Caltrain 2025 Preliminary Hazard Analysis Worksheets

December 2009

The following are the detailed Preliminary Hazard Analysis (PHA) worksheets developed for the Caltrain 2025 Preliminary Hazard Analysis. The format for the worksheet is given followed by worksheets for the PHA scenarios:

A. EMU collision with auto driving around crossing gate
B. EMU collision with highway truck driving around crossing gate
C. EMU collision with pedestrian at grade crossing
D. EMU collision with auto at non-gated maintenance of way crossing
E. EMU collision with auto fouling tracks at gated grade crossing
F. EMU collision with highway truck fouling tracks at gated grade crossing
G. EMU in shared corridor strikes fright cargo that has dislodged
H. EMU collision with FRA-compliant locomotive
I. EMU collision with flat immovable object
J. EMU collision with object (derailed train)

For a summary of the PHA analysis process and a description of the results, see Caltrain's Waiver Request to FRA to Operate Mixed Traffic on the Caltrain Corridor, Chapter 4.

Format of PHA Worksheets

The PHA analysis is summarized into worksheets for each scenario. A sample worksheet can be found as Table 1.

The format of the PHA worksheets is as follows:

(1) PHA No: Hazard reference number

(2) Hazard Scenario – Description of the hazard circumstances

(3) Level – A scenario subset indicating speed at which the collision occurs

(4) No. – Hazard reference number subset number

(5) Hazard Description - Description of each postulated hazard

(6) Potential Cause – Description of those causal factors that create the hazardous condition

(7) Effect on the EMU - Description of the probable effect on the train passengers and crew and equipment in terms of severity

(8) Probability/Severity – The probability and severity of the hazardous condition for the development of the Initial HRI

(9) Initial HRI – the Hazard Risk Index for the existing (2008) operating environment BEFORE the application of any mitigation measure

(10) Effect on the Motorist/Pedestrian - Description of the probable effect on the motor vehicle drive and passenger and vehicle or pedestrian in terms of severity in motorist/pedestrian scenarios

(11) Probability/Severity – The probability and severity of the hazardous condition relating to the Motorist/Pedestrian for the development of the Initial HRI

(12) Motorist/Pedestrian Initial HRI – the Hazard Risk Index for the existing (2008) operating environment BEFORE the application of any mitigation measure

(13) Controlling Measures – Practicable mitigation measures to be taken to reduce the severity and/or likelihood (probability) of the hazard condition

(14) Residual HRI – the Hazard Risk Index of the operating environment that is expected to result AFTER the application of the combined mitigation measures

(15) Resolution and Remarks Final HRI – The combination of the measures taken to reduce the severity/probability of the hazard condition AND the measures implemented through the Systemwide Grade Crossing Improvement Program

Table 1 - Sample PHA Worksheet

PHA NO.: (1) Hazard Scenario: (2) Level: (3) REV NO.:	CALTRAIN 2025 PRELIMINARY HAZARD ANALYSIS	Performed By: Reviewed By: Approved By:

		HAZARD CAUSE/EFFECT							MITIGATION OPTIONS		CORRECTIVE ACTION
No.	Hazard Description	Potential Cause	Effect on EMU	Probability Severity	EMU Initial HRI	Effect on Motor Vehicle	Probability Severity	Motor Vehicle Initial HRI	Controlling Measures	Residual HRI	Resolution and Remarks Residual HRI
(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)

PHA NO.: A.1 **Hazard Scenario:** Collision with Auto Driving Around Crossing Gate **Level:** EMU Traveling Up To 70 MPH **REV NO.:** 2	**CALTRAIN 2025** **PRELIMINARY HAZARD ANALYSIS**	**Performed By:** H. Saporta **Reviewed By:** M. Bailey **Approved By:** R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT							MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Motor Vehicle**	**Probability Severity**	**Motor Vehicle Initial HRI**	**Mitigation Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
A.1	Auto driving around or through crossing gate is struck by EMU traveling up to 70 MPH	2 quadrant gate system does not restrict motorist's action of driving around crossing gate	Minor injuries requiring medical treatment away for the scene of the accident Minor damage to exterior of vehicle. Occupied volume not compromised	Occasional Marginal	18	Loss of Life Major injuries Loss of Motor Vehicle	Occasional Critical	7	If space permits, install 60' median barrier If space permits, install 60' curb with channelization devices If configuration feasible, install 4 quadrant gates with presence detection Increase education and human enforcement Photo Enforcement	13 21	Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Remote. Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Remote.

