					
	Local Rds w/curbs - Horiz Clr fr edge of Traveled way to abutwalls, Retwall in cutslope			1.5' fr FOC or back of S/W	1.5' fr Foc or back of S/W				
10	**VERTICAL CURVES (L_{min})**								
	Crest Vertical Curve, Arterial				450 ft	200'	200'		
	Crest Vertical Curve, Collector				400 ft	100'	100'		
	Crest Vertical Curve, Residential				350 ft	100'	100'		
	Sag Vertical Curve, Arterial					200'	200'		
	Sag Vertical Curve, Collector					100'	100'		
	Sag Vertical Curve, Residential					100'	100'		
	Crest, HST Roads (A=alg diff in grades)	28 x A (20' min)							
	Sag, HST Roads (A=alg diff in grades)	35 x A (20' min)							
11	**HORIZONTAL CURVES (min R_c)**								
	Arterial (DS 45-55 mph); Caltrans (60-70 mph)			1150'-2100'	900'				

CAHSR JM
ROADWAY WORK (GRADE SEPARATION) DESIGN CHECKLIST

Note: Without knowing exactly which roads will be impacted, all criteria are assumed applicable except for rolling/mountainous rural roadways.

DESIGN ELEMENTS	REFERENCES							COMMENTS
	CAHSR	AASHTO	Caltrans (HDM)	City of San Jose	City of Morgan Hill	City of Gilroy	City of Los Banos	
Collector (DS 30-40 mph); Caltrans (40-50 mph)			550'-850'	300/667/900				
Residential (DS 25-30 mph); Caltrans (20-30 mph)			130'-300'	300'				

CAHSR JM
ROADWAY WORK (GRADE SEPARATION) DESIGN CHECKLIST

Note: Without knowing exactly which roads will be impacted, all criteria are assumed applicable except for rolling/mountainous rural roadways.

	DESIGN ELEMENTS	REFERENCES							COMMENTS
		CAHSR	AASHTO	Caltrans (HDM)	City of San Jose	City of Morgan Hill	City of Gilroy	City of Los Banos	
	Hillside								
	HST Roads (DS 20-30 mph)			130'-300'					
12	**STOPPING SIGHT DISTANCE (VERT)**								
	Highway (DS 65-75 mph)		645' - 820'	660'-840'					
	Arterial (DS 45-55 mph)		360' - 495'	360'-500'	360' - 500'	350'	350'		
	Collector (DS 35-40 mph)		250' - 305'	250'-300'	250' - 300'	200'	200'		
	Residential (DS 25-30 mph)		155' - 200'	150'-200'	150' - 200'	100'	100'		
	HST Roads (20-30 mph)		115' - 200'	120'-200'					
	Cul De Sac					100'	100'		
	*on Sag Curves, increase SSD 20% for g>3% & L>1mile								
13	**K-VALUES**								
	Highway (DS 65-75 mph): CREST/SAG		193-312/157-206						
	Arterial (DS 45-55 mph): CREST/SAG		61-114/79-115					125-220/90-130	
	Collector (DS 35-40 mph) : CREST/SAG		29-44/49-64					50-800/50-70	
	Residential (DS 25-30 mph) : CREST/SAG		12-19/26-37					20-30/30-25	
14	**SUPERELEVATION, e**								
	Urban Rd (<35 mph); e_{max}=0.04; Rc=500 to ovr 5k			0.04 to 0.02					
	Urban Rd (35-45 mph); e_{max}=0.06;Rc=600 to ovr 7k			0.06 to 0.02					
	Expwy/Multi-lane Hwy; e_{max}=0.10; Rc=1100-ovr 20k			0.10 to 0.02					
	Ramp/2-lane Hwy; e_{max}=0.12; Rc=625-ovr 20k			0.12 to 0.02					
15	**LANE WIDTH***								
	Local Rd Lane Width						1- 11' travel lane	2 lanes with parking	
	Arterial Rd Lane Width			12' min	4-6 Lanes 11/12/12/11	4-lanes total (2 in each direction)	13' travel lane	4 lanes with no parking with	
	Collector Rd Lane Width			12' min	2-4 Lanes 11/13/13/11	2 lane in each direction	1- 12' travel lane	parking, 2 lanes with no parking,	
	Residential Rd Lane Width			12' min	17/17	20'-18' (one direction)	1- 12' travel lane		
	Rural Rd Lane Width					14' in each direction			
	HST Roads	22' rd width							
	Sidewalk				9' res/10' coll/12' art	5'	6'	4'-10'	
	Bike Lane			4' min. Speed limit> 40, use 6'	5 ft				
	2-Lane Fwy/Expwy, Paved Shldr, LT/RT			8' min, 10' pref					
	2-lane Rd, Paved Shldr, LT/RT								
	4-lane Rd, Paved Shldr, LT/RT			5'/8' min, 10' pref					
	6-lane Rd, Paved Shldr, LT/RT			8'/8' min, 10' pref					
	Urban Rd, posted speed ≤45 mph & curb median, L/R			2'/8' min, 10' pref					
	Urban Rd, posted speed ≤35 mph & curb med, L/R			0'/8' min, 10' pref					
	Single Ramp, L/R			4'/8'					
17	**CUL DE SAC**								
	Commercial				Curb R=40'				
	Residential				Curb R=30'	Curb = 36'	curb = 36'		
	HST Roads								

CAHSR JM
ROADWAY WORK (GRADE SEPARATION) DESIGN CHECKLIST

Note: Without knowing exactly which roads will be impacted, all criteria are assumed applicable except for rolling/mountainous rural roadways.

	DESIGN ELEMENTS	REFERENCES							COMMENTS
		CAHSR	AASHTO	Caltrans (HDM)	City of San Jose	City of Morgan Hill	City of Gilroy	City of Los Banos	
18	**STREET KNUCKLE**								
	standard					Curb = 20' (min)-30'	Curb = 70'		
18	**STOPPING SIGHT DISTANCE (horizontal)**								
	Highway (DS 65-75 mph)			660'-840'					
	Arterial (DS 45-55 mph)			360'-500'				400'-660'	
	Collector (DS 35-40 mph)			250'-300'				350'-400'	
	Residential (DS 25-30 mph)			150'-200'				250'-300'	
	HST Roads (20-30 mph)			125'-200'					

* requires input from Cities.

CAHSR JM TEMPORARY CONSTRUCTION FACILITIES DESIGN CHECKLIST

The High Speed Rail Authority has no geometric design criteria for temporary construction facilities. Such facilities can be highly variable in extent and location, and are subject to site selection that depends on such factors as expected construction methods, distance to suppliers and material, access and egress to working areas, and many more. Moreover, although these facilities can be described and even acquired by the project owner in anticipation of construction, the means and methods of construction rely largely on the construction contractor's preferences. This being the case, imposition of rigid geometric criteria for temporary facilities would ignore many important factors and hold a contractor to rigid constraints that could adversely affect the efficiency and expense of the work.

Therefore, a design checklist would not be generated.

CAHSR JM
STATION DESIGN CHECKLIST

DESIGN ELEMENT		CAHSR JM DEDICATED HST CRITERIA	REFERENCE	COMMENTS
STATION FUNCTIONAL REQUIREMENTS	Station Design Consideration	HST TM 2.2.2, 6.1	HST TM 2 2.2, 6.1	
	Station Program Requirements	HST TM 2.2.2, 6.2	HST TM 2 2.2, 6.2	
PASSENGER STATION SITE	Station Site Spaces and Factors Influencing Sizing	HST TM 2.2.3, 6.2	HST TM 2 2.3, 6.2	
	Pedestrian Facilities	HST TM 2.2.3, 6.2.1	HST TM 2 2.3, 6.2.1	
	Transit Facilities	HST TM 2.2.3, 6.2.2	HST TM 2 2.3, 6.2 2	
	Bicycle Facilities	HST TM 2.2.3, 6.2.3	HST TM 2 2.3, 6.2 3	
	Pick-Up and Drop-Off Facilities	HST TM 2.2.3, 6.2.4	HST TM 2 2.3, 6.2.4	
	Automobile Parking	Max. distance from parking to station entrance = 1500' or a 5 to 7 minute walk. Provide ADA, carsharing, carpool/vanpool, and staff parking spaces.	HST TM 2 2.3, 6.2 5	
	Roadways and Vehicle Access and Circulation	Single lane driveway: min. 11 5' wide. Min. 10' wide driveway for multiple lanes.	HST TM 2 2.3, 6.2 6	
	Additional Site Layout Considerations	HST TM 2.2.3, 6.3.8	HST TM 2 2.3, 6.3 8	
STATION PLATFORM GEOMETRIC DESIGN	Platform Configuration	HST TM 2.2.4, 6.1.1	HST TM 2 2.4, 6.1.1	
	Usable Platform Length	800'. Not applicable for joint facility stations (e.g. 4th and King or LAUS) where the platform length should be the same as the other rail operators in the facility, but not shorter than 800 ft.	HST NTD 13	
	Platform Width	Center Platform: 30' Min.; 25' Exceptional. Side Platform: 20' Min.; 18' Exceptional	HST TM 2 2.4, 6.1 3	
	Platform Cross Slope	1% Min.; 2.1% Max.	HST TM 2 2.4, 6.1.4	
	Platform Longitudinal Slope	0% Desirable; 0 25% Max.	HST TM 2 2.4, 6.1 5	
	Platform Curvature	Largest radius possible, platform edge be convex, subject to variance process.	HST TM 2 2.4, 6.1 6	
	Platform Height Above Rail	45.47" to 51.18" above top of rail.	HST TM 2 2.4, 6.1.7	
	Track Centerline to Platform Dimension	1/2 width of vehicle + 2.75" (or 5'-9" nominal for preliminary design.)	HST TM 2 2.4, 6.1 8	
	Platform Edge to Train Gap	Horizontal Gap: 3" Max.; Vertical Gap +/- 5/8" Max.	HST TM 2 2.4, 6.1 9	
	Setback of Obstruction from Edge of Platform	6.5' min. setback for small obstruction less than 3.3' in length parallel to platform. 8.25' min. setback for obstruction greater than 3.3' in length parallel to platform	HST TM 2 2.4, 6.1.10	
	Under Platform Refuge Area	30" x 30" min. entire length of platform. Exits from this space shall be provided at platform ends.	HST TM 2 2.4, 6.1.11	
	Platforms Adjacent to Through Tracks	Train speed on tracks adjacent to station platforms not to exceed 125 mph. Through train operating on track adjacent to platform should have one or more following provisions: 1) Passenger access to platform shall only be permitted when train is intended to stop, 2)Provide platform doors/barriers as access control to train, 3) Provide audible and visual warning on platform to provide advance notice of approaching trains.	HST TM 2 2.4, 6.1.12	
	Protection Screen between Station platform & Through Tracks	Provide 25' between track centers to allow for installation of protection screens, if required.	HST TM 2 2.4, 6.1.13	
	OCS Poles on Platforms	To meet National Electrical Safety Code (NESC) requirements. Grounding and Bonding and Protection required per TM 3.2.6.	HST TM 2 2.4, 6.1.14	

