Final Quantitative
Road Safety Analysis Study Report

An Integrated Value Analysis/Road Safety Review Process

SR 84 – Niles Canyon Road Corridor

August 2012

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Prepared by

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Date: August 31, 2012

Attention: Mr. Ron Kiaaina, Project Manager District 4

Subject: Final QRSA Study Report
D-4 SR-84 – Niles Canyon Road Corridor

Dear Ron:

This report summarizes the results and events of the study conducted in two workshops: May 7 through 11 and May 21 through 23, 2012. These workshops employed a combination of Road Safety Analysis and Value Analysis tools and techniques. It also includes a review by VA team members and incorporates their comments.

If you have any questions or comments concerning this preliminary report, please do not hesitate to contact me at (916) 224-9812 or my email address above.

Sincerely,
VALUE MANAGEMENT STRATEGIES, INC.

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EXECUTIVE SUMMARY

A Quantitative Road Safety Analysis (QRSA) study using Value Analysis/Explicit Road Safety (VA/ERS) processes and techniques, sponsored by the California Department of Transportation (Caltrans), facilitated by Value Management Strategies, Inc., and supported by Delphi MRC, was conducted on the Niles Canyon Road corridor located on SR 84 in District 4, Alameda County, CA. The workshops were conducted May 7-11 and May 21-23, 2012 in the Livermore and Oakland offices of Caltrans District 4. This *Executive Summary* provides an overview of the project, key findings, and the countermeasures developed by the QRSA team.

This QRSA Report, prepared by Value Management Strategies, Inc., records the study findings and throughout references and summarizes the detailed road safety information elaborated in the Road Safety Review Report prepared by Delphi MRC (see the *Appendix* of this report).

The results of the study focus on safety and include roadway improvements that, where possible and prudent, reduce the impacts to the Niles Canyon environment. District 4 is evaluating the study findings in detail for feasibility and integration into the Caltrans project development and environmental processes.

Caltrans will be using the findings of this report to scope a Niles Canyon Road project. Some of the activities that will be employed to do this include the following:

- Community meetings to get feedback on the Final QRSA Study report.
- Caltrans consideration and evaluation of community feedback.
- Continued dialog with local agencies and organizations at stakeholder meetings.
- Start scoping process for potential projects.

BACKGROUND

The portion of the Niles Canyon Road (SR 84) corridor that lies between Mission Boulevard and I-680 (PM 10.83-17.9) (7.1 miles) was studied by two separate teams:

- Road Safety Audits (RSA)
- Quantitative Road Safety Analysis (QRSA)

The RSA findings are documented in a separate report prepared by the FHWA.

These studies were precipitated by a court injunction, filed June 23, 2011, by the Alameda Creek Alliance with the Alameda County Superior Court, that construction be stopped on the Niles Canyon 1 project.

The following summarizes the features of three Caltrans Niles Canyon projects, as originally designed by Caltrans:

- Niles Canyon 1 entails improvements to the roadway passing under the Rosewarnes Underpass (increased lateral distance between the structure supports and the edge of travelway) and the addition of an eastbound left turn pocket at the Palomares Road Intersection near the Farwell Underpass.

- Niles Canyon 2 entails corridor-wide addition of shoulders without structure widening.

- Niles Canyon 3 is a bridge replacement at the crossing of the Alameda Creek Bridge to correct two deficient horizontal curves.

The Niles Canyon 1 project was in construction when a court injunction halted the project due to concerns of impacts to federally threatened species. In December 2011, Caltrans terminated the construction contract. Plans to restart the Niles Canyon 1 project are on hold pending the outcome of the RSA and QRSA studies. The Niles Canyon 2 and Niles Canyon 3 projects are still in the Draft Environmental Document preparation project development phase.

The three original Niles Canyon projects, programmed and subsequently developed by Caltrans, were based on corridor safety needs identified in the early 2000s. These safety needs were identified by the Two-Lane and Three-Lane Safety Monitoring Program, a program that tracks the rates of head-on collisions. Since that timeframe some conditions have changed. For example:

- Traffic volumes are down by approximately 20% from the peak in 2005.

- A centerline rumble strip (2-foot soft barrier) has been installed to reduce head-on collisions.

- Greater cultural and human environment priorities for the Canyon have surfaced with the designation of Niles Canyon Road as a Scenic Corridor in 2007 and the impending restoration of the steelhead trout habitat in Alameda Creek.

- The corridor is growing in popularity as a destination, especially with bicyclists.

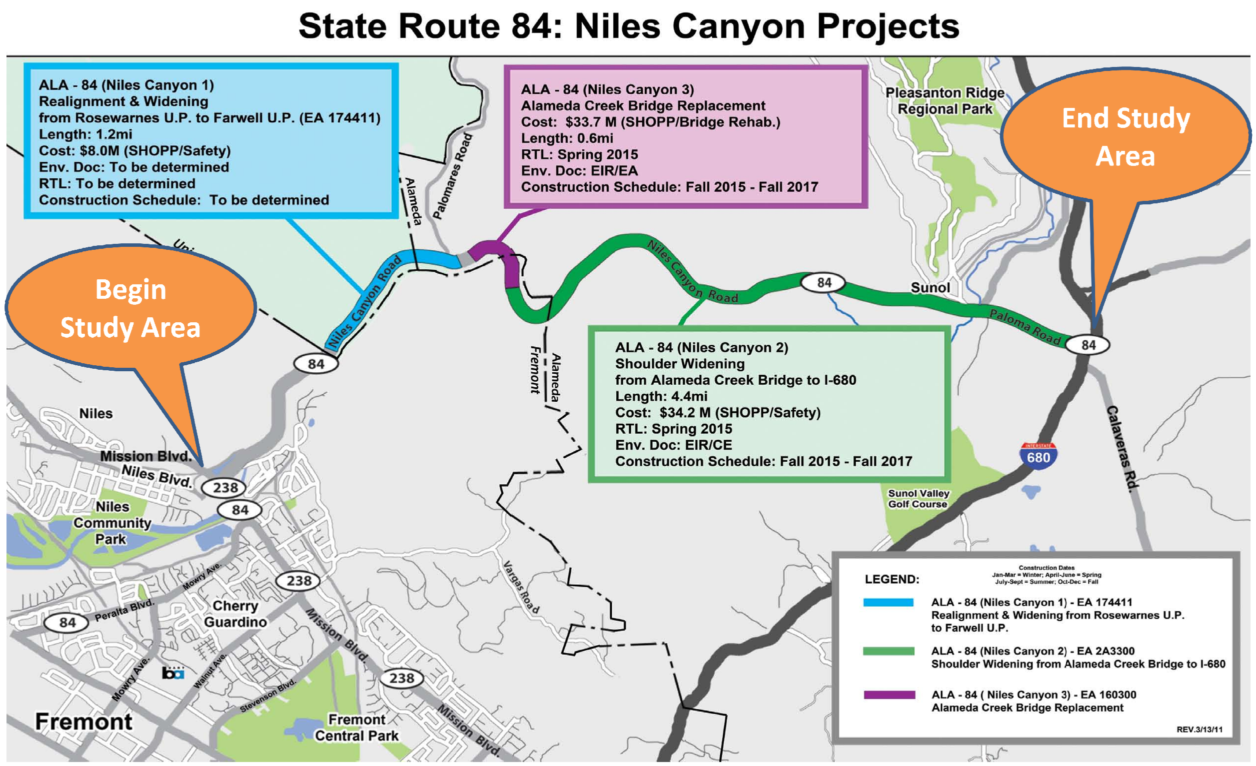

Figure 1: Project Location

The Niles Canyon projects, as originally designed by Caltrans, were opposed by environmental and community groups. These groups are interested in a variety of topics, which can generally be summarized with the following:

- Do the completed interim safety upgrades, such as the centerline rumble strip, negate the need for the proposed Niles 1, 2, and 3 improvements?
- Can the scope of the original projects be reduced while maintaining a reasonable level of safety to minimize the impacts to the recreational, cultural, community, and natural environment resources of the Canyon?
- The water quality of the creek is protected and preserved because it is a drinking water source and to facilitate the restoration of the steelhead trout habitat. Can the improvements be down-scoped to reduce the impact to this natural resource?

In summary, the project stakeholders question if there is a current safety need, and whether context-sensitive solutions, such as spot improvements, can be developed to provide the needed safety benefit but with less environmental impact.

STUDY OBJECTIVES

The s QRSA study had the following objectives:

- Establish corridor safety need.
- Identify countermeasures that address the safety need.
- Investigate the safety benefit associated with each countermeasure.
- Establish the impacts that the countermeasures will have on the Canyon environment.

Caltrans has chosen not to circulate the Niles Canyon 2 or Niles Canyon 3 projects' environmental documents until the corridor safety needs have been assessed, and project alternatives with less environmental impacts have been investigated. Towards that end, Caltrans requested assistance from the RSA and VA teams.

STUDY PROCESS

This is the third of three pilot studies employing the combined RSA-VA processes:

- Smith River, US-101 (November 2010)
- SR 16 in Yolo County (March 2012)
- SR 84 in Alameda County, Niles Canyon 1, 2, and 3 projects (May 2012)

This study, the SR 84 safety improvement project, entailed the following three-pronged approach:

1. **RSA Workshop.** This workshop is carried out by a team consisting of road safety experts, traffic operations specialists, highway engineers, and selected other specialists. The workshop starts with a Kick-Off Meeting, followed by a field investigation to evaluate the site under various traffic conditions and to identify surrounding land uses and road user types. An examination of historical collision data is also conducted as part of the audit to obtain details on the current road safety performance characteristics of the facility. All of this information is then used by the Audit Team to identify potential road safety risks. Road safety issues identified by the Audit Team, along with a description of the types of countermeasures that may be considered to improve safety performance, are then handed off to the VA team members for consideration. See the end of the brochure for more detailed RSA information.

2. **Explicit Road Safety (ERS) Analysis.** Based on findings from the RSA, the ERS experts quantify the project's safety need and provide prioritization guidance with regard to the safety issues identified by the RSA team. This information is a critical input to the VA workshop as it identifies key road safety elements and the likely areas where road safety value might be gained. Using a variety of analytical tools and techniques, the ERS experts also provide the QRSA team with measures of the relative change in road safety performance that may be achieved from the

implementation of the RSA's proposed countermeasures. See the end of the brochure for more detailed ERS information.

3. **VA Workshop.** While it is essential that safety be considered explicitly, it is not the only factor that will influence the final selection of countermeasures. With the project safety quantification in hand, the VA workshop completes the process by assessing the countermeasures and assembling them into project strategies with the input of additional disciplines, such as maintenance personnel, environmental planners, construction engineers, etc. The Value Methodology (VM) is a systematic approach to problem solving based on function analysis and supported by value metrics. Value metrics allows the study findings to be quantified in terms of the relationship of project performance to project resources. The VA study facilitated the input of a wide array of stakeholders, which in many cases included conflicting interests. The QRSA is achieved by integrating the RSA, ERS, and VM processes. The QRSA resulted in the following outcomes:

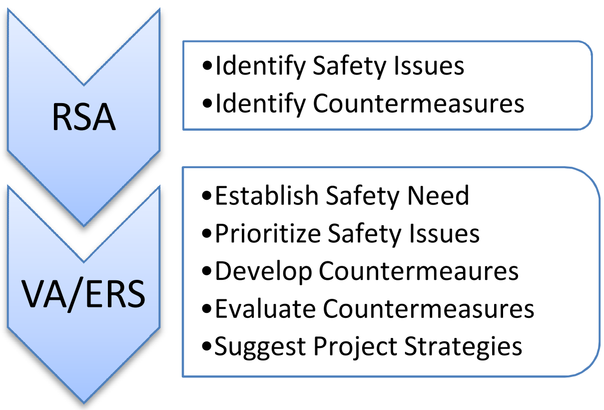

Figure 2: Quantitative Road Safety Analysis Study Process Outcomes

EVALUATION OF EXISTING CONDITIONS

The existing Niles Canyon Road corridor has the following features:

- A two-lane conventional highway that leaves the urbanized setting and transitions into a rural setting east of Mission Boulevard; designated a Scenic Highway in 2008.
- Current Niles Canyon traffic two-way AADT at Palomares Road is approximately 14,000 with 2.5% truck traffic.
- The Niles Canyon two-way AADT is forecast to grow to 22,250 in the vicinity of Palomares Road by the year 2030.
- Hazardous material trucks are restricted from using the corridor.
- The roadway is generally bounded by a steep canyon wall, Alameda Creek, and a historic railroad; i.e., a canyon with significant natural and human environment resources.

- There are key locations that have restricted sight distances and small lateral offsets to obstructions, notably the Rosewarnes Underpass and the Palomares Road/Farwell Underpass.
- The roadway carries narrow shoulders with a curvilinear horizontal alignment; the eastern portion is less curvilinear with more open roadside and generally flatter sideslopes.
- Centerline rumble strips were completed in October 2007 between Old Niles Canyon Road and Pleasanton-Sunol Road.
- Regulatory speed is 45 mph; there are curve warning speed signs to 30-35 mph at spot locations.

CORRIDOR SAFETY NEED

METHODOLOGY

The assessment of the existing road safety performance of the corridor was conducted based on a "lines of evidence" approach. This approach examined the safety performance of the study area using a range of tools and techniques that assessed the corridor, first individually, and then collectively. Where lines of evidence "overlap" and point to a common conclusion regarding a particular element of the roadway or location, that conclusion is strengthened by the independence of the indicators and the multiplicity of their occurrence, as well as the independence of the individual investigators pursuing the different approaches to the analysis.

The lines of evidence framework examined the performance of the SR 84 study area using four distinct examination methods as illustrated in Figure 3 on the following page. Findings from a synthesis of the lines of evidence were then used to prioritize risk levels associated with the safety concerns identified and to prioritize locations within the study area for road safety improvement.

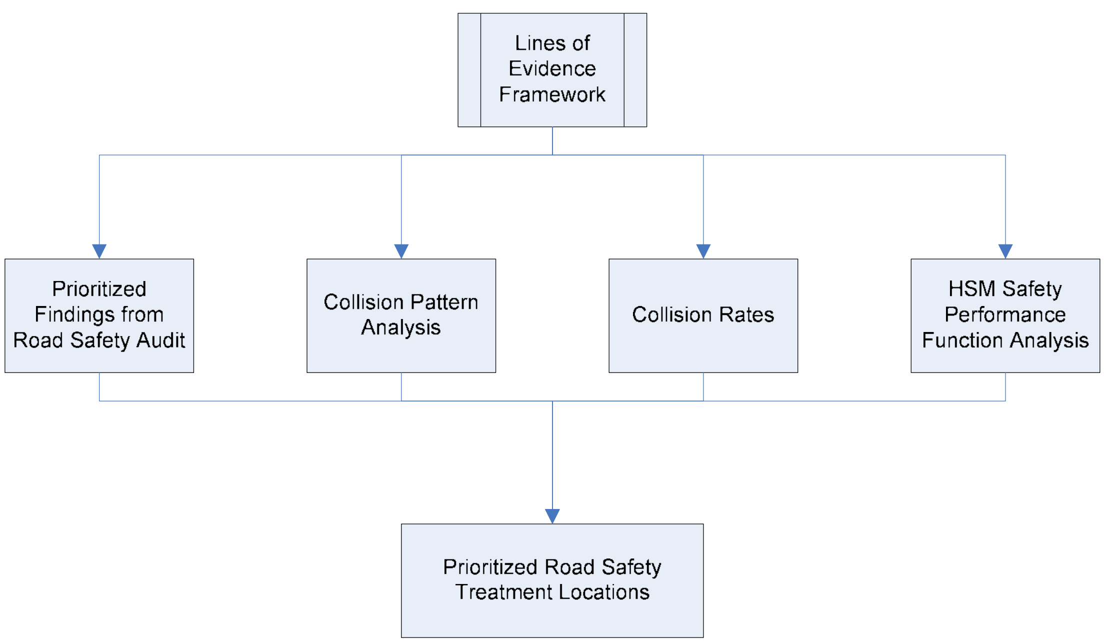

Figure 3: Lines of Evidence Framework

Table 1 on the following page presents a summary of findings from the four lines of evidence that were evaluated as part the ERS evaluation of the existing safety performance of the corridor. In this table, locations identified by each line of evidence that appear to be under-performing from a road safety perspective are identified, allowing each location under every line of evidence to be compared and to identify commonalities. Where lines of evidence "overlap" and point to a common conclusion regarding a particular location, that conclusion is strengthened by the independence of the indicators and the multiplicity of their occurrence, as well as the independence of the individual investigators pursuing the different approaches to the analysis.

Location	Lines of Evidence			
	Prioritized RSA Findings	Collision Pattern	Collision Rates	Safety Performance Function
Specific Locations				
Mission Boulevard		X		
Rosewarnes Underpass & Approaches (includes passing zone to east)	X	X	X	X
Station 11+350 (approx. mile post 12.8 - vicinity of church access)	X	X	X	X
Palomares Intersection/Farwell Underpass	X	X	X	X
Alameda Creek Bridge	X	X		X
Low-Speed Curve Near "The Spot"	X	X	X	X
Alameda BOH	X		X	
Station 7+800 (approx. mile post 14.6)			X	X
Kaiser Quarry Intersection	X			X
Station 11+800 (approx. mile post 15.3)				X
Station 13+800 (approx. mile post 15.7)				X
Sunol Interchange on/off ramps				X
Main Street and Pleasanton/Sunol Intersections -queues that extend to Silver Spring UP	X	X	X	X
Corridor Wide Issues				
Roadside Barrier Inconsistencies	X			
Clear Zone Provisions	X	X		
Accommodating Bicycles	X	X		
Shoulder discontinuities	X			
Vegetation limits sightlines	X			

Table 1: Summary of Lines of Evidence

CONCLUSIONS

Based on the four lines of evidence and as elaborated in the Road Safety Review Report (see the *Appendix* of this report), the following safety concerns were prioritized as needing attention along the corridor:

Spot Locations

The following lists, in order of priority, those spot locations identified in the Road Safety Review in need of safety improvement:

1. Rosewarnes Underpass and its approaches (includes passing zone to east)

2. Low-speed curve in the vicinity of "The Spot"
3. Palomares Road Intersection/Farwell Underpass and their approaches (includes vicinity of church access)
4. Main Street and Pleasanton-Sunol Road Intersections
5. Alameda Creek Bridge

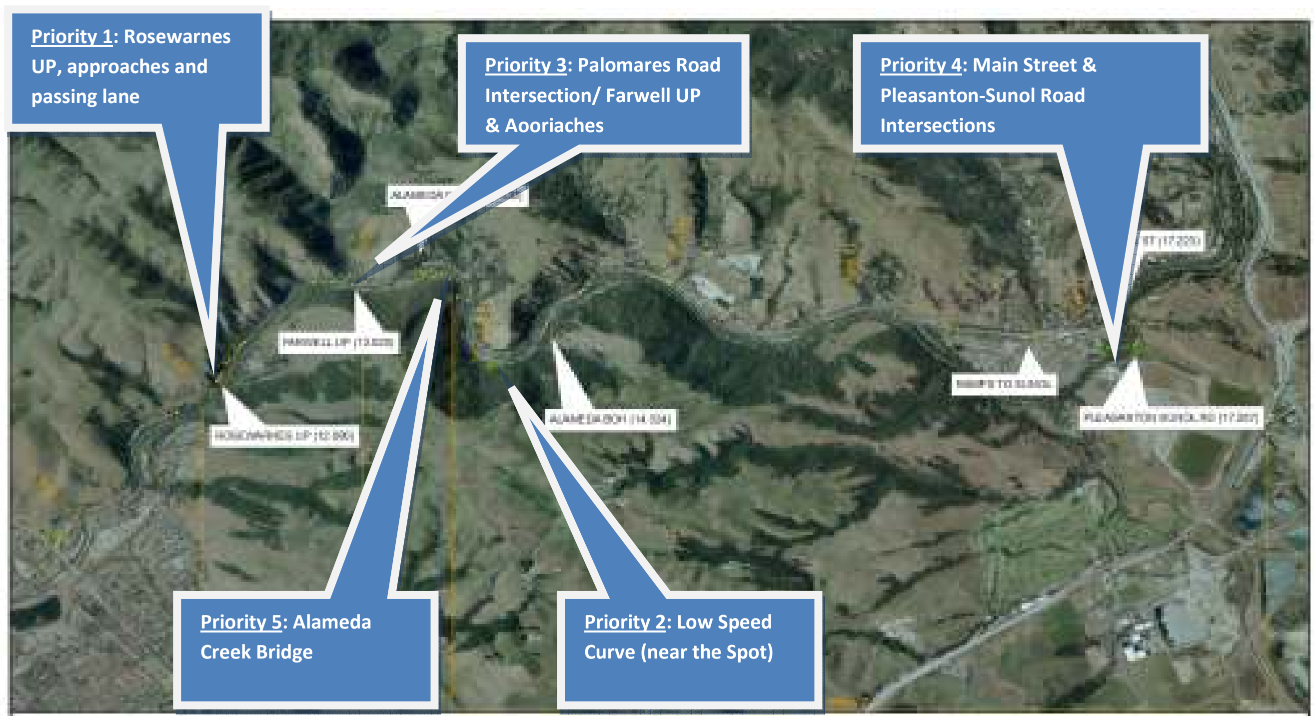

Figure 2: Prioritized Spot Improvement Locations

OTHER ISSUES

In addition to the spot locations identified above, the following lists a number of corridor-wide road safety improvement issues that require careful consideration:

- Accommodation of bicycles
- Roadside design issues
- Shoulder discontinuities
- Vegetation

For more information refer to the *Project Analysis* section of this report, or the Road Safety Review Report (see the *Appendix* of this report).

COUNTERMEASURES

The teams identified up to 51 countermeasures to improve safety where supported by the lines of evidence approach and to address the higher prioritized safety issues identified by the RSA team along the Niles Canyon Road corridor. The QRSA team, supported by the ERS tools and techniques, evaluated these countermeasures for safety benefit versus environmental impact, and carried 32 concepts forward into development. The countermeasures were screened into short-term, medium-term and long-term categories based on the level of project development effort required. Separate from the three previously mentioned ones is the community vision category. The resulting breakdown of countermeasures is:

- 15 short-term improvement countermeasures
- 12 medium-term improvement countermeasures
- 2 long-term improvement countermeasures
- 3 community-vision countermeasures

The last three countermeasures were developed to reflect the community vision for the Niles Canyon Road.

The assumptions made by the QRSA team to determine what is short-term and medium-term may be obvious in some cases – such as in the case of the Rosewarnes Underpass countermeasures, but may be more subjective in other cases. For example, the correction of the superelevation and roadway widening at the low speed curve near The Spot is possibly a short-term solution that can be bundled in short-term category in lieu of in medium-term category.

SHORT-TERM COUNTERMEASURES

These countermeasures are shorter term measures that improve safety with less environmental impact, addressing features such as: improved positive guidance, removing/ protecting roadside hazards, better identification of roadside hazards, minor intersection improvements, and upgrading roadway appurtenances.

The 15 short-term countermeasures are identified below.

