Road Safety Assessment Report

D-3 State Route 16, from I-505 to County Road 78 near Brooks

03-Yol-16-PM 18.6/31.7

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Prepared by

U.S. Department of Transportation, Federal Highway Administration
and
Value Management Strategies, Inc.

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This Road Safety Assessment (RSA) was initiated by the California Department of Transportation (Caltrans). The processes used during the workshop were a combination of the Federal Highway Administration (FHWA) RSA process and Caltrans' Value Analysis tools and techniques. The RSA team consisted of team members from FHWA and from Value Management Strategies, Inc. (VMS). The products of the workshop as documented in this report are a combination of FHWA-developed content and content developed by VMS. While the entire RSA team participated in the workshop and contributed to the content of this report, the majority of the narrative content in the Introduction, Existing Conditions, and Assessment Findings sections was developed by FHWA. The content in the Safety Improvement Countermeasures and Supporting Workshop Documentation sections was developed by VMS.

INTRODUCTION

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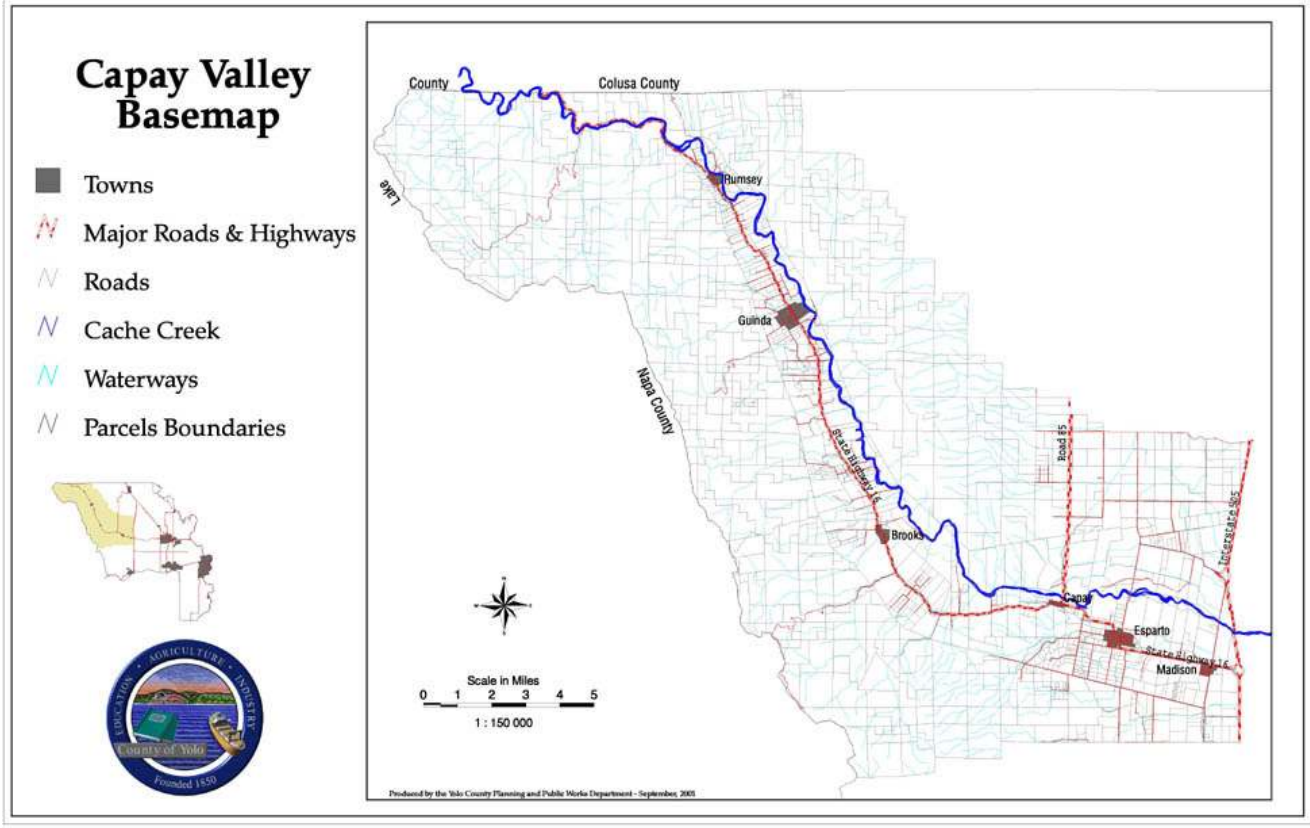
OBJECTIVES OF STUDY

The objective of this study was to complete a Road Safety Assessment (RSA) leading to proposed safety enhancements for California State Route 16 (SR 16) in Yolo County (see below). The study area extends west from Interstate 505 (I-505) near Madison to County Road 78 (CR 78) near Brooks – a distance of approximately 11 miles. Due to the crash history of the corridor and earlier project proposals that have not been implemented due to community concerns, FHWA was contacted by the California Department of Transportation (Caltrans) to conduct an RSA to evaluate the safety issues through the corridor.

STUDY AREA



[SOURCE: http://www.capayvalleyvision.org/maps.html]

Road Safety Assessments are a valuable tool for transportation agencies to evaluate road safety issues contributing to injuries and deaths and to identify opportunities for improvement. RSAs are also an effective tool for proactively improving roadway and roadside safety. As such, the RSA process may be employed on any type of facility and during any stage of the project development process, including existing facilities that are open to traffic.

The FHWA defines an RSA as a "formal safety performance evaluation of an existing or future road or intersection by an independent, multidisciplinary team." The primary focus of an RSA is safety while working within the context of other aspects such as mobility, access, surrounding land use, and/or aesthetics. Other factors to be considered include changes in facility ownership, traffic patterns (may be seasonal), and development. RSAs conducted by a team that is independent of the design and operations of the facility are able to address safety by means of a thorough review of roadway, traffic, environmental, and human factors and conditions. By focusing on safety, RSAs ensure that potentially hazardous roadway and roadside elements do not "fall through the cracks."RSAs typically follow an eight-step RSA process, shown below.

RSA PROCESS

Although past project proposals for this corridor had been triggered by a crash rate well above the statewide average for similar facilities, this RSA was undertaken with no pre-conceived notion about the relative degree of safety in the present context. It should also be understood that this RSA made no attempt to judge the appropriateness of any safety improvements incorporated in any past project or in any other way seek to "validate" any facet of other proposals.

Caltrans commitment to ensure an unbiased view by the RSA team and to promote transparency for the entire RSA process was voiced emphatically by Caltrans District Engineer Tom Brannan, when he informed attendees at the March 12 Kick Off Meeting in Esparto that the "table was being swept clean" and that the RSA team was to take a "fresh look" at the corridor. Caltrans decision to not have any staff serve on the RSA team was further evidence of their resolve to avoid even the appearance of potential conflicts of interest.

STUDY PURPOSE

The purpose of this RSA was to identify safety issues that may be contributing to the reported crashes along the corridor and to identify potential measures to mitigate these issues. Another goal of the RSA was to identify safety issues that have not yet resulted in crashes and suggest proactive improvements to correct or mitigate these issues.

STUDY TEAM

The RSA was performed during the week of March 12, 2012, during daytime and nighttime hours. The RSA team consisted of the following members:

George Hunter	Value Management Strategies (VMS)
Mark Watson	Value Management Strategies (VMS)
Craig Allred	FHWA Resource Center
Keith Harrison	FHWA Resource Center
David Cohen	FHWA, California Division
Jeff Holm	FHWA, California Division
Sgt. Andy Hill	California Highway Patrol – Woodland Area

PROJECT BACKGROUND

Within the limits of the study, SR 16 is a two-lane rural road, providing an east-west connection through north-central California from the Woodland urbanized area to the Clear Lake region. This road serves a variety of road users and vehicles, including local commuters/residents, tourists, pedestrians, bicyclists, heavy commercial vehicles, and farm equipment. SR 16 is the primary access to Cache Creek Casino near the town of Brooks. The casino is built on land owned by the Yocha Dehe Wintun Nation, and is a major employer in the study area.

During the last 10 years, various interim improvements along the study corridor have been implemented that may have addressed some of the safety concerns that originally triggered a need for an extensive safety project. The following table lists several of these efforts.

INTERIM IMPROVEMENTS ALONG THE STUDY CORRIDOR

Project	Location
Super-elevation improvements and metal beam guardrail	Capay Curve and two curves west of Capay
Install four-way flashing beacon	At CR 89
Install inverted thermoplastic on centerline	From I-505 to Brooks (except in Esparto and Capay)
Improve sight distance (tree removal)	At CR 85B
International striped crosswalks	Esparto
Left-turn centerline re-stripe along Yolo Avenue	Esparto
Install 45 mph sign; install no-passing stripe; add 55 mph and 35 mph signs; daylight headlight signs, etc.	Various Locations
Signalize intersection and access improvements	Cache Creek Casino frontage
Signalize intersection	Northbound I-505 exit to SR 16
Capay shoulders	SR 16 through Capay

[SOURCE: Approved Project Report, December 2009]

EXISTING CONDITIONS

EXISTING CONDITIONS

GENERAL CHARACTERISTICS

State Route 16 is a two-lane, rural road with mostly 12-foot travel lanes bordered by intermittent paved and/or gravel shoulders of varying width, and often leading to an open "vee" ditch. The roadway right-of-way is approximately 30 feet each side of centerline. Much of the abutting land use is agricultural (farms, ranches, orchards), interspersed with light-density residential areas. The terrain is generally flat to gently rolling.

Cache Creek meanders through the study area and is intersected by a number of sloughs and drainage channels. The roadway is bituminous pavement, with occasional areas of pavement distress. Paved and gravel shoulders are in generally good condition, although the gravel shoulder was "soft" in some locations and had subsided in many locations, exposing a vertical edge "drop off" and contributing to raveled edges in many areas. In and near Capay and Esparto, shoulders have been re-constructed of brick-colored stamped concrete. Marked crosswalks exist in several locations, accompanied by advance signing. In addition, Yolo Avenue (the segment of SR 16 through downtown Esparto) has several interim traffic-calming measures, including painted bulb-outs, colored crosswalks and markings, and back-in angled parking. Yellow centerlines and white edgelines are present throughout. Raised pavement markers and centerline rumble strips are also present in many areas. Post-mounted delineators and chevrons have been placed in and near horizontal curves.

The speed limit is posted at 55 mph in areas with long tangent sections outside of downtown Esparto and Capay. Lower speed limits are introduced upstream of restricted curves and residential areas. Speed limits through Esparto and Capay are generally 25 mph or 35 mph, respectively.

Traffic volumes are currently approximately 10,000 AADT, but are projected to more than double in 20 years. The increase in traffic can be attributed to the increase in gaming at the casino, expansion of the casino, and traffic destined for points west of this corridor, such as the Clear Lake recreation area. Traffic counts for a one-week period during mid-February 2012 ranged from about 8,000 mid-week to near 12,000 on weekend days. Daily peak periods are somewhat atypical due to the influence of Cache Creek Casino. Shift changes at the casino tend to cause spikes in traffic mid-afternoon and late evenings. In addition, casino patronage tends to be higher from Thursday to Sunday.

There are no signalized intersections within the study corridor except in the immediate vicinity of the Cache Creek Casino. All other major intersections are stop-controlled.

SAFETY CHARACTERISTICS

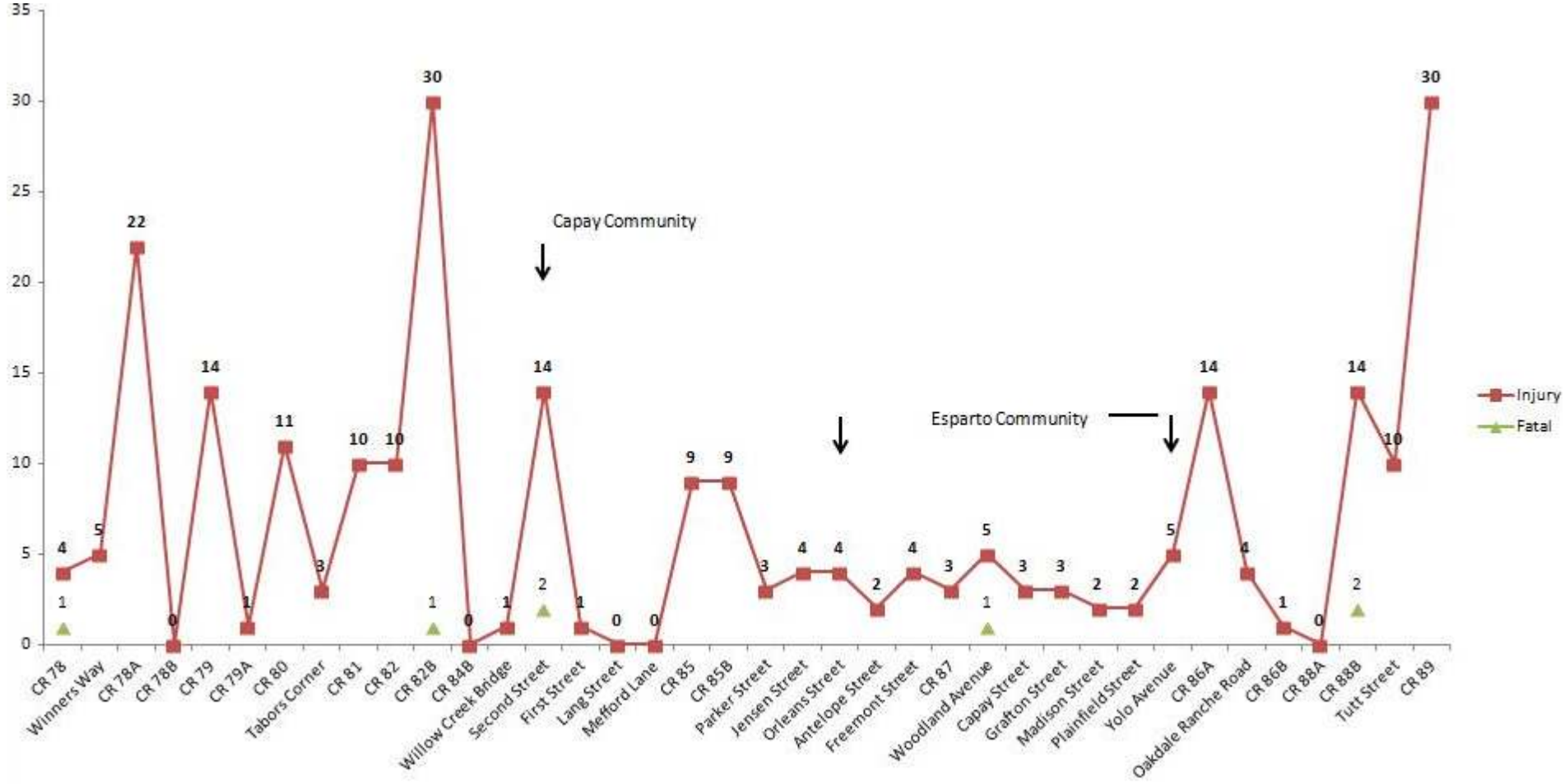
The total crash rate within the study area has improved since the 1999-to-2002 period, when the crash rate was more than twice the statewide average for similar facilities. Since that time, several interim safety improvements (see the table, "Interim Improvements along the Study Corridor" on page 4) have been made to reduce the number and severity of crashes.

However, crash statistics for the corridor are still a significant concern. The chart on the following page provides an overview of the distribution of fatal and injury crashes within the SR 16 corridor. While there were less than 10 fatal crashes in as many years, there were more than 250 injury crashes of varying severity – or a ratio of about 32:1. As might be expected, many of these are clustered at or near intersections – natural points of conflict between road users – and at locations where geometric features or traffic operations challenge driver capabilities – a sharp horizontal curve or a short passing zone, for example.

A more detailed analysis of corridor crashes for the period October 2007 through September 2010 provides further insights about crash patterns and contributing factors. During this three-year period, there were 129 total crashes, including 2 fatal crashes and 61 injury crashes. This equates to a Severity Index of 63/129 or 0.49 (49%).