CAHSR JM
BRIDGES AND ELEVATED STRUCTURE DESIGN CHECKLIST

DESIGN ELEMENT		HST TM	Caltrain Standards for Design and Maintenance of Structures	BNSF/UPRR Guidelines 1. UPRR - BNSF Railway Guidelines for Railroad Grade Separation Projects (Dated 01/05/2016)	AREMA	CAHSR JM CRITERIA
Superstructure	**General Span/Structure Type**	Proposed basic aerial structure is a prestressed concrete single cell box girder, spanning approximately 100 to 130 feet and supporting two parallel tracks. Simply supported spans. (TM 2.3.3)	Simple span structures are preferred over a continuous span type of superstructure for use along the corridor (2-2). Deck type structures are preferred over hrough type structures. (2-2)	Only simple spans with ballast decks are allowed. Cast-in-place concrete superstructures are unacceptable. (6.1)[1]		Proposed basic aerial structure is a prestressed concrete single cell box girder, spanning approximately 100 to 130 feet and supporting two parallel tracks. Simply supported spans. (TM 2.3.3)
	Structure Type	Prestressed concrete single cell box girder, spanning approximately 100 to 130 feet.	1. Steel rolled beams (4 or more per track) 2. Steel plate girders (4 or more per track) 3. Prestressed concrete box girders or solid slab girders (no voids) 4. Steel rolled beams (2 per track) 5. Prestressed concrete "AASHTO" type girders 6. CIP/RC box girder 7. PT box girder 8. Through type steel structures.	Cast-in-place concrete superstructures are unacceptable. (6.1)[1] 1. Steel rolled beams + steel plate deck (5 or more per track) 2. Steel plate girders + steel plate deck (4 or more per track) 3. Steel rolled beams + concrete deck (5 or more per track) 4. Steel plate girders + concrete deck (4 or more per track) 5. Railroad Standard Prestressed Double Cell Box Beams 6. Prestressed Concrete Box Beams 7. Prestressed Precast Concrete AASHTO Type Beams 8. Through type steel structures. (6.8.1)[1]		Prestressed concrete single cell box girder, spanning approximately 100 to 130 feet.
Substructure	**Type**	10'x6' elliptical single column supports (TM 2.3.3) Substructure to satisfy requirements of TM 2.3.3, Section 6.1 5.	Piers with two columns or solid pier wall are preferred over single column piers. (2.6.1)	Piers with a minimum of two columns shall be provided. A solid pier wall with a minimum of 4'-0" thickness is preferable. Single column piers shall not be considered for Underpass Structures. (6.9.1)[1]		10'x6' elliptical single column supports (TM 2.3.3)
	Skew	---	30 degree maximum, at abutment must be squared off support perpendicular to track (Figure 2-2, page 2-7)	15 degree maximum for concrete structures and 30 degrees max for a steel structure (6.3)[1]	15 degree maximum for precast concrete slabs and box girders, 30 degree maximum for precast concrete I-girder and T-girder, 60 degree maximum for CIP concrete slabs and girders. (8-2.1.6)	
Clearance	**Vertical Permanent Overhead**	27'-0" for new structures (TM 1.1.21) 24'-6" for shared use track (TM 1.1.21)	24'-6" Min. 25'-6" Preferred 23'-6" Absolute Min. (Fig 3.1)	23'-4" minimum within 25'-0" of centerline track (Plan 711100)[1]	23'-0" (Figure 28-1-6)	27'-0" for new structures (TM 1.1.21) 24'-6" for shared use track (TM 1.1.21)
	Vertical Permanent Underpass	16'-6" Freeway / Expressway (TM 1.1.21) Varies / Others (TM 1.1.21)	16'-6" over Freeways and Expressways (2.4 2) 15'-6" over highways and local streets (2.4.2) (Collision protection device required) (Page 2-14)	16'-6" for steel superstructure with 5 or more beams or 4 or more deck plate girders per track 17'-6" for concrete superstructure or steel through plate girders with bolted bottom flanges 20'-0" for steel through plate girders without bolted bottom flanges (6.6.1)[1]		16'-6" Freeway / Expressway (TM 1.1.21) Varies / Others (TM 1.1.21)
	Vertical Temporary	---	21'-6". CPUC approval required for vertical clearance less than 22'-6" (Fig 3.1)	21'-0"		
	Horizontal Permanent Overhead	25' preferred, 12' minimum from CL exterior track to face of column, protection required < 25'-0" (TM 1.1.21)	25' preferred, 15' minimum from CL exterior track to face of column (Fig 3.1)	25'-0" minimum (Plan 711100)[1] Piers within 25'-0" shall be protected. Absolute minimum shall be 18'-0" from centerline track to pier protection wall (5 2.2)[1]	25'-0", less than 25'-0" requires crash walls (Figure 28-1-6) Tangent track, 9'-0" minimum (Figure 28-1-1)	25' preferred, 12' minimum from CL exterior track to face of column, protection required < 25'-0" (TM 1.1.21)
	Horizontal Temporary	---	10'-0" (Note 5, Fig 3.1)	12' for UP (4.4.1)[1]		
Rail	**Ballast Depth**	24" minimum top of tie to deck (Directive Drawing)	8" of ballast over 4" HMAC on structure or 12" HMAC on approach (Fig 2.7)			
Serviceability	**Span to Depth Minimum**	Span Length / 10 (TM 2.3.3)	Span Length / 12.5 (Steel Beam Span, Concrete Box Girder Span, Precast Concrete Beams) (Figure 2.7, 2.8, 2.10, 2.11) Span Length / 10 (Steel Deck Plate Girder Span) (Figure 2.9)			Span Length / 10 (TM 2.3.3)
Loading	**Ballast**	24" minimum top of tie to deck (Directive Drawing)	Min. 12" / Max. 30" (Fig 2.8)	Up to 30" (6.1.1)[1]		
	Live Load	E-50 (TM 2.3.2)	E-80 (2.3.3)	per AREMA (6.1.1)[1]	E-80 (8-2.2 3)	E-80 (2-8)
	Track Placement	Assume that the track locations are fixed transversely.	Tracks can be placed anywhere on deck to maximize load.			Assume that the track locations are fixed transversely.
Construction	**Excavation adjacent to tracks**	N/A	8'-6" minimum from centerline of track unless approved by Chief Engineer (Appendix B)	Excavation not permitted within 12'-0" of track centerline. (Standard Plan 710000)		