- AN-2 Install active warning system to alert motorists to bikes on roadway
- AN-5 Install sharrows on shoulders or lane edges at select locations to demonstrate potential bicycle usage
- C-1 Install friction treatment to pavements at low-speed curve locations
- IO-8 Install mirror on the Farwell Underpass pier to alert vehicles at the Palomares Road Intersection
- IO-9 Modify flashing beacon at Palomares Road to indicate intersection is further to the east
- IO-11 Install ITS elements at Palomares Road to signal drivers of approaching vehicles

- IO-17 Lighting of key areas (Rosewarnes Underpass, Palomares Road Intersection/Farwell Underpass)
- P-1 Eliminate passing zone adjacent to low-speed curves
- R-5 Install steel mesh netting on slopes in rockfall areas
- R-12/R-14 Upgrade roadside protection appurtenances and address guard rail and K-rail end treatments
- R-15 Relocate select fixed objects immediately adjacent to roadway
- SIMA-1 Install reflective material on underpass abutments
- SIMA-2 Install reflective material on curbs and rock walls adjacent to roadway
- SIMA-3 Install dynamic active warning device for queuing conditions
- SPMA-2/3 Install speed feedback sign and transverse pavement markings at low-speed curves

MEDIUM-TERM COUNTERMEASURES

The following 12 countermeasures improve safety at those locations identified by the ERS analysis. The medium-term countermeasures in conjunction with the short-term countermeasures address the project safety needs. These improvements generally result in more significant impacts associated with roadway geometry or typical section modifications that lead to greater environmental impacts than those identified in the short-term countermeasures. These impacts require greater project development time and effort.

The medium-term safety locations and countermeasures are identified below.

Rosewarnes Underpass Spot Improvements

- Countermeasure R-4 Relocate the west abutment at the Rosewarnes Underpass
- Countermeasure R-9 Bifurcate the roadway at Rosewarnes Underpass with new viaduct constructed to the south
- Countermeasure RO-1 Realign Road and Construct Tunnel into Slope at the Rosewarnes Underpass

Palomares Road/Farwell Underpass Spot Improvements

- Countermeasure IO-2 Realign Palomares Road to join church driveway
- Countermeasure IO-5 Relocate the railroad abutment at the Farwell Underpass to improve sight distance

Alameda Creek Bridge Spot Improvements

- Countermeasure ACB-2 Replace Alameda Creek Bridge to upgrade the approach curves

Low-Speed Curve Located Between Alameda Creek and Alameda Creek BOH Bridges Spot Improvement East of The Spot

- Countermeasure C-2 Correct superelevation at low-speed curve between the two project bridges

- Countermeasure C-3 — Widen roadway curve east of Alameda Creek Bridge to accommodate off-tracking

Alameda Creek BOH Spot Improvements

- Countermeasure ALCRBO-1 — Remove curb on Alameda Creek Bridge BOH

Pleasanton-Sunol Road/SR 84 Intersection

- Countermeasure IO-1 — Construct a roundabout at the intersection of SR 84 and Pleasanton-Sunol Road
- Countermeasure IO-15 — Construct a signalized intersection at the Pleasanton-Sunol Road Intersection

Facilitate Corridor Enforcement

- Countermeasures SPMA-4/SW-3 — Provide widened locations at strategic spacing to accommodate enforcement and pullovers

LONG-TERM COUNTERMEASURES

The VA team recommends that Caltrans monitor the safety need of the corridor after the implementation of the short-term and medium-term countermeasures. If monitoring identifies a safety need, the following long-term countermeasures should be considered:

- Countermeasure RO-3 — Widen roadway to provide roadway cross section of 12-foot lanes, 8-foot shoulders, and spot widening for CRZ
- Countermeasures IO-13/QI-1 — Correct superelevation and vertical sight distance, and extend eastbound left turn pocket at the quarry road intersection

Some of the concepts listed above, such as Countermeasures QI-1 and IO-13 at the Kaiser Quarry and the roadside improvements suggested in RO-3, may require attention over a longer timeframe due to safety needs that could be triggered by traffic growth within the Niles Canyon corridor. This growth could be from vehicular and non-motorist use.

COMMUNITY VISION COUNTERMEASURES

The following 3 countermeasures reflect the community vision that should be considered in the long-range transportation planning for the region.

- Countermeasure AN-4 — Separate non-motorized traffic by constructing an off-roadway trail system
- Countermeasure AN-6 — Provide bike path adjacent to railroad grade
- Countermeasure RE-1 — Designate Niles Canyon as a park and install a toll booth at each end

Countermeasures AN-4, AN-6, and RE-1, cannot be implemented without local long-term planning effort, local involvement, and a commitment of local funding to the state highway system. Note that

RE-1, “Designate Niles Canyon as a park and install toll booths on each end,” is an approach to reduce the use of the corridor as a commuter route and would require legislative action.”

ANALYSIS OF COUNTERMEAURES

The table on the following pages lists safety benefit for every developed countermeasure. The chart on the following pages identifies the tradeoff between safety benefit versus environmental impact for each of the countermeasures developed in the short-term, medium-term, long-term and community vision categories.

ID No.	Idea Description	Annual Collision Reduction using 2012 Horizon Year		Environmental Impacts
		2012	Comments	
Short-Term Countermeasures				
AN-2	Install active warning system to alert motorists to bikes on roadway	0.03		Minimal environmental impacts
AN-5	Install sharrows on shoulders or lane edges at select locations to demonstrate potential bicycle usage	-	Although this measure offers no measureable change in collision frequency, it could be combined with the activated warning system in AN-2 to potentially improve likelihood of achieving a road safety benefit.	Minimal environmental impacts
C-1	Install friction treatment to pavements at low-speed curves and in icy areas	0.19		Minimal environmental impacts
AN-3	Install warning signs for roadway narrowing and shoulder reduction	-	No measureable change in collision frequency is expected.	Minimal environmental impacts
IO-8	Install mirrors at Palomares Road to view westbound traffic	0.03		Minimal environmental impacts
IO-9	Relocate flashing beacon at Palomares Road further to the east	-	Consider modifying signage at the existing location.	Minimal environmental impacts
IO-11	Install ITS elements at Palomares Road to signal drivers of approaching vehicles	-	No measureable change in collision frequency is expected.	Minimal environmental impacts
IO-17	Lighting of key areas	0.14		Minimal environmental impacts
P-1	Eliminate passing zone adjacent to low-speed curves	0.22		Minimal environmental impacts
R-5	Install steel mesh netting on slopes in rock fall areas	-	Not quantified. Potential for decrease in collision likelihood.	Potential aesthetic/visual impacts to scenic corridor Disturbs the uplands habitat
R-12	Address guard rail and k-rail end treatments	-	Although there is no change in collision likelihood associated with this safety improvement, there will be a reduction in the resulting collision severity.	Minimal environmental impacts

ID No.	Idea Description	Annual Collision Reduction using 2012 Horizon Year		Environmental Impacts
			Comments	
		2012		
Short-Term Countermeasures				
R-14	Upgrade roadside protection appurtenances	-	Although there is no change in collision likelihood associated with this safety improvement, there will be a reduction in the resulting collision severity.	Minimal environmental impacts
R-15	Relocate select fixed objects immediately adjacent to roadway	0.15	Approximate annual collision cost reduction = $54,800.	Potential impacts relative to tree removal Cultural impacts relative to Eucalyptus tree removal (community resource) Native species could to be replanted in the vicinity (but offset from the travelway) in support of Niles' Canyon endemic
SIMA-1	Install reflective material on underpass abutments	0.27		Minimal environmental impacts
SIMA-2	Install reflective material on curbs and rock walls adjacent to roadway	0.43		Minimal environmental impacts
SIMA-3	Install dynamic active warning device for queuing conditions	0.13		Minimal environmental impacts
SPMA-2	Install speed feedback sign and longitudinal pavement markings at low-speed curves	0.42	Reduction calculated for both SPMA-2 and SPMA-3	Minimal environmental impacts
SPMA-3	Narrow lane widths to 11 feet and reapportion to shoulder			
Medium-Term Countermeasures				
Rosewarnes UP Countermeasures				
R-4	Relocate the pier adjacent to the WB lane at Rosewarnes Underpass	0.84		Aesthetic impacts relative to retaining structure Potential impacts to historical railroad Potential impacts to upland trees and habitat Opportunity to use vacated area for water catchment/treatment Potential temporary impacts to creek habitat during construction Requires temporary shut down of the railroad to accommodate construction

ID No.	Idea Description	Annual Collision Reduction using 2012 Horizon Year Analysis Results 2012	Comments	Environmental Impacts
Medium-Term Countermeasures				
Rosewarnes UP Countermeasures				
R-9	Bifurcate the roadway at Rosewarne Underpass with new viaduct constructed to the south	-0.21	The avoidance of head-on and side swipe collisions provided by the installation of the median barrier does not compensate for the increased collision potential associated with the introduction of the median barrier and crashworthy end-treatments.	Requires constructing roadway into creek Reduced impacts to historic railroad Historic railroad can remain operational throughout construction
RO-1	Construct tunnel into slope at Rosewarnes and realign roadway accordingly	0.19		Increased impacts to upland trees and habitat Requires less temporary shut down of the railroad to accommodate construction Increased opportunity to use vacated area for water catchment/treatment Potential impacts to historic aqueduct in vicinity of Rosewarnes
Farwell UP / Palomares Road Intersection				
IO-2	Realign Palomares Road to join church driveway	0.05		Right of way acquisition required Potential impacts to church property Potential impacts to Stoneybrook Creek (steelhead trout habitat) Potential tree removal Reclamation of existing Palomares Road for permeable area improves water quality
IO-5	Relocate the railroad abutment at Farwell Underpass to improve sight distance	0.18		Impacts to historic railroad Requires temporary closure of the railroad
Alameda Creek Bridge				
C-2 (A)	Correct superelevation at low-speed curves	0.07	Collision reduction is combined from C-2(A) and C-2(B)	Minimial impacts as fill and AC would be accomplished within existing footprint
ACB-2	Replace Alameda Creek Bridge	0.37		Requires placing new piers in Alameda Creek, but removes pier from active channel

ID No.	Idea Description	Annual Collision Reduction using 2012 Horizon Year		Environmental Impacts
		2012	Comments	
Medium-term Countermeasures				
Alameda Creek Bridge BOH				
ALCRB0-1	Remove curb on Alameda Creek Bridge OH	0.17	Results in a significant reduction in collision severity (60% -92% fatal &30%-92% injury collisions	Aesthetic impacts relative to bridge rail, however, see-through railing is proposed to mitigate visual impacts Impacts to historic structure (Alameda Creek BOH)
Pleasanton-Sunol Road / Main Street Intersections / End of Queue				
IO-1	Construct a roundabout at the intersection of SR-84 and Sunol/Pleasanton	0.29	Benefit obtained from reduction in rear-ends associated with the existing road's end of queue condition	Potential impacts to historic Water Temple gates Potential tree removal Potential impacts to fruit stand (access, potential relocation) ROW acquisition Pedestrian accommodation issues
IO-15	Install signalized intersection at Pleasanton-Sunol Road	-0.52	Signalized intersection has increased collision potential as compared to a roundabout. The end of queue provides same benefit as the roundabout countermeasure.	Potential tree removal Reduced ROW acquisition
Speed Management				
SPMA-4/ SW-3	Provide widened locations at strategic spacing to accommodate enforcement and pull overs	0		Minimial impacts as fill and AC would be accomplished within existing footprint Minor impacts relative to increased runoff potential from increasing
Long-Term Countermeasures				
RO-3	Widen roadway to provide roadway cross-section of 12' lanes, 8' shoulders, and spot widening for CRZ	1.31		Not evaluated for environmental impacts.
IO-13	Correct superelevation and vertical sight distance at Quarry road intersection	0.02		Not evaluated for environmental impacts
QI-1	Extend the EB left turn pocket at the Quarry intersection	0.01		Not evaluated for environmental impacts
Community Vision				
AN-4	Separate non-motorized traffic to off-roadway trail system	Not quantified		Not evaluated for environmental impacts
AN-6	Provide bike path adjacent to railroad grade	Not quantified		Not evaluated for environmental impacts
RE-1	Designate Niles Canyon as a park and install toll booths on each end	Not quantified		Not evaluated for environmental impacts

COUNTERMEASURE STRATEGIES

A summary of the safety benefit and environmental impacts for the QRSA countermeasures, is provided below, within a short-term, medium-term and long-term category. Every countermeasure, not just those identified within the categories shown below, should be carefully reviewed by the Project Development Team (PDT). The ultimate decision on whether to pursue a countermeasure must be made upon further study based on cost, environmental, and other factors before deciding which countermeasure is to be implemented.

SAFETY IMPROVEMENT CATEGORY: SHORT-TERM

Table 2: Quantitative road safety analysis of short-term countermeasures (2012)

Short-Term Countermeasures						
Location	Countermeasures Applied	Annual Collision Frequency (2012)		Collision Rate (per mvm)		% Collision Reduction
		Before	After	Before	After	
Rosewarnes underpass	- Lighting of key areas (IO-17) - Install active warning system to alert motorists to bikes on roadway (AN-2) - Install friction treatment to pavements at low-speed curves and in icy areas (C-1) - Install reflective material on underpass abutments (SIMA-1) - Install speed feedback sign and longitudinal pavement markings at low-speed curves; narrow lane widths to 11 feet and reapportion to shoulder (SPMA-2&3)	0.41	0.30	1.33	0.97	27%
Between Rosewarnes underpass & Palomares Rd	- Install reflective material on curbs and rock walls adjacent to roadway (SIMA-2) - Eliminate passing zone adjacent to low-speed curves (P-1)	1.85	1.48	1.10	0.88	20%
Palomares Rd & Farwell underpass	- Install mirrors at Palomares Road to view westbound traffic (IO-8) - Lighting of key areas (IO-17) - Install active warning system to alert motorists to bikes on roadway (AN-2) - Install friction treatment to pavements at low-speed curves and in icy areas (C-1) - Install reflective material on underpass abutments (SIMA-1) - Install speed feedback sign and longitudinal pavement markings at low-speed curves; narrow lane widths to 11 feet and reapportion to shoulder (SPMA-2&3)	1.44	1.03	1.95	1.40	28%
Between Farwell underpass & Alameda Creek Bridge	- Install reflective material on curbs and rock walls adjacent to roadway (SIMA-2)	1.93	1.75	1.30	1.18	9%
Alameda Creek Bridge to Alameda Creek BOH	- Install active warning system to alert motorists to bikes on roadway (AN-2) - Install friction treatment to pavements at low-speed curves and in icy areas (C-1) - Install speed feedback sign and longitudinal pavement markings at low-speed curves; narrow lane widths to 11 feet and reapportion to shoulder (SPMA-2&3)	6.49	6.00	0.95	0.88	8%
East of Alameda Creek BOH (0.2 miles)	- Install reflective material on curbs and rock walls adjacent to roadway (SIMA-2)	0.82	0.74	0.72	0.65	9%
Between Silver Springs UP and Pleasanton-Sunol intersection	- Install dynamic active warning device for queuing conditions (SIMA-3)	1.29	1.16	0.74	0.67	10%
	Total collision frequency	**14.23**	**12.47**			
		Δ	**1.76**			

Table 2 on the previous page identifies the safety benefit organized by spot location for those select countermeasures in the short-term category. All of the countermeasures were integrated into the table except for IO-9, “Relocate flashing beacon at Palomares Road further to the east.” This countermeasure showed little safety benefit. Refer to the *Safety Improvement Countermeasures* section of this report for suggested modifications to this concept.

The safety benefit is to reduce the annual collisions by 1.76 (from 14.23 to 12.47) within the locations prioritized by the road safety expert.

Most of the short-term countermeasures have minimal environmental impacts; the most contentious item may be impacts to the trees at the “Spot” associated with countermeasure R-15.

SAFETY IMPROVEMENT CATEGORY: MEDIUM-TERM

Table 3: Quantitative road safety analysis of medium-term countermeasure (2012)

Medium-Term Countermeasures						
Location	Countermeasures Applied	Annual Collision Frequency (2012)		Collision Rate (per mvm)		% Collision Reduction
		Before	After	Before	After	
Rosewarnes underpass	- Construct tunnel into slope at Rosewarnes and realign roadway accordingly (RO-1)	0.30	0.11	0.97	0.37	62%
Palomares Rd & Farwell underpass	- Realign Palomares Road to join church driveway (IO-2)	1.03	0.98	1.40	1.33	5%
Alameda Creek Bridge	- Replace Alameda Creek Bridge (ACB-2)	1.87	1.42	0.27	0.21	24%
Low Speed curve in the vicinity of "The Spot"	- Widen roadway at low speed curve at the Spot to accommodate off-tracking (C-3) - Correct superelevation at low-speed curves (C-2)	0.40	0.31	1.39	1.07	23%
Alameda Creek BOH	- Remove curb on Alameda Creek BOH and upgrade rail (ALCRBO-1)	0.83	0.66	0.79	0.63	20%
Between Silver Springs UP and Pleasanton - Sunol intersection	- Construct a roundabout at the intersection of SR-84 and Sunol-Pleasanton (IO-1)	1.16	0.87	0.67	0.50	25%
	Total collision frequency	5.59	4.36			
		Δ	1.24			

Table 3 above identifies the safety benefit organized by spot location for select countermeasures identified in the medium-term category. The countermeasures excluded from the table above were not selected for the following reasons:

- R-4: Relocate the Pier Adjacent to the westbound lane at Rosewarnes Underpass

  This countermeasure was not selected as it had the greatest impact to the historic Niles Canyon Railroad.

- R-9: Bifurcate the roadway at Rosewarne Underpass with new viaduct constructed to the south

  This countermeasure was not selected due to its lower safety benefit and negative impacts to water quality.

- IO-5: Relocate the Railroad Abutment at Farwell Underpass to Improve Sight Distance

  This countermeasure had the greatest impact to the historic Niles Canyon Railroad.

- IO-15: Install Signalized Intersection At Pleasanton-Sunol Road

  This countermeasure was not selected for the strategy because it had a lower safety benefit and unlike the roundabout, did not contribute to speed management within the vicinity of Sunol; it also was found to have a lower level of service.

The safety benefit of this category reduces the annual collisions by 1.24 (from 5.59 to 2.36) within the locations prioritized by the road safety expert.

Most of the countermeasures in the medium-term category have significant environmental impacts; the ones with the greatest environmental concern are as follows:

RO-1 Construct tunnel into slope at Rosewarnes and realign roadway accordingly
- Increased impacts to upland trees and habitat
- Temporary shutdown of the railroad to accommodate construction
- Potential impacts to historic aqueduct in vicinity of Rosewarnes

IO-2 Realign Palomares Road to join church driveway
- Right-of-way acquisition required
- Potential impacts to church property
- Potential impacts to Stoneybrook Creek (steelhead trout habitat)
- Potential tree removal
- Reclamation of existing Palomares Road for permeable area improves water quality

ACB-2 Replace Alameda Creek Bridge
- Requires placing new piers in Alameda Creek, but removes pier from active channel
- Impact to water quality and riparian habitat
- Requires tree removal
- Potential encroachment on historic railroad
- Potential impacts to viewsheds from historic railroad

IO-1 Construct a roundabout at the intersection of SR 84 and Pleasanton-Sunol Road
- Potential impacts to historic Water Temple gates
- Potential tree removal
- Potential impacts to fruit stand (access, potential relocation)
- Pedestrian accommodation issues

One positive note is the potential to use vacated area in the vicinity of the Rosewarnes Underpass and the Alameda Creek Bridge to provide detention ponds for runoff water quality treatment.

LONG-TERM / COMMUNITY VISION CATEGORIES

The long-term road safety countermeasures and the community vision countermeasures were not organized into a category and analyzed collectively, as these countermeasures are long-term measures and subject to significant change over time and require a long-term regional approach to their implementation.

CONCLUSIONS

Table 4: Corridor Safety Benefit (2012) for Short-Term and Medium –Term Countermeasures

Location	Mileage	Collision Rate Reduction (ACC/MVM)	
		Short-Term	Medium-Term
Rosewarnes UP & Approaches	0.055	27%	62%
Between Rosewarnes UP & Palomares Road	0.300	20%	5%
Palomares Rd / Farwell UP & Approaches	0.132	28%	24%
Between Farwell UP & Alameda Creek Br.	0.273	9%	-
Alameda Creek Bridge	0.300	-	24%
Alameda Creek Bridge to Alameda Creek Bridge BOH	0.956	8%	23%
East of Alameda Creek Bridge (0.2 miles)	0.209	9%	-
Alameda Creek Bridge BOH	0.193		20%
Between Silver Springs UP & Pleasanton-Sunol Intersection	0.318	10%	25%
Aggregating the impact at the Spot Locations	**2.74**	**12%**	**22%**

Table 4, above, identifies a total of nine locations within the corridor, where the short-term countermeasures (Table 2) and medium-term countermeasures (Table 3) are concentrated. This table summarizes the safety benefit, expressed in percentage, within a particular location.

For example, expanding on the application of short-term and medium-term countermeasures at Rosewarnes Underpass and Approaches location shows:

- The countermeasures that can improve safety at this location are applied to a 0.055-mile segment of Niles Canyon Road (see Tables 2 and 3 for the applicable countermeasures that apply to this location).
- The application of short-term countermeasures at this location reduces the collision rate by 27%.
- The application of the medium-term countermeasures at this location reduces the collision rate by an additional 62%.

The sum benefit, within these nine concentrated locations, a distance of only 2.74 miles out of the total corridor's 7.1 miles, is as follows:

- The collision rates resulting from the implementation of the short-term countermeasures are reduced by 12%.

- There is an additional 22% collision rate reduction that can be achieved with the implementation of the medium-term countermeasures.

The countermeasures developed and evaluated in this study should not be considered the end of the search for good project solutions. The analysis of them, in fact, should stimulate improvements to them, or new ideas that may better address safety benefit, reduce environmental impacts, simplify construction or reduce capital investment.

The short-term and medium-term countermeasures should only be taken as suggestions at this point in time as they represent one of many ways to improve the safety at the prioritized locations identified by the safety need analysis.

It is suggested that Caltrans review all countermeasures for safety benefit versus impacts, cost, and project development time to make an informed decision on what countermeasures can reasonably be implemented in the short-term, medium-term, and long-term.

QRSA TEAM

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SAFETY IMPROVEMENT COUNTERMEASURES

SAFETY IMPROVEMENT COUNTERMEASURES

The QRSA team identified 35 safety issues for which 51 countermeasures were developed to improve the Niles Canyon Road corridor safety. The QRSA team, supported by the ERS analysis, evaluated these countermeasures for safety benefit versus environmental impact and retained 32 countermeasures. These countermeasures have been screened into short-term, medium-term and long-term categories based on the level of project development effort required as follows:

- 15 short-term improvement countermeasures
- 12 medium-term improvement countermeasures
- 2 long-term improvement countermeasures
- 3 community-vision countermeasures

The last three countermeasures were developed to reflect the community vision for the Niles Canyon Road.

SHORT-TERM COUNTERMEASURES

The short-term countermeasures can be developed relatively quickly, improve safety with little environmental impact featuring topics such as: improved positive guidance, removing/protecting roadside hazards, better identification of roadside hazards, minor intersection improvements, and upgrading roadway appurtenances.

- AN-2 Install active warning system to alert motorists to bikes on roadway
- AN-5 Install sharrows on shoulders or lane edges at select locations to demonstrate potential bicycle usage
- C-1 Install friction treatment to pavements at low-speed curve locations
- IO-8 Install mirror on the Farwell Underpass pier to alert vehicles at the Palomares Road Intersection
- IO-9 Modify flashing beacon at Palomares Road to indicate intersection is further to the east
- IO-11 Install ITS elements at Palomares Road to signal drivers of approaching vehicles
- IO-17 Lighting of key areas (Rosewarnes Underpass, Palomares Road Intersection/Farwell Underpass)
- P-1 Eliminate passing zone adjacent to low-speed curves
- R-5 Install steel mesh netting on slopes in rockfall areas
- R-12/R-14 Upgrade roadside protection appurtenances and address guard rail and K-rail end treatments
- R-15 Relocate select fixed objects immediately adjacent to roadway
- SIMA-1 Install reflective material on underpass abutments
- SIMA-2 Install reflective material on curbs and rock walls adjacent to roadway
- SIMA-3 Install dynamic active warning device for queuing conditions
- SPMA-2/3 Install speed feedback sign and transverse pavement markings at low-speed curves

Note: The following countermeasures include both metric and U.S. units of measurement. The differences in stationing and units of measurement are based on the original plan sets for each project provided to the QRSA team for their use during the study.