PHA NO.: B.1 **Hazard Scenario:** Collision with Highway Truck Driving Around Crossing Gate **Level:** EMU Traveling Up To 60 MPH **REV NO.:** 2	**CALTRAIN 2025** **PRELIMINARY HAZARD ANALYSIS**	**Performed By:** H. Saporta **Reviewed By:** M. Bailey **Approved By:** R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT							MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Motor Vehicle**	**Probability Severity**	**Motor Vehicle Initial HRI**	**Mitigation Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
B.1	Highway truck drives around crossing gate and is struck by EMU traveling up to 60 MPH	2 quadrant gate system does not restrict driver's action of driving around crossing gate	Minor injuries and limited major injuries. Major damage to exterior of vehicle. Occupied volume not compromised.	Remote Serious	17	Loss of Life Major injuries Loss of Motor Vehicle	Remote Critical	13	If space permits, install 60' median barrier If space permits, install 60' curb with channelization devices If configuration feasible, install 4 quadrant gates with presence detection Increase education and human enforcement Photo Enforcement	16	Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Improbable.
										20	Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Improbable.

PHA NO.: C.1

Hazard Scenario: Collision with Pedestrian at Grade Crossing

Level: EMU Traveling Up To 79 MPH

REV NO.: 2

CALTRAIN 2025
PRELIMINARY HAZARD ANALYSIS

Performed By: H. Saporta

Reviewed By: M. Bailey

Approved By: R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT							MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Ped**	**Probability Severity**	**Ped Initial HRI**	**Mitigation Measures**	**Residual HRI**	**Resolution and Remarks Final HRI**
C.1	Pedestrian ignores grade crossing warning devices and steps/stands in path of EMU traveling up to 79 MPH	a) Pedestrian ignores warning devices b) Crossing gate or other mechanisms do not impede pedestrian travel c) Pedestrian stands within dynamic envelope of passing train	None	Occasional Negligible	23	Loss of life or major injuries	Occasional Critical	7	Pedestrian gates Swing gates Increased education and enforcement Fencing and/or plantings to channel pedestrians Tactile warning strips STOP HERE sidewalk markings	13 24	Expected residual HRI improvement is for the pedestrian risk reduction that results from the reduced probability to Remote. Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Remote.

PHA NO.: D.1

Hazard Scenario: Collision with Auto at Non-Gated Maintenance of Way Crossing

Level: EMU Traveling Up To 70 MPH

REV NO.: 2

CALTRAIN 2025
PRELIMINARY HAZARD ANALYSIS

Performed By: H. Saporta

Reviewed By: M. Bailey

Approved By: R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT							MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Motor Vehicle**	**Probability Severity**	**Motor Vehicle Initial HRI**	**Mitigation Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
D.1	Unauthorized motor vehicle enters ROW at Maintenance of Way crossing and is struck by train traveling up to 70 mph	a) Gate or other barrier not provided b) MOW crew fails to request permission to enter ROW	Minor injuries requiring medical treatment away for the scene of the accident Minor damage to exterior of vehicle. Occupied volume not compromised	Remote Marginal	21	Loss of life or major injuries	Remote Critical	13	Install pipe gate with high security lock and fencing placed a minimum of 15 feet to each side of the gate Increase education and enforcement	16	Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Improbable.
										22	Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Improbable.