CAHSR JM
BRIDGES AND ELEVATED STRUCTURE DESIGN CHECKLIST

DESIGN ELEMENT		HST TM	Caltrain Standards for Design and Maintenance of Structures	BNSF/UPRR Guidelines 1. UPRR - BNSF Railway Guidelines for Railroad Grade Separation Projects (Dated 01/05/2016)	AREMA	CAHSR JM CRITERIA
STRUCTURE DESIGN LOADS	6.4 Permanent Loads	**TM 2.3.2** o 6.4.1 Dead Load (DC, DW, EV) o 6.4.2 Downdrag Force (DD) o 6.4.3 Earth Pressure (EV, EHAC, EHAR) o 6.4.4 Earth Surcharge (ES) o 6.4.5 Earth Settlement Effects (SE) o 6.4.6 Creep Effects (CR) o 6.4.7 Shrinkage Effects (SH) o 6.4.8 Secondary Forces from Prestressing (PS) o 6.4.9 Locked-In Construction Forces (EL) o 6.4.10 Water Loads (WA)	**Chap 2.3.3 Design Load for Railroad Bridge Structures** **Dead Loads: Table 2.1**	**AREMA CHAPTER 11**	**AREMA CHAPTER 11** **Dead Loads: Table 2.1**	**TM 2.3.2** Dead Load (DC, DW, EV) Downdrag Force (DD) Earth Pressure (EV, EHAC, EHAR) Earth Surcharge (ES) Earth Settlement Effects (SE) Creep Effects (CR) Shrinkage Effects (SH) Secondary Forces from Prestressing (PS) Locked-In Construction Forces (EL) Water Loads (WA)
	Transient Loads	o 6.5.1 Live Loads (LLP, LLV, LLRR, LLHR, LLH, LLHL, LLHT) o 6.5.2 Vertical Impact Factors (I) o 6.5.3 Centrifugal Force (CF) o 6.5.4 Trac ion and Braking Forces (LF) o 6.5.5 Nosing and Hunting Effects (NE) o 6.5.6 Wind Loads (WS) o 6.5.7 Slipstream Effects (SS) o 6.5.8 Thermal Load o 6.5.9 Frictional Forces (FR) o 6.5.10 Seismic Loads (EQM, EQD, EQL) o 6.5.11 Derailment Load (DR) o 6.5.12 Dynamic Earth Pressures (ED) o 6.5.13 Derailment Loads (DR) o 6.5.14 Collision Loads (CL)	**Chap 2.3.3 Design Load for Railroad Bridge Structures** **Live Load: Cooper E-80** **AREMA CHAPTER 11**	**AREMA CHAPTER 11**	**AREMA CHAPTER 11** **Live Load: Cooper E-80**	Live Loads (LLP, LLV, LLRR, LLHR, LLH, LLHL, LLHT) Vertical Impact Factors (I) Centrifugal Force (CF) Traction and Braking Forces (LF) Nosing and Hunting Effects (NE) Wind Loads (WS) Slipstream Effects (SS) Thermal Load Frictional Forces (FR) Seismic Loads (EQM, EQD, EQL) Derailment Load (DR) Dynamic Earth Pressures (ED) Derailment Loads (DR) Collision Loads (CL)
	Miscellaneous Loads	o 6.6.1 Overhead Contact System (OCS) Loads o 6.6.2 Construction Loads and Temporary Structures o 6.6.3 Rail-Structure Interaction Forces o 6.6.4 Blast Loading	**AREMA CHAPTER 11**	**AREMA CHAPTER 11**	**AREMA CHAPTER 11**	Overhead Contact System (OCS) Loads Construction Loads and Temporary Structures Rail-Structure Interaction Forces Blast Loading
	Load Factors and Load Modifiers	o 6.7.1 Design Load Combinations o 6.7.2 Resistance Factors	**AREMA CHAPTER 11** **Design Load Combinations: GROUP I & GROUP II**		**AREMA CHAPTER 11** **Design Load Combinations: GROUP I & GROUP II**	Design Load Combinations Resistance Factors
DESIGN GUIDELINES FOR HIGH-SPEED TRAIN AERIAL STRUCTURES	Basic High-Speed Train Aerial Structure	**TM 2.3.3** o 6.1.1 Material Type o 6.1.2 Constructability o 6.1.3 Span Length and Span to Depth Ratio o 6.1.4 Span Articula ion o 6.1.5 Substructures	**n/a**	**n/a**	**n/a**	**TM 2.3.3** Material Type Constructability Span Length and Span to Depth Ratio Span Articulation Substructures
TYPICAL CROSS SECTIONS FOR 15% DESIGN		**TM 1.1.21** o 6.1.2 Track Centers o 6.1.3 Overhead Contact System (OCS) Poles o 6.1.4 Walkways o 6.1.5 Drainage Requirement o 6.1.6 Systems Elements Requirement o 6.1.7 Access Control Appendix B: Supplemental Criteria In Shared Rail Corridors	**See Track Alignment Check List**	**See Track Alignment Check List**	**See Track Alignment Check List**	**TM 1.1.21** Track Centers Overhead Contact System (OCS) Poles Walkways Drainage Requirement Systems Elements Requirement Access Control
INTERIM SEISMIC DESIGN CRITERIA		**TM 2.10.4** 6.5 Bridges and Aerial Structures	**CHAPTER 4 Design Guide line for SEISMIC DESIGN**	**AREMA CHAPTER 9 SEISMIC DESIGN**	**AREMA CHAPTER 9 SEISMIC DESIGN**	**TM 2.10.4** Bridges and Aerial Structures
DEPTH OF DECK		**Design Criteria 5.9** T/R to top of deck is 3.0ft for ballasted track (DC 5.10) or 2.5ft for direct fixation track	**n/a**	**n/a**	**n/a**	T/R to top of deck is 3.0ft for ballasted track (DC 5.10) or 2.5ft for direct fixation track
THERMAL LENGTH		**Design Criteria 12.6.5.2** The thermal length kept under the 330ft threshold	**n/a**	**n/a**	**n/a**	The thermal length kept under the 330ft threshold
EMERGENCY ACCESS		**Design Criteria** Emergency Access is provided at a minimum of 2.5 miles via stairs	**n/a**	**n/a**	**n/a**	Emergency Access is provided at a minimum of 2.5 miles via stairs

CAHSR JM
TUNNELS DESIGN CHECKLIST

DESIGN ELEMENT	CAHSR JM DEDICATED HST CRITERIA	REFERENCE
Tunnel Plan and Profile		
1	22 feet width for emergency access road is provided on either side of the tracks.	TM 2.8.1
Tunnel Cross Section		
1	Tunnel diameter is shown at 28ft inner diameter.	NTD. 10 R1
2	Cross passages are shown at every 800ft	TM 2.4.2 R1
3	Finished bored tunnel cross sectional area includes the following: - Free tunnel cross sectional area as required - 20 sf for fixed equipment - 6-inch allowance on diameter for construction tolerance - 3-foot depth of invert concrete - An escape walkway at track level (slightly raised above invert level)	TM 2.4.2 R1
Tunnel Portal		
1	The tunnel portal is located where a minimum ground cover of half tunnel diameter can be provided over both tunnels, unless otherwise indicated.	TM 2.4.5 R0
Cut Slopes and Embankments (Pacheco Pass Subsection)		
1	For cut slopes, the slope angle shown in 3H:1V, unless otherwise specified.	TM 2.6.7
2	For embankments, the slope angle is assumed to be 2H:1V, unless otherwise specified.	TM 2.6.7
3	Slope benches are provided at every 30 feet for cut slopes and embankments higher than 30 feet.	DC 10.9.4, TM 2.6.7
4	Slope benches of at least 10 feet wide are provided for cut slopes and embankments higher than 30 feet.	DC 10.9.4, TM 2.6.7
Tunnel Portal Facilities		
1	Space is allocated for the following facilities at each tunnel portal unless otherwise indicated: - Detention pond - TPF site (2 options) - Rescue area (5000 sq. ft) - Train evacuation zone (1400') - Maintenance parking - 22' width maintenance access road - Radio tower site (100' x 100') - Water tanks (100' x 100')	Directive drawing: DD-TN-400 and discussions with RDP
2	Area of approximately 7500 sf is allocated for portal ventilation buildings	TM 2.4.6 R0

CAHSR JM
GRADING DESIGN CHECKLIST

DESIGN ELEMENT	CAHSR JM DEDICATED HST CRITERIA		REFERENCE	COMMENTS
Slope Angles	Normally Adopted	1.5H:1V or 2H:1V	HST TM 2.6.7	
	In case of coarse rock fill, benches, toe walls	1H:1V or 1.25H:1V		
	For slopes supported by compressible soft foundation soils	required slope stability analyses		
	For 15% Design Level: Soil Cuts	2H:1V		
	For 15% Design Level: Rock Cuts	1H:1V		
	Granular Soils	1.5H:1V to 2H:1V according to the height of the cut		
	Cohesive Soils	1.5H:1V to 2H:1V according to the height of the cut, or even flatter, with benches if required		
	Pre-historic landslide areas	required slope stability analyses		
Specific Consideration for Maintenance According to the Structure Height	Cuts with depth greater than 40' or Embankment over 40' height	6 feet wide bench with a 6% gradient toward the toe of the slope/the high-side line	HST TM 2.6.7	
		Place bench every 30 feet in height (allowance from 26 to 32 feet can be considered)		
		The bench shall be connected to the natural ground at each end of the cut/ground for access.		