Countermeasure AN-2: Install active warning system to alert motorists to bikes on roadway

Existing Conditions: Throughout the corridor bicyclists use the roadway. Most of the cyclists observed were experienced bicyclists as opposed to leisure and/or recreationalist bicyclists. Historical information indicates that cycle clubs use the SR 84 corridor on weekends and at least one day a year there is a gathering of a large number of cyclists for a day-long event. The roadway has some limited paved shoulders in many areas of the corridor that the cyclists use, but there are a number of sections where the shoulder disappears and the cyclists have to take the lane.

Proposed Improvements: Install active warning devices to alert motorists that bikes are on the roadway in the lane. The active warning devices would be placed at locations where there are no shoulders and the sight distance of drivers is limited. These locations are mainly at curves and approaches to bridges, including the bridge as well.

Application of this countermeasure includes the following locations that are constrained by little to no shoulders, lateral obstruction, and limited sight distance:

- Rosewarnes Underpass (10+112.259 m to 10+201.066 m) (Niles 1 stationing)
- Farwell Underpass (11+522 m to 11+734.370 m) (Niles 1 stationing)
- Horizontal curves between Alameda Creek Bridge and Alameda Creek Bridge BOH (7+190 m to 7+672 m and 2+325 ft to 7+371 ft) (Niles 2 Stationing)

Discussions with stakeholders indicate that bicycle ridership will likely increase in the future, primarily in the recreational bicycle numbers. As such, the potential for collisions between bicyclists and vehicles may increase over time. Although the calculated collision reduction is relatively small, the impact of any collision to bicyclists is quite high and may warrant consideration for this countermeasure.

Safety Analysis: The ERS analysis indicated that the safety benefit is to reduce the number of accidents as follows:

- 0.03 collisions per year (2012)

Advantages:

- Allows individual bicyclist to prompt the warning
- Warns drivers of a cyclist on the roadway
- Minimal environmental impacts

Disadvantages:

- Bicyclists could have a false sense of security
- Maintenance required to ensure workability
- Requires bicyclist to slow down or pull over to trigger warning signal

Countermeasure AN-5: Install sharrows on shoulders or lane edges at select locations to demonstrate potential bicycle usage

Existing Conditions: Throughout the corridor bicyclists use the roadway. Most of the observed bicyclists were not leisure and/or recreationalist bicyclists, but more of the experienced type. Historical information indicates that cycle clubs use the SR 84 corridor on weekends and at least one day a year there is a cycle gathering of a large number of cyclists for a day-long event. The roadway has limited paved shoulders along many areas of the corridor that the cyclists use, but there are a number of sections where the shoulder disappears and the cyclists have to take the lane.

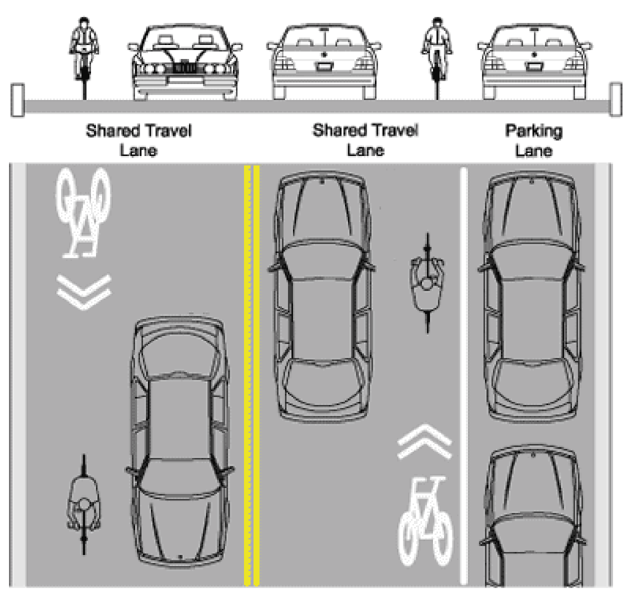
Proposed Improvements: The sharrows would remind drivers of the possibility that bicyclists may be in the lane ahead. The sharrows would be placed at locations where the shoulders narrow or are non-existent and the sight distance of drivers is limited. These locations are mainly located at curves and approaches to bridges

Location of improvements:

- Curvilinear section of SR 84 between the Alameda Creek Bridge and the Alameda Creek Bridge BOH and include the bridges
- Rosewarnes Underpass (10+110 m to 10+210 m) (Niles 1 Stationing)
- Farwell Underpass (11+580 m to 11+680 m) (Niles 1 Stationing)

Safety Analysis: The MUTCD does not recommend the application of sharrows on roadways with posted speeds in excess of 35 mph. Operating speeds through this section of the study area appear to be in excess of 35 mph.

Although there are no CRFs specific to the application of sharrows, the literature appears to suggest an increase in collision frequency (both bicycle and vehicle collisions associated with the installation of bike lanes) (Bicycle Tracks and Lanes: A before and After Study, Jenson, 2008). This suggests that careful consideration of site context and the appropriateness of the proposed facility for cycling will be required.



Sharrows would provide motorists with an indication that cyclists may be present on this section of the facility. Based on this discussion, a negligible impact on collision severity and likelihood is expected.

Advantages:

- Grabs drivers attention
- Minimal environmental impacts

Disadvantages:

- Requires additional maintenance to maintain pavement markings
- Markings could create a slippery surface for motorcycles and bicyclists

Countermeasure C-1: Install friction treatment to pavements at low-speed curve locations

Existing Conditions: The corridor is a curvilinear roadway with low-speed curves throughout. At some of the specific low-speed curve locations, crash concentrations were noted. One of the possible reasons for these crashes occurring is too high of speed entering the curve or slick conditions from rain or possible black ice.

Proposed Improvements: Apply friction treatment, such as shown below, at low-speed curves and the one area that experiences black ice. Friction treatment includes Tyregrip®. This system consists of a highly modified exothermic epoxy resin two-part binder, top dressed with a calcinated bauxite with a Polish Stone Value of 70 percent plus. This treatment proved effective at increasing the skid resistance value from 35 to 104. Another treatment option could be pavement grooving at these sites. Pavement grooving is a technique for installing longitudinal or transverse cuts on the surface to increase skid resistance and reduce the number of wet-weather crashes. Grooves cut in the longitudinal direction have proved most effective in increasing directional control of the vehicle, while transverse grooving is most effective at locations where vehicles make frequent stops. Grooved pavements can reduce wet-weather crashes. One study of a California two-lane road with sharp curves found a 72 percent reduction in wet-pavement accidents, but only 7 percent reduction in dry-pavement accidents.

Application locations include:

- Rosewarnes underpass (10+112.259 m to 10+201.066 m) (Niles 1 Stationing)
- Palomares Road and Farwell Underpass (11+522 m to 11+734 m) (Niles 1 Stationing)
- West end of Alameda Creek Bridge and through low-speed curves located between the Alameda Creek Bridges (7+190 m to 7+672 m and 2+325 ft to 7+371 ft) (Niles 2 Stationing)

This treatment provides a significant reduction in collisions and should be investigated further.

Safety Benefit: The explicit roadway safety analysis indicated that total collision reduction rates are as follows:

- 0.19 collisions per year (2012)

Advantages:

- Provides increase in skid resistance
- Reduces potential for wet-weather collisions
- Minimal environmental impacts

Disadvantages:

- May entice familiar drivers to drive faster
- May increase maintenance to maintain friction surface

Countermeasure IO-8: Install mirror on the Farwell Underpass pier to alert vehicles at the Palomares Road Intersection

Existing Conditions: The intersection of SR 84 and Palomares Road is a tee intersection and Palomares Road intersects on the north end of SR 84. The left turn from Palomares Road to eastbound SR 84 has a limited sight distance of westbound SR 84 traffic due to the abutments of the Farwell Underpass being at the edge of travel, on a curve and restricting sight distance.

Proposed Improvement: Attach a convex mirror to the eastbound side abutment for drivers making the left turn from Palomares Road to eastbound SR 84. This would allow drivers to easily identify oncoming traffic in the westbound lanes.

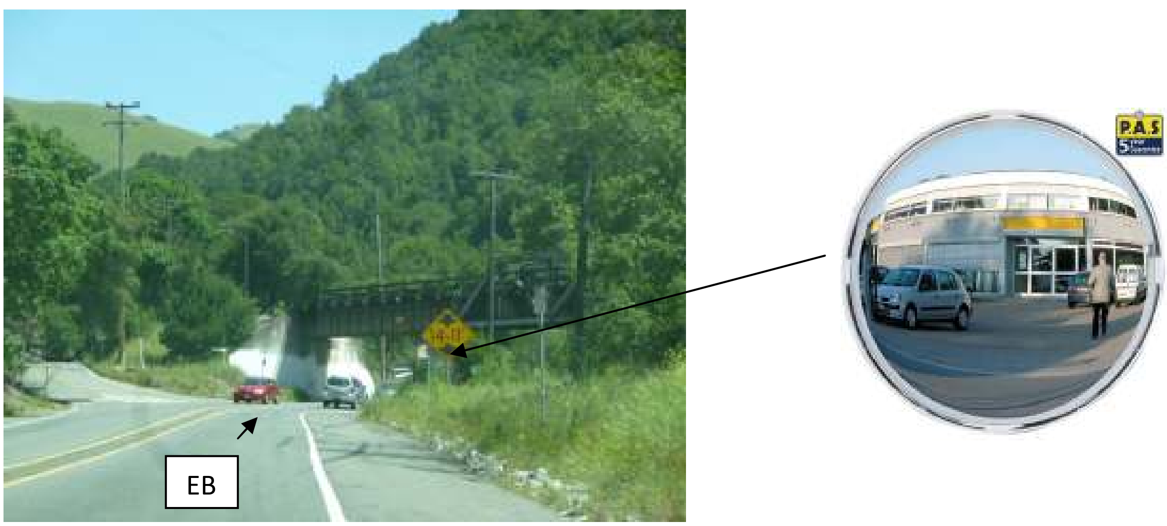
Safety Benefit: The explicit roadway safety analysis indicates that total collision reduction calculates to 0.03 collisions/year (2012).

Advantages:

- Allows drivers to track westbound vehicles approaching the intersection
- Minimal environmental impacts

Disadvantages:

- Vandalism could render the mirror useless (graffiti, gun target, etc.)
- Could be a maintenance issue
- Against Caltrans policy



Mirror would be located on eastbound abutment

Countermeasure IO-9: Modify flashing beacon at Palomares Road to indicate intersection is further to the east

Existing Conditions: A two-head flashing beacon with a tee intersection warning sign was placed just west of the Palomares Road and SR 84 Intersection. This system warns approaching drivers that there could be a car coming out of Palomares heading eastbound on SR 84. The warning system is located directly across from a private driveway on the north side of SR 84 leading to a church. As a driver approaches, the warning is noticed and scanning for the concern, the driver sees the church driveway and could think that the warning is for that driveway.

Proposed Improvements: Modify the flashing beacon signage by adding the word “AHEAD” to the sign (see suggested modification under Safety Benefit comments).

Safety Benefit: No CRF specific to this situation. Because of the limited sightlines, it is likely that relocating this sign further to the east will increase collision likelihood. Opportunities to improve the current signage should be considered. Options may include adding an "AHEAD" tab to the existing sign to improve the guidance offered to drivers.

Advantages:

- Confusion is somewhat mitigated
- Minimal environmental impacts

Disadvantages:

- It is likely that relocating this sign further to the east will increase collision likelihood

Countermeasure IO-11: Install ITS elements at Palomares Road to signal drivers of approaching vehicles

Existing Conditions: The intersection of SR 84 and Palomares Road is a tee intersection and Palomares Road intersects on the north end of SR 84. The left turn from Palomares Road to eastbound SR 84 has a limited sight distance of westbound SR 84 traffic due to the abutments of the Farwell Underpass being at the edge of travel, on a curve and restricting sight distance.

The existing intersection is currently noted by continuous flashing beacon/warning signs on the approaches to the intersection.

Proposed Improvements: Replace the existing flashing beacon signage with an active warning system that is tied to Palomares Road. The beacon would detect vehicles on Palomares Road and warn drivers on SR 84 that a vehicle is entering roadway for those motorists traveling westbound as they approach the Palomares Road Intersection.

In order to ensure effectiveness, ITS elements should replace the existing flashing warning sign as the combination of continuous and active warning devices will be confusing to drivers. As there is already a flashing "intersection warning" sign in advance of the intersection, the change in collision frequency resulting from changing the sign message will likely be limited.

Safety Benefit: No measured change in collision frequency is expected.

Advantages:

- Gives drivers awareness of a possible conflict
- Time to adjust their speeds
- Minimal environmental impacts

Disadvantages:

- Bikes would not be detected
- Installation costs much higher that just advanced warning signs
- No significant change in collision frequency is predicted

Countermeasure IO-17: Lighting of key areas (Rosewarnes Underpass, Palomares Road Intersection/Farwell Underpass)

Existing Conditions: There is currently no lighting at locations of key safety concern.

Proposed Improvements: Add lighting to the following locations:

- Rosewarnes Underpass (10+112.259 m to 10+201.006 m) (Niles 1 Stationing)
- Palomares Road and Farwell Underpass (11+522 m to 11+734.37 m) (Niles 1 Stationing)

Safety Benefit: The ERS analysis indicates that total collision reduction calculates the following:

- 0.14 collisions per year (2012)

Advantages:

- Reduces the collision frequency for nighttime vehicles at two locations of high potential for collision
- Minimal environmental impacts

Disadvantages:

- Installation investment

Countermeasure P-1: Eliminate passing zone adjacent to low-speed curves

Existing Conditions: There is approximately 1,600 feet of passing zone in the straighter stretches of roadway between the Rosewarnes Underpass and Palomares Road. This passing zone is bounded by curvilinear alignments at both ends. This is not an appropriate location for passing activity.

Proposed Improvements: Eliminate this passing zone and replace it with a 1,600-foot section of SR 84 west of the Rosewarnes Underpass (10+358 m to 10+841 m) (Niles 1 Stationing). The elimination of this passing zone permits the provision of a flush median treatment with centerline rumble strips. It also reduces the risk of high approach speeds into the low-speed horizontal curves.

Safety Benefit: The ERS analysis indicates that total collision reduction calculates to:

- 0.22 collisions per year (2012)

Advantages:

- Eliminates high-speed vehicles approaching the low-speed curves at the Farwell and Rosewarnes Underpass (especially westbound passing vehicles)
- Minimal environmental impact

Disadvantages:

- Eliminates the only passing zone within the project limits

Countermeasure R-5: Install steel mesh netting on slopes in rockfall areas

Existing Conditions: There are two rockfall locations along the westbound lanes of Niles Canyon Road between the Rosewarnes Underpass and Farwell Underpass. The maintenance personnel have indicated that these areas require constant maintenance and they are also a road hazard when rocks fall near or on the travelway.

Rock upslopes, facing eastbound approaching Palomares Road

Proposed Improvements: Install steel mesh netting on the rocky upslopes in these rockfall areas. The areas include one near Rosewarnes, approximately 600 feet long, and another closer to Palomares Road, approximately 1,200 feet long.

Application locations include:

- A 600-foot section of SR 84 just east of the Rosewarnes Underpass
- A 1,200-foot section of SR 84 in the vicinity of Palomares Road

Safety Benefit: Although there is no available explicit road safety data to quantify this countermeasure, the netting will reduce collisions by preventing fallen rock from becoming objects that can be struck by vehicles in the shoulder and travel lane.

Advantages:

- Reduces the presence of unpredictable "rocky road" hazards
- Reduces maintenance efforts and cost

Disadvantages:

- Disturbs the uplands habitat
- Potential impacts to aesthetics/visual impacts to scenic corridor

Countermeasure R-12/R-14: Upgrade roadside protection appurtenances and address guard rail and K-rail end treatments

Existing Conditions: Throughout the corridor there are installations of f barrier and metal beam guard rails that appear to be installed at the incorrect height and without the proper end treatments.

Proposed Improvements: Install crashworthy end-treatments at barrier installation and adjust or replace barriers/metal barrier guard railing to improve the function of the barrier in redirecting errant vehicles back into the travelway throughout the study area.

Metal beam guard rail at low height and without appropriate end treatment (east approaches to Alameda Creek Bridge)

Safety Benefit: Although replacing blunt end barriers with crashworthy end-treatments will not reduce the likelihood of collision, the resulting severity of the collision with the barrier end will be reduced. A Roadside Analysis Program (RSAP) suggests the severity index resulting from a collision with the barrier end will reduce from 3.90 to 2.55.

For those barriers/meta beam guard rail stretches adjusted according to their correctly designed r mounting height, barrier condition, etc., there could be a significant reduction in impact on collision severity as approximately 52% of collisions on the facility involve the roadside (fixed object and overturn collisions).

Advantages:

- Reduces the impact of a road departure where roadside is protected with barrier
- Minimal environmental impacts

Disadvantages:

- Installation investment

Countermeasure R-15: Relocate select fixed objects immediately adjacent to roadway

Existing Conditions: There are utility poles, trees, and headwalls within close proximity of the travelway.

Proposed Improvements: Remove or relocate the above listed hazards within 8 feet of the travelway. Also, consider removing vegetation/tree limbs that obscure sight lines around curves and to warning signs.

The identification of these obstacles was done by reviewing the team video of the corridor. The following is a rough sampling of these hazards:

Obstacle to be removed/moved	Obstacle PM	Comments
Begin Trees (Both Sides) / End Trees (Both Sides)	10.12-10.23	
Vegetation on Westbound Curve	10.41	
Tree (Eastbound)	11.47	
Tree blocks Rosewarnes Low-Speed Curve and Flashing Yellow Beacon	11.74	
Tree (Eastbound)	11.87	
Electrical Transformer	12.83	
Warning Sign Obstructed by Vegetation	12.83	
2 Utility Poles (1 Eastbound and 1 Westbound)	13.34	
Vegetation Obstructing Sight Lines (Eastbound Curve)	13.56	
Pole at Church Driveway (Eastbound) West of Palomares Road	13.15	
Utility Pole (Westbound) between Church Driveway and Palmorares Road	13.20	
Utility Pole (Eastbound)	13.49	
Utility Pole (Eastbound)	13.55	
Utility Pole (Eucalyptus Trees at The Spot)	13.84	
Headwall East of the Quarry Intersection (Westbound)	15.06	
Sims Park (3 Utility Poles) (Eastbound)	15.4 (±)	Greater offset than 8 feet, but in front of barrier placed to restrict site
East End of Sim Park (Tree in Front of Barrier) (Eastbound)	15.4 (+)	
Silver Springs UP	16.93	Replace curb and sidewalk with shoulder (support bicyclists) - PDT verify that pedestrians tend to walk through town and not on SR 84 in this location

Row of Eucalyptus Trees located within 2-4 feet of the "Spot"

Note: The trees between the Pleasanton-Sunol Road Intersection and I-680 (PM 17-28-PM 17.96) appear to be outside the 8-foot dimension – retain these and monitor accidents for this object on collision statistics.

Safety Benefit: The ERS analysis indicates that total collision reduction calculates to:

- 0.15 collisions per year (2012)

Approximate annual collision cost reduction = $54,800.

Advantages:

- Reduces the likelihood of a hit object for roadway departures
- Native species could be replanted in the vicinity (but offset from the travelway) in support of the Niles Canyon endemic species

Disadvantages:

- Community opposition to removing Eucalyptus trees
- Removal of trees may negatively affect water quality
- Possible environmental impacts of select removal of other trees
- Cultural impacts relative to Eucalyptus tree removal (community resource)

Countermeasure SIMA-1: Install reflective material on underpass abutments

Existing Conditions: At the Farwell and Rosewarnes Underpasses, the abutments are located at the edge of the travel way. The abutments have been painted white to increase the target value and small chevron signs have been installed. However, the white paint washes out at night and the abutments have become large graffiti canvases.

Proposed Improvements: Install reflective tape or other type of reflective targets to the abutments that will increase the target value of the abutments at night.

Application locations include:

- Rosewarnes Underpass (10+112 m to 10+201 m) (PM 12.10)
- Farwell Underpass (11+522 m to 11+734 m) (PM 13.03)

Traveling Eastbound at Rosewarnes Underpass (Left Picture) and at Farwell Underpass (Right Picture)

Safety Benefit: The explicit roadway safety analysis indicates applying these treatments at the Rosewarnes and Farwell Underpasses reduces total collision rates by:

- 0.27 collisions per year (2012)

Advantages:

- Increases visibility of the obstacle at night
- Ease of installation
- Minimal environmental impacts

Disadvantages:

- Easy to vandalize
- Periodic maintenance may be required to keep this treatment in a good state of repair to provide the intended benefit

Countermeasure SIMA-2: Install reflective material on curbs and rock walls adjacent to roadway

Existing Conditions: There are bridge curbs (i.e., Alameda Creek BOH) and rock walls throughout a large portion of the project that are adjacent to the edge of the shoulder.

Proposed Improvements: Identify these hazards with reflective tape. Concrete walls and rock walls are prevalent between preceding Rosewarnes (PM 12) and between it and the Farwell Underpass (13.1) and the barrier east of the Farwell Underpass (approximately 1,200 feet long).

Application locations include:

- 10+358 m to 10+841 m (Niles 1 Stationing)
- 11+621 m to 12+061 m (Niles 1 Stationing)
- 7+794 ft to 8+898 ft (Niles 2 Stationing)

Safety Benefit: The ERS analysis indicates total collision reduction calculates to:

- 0.43 collisions per year (2012)

Advantages:

- Increases visibility of the obstacle at night
- Ease of installation

Disadvantages:

- Easy to vandalize

Barrier east of Farwell UP along eastbound lanes

Concrete/Rock Wall (east of Rosewarnes Underpass)

Rock wall preceding Rosewarnes Underpass

Countermeasure SIMA-3: Install dynamic active warning device for queuing conditions

Existing Conditions: Due to the volume of traffic on SR 84, queuing occurs on a daily basis at the intersection of SR 84 and Sunol Road. This creates a backup that sometimes stretches a long distance, creating a hazard for oncoming vehicles that may have limited sight distance to identify stopped traffic. The queuing occurs during peak hours in a vertical sag profile ("dip") under the Silver Spring Underpass structure that has very poor sight lines. Vehicles in the eastbound lanes during peak hours can potentially be rear-ended at this location at significant velocity differentials.

Traveling eastbound approaching the Silver Springs Underpass

Proposed Improvements: Install a dynamic warning system intersection that will detect stopped traffic and be tied into advanced signing that would warn oncoming traffic of the stopped condition. Queues need to be analyzed to determine what queue lengths are typical for locating the advance warning signs.

Application locations include:

- Sunol Road Interchange underpass 19+150 ft to 20+830 ft (Niles 2 Stationing)

Safety Benefit: The explicit roadway safety analysis indicates that total collision reduction calculates to:

- 0.13 collisions per year (2012)

Advantages:

- Drivers are warned of stopped conditions
- Minimal environmental impacts

Disadvantages:

- Initial installation costs

Countermeasure SPMA-2/3: Install speed feedback sign and transverse pavement markings at low-speed curves

Existing Conditions: The approaches to the low-speed curves include signage warning drivers of upcoming curves, but most of the drivers using this corridor become complacent and do not watch their speed. A cluster of crashes are occurring at most of the low-speed curves and speed is attributable to the crashes.