PHA NO.: E.1

Hazard Scenario: Collision with Auto Fouling Tracks at Gated Grade Crossings

Level: EMU Traveling Up To 70 MPH

REV NO.: 2

CALTRAIN 2025
PRELIMINARY HAZARD ANALYSIS

Performed By: H. Saporta

Reviewed By: M. Bailey

Approved By: R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT							MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Motor Vehicle**	**Probability Severity**	**Motor Vehicle Initial HRI**	**Mitigation Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
E.1	EMU traveling up to 70 MPH strikes auto fouling tracks	a) Auto stops on tracks due to traffic back-up from adjacent intersection controlled by traffic signals	Minor injuries requiring medical treatment away for the scene of the accident Minor damage to exterior of vehicle. Occupied volume not compromised	Probable Marginal	12	Loss of life Major injuries Loss of vehicle	Probable Critical	5	Presence sensing device interfaced with traffic controller to clear traffic when train approaches crossing Provide sufficient queuing for traffic between grade crossing and adjacent intersection Install DO NOT STOP ON TRACKS sign Pavement markings clearly indicating fouling area Increase No Stopping on Tracks education and enforcement Increase traffic light GO signal time for railroad crossing traffic	13 21	Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Remote. Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Remote.

PHA NO.: E.1

Hazard Scenario: Collision with Auto Fouling Tracks at Gated Grade Crossings

Level: EMU Traveling Up To 70 MPH

REV NO.: 2

CALTRAIN 2025
PRELIMINARY HAZARD ANALYSIS

Performed By: H. Saporta

Reviewed By: M. Bailey

Approved By: R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT							MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Motor Vehicle**	**Probability Severity**	**Motor Vehicle Initial HRI**	**Mitigation Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
E.1	EMU traveling up to 70 MPH strikes auto fouling tracks	b) Auto stops on tracks due to traffic back-up from adjacent intersection controlled by stop sign.	Minor injuries requiring medical treatment away for the scene of the accident Minor damage to exterior of vehicle. Occupied volume not compromised	Probable Marginal	12	Loss of life Major injuries Loss of vehicle	Probable Critical	5	Provide sufficient queuing for traffic between grade crossing and adjacent intersection Install DO NOT STOP ON TRACKS sign Pavement markings clearly indicating fouling area Increase Do Not Stop on Tracks education and enforcement Evaluate crossing for potential sight obstructions Eliminate stop sign on railroad crossing road Coordinate traffic control device upgrades	13 21	Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Remote. Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Remote.

PHA NO.: E.1

Hazard Scenario: Collision with Auto Fouling Tracks at Gated Grade Crossings

Level: EMU Traveling Up To 70 MPH

REV NO.: 2

CALTRAIN 2025
PRELIMINARY HAZARD ANALYSIS

Performed By: H. Saporta

Reviewed By: M. Bailey

Approved By: R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT							MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Motor Vehicle**	**Probability Severity**	**Motor Vehicle Initial HRI**	**Mitigation Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
E.1	EMU traveling up to 70 MPH strikes auto fouling tracks	c) Auto stops on tracks due to construction activity ahead	Minor injuries requiring medical treatment away for the scene of the accident Minor damage to exterior of vehicle. Occupied volume not compromised	Probable Marginal	12	Loss of life Major injuries Loss of vehicle	Probable Critical	5	Coordinate construction activities with local jurisdiction and utilities so as to provide sufficient queuing between tracks and construction activity Increase Do Not Stop on Tracks education and enforcement Employ alternative construction methods that do not impact or reduce queuing impacts Employ “Flag Persons” at the crossing to coordinate traffic flow and avoid queuing on the crossing	13 21	Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Remote. Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Remote.

PHA NO.: E.1 **Hazard Scenario:** Collision with Auto Fouling Tracks at Gated Grade Crossings **Level:** EMU Traveling Up To 70 MPH **REV NO.:** 2	**CALTRAIN 2025** **PRELIMINARY HAZARD ANALYSIS**	**Performed By:** H. Saporta **Reviewed By:** M. Bailey **Approved By:** R. Doty

GENERAL DESCRIPTION		**HAZARD CAUSE/EFFECT**							**MITIGATION OPTIONS**		**CORRECTIVE ACTION**
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Motor Vehicle**	**Probability Severity**	**Motor Vehicle Initial HRI**	**Mitigation Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
E.1	EMU traveling up to 70 MPH strikes auto fouling tracks	d) Auto fails to stop at stop bar and front end fouls tracks	Minor injuries requiring medical treatment away for the scene of the accident Minor damage to exterior of vehicle. Occupied volume not compromised	Probable Marginal	12	Loss of life Major injuries Loss of vehicle	Probable Critical	5	Locate crossing gate sufficiently back to account for auto failing to stop at stop bar Install STOP HERE sign Increase education and enforcement Install DO NOT STOP ON TRACKS sign Install embedded red LED lights along stop bar edge (experimental in LA and Houston) Install reflective stop bar Illuminate crossing Improve motorist's sight of crossing approach	7 18	Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Occasional. Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Occasional.