CAHSR JM
HYDROLOGY / HYDRAULICS / DRAINAGE DESIGN CHECKLIST

DESIGN ELEMENT	HST TM 2.6.5	CALTRAIN DESIGN STANDARD (Chapter 8)	CALTRANS HDM	Amtrak Spec No. 63	CAHSR JM DEDICATED HST CRITERIA
Storm Frequency	Drainage Facilities Crossing the HST track (i.e. culverts) Urban 1% (100-yr) Rural 2% (50-yr) Drainage facilities not crossing the HST track (i e. parking lots, station drainage facilities) Urban 2% (50-yr) Rural 10% (10-yr) Ditches/storm drainage systems adjacent to the HST track Urban 2% (50-yr) Rural 4% (25-yr) Drainage systems crossing under bridge structure and on the ROW Urban 1% (100-yr) Rural 2% (50-yr) Critical Facilities (Electrical, vents, communication buildings, etc.) Min 1% (100-yr)	Culverts crossing beneath at-grade track 100-yr Yard & Station runoff collection systems (including those in streets and parking lots) 100-yr Ditches 50-yr Drainage systems crossing under bridge structure and on the ROW 100-yr Strom drain systems adjacent to tracks 100-yr All facilities 100-yr	Refer to Hydraulic Engineering Circular No. 22, 3rd Edition Most highway agencies min. 10-year drain sag points min. 50-year High check storm 100-year	Drainage Facilities 100-yr	Drainage Facilities Crossing the HST track (i.e. culverts) Urban 1% (100-yr) Rural 2% (50-yr) Drainage facilities not crossing the HST track (i e. parking lots, station drainage facilities) Urban 2% (50-yr) Rural 10% (10-yr) Ditches/storm drainage systems adjacent to the HST track Urban 2% (50-yr) Rural 4% (25-yr) Drainage systems crossing under bridge structure and on the ROW Urban 1% (100-yr) Rural 2% (50-yr) Critical Facilities (Electrical, vents, communication buildings, etc.) Min 1% (100-yr)
Basin Characteristics	Refer to Caltrans HDM, Topic 812	Not Defined	Size, Shape, Slope, Land Use, Soil and Geology, Storage, Elevation, and Orientation are the characters described in Topic 812.	Not Defined	Refer to Caltrans HDM, Topic 812
Design Discharge	Refer to Caltrans HDM, Topic 819	Max expected discharge from drainage tributary area shall be computed by using the Rational Method Facilities owned and/or maintained by the Local Agency, the design discharge shall be computed using other applicable procedures as required and approved by the Local Agency Precipitation, intensity, and duration data shall be based on the data either from San Francisco, San Mateo, or Santa Clara counties depending on where the project is located	Refer to Caltrans HDM, Topic 819, Table 819 5A Summary of Methods for Estimating Design Discharge Empirical methods have been used in hydrology, including: Rational methods, Regional Analysis Methods, Flood Frequency Analysis, National Resources Conservation Service (NRCS) Methods, Statistical Methods, Hydrograph Methods	Not Defined	Refer to Caltrans HDM, Topic 819
Floodplain Information	FEMA provides floodplain maps with flood zones identified improvements cannot be higher than the 100-year BFE Refer to Caltrans HDM, Topic 804, Floodplain Encroachments, for FEMA guidelines	Not Defined	23CFR, Section 650.115 Identify flood hazards Water surface elevation for the 100-yr flood Provide floodway data	Not Defined	FEMA provides floodplain maps with flood zones identified improvements cannot be higher than the 100-year BFE Refer to Caltrans HDM, Topic 804, Floodplain Encroachments, for FEMA guidelines Consult with local flood control agency.
Application of Approved Software	Hydrologic/hydraulic - industry accepted design programs are recommended (see Caltrans HDM Topic 808.	Follow Caltrans HDM/Local Agency	Various H&H software including FHWA Hydraulic Toolbox, TR-55, HEC-HMS, HY-8, HEC-RAS, FESWMS, WMS, NOAA Atlas 14, USGS SteamStats, AutoDesk Civil 3D/Hydraflow	Not Defined	Hydrologic/hydraulic - industry accepted design programs are recommended (see Caltrans HDM Topic 808.
Culvert Design	Max allowable headwater of 1.5 times pipe diameter up 0.5 feet below sub-ballast. For 100-year storm event, min freeboard between water surface elevation and the subballast shall be 2 feet 36" Min. Dia RCP (Class V) within ROW Min. 6' below top of rail, and 3' below the flow line of ditch along the track way For pipes not under track use 4' of cover with 45' of the track centerline & 3' min elsewhere	Min. diameter 12" Pipes directly under the track or within 15' from centerline of the tracks: Caltrans Class V RCP required pipe size min. 24" diameter	Caltrans HDM, Topic 825 Min diameter for cross culverts under the roadways 18" Self-cleaning velocity, pipe sizes of 18" or more in diameter should be considered Pipe runs exceed 100' between inlet and outlet, or intermediate cleanout access, the min. diameter of pipe to be used is 24" Larger diameter pipe without the median access is preferred	n/a	Max allowable headwater of 1.5 times pipe diameter up 0.5 feet below sub-ballast. For 100-year storm event, min freeboard between water surface elevation and the subballast shall be 2 feet 36" Min. Dia RCP (Class V) within ROW Min. 6' below top of rail, and 3' below the flow line of ditch along the track way For pipes not under track use 4' of cover with 45' of the track centerline & 3' min elsewhere
Open Channel Design	Avoid critical and supercritical flow in trackside ditches Ditches should be deep enough and sized for handling the design runoff anticipated while allowing the subgrade to drain Required minimum freeboard, minimize erosion, maintain soil stability Refer AREMA Chapter 1, Part 1 for design adjacent to tracks. Also refer to Caltrans HDM Topic 860.	Not Defined	Caltrans HDM, Topic 860 The shape of a channel section is generally determined by considering the intended purposed, terrain, flow velocity and quantity of flow to be conveyed. Rectangular Channel Freeboard Height Subcritical Flow: 0.1He Supercritical Flow: 0 20d Trapezoidal Channel Freeboard Height Subcritical Flow: 0.2He Supercritical Flow: 0 25d	Not Defined	Avoid critical and supercritical flow in trackside ditches Ditches should be deep enough and sized for handling the design runoff anticipated while allowing the subgrade to drain Required minimum freeboard, minimize erosion, maintain soil stability Refer AREMA Chapter 1, Part 1 for design adjacent to tracks. Also refer to Caltrans HDM Topic 860.
Bridge/Aerial Structure Design	Freeboard above the design frequency water surface elevation min. 2' For ballasted bridge deck drains up to 500' Min. 6" pipe For ballasted bridge deck drains over 500' 8" pipe Longitudinal slope on bridge deck min. 0.5% Or generate minimum velocity 2 ft/sec No standing water on bridge HEC-21 Design of Bridge Drainage HDS-01 Hydraulic of Bridge Waterways AREMA Chapter 1, Part 3 HEC-09, Debris Control Structures Evaluations nd Countermeasures	Not Defined	Not Defined	Not Defined	Freeboard above the design frequency water surface elevation min. 2' For ballasted bridges lengths up to 500' Min. 6" pipe For ballasted bridges lengths over 500' 8" pipe Longitudinal slope on bridge deck min. 0.5% Or generate minimum velocity 2 ft/sec No standing water on bridge
Underdrain System	HDS-01 Hydraulics of Bridge Waterways AREMA Chapter 1, Part 3 HEC-09, Debris Control Structures Evaluations and Countermeasures Refer Caltrain Chapter 8.0 & Caltrans HDM	min. 6" in diameter at min. grade of 0.2% Cleanout Every 300' Manhole/inlet spacing 500' max (up to 30" diameter) 600' - 1000' (>30" diameter) Pipe cover below top of rail min. 48"	n/a for track	Not Defined	min 6" in diameter Cleanout installed every 300' pipe cover min. 48" below top of rail for all pipes Refer to Caltrain Chapter 8 0 & Caltrans HDM
Roadway Drainage	Refer Caltrans HDM, Topic 830	Not Defined	Min pipe diameter for storm drain systems Trunk drain 18" Trunk Laterals 15" Inlet Laterals 15"	Not Defined	Refer Caltrans HDM, Topic 830

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DESIGN ELEMENT	HST TM 2.6.5	CALTRAIN DESIGN STANDARD (Chapter 8)	CALTRANS HDM	Amtrak Spec No. 63	CAHSR JM DEDICATED HST CRITERIA
Pump Station	Refer HEC-24 to design pumps & pump stations	Avoid as much as possible Require prior approval of Caltrain Deputy Director of Engineering	District and the Division of Structures responsible for the design	Not Defined	Refer HEC-24 to design pumps & pump stations
Debris Control	Refer FHWA, HEC-9 on Debris Control Structures Evaluation & Countermeasures Refer Caltrans HDM, Topic 822	Not Defined	Refer FHWA Hydraulic Engineering Circular No. 9 to aid the designer in selecting the appropriate type of debris control structures	Not Defined	Refer FHWA, HEC-9 on Debris Control Structures Evaluation & Countermeasures Refer Caltrans HDM, Topic 822
Detention / Retention of Surface Water Runoff	Refer Caltrans Project Planning and Design Guide HEC-22, Urban Drainage Design Manual, FHWA	Not Defined		Not Defined	Refer Caltrans Project Planning and Design Guide HEC-22, Urban Drainage Design Manual, FHWA Consult with local flood control agency.