Proposed Improvements: At each of the low-speed curves where the cluster of speed-related crashes are occurring, install a speed feedback sign prior to the curves that lets the driver know what speed they are traveling prior to entering the curves. In conjunction with the speed feedback sign, transverse pavement markings are placed on the roadway perpendicular to the direction of travel. Typically, transverse markings are placed on the roadway at progressively closer distances apart creating the illusion of acceleration. The two major types of transverse pavement markings used to reduce traffic speeds are transverse bars and transverse chevrons.

Vehicle Speed Indicator

Consider also installing optical bars. Optical bars are about 2 feet long and 1 foot wide, and are placed at intervals that narrow from 24 feet at the start to 15 feet at the end. This creates an optical illusion – a flip book effect – that tricks speeding drivers into thinking they are driving faster than they actually are, causing them to slow down. A British study has shown that optical speed bumps reduced fatal and serious injury crashes, and the method has already been successfully tested in Texas, Kansas, and Mississippi. This treatment can also be combined with a reallocation of 1 ft of the travel way apportioned to the shoulder for a narrowing effect on the driver.

Example of Optical Bars

Application locations include:

- Rosewarnes Underpass (10+112 m to 10+201 m) (Niles 1 Stationing)
- Farwell Underpass (11+522 m to 11+734 m) (Niles 1 Stationing)
- West end of Alameda Creek Bridge (7+189 m to 7+672 m) (Niles 2 Stationing)
- Low-speed curves located between the Alameda Creek Bridge and Alameda Creek BOH Bridge (2+325 ft to 7+371 ft) (Niles 3 Stationing)

Safety Benefit: The ERS analysis indicates the total collision reduction calculations are as follows:

- 0.42 collisions per year (2012)

As the effects of speed management measures diminish as drivers become accustomed to the roadway changes, combining the various speed management measure CRFs creates an over-optimistic level of improvement. The ERS expert therefore applied a more conservative 5% collision frequency reduction that includes speed feedback signs, pavement markings and lane narrowing.

Advantages:

- Grabs driver's attention

Disadvantages:

- Requires additional maintenance
- Transverse markings could create a slippery surface for motorcycles and bicyclists
- Against Caltrans policy

MEDIUM-TERM COUNTERMEASURES

These countermeasures provide solutions that will improve safety, at those locations identified in the Road Safety Report, with modifications to roadway geometry or the typical section that result in increased footprint. Therefore these improvements require more effort and time than the short-term countermeasures. The 12 medium-term safety locations and countermeasures identified are listed below:

Rosewarnes Underpass Spot Improvements

- Countermeasure R-4 — Relocate the west abutment at the Rosewarnes Underpass
- Countermeasure R-9 — Bifurcate the roadway at Rosewarnes Underpass with new viaduct constructed to the south
- Countermeasure RO-1 — Realign Road and Construct Tunnel into Slope at the Rosewarnes Underpass

Palomares Road/Farwell Underpass Spot Improvements

- Countermeasure IO-2 — Realign Palomares Road to join church driveway
- Countermeasure IO-5 — Relocate the railroad abutment at the Farwell Underpass to improve sight distance

Alameda Creek Bridge Spot Improvements

- Countermeasure ACB-2 — Replace Alameda Creek Bridge to upgrade the approach curves

Low-Speed Curve Located Between Alameda Creek and Alameda Creek BOH Bridges Spot Improvement East Of The Spot

- Countermeasure C-2 — Correct superelevation at low-speed curve between the two project bridges
- Countermeasure C-3 — Widen roadway curve east of Alameda Creek Bridge to accommodate off-tracking

Alameda Creek BOH Spot Improvements

- Countermeasure ALCRBO-1 — Remove curb on Alameda Creek Bridge BOH

Pleasanton-Sunol Road/SR 84 Intersection

- Countermeasure IO-1 — Construct a roundabout at the intersection of SR 84 and Pleasanton-Sunol Road
- Countermeasure IO-15 — Construct a signalized intersection at the Pleasanton-Sunol Road Intersection

Facilitate Corridor Enforcement

- Countermeasures SPMA-4/SW-3 — Provide widened locations at strategic spacing to accommodate enforcement and pullovers

ROSEWARNES UNDERPASS SPOT IMPROVEMENTS

Countermeasure R-4: Relocate the west abutment at the Rosewarnes Underpass

Existing Conditions: The existing Rosewarnes Underpass constrains Niles Canyon Road geometrically and provides minimal lateral distance between the roadway edge of travelway and the pier/abutment. The short S-curves are signed for 25 mph and the sight distance is roughly 150 feet. The clearance is 14'-6" according to the posted sign. The pier in the photograph below shows clear evidence of vehicle strikes.

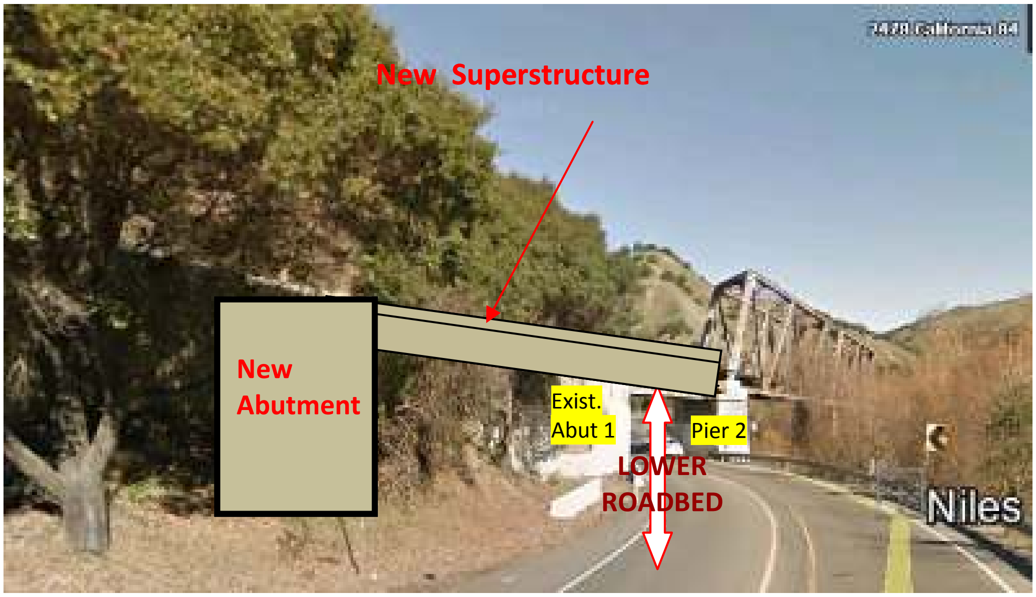
Traveling east approaching first curve at the Rosewarnes Underpass

View of Rosewarnes Underpass traveling eastbound

<u>Proposed Improvements:</u> Relocate the railroad abutment west of its current location to improve the roadway alignment. Replace the railroad bridge and pier to support increased loading/span. The replaced structure, to the extent possible, should mimic the look of the current bridge to retain the historical context of the Niles Canyon Railroad. In order to keep the railroad bridge in service, a shoofly will need to be incorporated into the revised span.. However, the retaining wall between the existing roadway and Alameda Creek will impact water quality and riparian habitat.

On the northeast corner of the abutment some retaining wall will be required. It should be noted that the substructure at Rosewarnes has already been modified by a seismic retrofit in previous years.

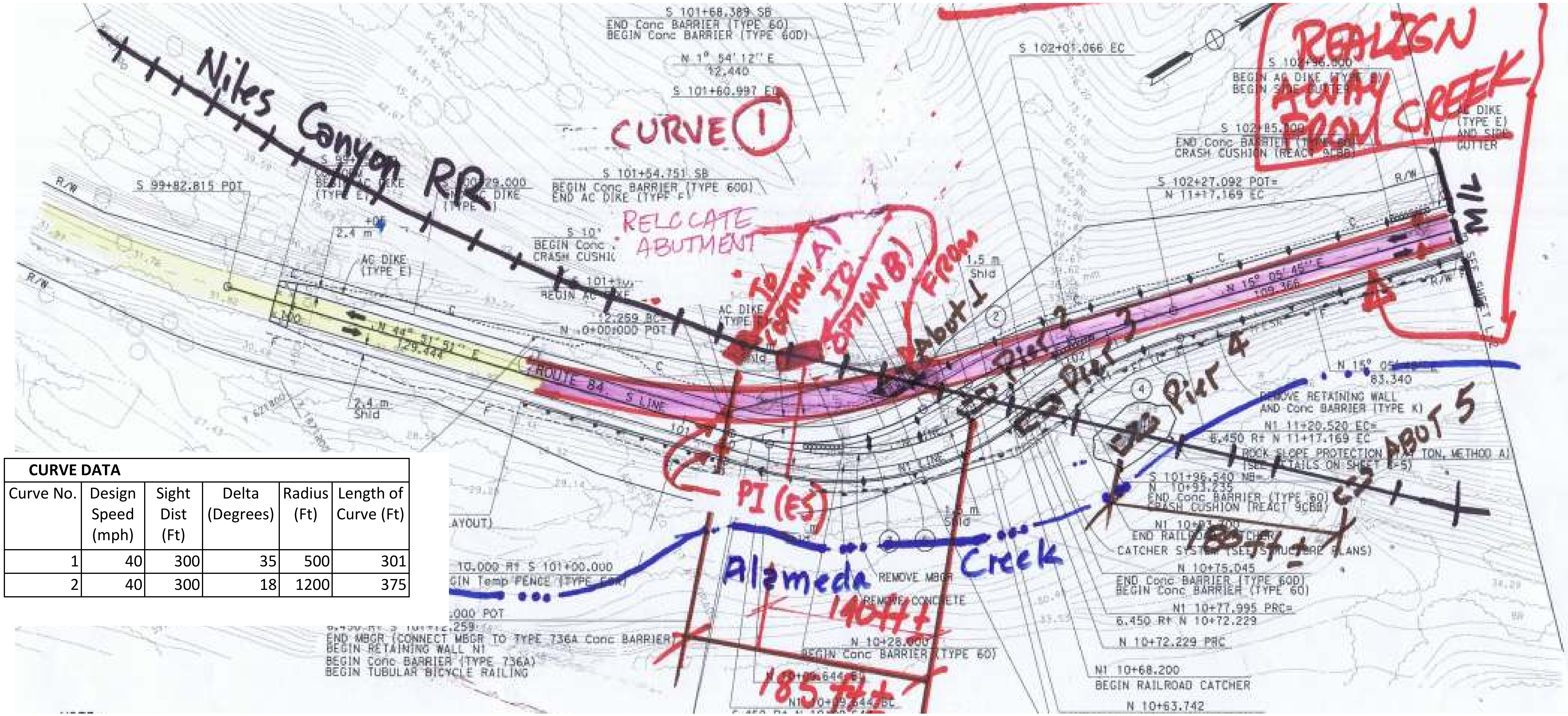
The countermeasure has technical challenges that may make it technically and economically infeasible. For instance, this concept will require a shoofly that passes over the roadbed, and there are technical challenges in designing a new superstructure with longer spans that integrates with the existing structure while allowing passage of vehicles underneath.



Proposed Improvements

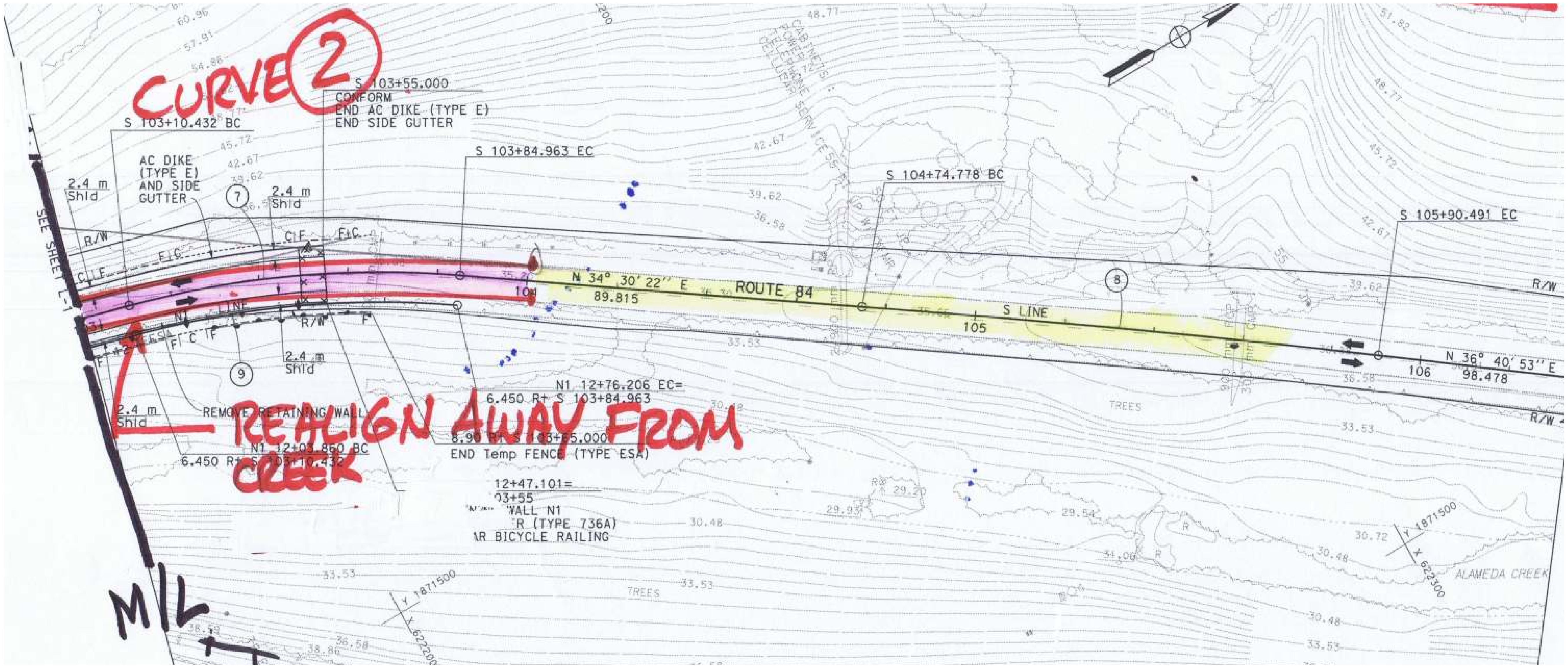
New Curve Data:

CURVE DATA					
Curve No.	Design Speed (mph)	Sight Dist (Ft)	Delta (Degrees)	Radius (Ft)	Length of Curve (Ft)
1	40	300	35	500	301
2	40	300	18	1200	375

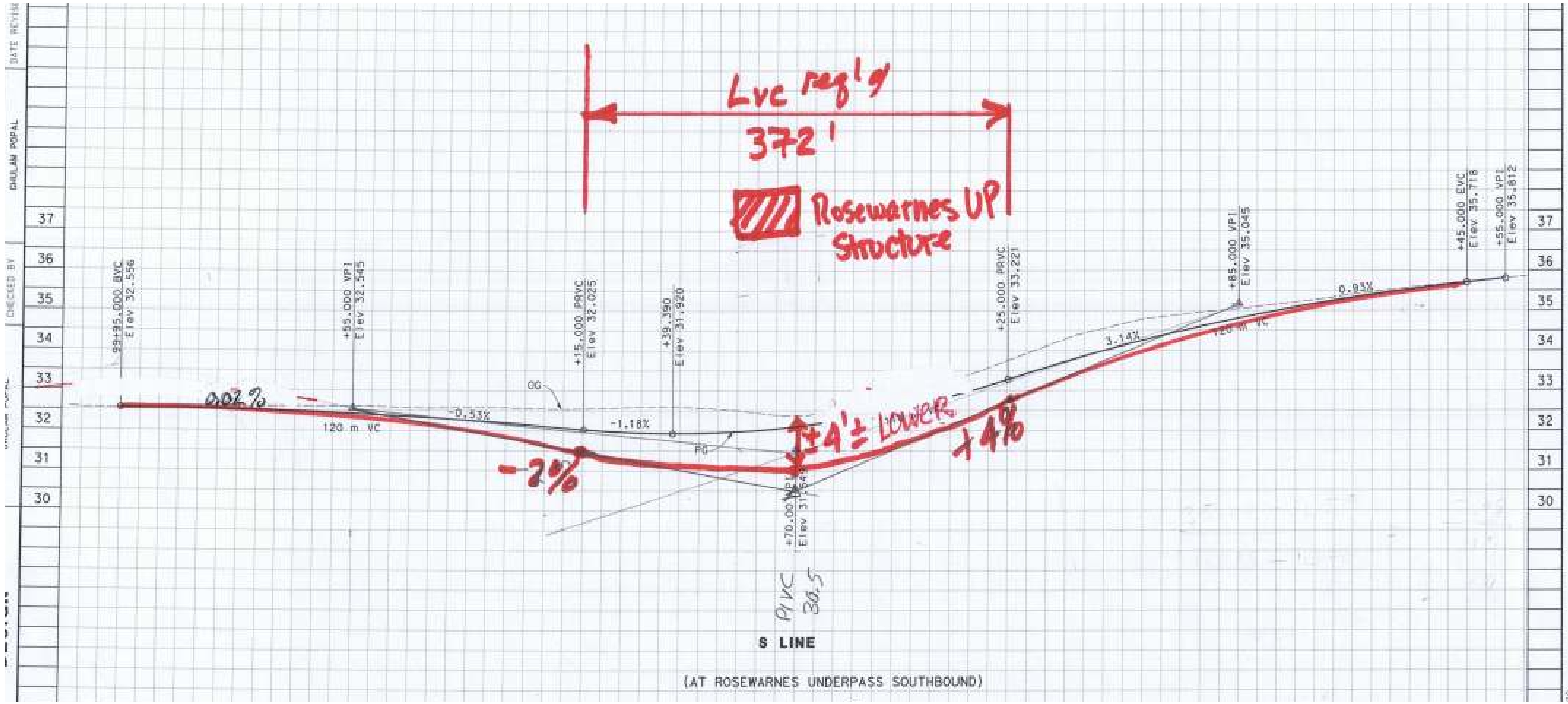


CURVE DATA					
Curve No.	Design Speed (mph)	Sight Dist (Ft)	Delta (Degrees)	Radius (Ft)	Length of Curve (Ft)
1	40	300	35	500	301
2	40	300	18	1200	375

Proposed Improvements at Curve 1



Proposed Improvements at Curve 2


Lvc req'd
372'
Rosewarnes UP Structure
29+95.000 BVC
Elev 32.556
+55.000 VPI
Elev 32.545
+15.000 PRVC
Elev 32.025
+39.390
Elev 31.920
+25.000 PRVC
Elev 33.221
+85.000 VPI
Elev 35.045
+45.000 EVC
Elev 35.718
+55.000 VPI
Elev 35.812
-0.53%
-1.18%
3.14%
0.93%
120 m VC
OG
PG
-2%
±4'± LOWER
+4%
PIVC
30.5
S LINE
(AT ROSEWARNES UNDERPASS SOUTHBOUND)

<u>Modified Structure:</u> To achieve a 40 mph design speed with 300-foot sight distance the modified horizontal alignment listed above could be used with a modified Span 1. This entails either moving or recreating the abutment at a location further west of the current location. This new railroad structure arrangement would require span lengths in the range of 140 to 185 feet, depending on the skew angle of the abutment. The superstructure of the new span would include girders that are significantly deeper than the existing ones. To address this new condition, consider the use of through-girders and/or lower the roadway grade. Through-girders project above the deck to reduce the clearance impacts below the deck; this type of girder is commonly used in railroad structures. Alternatively, a truss structure could also be considered (possibly without lowering the roadway), but is not very compatible with the existing look of the structure.

For the railroad to remain operational a shoofly will need to be constructed.

<u>Safety Analysis:</u> The ERS analysis indicated that this countermeasure would reduce the number of accidents by:

- 0.18 collisions per year (2012)

<u>Advantages:</u>

- Improves the roadway alignment
- Increases stopping sight distance to 300 feet (40 mph)
- Provides the lateral offset needed to accommodate standard (8-foot) shoulders
- Increases vertical clearance to standard 15 feet
- Improves the safety of passage through the underpass for vehicles, bicyclists, and pedestrians
- Increases clearance between the traveled way and abutment/pier
- New roadbed can be built with more superelevation through the curves
- Provides roadway improvements without direct impact to the creek
- Impact of rock fall in vicinity of Rosewarnes is reduced
- Provides an opportunity for a small water treatment pond/facility where the existing road is now vacated

<u>Disadvantages</u>

- High costs for railroad improvements (temporary and permanent)
- Likely need to change (lower) vertical profile for clearance under bridge (more than .5; max currently planned)
- Impacts the existing Rosewarnes structure
- Shoofly required to maintain the existing railroad operations
- Impacts the hillside

Countermeasure R-9: Bifurcate the roadway at Rosewarnes Underpass with new viaduct constructed to the south

Existing Conditions: The existing Rosewarnes Underpass constrains Niles Canyon Road geometrically and provides minimal lateral distance between the roadway edge of travelway and the pier/ abutment. The short S-curves are signed for 25 mph and the sight distance is roughly 150 feet. The clearance is 14'-6" according to the posted sign. The pier in the photograph below shows clear evidence of vehicle strikes.

View of Rosewarnes Underpass traveling eastbound

Proposed improvements: This concept was developed in the original Niles Canyon 1 project. It involves realigning the northbound lane around the existing railroad trestle Pier #2 at Rosewarnes Underpass to improve sight distance. The improvements will include standard shoulders and lanes with a 1.5-meter left shoulder, a 2.4-meter right shoulder, and a 3.6-meter travelway in each direction.

These improvements will require removal of existing retaining walls at some locations and construction of a retaining wall between the existing roadway and Alameda Creek. The length of this wall is 276 meters with its height varying from 1.2 to 3 meters. The layout line of the wall is approximately 8 meters from face of Pier #2 of Rosewarnes Underpass and is parallel with the new alignment of the northbound lane. This retaining wall minimizes impacts to Alameda Creek, as placing fill to support the new roadway would have increased the footprint of the project further into Alameda Creek. Existing drainage culverts will be extended through the proposed retaining wall, with outfall to Alameda Creek.

No widening is planned on the southbound side of the existing roadway because of the possible impact to a historic Vallejo aqueduct or its remnants at this location. Safety shape barriers with a tubular bicycle railing will be installed on top of the proposed retaining walls along Alameda Creek. In addition, safety shape barriers will be placed at face of Abutment #1 and around the perimeter of Pier #2 of Rosewarnes Underpass.

It is also proposed to lower the profile of the roadway approximately 300 mm to achieve standard vertical clearance of 4.6 meters through Rosewarnes Underpass. The existing asphalt concrete, part of the base layer and a portion of the existing retaining wall will need to be removed to make subgrade for placing asphalt concrete to finish grade. These operations will include exposing the faces of Abutment #1 and Pier #2 of Rosewarnes Underpass prior to placing asphalt concrete and the previously mentioned safety shape barriers. Line and grade of the historic aqueduct, will be established to avoid impacts to this historic resource. Appropriate protection of the exterior of the abutment and pier during construction will be incorporated in the project and monitored by Caltrans staff.