- 38 crashes occurred at night, 29 of which were coded as "Dark, No Streetlight"
- 117 crashes occurred on dry pavement
- 124 crashes had "Roadway Condition" coded as "No Unusual Condition;" *none* were coded as "Flooded"
- 140 of the crash vehicles were passenger cars or pickup trucks
- 6 crash vehicles were large single-unit trucks or tractor-trailers; 2 crashes involved a bus other than a school bus; 2 involved emergency vehicles
- There were 48 rear-end crashes; 35 hit object; 15 broadside; 15 overturn; 7 head-on; 6 sideswipe
- Only 24 of the crashes were coded as having occurred "at" an intersection – this distinction is important, because a cursory glance at the following chart might imply that the crashes are <u>all</u> occurring at intersections. (The cross-streets shown on the horizontal axis simply represent the nearest intersection that could be used for an easy point-of-reference).
- 49 crashes listed "Speeding" as the Principle Contributing Factor (PCF) [Note that "speeding" does not always mean that the driver exceeded the regulatory speed limit. Instead, it often reflects the judgment of law enforcement personnel that the driver was traveling too fast for conditions.]
- 13 cited alcohol involvement as PCF; 4 crashes identified a driver as having been using a cell phone; under the heading of "Other Associated Factors," 3 crashes involved drivers who were "Unfamiliar with Road"
- 21 crashes resulted in a vehicle going "Beyond Shoulder Driver's Left;" 59 show that the vehicle went "Beyond Shoulder Driver's Right"
- Of the objects struck (excluding other vehicles as the objects struck), 28 were "Ditch;" 21 Overturn; 12 trees or plants, and 8 involved cut slopes or embankment

CRASH LOCATIONS BY NEAREST CROSSROAD



[SOURCE: CHP AIS Database, March 2012]

Note: The cross-streets shown on the horizontal axis simply represent the nearest intersection that could be used for an easy point-of-reference.

ASSESSMENT FINDINGS

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SAFETY BENEFITS OF EXISTING ROADWAY FEATURES

Based on a review of existing site conditions, the RSA team observed numerous geometric and traffic-control features that enhance road safety in the study area, many of which have already been cited on page 4. These efforts have begun to make a difference in reducing crashes in the corridor.

SAFETY BENEFITS OF PLANNED ROADWAY IMPROVEMENTS

The safety benefits of planned or constructed improvements were not evaluated as part of this RSA, as the RSA team wanted to ensure that a high degree of impartiality was maintained.

IDENTIFIED SAFETY ISSUES

In an effort to further improve safety throughout the study area, the RSA team identified nineteen (19) general safety issues, broadly categorized into 9 major safety-related themes. The RSA team members prioritized the safety issues, according to their perceived importance in the study area based on the review of crash data and observations in the field, and developed suggestions to mitigate the safety concerns.

1. Flooding
2. Farm Vehicle Mobility
3. Roadside Departures
4. Shoulder Width
5. Curves
6. Intersections
7. Passing
8. Pedestrian Safety
9. Signs and Markings

1. FLOODING

State Route 16 is frequently inundated during flood events between Esparto and Madison. Historical data, shown on the following page, indicates the number of days (in a given year) during which the road was closed for some time – even if only a few hours. The average is 2 days per year.

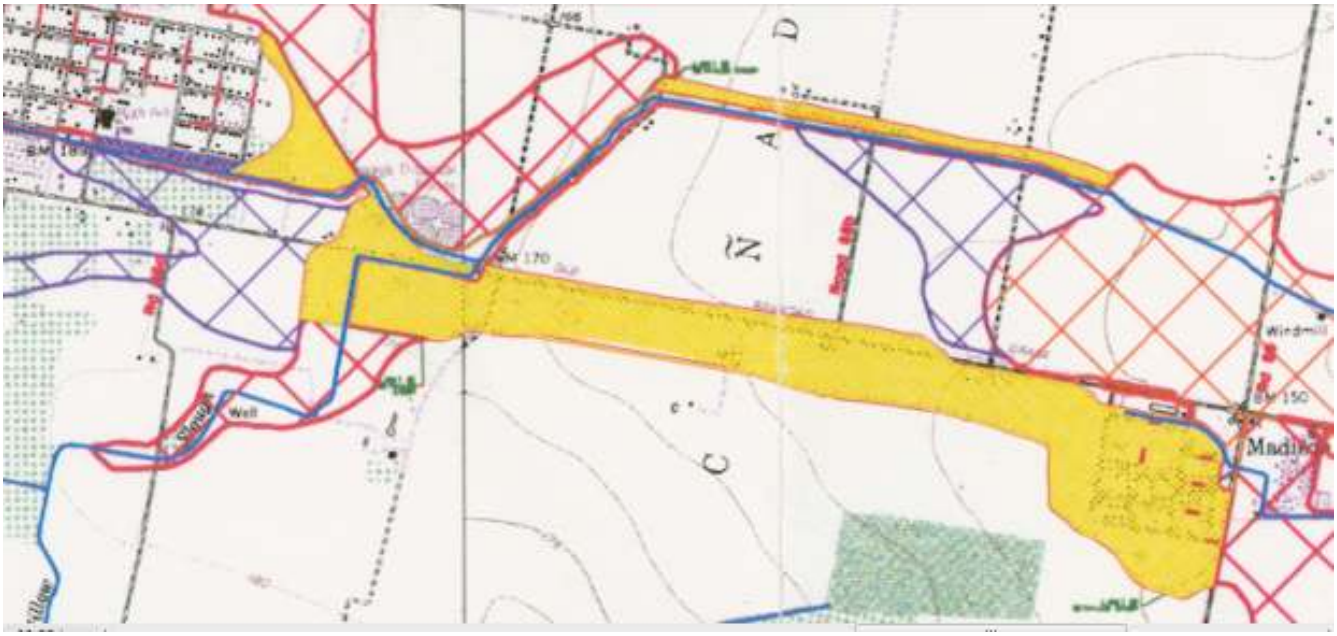
NUMBER OF DAYS SR 16 CLOSED BETWEEN I-505 AND ESPARTO

6 (1966)	7 (1978)	0 (1990)	1 (2002)
4 (1967)	0 (1979)	0 (1991)	2 (2003)
0 (1968)	7 (1980)	0 (1992)	3 (2004)
1 (1969)	2 (1981)	1 (1993)	
7 (1970)	5 (1982)	9 (1994)	
0 (1971)	9 (1983)	0 (1995)	
2 (1972)	0 (1984)	2 (1996)	
3 (1973)	1 (1985)	1 (1997)	
0 (1974)	6 (1986)	2 (1998)	
3 (1975)	0 (1987)	0 (1999)	
0 (1976)	2 (1988)	0 (2000)	
1 (1977)	0 (1989)	0 (2001)	

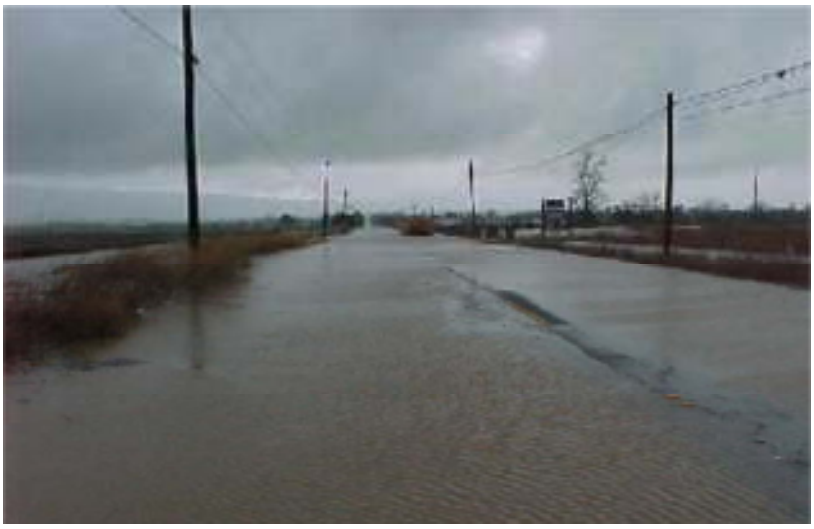
No correlation between road safety issues (number of crashes) and flooding was identified. A review of 339 crashes covering the six-year period of October 2004 through September 2010 identified zero crashes where the Roadway Condition was coded as "Flooded." While flood events always present potential risk for drowning, electrocution, slips and falls, the *crash* risk for SR 16 road users has not been borne out by the historical data. Nevertheless, the risk of a motorist trying to drive through high water in a future flood still exists. So, several countermeasures have been identified later in this report.

The RSA team understood that the flooding is concentrated between where the South Fork Willow Slough first crosses SR 16 and the City of Madison (depicted below by the yellow shaded area).

AREA OF CONCENTRATED FLOODING



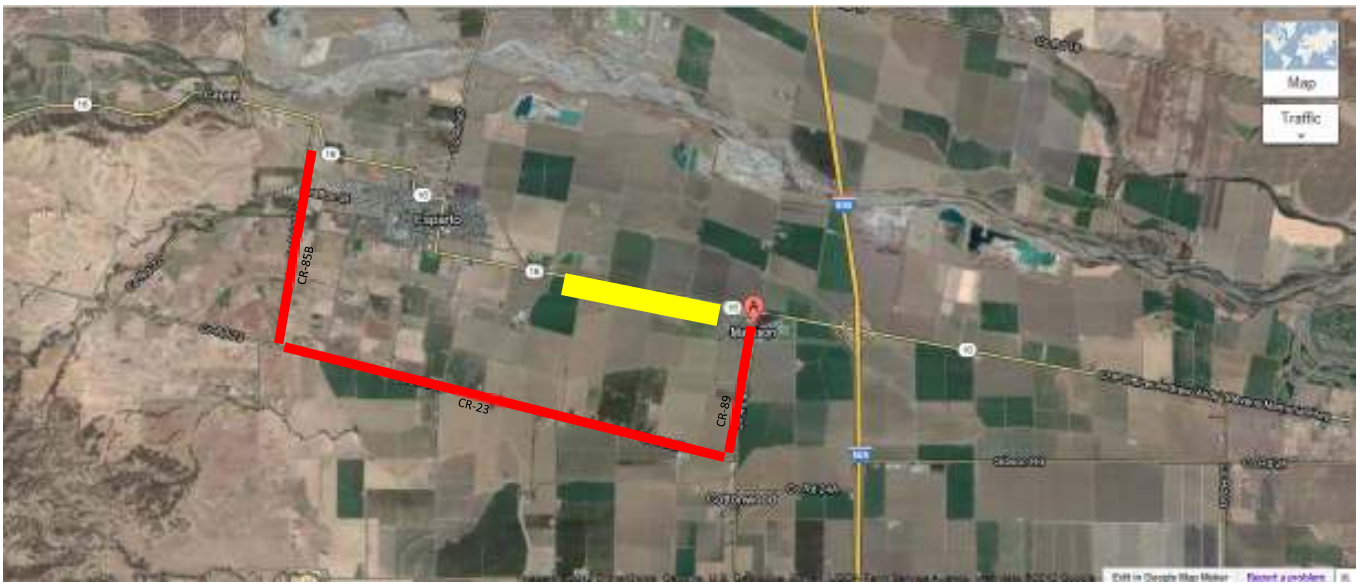
WILLOW CREEK SLOUGH CROSSING DURING FLOOD CONDITIONS IN 2006



SR 16 is closed by the California Highway Patrol (CHP) under flooding conditions between Madison and Esparto – typically between the CR 89 intersection and Willow Slough. The towns that flood in the valley upstream of Esparto typically share information with downstream towns when the flood stages have arrived, and therefore the Esparto and Madison authorities have the ability to mobilize and prepare for the impending flood, including barricading the portion of SR 16 at CR 89 and at CR 21A. There have been isolated cases of motorists bypassing the barricades. If SR 16 is inundated, the flooding many times affects I-505 as well. Any proposed flood protection improvements proposed for SR 16 must also consider the effects on I-505, as it is the principle access route for emergency responders.

The area blocked by flooding on SR 16 shown above can be bypassed via a detour of CR 89 to CR 23 to CR 85B as shown in the image to follow, titled “Possible Detour of Flooded Area.” Although the roads that comprise this detour route also experience flooding, the flood depth and duration tend to be less than SR 16.

POSSIBLE DETOUR OF FLOODED AREA



2. FARM VEHICLE MOBILITY

Farm Vehicles Accessing and Traveling on SR 16

Implements of husbandry essential for farming operations must occasionally travel SR 16. For example, from Esparto to I-505, there are at least 9 formally recognized driveways/access points for farm vehicles. However, farm vehicle travel can be anticipated anywhere within the study corridor. The size and weight of these vehicles require careful consideration in highway design to ensure that they can be safely accommodated as they travel between fields. Many farm vehicles travel at relatively low speeds, have very low ground clearances, and extreme widths up to 20 feet.

EXAMPLES OF FARM EQUIPMENT

During the field reviews by the RSA team, many areas of the roadway were noticed to be "scuffed" near the pavement edge. This damage is consistent with what likely occurs when farm vehicle operators steer as far right as possible, probably with one wheel on the shoulder, to avoid encroaching into the opposing lane of travel. At one location, "Capay Curve" (near Second Street in Capay), some farming equipment is required to intrude into the oncoming traffic lane to avoid hitting the guardrail on the outside of the curve.

GUARDRAIL AT CURVE

Many types of farm equipment have only 5 to 7 inches of clearance. In addition, "low boy or low bed" trailers often have a 16-inch clearance and a length of 48 feet. All of these vehicles have a high potential to get hung up when entering or exiting access points to fields. Per California Vehicle Code, farm vehicles are allowed to access State highways as long as they are not over 10 feet wide, go over 25 miles per hour, and do not exceed the highway maximum weight limits.

The speed differential between farm equipment and other vehicles is also potentially very hazardous, as drivers approaching from behind may not slow in time to avoid a rear-end collision or may become impatient and attempt to pass even in locations where it may not be safe and/or prudent.

3. ROADSIDE DEPARTURES

Limited Recovery Space for Roadway Departures

Drivers that run off the road require space to safely recover. To do that, the roadside needs to be relatively free of fixed objects or steep slopes. This area for recovery is known as the Clear Recovery Zone or simply "Clear Zone." Current Caltrans design standards specify a minimum Clear Recovery Zone width of 20 feet for a two-lane road like SR 16. National guidance from the AASHTO Roadside Design Guide suggests that a Clear Zone width of as much as 30 feet might be appropriate. This recovery area is particularly important on the outside of horizontal curves. Much of SR 16 has roadsides that are narrow, have steep side slopes, ditches, creeks, and/or utility poles, trees and other fixed objects. The shoulder of the road, which is the beginning of the Clear Recovery Zone, allows many of the run-off drivers to recover.

In many locations along the SR 16 corridor, paved shoulders range from 0 to 2 feet, a variety of widths of unpaved shoulders, and many have pavement edge drop-offs. Crash data from October 2007 through September 2010 indicate that 80 crash vehicles went "Beyond the Shoulder" (left or right) and 70 vehicles encountered a roadside fixed object, slope, or ditch.

Centerline Crossovers

SR 16 is a rural curvilinear, undivided highway with high speeds and limited passing opportunities. At times vehicles are entering low-speed curves (Capay and Taber Curves) from straight ("tangent") sections of the highway, which induce a potential for vehicles to encroach into the opposing lane. SR 16, like most rural two-lane roadways, lacks physical features that separate the travel lanes. As a result, a distinct potential exists for vehicles to cross centerlines, possibly leading to sideswiping or striking oncoming vehicles head-on.

Seven sideswipe and 6 head-on crashes occurred from October 2007 to September 2010. Two of these occurred in the tangent section between Esparto and Madison in the vicinity of CR 88B and resulted in 3 fatalities. More recently, a fatal crash occurred at Capay Curve, when an eastbound tractor-trailer crossed the centerline near the middle of the curve. According to published studies, these types of centerline crossover crashes account for about 20 percent of fatal crashes on two-lane rural roads. On SR 16, 4 crossover crashes have been identified in the last 10 years – 2 in the vicinity of Second Street/Capay Curve and 2 in the vicinity of CR 88B.

SITE OF FATAL ACCIDENT

4. SHOULDER WIDTH

Limited Storage for Disabled Vehicles, Crash Response, or Maintenance

Throughout the SR 16 corridor from I-505 to the Cache Creek Casino, the shoulder width ranges from 0 to 2 feet, except in the Cities of Esparto, Capay, and the Cache Creek Casino area where wider shoulders exist. Along the corridor, there are existing areas of stable gravel shoulders that can allow passenger car drivers to pull over in emergencies, but they are very limited and not wide enough to accommodate emergency vehicles and roadway maintenance vehicles. Over time, gravel shoulders can subside, thus exposing the outer edge of the abutting pavement. This exposed edge or "drop-off" can cause a driver to lose control of his vehicle should he stray off the pavement onto the shoulder and attempt to steer back onto the pavement.

