Greenlight Traffic Engineering

January 26, 2024

Mr. Russell Skuse
Director, Land Development
Horrocks
1401 N Green Valley Pkwy, Suite 160
Henderson, NV 89074

Re: Terrible Herbst Truck Stop | Traffic Safety Analysis
SEC I-15 NB Ramp/Halloran Summit Road, Nipton, San Bernardino County, CA

1 INTRODUCTION

This Traffic Safety Analysis was prepared for the proposed a Terrible Herbst Truck Stop development located on the southeast of I-15 NB Ramp and Halloran Summit Road in Nipton, San Bernardino, CA (Project), as shown in the site plan (Attachment A). The proposed Project will consist of Institute of Transportation Engineers (ITE) Land Use 950 "Truck Stop" with 6 pumps (6 fuel dispensers) and Land Use 945 "Convenience Store/Gas Station - GFA (5.5-10k)" of 7,433 SF with 16 vehicle fueling positions. The Project also includes 2 EV charging stations.

The purpose of this study is to analyze the existing crash data and discuss the project's possible impact on safety. This memo utilized Local Development and Intergovernmental Review (LDIGR) Safety Review Practitioners Guidance in December 2020 to analyze the safety analysis.

2 CRASH DATA ANALYSIS

Crash data was obtained for the study area from the Caltrans from Year April 01, 2020 – March 31, 2023. A report was generated on 11/16/2023 by Caltrans, and Table 1 depicts existing crash rates per million vehicles for the most recent 36-month period from 04/01/2020 to 03/31/2023 from the Traffic Accident Surveillance and Analysis System (TASAS). The crash data response from Caltrans is attached as Attachment B.

Table 1: TASAS Crash Rates

Segment	Total No. of Crashes	ACTUAL (Per million vehicles)			AVERAGE (Per million vehicles)		
		Fatal Crashes	Fatal + Injury Crashes	Total	Fatal Crashes	Fatal + Injury Crashes	Total
I-15 NB Off Ramp to Halloran Summit Road	2	0.000	0.00	4.57	0.009	0.48	1.31
I-15 SB On Ramp from Halloran Summit Road	0	0.000	0.00	0.00	0.005	0.22	0.63
I-15 NB On Ramp from Halloran Summit Road	0	0.000	0.00	0.00	0.005	0.22	0.63
I-15 SB Off Ramp to Halloran Summit Road	0	0.000	0.00	0.00	0.009	0.48	1.31

- I-15 NB Off Ramp to Halloran Summit Road
  - Two crashes were documented within the I-15 NB Off Ramp to Halloran Summit Road during this period queried, with no reported fatalities.
  - Detailed analysis per the TASAS Selective Accident Retrieval (TSAR) shows that the primary and only crash factor in the segment were "Improper Turn".
  - The types of collisions retrieved include "Rear-End" and "Hit Object".

    - This segment was not flagged in TASAS Table C, that identifies high crash frequency spot locations with either Type 'W' (Wet) crashes or Type 'A' (All) crashes where four or more significant crashes within twelve, six, or a three- month period have occurred.
- I-15 SB On Ramp to Halloran Summit Road
    - No crashes were documented within the I-15 NB Off Ramp to Halloran Summit Road during this period queried.
    - This segment was not flagged in TASAS Table C, that identifies high crash frequency spot locations with either Type 'W' (Wet) crashes or Type 'A' (All) crashes where four or more significant crashes within twelve, six, or a three- month period have occurred.
- I-15 NB On Ramp to Halloran Summit Road
    - No crashes were documented within the I-15 NB Off Ramp to Halloran Summit Road during this period queried.
    - This segment was not flagged in TASAS Table C, that identifies high crash frequency spot locations with either Type 'W' (Wet) crashes or Type 'A' (All) crashes where four or more significant crashes within twelve, six, or a three- month period have occurred.
- I-15 SB Off Ramp to Halloran Summit Road
    - No crashes were documented within the I-15 NB Off Ramp to Halloran Summit Road during this period queried.
    - This segment was not flagged in TASAS Table C, that identifies high crash frequency spot locations with either Type 'W' (Wet) crashes or Type 'A' (All) crashes where four or more significant crashes within twelve, six, or a three- month period have occurred.

The existing crash data, combined with the remote location of the Project and the expectation that the ramps will mainly serve trips related to the Project, leading to fewer potential conflicts, all indicate that the Project is not likely to have a substantial impact on safety along the analyzed roadway segments.

3 HSM SAFETY ANALYSIS

A predictive crash analysis was performed for the I-15 NB Ramp/Halloran Summit Road and I-15 SB Ramp/Halloran Summit Road intersections. Predictive crash analysis using the Highway Safety Manual (HSM) involves employing statistical models and methodologies to anticipate and evaluate potential traffic accidents before they occur. The HSM provides a systematic approach to assessing road safety by considering various factors, such as roadway characteristics, traffic conditions, and Average Annual Daily Traffic (AADT) for the major and minor approaches.

Safety Performance Functions (SPFs) are mathematical models derived from observed crash data. These functions relate the frequency or severity of crashes to specific roadway and traffic characteristics. They form the basis for predicting future crash rates.

The SPFs were calculated for the following conditions:

- Existing Conditions: with and without Project
- Opening Year 2025: with and without Project
- Horizon Year 2040: with and without Project

The predictive approach relies on research utilizing existing data that describes the geometric and traffic attributes of road systems in the United States. The predictive models take into account the impacts of numerous geometric designs and traffic control features that may be of interest. However, the absence of a specific factor from these models does not necessarily imply that the factor has no influence on crash frequency. It may simply indicate that the effect is not fully understood or has not been quantified at the present time.