CAHSR JM
UTILITIES DESIGN CHECKLIST

DEDICATED HST CRITERIA | COMMON CRITERIA | DEDICATED CALTRAIN CRITERIA | DEDICATED UPRR CRITERIA

DESIGN ELEMENT	HST TM 2.7.4	CALTRAIN DESIGN STANDARD (CHPATER 8)	CALIFORNIA PUBLIC UTILITIES COMMISSION	UP Wireline/Pipeline Encroachment Planning Guide & Construction Procedures	DEDICATED HST CRITERIA	DEDICATED CALTRAIN CRITERIA	DEDICATED UPRR CRITERIA	COMMENTS
Underground Utilities	Underground facilities located within the right of way must be located in a steel casing pipe (3/8" minimum thickness) with welded joints. Exception: For electrical and communication lines, a duct bank can be used in lieu of steel casing pipe. Where a portion of the line crosses under the tracks or is located within 45 feet of the nearest track centerline, it must meet the requirements of Exhibit A. Underground Utilities High Risk facilities: • Maintain 500 feet minimum horizontal separation from other High Risk facilities • Maintain 5 feet minimum horizontal separation from other Low Risk facilities • Maintain 20 feet minimum horizontal separation from load carrying structural elements Underground Utilities Low Risk facilities: • Maintain 3 feet minimum horizontal separation from other Low Risk facilities • Maintain 5 feet minimum horizontal separation from load carrying structural elements and 3 feet minimum horizontal separation from other structures • Maintain 1 foot minimum vertical separation from drainage conduits	Utilities specifically designed for the Caltrain facilities at stations and right-of-way shall conform to the standards, codes, and requirements of the CPUC and the local jurisdiction within which the utilities are located, as appropriate. Third party utilities owners include private owners, state, and municipal government. Work shall be coordinated with and done in accordance with the standards of the utilities owner.	Clearance and Depth Requirements for Supply and Communication Systems: General Order No. 128 Appendix A. Table 1	If the proposed location of the encroachment crosses existing culverts, the top of the buried encroachment will have to be installed a minimum of 5' below the culvert invert. If the location crosses a ditch beyond the end of the culvert (field side) then the top of the buried encroachment must be installed 5' below the clean bottom elevation of the ditch. Track bores must be a minimum of 60 inches below base of rail. Wet bores are not permitted on Union Pacific property. The ends of steel casing (see Union Pacific Common Standard 1029) will have to be a minimum of 30 feet from centerline of the track when measured at right angle to the track. Also, bore pits must be a minimum of 30 feet from centerline of track when measured at right angle to the track. In addition, no bore pits can be located in the slope of a cut or fill section of the roadbed. The bore pit size must be kept to a minimum. Manholes must be capable of withstanding H-20 highway loading requirements and must be installed so as not to create a stumbling hazard.	Underground facilities located within the right of way must be located in a steel casing pipe (3/8" minimum thickness) with welded joints. Exception: For electrical and communication lines, a duct bank can be used in lieu of steel casing pipe. Where a portion of the line crosses under the tracks or is located within 45 feet of the nearest track centerline, it must meet the requirements of Exhibit A. Underground Utilities High Risk facilities: • Maintain 500 feet minimum horizontal separation from other High Risk facilities • Maintain 5 feet minimum horizontal separation from other Low Risk facilities • Maintain 20 feet minimum horizontal separation from load carrying structural elements Underground Utilities Low Risk facilities: • Maintain 3 feet minimum horizontal separation from other Low Risk facilities • Maintain 5 feet minimum horizontal separation from load carrying structural elements and 3 feet minimum horizontal separation from other structures • Maintain 1 foot minimum vertical separation from drainage conduits Underground Electric Supply and Communication Systems: General Order No. 128	Utilities specifically designed for the Caltrain facilities at stations and right-of-way shall conform to the standards, codes, and requirements of the CPUC and the local jurisdiction within which the utilities are located, as appropriate. Third party utilities owners include private owners, state, and municipal government. Work shall be coordinated with and done in accordance with the standards of the utilities owner. Clearance and Depth Requirements for Supply and Communication Systems: General Order No. 128 Appendix A. Table 1	If the proposed location of the encroachment crosses existing culverts, the top of the buried encroachment will have to be installed a minimum of 5' below the culvert invert. If the location crosses a ditch beyond the end of the culvert (field side) then the top of the buried encroachment must be installed 5' below the clean bottom elevation of the ditch. Track bores must be a minimum of 60 inches below base of rail. Wet bores are not permitted on Union Pacific property. The ends of steel casing (see Union Pacific Common Standard 1029) will have to be a minimum of 30 feet from centerline of the track when measured at right angle to the track. Also, bore pits must be a minimum of 30 feet from centerline of track when measured at right angle to the track. In addition, no bore pits can be located in the slope of a cut or fill section of the roadbed. The bore pit size must be kept to a minimum. Manholes must be capable of withstanding H-20 highway loading requirements and must be installed so as not to create a stumbling hazard.	
Overhead Utilities	Except for electrical and communication lines, overhead utilities shall cross the tracks at local street overpasses encased in a steel casing sleeve. Where electrical and communication lines cannot be accommodated in an overpass structure, their design shall be governed by the requirements of CPUC General Orders.	Minimum Vertical Clearance per CPUC General Order 95: Standard Drawing SD-2005	Minimum Clearances of Wires above Railroads: General Order No. 95 Section III Table 1	N/A	Except for electrical and communication lines, overhead utilities shall cross the tracks at local street overpasses encased in a steel casing sleeve. Where electrical and communication lines cannot be accommodated in an overpass structure, their design shall be governed by the requirements of CPUC General Orders. Minimum Clearances of Wires above Railroads: General Order No. 95 Section III Table 1	Minimum Clearances of Wires above Railroads: General Order No. 95 Section III Table 1 Minimum Vertical Clearance per CPUC General Order 95: Standard Drawing SD-2005	N/A	
Above Ground Utilities	In exclusive Authority right of way, all above ground utilities shall be moved outside of the right of way or conform to the requirements of Sections 6.3.1 and 6.3.2. In shared corridors, where design and location of existing utilities may be governed by existing agreements, and where relocation of the utility will have significant impact with respect to cost, environment or public inconvenience, the designer shall investigate the use of fencing, walls, cages, or other sources of protection in order to separate or isolate the utility from CHSTP features.	N/A	Minimum Clearances of Wires above Railroads: General Order No. 95 Section III Table 1	N/A	In exclusive Authority right of way, all above ground utilities shall be moved outside of the right of way or conform to the requirements of Sections 6.3.1 and 6.3.2. In shared corridors, where design and location of existing utilities may be governed by existing agreements, and where relocation of the utility will have significant impact with respect to cost, environment or public inconvenience, the designer shall investigate the use of fencing, walls, cages, or other sources of protection in order to separate or isolate the utility from CHSTP features. Minimum Clearances of Wires above Railroads: General Order No. 95 Section III Table 1	Minimum Clearances of Wires above Railroads: General Order No. 95 Section III Table 1	N/A	
Exempt Utilities	Exemptions from these requirements will not be permitted. Where the requirements of this technical memorandum 2.7.4 can not be met, the Design Variance process shall be followed.	N/A	N/A	N/A	Exemptions from these requirements will not be permitted. Where the requirements of this technical memorandum 2.7.4 can not be met, the Design Variance process shall be followed.	N/A	N/A	
Location of Proposed Utilities	Proposed utilities that are not related to the operation and maintenance of CHSTP shall be located outside the Authority right of way.	N/A	N/A	The wireline/pipeline (encroachment) must be located at the outer limits of railroad right-of-way within 5 feet of property line and a minimum of 35 feet from centerline of nearest track.	Proposed utilities that are not related to the operation and maintenance of CHSTP shall be located outside the Authority right of way.	N/A	The wireline/pipeline (encroachment) must be located at the outer limits of railroad right-of-way within 5 feet of property line and a minimum of 35 feet from centerline of nearest track.	

10/12/2016

CAHSR JM GEOTECHNICAL DESIGN CHECKLIST

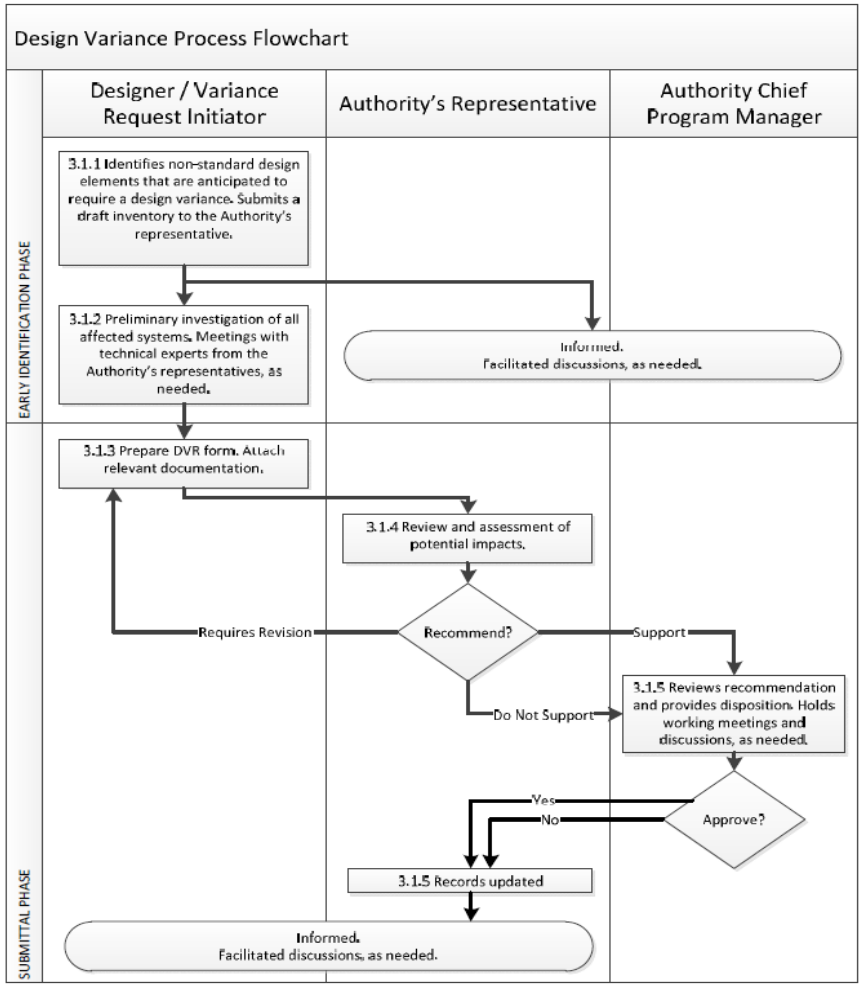
Three Geotechnical Investigation Plans and one Geotechnical Data Report were prepared by ENGEO between March and Sept 2016. These reports do not contain recommendations nor design values. Therefore, a design checklist would not be generated.