When maintenance crews or emergency response personnel must stop, lane closures are often required, as no refuge areas for staging (e.g., shoulders) are available, thus resulting in queuing in both directions, which could lead to end of queue crashes. Colored and stamped shoulders through the City of Capay have good contrast between the pavement and shoulder during the day, but the contrast is diminished at night.

Also, because of the narrow (0 to 2-foot) existing shoulder widths, bicyclists must often travel in the roadway, exposing them to high-speed conflicts.

EXISTING SHOULDERS ALONG SR 16 CORRIDOR

EXISTING GRAVEL SHOULDER ALONG SR 16 CORRIDOR

PICK-UP TRUCK STOPPED ON SHOULDER OF WB SR 16 JUST WEST OF MADISON

[Note that right side of truck is very close to vee ditch.]

Lack of Areas for Enforcement

CHP ENFORCEMENT ON SR 16 SHOULDER

State Route 16, within the designated project area, consists of unimproved shoulders, narrow shoulder widths, and few clearly delineated safe stopping locations or pull offs, most notably from the community of Capay west to the community of Brooks. This, combined with limited sight segments, lends to reduced traffic violation enforcement and delayed emergency responses. The safety of soft and/or sloped shoulders, most notably during hours of darkness, severely limits safe stopping locations for law enforcement stops, whereby law enforcement officers wait until the violator reaches urban areas where the roadway shoulders are improved or visible. Additionally, violators are unwilling to pull off the mainline roadway risking damage to their vehicle or running off the roadway when the condition of the shoulder is unknown. The reduced capability of traffic violation enforcement increases violation frequencies and decreases the overall roadway safety throughout the roadway segment. Unenforced traffic laws diminish compliance. Additionally, emergency vehicle travel is encumbered by the lack of quick and safe areas to pull right and slow, as required by California law. As a result, emergency vehicles are unable to traverse the segment quickly and safely.

5. CURVES

Transitioning from High-Speed to Low-Speed Road Segments

Outside of the central business districts of Esparto and Capay, the posted speed limit in straight ("tangent") sections of SR 16 is 55 mph, though actual operating speeds may often be higher. In several locations, these tangent sections lead to horizontal curves that cannot be safely driven at such high speeds; these curves are marked with "advisory" speed signs (black lettering on a yellow background). To help drivers transition from a high-speed approach to a speed suitable for safely negotiating these curves, Caltrans has installed a series of signs advising of the reduced speed followed by a sign marking the beginning of a lower posted speed limit upstream of the curve. Crash patterns at several curves near Taber's Corner Road, for example, and Capay Curve (just west of Second Street in Capay) suggest that drivers are not slowing enough.

TABER CURVE

The RSA team reviewed the geometry and the operation of these curves. The Taber Curve has a history of roadway departures, and the team observed skid marks from a recent roadway departure in the eastbound approach to the curve. However, because of the wide recovery area, the vehicle was able to regain control and return to the roadway at the tangent section east of the curve.

The Capay Curve has a history of fatal crashes. The posted advisory speed limit at the curve is 25 mph. However, the advance speed signing may be too far upstream of the curve to allow eastbound drivers to readily discern the need to slow down. The curve itself may not be within the driver's field of vision until having actually entered the curve. This inability to readily associate the hazard with the "advice" is even more pronounced during darkness.

The close proximity of metal beam guardrail on the outside of Capay Curve may cause farm equipment operators to shy away and intrude into oncoming traffic. In addition, eastbound traffic approaching Capay Curve has limited sight distance; drivers have difficulty seeing around the inside of the curve.

6. INTERSECTIONS

Intersection Traffic Control and Signage

Two intersections in Esparto have conditions that may violate driver expectations, increasing the likelihood of a crash. These two intersections are at each end of Yolo Avenue where SR 16 traffic executes a 90-degree turn.

INTERSECTION 1

INTERSECTION 2

Intersection 1 is the 3-way "tee" intersection at the south end of Esparto, where CR 21A and SR 16 come together. Here, "westbound" SR 16 traffic turns to the north in a moderate-speed, "free" right turn, i.e., no yield or stop control. Drivers making the opposing turn (east to north) may falsely assume that they have the right of way and that "westbound" drivers will stop or yield.

STREET VIEW OF INTERSECTION 1

Intersection 2 is a traditional 4-way "cross" intersection at the north end of town, where "westbound" SR 16 motorists turn left (north to west) without being required to yield or stop. Drivers approaching from any of the other three directions ("eastbound" SR 16, southbound CR 87, and westbound Woodland Avenue) all have stop sign control. Drivers unfamiliar with the area may logically assume that "westbound" motorists will also be governed by stop sign control, when in fact they are not. The resulting confusion may cause drivers on any of those other three approaches to enter the intersection thinking that "westbound" traffic will not conflict with their movement.

The other possible scenario is that the unfamiliar motorist approaching the intersection in the "westbound" direction, seeing cars stopping on the other legs, may think he must also stop. This creates a potentially hazardous condition if drivers of following cars are familiar with the unopposed left turn and are not expecting the vehicle ahead to slow or stop.

Crash data indicates that a fatality crash occurred at this intersection when a motorist proceeding west on Woodland Avenue ran into an SR 16 vehicle taking the free left turn.

Limited or No Lighting at Key Intersections

Due to the rural nature of much of the SR 16 corridor, street lighting is not common outside of the central business districts and the Cache Creek Casino.

However, there are numerous intersections with county roads where it is difficult to see the entrance and exit to the intersecting roadway until an approaching driver has actually reached the intersection. This may lead to erratic, last-minute maneuvers. In locations where pedestrians might be walking along the roadway or crossing the roadway (whether at a marked crosswalk or not), the absence of overhead lighting may make it difficult for drivers to see pedestrians.

EXISTING NIGHTTIME DRIVING CONDITIONS ALONG SR 16

Intersection Safety and Operations at CR 89 and SR 16

Several locations had the potential for slowed or stopped traffic in the travel lane, especially for vehicles waiting to make left turns or right turns. Reportedly, the only location where there is recurring queuing of traffic is the intersection of SR 16 at CR 89 in Madison. Traffic on SR 16 often queues in both directions during special events and during times of daily peak traffic volumes. Cache Creek Casino opened its concert venue in 2005, but closed the venue in 2007. Since closing the concert venue, the casino has periodically hosted smaller events. CHP has reported that traffic tends to back up at the intersection during and after these events. To help manage the increased traffic volume generated by these events, CHP typically provides officers to help move traffic through this intersection.

Currently, the intersection of SR 16 and CR 89 is a four-way intersection with all-way stop control. "Stop Ahead" warning signs and an overhead mast arm flashing red light warns of the approaching signal. The highest number and severity of crashes in the segment occurred in "near" proximity of the SR 16 and CR 89 intersection, especially westbound. The highest number of crashes are rear-end crashes of vehicles slowed or stopped at this 4-way stop-controlled intersection. The crashes identified at this intersection correspond with peak traffic volumes.

A possible factor in these crashes are motorists that have been traveling at freeway speeds on I-505 for a significant amount of time may not reduce their speeds enough prior to reaching the back of the queue. This phenomenon is known as "speed adaptation. " Another factor may be that drivers traveling west out of Woodlands may not expect to encounter a stop-controlled intersection at CR 89. The rural character of the surrounding area shows little difference from upstream conditions and CR 89 does not appear to be any more significant than many similar roads that the motorist had previously driven through without any 4-way stops.

Compounding these factors is the deteriorated condition of pavement markings, which makes the intersection difficult to navigate, particularly at night. The intersection is marked with advance signage informing the driver of the upcoming stop condition and these signs are well lit at night, but tend to be less conspicuous during the day.

EXISTING SIGNAGE AND PAVEMENT MARKINGS AT INTERSECTION OF CR 89 AND SR 16

Intersection Safety and Operations at CR 85B and SR 16

"T" INTERSECTION OF CR 85B & SR 16

An informal bypass around Esparto via CR 21A ties back into SR 16 at CR 85B with a "T" intersection. The RSA team found issues related to limited sight distance looking east when traveling north on CR 85B and difficulty turning left from CR 85B to westbound SR 16. This maneuver poses several concurrent challenges: first, identifying a safe gap in traffic on SR 16, and second, turning left "up" the slope in the middle of a curve to the left and without the benefit of a dedicated acceleration lane. The maneuver is particularly troublesome to some aging drivers whose visual acuity may be poor, ability to judge size and motion is diminished, capability to multi-task is severely taxed, and whose head and neck flexibility makes it difficult to quickly scan the environment. The most significant sightline obstruction is a small number of trees in an orchard on the east side of CR 85B. The "upslope" condition is simply a result of entering SR 16 curve at a right angle and driving "up" the fully super-elevated section of the curve.

VIEW LOOKING EAST FROM CR 85B THROUGH THE ORCHARD

AERIAL VIEW OF SR 16 INTERSECTION WITH CR 85B EAST OF CAPAY

Esparto has recently added stop signs on CR 21A and removed westbound stop signs on SR 16 through Esparto. As such, westbound traffic tends to stay on SR 16 and not use the bypass, but given the multiple stop signs on SR 16 through Esparto in the eastbound direction, traffic tends to use the bypass. Reportedly, this intersection was improved relatively recently. The eastbound SR 16 to southbound CR 85B has a dedicated right-turn lane that appears to be functioning well.

7. PASSING

Limited Distance for Vehicle Passing and Improper Passing

The existing SR 16 has only a few locations where vehicles are allowed to pass legally. In addition, these passing zones are relatively short. In some locations, the passing zones transition into reduced speed zones, curves, or areas of limited sight distance. For example, west of Capay, eastbound traffic has approximately 1,400 feet of passing zone which immediately transitions into the reduced speed zone leading to the Capay curve. Another example is just west of Esparto where approximately 2,000 feet of passing zone is flanked by slow-speed curves on each side. This is just enough distance to entice drivers to attempt to pass slower moving vehicles while requiring them to dramatically slow their speed immediately after completing the pass. The Caltrans Highway Design Manual requires a minimum of 1,950 feet for passing sight distance. The American Association of State Highway Transportation Officials 2011 Geometric Design for Highways and Streets (AASHTO Green Book), Table 3-5, Minimum Passing Zone Lengths, recommends a minimum of 800 feet for two-lane conventional highways. Admittedly, the two examples and a majority of the passing zones in the project limits meet this minimum; however, the quick transition into reduced speed zones create a situation that may result in increased crash frequency.

APPROXIMATE LENGTH OF PASSING ZONE WEST OF ESPARTO (~2,000 FEET)
FLANKED BY SLOW-SPEED CURVES ON EACH SIDE

PHOTO SHOWING TREE BLOCKING THE SIGHT DISTANCE NEAR INTERSECTION OF SR 16 & CR 82B

There are also areas that are prone to improper or illegal passing. One example location is west of Capay where the roadway opens up to a straightaway, but due to limited sight distances passing is not allowed. According to CHP, this area experiences many illegal passing infractions primarily by the local users who are familiar with the roadway.

8. PEDESTRIAN SAFETY

Pedestrian Crossings

Concern for pedestrian safety is primarily focused on the relatively urbanized centers in Esparto and Capay. Two pedestrian injury crashes occurred recently in downtown Esparto. One occurred in March 2008 just after midnight near Capay Street; the other occurred in April 2010 late afternoon near Grafton Street. However, it is worth noting that a pedestrian was struck and injured in April 2007 around 11PM in the vicinity of CR 82, well away from any "downtown" area. In considering the potential for *future* pedestrian-involved crashes, the perceived "walkability" of the corridor needs to be carefully considered. There may be a latent demand for residents to walk more often and in more places than is currently apparent.

The Yocha Dehe Wintun Nation, which operates the Cache Creek Casino, has already funded some pedestrian safety improvements in Esparto and Capay, and these improvements resulted in clearly visible pedestrian signage along the main thoroughfares in Esparto and Capay. In addition, several traffic-calming measures have been implemented along Yolo Avenue (SR 16) through downtown Esparto. Most notable are the numerous "bulbouts" that have been defined by white diagonal "crosshatch" pavement markings. These bulbouts are meant to designate portions of the roadway meant for pedestrian usage and off-limits to motorized traffic.

Although these painted bulbouts were intended to be only temporary, a lack of local matching funds has prevented construction of raised islands in their place. The unintended consequence is that drivers are encroaching into these areas because the painted markings are flush with the pavement and do not have the same deterrent effect that raised channelization would have. This behavior is most evident near the intersection with Plainfield Street, where the pavement widens (flares out) in the northwest quadrant, allowing drivers to execute a south-to-west turn at relatively high speed. Tire marks and wear patterns in that bulbout suggest that this is frequently occurring. This is particularly troubling because the striped bulbout may give pedestrians a false sense of security and does not provide pedestrians adequate protection.

During the RSA team's nighttime review, the team noticed that lighting is very limited at the crosswalk locations and the yellow striping and lettering prior to the crosswalks was barely visible. In addition, the RSA team observed that the bus stops in downtown Esparto at the Community Center are located such that pedestrians will pass in front of the buses, thus obstructing views from following traffic.

DOWNTOWN ESPARTO BUS STOP

PEDESTRIAN BULBOUT

9. SIGNING AND MARKING

Limited or Missing Chevrons, Striping, and Signs

The SR 16 corridor from I-505 to Brooks has had some intermittent roadway upgrades that in includes new pavement, pavement markers, and flashing beacons. However, the intermittent nature of the installation of these elements leaves a number of long stretches where the striping is fading, signs are losing their retro-reflectivity, and raised pavement markers are missing or losing reflectivity. Location of the signs is a factor in warning drivers of changing conditions ahead. The RSA team found that some signs were located in areas that surprise drivers rather than warn them. Because of the rural nature of this corridor, roadway lighting is almost non-existent, which makes driving at night sometimes difficult to recognize when the roadway may be turning or the motorist is approaching a decision point. In the Cities of Esparto and Capay, the striping and signing was adequate (apart from the concerns regarding striping contrast, coloring, and hashed striping bulbouts).

EXISTING PAVEMENT MARKINGS, STRIPING, AND SIGNAGE ALONG SR 16

SAFETY IMPROVEMENT COUNTERMEASURES

SAFETY IMPROVEMENT COUNTERMEASURES

After analyzing the existing conditions and identifying the key safety issues of the existing SR 16 corridor, the RSA team identified individual Safety Improvement Countermeasures to be considered by all project stakeholders as options for future improvements to the corridor.

COUNTERMEASURE SUMMARY TABLES

The RSA team identified 45 countermeasures, which are intended to assist the project development team in formulating plans to carry forward into the next phase of project development. The countermeasures are categorized per the safety issue they most specifically address; however, it should be noted that many countermeasures have impacts to multiple safety issues. Note that countermeasures related to "Farm Vehicle Mobility," as identified earlier, are rolled into other countermeasures and not distinctly grouped.