The Highway Safety Manual (HSM) was used to calculate the predicted crash frequency for one-way stop-controlled diagonal ramps (D4). SPF was computed for one-way stop-controlled crossroads ramps (*Eq 19-31*) using the method outlined below:

$N_{spf,w,ST,at,z} = exp(a + b \times In[c \times AADT_{xrd}] + d \times In[c \times AADT_{ex} + c \times AADT_{en}])$

Where:

$N_{spf,w,ST,at,z}$ = predicted average crash frequency of a one-way stop-controlled crossroad ramp terminal of site type w (w = D3ex, D3en, D4, A4, B4, A2, B2) with base conditions, all crash types at, and severity z (z = fi: fatal and injury, pdo: property damage only) (crashes/yr).

$AADT_{xrd}$ = AADT (vehicles per day) for the cross road;

$AADT_{ex}$ = AADT (vehicles per day) for the exit ramp; and

$AADT_{en}$ = AADT (vehicles per day) on the entrance ramp.

a,b,c= SPF Coefficients for crashes at one-way stop controlled ramp terminals

The following are the facts and assumptions used for calculating the predicted crash frequency and the crash modification factors (CMFs) for the ramp terminal:

- **Facts**
  - The existing I-15 ramp is a four-leg ramp terminal with diagonal ramps (D4) configuration.
  - The ramp terminal is a one-way stop controlled Intersection.
  - The ramp terminal does not have left-turn lanes or bays on the crossroad legs, which is the base condition for the crossroad left-turn lane CMF (CMF_{11}=1.00).
  - The ramp terminal does not have right-turn lanes or bays on the crossroad legs, which is the base condition for the crossroad right-turn lane CMF (CMF_{12}=1.00).
  - The ramp terminal has no unsignalized driveways or unsignalized public street approaches on the outside leg, which are the base conditions for the access point frequency CMF (CMF_{13}=1.00).
  - There is no public street intersection on the outside crossroad leg for 6 miles (CMF_{14}=N/A).
  - There is no median along the crossroads at the ramp terminals (CMF_{15}=N/A).
  - The skew angle between the crossroads and exit ramps is 22 degrees.
- **Assumptions**
  - As shown in Section 2, there are only 2 crashes observed over a period of 3 years. Therefore, the Empirical Bayes (EB) Method is assumed to be not applicable for analytical purposes.
  - Calibration Factor is assumed to be 1.00.
  - The peak hour volume was divided by 10 percent to calculate the AADT for the intersection. The AADT for the approaches were calculated based on the exiting peak hour data collected between 12:00 to 3:00 p.m. on Sunday, December 3, 2023, at the intersections of:
    - I-15 NB Ramp/Halloran Summit Road
    - I-15 SB Ramp/Halloran Summit Road
  - A growth rate of 2% was used to grow the AADT for the future conditions.

The result for the predictive HSM analysis is shown in Table 2. Detailed calculations of the predictive crashes analysis are provided in Attachment C.

Table 2: Predicitve HSM Analysis Results with and without Project

Description	2023			2028			2040		
	w/o Project	w/ Project	Difference	w/o Project	w/ Project	Difference	w/o Project	w/ Project	Difference
$AADT_{xrd}$	105	3,583	3,478	116	3,594	3,478	147	3,625	3,478
$AADT_{ex}$	120	3,598	3,478	132	3,610	3,478	168	3,646	3,478
$AADT_{en}$	140	3,618	3,478	155	3,633	3,478	196	3,674	3,478
$AADT_{in}$	60	3,538	3,478	66	3,544	3,478	84	3,562	3,478
$AADT_{out}$	150	3,628	3,478	166	3,644	3,478	210	3,688	3,478
$N_{spf,fi}$ (crashes/year)	**0.0052**	**0.4398**	**0.4346**	**0.0059**	**0.4413**	**0.4354**	**0.0078**	**0.4455**	**0.4377**
$N_{spf,pdo}$ (crashes/year)	**0.0069**	**0.6759**	**0.6690**	**0.0079**	**0.6794**	**0.6716**	**0.0107**	**0.6894**	**0.6786**
$N_{p,fi}$ (crashes/year)	**0.0053**	**0.4826**	**0.4773**	**0.0060**	**0.4847**	**0.4787**	**0.0079**	**0.4908**	**0.4829**
$N_{p,pdo}$ (crashes/year)	**0.0069**	**0.6759**	**0.6690**	**0.0079**	**0.6794**	**0.6716**	**0.0107**	**0.6894**	**0.6786**
$N_{p,at}$ (crashes/year)	**0.0122**	**1.1585**	**1.1463**	**0.0138**	**1.1641**	**1.1503**	**0.0187**	**1.1802**	**1.1616**

Notes:

1. *$AADT_{xrd}$ -AADT for Cross Road*
2. *$AADT_{ex}$ - AADT for exit ramp*
3. *$AADT_{en}$ - AADT for entrance ramp*
4. *$AADT_{in}$ - AADT for crossroad leg between ramps*
5. *$AADT_{out}$ - AADT for crossroad leg outside of interchange*
6. *$N_{spf,fi}$ (crashes/year) - SPF for Fatal-Injury Crashes*
7. *$N_{spf,pdo}$ (crashes/year) - SPF for PDO Crashes*
8. *$N_{p,fi}$ (crashes/year) - Predicted Crashes Frequency for Fatal-Injury Crashes*
9. *$N_{p,pdo}$ (crashes/year) - Predicted Crashes Frequency for PDO Crashes*
10. *$N_{p,at}$ (crashes/year) - Predicted Crashes Frequency for All Type Crashes*

The Table 2 shows the results of the HSM predictive crash analysis. As indicated, the projected average crash frequency related to the intersection is higher under conditions involving the Project. However, the existing traffic volumes at the intersection are quite low, and any increase in traffic due to the development is likely to significantly raise the crash frequency associated with the Project. Moreover, factors such as the Project's remote location and the anticipation that the ramps will primarily cater to trips related to the Project, thereby reducing potential conflicts, all suggest that the Project is not expected to have a significant impact on safety along the studied roadway intersections.