Rendering of Bifurcation of Rosewarnes Underpass Pier 2

Safety Analysis: The explicit roadway safety analysis indicated that this countermeasure increases the number of collisions by:

- 0.21 collisions per year (2012)

Despite the increase in collisions, there is an overall reduction in collision severity.

Advantages:

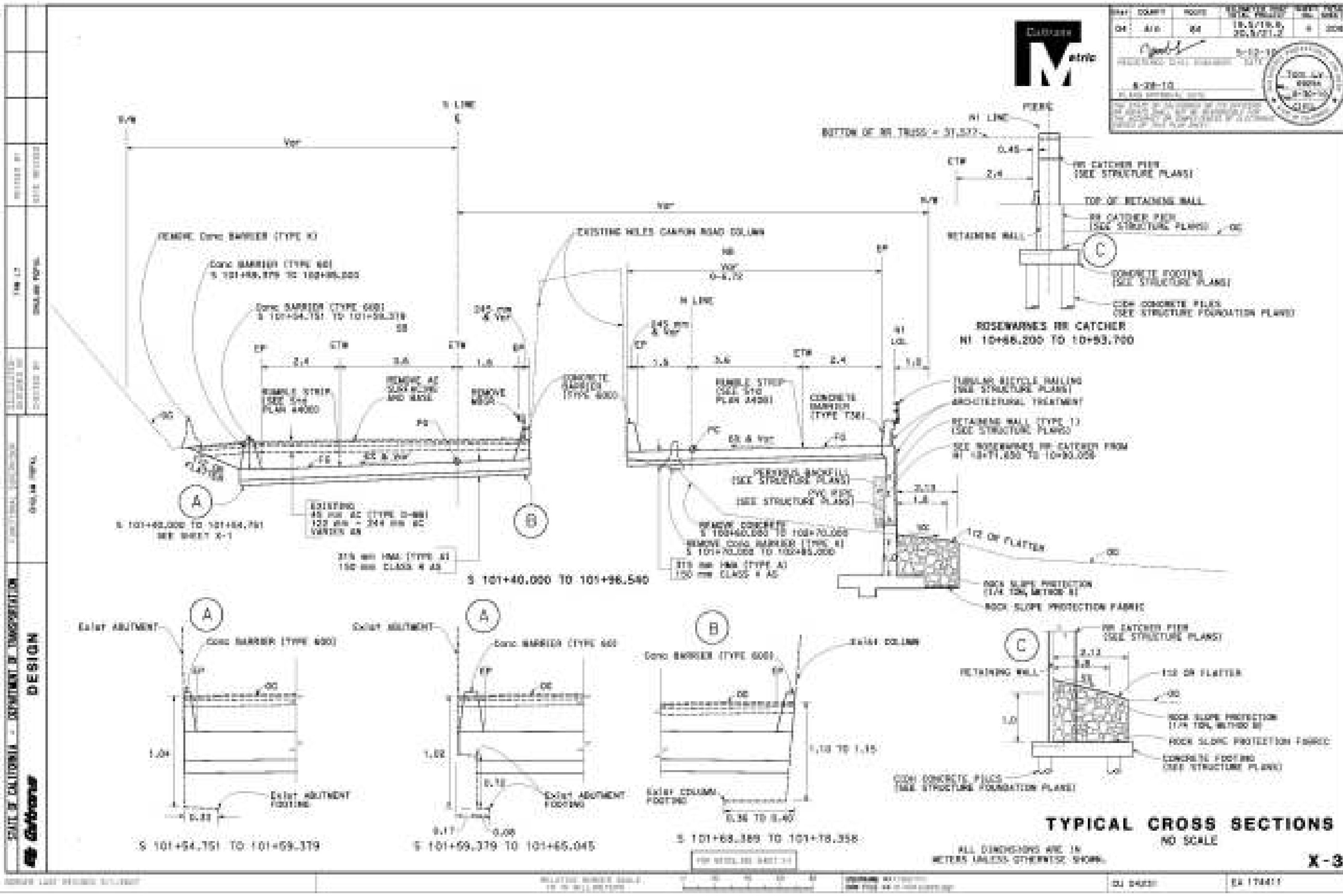
- Increases sight distance to 60 meters (eastbound) and 100 meters (westbound) for a 30 mph design speed

- Provides the lateral offset needed to accommodate standard section: 12-foot lanes, 8-foot right shoulder, 4-foot left shoulder within the spot improvement limits
- Standard cross section (1.5-meter left shoulder)/3.6-meter lane/2.4-meter right shoulder) along spot improvement limits (limits of improvement are Station 100+00 to Station 103+55
- Increase vertical clearance to standard 15 feet (4.9 meters)
- Improves the safety of passage through the Underpass for vehicles, bicyclists, and pedestrians
- New roadbed can be built with more superelevation through the curves
- Reduces conflicts between the travelway and abutment/pier
- Does not require modifications to the existing Rosewarnes Underpass
- Median barrier eliminates crossover collisions within the limits of the barrier, reducing collision severity

<u>Disadvantages:</u>

- Degrades highway geometry in lieu of improving it
- Standard distance and design speed not achieved
- Increases in roadside related collisions associated with the bifurcation (introduction of median barrier and crashworthy end-treatments)
- Impacts the creek and creek habitat
- Water quality impacts

<u>Plan Sheets:</u> The following plan sheets are taken from the original Niles 1 plan set.


DESIGN
ROSEWARNES RR CATCHER
S 101+40.000 TO 101+96.540
TYPICAL CROSS SECTIONS
NO SCALE
X-3

FOR COMPLETE RIGHT OF WAY DATA, SEE RIGHT OF WAY RECORD MAPS AT DISTRICT OFFICE.

Dist	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET No.	TOTAL SHEETS
04	Ala	84	19.5/19.9, 20.5/21.2	16	209

REGISTERED CIVIL ENGINEER 3-8-10 DATE

6-28-10 PLANS APPROVAL DATE

Tam Ly No. 69254 Exp. 6-30-10 CIVIL

THE STATE OF CALIFORNIA OR ITS OFFICERS OR AGENTS SHALL NOT BE RESPONSIBLE FOR THE ACCURACY OR COMPLETENESS OF ELECTRONIC COPIES OF THIS PLAN SHEET.

Caltrans Metric

LEGEND:

- PERMANENT EASEMENT OR TEMPORARY CONSTRUCTION EASEMENT LINE
- TEMPORARY FENCE (TYPE ESA)
- PERMANENT CUT LINE
- PERMANENT FILL LINE
- DIRECTION OF TRAFFIC
- COLD PLANE AC PAVEMENT
- ENVIRONMENTALLY SENSITIVE AREA (ESA)

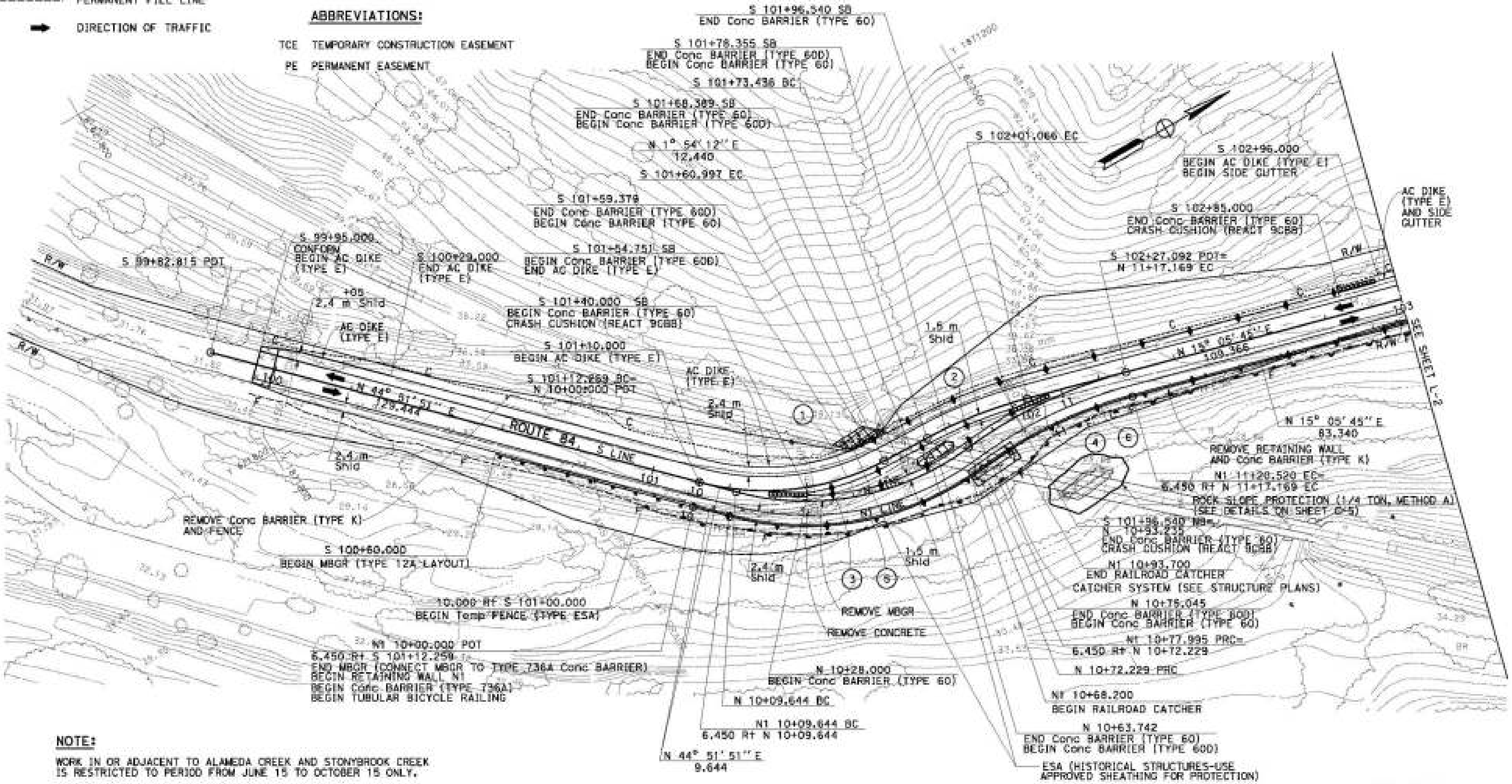
CURVE DATA

No.	R	Δ	T	L	N-COORDINATE	E-COORDINATE
1	65.000	42° 57' 39"	25.579	48.738	621936.495	1871214.857
2	120.000	13° 11' 32"	13.876	27.630	621942.784	1871400.169
3	70.000	51° 13' 34"	33.558	62.584	621946.858	1871218.117
4	120.000	21° 27' 27"	22.737	44.941	621967.911	1871406.947
5	76.450	51° 13' 34"	36.650	68.351	621946.858	1871218.117
6	113.550	21° 27' 27"	21.515	42.525	621967.911	1871406.947

ABBREVIATIONS:

TCE TEMPORARY CONSTRUCTION EASEMENT

PE PERMANENT EASEMENT



NOTE:

WORK IN OR ADJACENT TO ALAMEDA CREEK AND STONYBROOK CREEK IS RESTRICTED TO PERIOD FROM JUNE 15 TO OCTOBER 15 ONLY.

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN

LAYOUT

SCALE 1:500

L-1

IPLETE RIGHT OF WAY DATA,
GHT OF WAY RECORD MAPS
TRICT OFFICE.

CURVE DATA

No.	R	Δ	T	L	N-COORDINATE	E-COORDINATE
⑦	220.000	19° 24′ 38″	37.626	74.531	622022.332	1871525.200
⑧	3048.000	2° 10′ 31″	57.863	115.713	620494.299	1873906.537
⑨	213.550	19° 24′ 38″	36.523	72.346	622022.332	1871525.200

Caltrans Metric

Dist	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET No.	TOTAL SHEETS
04	Ala	84	19.5/19.9, 20.5/21.2	17	209

REGISTERED CIVIL ENGINEER 3-8-10 DATE

6-28-10
PLANS APPROVAL DATE

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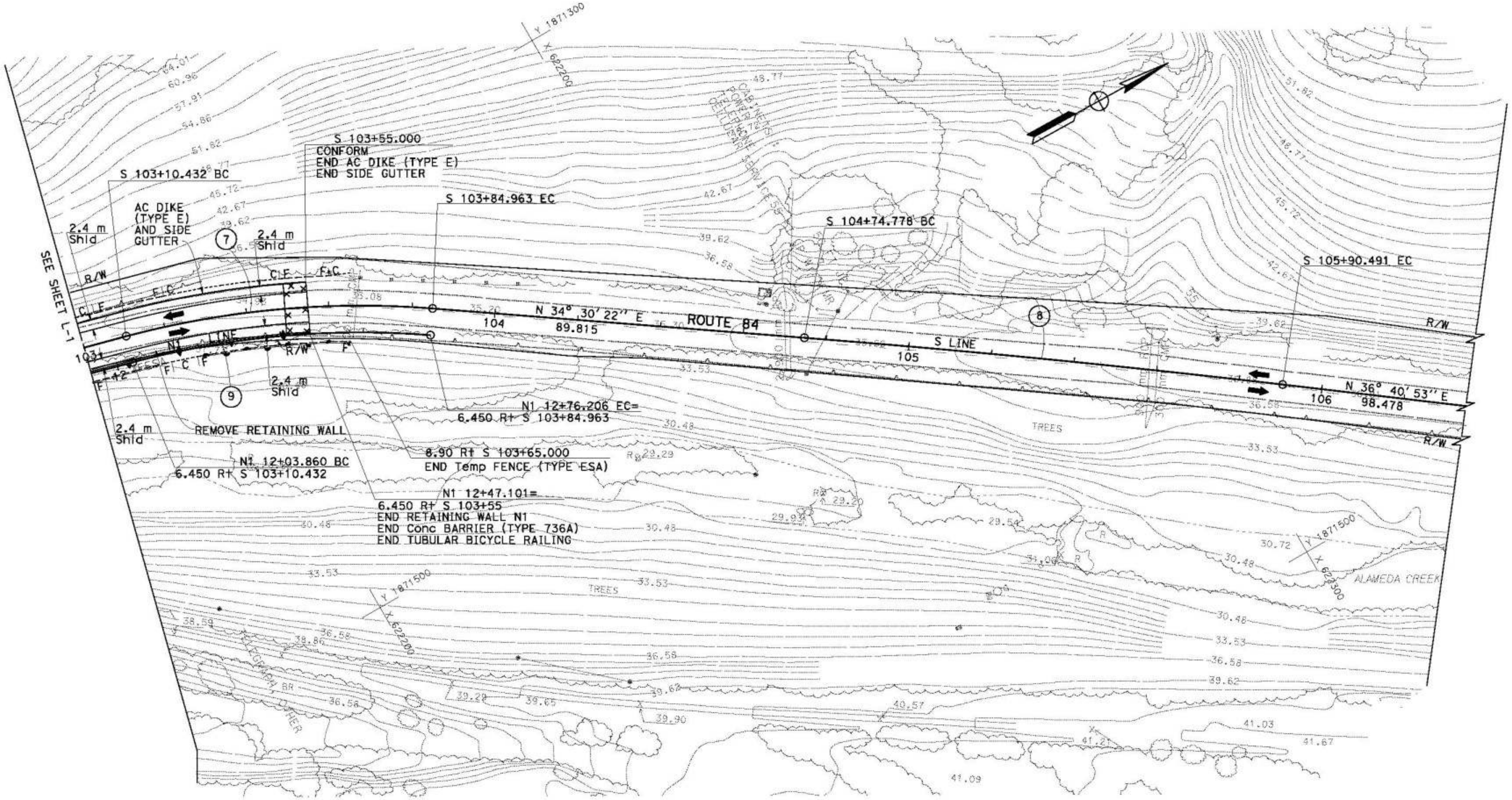
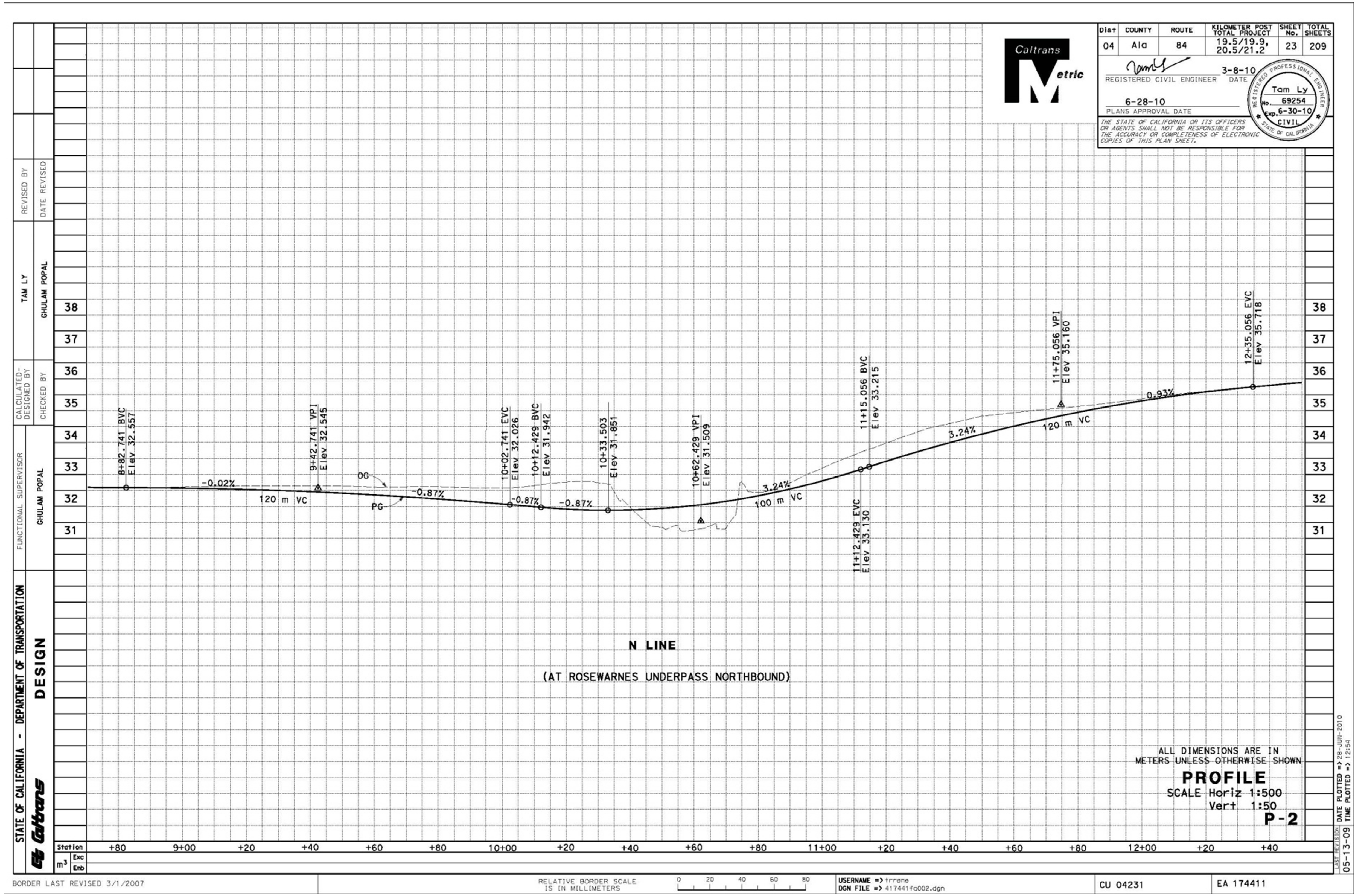
REGISTERED PROFESSIONAL ENGINEER Tam Ly No. 69254 Exp. 6-30-10 CIVIL STATE OF CALIFORNIA



LAYOUT
SCALE 1:500

FOR ABBREVIATIONS

ALL DIMENSIONS ARE IN



Dist 04 COUNTY Ala ROUTE 84 KILOMETER POST TOTAL PROJECT 19.5/19.9, 20.5/21.2 SHEET No. 23 TOTAL SHEETS 209
REGISTERED CIVIL ENGINEER 3-8-10 DATE
6-28-10 PLANS APPROVAL DATE
THE STATE OF CALIFORNIA OR ITS OFFICERS OR AGENTS SHALL NOT BE RESPONSIBLE FOR THE ACCURACY OR COMPLETENESS OF ELECTRONIC COPIES OF THIS PLAN SHEET.
REGISTERED PROFESSIONAL ENGINEER Tam Ly No. 69254 Exp. 6-30-10 CIVIL STATE OF CALIFORNIA
Caltrans Metric
STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION
DESIGN
FUNCTIONAL SUPERVISOR GHULAM POPAL
CALCULATED-DESIGNED BY TAM LY
CHECKED BY GHULAM POPAL
REVISED BY
DATE REVISED
8+82.741 BVC Elev 32.557
9+42.741 VPI Elev 32.545
10+02.741 EVC Elev 32.026
10+12.429 BVC Elev 31.942
10+33.503 Elev 31.851
10+62.429 VPI Elev 31.509
11+12.429 EVC Elev 33.130
11+15.056 BVC Elev 33.215
11+75.056 VPI Elev 35.160
12+35.056 EVC Elev 35.718
-0.02%
120 m VC
OG
PG
-0.87%
-0.87%
-0.87%
3.24%
100 m VC
3.24%
120 m VC
0.93%
N LINE
(AT ROSEWARNES UNDERPASS NORTHBOUND)
ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN
PROFILE
SCALE Horiz 1:500
Vert 1:50
P-2
Station +80 9+00 +20 +40 +60 +80 10+00 +20 +40 +60 +80 11+00 +20 +40 +60 +80 12+00 +20 +40
m³ Exc Emb
BORDER LAST REVISED 3/1/2007
RELATIVE BORDER SCALE IS IN MILLIMETERS
USERNAME => trrene
DGN FILE => 417441fo002.dgn
CU 04231
EA 174411
LAST REVISION 05-13-09
DATE PLOTTED => 28-JUN-2010
TIME PLOTTED => 12:54

Countermeasure RO-1: Realign Road and Construct Tunnel into Slope at the Rosewarnes Underpass

Existing Conditions: The existing Rosewarnes Underpass constrains Niles Canyon Road geometrically and provides minimal lateral distance between the roadway edge of traveled way to the pier/ abutment. The short S-curves are signed for 25 mph and the sight distance is in the 150-foot range.