The following table indicates the safety issues related to each idea code that form part of the countermeasure naming convention:

Code	Safety Issue
F	Flooding
RS	Roadside Departures
SW	Shoulder Width
C	Curves
I	Intersections
P	Passing
PS	Pedestrian Safety
S	Signs and Markings

Safety Issue / ID No. & Description
FLOODING
F-1 Install changeable message signs and ITS elements to inform users of flooding conditions and detours
F-2 Use I-505 elevation to set design flood elevation for raising SR 16
F-3 Line South Fork Willow Slough to increase hydraulic efficiency
F-4 Straighten South Fork Willow Slough by eliminating bends

Safety Issue / ID No. & Description
ROADSIDE DEPARTURES
RS-1 Install rumble strips on shoulders through project limits
RS-2 Remove trees along the outside of horizontal curves
RS-3 Remove trees and relocate utility poles and mailboxes within 20 feet of traveled way
RS-4 Fill in pavement drop-offs and construct Safety Edge
RS-5 Reevaluate existing guardrail and install new guardrail at select locations
RS-6 Protect roadway runoffs against hazards such as adjacent creeks and native trees with guardrail
RS-7 Relocate drainage ditches away from edge of traveled way
RS-8 Grade existing side slopes to be recoverable
SHOULDER WIDTH
SW-1 Construct 12-foot lanes and 8-foot shoulders throughout project limits
SW-2 Provide full standard-width cross section on same alignment (12-foot lanes, 8-foot shoulders within a 20-foot CRZ with recoverable slopes)
SW-3 Pave all existing gravel shoulders
SW-4 Construct widened areas for vehicle refuge at periodic locations (turn out)
SW-5 Provide widened areas in the location of consolidated mailboxes
CURVES
C-1 Widen Taber's Curve to the south to increase curve radius
C-2 Install delineators on outside edge of roadway at curves
INTERSECTIONS
I-1 Install a roundabout at CR 89 and SR 16
I-2 Eliminate stoppage for SR 16 through traffic at CR 89 intersection
I-3 Install advance warning signal for red light signal at CR 89 and SR 16 intersection
I-4 Relocate Migrant Center driveway off of SR 16
I-5 Improve intersection at Woodland Avenue, SR 16, and CR 87 by adding movement clarity signage and lighting
I-6 Improve intersection at Woodland Avenue, SR 16, and CR 87 by constructing roundabout

Safety Issue / ID No. & Description
I-7 Disconnect CR 87 and west leg of Woodland Avenue from SR 16 at the west end of Esparto
I-8 Install acceleration lane for westbound traffic at CR 85B intersection
I-9 Remove or trim trees at CR 85B intersection with SR 16
I-10 Relocate the CR 85B intersection but retain existing intersection for right-turn movement only
PASSING
P-1 Install optical bars at strategic locations for speed management at low-speed transitions
P-2 Vary the lane widths and shoulder widths at select locations
P-3 Eliminate passing zones at locations adjacent to speed transitions
P-4 Construct centerline rumble strip in no-passing zones
P-5 Remove tree at intersection with CR 82B
P-6 Eliminate all passing zones within project limits
P-7 Provide single passing zone within project limits per current Caltrans standards
P-8 Install advance passing zone and no-passing zone signage
PEDESTRIAN SAFETY
PS-1 Install high visibility pavement markings for pedestrian crosswalks
PS-2 Install raised bulbouts at pedestrian crossings
PS-3 Install raised median between lanes in downtown Esparto and Capay
PS-4 Relocate bus stops in Esparto to far side of intersections
PS-5 Install rapid flash beacons at pedestrian crossings in the towns of Esparto and Capay
PS-6 Install activated advance warning signs for pedestrians in downtown Esparto and Capay
SIGNS AND MARKINGS
S-1 Reevaluate signage throughout the project
S-2 Improve signage to warn drivers of the possibility of farm vehicles on roadway

Flooding

F-1 Install CMS and ITS elements to inform users of flooding conditions and detours

At this time, there are no changeable message signs (CMS) and other Intelligent Transportation Systems (ITS) elements to inform roadway users of flooding conditions and detours. Caltrans could deploy ITS to detect and inform motorists of flooding conditions and detours by positioning CMS at key locations. An emergency readiness/ continuity of operations plan can be prepared by Caltrans, Yolo County, California Highway Patrol, and the Tribe to determine the key locations for the CMS equipment and appropriate messaging. The ITS and CMS equipment will improve local operations, and they can be used for purposes other than flooding, such as the accommodation of special events. This is a low-cost, high-impact countermeasure which provides a very cost-effective alternative to Caltrans' previous proposal to construct a new, raised SR 16 in this corridor.

F-2 Use I-505 elevation to set design flood elevation for raising SR 16

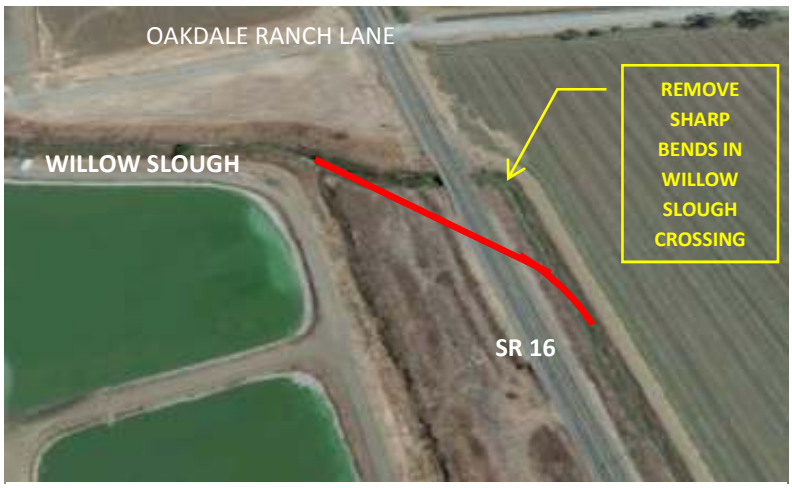
The team understood that the I-505 in the vicinity of the SR 16 interchange floods intermittently, leaving the connection between SR 16 and I-505 inaccessible. The project plan set that was prepared by Caltrans for SR 16 identified measures that keep 100-year floodwaters from overtopping SR 16. This design-year flood appears excessive, when I-505 appears to flood to during significantly lower flood events. First responders would be arriving via I-505 to SR 16 under such an event. The team recommends that the design year flood be reduced to a frequency of the flooding of I-505 or consider improvements that remove floodwaters from I-505 and SR 16.

F-3 Line Willow Creek Slough to increase hydraulic efficiency

Lining portions of Willow Slough where additional conveyance is needed (such as at the crossing with SR 16) will decrease the Manning's coefficient and increase the hydraulic carrying capacity where needed to reduce the impacts of flooding on SR 16. This treatment should be judiciously applied as it does not provide water quality characteristics associated with naturalized waterways.

F-4 Straighten Willow Creek Slough by eliminating bends

The undersized crossing of Willow Creek significantly contributes to the flooding of the SR 16. It appears that the hydraulic constraint of the crossing causes overflow into the drainage ditches and overtopping of the roadway. Replacing the bent crossing will reduce the turbulence, providing more laminar flow, in the vicinity of the crossing that can increase the capacity of the crossing. Furthermore, the headwalls and entrance conditions should be designed to enhance the hydraulic capacity of the crossing associated with the suggested crossing.



LOOKING EASTBOUND OVER SR 16 WITH WILLOW SLOUGH CROSSING

Roadside Departures

RS-1 Install rumble strips on shoulders through project limits

Shoulder rumble strips are undulations rolled into or ground into a paved shoulder. They are meant to alert motorists that stray outside their lane by producing both a load humming noise and a noticeable vibration as a driver passes over them.

The use of rumble strips at the edge of the traveled way (fog line) warns drivers drifting off the roadway due to sleepiness, distractions, and impaired judgments, thereby reducing the probability and severity of roadside runoffs. Consider locating rumble strips just outside the edge of traveled way (fog line) on the shoulders on SR 16, perpendicular to the direction of travel. Rumble strips are both effective and cost-effective at reducing runoffs and incidents.

On SR 16, shoulder widths are generally 2 feet or less, and therefore rumble strips should be considered in conjunction with shoulder widening. Where wide shoulders are available, consider milling in the rumble strips. To enhance the delineation of the roadbed – especially at night – also consider providing painted pavement markings in these rumble strips.

If bicycle use of the shoulder is not properly considered, the width or offset of the rumbles may be problematic for a bike rider. If silt is allowed to accumulate, the undulations can become clogged and may be less effective. There can occasionally be community concerns about noise impacts for abutting residences.

EXAMPLES OF RUMBLE STRIPS

RS-2 Remove trees along the outside of horizontal curves

Trees create hazards for roadway run-offs, particularly on the outside of horizontal curves due to centrifugal acceleration. Trees that are not environmental resources within the State right of way could easily be identified and removed to reduce crash potential.

RS-3 Remove trees and relocate utility poles and mailboxes that are within 20 feet of traveled way (CRZ)

Another approach that could have significant benefit to reducing run-offs would be to clear out trees, relocate utility poles, and mailboxes from within 20 feet of the edge of traveled way, in conjunction with other incremental clear recovery zone measurement (see above).

RS-4 Fill in pavement drop-offs and construct Safety Edge

The roadway is poorly maintained and subject to occasional inundation by local floods. As such, the pavement edges are crumbling at multiple locations, some with steep drop-offs. A countermeasure is for Caltrans to maintain the roadway and initiate a rehab/resurfacing project to improve its longevity. The Safety Edge is applied at the pavement edges to minimize roadway departures and head-on collisions. Safety Edge is one of the proven safety countermeasures; it is low cost and easy to apply. Caltrans has integrated the Safety Edge into its standard specs.

RS-5 Modify existing guard rail and install new guard rail at select locations

Metal beam guardrail has been installed at a few locations within the study limits. There are other locations within the project limits where installing guardrail to shield a roadside hazard might be appropriate. For example, where it would be impractical to relocate or redesign a drainage ditch within the CRZ, shielding the ditch with guardrail might be considered. In locations where guardrail now exists such as the north side of the Capay Curve, the length and offset of the guardrail should be reviewed to ensure that its placement is optimal. Casual observation suggests that moving the guardrail further from the edge of the travel lane might be feasible at Capay Curve, allowing more recovery area for runoff-the-road vehicles and additional horizontal clearance for wide loads and farm vehicles. Another example location where installing guardrail might be appropriate is on the inside (north side) of the curve at Taber's Corner, where Taylor's Creek meanders close to the roadway.

RS-6 Protect roadway run-offs against hazards such as adjacent creeks and native trees with guardrail; remove fixed obstacles adjacent to roadway

There are locations, such as: Capay Curve, Taber Curve, and the tree-lined straight roadway stretch east of the casino with native trees and creeks that could lead to severe crash impacts for vehicle runoffs. Native trees and creeks are environmental resources that typically require avoidance efforts. Consider protecting potential runoffs with the placement of metal beam guardrail at these locations. These should be considered on a case by case basis. There are other hazards, such as mailboxes and drainage ditches that should be relocated based on their collision potential.

RS-7 Relocate drainage ditches away from edge of traveled way; convert drainage ditches adjacent to roadway to recoverable slopes

To reduce this hazard to runoffs relative to the drainage ditches, consider relocating drainage ditches away from the traveled way to maximize the clear recovery zone. A good approach to moving out the drainage ditches away from the edge of traveled way while improving the roadside for errant vehicles would be to drain the roadbed with recoverable slopes that also define the flow line of the relocated drainage ditches. Consider these in consultation with the landowners, possibly with a drainage easement.

RS-8 Grade existing side slopes to be recoverable

A recoverable slope is a slope on which a motorist may, to a greater or lesser extent, retain or regain control of a vehicle by slowing or stopping. Slopes flatter than 1V:4H are generally considered recoverable. Consider providing recoverable slopes where feasible to reduce runoff impacts and improve the ability to regain control by run-off drivers. Recoverable slopes that can be located within State right of way should be considered as a first order or priority.

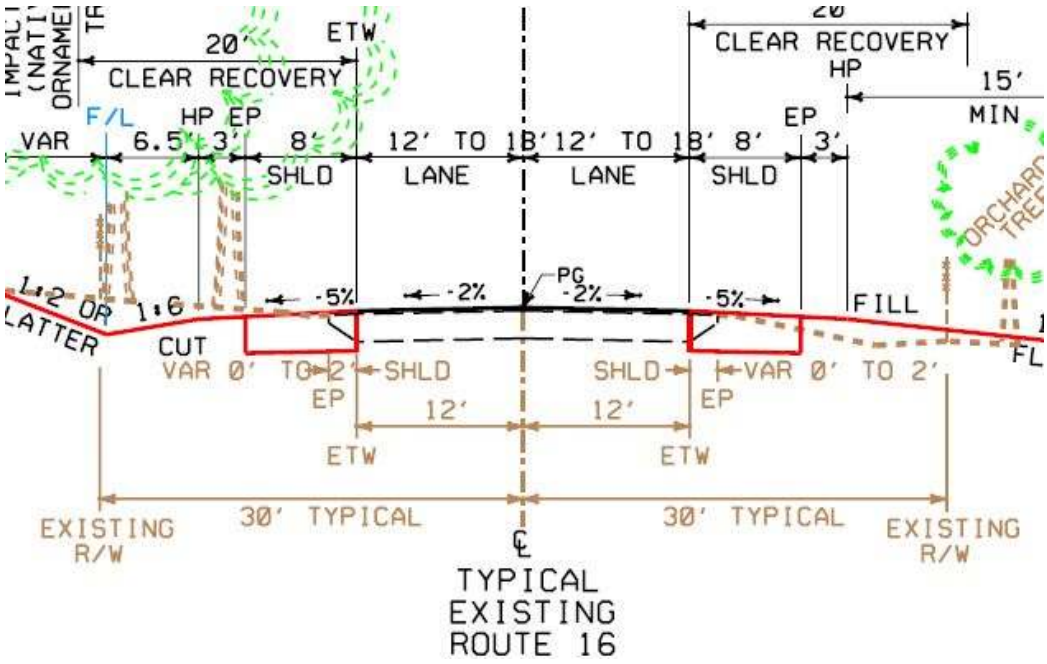
Shoulder Width

SW-1 Construct 12-foot lanes and 8-foot shoulders throughout project limits

The countermeasure suggests providing a consistent cross section consisting of a 12-foot travel lane, combined with an 8-foot paved shoulder. The RSA team noted that where existing right of way is constrained, accommodating this cross section may be difficult to fit in, and/or the roadside slope beyond the shoulder may be steeper than desired.

EXAMPLE ROADWAY CROSS-SECTION WITH 12-FOOT LANES AND 8-FOOT SHOULDERS

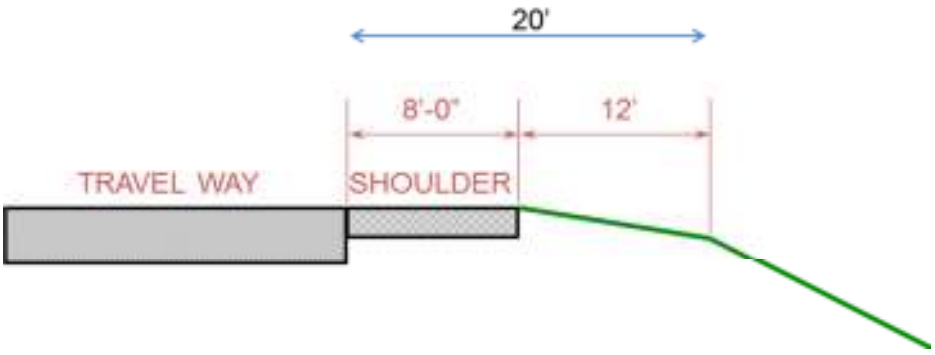
Sketch includes the 20-foot clear recovery zone which could also be considered.



SW-2 Provide full standard-width cross section on same alignment (12-foot lanes, 8-foot shoulders, and 20-foot CRZ with recoverable slopes)

This countermeasure would incorporate a 20-foot CRZ. The roadway cross section would consist of 12-foot travel lanes, an 8-foot paved shoulder, and an additional 12 feet of clear slope, built mostly on existing alignment. (Some minor offsets may be needed to flatten a horizontal curve, for example.) This total 32-foot cross section can be built almost entirely within the existing 30-foot right of way.

DIAGRAM SHOWING 8-FOOT SHOULDER AS THE FIRST PART OF THE 20-FOOT CRZ



SW-3 Pave all existing gravel shoulders

This countermeasure would pave all the existing gravel shoulders, whether the shoulder is full width or is a portion of a composite shoulder. The paved shoulders are stronger and more durable than gravel shoulders. They are more comfortable for bicyclists and pedestrians to ride/walk on. They are better able to support the weight of vehicles without deforming and are largely unaffected by rainfall, which can "soften" gravel shoulders and cause erosion.

SW-4 Construct widened areas for vehicle refuge at periodic locations (turnout)

This countermeasure suggests installing paved turnouts every mile or two outside of Esparto and Capay where sufficient existing right of way is available. Lengths of the turnouts can vary in length (depending on available shoulder area) with approximately 15 feet wide either paved (recommended) or stable gravel with good drainage. On a two-lane highway where passing is limited, Section 21656 of the California Vehicle Code requires slow moving vehicles followed by five or more vehicles to turn off at designated turnouts or wherever sufficient area for a safe turnout exists. However, along this corridor safe turnouts do not exist. Turnouts should be located where there is stopping sight distance for approaching drivers to see vehicles leaving and re-entering the through lanes. Advance signing indicating turnout ahead will prepare a motorist to start slowing and searching for the turnout. Law enforcement, fire, and EMS can use turnouts for enforcement purposes, accident investigations, etc. without blocking a lane. Potential signs to use can be "Slower Traffic Use Turnouts," "Turnout Ahead," "Turnout ¼ mile," or "Turnout 500 feet."