4 CONCLUSIONS

The following conclusions are based on the findings of the Project Safety Analysis:

- The existing crash data, traffic volumes, combined with the remote location of the Project and the expectation that the ramps will primarily serve trips related to the Project, leading to fewer potential conflicts, indicate that the Project should not have significant impact on the safety along the study roadway segments.
- Based on the predictive analysis, the projected average crash frequency related to the intersection is higher with Project traffic. However, the existing traffic volumes at the intersection are quite low, and any development with traffic that accesses the interchange is likely to significantly raise the crash frequency.

Sincerely,
Greenlight Traffic Engineering, LLC

Scott Kelley, PE, PTOE
Principal/Senior Project Manager
scottk@greenlightte.com
(602) 499-1339

Attachments:

A – Site Plan
B – Crash Data Response
C – Predictive Crash Analysis Calculation

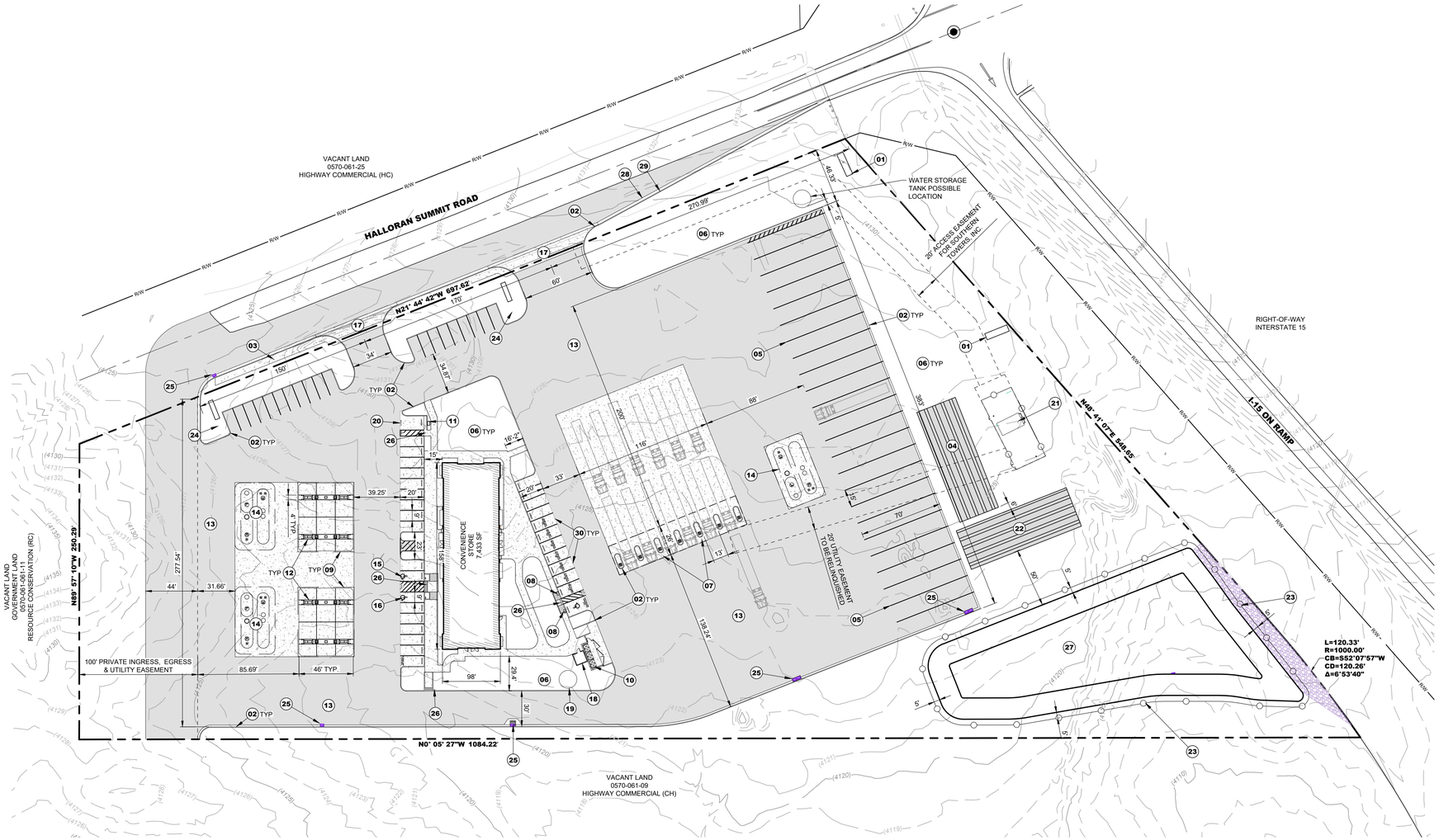
ATTACHMENT A

PROJECT SCOPE:

THIS IS FOR A "MUP" APPLICATION
THERE ARE NO INDOOR SEAT. THERE IS SPACE FOR ABOUT 16 SEATS & TABLES OUTDOORS
THIS PROJECT WILL OPERATE 24/7 - 365
THERE WILL BE OFF-SALE OF BEER AND WINE
LOTTERY TICKETS WILL BE SOLD
THERE ARE 8 MPD' FOR AUTO FUELING, 16 POSITIONS
THERE WILL BE 6 LANES OF TRUCK FUELING AND 24 TRUCK PARKING STALLS
THE CONVENIENCE STORE IS 7,433 S.F.