CAHSR JM RIGHT OF WAY DESIGN CHECKLIST

The High Speed Rail Authority has not promulgated geometric criteria for Right of Way. Right of way limits, both permanent and temporary construction easements (TCEs), are designed taking a number of factors into account. Many of these are qualitative and have to do with the surroundings of the rail alignment. HSRA design guidance exists for typical cross-sections. The right of way width and TCE limits vary for different standard cross-sections. Right of way and TCE will also vary depending on surrounding topography and land features, development, environmental considerations, and a host of other non-quantifiable conditions. For these reasons, right of way and TCE are generally determined by the judgment of the engineers, which reflects railroad clearance and alignment requirements, but also the many other factors that do not lend themselves to strict quantification.

Therefore, a design checklist would not be generated.

CAHSR FJ
GENERAL DESIGN CHECKLIST

DESIGN ELEMENT	DEDICATED HST CRITERIA (HST TM 1.1.18)	DEDICATED CALTRAIN CRITERIA (CALTRAIN DESIGN STANDARD- Chapter 1)	DEDICATED UPRR CRITERIA
DESIGN VARIANCE PROCESS		Standard ('shall') means required, no exception. Guidance ('should') means recommended, involving engineering judgment. Option ('may') means permission. Support is informational statement. Any deviations from all these criteria shall receive prior aproval by The Caltrain Deputy Director of Engineering. It shall be noted that variances or deviations are not for convenience. They shall be very rare, and only as a last resource and only after exhaustive analysis. Designers or other Project personnel shall not request a variance based on precedence. To request a variance, designers shall prepare written justifications documenting the reasons and justifications. If approved, the variance is only valid for the specific location of the project. This variance can not be used for future variance request. Any design variances shall never be less than the regulatory standards, and shall not introduce unacceptable safety and functionality of the railroad.	N/A
DOCUMENT CONTROL	1) Design Variance Request Form 2) Required Data 3) Supporting Documentation	To request a variance, designers shall prepare written justifications documenting the reasons and justifications.	N/A

CAHSR JM
SYSTEMS DESIGN CHECKLIST

	HIGH-SPEED TRAIN TM			HIGH-SPEED TRAIN DIRECTIVE DRAWING			HIGH-SPEED TRAIN NTD			CAHSR JM DEDICATED HST CRITERIA		COMMENTS
AUTOMATIC TRAIN CONTROL SITE												
TYPE A SITE	SITE SIZE	TM 3.3.2	45'x25'	SITE SIZE	TM-3.3.2-DD	70'x35'	SITE SIZE	NTD 11	70'x35'	SITE SIZE	70'x35'	NO REQUIREMENT ON SIZE OF PARKING AREA
	LOCATION	TM 3.3.2	WITHIN INTERLOCKING LIMITS	LOCATION		-	LOCATION	NTD 11	WITHIN INTERLOCKING LIMITS	LOCATION	WITHIN INTERLOCKING LIMITS	
	ALTERNATE LOCATION		N/A	ALTERNATE LOCATION	TM-3.3.2-AA	PROVIDED ON OPPOSITE SIDE OF TRACK WHERE POSSIBLE	ALTERNATE LOCATION	NTD 11	PROVIDED ON OPPOSITE SIDE OF TRACK WHERE POSSIBLE	ALTERNATE LOCATION	PROVIDED ON OPPOSITE SIDE OF TRACK WHERE POSSIBLE	
	SITE POSITION	TM 3.3.2	LONGEST SIDE OF ATC SITES PARALLEL TO MAIN TRACKS	SITE POSITION	TM-3.3.2-CC	LONGEST SIDE OF ATC SITES PARALLEL TO MAIN TRACKS	SITE POSITION	NTD 11	LONGEST SIDE OF ATC SITES PARALLEL TO MAIN TRACKS	SITE POSITION	LONGEST SIDE OF ATC SITES PARALLEL TO MAIN TRACKS	
	SITE SPACING		N/A	SITE SPACING		N/A	SITE SPACING		N/A	SITE SPACING	N/A	
	ACCESS REQUIRED	TM 3.3.2 TM 2.8.1	ACCESS ROAD AND GATE	ACCESS REQUIRED		-	ACCESS REQUIRED	NTD 11	ACCESS ROAD AND GATE	ACCESS REQUIRED	ACCESS ROAD AND GATE	
	PARKING	TM 3.3.2 TM 2.8.1	REQUIRED FOR EACH SITE	PARKING		-	PARKING	NTD 11	REQUIRED FOR EACH SITE	PARKING	REQUIRED FOR EACH SITE	
	STAIRWAY	TM 3.3.2	WITHIN 250' OF ATC SITES FROM PARKING AREATO R/W FOR ELEVATED STRUCTURE OR IN A CUT	STAIRWAY		-	STAIRWAY	NTD 11	WITHIN 250' OF ATC SITES FROM PARKING AREATO R/W FOR ELEVATED STRUCTURE OR IN A CUT	STAIRWAY	WITHIN 250' OF ATC SITES FROM PARKING AREATO R/W FOR ELEVATED STRUCTURE OR IN A CUT	
TYPE AA SITE	SITE SIZE			SITE SIZE	TM-3.3.2-DD	90'x35'	SITE SIZE	NTD 11	90'x35'	SITE SIZE	90'x35'	NO REQUIREMENT ON SIZE OF PARKING AREA
	LOCATION			LOCATION		-	LOCATION	NTD 11	WITHIN INTERLOCKING LIMITS	LOCATION	WITHIN INTERLOCKING LIMITS	
	ALTERNATE LOCATION			ALTERNATE LOCATION		N/A	ALTERNATE LOCATION		N/A	ALTERNATE LOCATION	N/A	
	SITE POSITION			SITE POSITION	TM-3.3.2-CC	LONGEST SIDE OF ATC SITES PARALLEL TO MAIN TRACKS	SITE POSITION	NTD 11	LONGEST SIDE OF ATC SITES PARALLEL TO MAIN TRACKS	SITE POSITION	LONGEST SIDE OF ATC SITES PARALLEL TO MAIN TRACKS	
	SITE SPACING			SITE SPACING		N/A	SITE SPACING		N/A	SITE SPACING	N/A	
	ACCESS REQUIRED			ACCESS REQUIRED		-	ACCESS REQUIRED	NTD 11	ACCESS ROAD AND GATE	ACCESS REQUIRED	ACCESS ROAD AND GATE	
	PARKING			PARKING		-	PARKING	NTD 11	REQUIRED FOR EACH SITE	PARKING	REQUIRED FOR EACH SITE	
	STAIRWAY			STAIRWAY		-	STAIRWAY	NTD 11	WITHIN 250' OF ATC SITES FROM PARKING AREATO R/W FOR ELEVATED STRUCTURE OR IN A CUT	STAIRWAY	WITHIN 250' OF ATC SITES FROM PARKING AREATO R/W FOR ELEVATED STRUCTURE OR IN A CUT	
TYPE B SITE	SITE SIZE	TM 3.3.2	30'x25'	SITE SIZE	TM-3.3.2-DD	30'x35'	SITE SIZE	NTD 11	30'x35'	SITE SIZE	30'x35'	NO REQUIREMENT ON SIZE OF PARKING AREA
	LOCATION	TM 3.3.2	WITHIN INTERLOCKING LIMITS	LOCATION		-	LOCATION	NTD 11	WITHIN INTERLOCKING LIMITS	LOCATION	WITHIN INTERLOCKING LIMITS	
	ALTERNATE LOCATION		N/A	ALTERNATE LOCATION	TM-3.3.2-AA, TM-3.3.2-BB	PROVIDED ON OPPOSITE SIDE OF TRACK WHERE POSSIBLE	ALTERNATE LOCATION	NTD 11	PROVIDED ON OPPOSITE SIDE OF TRACK WHERE POSSIBLE	ALTERNATE LOCATION	PROVIDED ON OPPOSITE SIDE OF TRACK WHERE POSSIBLE	
	SITE POSITION		-	SITE POSITION		-	SITE POSITION		-	SITE POSITION	N/A	
	SITE SPACING		N/A	SITE SPACING		N/A	SITE SPACING		N/A	SITE SPACING	N/A	
	ACCESS REQUIRED	TM 3.3.2 TM 2.8.1	ACCESS ROAD AND GATE	ACCESS REQUIRED		-	ACCESS REQUIRED	NTD 11	ACCESS ROAD AND GATE	ACCESS REQUIRED	ACCESS ROAD AND GATE	
	PARKING	TM 3.3.2 TM 2.8.1	REQUIRED FOR EACH SITE	PARKING		-	PARKING	NTD 11	REQUIRED FOR EACH SITE	PARKING	REQUIRED FOR EACH SITE	
	STAIRWAY	TM 3.3.2	WITHIN 250' OF ATC SITES FROM PARKING AREATO R/W FOR ELEVATED STRUCTURE OR IN A CUT	STAIRWAY		-	STAIRWAY	NTD 11	WITHIN 250' OF ATC SITES FROM PARKING AREATO R/W FOR ELEVATED STRUCTURE OR IN A CUT	STAIRWAY	WITHIN 250' OF ATC SITES FROM PARKING AREATO R/W FOR ELEVATED STRUCTURE OR IN A CUT	
TYPE C SITE	SITE SIZE	TM 3.3.2	35'x25'	SITE SIZE	TM-3.3.2-DD	35'x35'	SITE SIZE	NTD 11	35'x35'	SITE SIZE	35'x35'	NO REQUIREMENT ON SIZE OF PARKING AREA
	LOCATION	TM 3.3.2	WITHIN INTERLOCKING LIMITS	LOCATION		-	LOCATION	NTD 11	WITHIN INTERLOCKING LIMITS	LOCATION	WITHIN INTERLOCKING LIMITS	
	ALTERNATE LOCATION		N/A	ALTERNATE LOCATION	TM-3.3.2-AA	PROVIDED ON OPPOSITE SIDE OF TRACK WHERE POSSIBLE	ALTERNATE LOCATION	NTD 11	PROVIDED ON OPPOSITE SIDE OF TRACK WHERE POSSIBLE	ALTERNATE LOCATION	PROVIDED ON OPPOSITE SIDE OF TRACK WHERE POSSIBLE	
	SITE POSITION		-	SITE POSITION		-	SITE POSITION		-	SITE POSITION	N/A	
	SITE SPACING		N/A	SITE SPACING		N/A	SITE SPACING		N/A	SITE SPACING	N/A	