EMERGENCY REFUGE AREA ON FACILITY WITH ACTIVE TRAFFIC MANAGEMENT

SW-5 Provide widened areas in the location of consolidated mailboxes

Many mailboxes on the site are on unpaved shoulders and tend to be scattered along the route. This placement is typically inconvenient for both mailbox addressees and postal delivery. A good measure would be to consolidate the mailboxes and pave a turnout to provide access setback from the traveled way a good distance to enhance safety during delivery and pickup**.**

Curves

C-1 Widen Taber's Curve to the south to increase curve radius

The curve radius at Taber's Corner is very tight, thus requiring a reduction in speed and limiting the sight distance. The location of the curve requires traffic in the westbound direction to dramatically slow their speed after a relatively long tangent section with passing zones. The area to the south of the curve is designated as a 4F Historic Property, however, there is also some available right of way immediately adjacent to the existing alignment that could be used to flatten the curve, thus increasing its radius. This would serve to improve sight distances and reduce the potential for run-offs by traffic having to negotiate the curve after the high-speed zones.

C-2 Install delineators on outside edge of roadway at curves

It is common practice to use delineators along the outside edge of roadway curves. The use of these delineators should be standardized throughout the project limits for consistency and clarity of warning to the drivers.

TABER'S CURVE

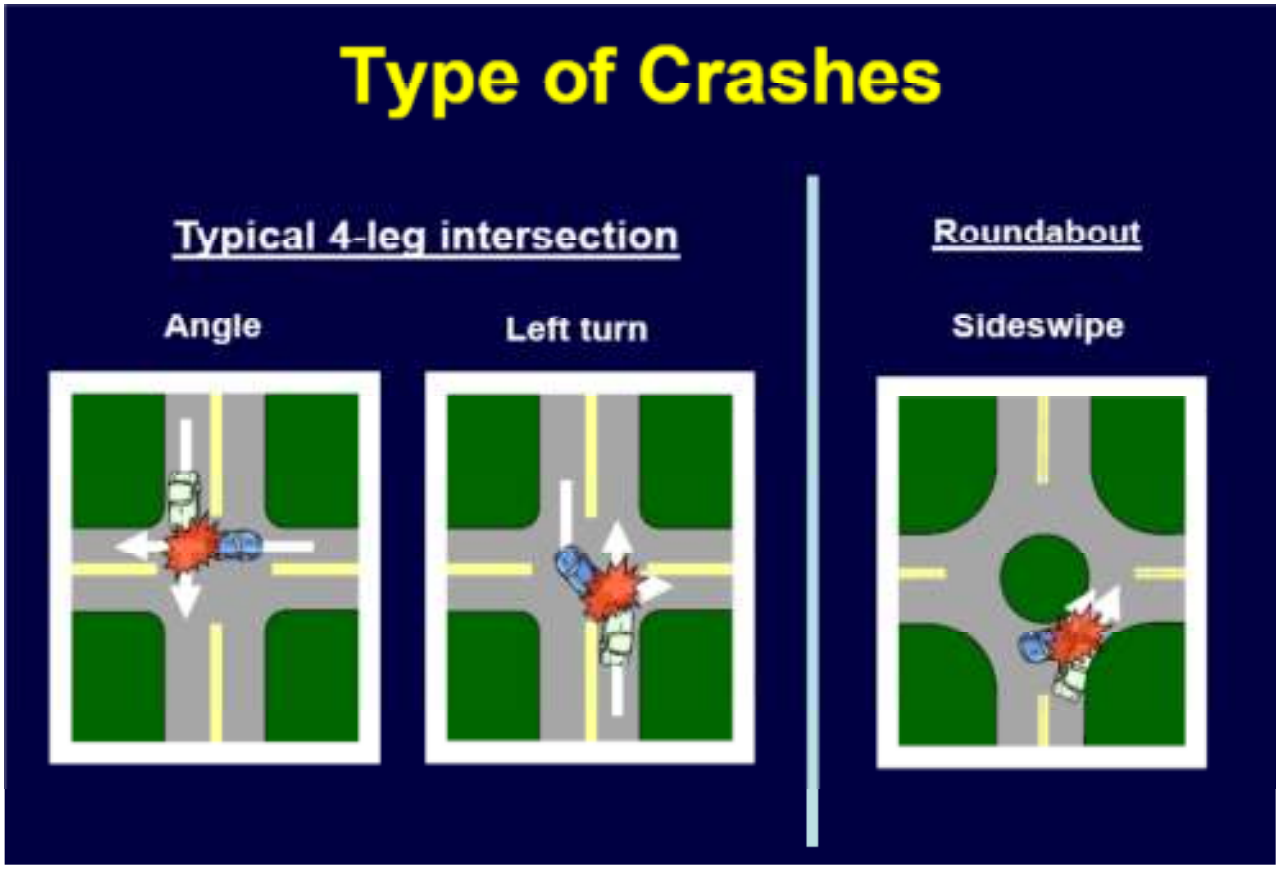
Intersections

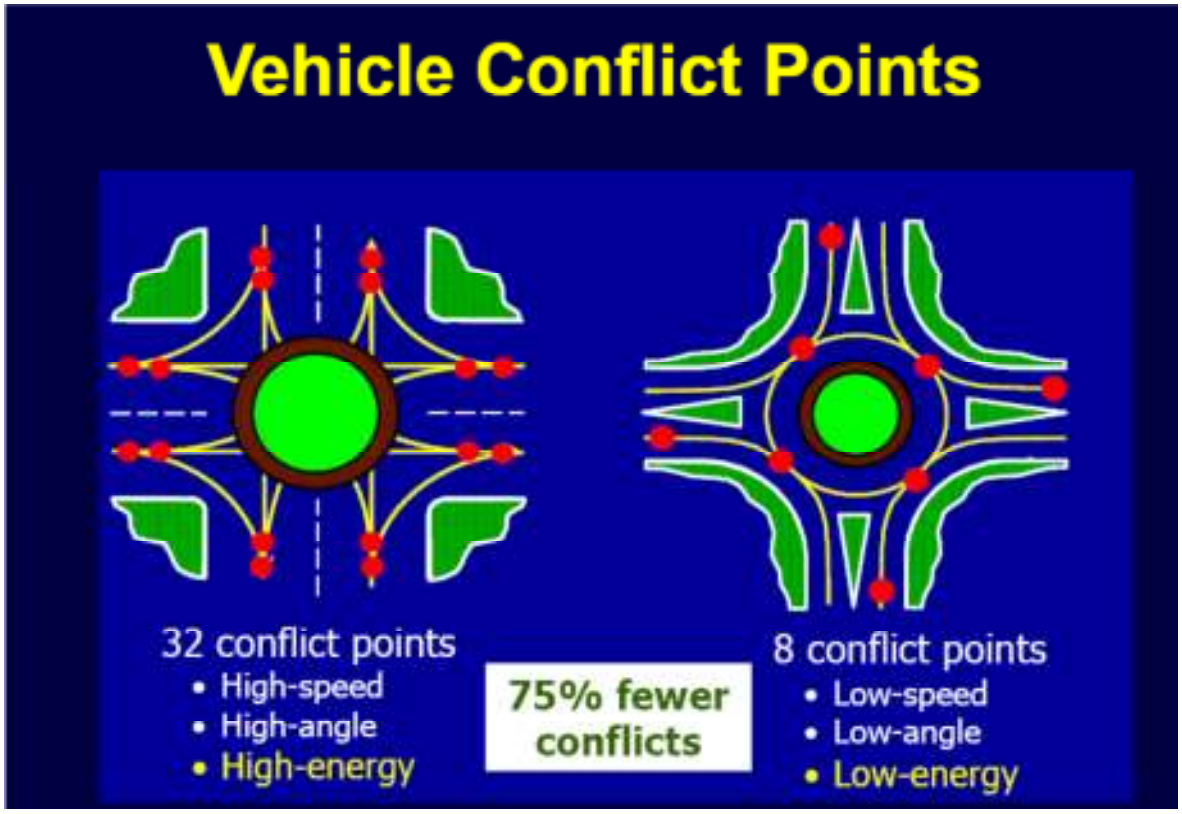
I-1 Install a roundabout at CR 89 and SR 16

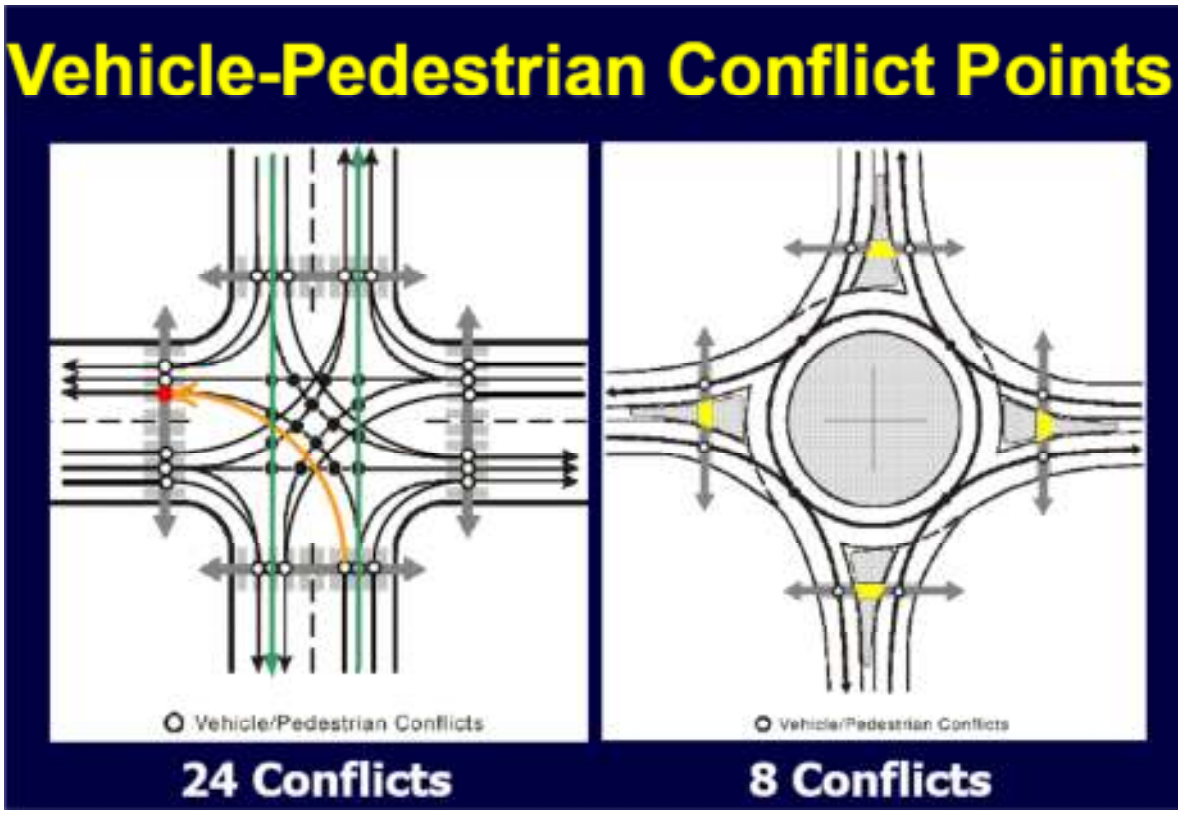
A single-lane rural roundabout at the intersection of CR 89 and SR 16 would increase safety by reducing speeds to approximately 14 to 18 mph, reduce potential conflict points by 75%, accommodate farm equipment, reduce or eliminate queues at all but the most extreme traffic volumes (Almond Day), and reduce the potential of rear end crashes by reducing the queuing. Preliminary review appears to fit within the current right of way.

Roundabouts have proven to result in 39% overall crash reduction, 76% overall injury crash reduction, and 89% fatal crash reduction. They reduce speeds to approximately 14 to 18 mph and reduce the potential of rear-end crashes by reducing queuing.

COUNTERMEASURE CONCEPT SKETCHES




Vehicle Conflict Points
32 conflict points
• High-speed
• High-angle
• High-energy
75% fewer conflicts
8 conflict points
• Low-speed
• Low-angle
• Low-energy


Vehicle-Pedestrian Conflict Points
Vehicle/Pedestrian Conflicts
Vehicle/Pedestrian Conflicts
24 Conflicts
8 Conflicts

I-2 Eliminate stoppage for SR 16 through traffic at CR 89 intersection

Eliminate the stop control in the east and west directions on SR 16, but maintain the stop control northbound and southbound on CR 89. Add dedicated left-turn lanes on SR 16 to allow for safer turns, northbound and southbound, on CR 89. The red flashing light east and west should be changed to amber. "Stop Ahead" signs in the east and west directions on SR 16 could be changed to "Intersection Ahead". It is recommended that free right turns be closed or the radius tightened to reduce skewed angles and high-speed merges at the intersection.

The countermeasure would reduce queuing and crashes on eastbound and westbound approaches on SR 16 near CR 89. However, it also has the potential to increase speeds on SR 16 and thereby increase severity of crashes of turning vehicles from CR 89.

I-3 Install advance warning signal for red light signal at CR 89 and SR 16 intersection

Install an advance warning signal for the red light signal at the CR 89 and SR 16 intersection that would activate if the traffic signal is in or will be entering a red/stop phase in the users direction in order to alert the user of their need to stop and/or be alert to slowed or stopped traffic ahead. Alternatively, or in addition to the advance warning light, installing a prioritized stop light and installing transverse rumble strips could also be considered. This intelligent transportation system would only trigger with the proper phase of the signal increasing the value of information to the approaching user.

EXAMPLES OF ADVANCE WARNING SIGNALS

I-4 Relocate Migrant Center driveway off of SR 16

The Migrant Center driveway is located just east of the CR 89/SR 16 intersection. The driveway becomes blocked during peak periods and is not ideally located due to its proximity to the intersection. Consider relocating the driveway to CR 89 with a new driveway connection and driveway. (The land adjacent to CR 89 is currently vacant.) This entrance also feeds a high number of other properties, and the removal of access to from SR 16 and the elimination of its interference with the CR 89/SR 16 intersection would improve access quality and safety.

I-5 Improve the intersection at Woodland Avenue, SR 16, and CR 87 by adding movement clarity signage and lighting

This countermeasure suggests installing signage warning motorist in the direction of SR 16 to Woodland Avenue (through-movement) and CR 87 to SR 16 eastbound (through-movement) that

westbound SR 16 traffic does not stop, install lighting to make the intersection and vehicles more visible to all users, restripe the intersection, and remove the striped bulb-out.

Installing good signage for all legs that the westbound SR 16 movement is not stop-controlled will alert the motorists of this condition. Warning signs such as "Left Turn Does Not Stop" can be installed for the eastbound SR 16-to-Woodland through-movement. Other legs would warn of the free westbound through-movement. Adding lighting will offer better nighttime visibility of turning vehicles as well as signage. Re-striping of the intersection should be performed; faded striping, partially removed striping, and striped bulb-outs all create confusion. Also consider possibly removing the striped bulb-out as this creates a false sense of security for pedestrians crossing at this intersection.

I-6 Improve intersection at Woodland Avenue, SR 16, and CR 87 by constructing roundabout

There is a three-way stop at the four-legged intersection at the west end of Esparto's Downtown district. This intersection was originally a four-way-stop intersection that was temporarily converted to a three-way stop (westbound SR 16 does not stop) in order to facilitate the demolition of a structure in the southwest quadrant of the intersection. The intersection reverted back to its original condition (four-way stop) after the building demolition was completed, but westbound traffic was used to not stopping, so the intersection was converted back to a three-way stop. This application of a three-way stop to a four-legged intersection has the potential for collisions that could be redressed with the installation of a roundabout. Roundabouts have statistically shown to reduce the severity of crashes at intersections. Roundabouts typically trade high-severity, high-speed "T-bones" (90-degree broadside crashes at high speeds, typical of 4-legged signalized or unsignalized intersections) for low-severity, low-speed sideswipes. The impact of backups during peak travel periods should be compared to evaluate a roundabout application at this location. The roundabout would also require additional land in one of the three currently vacant parcels.

I-7 Disconnect CR 87 and Woodland Avenue from SR 16 at the west end of Esparto

Another approach to improve the intersection at the west end of Esparto would be to disconnect the Woodland Avenue and CR 87 from the SR 16 intersection. This would make SR 16 operate as a curve where there was once an intersection, as with the CR 87/east leg of Woodland Avenue curve (see figure below). Approval from the town of Esparto would be required.