NOTES:

1. THERE ARE NO COUNTY WATER OR SEWER SERVICES TO THIS SITE. WELL WATER WILL BE USED FOR THE BUILDINGS AND WATER WILL BE STORED FOR THE FIRE DEPARTMENT IN A 210,000+ GALLON TANKS. THERE WILL BE AN ON-SITE SEPTIC SYSTEM.
2. ALL WALKWAYS AND SIDEWALKS ALONG ACCESSIBLE ROUTES OF TRAVEL
   - 2.1. ARE CONTINUOUSLY ACCESSIBLE
   - 2.2. HAVE A MAXIMUM 1/2" CHANGE IN ELEVATION
   - 2.3. ARE MINIMUM 48" IN WIDTH
   - 2.4. HAVE A MAXIMUM 2% CROSS SLOPE
   - 2.5. SHALL HAVE RAMPS COMPLYING WITH 2022 CBC, SECTION 11B-405 OR 11B-406 AS APPROPRIATE WHERE THERE IS A CHANGE IN ELEVATION AT A SLOP EXCEEDING 5%
3. WHERE AN ACCESSIBLE WALKWAY CROSSES OR ADJOINS A VEHICULAR WAY AND THE WALKING SURFACES ARE NOT SEPARATED BY CURBS, RAILINGS OR OTHER ELEMENTS BETWEEN THE PEDESTRIAN AREAS AND VEHICULAR ARES SHALL BE DEFINED BY CONTINUOUS DETECTABLE WARNING WHICH IS 36" WIDE, COMPLYING TO 2022 CBC, SECTION 11B-705.1.2.5



DEVELOPER:

TIMOTHY P. HERBST
TERRIBLE HERBST
5195 LAS VEGAS BLVD.
LAS VEGAS, NV 89119
(702) 798-6400
CONTACT: HOLLEN HERBST

ENGINEER:

HORROCKS ENGINEERS
2162 WEST GROVE PKWY., SUITE 100
PLEASANT GROVE, UT 84062
(801) 763-5100
CONTACT: ERIC VILLALOBOS, PE

ARCHITECT:

PGAL, LLC
7373 PEAK DRIVE, SUITE 170
LAS VEGAS, NV 89128
(702) 435-4448
CONTACT: ROMEO S. BELTRAN

NORTH
SCALE: 1" = 50'

SITE PLAN KEYNOTES

01 FUEL/RETAIL TENANT MONUMENT SIGN. UNDER SEPARATE PERMIT
02 6" VERTICAL CONCRETE CURB
03 CONCRETE SIDEWALK
04 PRIMARY LEACH FIELD 100' X 35'
05 TYPICAL TRUCK PARKING STALLS, 15'-0" X 70'-0"
06 LANDSCAPING, SEE LANDSCAPING LAYOUT PLAN
07 CONCRETE PAVING WITH DIESEL FUEL DISPENSERS
08 ELECTRIC VEHICLE CHARGING STATION (EVCS)
09 LINE OF AUTO GAS FUELING CANOPY OVERHANG
10 TRASH ENCLOSURE AND CONC. APRON SLAB. SEE SHEET __ FOR DETAILS
11 AIR & WATER SERVICE
12 MULTI-PRODUCT FUEL DISPENSER
13 ASPHALT PAVEMENT
14 UNDERGROUND FUEL STORAGE TANKS
15 ACCESSIBLE VAN PARKING STALL
16 ACCESSIBLE PARKING STALL
17 NEW DRIVEWAY- PER COUNTY STANDARDS
18 WELL PUMP HOUSE
19 WATER STORAGE TANK, 210K GALLONS
20 CLEAN AIR VEHICLE PARKING SPACES WHITE LETTERING
21 EXISTING CELL TOWER
22 SECONDARY LEACH FIELD 100' X 35' PER COUNTY REQUIREMENTS
23 4' CHAIN LINK FENCE
24 GAS PRICE MONUMENT SIGN, UNDER SEPARATE PERMIT
25 STORM DRAIN CATCH BASIN
26 ADA SIDEWALK RAMP W/ TRUNCATED DOMES
27 DETENTION BASIN 6' DEEP (26,729 SQ. FT.)
28 SINGLE WHITE LINE STRIPING
29 6" AC CURB
30 ELECTRIC VEHICLE CAPABLE SPACES

PAVEMENT QUANTITIES	
ASPHALT PAVEMENT	CONCRETE PAVEMENT
166,588 SF	37,481 SF

PROJECT DATA	
PARCEL NUMBER:	0570-061-26-0-000
GENERAL PLAN DESIGNATION:	COMMERCIAL
ZONING:	CH COMMERCIAL - HIGHWAY
LOT AREA:	358,431 S.F., 8.2 ACRES
MAXIMUM LOT COVERAGE ALLOWED:	80%, 285,753.6 S.F.
FLOOR AREA RATIO:	0.3:1
TOTAL BUILDING AREA:	16,645 S.F., 0.38 ACRES
TOTAL LANDSCAPING AREA:	140,900 S.F. 3.2 ACRES
PERCENTAGE OF SITE LANDSCAPED:	41.4%

BUILDING DATA			
STRUCTURE	CBC OCCUP.	TYPE OF CONST.	AREA
CONVENIENCE STORE	M	VB	7,433 S.F.
AUTO FUEL CANOPY #1	B	II	2,795 S.F.
AUTO FUEL CANOPY #2	B	II	2,795 S.F.
TRUCK FUEL CANOPY	B	II	3,016 S.F.
TRASH ENCLOSURE	U	VB	256 S.F.
PUMP HOUSE	U	VB	100 S.F.
WATER STORAGE TANK	U	VB	250 S.F.
TOTAL LOT COVERAGE			16,645 S.F.