PHA NO.: E.1 **Hazard Scenario:** Collision with Auto Fouling Tracks at Gated Grade Crossings **Level:** EMU Traveling Up To 70 MPH **REV NO.:** 2	**CALTRAIN 2025** **PRELIMINARY HAZARD ANALYSIS**	**Performed By:** H. Saporta **Reviewed By:** M. Bailey **Approved By:** R. Doty

GENERAL DESCRIPTION		**HAZARD CAUSE/EFFECT**							**MITIGATION OPTIONS**		**CORRECTIVE ACTION**
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Motor Vehicle**	**Probability Severity**	**Motor Vehicle Initial HRI**	**Mitigation Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
E.1	EMU traveling up to 70 MPH strikes auto fouling tracks	e) Auto stalls or is stuck on tracks f) Abandoned auto on tracks	Minor injuries requiring medical treatment away for the scene of the accident Minor damage to exterior of vehicle. Occupied volume not compromised	Remote Marginal	21	Loss of life Major injuries Loss of vehicle	Remote Critical	13			Practicable effective means of mitigation are not available to reduce the probability of collision with an auto stuck on track due to stall or abandoned

PHA NO.: E.1 **Hazard Scenario:** Collision with Auto Fouling Tracks at Gated Grade Crossings **Level:** EMU Traveling Up To 70 MPH **REV NO.:** 2	**CALTRAIN 2025** **PRELIMINARY HAZARD ANALYSIS**	**Performed By:** H. Saporta **Reviewed By:** M. Bailey **Approved By:** R. Doty

GENERAL DESCRIPTION		**HAZARD CAUSE/EFFECT**							**MITIGATION OPTIONS**		**CORRECTIVE ACTION**
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Motor Vehicle**	**Probability Severity**	**Motor Vehicle Initial HRI**	**Mitigation Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
E.1	EMU traveling up to 70 MPH strikes auto fouling tracks	g) While in the grade crossing, the motorist misjudges turn into parallel road way and enters ROW	Minor injuries requiring medical treatment away for the scene of the accident Minor damage to exterior of vehicle. Occupied volume not compromised	Remote Marginal	21	Loss of life Major injuries Loss of vehicle	Remote Critical	13	Increase the level of roadway illumination at the crossing to better illuminate the railroad environment		Other additional practicable and more positive means of mitigation are not available to significantly reduce the probability of motorists turning from the crossing onto the track. Increasing the illumination of the area is not considered sufficient to reduce the probability of the mishap to improbable.

PHA NO.: F.1 **Hazard Scenario:** Collision with Highway Truck Fouling Tracks at Gated Grade Crossings **Level:** EMU Traveling Up To 70 MPH **REV NO.:** 2	**CALTRAIN 2025** **PRELIMINARY HAZARD ANALYSIS**	**Performed By:** H. Saporta **Reviewed By:** M. Bailey **Approved By:** R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT							MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Motor Vehicle**	**Probability Severity**	**Motor Vehicle Initial HRI**	**Controlling Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
F.1	EMU traveling up to 70 MPH strikes truck fouling tracks	a) Truck stops on tracks due to traffic back-up from adjacent intersection controlled by traffic signals	Minor injuries and limited major injuries. Major damage to exterior of vehicle. Occupied volume not compromised.	Remote Serious	17	Loss of life Major injuries Loss of vehicle	Remote Critical	13	Presence sensing device interfaced with traffic controller to clear traffic when train approaches crossing Provide sufficient queuing for traffic between grade crossing and adjacent intersection Install DO NOT STOP ON TRACKS sign Pavement markings clearly indicating fouling area Education and enforcement of No Stopping On Tracks Provide increased GO signal for railroad crossing traffic	16 20	Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Improbable. Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Improbable.