SUGGESTED ELIMINATION OF INTERSECTION AT WEST END OF ESPARTO

I-8 Install acceleration lane for westbound traffic at CR 85B intersection

At this time, there is no acceleration lane at the SR 16/CR 85B intersection. An acceleration lane of appropriate length could be added to provide a refuge for the left-turning movement from CR 85B to westbound SR 16. Both local and regional travelers appear to use this bypass around Esparto. The highway alignment may have to shift slightly to accommodate the addition of the acceleration lane.

SR 16 LOOKING WEST FROM THE INTERSECTION WITH CR 85B

I-9 Remove or trim trees at CR 85B intersection with SR 16

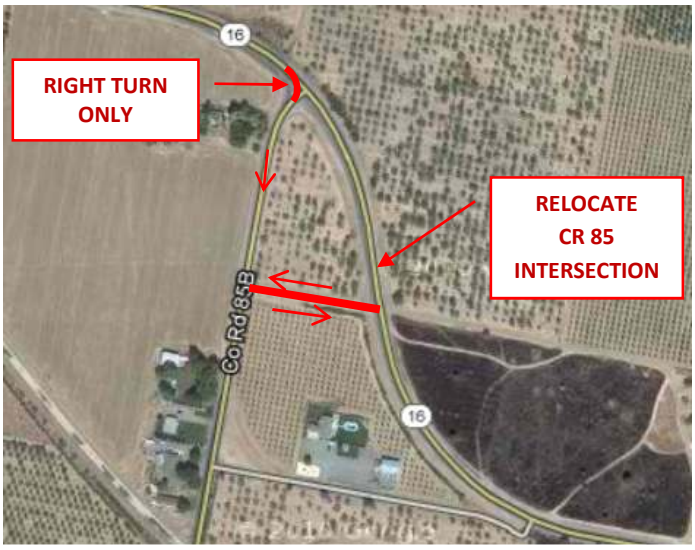
The one-way stop at CR 85B has limited intersection sight distance that compromises left turns from CR 85B to westbound SR 16. There are a few trees, possibly as few as three or four that if removed would increase the sight distance available for the previously mentioned movement.

LOOKING EAST FROM THE INTERSECTION OF CR 85B AT SR 16

I-10 Relocate the CR 85B intersection but retain existing intersection for right-turn movement only

Realign CR 85B to connect to SR 16 at the point of reversal of curve east of the existing intersection for all movements between CR 85B and SR 16 but the right-turn movement from eastbound SR 16 to southbound CR 85B. The left-turn movement from CR 85B to westbound SR 16 should be improved by the relocation of the intersection to a straighter segment of SR 16. The SR 16 super-elevation at the point of reversal of curve should be very little to none which will facilitate the movements at this new intersection.

PROPOSED REVISIONS TO CR 85B/ SR 16 INTERSECTION



Passing

P-1 Install optical bars at strategic locations for speed management at low-speed transitions

Optical speed bars are transverse stripes spaced at gradually decreasing distances, intended to create a visual effect on driver's speed as they react to the spacing of the painted lines. This can increase drivers' perception of speed and cause them to reduce speed. These white transverse stripes are 18 inches long and 12 inches wide. The preferred material is thermoplastic because of the exposure to traffic volume over time. (For further information on optical bars, see the following FHWA website: http://safety.fhwa.dot.gov/roadway_dept/horicurves/fhwasa07002/ch7.cfm)

EXAMPLE OF OPTICAL BARS

(Photo Courtesy of Virginia Department of Transportation from FHWA website)

The MUTCD considers the two treatments in this section as "experimental" and does not approve them for general use. The MUTCD advises agencies to obtain FHWA approval before installing any experimental treatment. Visit http://mutcd.fhwa.dot.gov for information on how to submit a request for experimentation.

P-2 Vary the lane widths and shoulder widths at select locations

A simple, inexpensive way to encourage speed reduction is to vary the roadbed width apportionment between lane and shoulder. For example, for a given 20-foot roadbed half-width consisting of 12-foot lanes and 8-foot shoulders, consider reapportioning the roadbed to 11-foot lanes and 9-foot shoulders. This has an incremental effect on drivers to reduce speed to due to perceived "squeezing down" of the lane.

P-3 Eliminate passing zones at locations adjacent to speed transitions

This countermeasure suggests removing the passing zone in both directions between Esparto and Capay and the passing zone for eastbound SR 16 just west of Capay. Tangent sections of the highway lead into both residential areas and tight curves. As motorists approach slow vehicles and see a straight tangent, they feel they have time to pass based on the striping allowing passing. If the passing is done as vehicles get closer to the end of the passing zone, they more than likely will travel at higher speed than 55 mph. With high speeds and rapidly approaching sharp curve (that they may not identify due vehicles in

front that hide signs warning of a curve), heavy breaking is required to bring speeds down in a short transition. Removing the passing zones will discourage most drivers from passing and vehicles will be able to identify the curve in time to slow down and complete the turning maneuver.

Bicyclists also use this route; having a no-passing zone can alleviate potential conflicts for vehicles passing bicyclists.

P-4 Construct centerline rumble strip in no-passing zones

Several areas of the project, while marked as no-passing zones with striping and signs, continue to experience passing violations. This countermeasure suggests installing milled-in centerline rumble strips in the no-passing zones along the project, which offer a positive audible and tactile message of improper lane travel. Milled-in rumble strips demonstrate a higher safety benefit than thermoplastic.

The crash modification factor on rural roads for reduction of head-on type crashes is 0.45 for all crashes, or an expected 55% reduction. The crash modification factor on rural roads for reduction of head-on type crashes is 0.74 for minor injury crashes, or an expected 26% reduction.

P-5 Remove tree at intersection with CR 82B

At the westbound passing zone just past CR 82B, the sight distance is blocked by a lone tree on the right side of the road. The tree hides a large portion of the passing zone at the beginning of the westbound passing zone which is located on a slight curve. Passing or potentially passing vehicles cannot see vehicles coming around the curve. The countermeasure is to remove the tree.

TREE AT INTERSECTION WITH CR 82B

P-6 Eliminate all passing zones within project limits

There are two main locations in the project limits delineated as passing zones:

1. A 1,400-foot passing zone for eastbound traffic that transitions into the reduced speed zone leading to the Capay Curve just outside Capay.

2. A 2,000-foot of passing zone west of Esparto flanked by slow-speed curves on each side.

These passing zones allow drivers to pass but create higher speeds that can be impeded by low-speed curves ahead that flank the above two passing zones. Consider the benefit of eliminating the passing zones completely within the project limits. This approach could also benefit when combined with turnouts. (See Countermeasure No. IS-46, Construct widened areas for vehicle refuge at periodic locations [turnout].)

P-7 Provide single passing zone within project limits per current Caltrans standards

Caltrans guidelines specify that passing lanes should have 1,950 feet passing sight distance. There is already one location between Esparto and Capay that is in agreement with this requirement; however, this location is bound by low-speed curves that compromise the integrity of the passing lane. The other longer location west of Capay could be identified as a passing zone due to its potential to provide passing zones well in advance of the lower-speed curves (see figure below). The passing zones could be provided between CR 82 and 82B, for example. There are other areas of passing or increased passing zone lengths could be achieved if geometric improvements were to be provided between the two low speed curves shown below. The preferred approach would be to locate the eastbound passing zones closer to Taber's Corner and the westbound passing zones closer to Capay Curve to allow the respective direction of traffic ample room to reduce speed while approaching the low speed curves ahead.

LOCATIONS OF LOW-SPEED CURVES

P-8 Install advance passing zone and no-passing zone signage

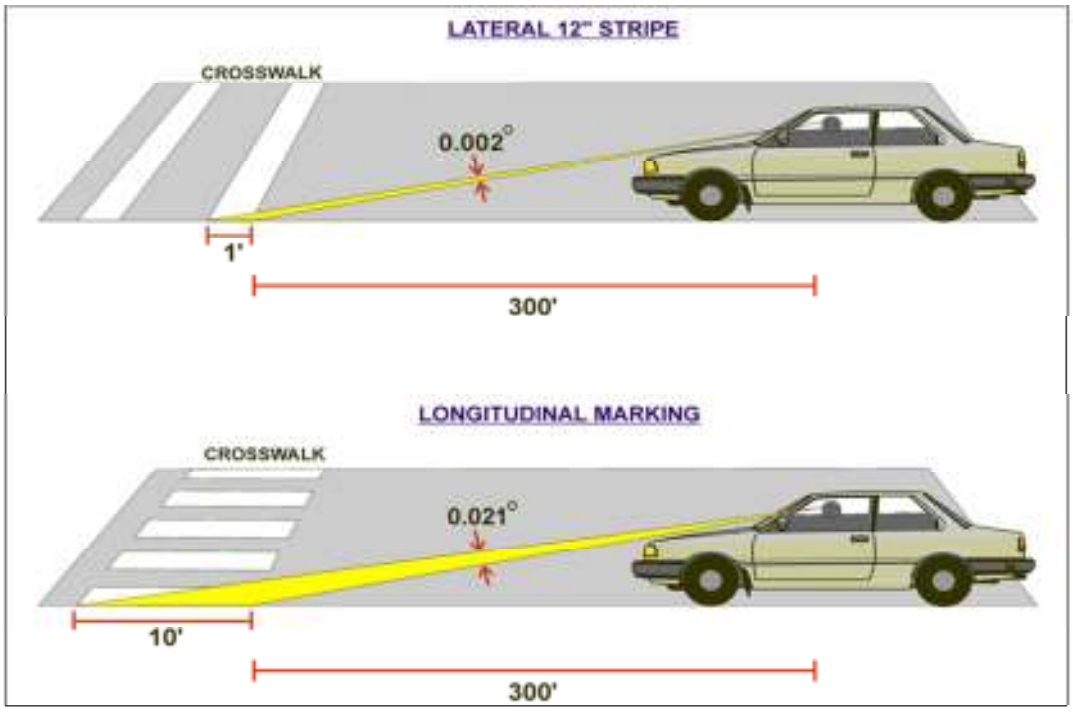
A key , yet simple improvement measure in support of the existing passing zones on SR 16 would be to complement them with passing zone/no passing zone signage that informs the motorist of locations where passing is permitted versus areas where it is prohibited.

Pedestrian Safety

PS-1 Install high-visibility pavement markings for pedestrian crosswalks

The provision of high-visibility pavement markings (see figure below) following the pedestrian crosswalks would provide greater contrast and draw motorist attention to the presence of the crosswalk. This would be particularly beneficial for nighttime conditions.

HIGH-VISIBILITY PAVEMENT MARKINGS



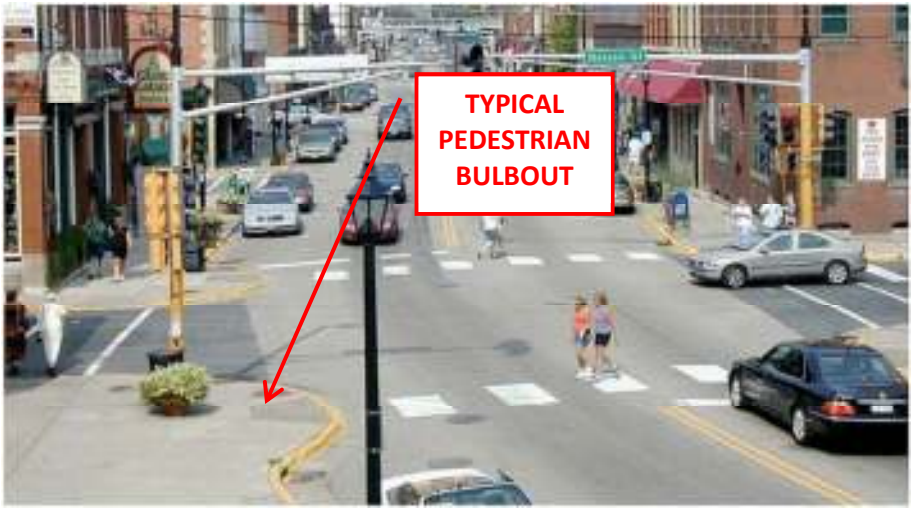
Longitudinal markings are more visible to driver from afar

CROSSWALK IN ESPARTO NEAR THE HIGH SCHOOL

PS-2 Install raised bulbouts at pedestrian crossings

Pedestrian bulbouts decrease pedestrian crossing time across roadways. A negative effect is that they may impede bike and pedestrian traffic for that reason. A rough estimated cost of a pedestrian bulbout is $40, 000.

EXAMPLE PEDESTRIAN BULBOUT



PS-3 Install raised median between lanes in downtown Esparto and Capay

Raised medians, if installed in Esparto and Capay, would provide a refuge area for pedestrians while providing incremental benefit in traffic calming. The placement of the median could mitigate unsafe pedestrian crossing during busy peak traffic periods by reducing the average waiting time for impatient pedestrians crossing through gaps too short for safe crossing. The median could also help channelize the crossing of pedestrians to the crosswalk in the vicinity of the high school in Esparto. The impact of the additional space needed for the median would need to be weighed against its impact on adjacent residents and businesses.

EXAMPLE RAISED MEDIAN

PS-4 Relocate bus stops in Esparto to far side of intersections

There is an eastbound and westbound bus stop in Esparto located upstream of the pedestrian crosswalk at an unsignalized intersection that blocks motorists vision of the pedestrian crosswalk. A simple solution would be to relocate the bus stop downstream of the crosswalk to eliminate stopped buses from blocking the visibility the crosswalk.

EASTBOUND BUS STOP IN ESPARTO

PS-5 Install rapid flash beacons at pedestrian crossings in the towns of Esparto and Capay

Consider installing rapid flash beacons at pedestrian crossings in the towns of Esparto and Capay to increase the awareness and reaction to the presence of pedestrian crossings at the various unsignalized intersections in Esparto and Capay. Rectangular Rapid Flash Beacon (RRFBs) are user-actuated amber LEDs that supplement warning signs at uncontrolled intersections or mid-block crosswalks. They can be activated by pedestrians manually by a pushbutton or passively by a pedestrian detection system. RRFBs use an irregular flash pattern that is similar to emergency flashers on police vehicles and may be installed on either two-lane or multi-lane roadways. These devices could be considered at the crosswalk in downtown Esparto.

EXAMPLE RAPID FLASH BEACON (RRFB)

"An Analysis of the Effects of Stutter Flash LED Beacons to Increase Yielding to Pedestrians Using Multilane Crosswalks," and "The Use of Stutter Flash LED Beacons to Increase Yielding to Pedestrians at Crosswalks," presented at the Transportation Research Board Annual Meeting in 2008, summarized the results of two studies on the effects of RRFBs when used to supplement standard pedestrian crossing warning signs at crosswalks. The former found that going from a no-beacon arrangement to a two-beacon system, mounted on the supplementary warning sign on the right side of the crossing, increased yielding from 18 percent to 81 percent. There was a further increase in yielding behavior, with a four-beacon system (with two beacons each on both the right and left sides of the crossing) to 88 percent. It also evaluated the sites over a one-year period,

and found that there was little to no decrease in yielding behavior over time. The MUTCD gave interim approval to RRFBs for optional use in limited circumstances in July 2008. The interim approval allows for usage as a warning beacon to supplement standard pedestrian crossing warning signs and markings at either a pedestrian or school crossing; where the crosswalk approach is not controlled by a yield sign, stop sign, or traffic-control signal; or at a crosswalk at a roundabout. A rough cost of $50,000 is required for the hardware and installation of rapid flash beacons (exclusive of power supply) per crosswalk.

PS-6 Install activated advance warning signs for pedestrians in downtown Esparto and Capay

Consider installing activated advance warning signs at the various pedestrian crossings in the towns of Esparto and Capay to increase the awareness and reaction to the presence of pedestrians using the existing pedestrian crossings at the various unsignalized intersections in Esparto and Capay. This system consists of an extinguishable message sign (EMS) activated by pedestrians. This improvement would augment the traffic-calming minimum alternative elements in the two urbanized areas. The hardware and installation cost for rapid flash beacons (exclusive of power supply) is approximately $40,000 per crosswalk.