PARKING DATA	
REQUIRED PARKING	30 SPACES, 1/250 S.F.
PARKING PROVIDED	
REGULAR SPACES:	39
ACCESSIBLE SPACES:	3 *
ELECTRICAL VEHICLE CHARGING:	2 *
ELECTRICAL VEHICLE READY:	6
CLEAN AIR PARKING:	1
TOTAL PARKING SPACES:	50 *
AUTO AIR / WATER:	1
AUTO FUELING POSITIONS	16
RV PARKING	3
LOADING ZONE	2
TRUCK FUELING POSITIONS	6
TRUCK PARKING	24

*** NOTE:**

ONE (1) ACCESSIBLE PARKING STALL IS A SHARED ELECTRICAL VEHICLE CHARGING STATION

6 EV CAPABLE STALLS ARE PROVIDED.

Horrocks.
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www.horrocks.com

WARNING
0 1 2
IF THIS BAR DOES NOT MEASURE 2" THEN DRAWING IS NOT TO SCALE

REVISIONS
REV # | DATE

DRAWING INFO
DATE 12/01/2023
DESIGNED TD
DRAWN OM
CHECKED EV
PROJECT UT-8052-23

*SEE GENERAL NOTES SHEET

PRELIMINARY
NOT FOR CONSTRUCTION

TERRIBLE HERBST TRAVEL CENTER

NIPTON, CA

PRELIMINARY SITE PLAN

SP-01

PAGE 01

ATTACHMENT B

Memorandum

Making Conservation a California Way of Life.

To: ZUSSANE RAYA
CUSTODIAN OF RECORD

FWD TO: RAUNAK BETALA
ENGINEERING INTERN II

Date: November 22, 2023

File: 08-SBD-I-15
NB and SB Ramps at Halloran Summit Road
PM 155.362-155.795

From: MARY PADRES
Office Chief
District 8 Traffic Operations
Surveillance Region C

Subject: **COLLISION DATA FOR TRAFFIC SAFETY REVIEW**

The data provided is protected by 23 U.S.C. § 407, and the data shall not be subject to discovery, nor admitted as evidence in any applicable legal proceeding against the State of California. The State of California, Department of Transportation does not, by allowing the release of this information waive any rights it has under 23 U.S.C. § 407.

This Traffic Accident Surveillance and Analysis System (TASAS) covers the following location(s):

I-015 NB and SB Ramps at Halloran Summit Road PM 155.362-PM 155.795

Table 1A summarizes crash rates for the segments of the project on I-015 northbound (NB) Ramps and I-015 southbound (SB) Ramps at Halloran Summit Road from PM 15.362 to PM 15.795. The Table B report were generated on 11/16/2023, and they depict existing crash rates per million vehicles for the most recent 36-month period from 04/01/2020 to 03/31/2023 from the Traffic Accident Surveillance and Analysis System (TASAS).

TABLE 1A

TASAS Table B Crash Rates (04/01/2020 – 03/31/2023)

Segment	TOTAL No. of Crashes	ACTUAL (Per million vehicles)			AVERAGE (Per million vehicles)		
		Fatal Crashes	Fatal + Injury Crashes	Total (1)	Fatal Crashes	Fatal + Injury Crashes	Total (1)
I-015 NB Off Ramp to Halloran Summit Road PM 155.362	2	0.000	0.00	4.57	0.009	0.48	1.31
I-015 SB On Ramp fr. Halloran Summit Road PM 155.368	0	0.000	0.00	0.00	0.005	0.22	0.63
I-015 NB On Ramp fr. Halloran Summit Road PM 155.787	0	0.000	0.00	0.00	0.005	0.22	0.63
I-015 SB Off Ramp to Halloran Summit Road PM 155.795	0	0.000	0.00	0.00	0.009	0.48	1.31

(1) All reported crashes (includes Property Damage Only (PDO) Crashes)

Table 1A above summarizes and compares the actual crash rates for the segment on I-015 northbound (NB) Ramps and I-015 southbound (SB) Ramps at Halloran Summit Road from PM 155.362 to PM 155.795 to the average rates for similar facilities throughout the State. The Total crash rates include all reported crashes: Fatal, Injury, and Property Damage.

I-015 NB Off Ramp to Halloran Summit Road PM 155.362:

Analysis of the TASAS Table B records shows a total of 2 crashes within the segment I-015 NB Off Ramp to Halloran Summit Road at PM 155.362 and study periods summarized above, with a total rate of fatal related crashes that is below the average for similar facilities statewide, a total rate of fatal and injury related crashes that is below the average for similar facilities statewide, and a total rate of crashes that is above the average for similar facilities statewide.

Detailed analysis per the TASAS Selective Accident Retrieval (TSAR) generated on 11/16/2023 shows that the primary and only crash factor in the segment were:

- "Improper Turn,"

The types of collisions retrieved includes:

- Rear-End
- Hit Object

In addition, this segment was not flagged in TASAS Table C. Table C identifies high crash frequency spot locations with either Type 'W' (Wet) crashes or Type 'A' (All) crashes where four or more significant crashes within twelve, six, or a three- month period have occurred.

I-015 SB On Ramp from Halloran Summit Road PM 155.368:

Analysis of the TASAS Table B records shows a total of 0 crashes within the segment I-015 SB On Ramp from Halloran Summit Road at PM 155.368 and study periods summarized above, with a total rate of fatal related crashes that is below the average for similar facilities statewide, a total rate of fatal and injury related crashes that is below the average for similar facilities statewide, and a total rate of crashes that is below the average for similar facilities statewide.

In addition, this segment was not flagged in TASAS Table C. Table C identifies high crash frequency spot locations with either Type 'W' (Wet) crashes or Type 'A' (All) crashes where four or more significant crashes within twelve, six, or a three- month period have occurred.

I-015 NB On Ramp from Halloran Summit Road PM 155.787:

Analysis of the TASAS Table B records shows a total of 0 crashes within the segment I-015 NB On Ramp from Halloran Summit Road at PM 155.787 and study periods summarized above, with a total rate of fatal related crashes that is below the average for similar facilities statewide, a total rate of fatal and injury related

crashes that is below the average for similar facilities statewide, and a total rate of crashes that is below the average for similar facilities statewide.