PHA NO.: F.1 **Hazard Scenario:** Collision with Highway Truck Fouling Tracks at Gated Grade Crossings **Level:** EMU Traveling Up To 70 MPH **REV NO.:** 2	**CALTRAIN 2025** **PRELIMINARY HAZARD ANALYSIS**	**Performed By:** H. Saporta **Reviewed By:** M. Bailey **Approved By:** R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT							MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Motor Vehicle**	**Probability Severity**	**Motor Vehicle Initial HRI**	**Controlling Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
F.1	EMU traveling up to 70 MPH strikes truck fouling tracks	b) Truck stops on tracks due to traffic back-up from adjacent intersection controlled by stop sign.	Minor injuries and limited major injuries. Major damage to exterior of vehicle. Occupied volume not compromised.	Remote Serious	17	Loss of life Major injuries Loss of vehicle	Remote Critical	13	Provide sufficient queuing for traffic between grade crossing and adjacent intersection Install DO NOT STOP ON TRACKS sign Pavement markings clearly indicating fouling area Increase Do Not Stop on Tracks education and enforcement Evaluate crossing for potential sight obstructions Coordinate traffic control device upgrades or eliminate stop sign for railroad crossing traffic	16 20	Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Improbable. Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Improbable.

PHA NO.: F.1

Hazard Scenario: Collision with Highway Truck Fouling Tracks at Gated Grade Crossings

Level: EMU Traveling Up To 70 MPH

REV NO.: 2

CALTRAIN 2025
PRELIMINARY HAZARD ANALYSIS

Performed By: H. Saporta

Reviewed By: M. Bailey

Approved By: R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT							MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Motor Vehicle**	**Probability Severity**	**Motor Vehicle Initial HRI**	**Controlling Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
F.1	EMU traveling up to 70 MPH strikes truck fouling tracks	c) Truck stops on tracks due to construction activity ahead	Minor injuries and limited major injuries. Major damage to exterior of vehicle. Occupied volume not compromised.	Remote Serious	17	Loss of life Major injuries Loss of vehicle	Remote Critical	13	Coordinate construction activities with local jurisdiction and utilities so as to provide sufficient queuing between tracks and construction activity Increase Do Not Stop on Tracks education and enforcement Employ construction methods that do not result in queuing or reduces queuing Employ “Flag Persons” at the crossing to regulate the flow of traffic and control queuing	16 20	Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Improbable. Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Improbable.

PHA NO.: F.1 **Hazard Scenario:** Collision with Highway Truck Fouling Tracks at Gated Grade Crossings **Level:** EMU Traveling Up To 70 MPH **REV NO.:** 2	**CALTRAIN 2025** **PRELIMINARY HAZARD ANALYSIS**	**Performed By:** H. Saporta **Reviewed By:** M. Bailey **Approved By:** R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT							MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Motor Vehicle**	**Probability Severity**	**Motor Vehicle Initial HRI**	**Controlling Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
F.1	EMU traveling up to 70 MPH strikes truck fouling tracks	d) Truck fails to stop at stop bar and front end fouls tracks	Minor injuries and limited major injuries. Major damage to exterior of vehicle. Occupied volume not compromised.	Remote Serious	17	Loss of life Major injuries Loss of vehicle	Remote Critical	13	Locate crossing gate sufficiently back to account for truck failing to stop at stop bar Install STOP HERE sign Increase education and human enforcement Install DO NOT STOP ON TRACKS sign Install embedded red LED lights along stop bar edge (experimental in LA and Houston) Install reflective stop bar Illuminate crossing	16 20	Expected residual HRI improvement is for the motorist and motor vehicle risk reduction that results from the reduced probability to Improbable. Expected residual HRI improvement is for the railroad carried people and equipment that results from the reduced probability to Improbable.