CAHSR JM
SYSTEMS DESIGN CHECKLIST

	HIGH-SPEED TRAIN TM			HIGH-SPEED TRAIN DIRECTIVE DRAWING			HIGH-SPEED TRAIN NTD			CAHSR JM DEDICATED HST CRITERIA		COMMENTS
	ACCESS REQUIRED	TM 3.3.2 TM 2.8.1	ACCESS ROAD AND GATE	ACCESS REQUIRED		-	ACCESS REQUIRED	NTD 11	ACCESS ROAD AND GATE	ACCESS REQUIRED	ACCESS ROAD AND GATE	
	PARKING	TM 3.3.2 TM 2.8.1	REQUIRED FOR EACH SITE	PARKING		-	PARKING	NTD 11	REQUIRED FOR EACH SITE	PARKING	REQUIRED FOR EACH SITE	
	STAIRWAY	TM 3.3.2	WITHIN 250' OF ATC SITES FROM PARKING AREATO R/W FOR ELEVATED STRUCTURE OR IN A CUT	STAIRWAY		-	STAIRWAY	NTD 11	WITHIN 250' OF ATC SITES FROM PARKING AREATO R/W FOR ELEVATED STRUCTURE OR IN A CUT	STAIRWAY	WITHIN 250' OF ATC SITES FROM PARKING AREATO R/W FOR ELEVATED STRUCTURE OR IN A CUT	
TYPE D SITE	SITE SIZE			SITE SIZE	TM-3.3.2-CC	100'x65'	SITE SIZE	NTD 11	100'x65'	SITE SIZE	100'x65'	NO REQUIREMENT ON SIZE OF PARKING AREA
	LOCATION			LOCATION		-	LOCATION	NTD 11	WITHIN INTERLOCKING LIMITS	LOCATION	WITHIN INTERLOCKING LIMITS	
	ALTERNATE LOCATION			ALTERNATE LOCATION		N/A	ALTERNATE LOCATION	NTD 11	PROVIDE ALTERNATE LOCATION ON DIFFERENT PARCEL	ALTERNATE LOCATION	PROVIDE ALTERNATE LOCATION ON DIFFERENT PARCEL	
	SITE POSITION			SITE POSITION	TM-3.3.2-CC	LONGEST SIDE OF ATC SITES PARALLEL TO MAIN TRACKS	SITE POSITION	NTD 11	LONGEST SIDE OF ATC SITES PARALLEL TO MAIN TRACKS	SITE POSITION	LONGEST SIDE OF ATC SITES PARALLEL TO MAIN TRACKS	
	SITE SPACING			SITE SPACING	TM-3.3.2-CC	NOMINAL 7.5 MI MIN 5.8 MI MAX 8.7 MI	SITE SPACING	NTD 11	NOMINAL 7.5 MI MIN 5.8 MI MAX 8.7 MI	SITE SPACING	NOMINAL 7.5 MI MIN 5.8 MI MAX 8.7 MI	
	ACCESS REQUIRED			ACCESS REQUIRED		-	ACCESS REQUIRED	NTD 11	ACCESS ROAD AND GATE	ACCESS REQUIRED	ACCESS ROAD AND GATE	
	PARKING			PARKING		-	PARKING	NTD 11	REQUIRED FOR EACH SITE	PARKING	REQUIRED FOR EACH SITE	
	STAIRWAY			STAIRWAY		-	STAIRWAY	NTD 11	WITHIN 250' OF ATC SITES FROM PARKING AREATO R/W FOR ELEVATED STRUCTURE OR IN A CUT	STAIRWAY	WITHIN 250' OF ATC SITES FROM PARKING AREATO R/W FOR ELEVATED STRUCTURE OR IN A CUT	
TYPE E SITE	SITE SIZE			SITE SIZE	TM-3.3.2-CC	110'x65'	SITE SIZE	NTD 11	110'x65'	SITE SIZE	110'x65'	NO REQUIREMENT ON SIZE OF PARKING AREA
	LOCATION			LOCATION		-	LOCATION	NTD 11	WITHIN INTERLOCKING LIMITS	LOCATION	WITHIN INTERLOCKING LIMITS	
	ALTERNATE LOCATION			ALTERNATE LOCATION	TM-3.3.2-BB	PROVIDED ON OPPOSITE SIDE OF TRACK WHERE POSSIBLE	ALTERNATE LOCATION	NTD 11	PROVIDED ON OPPOSITE SIDE OF TRACK WHERE POSSIBLE	ALTERNATE LOCATION	PROVIDED ON OPPOSITE SIDE OF TRACK WHERE POSSIBLE	
	SITE POSITION			SITE POSITION	TM-3.3.2-CC	LONGEST SIDE OF ATC SITES PARALLEL TO MAIN TRACKS	SITE POSITION	NTD 11	LONGEST SIDE OF ATC SITES PARALLEL TO MAIN TRACKS	SITE POSITION	LONGEST SIDE OF ATC SITES PARALLEL TO MAIN TRACKS	
	SITE SPACING			SITE SPACING		N/A	SITE SPACING		N/A	SITE SPACING	N/A	
	ACCESS REQUIRED			ACCESS REQUIRED		-	ACCESS REQUIRED	NTD 11	ACCESS ROAD AND GATE	ACCESS REQUIRED	ACCESS ROAD AND GATE	
	PARKING			PARKING		-	PARKING	NTD 11	REQUIRED FOR EACH SITE	PARKING	REQUIRED FOR EACH SITE	
	STAIRWAY			STAIRWAY		-	STAIRWAY	NTD 11	WITHIN 250' OF ATC SITES FROM PARKING AREATO R/W FOR ELEVATED STRUCTURE OR IN A CUT	STAIRWAY	WITHIN 250' OF ATC SITES FROM PARKING AREATO R/W FOR ELEVATED STRUCTURE OR IN A CUT	
TRACTION POWER SITES												
TP SUBSTATION W/ TWO POWER TRANSFORMERS	SITE SIZE	TM 3.1.1.3	200'x160'	SITE SIZE	TM-3.1.1.3-A	200'x160'	SITE SIZE		-	SITE SIZE	200'x160'	NO REQUIREMENT ON SIZE OF PARKING AREA
	LOCATION	TM 3.1.1.3	MAX 100' FROM HSR ALIGNMENT	LOCATION		-	LOCATION		-	LOCATION	MAX 100' FROM HSR ALIGNMENT	
	SITE SPACING	TM 3.1.1.3	APPROXIMATELY 30 MI	SITE SPACING		-	SITE SPACING		-	SITE SPACING	APPROXIMATELY 30 MI	
	ALTERNATE LOCATION	TM 3.1.1.3	PROVIDE ALTERNATE LOCATION ON DIFFERENT PARCEL	ALTERNATE LOCATION		-	ALTERNATE LOCATION		-	ALTERNATE LOCATION	PROVIDE ALTERNATE LOCATION ON DIFFERENT PARCEL	
	ACCESS REQUIRED	TM 3.3.2 TM 2.8.1	ACCESS ROAD AND GATE	ACCESS REQUIRED		-	ACCESS REQUIRED		-	ACCESS REQUIRED	ACCESS ROAD AND GATE	
	PARKING	TM 3.3.2 TM 2.8.1	REQUIRED FOR EACH SITE	PARKING		-	PARKING		-	PARKING	REQUIRED FOR EACH SITE	
	EASEMENT	TM 3.1.1.3	40' WIDE PERMANENT EASEMENT PROVIDED WHEN TP SITE LOCATED AWAY FROM HSR ALIGNMENT FOR DUCTBANK AND MANHOLE	EASEMENT		-	EASEMENT		-	EASEMENT	40' WIDE PERMANENT EASEMENT PROVIDED WHEN TP SITE LOCATED AWAY FROM HSR ALIGNMENT FOR DUCTBANK AND MANHOLE	