In addition, this segment was not flagged in TASAS Table C. Table C identifies high crash frequency spot locations with either Type 'W' (Wet) crashes or Type 'A' (All) crashes where four or more significant crashes within twelve, six, or a three- month period have occurred.

I-015 SB Off Ramp to Halloran Summit Road PM 155.795:
Analysis of the TASAS Table B records shows a total of 0 crashes within the segment I-015 SB Off Ramp to Halloran Summit Road at PM 155.795 and study periods summarized above, with a total rate of fatal related crashes that is below the average for similar facilities statewide, a total rate of fatal and injury related crashes that is below the average for similar facilities statewide, and a total rate of crashes that is below the average for similar facilities statewide.

In addition, this segment was not flagged in TASAS Table C. Table C identifies high crash frequency spot locations with either Type 'W' (Wet) crashes or Type 'A' (All) crashes where four or more significant crashes within twelve, six, or a three- month period have occurred.

Analysis Conducted By:

Elizabeth Nguyen 11/27/2023

Name: Elizabeth Nguyen Date

Title: Transportation Engineer
Email: Elizabeth.nguyen@dot.ca.gov

Approved for Release

11/28/2023

Name: Mary Padres Date

Title: Traffic Operations Office Chief, Surveillance C
Email: Mary.Padres@dot.ca.gov Phone (909) 226-0913

ATTACHMENT C

Predictive Crash Analysis for One-Way Stop Controlled Crossroad Ramp Terminals

Growth Rate 2.00%
Growth Factor for 2028 1.104
Growth Factor for 2040 1.400
AADT Project 6,956

	2023		2028		2040	
	w/o Project	**w/ Project**	**w/o Project**	**w/ Project**	**w/o Project**	**w/ Project**
$AADT_{xrd}$	105	5322	116	5333	147	5364
$AADT_{ex}$	120	1859	132	1871	168	1907
$AADT_{en}$	140	1879	155	1894	196	1935
$AADT_{in}$	60	3538	66	3544	84	3562
$AADT_{out}$	150	7,106	166	7,122	210	7,166

Base Safety Performance Function

Fatal-Injury

a	-2.740
b	1.008
c	0.001
d	0.177
K	2.580

$c*AADT_{xrd}$	0.105	5.322	0.116	5.333	0.147	5.364
$c*AADT_{ex}$	0.120	1.859	0.132	1.871	0.168	1.907
$c*AADT_{en}$	0.140	1.879	0.155	1.894	0.196	1.935
$\ln(c*AADT_{xrd})$	-2.2538	1.6718	-2.1542	1.6739	-1.9173	1.6797
$\ln(c*AADT_{ex}+c*AADT_{en})$	-1.3471	1.3186	-1.2483	1.3257	-1.0106	1.3460
$N_{spf,fi}$	**0.0052**	**0.4398**	**0.0059**	**0.4413**	**0.0078**	**0.4455**

PDO

a	-2.432
b	0.845
c	0.001
d	0.476
K	4.280

$c*AADT_{xrd}$	0.105	5.322	0.116	5.333	0.147	5.364
$c*AADT_{ex}$	0.120	1.859	0.132	1.871	0.168	1.907
$c*AADT_{en}$	0.140	1.879	0.155	1.894	0.196	1.935
$\ln(c*AADT_{xrd})$	-2.2538	1.6718	-2.1542	1.6739	-1.9173	1.6797
$\ln(c*AADT_{ex}+c*AADT_{en})$	-1.3471	1.3186	-1.2483	1.3257	-1.0106	1.3460
$N_{spf,pdo}$	**0.0069**	**0.6759**	**0.0079**	**0.6794**	**0.0107**	**0.6894**

	Crash Modification Factor					
Calibratin Factor, C	1.000	1.000	1.000	1.000	1.000	1.000
CMF_{10}	1.009	1.097	1.010	1.098	1.013	1.102
CMF_{11}						
CMF_{12}						
CMF_{13}	1.000	1.000	1.000	1.000	1.000	1.000
CMF_{14}	1.000	1.000	1.000	1.000	1.000	1.000
CMF_{15}						
CMF_{16}						
CMF_{17}						
CMF_{18}						
CMF_{19}						
CMF_{20}	1.000	1.000	1.000	1.000	1.000	1.000

	Predicted Crash Frequency (crashes/year)					
Fatal-Injury Type Crashes($N_{p,fi}$)	**0.0053**	**0.4826**	**0.0060**	**0.4847**	**0.0079**	**0.4908**
PDO Crashes ($N_{p,pdo}$)	**0.0069**	**0.6759**	**0.0079**	**0.6794**	**0.0107**	**0.6894**
All Type of Crashes ($N_{p,at}$)	**0.0122**	**1.1585**	**0.0138**	**1.1641**	**0.0187**	**1.1802**

$$AADT_{xrd} = 0.5 \times (AADT_{in} + AADT_{out}) \quad (19\text{-}29)$$

The SPF for crashes at one-way stop-controlled ramp terminals is applied as follows:

$$N_{spf,w,ST,at,z} = \exp\left(a + b \times \ln[c \times AADT_{xrd}] + d \times \ln[c \times AADT_{ex} + c \times AADT_{en}]\right) \quad (19\text{-}31)$$

Where:

$N_{spf,w,ST,at,z}$ = predicted average crash frequency of a one-way stop-controlled crossroad ramp terminal of site type w (w = *D3ex*, *D3en*, *D4*, *A4*, *B4*, *A2*, *B2*) with base conditions, all crash types *at*, and severity z (z = *fi*: fatal and injury, *pdo*: property damage only) (crashes/yr).