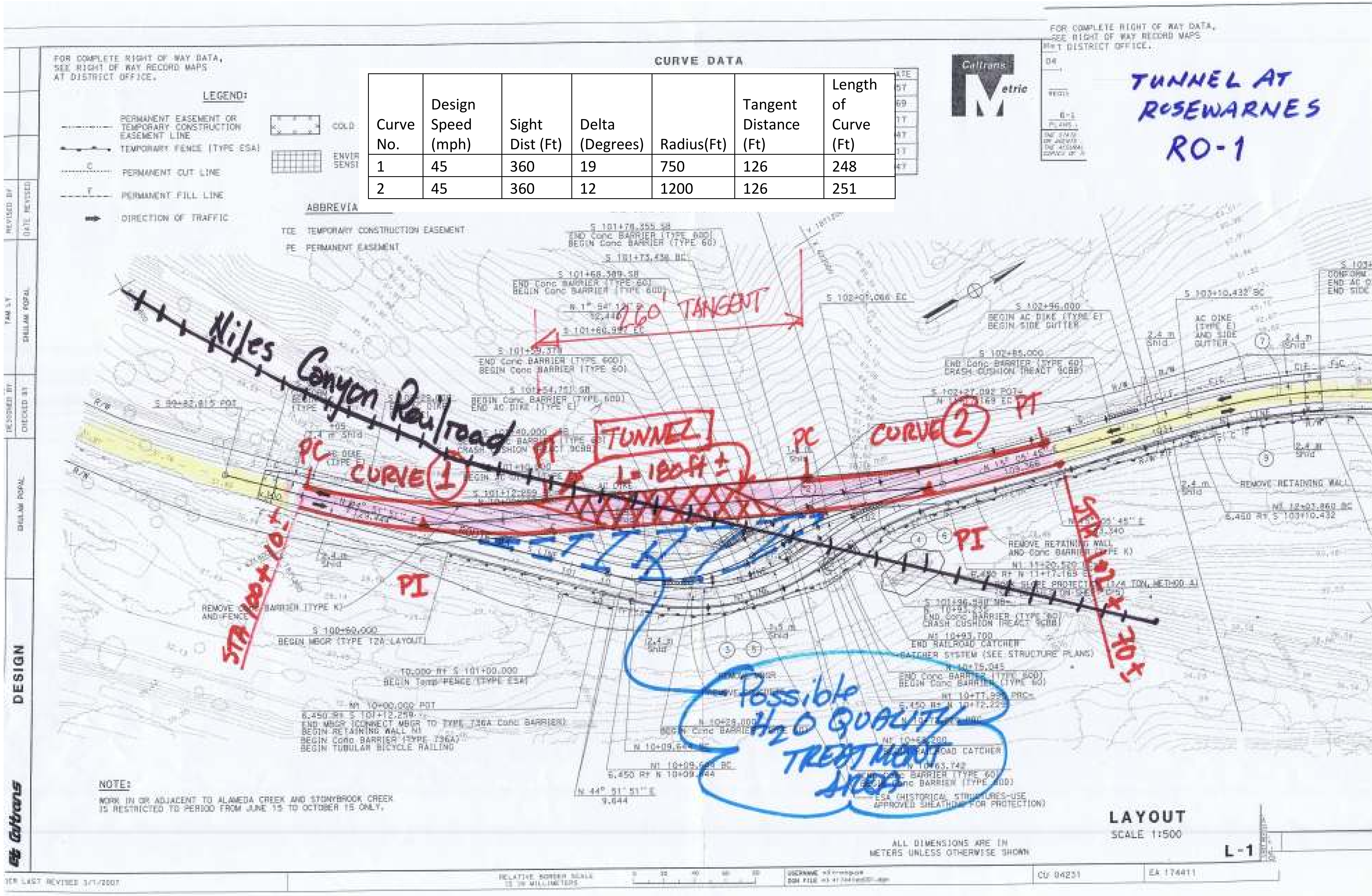
View of Rosewarnes Underpass traveling eastbound

Proposed improvements: Relocate the road into the hillside west of the existing Rosewarnes Underpass abutment to improve the roadway alignment while increasing sight distance. The new Niles Canyon Road alignment would punch under the Niles Canyon Railroad tracks with a tunnel that begins at the Niles Canyon Railroad and exits shortly after passing onto the east side of the railroad. One method that may be employed to create the tunnel is to grout the tunnel area and use the New Austrian Tunneling Method, which would negate the need to build a shoofly to maintain the railroad operations during construction (see more on this below). The tunnel portal should match the style of the Rosewarnes Bridge abutments and piers.

New Curve Data:

Curve No.	Design Speed (mph)	Sight Dist (Ft)	Delta (Degrees)	Radius (Ft)	Tangent Distance (Ft)	Length of Curve (Ft)
1	45	360	19	750	126	248
2	45	360	12	1200	126	251

Proposed Structure: The tunnel may be a "hard" rock tunnel construction [consider New Austrian Tunneling method (NATM) with grout injection]. Alternatively, the tunnel could consist of cut and cover style trench (walls on the sides and top) through the hillside. In the case of the latter, if ***top-down*** construction is employed and the existing railroad operations are to remain active during construction, then a shoofly or some period of closure of the railroad will be required. In any case, some duration of interruption will be incurred by the railroad.



Curve No.	Design Speed (mph)	Sight Dist (Ft)	Delta (Degrees)	Radius(Ft)	Tangent Distance (Ft)	Length of Curve (Ft)
1	45	360	19	750	126	248
2	45	360	12	1200	126	251

Safety Analysis: The explicit roadway safety analysis indicated that the safety benefit would reduce the number of accidents by:

- 0.19 collisions per year (2012)

Advantages:

- Improves the roadway alignment
- Increases sight distance to standard value for a 45 mph design speed (360 feet)
- Provides the lateral offset needed to accommodate standard (8-foot) shoulders within the spot improvement limits
- Standard cross section (3.6-meter lane/2.4-meter shoulder) along spot improvement limits [Station 1000 to Station 1681 (metric)]
- Increases vertical clearance to standard 15 feet
- Improves the safety of passage through the underpass for vehicles, bicyclists, and pedestrians
- New roadbed can be built with more superelevation through the curves
- Increases sight distance to standard requirements
- Eliminates conflicts between the traveled way and abutment/pier
- Does not require modifications to the existing Rosewarnes Underpass
- Provides roadway improvements without direct impact to the creek
- Provides an opportunity for a small water treatment pond/facility where the existing road is now vacated

Disadvantages

- Tunnel costs
- Horizontal alignment is not ideal - broken back curve (two shorter length curves with a short tangent section)
- Introduces a 180-foot-long tunnel section
- May require a lowering in the vertical profile for clearance under bridge
- Impacts the hillside, including those potions immediately adjacent to portal (i.e., may require retaining walls)

PALOMARES ROAD/FARWELL UNDERPASS SPOT IMPROVEMENTS

Countermeasure IO-2: Realign Palomares Road to join church driveway

Existing Conditions: The location of the existing Palomares Road Intersection in relation to the Farwell Underpass provides inadequate sight distance (towards the east) for both right and left-turning vehicles at southbound Palomares Road primarily due to the location of the existing northern abutment of the railroad bridge structure.

Proposed improvements: To improve sight distance, Palomares Road would be realigned such that it intersects Niles Canyon Road further to the west. In an effort to minimize impacts to the existing topography, the new intersection would be relocated to the same location as the existing church driveway, approximately 125 meters to the west of the current Palomares Road Intersection. This location would avoid conflicts with the existing tributary creek and culvert passing under the Niles Canyon Road, maximize intersection sight distance, and minimize grading and impacts to the existing church. Palomares Road would intersect Niles Canyon Road at approximately an 80 degree angle, similar to the existing configuration.

Safety Analysis: The ERS analysis indicated this countermeasure decreases the number of accidents by:

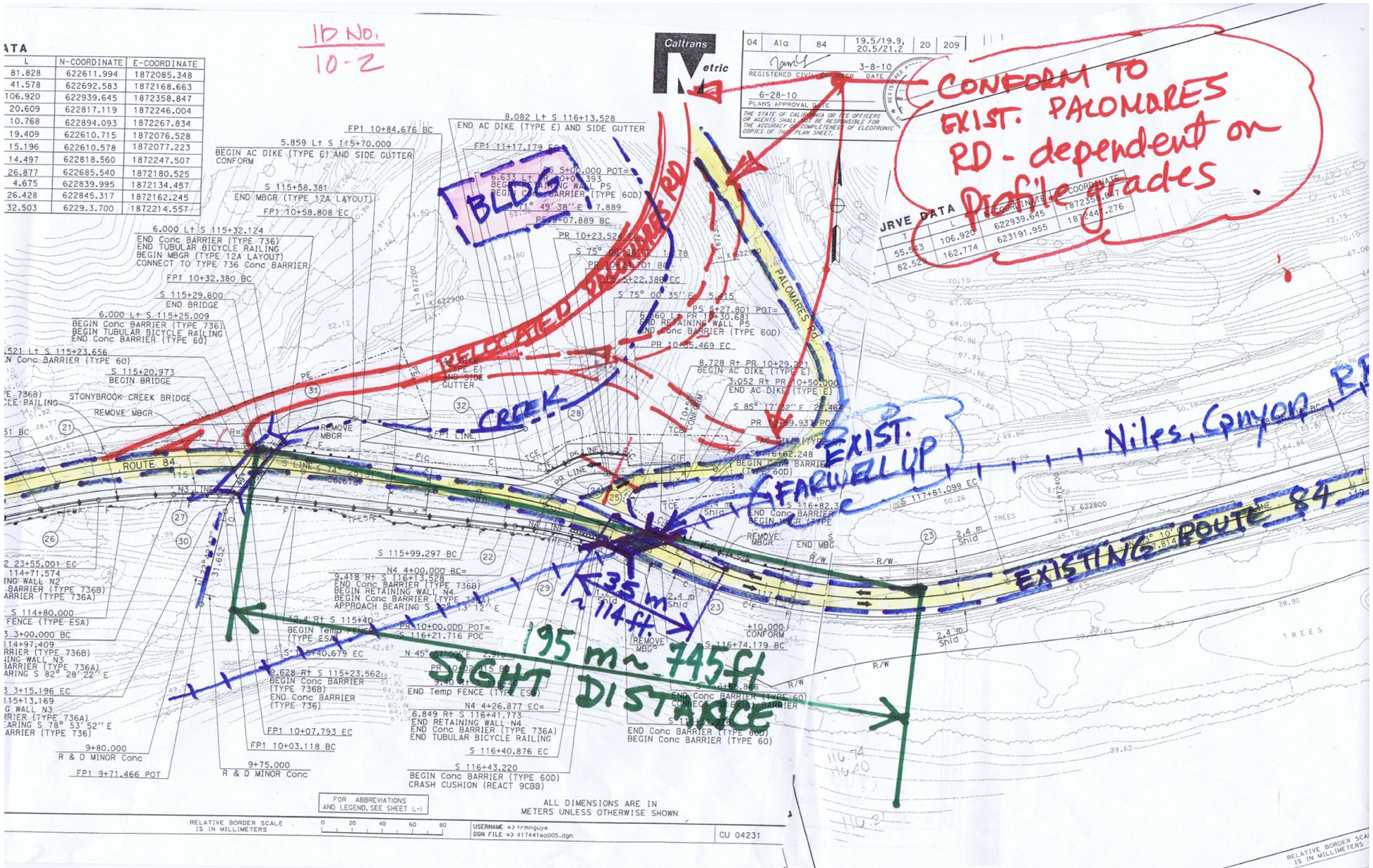
- 0.05 collisions per year (2012)

Advantages

- Provides new sight distance for right-turning and left-turning vehicles from Palomares Road by 200 meters (656 feet)
- Utilizes existing church driveway to minimize the impact to the existing tributary creek and culvert (note in the original project this culvert crossing was planned to be upsized)

Disadvantages

- Would involve right-of-way take from the existing church parcel – potentially a complete take – to facilitate realignment of Palomares Road
- Realignment of Palomares Road may need to cross the existing tributary creek (Stonybrook Creek) north of the existing church
- Widening of the existing church driveway to facilitate standard roadway cross section may require retaining walls along the northern edge of pavement
- Environmental impacts to Stonybrook Creek and trout mitigation.


ID No.
10-2
CONFORM TO EXIST. PALOMARES RD - dependent on Profile grades
BLDG
RELOCATED PALOMARES RD
CREEK
EXIST. FARWELL UP
Niles Canyon RD
EXISTING ROUTE 84
35 m ~ 114 ft.
195 m ~ 745 ft
SIGHT DISTANCE
ROUTE 84
STONYBROOK CREEK BRIDGE
PALOMARES RD
ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN
CU 04231

Countermeasure IO-5: Relocate the railroad abutment at the Farwell Underpass to improve sight distance

Existing Conditions: The location of the existing Palomares Road Intersection in relation to the Farwell Underpass provides inadequate sight distance (towards the east) for both right-turning and left-turning vehicles at southbound Palomares Road primarily due to the location of the existing northern abutment of the railroad structure. The posted speed on Niles Canyon Road is 45 mph. Assuming a 50 mph design speed, the Highway Design Manual requires a minimum corner sight distance of 550 feet (168 meters). Under existing conditions, left-turning and right-turning vehicles from Palomares Road have approximately 40 meters and 55 meters of sight distance, respectively. Table 405.1A "Corner Sight Distance (7-1/2 Second Criteria)" indicates this value corresponds to a design speed under the minimum value listed at 40 kph.

Proposed Improvements: The existing northern railroad abutment would be relocated to the north along the tracks in order to increase the amount of sight distance provided to drivers entering from Palomares Road. In order to provide at least 168 meters of sight distance, the abutment would need to be shifted approximately 20 meters (66 feet) to the north along the track alignment providing an increased lateral clearance to the roadway of approximately 11 meters (36 feet). This modification would provide 133 meters (436 foot) of sight distance. Table 405.1A "Corner Sight Distance (7-1/2 Second Criteria)" indicates this value corresponds to a design speed of approximately 61 kph.

The structure modifications would be similar to those described in Countermeasure R-4 and will likely entail lowering of the roadway and deeper girder to accommodate the longer spans.

Safety Analysis: The ERS analysis indicated this countermeasure decreases the number of accidents as follows:

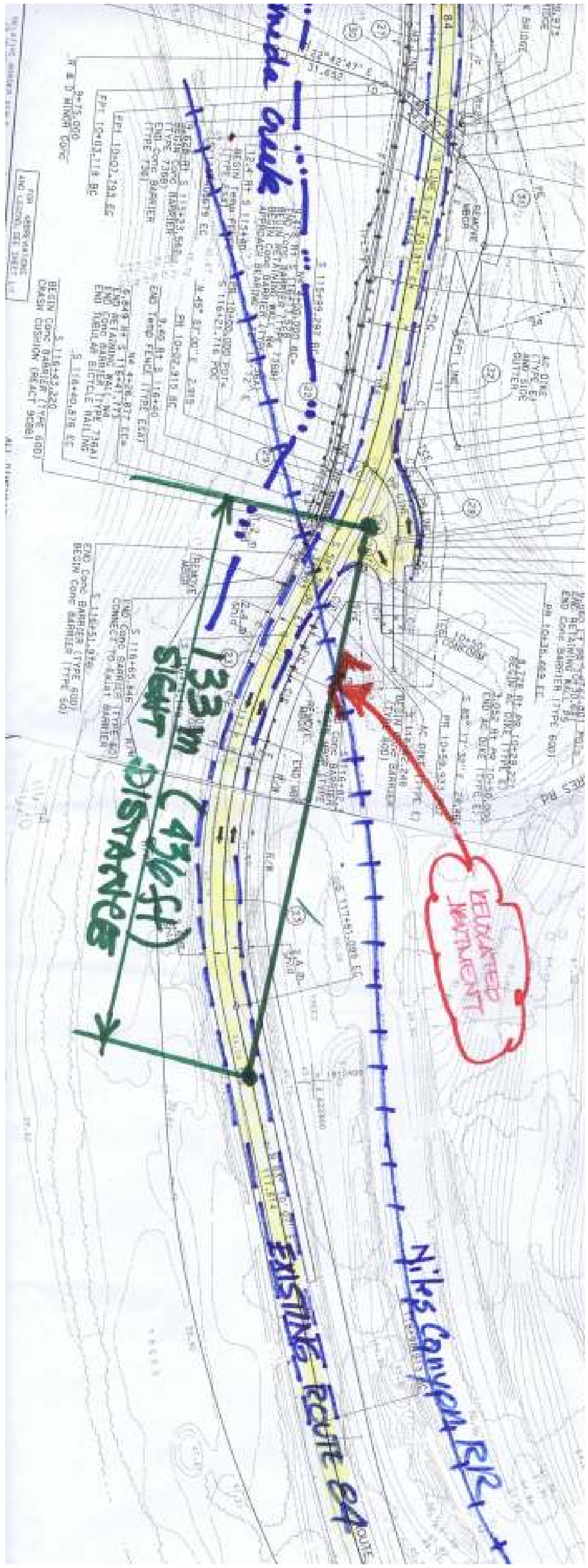
- 0.18 collisions per year (2012)

Advantages:

- Increases sight distance for right-turning and left-turning vehicles from Palomares Road
- The project would not have to acquire additional right-of-way from the existing church parcel
- Shifting of the abutment would also provide additional room to provide standard shoulders along the westbound lanes

Disadvantages:

- Would require new railroad bridge structure
- Significant impacts to the operations of the historic Niles Railroad
- Structure and shoofly may make this countermeasure infeasible


133 m (436 ft)
SIGHT DISTANCE
EXISTING ROUTE 84
Niles Canyon R/R

ALAMEDA CREEK BRIDGE SPOT IMPROVEMENTS

Countermeasure ACB-2: Replace Alameda Creek Bridge to upgrade the approach curves

Existing Conditions: The existing Alameda Creek Bridge (Bridge No. 33-36) (PM 13.33) has a low-speed curve (signed for 30 mph) on the west approach/west bridge spans, followed by another low-speed curve (signed for 35 mph) beyond the east end of the bridge, on the east bridge approach. Between these two tight curves exists a short tangent section (i.e., a broken back curve). The barrier is open-pilaster barrier without safety shape, immediately adjacent to the edge of travelway. The smaller radius on the west approach/west bridge spans on the existing alignment is only 76 meters.

Proposed Improvements: The project proposes to realign the roadway and construct a new bridge to the north of the existing alignment, with new approaches. A new Alameda Creek Bridge will be on a 215-meter curve.

The replacement bridge would be a 426-foot-long three-span cast-in-place prestressed box girder bridge on arrays of cast-in-drilled-hole (CIDH) piles. On the eastern approach, the alignment shift requires a soil nail wall, 290 meters long and 3 meters high, between the roadway and Alameda Creek, and a concrete retaining wall, 290 meters long and 6.7 meters high, between a cut slope and the roadway to tie back to the existing alignment on the east end, minimizing encroachment into the waterway.

According to the Highway Design Manual, the design speed for a two-lane conventional highway in rolling terrain in a rural area, such as the project site, is 80-1 00 kph. The proposed design speed for the bridge approaches is 70 kph (see below). A fact sheet "Exceptions to Mandatory Design Standards" was prepared for the use of the 70 kph design speed, and was approved. No other design exceptions are required for the project.

The existing western bridge approach alignment has a 76.2-meter radius curve, which provides for a design speed of 51 kph (32 mph). The existing eastern bridge approach alignment has a 91.4-meter radius curve, which provides for a design speed of 55 kph. New bridge approaches of 175-meter radii are proposed for the project, thereby increasing the design speed to 70 kph (43 mph).

Facility	Minimum Curve (Radius)	Through Traffic Lanes			Paved Shoulder		Median Width	Median Barrier (Yes/No)
		No. of Lanes	Lane Width	Type (AC, PCC or AC over PCC)	Left	Right		
Existing	76.2m	2	3.65m	PCC	0	0	N/A	No
Proposed	175.0m	2	3.65m	PCC	2.535m	2.535m	N/A	No
Min. 3R Stds	200.0m	2	3.65m	PCC	2.535m	2.535m	N/A	No

Curve Data taken from Niles 2 Plan Set

In conclusion, the new design will increase the design speed, and sight distance, and provide standard cross section of 3.6-meter (12-foot) traveled way and 2.4-meter shoulders (8-foot) design speeds with safety shape barrier on the bridge railing. Ancillary to the safety improvements, the bridge replacement would improve load capacity to meet current and anticipated use, and improve seismic characteristics and resistance to scour. The project would also reduce future maintenance costs.

Safety Analysis: The explicit roadway safety analysis indicated this countermeasure decreases the number of accidents by:

- 0.37 collisions per year (2012)

Advantages:

- Increases sight distance and design speed
- Standard cross section (3.6-meter lane/2.4-meter shoulder) within spot improvement limits [Station 1000 to Station 1681 (metric)]
- Improves the safety of passage across the bridge for vehicles, bicyclists, and pedestrians
- Provides greater separation between motorists and bicyclists/pedestrians within the spot improvement locations
- Most of the alignment is "offline," facilitating the construction of the spot curve correction
- Provides an opportunity for a small water treatment pond/facility where the existing road is now vacated
- New piers can be located out of the low flow channel
- Increases speed

Disadvantages:

- Requires a new footprint for the realigned roadway
- Potential impacts to endangered species
- Impacts Alameda Creek Bridge during construction and permanently
- Environmental impact to Alameda Creek
- Potential loss of riparian habitat

LOW-SPEED CURVE LOCATED BETWEEN ALAMEDA CREEK AND ALAMEDA CREEK BOH BRIDGES SPOT IMPROVEMENT EAST OF THE "SPOT"

Countermeasure C-2: Correct superelevation at low-speed curve between the two project bridges

Existing Conditions: A low-speed curve, signed for 30 mph, is located approximately ½-mile east of the Alameda Creek Bridge and east of The Spot. This area features a sharp (300-foot radius/53-degree central angle) curve. Within the confines of this curve the lane widths are approximately 12 feet wide in each direction; however, shoulder widths less than 8 feet exist in the eastbound direction at the following locations:

- 40+12 to 40+60 (Niles 2 Stationing)
- 41+80 and 42+90 (Niles 2 Stationing)

Traveling eastbound approaching 30 mph curve between the two bridges

Proposed Improvements: The Highway Design Manual requires a 12% superelevation along curves with radii less than 625 feet. The existing roadway pavement would be ground and overlaid to provide the additional 3% superelevation throughout the curve. In order to minimize potential impacts to the creek bank along the westbound lanes, the increase in superelevation would "hinge" around the westbound edge of the travelway. Approximate length of increased superelevation would be 280 feet.

Safety Analysis: The ERS analysis indicated this countermeasure decreases the number of accidents by:

- 0.07 collisions per year (2012)

Advantages:

- Increased superelevation would help prevent off-tracking of vehicles as they navigate the curve

Disadvantages:

- Impact would be limited to additional fill along the eastbound lanes. Amount of fill would be relatively minimal due to existing superelevation of the roadway.
- It should be noted that there is an existing "ICY" roadside warning sign posted in the eastbound direction just prior to the 30 mph curve at approximate Station 40+00. "Black ice" conditions have been previously reported in the area, which may discourage the use of higher superelevation rates.