PHA NO.: F.1 **Hazard Scenario:** Collision with Highway Truck Fouling Tracks at Gated Grade Crossings **Level:** EMU Traveling Up To 70 MPH **REV NO.:** 2	**CALTRAIN 2025** **PRELIMINARY HAZARD ANALYSIS**	**Performed By:** H. Saporta **Reviewed By:** M. Bailey **Approved By:** R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT							MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Motor Vehicle**	**Probability Severity**	**Motor Vehicle Initial HRI**	**Controlling Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
F.1	EMU traveling up to 70 MPH strikes truck fouling tracks	e) Truck stalls or is stuck on tracks f) Abandoned truck on tracks	Minor injuries and limited major injuries. Major damage to exterior of vehicle. Occupied volume not compromised..	Remote Serious	17	Loss of life Major injuries Loss of vehicle	Remote Critical	13			Practicable effective means of mitigation are not available to reduce the probability of a collision with a truck stuck on track due to stall or left abandoned there

PHA NO.: F.1 **Hazard Scenario:** Collision with Highway Truck Fouling Tracks at Gated Grade Crossings **Level:** EMU Traveling Up To 70 MPH **REV NO.:** 2	**CALTRAIN 2025** **PRELIMINARY HAZARD ANALYSIS**	**Performed By:** H. Saporta **Reviewed By:** M. Bailey **Approved By:** R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT							MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on Motor Vehicle**	**Probability Severity**	**Motor Vehicle Initial HRI**	**Controlling Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
F.1	EMU traveling up to 70 MPH strikes truck fouling tracks	g) While in grade crossing, truck driver misjudges turn into parallel road way and enters ROW	Minor injuries and limited major injuries. Major damage to exterior of vehicle. Occupied volume not compromised.	Remote Serious	17	Loss of life Major injuries Loss of vehicle	Remote Critical	13	Increase the level of illumination at and adjacent to the crossing to better show the railroad environment.		Other additional practicable effective means of mitigation are not available to significantly reduce the probability of motorists turning from the crossing onto the track The identified mitigation is not considered to be sufficient to reduce the probability of this type of mishap to improbable

PHA NO.: G.1 **Hazard Scenario:** EMU in Shared Corridor Strikes Freight Cargo **Level:** EMU Traveling Up To 70 MPH **REV NO.:** 2	**CALTRAIN 2025** **PRELIMINARY HAZARD ANALYSIS**	**Performed By:** H. Saporta **Reviewed By:** M. Bailey **Approved By:** R. Doty

GENERAL DESCRIPTION		**HAZARD CAUSE/EFFECT**				**MITIGATION OPTIONS**		**CORRECTIVE ACTION**
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Mitigation Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
G.1	EMU in shared corridor strikes freight cargo that has dislodged	a) Freight shifts while in transport and encroaches the dynamic envelope of EMU on adjacent track b) Freight shifts while in transport and falls into path of EMU on adjacent track	Minor injuries requiring medical treatment away for the scene of the accident Minor damage to exterior of vehicle. Occupied volume not compromised	Remote Marginal	21	Install presence sensing devices at strategic locations on the ROW. Upon detection of improperly extended lading, an alert is sent to the EMU operating engineer and the dispatcher. Implementation of temporal separation of freight and passenger (EMU) traffic and dispatch control functions to manage commingling.	22	Application of irregular load sensing equipment and temporal separation functions reduce the expected probability of such conditions within the operating environment to Improbable

PHA NO.: H.1.1 **Hazard Scenario:** Collision between EMU and FRA Compliant Locomotive **Level:** EMU Traveling 20 MPH **REV NO.:** 2	**CALTRAIN 2025** **PRELIMINARY HAZARD ANALYSIS**	**Performed By:** M. Bailey **Reviewed By:** D. DiBrito **Approved By:** R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT							MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Effect on FRA Compliant**	**Probability Severity**	**FRA Compliant Initial HRI**	**Mitigation Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
H.1.1	Engineer fails to slow the train adequately and stop short of another train to avoid impact while under manual control subject to Restricted Speed	Train engineer inattention	Minor injuries and limited major injuries Major Damage to Exterior of EMU, Occupied volume is not compromised	Improbable Serious	20	Minor injuries and limited major injuries Major Damage to Exterior of EMU, Occupied volume is not compromised	Improbable Serious	20	Reduce Restricted Speed to 15 MPH the level at which severity transitions to “Marginal” CBOSS limits the train speed to 20 MPH when in the Restricted Manual Mode	22	A design solution that completely avoids the risk of collision caused by inattention of the Engineer is not possible. RESTRICTED SPEED enforcement by CBOSS is expected to marginally reduce this risk by capping travel speed to 20 MPH in manual mode. The reduction of permitted manual operating speed to 15 MPH might be expected to result in lower impact speeds resulting in reduced severity and probability of collision. The assumption that 20 mph is a typical impact speed for such conditions is not supported by available data. It is reasonable to assume that a lower impact speed is more typical. The very small and uncertain safety improvement from a lowering of RESTRICTED SPEED from 20 MPH to 15 MPH is not justifiable. RESTRICTED SPEED will remain at 20 MPH.