Table 19-20. SPF Coefficients for Crashes at One-Way Stop-Controlled Ramp Terminals—Four-Leg Terminal with Diagonal Ramps (*D4*)

Crash Severity (z)	Area Type	Number of Crossroad Through Lanes (n)	SPF Coefficient a	b	c	d	Inverse Dispersion Parameter $K_{w,ST,at,z}$
Fatal and injury (*fi*)	Rural	All lanes	–2.740	1.008	0.001	0.177	2.58
	Urban	All lanes	–3.064	1.008	0.001	0.177	2.58
Property damage only (*pdo*)	Rural	All lanes	–2.432	0.845	0.001	0.476	4.27
	Urban	All lanes	–2.432	0.845	0.001	0.476	4.27

Table 19-23. Crossroad Ramp Terminal Crash Modification Factors and their Corresponding SPFs

Applicable SPF(s)	CMF Variable	CMF Description	CMF Equations
Signal-controlled or one-way stop-controlled ramp terminals	$CMF_{10,w,x,at,fi}$	Exit ramp capacity	Equation 19-42
	$CMF_{11,w,x,at,z}$	Crossroad left-turn lane	Equation 19-45
	$CMF_{12,w,x,at,z}$	Crossroad right-turn lane	Equation 19-48
	$CMF_{13,w,x,at,z}$	Access point frequency	Equation 19-49
	$CMF_{14,w,x,at,z}$	Segment length	Equation 19-50
	$CMF_{15,w,x,at,z}$	Median width	Equation 19-51
Signal-controlled crossroad ramp terminals	$CMF_{16,w,SGn,at,z}$	Protected left-turn operation	Equation 19-53
	$CMF_{17,w,SGn,at,z}$	Channelized right turn on crossroad	Equation 19-55
	$CMF_{18,w,SGn,at,z}$	Channelized right turn on exit ramp	Equation 19-56
	$CMF_{19,w,SGn,at,z}$	Non-ramp public street leg	Equation 19-57
One-way stop-controlled ramp terminals	$CMF_{20,w,ST,at,fi}$	Skew angle	Equation 19-58

Note: Subscripts to the CMF variables use the following notation:
- Site type w (w = *D3ex*, *D3en*, *D4*, *A4*, *B4*, *A2*, *B2*),
- Cross section x (x = *ST*: one-way stop control; *SGn*: signal control with n-lane crossroad; *ac*: any cross section),
- Crash type y (y = *sv*: single vehicle, *mv*: multiple vehicle, *at*: all types), and
- Severity z (z = *fi*: fatal and injury, *pdo*: property damage only, *as*: all severities).

The predictive model for one-way stop-controlled crossroad ramp terminals is presented in Equation 19-12. This equation consists of two terms, where each of Equation 19-13 and Equation 19-14 correspond to one term.

$$N_{p,w,ST,at,as} = N_{p,w,ST,at,fi} + N_{p,w,ST,at,pdo} \quad (19\text{-}12)$$

$$N_{p,w,ST,at,fi} = C_{aS,ST,at,fi} \times N_{spf,w,ST,at,fi} \times \left(CMF_{1,aS,ST,at,fi} \times \ldots \times CMF_{m,aS,ST,at,fi}\right) \quad (19\text{-}13)$$

$$N_{p,w,ST,at,pdo} = C_{aS,ST,at,pdo} \times N_{spf,w,ST,at,pdo} \times \left(CMF_{1,aS,ST,at,pdo} \times \ldots \times CMF_{m,aS,ST,at,pdo}\right) \quad (19\text{-}14)$$

Where:

$N_{p,w,ST,at,z}$ = predicted average crash frequency of a stop-controlled crossroad ramp terminal of site type w (w = *D3ex*, *D3en*, *D4*, *A4*, *B4*, *A2*, *B2*), all crash types *at*, and severity z (z = *fi*: fatal and injury, *pdo*: property damage only, *as*: all severities) (crashes/yr);

$C_{aS,ST,at,z}$ = calibration factor for a stop-controlled crossroad ramp terminal (any site type *aS*) with all crash types *at* and severity z (z = *fi*: fatal and injury, *pdo*: property damage only);

$N_{spf,w,ST,at,z}$ = predicted average crash frequency of a one-way stop-controlled crossroad ramp terminal of site type w (w = *D3ex*, *D3en*, *D4*, *A4*, *B4*, *A2*, *B2*) with base conditions, all crash types *at*, and severity z (z = *fi*: fatal and injury, *pdo*: property damage only) (crashes/yr); and

$CMF_{m,aS,ST,at,z}$ = crash modification factor for a stop-controlled crossroad ramp terminal (any site type *aS*) with feature m, all crash types *at*, and severity z (z = *fi*: fatal and injury, *pdo*: property damage only).

$AADT_{xrd}$ = AADT volume for the crossroad (veh/day);

$AADT_{ex}$ = AADT volume for the exit ramp (veh/day);

$AADT_{en}$ = AADT volume for the entrance ramp (veh/day);

$AADT_{in}$ = AADT volume for the crossroad leg between ramps (veh/day); and

$AADT_{out}$ = AADT volume for the crossroad leg outside of interchange (veh/day).