Countermeasure C-3: Widen roadway curve east of Alameda Creek Bridge to accommodate off-tracking

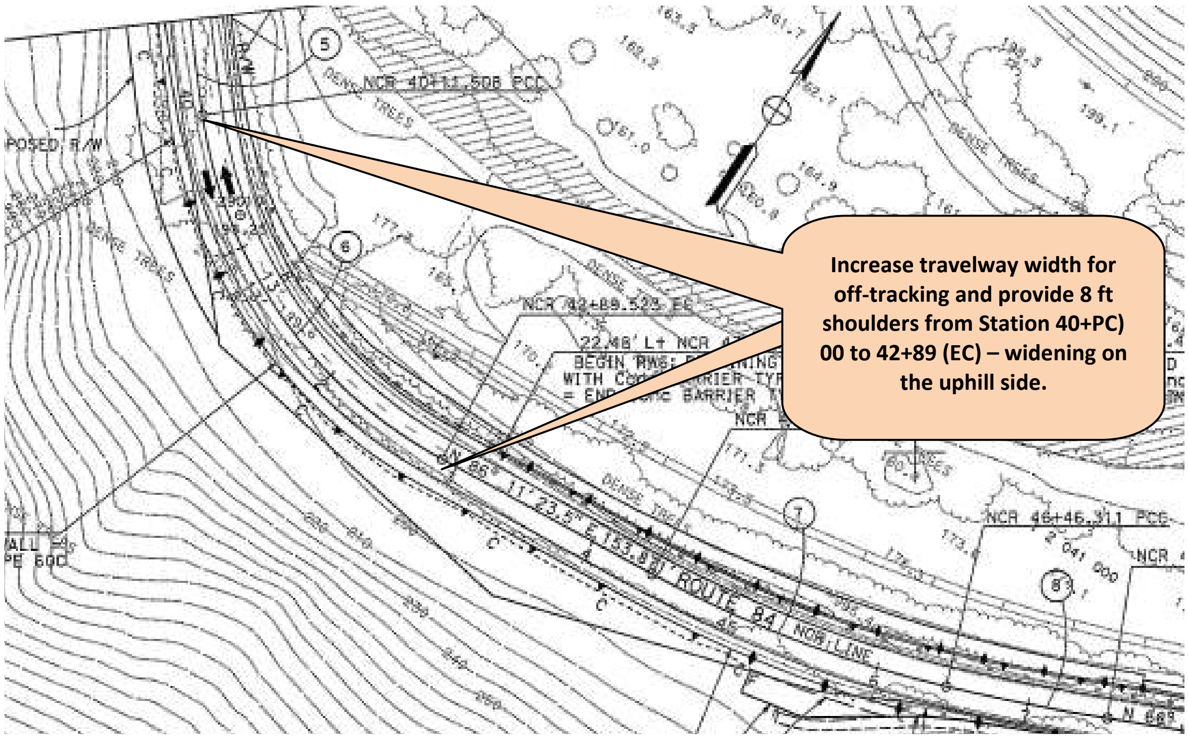
Existing Conditions: A sharp (300-foot radius/ 53 degree central angle) curve is located approximately ½ mile east of the Alameda Creek Bridge. The lane widths through the curve are approximately 12 feet in each direction. Shoulder width between Stations 40+11.508 & 40+60 and 41+80 and 42+90 are less than the required 8 feet in the eastbound direction.

View of 30 mph curve (facing eastbound)

Proposed Improvements: The Highway Design Manual does not require lane widening for curves with radii of 300 feet or greater. However, as noted, the existing curve radius at this location is unknown based on the data provided; an assumed radius of 300 feet was used for this analysis, based on the proposed roadway alignment reflected in the Niles 2 design. If the curve radius is actually less than 300 feet, the Highway Design Manual requires that the lane width be increased to a minimum of 13 feet to account for trucks. In addition, although the curve is posted at a reduced speed of 30 mph, the posted speed on the roadway approaching the curve is 45 mph. This increases the potential for vehicles to enter the curve at speeds higher than the design speed.

Increasing the lane widths to 13 feet though this curve would provide additional space for trucks to navigate the curve without encroaching into the adjacent lane. The additional width would also accommodate off-tracking of vehicles that may enter the curve at higher speeds. The total length of the widening would be ~280 feet along the entire curve.

Beginning approximately at Station 40+40, there appears to be sufficient room along the eastbound lanes to provide additional pavement width. Pavement widening from Station 40+10 to 40+40 would require retaining walls along the uphill slope (along eastbound lanes). Similar widening between Station 42+00 and 42+90 would require filling of an apparent roadside swale along the eastbound lanes. A standard 8-foot shoulder would be provided through this curve (length ~280 feet).



Safety Analysis: The ERS analysis indicated this countermeasure decreases the number of accidents by:

- 0.06 collisions per year (2012)

Advantages:

- Increased lane width would accommodate truck turning through the smaller curve radius
- Providing a standard 8-foot shoulder along the eastbound lanes enables off-tracking of vehicles as they navigate the tighter curve (designed for a reduced speed of 30 mph)
- Space adjacent to the eastbound lane is available along a portion of the curve to facilitate widening; the widening would not require modifications to the creek bank to the west of the existing alignment

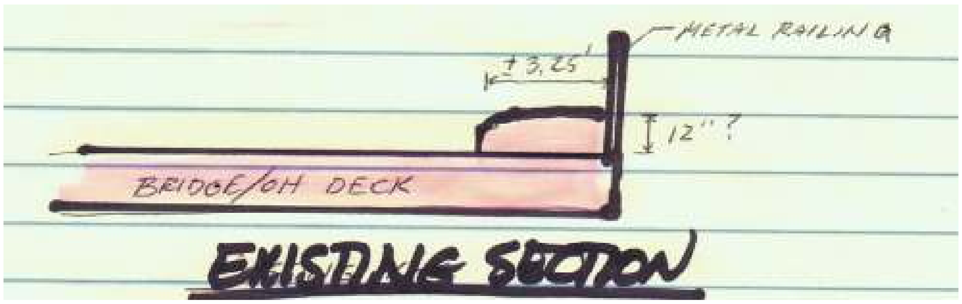
Disadvantages:

- Widening adjacent to the eastbound lanes would require the use of retaining walls along a portion of the curve
- Widening would also compromise the existing roadside swale/ditch along the eastbound lanes; this may require a formal drainage system to be installed
- Potential increase in illegal stopping/ parking
- Potential increase of illegal trash dumping

ALAMEDA CREEK BOH SPOT IMPROVEMENTS

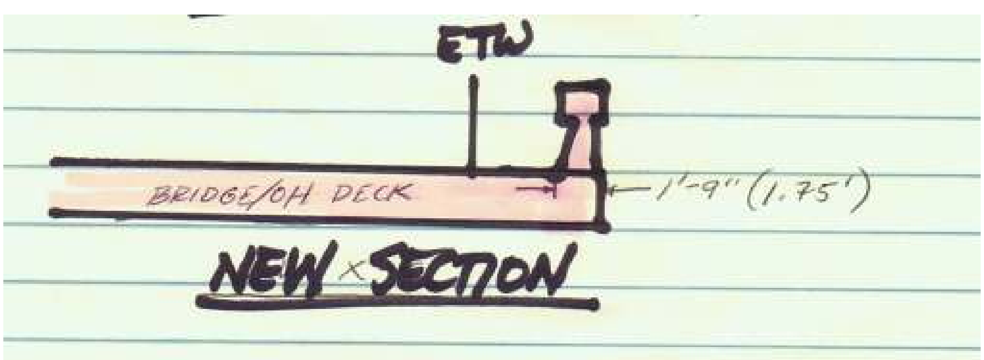
Countermeasure ALCRBO-1: Remove curb on Alameda Creek Bridge BOH

Existing Conditions: The existing Alameda Creek Bridge BOH has little to no shoulder and has tubular steel, non-safety shape barrier. This barrier is not likely to protect a heavy vehicle from a departure off the bridge, nor does it redirect glancing blows without the presence of a safety shape. The existing curb is approximately 0.93 meter (3.25 feet) wide.



Looking eastbound across the Alameda Creek Bridge BOH

Proposed Improvements: Replace the Alameda Creek BOH barrier with a Type 80 barrier (see through concrete/tubular bicycle railing on top) or ST-70 (see through metal barrier). The barrier width would be 1.75 feet wide and the shoulder width would be approximately 1.5 feet wide on each side. This type of barrier is "see through".



Safety Analysis: The ERS analysis indicated that the safety benefit is to decrease the number of accidents by:

- 0.17 collisions per year (2012)

Advantages:

- Provides 1.5 feet + additional width for bicyclists/pedestrians
- The bridge complies with current standards
- The upgraded barrier is crashworthy (the existing one was not)
- Reduces collision likelihood and severity

Disadvantages:

- None apparent

PLEASANTON-SUNOL ROAD/SR 84 INTERSECTION

Countermeasure IO-1: Construct a roundabout at the intersection of SR 84 and Pleasanton-Sunol Road

Existing Conditions: The existing intersection of SR 84 and Pleasanton-Sunol Road consists of a four-way stop controlled configuration. During the field review, significant queues were observed during the AM and PM peak periods on the eastbound and southbound approaches to the intersection. The queue on the eastbound approach was of particular concern, as it appears to create both road safety and operational concerns. During peak periods, the queue extends approximately 2,100 feet to the west, locating the end of queue under the Silver Springs Underpass structure. At this location, sightlines to the end of queue are limited due to the surrounding terrain, roadway geometry, vegetation, and the closed nature of the underpass structure. This creates an increased risk of high-speed rear-end collision. The delay associated with this queue also appears to promote shortcutting through Sunol in order to "jump" the queue.

An analysis of recent intersection turning maneuvers conducted by Caltrans[1] indicates that the existing SR 84 Intersections at Pleasanton-Sunol Road and Main Street operate at LOS E and F during peak periods.

AM Peak				PM Peak			
Intersection	Existing STOP controlled I/S			Intersection	Existing STOP controlled I/S		
	I/S Delay (sec)	LOS	Queue length* (ft)		I/S Delay (sec)	LOS	Queue length* (ft)
"A"	148	F	670	"A"	168	F	670
Intersection				Intersection			
"B"	48	E	590	"B"	90	F	1,180

Intersection A = SR 84 at Pleasanton-Sunol Road
Intersection B = SR 84 at Main Street

[1] Technical memorandum from Emily Tang to Ron Kiaaina, dated June 8, 2011

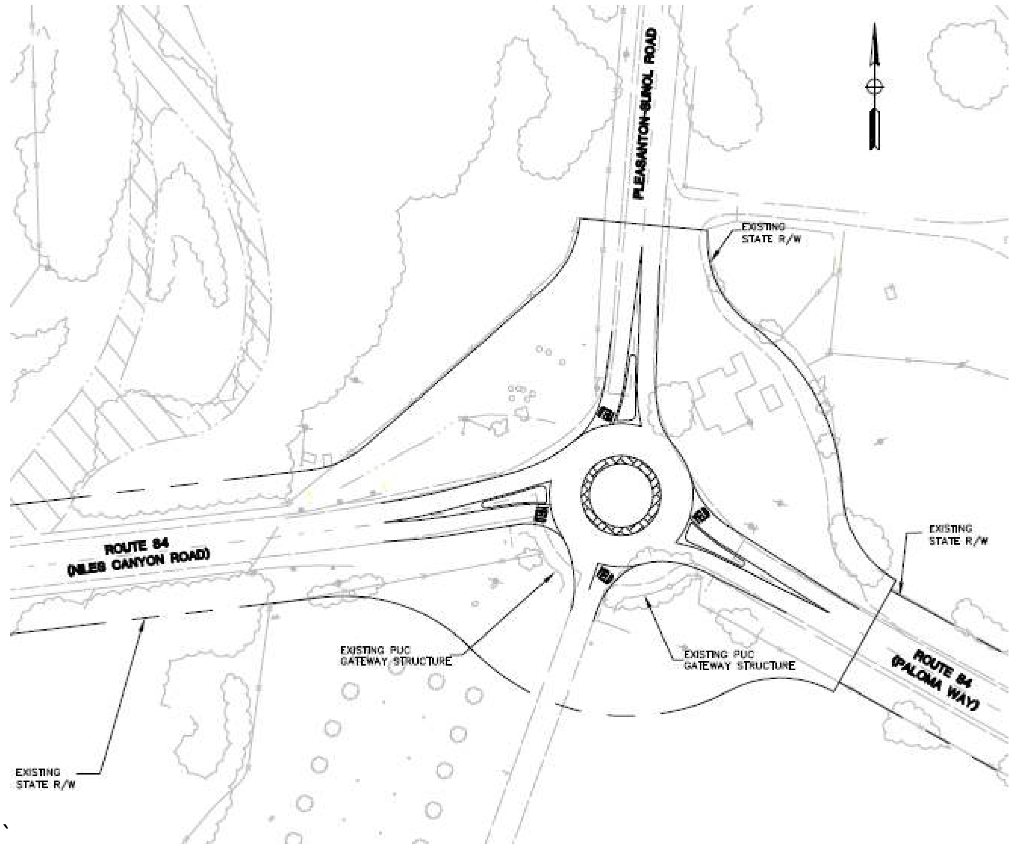
Traveling eastbound on SR 84 approaching Silver Spring Underpass

Traveling eastbound on SR 84 approaching Main Street Interchange

Traveling eastbound on SR 84 approaching Pleasanton-Sunol Road Intersection

<u>Proposed Improvements:</u> In this concept, the existing four-way stop control intersection at SR 84 and Pleasanton-Sunol Road is replaced with a single-lane modern roundabout in order to reduce the eastbound approach queue lengths.

<u>Concept Sketch:</u> The sketch on the following page has been extracted from a report prepared by TYLIN International dated January 6, 2006. This roundabout consists of a central island diameter of 50 feet, a circulating lane width of 20 feet, and a 10-foot-wide truck turning apron (ICD = 110 feet). TYLIN's analysis suggests this configuration can be accommodated within the available right-of-way. Although it is desirable to minimize the available ICD to reduce circulating speeds within the roundabout, a 110-foot ICD may be tight for a California Truck -65 design vehicle. Verification of the truck turning movements is recommended. The sketch is atypical of a rural roundabout, which features roundabout approach legs on chicaned alignments. The center of the roundabout, therefore, need not reside at the intersection of the three approaches with the chicaning approaches – this would support locating the roundabout in a position that could reduce impacts to the trees, store, or water temple monument.



Conceptual Roundabout Layout SR 84 at Pleasanton-Sunol Road Intersection (features shown are generic)

<u>Safety Analysis:</u> The ERS analysis indicated this countermeasure decreases the number of accidents by:

- 0.29 collisions per year (2012)

<u>Advantages</u>:

Safety:

- The roundabout improves traffic operations at the Pleasanton-Sunol Road Intersection by reducing the peak period queue length on the eastbound approach to the intersection (projected to only 6 vehicles). Removing the end of queue from the high-speed environment and limited sightlines at the Sunol Road interchange reduces the risk of high-speed end of queue collisions.
- NCHRP 672 – Roundabouts: An informational guide indicates that conversion of a four-way stop controlled intersection to a modern roundabout configuration results in an insignificant change in safety performance and resulting collision severity.
- Improved traffic operations will result from implementation of a roundabout at this location. Improvements include improved level of service, reduced queue lengths, and reduced delay.

- An HCM analysis of 2010 traffic volumes at the Pleasanton-Sunol Road Intersection indicates that the eastbound queue length between Main Street and the Pleasanton Intersections is reduced to 6 vehicles (approximately 160 feet).
- The HCM analysis indicates that the southbound-to-westbound and eastbound-to-northbound movements operate at a V/C ration of 0.8 and 0.7, respectively. This indicates that the roundabout should be designed to accommodate a future widening to 2 circulating lanes and/or bypass lanes.
- Roundabouts also serve as effective speed management treatment.

Human Environment

- Provides an opportunity to provide a gateway statement for the Niles Canyon Valley/Sunol community.

Disadvantages:

Natural Environment:

- Potential impact to existing oak trees at the northwest quadrant of the intersection.

Human Environment:

- Roundabouts are relatively new in North America. As a result, some drivers may not be familiar with their operations.
- The community of Sunol has rejected past proposals to change this intersection to a roundabout configuration.
- Potential commercial impacts to the existing market located on the north/east quadrant of the intersection. Relocation of the business or reconfiguration of its access may be required.
- The gates to the Water Temple will likely need to be relocated to accommodate the necessary sightlines (intersection approach and pedestrian crossing sightlines).

Maintainability:

- A landscaped center island in the roundabout would require additional maintenance.
- Additional roadway lighting would be required.
- Potential for premature pavement deterioration due to turning trucks.

Constructibility:

- Construction of the roundabout while maintaining live traffic will be complicated.

Countermeasure IO-15: Construct a signalized intersection at the Pleasanton-Sunol Road Intersection

Existing Conditions: The existing intersection of SR 84 and Pleasanton-Sunol Road consists of a four-way stop controlled configuration. During the field review, significant queues were observed during the AM and PM peak periods on the eastbound and southbound approaches to the intersection. The queue on the eastbound approach was of particular concern as it appears to create both road safety and operational concerns. During peak periods, the queue extends approximately 2,100 feet to the west, locating the end of queue inside the Sunol Road Underpass structure. At this location, sightlines to the end of queue are limited due to the surrounding terrain, roadway geometry, vegetation, and the closed nature of the underpass structure. This creates an increased risk of high-speed rear-end collision. The delay associated with this queue also appears to promote shortcutting through Sunol in order to “jump” the queue.

An analysis of recent intersection turning maneuvers conducted by Caltrans indicates that the existing SR 84 Intersections at Pleasanton-Sunol Road and Main Street operate at LOS E and F during peak periods.

AM Peak			
Intersection	Existing STOP controlled I/S		
	I/S Delay (sec)	LOS	Queue length* (ft)
Intersection "A"	148	F	670
Intersection "B"	48	E	590

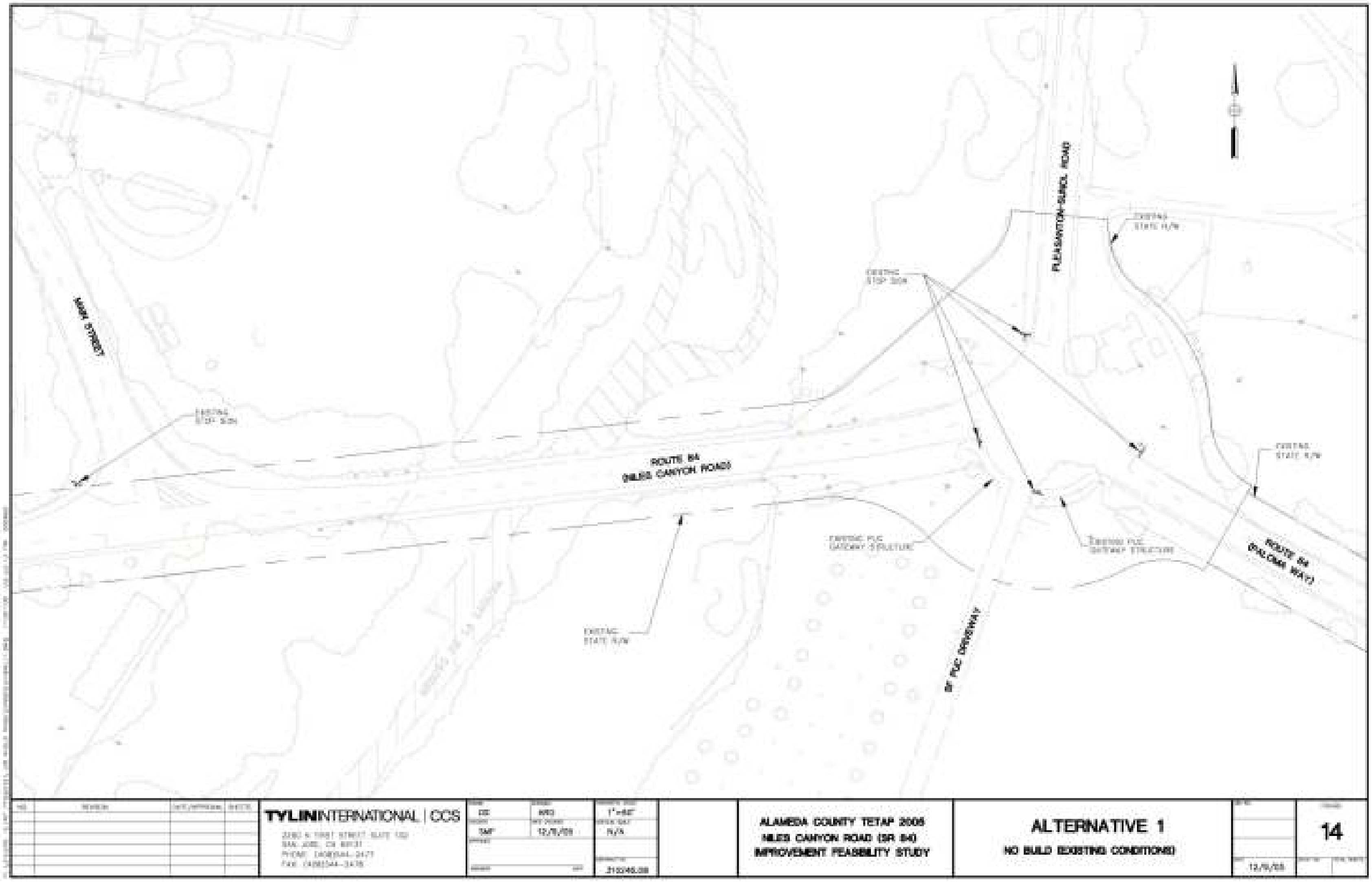
PM Peak			
Intersection	Existing STOP controlled I/S		
	I/S Delay (sec)	LOS	Queue length* (ft)
Intersection "A"	168	F	670
Intersection "B"	90	F	1,180

Intersection A = SR 84 at Pleasanton-Sunol Road
Intersection B = SR 84 at Main Street

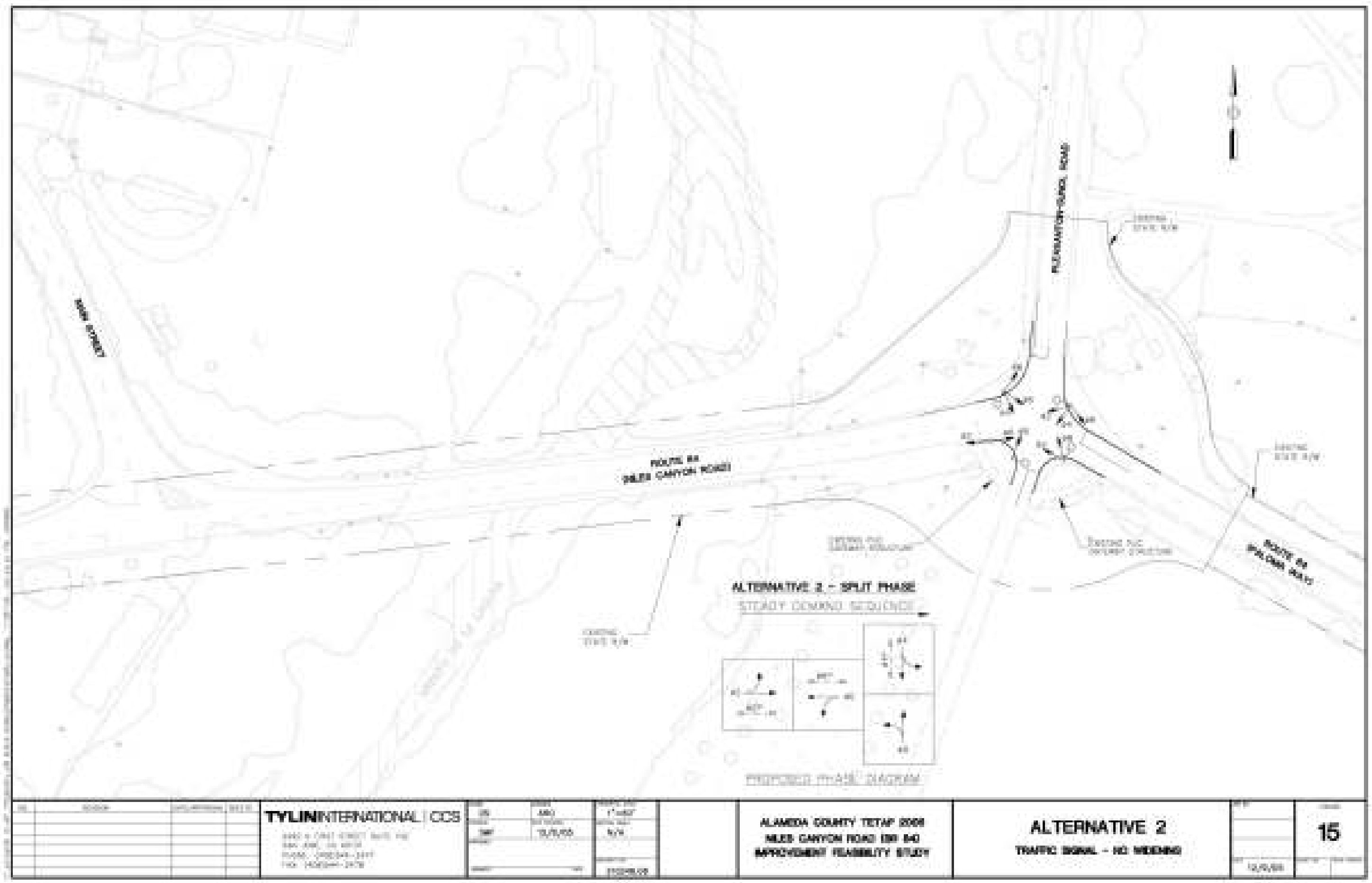
Proposed Improvements: A previous study prepared for the Alameda County and Metropolitan Transportation Commission (MTC) by TYLIN, dated January 2006, studied three four-way signalized intersections and a roundabout. The following, taken from the above mentioned report, describes the intersection alternatives and their LOS.