Signs and Markings

S-1 Reevaluate signage throughout project

Signage throughout the corridor uses regular-sized CAMUTCD-approved signs in most locations, except for curve warning signs, which are larger than the regular-sized signs. The RSA team suggests evaluating all signs throughout the corridor for locations that may be enhanced by the use of oversized signs. Locations applicable to oversized signs are high crash locations (intersections), passing/no passing signs, signs at approaches to residential zones.

Additional considerations for signage could also include reviewing the size and placement of chevrons and improving signage to warn drivers of the possibility of farm vehicles on the roadway.

Chevrons are intended to warn and slow motorists at locations transitioning from higher speed to lower speed encountered on curves. The effectiveness of the chevrons depends on their total number, spacing, panel size, vertical position, and placement within in the curve. The team observed at the Capay Curve and Taber's Curve that the use of chevrons could improve curve operations.

There currently is a single sign to indicate the presence of farm equipment and vehicles on SR 16. Signage would also reinforce the presence of vehicles, making drivers more likely to anticipate slower-moving farm equipment. Additionally, If variable message signs (VMSs) were to be located in strategic locations, then warning drivers could be coordinated with seasons and timeframes when farm vehicles and equipment are in greater use (i.e., harvesting season).

Easily identified oversized signs at passing locations will not only let drivers know when to pass but also warn drivers that they are entering a passing zone and to be aware of possible oncoming vehicles in their lane. Oversized signs can help older drivers in particular, and drivers in general, identify changing conditions sooner than under normal conditions. Oversized signs on a curvilinear alignment will help drivers identify changing conditions a further distance away.

S-2 Improve signage to warn drivers of the possibility of farm vehicles on roadway

There currently is a single sign to indicate the presence of farm equipment and vehicles on Highway 16. Additional placement of signs and different types of signs would reinforce the presence of vehicles making drivers more likely to anticipate slower moving farm equipment. Additionally, If VMS signs were to be located in a strategic locations then warning drivers could be coordinated with seasons and timeframes when farm vehicles and equipment are in greater use (i.e. harvesting season).

SINGLE EXISTING FARM VEHICLE SIGNAGE

SUPPORTING WORKSHOP DOCUMENTATION

SUPPORTING WORKSHOP DOCUMENTATION

This section contains additional documentation of items produced during the RSA workshop. It is followed by the RSA Study Agenda and Study Attendance Sheets.

SUMMARY OF VALUE ANALYSIS PROCESS

To supplement FHWA's RSA process, the workshop utilized tools and techniques from Value Analysis to guide the team in the consideration of functionality and performance.

The following tools and techniques from Value Analysis were used to study the project and identify potential safety countermeasures:

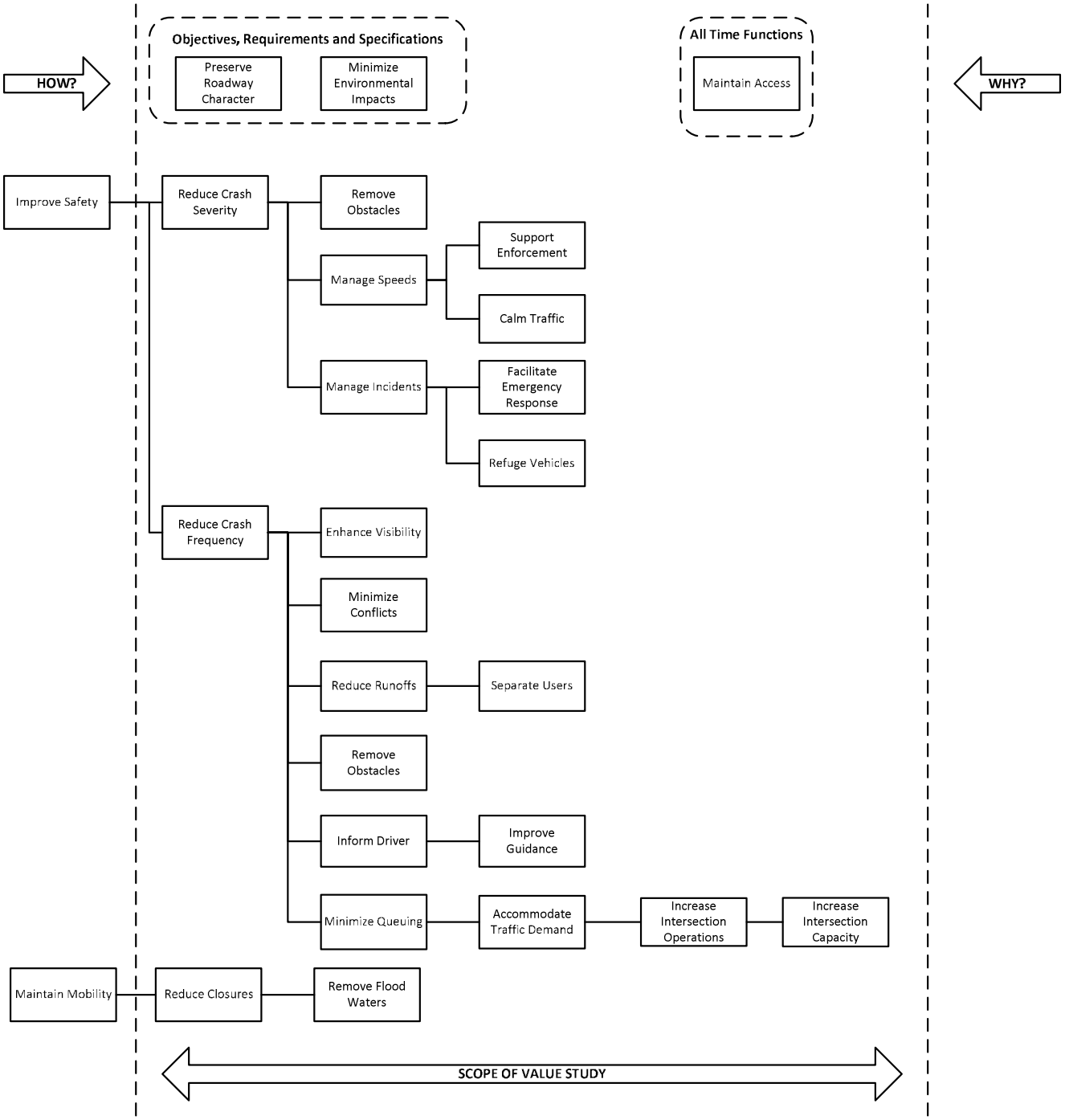
- Function Analysis
- Idea Evaluation
- Crash Modification Factors of Countermeasures (TBD)

FUNCTION ANALYSIS

Function analysis was performed and a Function Analysis System Technique (FAST) Diagram was produced, which revealed the key functional relationships for the project. This procedure is beneficial to the RSA team, as it forces the participants to think in terms of functional purpose and need and facilitates a deeper understanding of the project.

The FAST diagram arranges the functions in logical order so that when read from left to right, the functions answer the question, "How?" If the diagram is read from right to left, the functions answer the question, "Why?" Functions connected with a vertical line are those that happen at the same time as, or are caused by, the function at the top of the column (a "When?" relationship).

FAST Diagram



COUNTERMEASURE SPECULATION

Countermeasure Speculation involves identifying and listing creative ideas. During this phase, the RSA team participated in a brainstorming session to identify as many means as possible to provide the necessary project functions. Judgment of the ideas was not permitted in order to generate a broad range of ideas.

The idea list includes all of the ideas suggested during the study. These ideas should be reviewed further by the project stakeholders, since they may contain ideas that are worthy of further evaluation and may be used as the design develops. These ideas could also help stimulate additional ideas by others.

CREATIVE IDEA EVALUATION

The purpose of the Creative Idea Evaluation is to systematically assess the potential impacts of ideas generated during the Speculation Phase relative to their potential for value improvement. Each idea was evaluated in terms of its safety improvement potential (i.e., ability to reduce the quantity and/or severity of crashes) compared to its impacts to other project performance criteria such as environmental impacts, right-of-way impacts, and temporary construction impacts

Once each idea was fully evaluated, it was given a total rating number. This is based on a scale of 1 to 3, as indicated by the following rating index. This rating represents the subjective opinion of the RSA team regarding the potential benefits of the concepts in order to prioritize them for development.

1 = Develop	Concept results in safety improvements in a manner that results in high value potential. Concepts in this rating group may be considered during early project development.
2 = Consider	Concept may result in safety improvements; however, additional information may be required for concept to be fully evaluated. The concept may also require additional impacts to the environment and/or right-of-way acquisition.
3 = Dismiss	Concept is not technically feasible, does not meet identified requirements, or represents programmatic operations outside of design development.

Ideas rated 1 or 2 were developed further and are documented in the *Safety Improvement Countermeasures* section of this report. Additionally, some ideas were similar to concepts addressed by other ideas, in which case they were combined. Some ideas were concepts already being considered or already being done by others.

IDEA SUMMARY

All of the ideas that were generated during the Countermeasure Speculation using brainstorming techniques were recorded on the following pages. Ideas received an idea code based upon the function statement or safety issue under which it was brainstormed. The following table indicates the functions related to each idea code.

Idea Code	Related Function
IS	Improve Safety
FV	Farm Vehicle
C	CR-89
CR	CR-85B
CU	Curves
PECR	Pedestrian Crossings
RF	Reduce Flooding
RS	Recovery Space
VP	Vehicle Passing

IDEA SUMMARY LIST

ID No.	Idea Description	Development Rating
C-1	Provide left-turn lane and eliminate stop for SR 16 through traffic at CR 89 intersection	2
C-2	Install left-turn lane at CR 89 intersection with SR 16	Combined
C-3	Improve striping, signage, and pavement markers at CR 89 intersection with SR 16	1
C-4	Relocate Migrant Center driveway off of SR 16	1
C-5	Install transverse rumble strips in lanes of SR 16 in advance of CR 89 intersection with SR 16	2
CR-1	Remove or trim trees at CR 85B intersection with SR 16	2
CR-2	Realign CR 85B to connect to SR 16 at point of reversal of curve east of existing intersection for dedicated left-turn movement from CR 85B; Use existing intersection location for dedicated right turn for eastbound SR 16 to southbound CR 85B	2
CR-3	Realign CR 85B intersection with SR 16 to the east to align with public access road (warehouse road)	3
CR-4	Install a roundabout at CR 89 and SR 16	Combined
CU-1	Widen Taber's Curve to the south to increase curve radius	2
CU-2	Separate opposing lanes at Taber's Curve	3
CU-3	Relocate eastbound advisory speed signage at Capay Curve closer to curve	Combined
CU-4	Remove fixed obstacles adjacent to roadway at Capay Curve and Taber's Curve	Combined

ID No.	Idea Description	Development Rating
CU-5	Install guardrail on inside of Taber's Curve	1
FV-1	Widen lanes to 16' to accommodate all farm vehicles	3
FV-2	Remove guardrail at Capay Curve	Combined
FV-3	Provide dedicated frontage road for farm vehicles adjacent to SR 16	3
FV-4	Construct raised SR 16 on new alignment and use old alignment as frontage road for farm vehicles	3
FV-5	Improve signage to warn drivers of the possibility of farm vehicles on roadway	2
IS-1	Construct new raised roadway from I-505 to Cache Creek Casino	3
IS-2	Install rumble strips on shoulders through project limits	2
IS-3	Construct 12' lanes and 8' shoulders throughout project limits	2
IS-4	Implement specially funded traffic enforcement dedicated to SR 16	3
IS-5	Overlay existing roadway with new pavement	2
IS-6	Close SR 16	3
IS-7	Install a roundabout at CR 89 and SR 16	1
IS-8	Install median barrier to physically separate opposing traffic	3
IS-9	Install raised median between lanes in downtown Esparto and Capay	1
IS-10	Vary the lane widths and shoulder widths at select locations	2
IS-11	Install additional horizontal curves	3
IS-12	Install prioritized stop light at CR 89 and SR 16 intersection	1
IS-13	Install advance warning signal for traffic signal at CR 89 and SR 16 intersection	1
IS-14	Implement driver education	3
IS-15	Improve intersection at Woodland Avenue, SR 16, and CR 87 by making Woodland Avenue a cul-de-sac	1
IS-16	Improve intersection at Woodland Avenue, SR 16, and CR 87 by constructing roundabout	1
IS-17	Improve intersection at Woodland Avenue, SR 16, and CR 87 by converting to 4-way stop	3
IS-18	Improve intersection at Woodland Avenue, SR 16, and CR 87 by adding movement clarity signage and lighting	1
IS-19	Protect roadway runoffs against hazards such as adjacent creeks and native	1

ID No.	Idea Description	Development Rating
	trees with guardrail	
IS-20	Install flexible delineators in median between lanes at select locations with centerline crossover potential	3
IS-21	Install Optical Bars at strategic locations for speed management at low-speed transitions	2
IS-22	Modify existing guardrail at Capay Curve	1
IS-23	Install lighting at key intersections and pedestrian crosswalks	2
IS-24	Flatten side slopes	2
IS-25	Convert open ditches to drainage culverts	1
IS-26	Replace Willow Slough Bridge	3
IS-27	Provide full standard-width cross section on same alignment (12' lanes, 8' shoulders, and 20' CRZ with recoverable slopes)	1
IS-28	Eliminate passing zones at locations of limited sight distance or speed transitions	2
IS-29	Relocate drainage ditches away from edge of traveled way	2
IS-30	Reevaluate signage throughout project	2
IS-31	Install signage on each side of the roadway	Combined
IS-32	Review size and placement of chevrons throughout project limits	Combined
IS-33	Install high-visibility pavement markings for pedestrian crosswalks	2
IS-34	Resurface SR 16 with new pavement section	Combined
IS-35	Install raised bulbouts at pedestrian crossings	2
IS-36	Improve roadway drainage at pedestrian crosswalks	1
IS-37	Install acceleration lane for westbound traffic at CR 85B intersection	1
IS-38	Install in-pavement lighting at pedestrian crosswalks	1
IS-39	Remove trees along outside of horizontal curves	Combined
IS-40	Construct dedicated bike lane	3
IS-41	Construct centerline rumble strip in no-passing zones	2
IS-42	Eliminate all passing zones within project limits	2
IS-43	Provide single passing zone within project limits per current Caltrans standards	2
IS-44	Install advance passing zone and no-passing zone signage	2

ID No.	Idea Description	Development Rating
IS-45	Pave all existing gravel shoulders	1
IS-46	Construct widened areas for vehicle refuge at periodic locations (turnout)	1
IS-47	Construct dedicated passing lanes at select locations	3
IS-48	Construct passing turnouts at dedicated locations	3
IS-49	Encourage ride sharing through park-and-ride lots and shuttles	ABD
IS-51	Relocate guardrails at Capay Curve	Combined
PECR-1	Relocate bus stops in Esparto to far side of intersections	2
PECR-2	Install raised pedestrian refuge areas in downtown Esparto	Combined
PECR-3	Install rapid flash beacons in downtown Esparto	2
PECR-4	Install activated advance warning signs for pedestrians in downtown Esparto	Combined
PECR-5	Install high-intensity activated crosswalk in downtown Esparto	3
PECR-6	Install community bollard lights in Capay and Esparto	3
RF-1	Construct raised roadway from CR 89 to Esparto to 100-year flood elevation	3
RF-2	Install changeable message signs and ITS elements to inform users of flooding conditions and detours	2
RF-3	Use I-505 elevation to set design flood elevation for raising SR 16	Combined
RF-4	Store road closure barricade materials near CR 89 and SR 16 intersection	3
RF-5	Line Willow Creek Slough to increase hydraulic efficiency	Combined
RF-6	Straighten Willow Creek Slough by eliminating bends	Combined
RF-7	Review design year flood that can be conveyed through Willow Creek Slough with necessary maintenance to maintain original hydraulic capacity	Combined
RF-8	Raise CR 89 intersection with SR 16 above design year flood elevation	3
RS-1	Grade existing side slopes to be recoverable	2
RS-2	Remove trees that encroach on roadway within 20'	Combined
RS-3	Relocate utility poles and mailboxes that are within 20' of roadway	Combined
RS-4	Provide widened areas in the location of consolidated mailboxes	1
RS-5	Re-grade and fill in pavement drop-offs	2
RS-6	Convert drainage ditches to culvert	Combined
RS-7	Relocate drainage ditches away from roadway edge	Combined

ID No.	Idea Description	Development Rating
RS-8	Install delineators on outside edge of roadway at curves	2
RS-9	Remove or relocate guardrails near edge of roadway	Combined
RS-10	Provide painted pavement markings in rumble strips	Combined
RS-11	Construct widened areas for vehicle refuge at periodic locations (turnout)	2
RS-12	Provide a continuous shoulder less than the full 8' width	3
RS-13	Convert drainage ditches adjacent to roadway to recoverable slopes	2
VP-1	Remove tree at intersection with CR 82B	2

CRASH MODIFICATION FACTORS OF COUNTERMEASURES

The RSA team developed 45 countermeasures which are intended to assist the project development team in formulating plans to carry forward into the next phase of project development. The intent of the table below is to provide Caltrans a means of assigning prioritized rankings of the relative safety performance improvement using Crash Modification Factors (CMF) from the Highway Safety Manual.