CAHSR JM
SYSTEMS DESIGN CHECKLIST

	HIGH-SPEED TRAIN TM			HIGH-SPEED TRAIN DIRECTIVE DRAWING			HIGH-SPEED TRAIN NTD			CAHSR JM DEDICATED HST CRITERIA		COMMENTS
TP SUBSTATION W/ THREE POWER TRANSFORMERS	SITE SIZE	TM 3.1.1.3	200'x210'	SITE SIZE	TM-3.1.1.3-B	200'x210'	SITE SIZE		-	SITE SIZE	200'x210'	NO REQUIREMENT ON SIZE OF PARKING AREA
	LOCATION	TM 3.1.1.3	MAX 100' FROM HSR ALIGNMENT	LOCATION		-	LOCATION		-	LOCATION	MAX 100' FROM HSR ALIGNMENT	
	SITE SPACING	TM 3.1.1.3	APPROXIMATELY 30 MI	SITE SPACING		-	SITE SPACING		-	SITE SPACING	APPROXIMATELY 30 MI	
	ALTERNATE LOCATION	TM 3.1.1.3	PROVIDE ALTERNATE LOCATION ON DIFFERENT PARCEL	ALTERNATE LOCATION		-	ALTERNATE LOCATION		-	ALTERNATE LOCATION	PROVIDE ALTERNATE LOCATION ON DIFFERENT PARCEL	
	ACCESS REQUIRED	TM 3.3.2 TM 2.8.1	ACCESS ROAD AND GATE	ACCESS REQUIRED		-	ACCESS REQUIRED		-	ACCESS REQUIRED	ACCESS ROAD AND GATE	
	PARKING	TM 3.3.2 TM 2.8.1	REQUIRED FOR EACH SITE	PARKING		-	PARKING		-	PARKING	REQUIRED FOR EACH SITE	
	EASEMENT	TM 3.1.1.3	40' WIDE PERMANENT EASEMENT PROVIDED WHEN TP SITE LOCATED AWAY FROM HSR ALIGNMENT FOR DUCTBANK AND MANHOLE	EASEMENT		-	EASEMENT		-	EASEMENT	40' WIDE PERMANENT EASEMENT PROVIDED WHEN TP SITE LOCATED AWAY FROM HSR ALIGNMENT FOR DUCTBANK AND MANHOLE	
TP SWITCHING STATION (SWS)	SITE SIZE	TM 3.1.1.3	160'x90'	SITE SIZE	TM-3.1.1.3-C	160'x90'	SITE SIZE		-	SITE SIZE	160'x90'	NO REQUIREMENT ON SIZE OF PARKING AREA
	LOCATION	TM 3.1.1.3	MAX 100' FROM HSR ALIGNMENT	LOCATION		-	LOCATION		-	LOCATION	MAX 100' FROM HSR ALIGNMENT	
	SITE SPACING	TM 3.1.1.3	APPROXIMATELY MIDWAY BETWEEN TPSS SITES	SITE SPACING		-	SITE SPACING		-	SITE SPACING	APPROXIMATELY MIDWAY BETWEEN TPSS SITES	
	ALTERNATE LOCATION	TM 3.1.1.3	PROVIDE ALTERNATE LOCATION ON DIFFERENT PARCEL	ALTERNATE LOCATION		-	ALTERNATE LOCATION		-	ALTERNATE LOCATION	PROVIDE ALTERNATE LOCATION ON DIFFERENT PARCEL	
	ACCESS REQUIRED	TM 3.3.2 TM 2.8.1	ACCESS ROAD AND GATE	ACCESS REQUIRED		-	ACCESS REQUIRED		-	ACCESS REQUIRED	ACCESS ROAD AND GATE	
	PARKING	TM 3.3.2 TM 2.8.1	REQUIRED FOR EACH SITE	PARKING		-	PARKING		-	PARKING	REQUIRED FOR EACH SITE	
	EASEMENT	TM 3.1.1.3	40' WIDE PERMANENT EASEMENT PROVIDED WHEN TP SITE LOCATED AWAY FROM HSR ALIGNMENT FOR DUCTBANK AND MANHOLE	EASEMENT		-	EASEMENT		-	EASEMENT	40' WIDE PERMANENT EASEMENT PROVIDED WHEN TP SITE LOCATED AWAY FROM HSR ALIGNMENT FOR DUCTBANK AND MANHOLE	
TP PARALLELING STATION (PS)	SITE SIZE	TM 3.1.1.3	120'x80'	SITE SIZE	TM-3.1.1.3-D	120'x80'	SITE SIZE		-	SITE SIZE	120'x80'	NO REQUIREMENT ON SIZE OF PARKING AREA
	LOCATION	TM 3.1.1.3	MAX 100' FROM HSR ALIGNMENT	LOCATION		-	LOCATION		-	LOCATION	MAX 100' FROM HSR ALIGNMENT	
	SITE SPACING	TM 3.1.1.3	APPROXIMATELY 5 MI INTERVALS BETWEEN SWITCHING AND SUBSTATION	SITE SPACING		-	SITE SPACING		-	SITE SPACING	APPROXIMATELY 5 MI INTERVALS BETWEEN SWITCHING AND SUBSTATION	
	ALTERNATE LOCATION	TM 3.1.1.3	PROVIDE ALTERNATE LOCATION ON DIFFERENT PARCEL	ALTERNATE LOCATION		-	ALTERNATE LOCATION		-	ALTERNATE LOCATION	PROVIDE ALTERNATE LOCATION ON DIFFERENT PARCEL	
	ACCESS REQUIRED	TM 3.3.2 TM 2.8.1	ACCESS ROAD AND GATE	ACCESS REQUIRED		-	ACCESS REQUIRED		-	ACCESS REQUIRED	ACCESS ROAD AND GATE	
	PARKING	TM 3.3.2 TM 2.8.1	REQUIRED FOR EACH SITE	PARKING		-	PARKING		-	PARKING	REQUIRED FOR EACH SITE	
	EASEMENT	TM 3.1.1.3	30' WIDE PERMANENT EASEMENT PROVIDED WHEN TP SITE LOCATED AWAY FROM HSR ALIGNMENT FOR DUCTBANK AND MANHOLE	EASEMENT		-	EASEMENT		-	EASEMENT	30' WIDE PERMANENT EASEMENT PROVIDED WHEN TP SITE LOCATED AWAY FROM HSR ALIGNMENT FOR DUCTBANK AND MANHOLE	
STAND-ALONE RADIO SITES												
STAND-ALONE RADIO SITES	SITE REQUIREMENT			SITE REQUIREMENT		-	SITE REQUIREMENT	NTD 6	SITE ARE REQUIRED WHEN SPACING BETWEEN TP FACILITIES, SIGNAL EQUIPMENT HOUSES (TYPE A, AA, D, E), AND TUNNEL PORTAL SITES IS GREATER THAN 3 MILES	SITE REQUIREMENT	SITE ARE REQUIRED WHEN SPACING BETWEEN TP FACILITIES, SIGNAL EQUIPMENT HOUSES (TYPE A, AA, D, E), AND TUNNEL PORTAL SITES IS GREATER THAN 3 MILES	NO REQUIREMENT ON SIZE OF PARKING AREA
	SITE SIZE	TM 3.4.2	8'X12'	SITE SIZE	NTD 6 - DRAWING NO. 2	40'x25'	SITE SIZE	NTD 6	40'x25'	SITE SIZE	40'x25'	
	SITE SPACING		N/A	SITE SPACING		-	SITE SPACING	NTD 6	NOMINAL 2.5 MI NO GREATER THAN 3 MI	SITE SPACING	NOMINAL 2.5 MI NO GREATER THAN 3 MI	
	ACCESS REQUIRED	TM 3.3.2 TM 2.8.1	ACCESS ROAD AND GATE	ACCESS REQUIRED		-	ACCESS REQUIRED	NTD 6	ACCESS ROAD AND GATE	ACCESS REQUIRED	ACCESS ROAD AND GATE	
	PARKING	TM 3.3.2 TM 2.8.1	REQUIRED FOR EACH SITE	PARKING		-	PARKING	NTD 6	REQUIRED FOR EACH SITE	PARKING	REQUIRED FOR EACH SITE	
	TCE FOR INSTALLATION		N/A	TCE FOR INSTALLATION	NTD 6 - DRAWING NO. 2	MINIMUM 40'x60'	TCE FOR INSTALLATION	NTD 6	MINIMUM 40'x60'	TCE FOR INSTALLATION	MINIMUM 40'x60'	