Crash Modification Factor - Exit Ramp Capacity

Growth Rate	2.00%
Growth Factor for 2028	1.104
Growth Factor for 2040	1.400
AADT Project	6,956

Fatal-Injury

a	0.151
c	0.001

	w/o Projec	w/ Project	w/o Projec	w/ Project	w/o Projec	w/ Project
	2023	**2023**	**2028**	**2028**	**2040**	**2040**
$AADT_{xrd}$	105	5322	116	5333	147	5364
$AADT_{ex}$	120	1859	132	1871	168	1907
$AADT_{en}$	140	1879	155	1894	196	1935
$AADT_{in}$	60	3538	66	3544	84	3562
$AADT_{out}$	150	7106	166	7122	210	7166

n_{ex}	1
$n_{ex,eff}$	0.5

P_{ex}	0.255	0.129	0.254	0.130	0.255	0.131
1- P_{ex}	0.745	0.871	0.746	0.870	0.745	0.869
CMF_{10}	1.009	1.097	1.010	1.098	1.013	1.102

The CMFs are described using the following equation:

$$CMF_{10,w,x,at,fi} = (1.0 - P_{ex}) \times 1.0 + P_{ex} \times \exp\left(a \times \frac{c \times AADT_{ex}}{n_{ex,eff}}\right) \quad (19\text{-}42)$$

with

$$n_{ex,eff} = \begin{cases} 0.5 \times (n_{ex} - 1.0) + 1.0 & : \text{merge or free-flow right turn} \\ 0.5 \times n_{ex} & : \text{signal, stop, or yield-controlled right turn} \end{cases} \quad (19\text{-}43)$$

$$P_{ex} = \frac{AADT_{ex}}{AADT_{in} + AADT_{out} + AADT_{en} + AADT_{ex}} \quad (19\text{-}44)$$

Where:

$CMF_{10,w,x,at,fi}$ = crash modification factor for exit ramp capacity at a site of type w, control type x, and all types at of fatal-and-injury crashes;

P_{ex} = proportion of total leg AADT on exit ramp leg;

$AADT_{ex}$ = AADT volume for the exit ramp (veh/day);

$n_{ex,\,eff}$ = effective number of lanes serving exit ramp traffic (lanes);

n_{ex} = number of lanes serving exit ramp traffic (lanes).

$AADT_{in}$ = AADT volume for the crossroad leg between ramps (veh/day);

$AADT_{out}$ = AADT volume for the crossroad leg outside of interchange (veh/day); and

$AADT_{en}$ = AADT volume for the entrance ramp (veh/day).

The coefficients for Equation 19-42 are provided in Table 19-32. When computing P_{ex}, the AADT volume of the loop exit ramp at a *B4* terminal configuration is not included in $AADT_{ex}$. Similarly, the AADT volume of the loop entrance ramp at an *A4* configuration is not included in $AADT_{en}$.

Table 19-32. Coefficients for Exit Ramp Capacity CMF—Crossroad Ramp Terminals

				CMF Coefficients	
Control Type (*x*)	**Crash Type (*y*)**	**Crash Severity (*z*)**	**CMF Variable**	*a*	*c*
One-way stop control (*ST*)	All types (*at*)	Fatal and injury (*fi*)	$CMF_{10,\,x,\,ST,\,at,\,fi}$	0.151	0.001
Signal control, *n* lanes (*SGn*)	All types (*at*)	Fatal and injury (*fi*)	$CMF_{10,\,x,\,SGn,\,at,\,fi}$	0.0668	0.001

Crash Modification Factor - Skew Angle

Growth Rate 2.00%
Growth Factor for 2028 1.104
Growth Factor for 2040 1.400
AADT Project 6,956

Fatal-Injury

Skew Angle, I_{sk} 22 degrees

	w/o Project 2023	w/ Project 2023	w/o Project 2028	w/ Project 2028	w/o Project 2040	w/ Project 2040
$AADT_{xrd}$	105	5322	116	5333	147	5364
$AADT_{ex}$	120	1859	132	1871	168	1907
$AADT_{en}$	140	1879	155	1894	196	1935
$AADT_{in}$	60	3538	66	3544	84	3562
$AADT_{out}$	150	7106	166	7122	210	7166

n_{ex}	1
$n_{ex,eff}$	0.5

P_{ex}	0.255	0.129	0.254	0.130	0.255	0.131
1- P_{ex}	0.745	0.871	0.746	0.870	0.745	0.869
CMF_{20}	1.000	0.999	1.000	0.999	1.000	0.999

$CMF_{20,\,w,\,ST,\,at,\,fi}$—Skew Angle

One CMF is used to describe the relationship between the exit ramp skew angle and predicted crash frequency. The SPF applicable to three-leg terminals with a diagonal exit ramp (*D3ex*) is identified as follows:

- SPF for fatal-and-injury crashes, three-legs with diagonal exit ramp, stop control, *n* lanes (*D3ex*, *ST*, *at*, *fi*).

There is one more SPF for each of six terminal configurations (i.e., site types) to which these CMFs apply. They are not shown in the previous list. However, the only difference is that the *D3ex* subscript (shown in parentheses in the previous list) is replaced by the other configuration subscripts (*D3en*, *D4*, *A4*, *B4*, *A2*, *B2*).

The base condition is no skew in the intersecting alignments (i.e., a skew angle of 0.0 degrees). The CMFs are described using the following equation:

$$CMF_{20,w,ST,at,fi} = (1.0 - P_{ex}) \times 1.0 + P_{ex} \times \exp(0.341 \times \sin[I_{sk}] \times 0.001 \times AADT_{ex}) \quad (19\text{-}58)$$

Where:

$CMF_{20,\,w,\,ST,\,at,\,fi}$ = crash modification factor for skew angle at a stop-controlled site of type *w*, with *n* crossroad lanes, and all types *at* of fatal-and-injury crashes *fi*; and

I_{sk} = skew angle between exit ramp and crossroad (degrees).

The variable P_{ex} is computed using Equation 19-44.

This CMF is applicable to any one-way stop-controlled ramp terminal with an exit ramp that has stop or yield control for the "reference" exit ramp movement. The reference movement is the left-turn movement for all terminal configurations except the *B4* configuration. At a *B4* ramp terminal, the reference movement is the right-turn movement on the diagonal exit ramp (not the loop exit ramp). This CMF is applicable to skew angles in the range of 0 to 70 degrees.