Safety Issue / ID No. & Description	*CMF for Total Crashes*	*CMF for Fatal and Injury Crashes*	*Remarks*
FLOODING			
F-1 Install changeable message signs and ITS elements to inform users of flooding conditions and detours			
F-2 Use I-505 elevation to set design flood elevation for raising SR 16			
F-3 Line South Fork Willow Slough to increase hydraulic efficiency			
F-4 Straighten South Fork Willow Slough by eliminating bends			
ROADSIDE DEPARTURES			
RS-1 Install rumble strips on shoulders through project limits			
RS-2 Remove trees along outside of horizontal curves			
RS-3 Remove trees and relocate utility poles and mailboxes within 20' of traveled way			
RS-4 Fill in pavement drop-offs and construct safety edge			
RS-5 Reevaluate existing guard rail and install new guard rail at select locations			
RS-6 Protect roadway runoffs against hazards such as adjacent creeks and native trees with guardrail			

Safety Issue / ID No. & Description	*CMF for Total Crashes*	*CMF for Fatal and Injury Crashes*	*Remarks*
RS-7 Relocate drainage ditches away from edge of traveled way			
RS-8 Grade existing side slopes to be recoverable			
SHOULDER WIDTH			
SW-1 Construct 12' lanes and 8' shoulders throughout project limits			
SW-2 Provide full standard width cross-section on same alignment (12' lanes, 8' shoulders within a 20' CRZ with recoverable slopes)			
SW-3 Pave all existing gravel shoulders			
SW-4 Construct widened areas for vehicle refuge at periodic locations (turnout)			
SW-5 Provide widened areas in the location of consolidated mailboxes			
CURVES			
C-1 Widen Taber's Curve to the south to increase curve radius			
C-2 Install delineators on outside edge of roadway at curves			
INTERSECTIONS			
I-1 Install a roundabout at CR 89 and SR 16			
I-2 Eliminate stoppage for SR 16 through traffic at CR 89 intersection			
I-3 Install advance warning signal for traffic signal at CR 89 and SR 16 intersection			
I-4 Relocate Migrant Center driveway off of SR 16			

Safety Issue / ID No. & Description	*CMF for Total Crashes*	*CMF for Fatal and Injury Crashes*	*Remarks*
I-5 Improve intersection at Woodland Avenue, SR 16, and CR 87 by adding movement clarity signage and lighting			
I-6 Improve intersection at Woodland Avenue, SR 16, and CR 87 by constructing roundabout			
I-7 Disconnect CR 87 and west leg of Woodland Avenue from SR 16 at the west end of Esparto			
I-8 Install acceleration lane for westbound traffic at CR 85B intersection			
I-9 Remove or trim trees at CR 85B intersection with SR 16			
I-10 Relocate the CR 85B intersection but retain existing intersection for right-turn movement only.			
PASSING			
P-1 Install optical bars at strategic locations for speed management at low-speed transitions			
P-2 Vary the lane widths and shoulder widths at select locations			
P-3 Eliminate passing zones at locations adjacent to speed transitions			
P-4 Construct centerline rumble strip in no-passing zones			
P-5 Remove tree at intersection with CR 82B			
P-6 Eliminate all passing zones within project limits			
P-7 Provide single passing zone within project limits per current Caltrans standards			
P-8 Install advance passing zone and no-passing zone signage			

Safety Issue / ID No. & Description	*CMF for Total Crashes*	*CMF for Fatal and Injury Crashes*	*Remarks*
PEDESTRIAN SAFETY			
PS-1 Install high visibility pavement markings for pedestrian crosswalks			
PS-2 Install raised bulbouts at pedestrian crossings			
PS-3 Install raised median between lanes in downtown Esparto and Capay			
PS-4 Relocate bus stops in Esparto to far side of intersections			
PS-5 Install rapid flash beacons at pedestrian crossings in the towns of Esparto and Capay			
PS-6 Install activated advance warning signs for pedestrians in downtown Esparto and Capay			
SIGNS AND MARKINGS			
S-1 Reevaluate signage throughout the project			
S-2 Improve signage to warn drivers of the possibility of farm vehicles on roadway			

Combined RSA/VA Agenda

District 3 –Highway 16 Safety Improvement Project

Yolo County

LOCATIONS

Kick off Meeting:	Esparto Community Hall, 17020 Yolo Ave (Hwy 16). Esparto, CA
March 13-16 RSA-VA Team Workshop:	Woodland Maintenance Station/Ron LeCroix Training Center 624 N. East Street, Woodland, CA6
April 10 Workshop Meeting:	Venture Oaks Building, 2389 Gateway Oaks Drive, Sacramento, CA
April 11 Presentation:	Esparto Community Hall, 17020 Yolo Ave. (Hwy 16), Esparto, CA

DAY ONE (Monday, March 12)

PROJECT STAKEHOLDER ACTIVITY

8:00 AM **Kick-Off Meeting** (Esparto Community Hall)

- Attended by all available stakeholders (RSA/VA Team, Caltrans staff, Stakeholders)
- Introductions (5 minutes)
- Overview of Agenda RSA/VA Process (15 minutes)
- Project Background, Stakeholder Issues & Concerns (60 minutes)
- Question and Answer (15 minutes)

9:45 AM Break (15 minutes)

10:00 Value Metrics- Prioritize and Rate Project Performance Attributes. Meeting attendees will be provided controllers that allows them to "vote" without bias their priority for the performance of the current project.

12:00 PM **End Kickoff Meeting**

RSA/VA TEAM ACTIVITY-– Ron LeCroix Training Center, Woodland, CA

1:00 PM Project Analysis (VA focus) – VA/RSA team lists project issues, conflicts and constraints. The analysis includes establishing the project functions and project risks.

2:30 PM Site Visit No. 1: Mid-day Off-Peak Site Visit and Investigation (RSA focus) (Bring vests and hardhats and safety shoes)

- Drive study corridor in both directions, end-to-end
- Record observations/take photos
- Pull off at key intersections/locations for further assessment

4:00 PM VA/RSA Team will carry out first review of project documents (plans, reports, traffic and crash data, etc.) and discussion of field review/observations (RSA Focus)

5:00 PM Adjourn for the day

8:30 PM Site Visit No. 2: Night Off-Peak Site Visit and Investigation (in –vehicle)
(*NOTE: Participation in the night field visit is "encouraged, but optional" for every Team member; at a minimum, it is hoped that those on travel and staying nearby would participate)*

DAY TWO (Tuesday, March 13) – Ron LeCroix Training Center, Woodland, CA

7:00 AM	Site Visit No. 3: Morning Peak Period Site Visit and Investigation (RSA Focus) (District 3 to verify the right time)
10:00 AM	Further review of project documents and continued discussion of field observations (RSA Focus)
12:00 PM	Lunch Break
1:00 PM	Further review of project documents, continued discussion of field observations and issue/recommendations brainstorming (RSA Focus)
4:30 PM	Site Visit No. 4: PM Peak Period Site Visit and Investigation (District 3 to verify the right time)
6:00 PM	Adjourn for the day
8:30 PM	(TENTATIVE – Alternate for Night Field Visit if not possible on Day 1)

DAY THREE (Wednesday, March 14) – Ron LeCroix Training Center, Woodland, CA

8:00 AM	Further review of project documents, continued discussion of field observations and issue/recommendations brainstorming
11:00 AM	Identify Safety Issues and Other Suggestions for Improvements ─team members prioritize the safety issues/ other project issues based upon their perceived importance in the study area based on project analysis, review of crash data and observations in the field.
12:00 PM	Lunch Break
1:00 PM	Team Brainstorming against RSA/VA topics. The team brainstorms solutions against creativity targets that include: improving highway safety topics, delivering project functions with alternative means, improving project performance (multiple attributes previously established and reducing project risks (RSA/VA Focus)
5:00 PM	Adjourn for the day

DAY FOUR (Thursday, March 15) – Ron LeCroix Training Center, Woodland, CA

8:00 AM Evaluation of Ideas (VA Focus)

11:00 AM	Assign Development to Team Members/Review development guidelines
12:00 PM	Lunch Break
1:00 PM	Alternative Development (VA Focus) – *Team please bring laptops*
5:00 PM	Adjourn for the day

DAY FIVE (Friday, March 16) – Ron LeCroix Training Center, Woodland, CA

8:00	Alternative Development (continued)- *Team please bring laptops*
12:00 PM	Lunch Break
1:00 PM	Team Review of Alternatives
4:00 PM	Adjourn for the day

DAY SIX (APRIL 10)- Venture Oaks Building, Sacramento, CA

8:00 AM	Review Cleaned Up Alternatives
10:00 AM	Measure Alternative Performance
12:00 PM	Lunch Break
1:00 PM	Establish VA Strategies/ Measure Performance & Apply Crash Modification Factors to VA Alternatives/ Strategies
4:00 PM	Adjourn for the day

DAY SEVEN (APRIL 11) - Esparto Community Hall, Esparto, CA

8:00 AM	Prepare for RSA/VA Presentation.

PROJECT STAKEHOLDER ACTIVITY- ESPARTO COMMUNITY HALL, ESPARTO, CA

1:00 -3:00 PM ***Presentation of VA/RSA Alternatives Meeting to Management and Stakeholders at the Esparto Community Hall***

- Review the list of RSA/VA findings and inputs
- Identify VA alternatives/countermeasures developed for the RSA inputs
- Identify corridor solutions packaged short-term, medium-term and long-term options

MEETING ATTENDEES

3/12	3/13	3/14	3/15	3/16	4/10	4/11	Name	Position/Role	Organization	Telephone	E-mail
X					X	X	Doug Lange	Project Manager	Caltrans		doug.lange@dot.ca.gov
X							Jody Brown	Environmental Liaison	Caltrans		
X							Mark Nichols	Maintenance	Caltrans	(530) 787-3520	mark.nichols@dot.ca.gov
X					X	X	Mike Hagen	Traffic Safety	Caltrans		mike.hagen@dot.ca.gov
X					X	X	Tom Brannon	D3 Deputy District Director, Program Project Management	Caltrans	(916) 826-6052	
X					X	X	Jennifer Clark	Environmental	Caltrans, District 3		jennifer.clard@dot.ca.gov
X							Dean Samuelson	Traffic Safety	Caltrans, HQ		dean.samuelson@dot.ca.gov
X				X			Janice Benton	Traffic	Caltrans, HQ		jannic.benton@dot.ca.gov
X					X	X	Jim Deluca	Design Coordinator	Caltrans, HQ		jim.deluca@dot.ca.gov
X					X		Ken Cozad	Traffic Liaison	Caltrans, HQ		ken.cozad@dot.ca.gov
X					X		Robert Peterson	Traffic Safety	Caltrans, HQ		robert.peterson@dot.ca.gov
X				X	X	X	Troy Tusup	VA Manager	Caltrans, HQ		troy.tusup@dot.ca.gov
X	X	X	X	X	X	X	Craig Allred	RSA Team Leader	FHWA		craig.allred@dot.gov
X	X	X	X	X	X	X	Dave Cohen	Highway Safety	FHWA		david.cohen2@dot.gov
X	X	X	X	X	X	X	Jeff Holm	Highway Design	FHWA		jeff.holm@fhwa.dot.gov
X	X	X	X	X	X	X	Keith Harrison	CSS/Human Factors	FHWA		keith.harrison@dot.gov
X							Judith Redmond	Citizen Interest Group	Guinda Grange		judith@fullbellyfarm.com
X						X	Gretchen Ceteras	Citizen Interest Group	Rumsey Improvement Association		gceteras@guni.com
X							Todd Gettleman	Citizen Interest Group	Rumsey Improvement Association		tgettleman@yochadehe-nsn.gov
X	X	X	X	X	X	X	George Hunter	VA Team Leader	Value Management Strategies		george@vms-inc.com
X	X	X	X	X	X	X	Mark Watson	Assistant VA Team Leader	Value Management Strategies	(816) 206-0067	mark@vms-inc.com
X							Colleen Fescenmeyer	Chair	ECAC	(707) 580-6650	fescenmeyer@yahoo.com

3/12	3/13	3/14	3/15	3/16	4/10	4/11	Name	Position/Role	Organization	Telephone	E-mail
X							Vicki Murphy		CVCAC	(530) 219-3899	murphyranch@guni.com
X							Betsy Marchard		YDWN	(530) 979-6330	
X							Glenn Mouko	President	Davis Bike Club	(530) 220-3513	president@davisbikeclub.org
X							Chris Lee	County-Tribe Coordinator	County of Yolo	(530) 666-8068	clee@yolocounty.org
X						X	Dan Garrison	Chief/Land Owner	Capay Valley Fire	(530) 304-3960	dgfarm57@gmail.com
X	X	X	X			X	Andy Hill	Sargeant	California Highway Patrol	(530) 839-9728	ahill@chp.ca.gov
X							Denise Sagara		Farm Bureau	(530) 304-4851	denise@yolofarmbureau.org
X							Barry Burns		Esparto Fire	(530) 787-3300	parson90@afes.com
X							Leo Refscand		Madison CSD	(530) 666-2888	lrefmcsdist@yahoo.com
X							Sue Hectora		CVV	(530) 796-3005	hietmanse@gvni.com
X							Heidi Sykes	Design	Caltrans	(916) 825-2600	heidi_sykes@dot.ca.gov
X							Orrin Heatlie	Sgt	YCSO	(530) 668-5280	
X							Daniel Delcastilo	Deputy	YCSO	(530) 668-5280	
X							John Mikaicich	Senior Department Manager	Yocha Dehe Nation	(910) 508-0112	jmikaicich@yocahdehe-nsn.gov
X							Michael McDonald		Capay Valley Coalition	(530) 796-3821	mcm@gvni.com
X							Linda Pillard		CRV Advisor	(530) 713-6121	l.pillard@gmail.com
X						X	Tim Craggs	Traffic	Caltrans	(916) 275-2890	tim.craggs@dot.ca.gov
X						X	Pam Welch	President	Capay Valley Coalition	(530) 796-3788	pamwelch@frontiernet.net
X							Mark Nichols	Maintenance	Caltrans	(530) 682-5034	mark_nichols@dot.ca.gov
X							Mark Wilson	Project Manager	Summit Project Management	(503) 757-5665	mw@summit-pm.com
X						X	Bonnie Stormont		Madison Advisory Committee	(530) 666-1519	bonniestormont@att.net
X							George Neill	President	Sacramento Wheelman	(916) 787-3300	geor63@jps.net
					X		Jody Jones	D3 Director	Caltrans	(530) 741-4233	jody.jones@dot.ca.gov
					X		Joe Caputo	D3 Div Engineering	Caltrans	(530) 741-4168	joe.caputo@dot.ca.gov
					X		Steve Kirkpatrick	D3 Maintenance & Traffic Ops	Caltrans	(530) 741-4318	steve_kirkpatrick@dot.ca.gov

3/12	3/13	3/14	3/15	3/16	4/10	4/11	Name	Position/Role	Organization	Telephone	E-mail
					X		Hossein Rostam	HQ - Division of PM	Caltrans	(916) 653-6487	hossein.rostama@dot.ca.gov
					X		Katrina Pierce	North Region Environmental Div	Caltrans	(530) 741-4277	katrina_pierce@dot.ca.gov
					X		Andrew Brandt	D3 Traffic Operations	Caltrans	(530) 741-5710	andrew_brandt@dot.ca.gov
						X	Paul Muller		Guinda Grange	(530) 908-0525	paul@fullbellyfarm.com
						X	Anne McDonald	Citizen	Taxpayer	(530) 796-3821	apyymmc@gmail.com
						X	John Hulsman, Jr.		Esparto Citizens Advisory Committee	(530) 787-4046	john.r.hulsman@gmail.com
						X	Dave Cannon		California Highway Patrol	(530) 662-4685	dcannon@chp.ca.gov