PHA NO.: I.1 **Hazard Scenario:** EMU Collides with Flat Immovable Structure **Level:** EMU derails and impacts with fixed object at 10MPH **REV NO.: 2**	**CALTRAIN 2025** **PRELIMINARY HAZARD ANALYSIS**	**Performed By:** M. Bailey **Reviewed By:** D. DiBrito **Approved By:** R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT				MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Mitigation Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
I.1.1	EMU collides with wayside immoveable structure	Post derailment after: a) Collision with another EMU or FRA-compliant Vehicle b) Track in poor repair c) EMU in poor repair d) Rail vehicle overspeed	Minor injuries and limited major injuries Major Damage to Exterior of EMU, Occupied volume is not compromised	Improbable Serious	20	Implement more rigorous track preventive maintenance program Implement more rigorous EMU preventive maintenance program Maintain infrastructure design criteria requiring adjacent fixed object structures be kept to a minimum and placed back away from the operating envelope to the degree possible and particularly away from special trackwork areas Continue to apply Caltrain design criteria that requires a check rail to be used when in areas that exhibit this risk.	20	A design solution that completely avoids the risk of derailment due to improper operation or vehicle equipment or track failures is not possible. Continue use of existing controlling measures.

PHA NO.: J.1.1

Hazard Scenario: EMU Collision with Object (Derailed Train)

Level: Train derails and EMU impacts with side of train at or above 25 MPH

REV NO.: 1

CALTRAIN 2025
PRELIMINARY HAZARD ANALYSIS

Performed By: M. Bailey

Reviewed By: D. DiBrito

Approved By: R. Doty

GENERAL DESCRIPTION		HAZARD CAUSE/EFFECT				MITIGATION OPTIONS		CORRECTIVE ACTION
No.	**Hazard Description**	**Potential Cause**	**Effect on EMU**	**Probability Severity**	**EMU Initial HRI**	**Mitigation Measures**	**Residual HRI**	**Resolution and Remarks Residual HRI**
J.1.1	EMU collision with object (derailed train) across the path	a) Track in poor repair b) EMU in poor repair c) Earthquake d) Bridge displacement (due to strike, earthquake) e) Adjacent Railroad Derailment f) Rail vehicle overspeed	Major Damage to Exterior of EMU, Occupied volume is compromised	Improbable Catastrophic	14	Implement more rigorous track preventive maintenance program Implement more rigorous EMU preventive maintenance program Integrate seismic event detection into CBOSS to allow direct and immediate speed reduction when the condition is indicated Implement sensors to detect a derailment and require CBOSS to automatically reduce speed (and stop) of approaching trains. Implement sensors to enable CBOSS to respond to degraded track conditions inconsistent with the allowable speed. Implement intrusion/derailment detection equipment to interface with CBOSS for automatic intervention. Implement derailment containment structures Temporal separation of freight train operations.	14	Collision with a derailed train is a possibility and can be expected to result in casualties, particularly involving persons unable to quickly move to an area of safety from the derailed train cars. Accident consequences are expected to be equivalent for EMU and compliant trains in these scenarios, both being Catastrophic. Reducing the severity of the mishap consequences to Critical is not practicable for either type of vehicle. While the severity of the outcome cannot be practically reduced. Probability can be reduced but not eliminated. The benefits of introducing additional mitigation is limited since the mishap probability is already classified as improbable. CBOSS based mitigation might reduce some risks, but would introduce other risks due to false activation. Controlling measures involving infrastructure changes are disproportionately costly for benefit. Temporal separation segregates and reduces freight operations on adjacent tracks during passenger operating hours and lowers derailment risk though as the risk is already low, the improvement is marginal.