The VA team suggests that as part of the signalized intersection analysis – that a realignment of the east leg of the intersection be considered. Retaining the east leg’s high skew, as it exists in the current 4-way stop intersection, has concerns with high-speed traffic traversing for a signalized intersection.

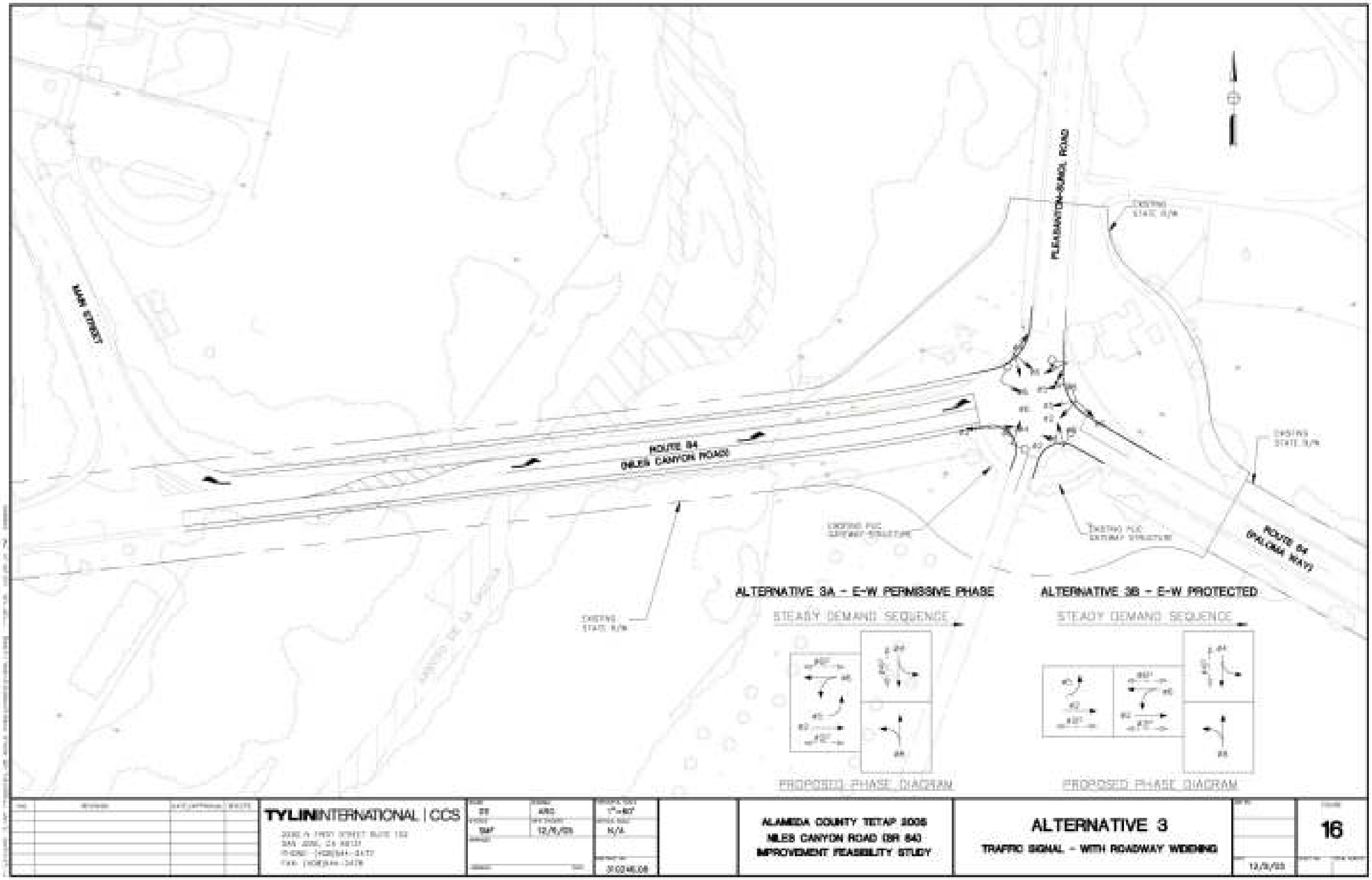
- Alternative 1 would keep the intersection of SR 84 and Pleasanton-Sunol Road as existing with no improvements. Under this condition, the roadway geometry, lane configuration, and layout would remain the same as existing. The existing stop signs would continue to control the intersection as an all-way stop. The analysis of this alternative captures the level of service of existing conditions for comparison purposes.



- Alternative 2 includes the installation of a traffic signal at the intersection of SR 84 and Pleasanton-Sunol Road without any roadway widening. The eastbound SR 84 through and left turn movements would continue to share one lane, as existing. The assumed signal phasing would operate the eastbound and westbound SR 84 movements as split phase. The split phase would allow the eastbound left turns to operate without any conflicting traffic by allowing each approach to have a dedicated green with protected turns. Based upon the high number of intersection broadsides in the collision data, permissive turns are undesirable. This phasing allows the high number of eastbound left-turning vehicles from SR 84 to complete their movement unimpeded, but would increase overall delay at the intersection. This alternative would not require any roadway widening, but would likely require the construction of curbs and removal of pavement on all four corners for traffic signal pole placement.



- Alternative 3 includes the installation of a traffic signal at the intersection of SR 84 and Pleasanton-Sunol Road, as well as widening the eastbound approach to provide a left turn pocket. The preliminary analysis indicates that approximately 400 feet should be provided for the left turn pocket. There are two options for phasing this signal: (A) allowing eastbound left turns to operate permissively or (B) creating a protected phase for the eastbound left turns.



- Alternative 4 – Roundabout (see Countermeasure IO-1 for details)

The following summarizes the LOS for the alternatives discussed above:

Alternative	Control	Weekday AM Peak Hour LOS (Intersection Delay/Maximum Delay)	Weekday PM Peak Hour LOS (Intersection Delay/Maximum Delay)
Existing Conditions	Existing Conditions	All Way Stop	E (48.9/64.9)
Alternative 1: Install Signal-No Widening	Install Signal-No Widening	Signal-Split	E (69.8/97.4)
Alternative 2: Install Signal With Widening	Signal-Permissive	C (26.4/38.4)	D (38.6/72.2)
Alternative 3: Install Signal With Widening	Signal-Protected	D (42.0/49.5)	D (54.8/74.1)
Alternative 4: Roundabout	Roundabout	Roundabout	A (9.4/12.3)

See TYLIN report for additional details on the above intersection treatments.

Safety Analysis: The ERS analysis indicated this countermeasure an increase the number of accidents by:

- 0.52 collisions per year (2012)

The following advantages/disadvantages, unlike the rest of this section, relate to the advantages and disadvantages in relation to the previous countermeasure, IO-1.

Advantages:

- Favored by the community
- Reduces rear-end collision associated with the end of queue condition near Silver Springs UP
- Has reduced footprint over a roundabout with likely less environmental related to trees, Water Temple monument, and right-of-way impacts to the fruit stand

Disadvantages:

- Increases intersection collision frequency Improves LOS, but not nearly to the level of a roundabout
- Does not provide speed management benefit as opposed to a roundabout

FACILITATE CORRIDOR ENFORCEMENT

Countermeasure SPMA-4/SW-3: Provide widened locations at strategic spacing to accommodate enforcement and pullovers

Existing Conditions: Within the 6 miles of the project limits, west of Rosewarnes to I-680, there is only one location that provides adequate shoulder area to facilitate enforcement. This area is the approximately 2-mile section between the quarry road Intersection and the Silver Springs Underpass. It appears that the section of roadway between the Kaiser Quarry intersection (PM 15.05) and the Silver Springs Underpass (PM 16.93) currently has the best cross section for enforcement. Other areas are more constrained from an enforcement perspective. The most constrained cross section is the 1-mile stretch between the Alameda Creek Bridge (PM 13.33) and Alameda Creek BOH Bridge (PM 14.23).

Proposed Improvements: To provide enforcement areas, the following two sections of road can have the shoulders widened/paved with little to no footprint increase or impact to the roadside environment:

- New Eastbound Enforcement/Paved Shoulder Locations:
  - Location 1: PM 15.0 - 15.4; 0.4 miles
  - Location 2: PM 17.3 - 17.95 (between Pleasanton-Sunol Road and I-680); 0.67 miles

- New Westbound Enforcement/Paved Shoulder Locations:
  - Location 1: Westbound (PM 14.27 - 14.44); 0.67 miles
  - Location 2 Westbound (PM 15.26 - 15.44); 0.18 miles (may be too short)
  - Location 3: Westbound (PM 16.27 - 16.8); 0.53 miles

The locations specified above, do not require removal of trees or create any significant footprint impact of the existing terrain. The shoulder paving proposed, would use existing graded shoulder area , while bringing the edge of pavement out by 2-4 feet to provide an 8-foot shoulder. This area would be paved. When widening and repaving the shoulder - install safety edge as dictated by most recent Caltrans specifications for edge of pavement. Also consider pervious pavement for the shoulders in this area to reduce the runoff associated with the widened paved shoulders.

Law enforcement requires 8-foot shoulders of sufficient length to store disabled vehicles (mechanical/collision), remove them as obstacles from the traveled lane and to provide sufficient length for vehicles to decelerate safety off/ accelerate safety into the traveled lane.

This countermeasure may also contribute to the effectiveness of proposed speed management measures at Rosewarnes, Farwell, and the area between the two bridges.

Safety Analysis: The ERS analysis indicated this countermeasure decreases the number of accidents by 0.01 collisions per year (2012).

Advantages:

- Provides an area for CHP to enforce infractions, particularly speeding

- First response can utilize the added shoulders to attend to incidents without blocking the traveled lane
- Controlling speeding improves safety for vehicle-vehicle/pedestrian/bicyclist conflicts
- Wider paved shoulders in the subject areas incrementally increases safety for vehicle refuge, pedestrian and bicycle usage

Disadvantages:

- Nominally increases the impervious surfacing/increased runoff
- Nominal impact on the natural environment
- Potential increase in illegal stopping/parking
- Potential increase in illegal trash dumping

LONG-TERM COUNTERMEASURES

These countermeasures should be studied and considered in long-range transportation planning for the region. With increasing traffic volumes, the roadway deficiencies that currently exist will pose increasingly greater safety hazards. The following list of long-term countermeasures are topics that may need to be addressed as commuter volumes increase within the canyon. These countermeasures should be justified by additional safety investigations after the more urgent safety improvements, such as the short-term and medium-term improvements described in this report, are implemented. If the short-term and medium-term improvements are implemented, the VA team recommends that corridor be monitored before pursuing the long-term countermeasures.

- Countermeasure RO-3 — Widen roadway to provide roadway cross section of 12-foot lanes, 8-foot shoulders, and spot widening for clear recovery zone
- Countermeasures IO-13/QI-1 — Correct superelevation and vertical sight distance, and extend eastbound left turn pocket at the quarry road intersection

Countermeasure RO-3: Widen roadway to provide roadway cross section of 12-foot lanes, 8-foot shoulders, and spot widening for CRZ

Existing Conditions: Substandard lane widths and shoulders along with substandard sight distances increase the potential for cross-centerline collisions and hit-object accidents, reduce motorists' ability to recover and return to the travel way, and do not provide safe locations for disabled vehicles to pull over. This potential increases with an increase in AADT.

Proposed Improvement: 12-foot travel lanes, 8-foot shoulders, and 2-foot soft-median barriers would be constructed throughout the corridor with spot widening for a 20-foot CRZ where environmental impacts are not excessive.

Safety Analysis: The ERS analysis indicated that this countermeasure reduces the number of accidents by:

- 1.31 collisions per year (2012)

Advantages and Disadvantages:

- Safety: Reduction in the kinds of accidents listed above. Shoulders would provide refuge for disabled vehicles, parking for CHP enforcement, and a safer area for non-motorized transportation.
- Natural Environment: Slopes would be cut back, the creek channel would be encroached upon, many trees and other vegetation would be cleared. More runoff would result from the increase in impermeable surface. Potential effects on creek flow. Loss of or damage to wildlife habitat, including several listed species. Possible increase in illegal trash dumping due greater ease of access to the creek.
- Human Environment: This would further urbanize the Niles Canyon environment. Visual impacts would result from cut slopes, retaining walls, traffic barriers, viaducts, signage, and loss of vegetation, and from an increase in graffiti. The National-Register-eligible aqueduct would be damaged. The increased shoulder would probably be used for parking by recreational users. The route would potentially become more popular among commuters, increasing traffic volumes. The increased shoulder could result in increased illegal parking by recreational users.
- Increased ease of maintenance of roadway shoulders. Increased maintenance needed for graffiti abatement, especially on specially textured or painted surfaces. Possible maintenance issues with mechanical treatment facilities for stormwater runoff.
- Constructibility: Bridges would be widened, or replaced if widening would not be feasible. Cuts made in the railroad embankment would require walls able to resist the forces involved. Widening into the creek would require the use of side-hill viaducts. Traffic management plan required.

IO-13/QI -1: Correct superelevation and vertical sight distance, and extend eastbound left turn pocket at the quarry road intersection

Existing Conditions: Eastbound motorists have limited views of the quarry driveway, and motorists in the quarry driveway have limited views of eastbound motorists because the crest of the roadway is blocking views. The left turn pocket begins at the top of the rest and does not allow reasonable space for deceleration.

Proposed Improvements: Superelevation would be corrected and the turn pocket extended.

Safety Analysis: The ERS analysis indicated that this countermeasure reduces the number of accidents through the suggested superelevation correction by:

- 0.02 collisions per year (2012)

And reduces the number of accidents for suggested left turn pocket by:

- 0.01 collisions per year (2012)

Advantages/ Disadvantages:

- Safety: Visual sight distances would be increased, creating safer driving conditions both for eastbound motorists and for those exiting the driveway. The longer turn lane would allow for safer deceleration.
- Requires the construction of retaining walls.
- Human Environment: There would be small visual impacts associated with wall construction.
- Maintainability: No significant issues.
- Constructibility: Close proximity to railroad tracks means that walls must be able to support embankment and resist vibration. Traffic management plan required.

COMMUNITY VISION COUNTERMEASURES

Regional planning organizations and local government agencies must make decisions about what the future of Niles Canyon Road will be. If the natural and community values of Niles Canyon are to be preserved or enhanced, ways must be identified to reduce the attractiveness of Niles Canyon Road to commuters, and perhaps to restore access to recreational users who have increasingly been discouraged from using it.

Niles Canyon Road currently represents an uneasy compromise between its function as a commuter corridor, water supply and conveyance, and the desire of many to preserve it as a rural and natural river canyon. The traffic volumes through Niles Canyon can be expected to rise over the coming decades exacerbating the conflict between the use of the canyon as commuter route and the recreational, cultural, community and natural environment resources of the Niles Canyon area. The following countermeasures outline a few topics that Regional Planning study to address this dichotomy.

The following list is a representation of topics that represent some of the community vision for Niles Canyon area:

- Countermeasure AN-4 — Separate non-motorized traffic by constructing an off-roadway trail system
- Countermeasure AN-6 — Provide bike path adjacent to railroad grade
- Countermeasure RE-1 — Designate Niles Canyon as a park and install a toll booth at each end

Countermeasure AN-4: Separate non-motorized traffic by constructing an off-roadway trail system

Existing Conditions: Non-motorized traffic (including bicycles and pedestrians) share the roadway with motorists, with the potential for conflict with motorized traffic. When there is non-motorized traffic in the travel way, motorists slow down or swerve into the opposite lane to pass. If AADT increases, this conflict can be expected to worsen.

Proposed improvements: Provide an off-mainline roadway trail system that would separate pedestrians, bicyclists, and equestrians from motorists, possibly through nearby park or public land. Appropriate signage would be installed. Right-of-way would be acquired where necessary from public and private landholders.

Advantages and Disadvantages:

- Safety: Eliminates the potential for conflict and collisions between motorized and non-motorized traffic. For user safety, trail may need to be closed at night.
- Natural Environment: Vegetation would need to be removed to accommodate trail. Creating a trail of sufficient width may require the construction of retaining walls. Slope rounding, erosion control techniques, and re-vegetation may help minimize impacts. Possible damage to natural environments due to increased foot traffic and litter.
- Human Environment: Sport cyclists may resent sharing a lower-speed trail with other uses. Steep ascents and descents, if necessary, may pose challenges to casual trail users. Possible hazards associated with steep drop-offs next to trail, if these exist.
- Maintainability: Resources and access would be required for weed control and trail maintenance.
- Constructibility: Difficult to find space for trail at bottom of canyon near current road. Due to steep slopes, grading and/or retaining walls or other slope-stability measures would be necessary.

Countermeasure AN-6: Provide bike path adjacent to railroad grade

Existing Conditions: Non-motorized traffic (including bicycles and pedestrians) share the roadway with motorists, with the potential for conflict with motorized traffic. When there is non-motorized traffic in the travel way, motorists slow down or swerve into the opposite lane to pass. If AADT increases, this conflict can be expected to worsen.

Proposed Improvements: Provide an off-mainline roadway trail system on the railroad embankments that would separate pedestrians, bicyclists, and equestrians from motorists. Fencing and appropriate signage would be installed. Easements would be acquired from railroad operators.

Advantages and Disadvantages:

- Safety: Eliminates the potential for conflict and collisions between motorized and non-motorized traffic, but increases the potential for conflict with rail traffic. Fencing would restrict users' ability to exit the trail, increasing the risk of assault on users. For user safety, trail may need to be closed at night.
- Natural Environment: Little damage to environment as trail would be constructed on man-made embankment.
- Human Environment: Fencing would be required to restrict access to rail lines and possibly the creek. Fencing would not be attractive. Rail traffic is extremely loud and would detract from users' enjoyment of the facility. The possibility of vandalism to the rail facilities would be increased.
- Maintainability: Resources and access would be required for weed control and trail maintenance.
- Constructibility: Vibration could prohibit the use of the retaining walls needed to construct a level path and would damage path paving.

Countermeasure RE-1: Designate Niles Canyon as a park and install a toll booth at each end

Existing Conditions: Niles Canyon Road follows Alameda Creek through Niles Canyon. The area is considered the most scenic in the vicinity, but public access for recreation is severely limited. The main remaining recreational uses are the historic train and the use of the roadway for non-motorized transportation. Many decades of recreational use in the canyon ended following restrictions on parking by the creek, the removal of "The Spot," closing of "Sims Park," and other measures intended to reduce illegal activities at the creek and protect water quality and fisheries restoration. As traffic volumes increase, incompatibility between recreational and transportation uses will increase.

Proposed improvement: This countermeasure is an approach to reduce the use of the corridor as a commuter route by designating Niles Canyon a public park by installing toll booths to limit access to more recreational use. This should reduce the traffic volume, and possibly the traffic speeds in Niles Canyon (recreational drivers probably drive slower than commuters). However, this would redirect commuters to alternate routes.

Advantages:

- Safety: With the elimination of through traffic, non-motorized traffic would still have to share lanes with motorized traffic at locations throughout Niles Canyon, but volumes and speeds of motorized traffic would be minimized, reducing the potential for accidents accordingly.
- Natural Environment: There would large reductions in roadway runoff contaminants, noise, and airborne pollutants.
- Human Environment: The community of Sunol would be effectively insulated from growth, and it and the quarry would be cut off from direct access to Fremont. Niles Canyon would be preserved in its current quasi-rural state indefinitely. Recreational access to Niles Canyon would be restored after decades of reduction.
- Maintainability: The elimination of truck traffic would reduce pavement wear due to roadway use. Responsibility for maintenance of the bridges would fall to Alameda County.
- Capacity increasing construction may be required on alternate routes.

Disadvantages:

- Safety: Due to the increased emphasis on appreciating the scenery, distracted driving could increase.
- Natural Environment: Parking, pull-outs, and other park facilities would require roadside widening or other development off the roadway. These would possibly entail the construction of retaining walls or other structures, some encroaching into the creek. Widening would also be required if non-motorized and motorized traffic were to be separated throughout the park. Increased recreational access to the creek could impact water quality and aquatic habitat.
- Human Environment: Commuters would be forced into taking other, potentially less direct routes. Increase in AADT on alternate routes may increase traffic impacts on businesses and residents along those corridors, and may require expansion of capacity.
- Maintainability: The area would require management as a park, which would require additional resources for East Bay Parks. Park facilities would have to be built, including, but not restricted to parking, visitor centers and restrooms, trails, signage, and toll booths.

CORRIDOR INFORMATION

CORRIDOR INFORMATION

BACKGROUND

The portion of the Niles Canyon Road (SR 84) corridor that lies between Mission Boulevard and I-680 (PM 10.83-17.9) (7.1 miles) was studied by two separate teams:

- Road Safety Audits (RSA)
- Quantitative Road Safety Analysis (QRSA) team

These studies were precipitated by a court injunction, filed June 23, 2011 by the Alameda Creek Alliance with the Alameda County Superior Court, that construction be stopped on the Niles Canyon 1 project. The RSA findings are documented in a separate report prepared by the FHWA.

The following summarizes the features of three Caltrans Niles Canyon projects, as originally designed by Caltrans:

- Niles Canyon 1 entails improvements to the roadway passing under the Rosewarnes Underpass (increased lateral distance between the structure supports and the edge of travelway) and the addition of an eastbound left turn pocket at the Palomares Road Intersection near the Farwell Underpass.
- Niles Canyon 2 entails corridor-wide addition of shoulders without structure widening.
- Niles Canyon 3 is a bridge replacement at the crossing of the Alameda Creek Bridge to correct two deficient horizontal curves.

The Niles Canyon 1 project was in construction when a court injunction halted the project due to concerns of impacts to federally threatened species. In December 2011, Caltrans terminated the construction contract. Plans to restart the Niles Canyon 1 project are on hold pending the outcome of the RSA and QRSA studies. The Niles Canyon 2 and Niles Canyon 3 projects are still in the Draft Environmental Document preparation project development phase.

The three original Niles Canyon projects, programmed and subsequently developed by Caltrans, were based on corridor safety needs identified in the early 2000s. These safety needs were identified by the Two-Lane and Three-Lane Safety Monitoring Program, a program that tracks the rates of head-on collisions. Since that timeframe some conditions have changed. For example:

- Traffic volumes are down by approximately 20% from the peak in 2005.
- A centerline rumble strip (2-foot soft barrier) has been installed to reduce head-on collisions.
- Greater cultural and human environment priorities for the Canyon have surfaced with the designation of Niles Canyon Road as a scenic corridor in 2007 and the impending restoration of the steelhead trout habitat in Alameda Creek.
- The corridor is growing in popularity as a destination, especially with bicyclists.

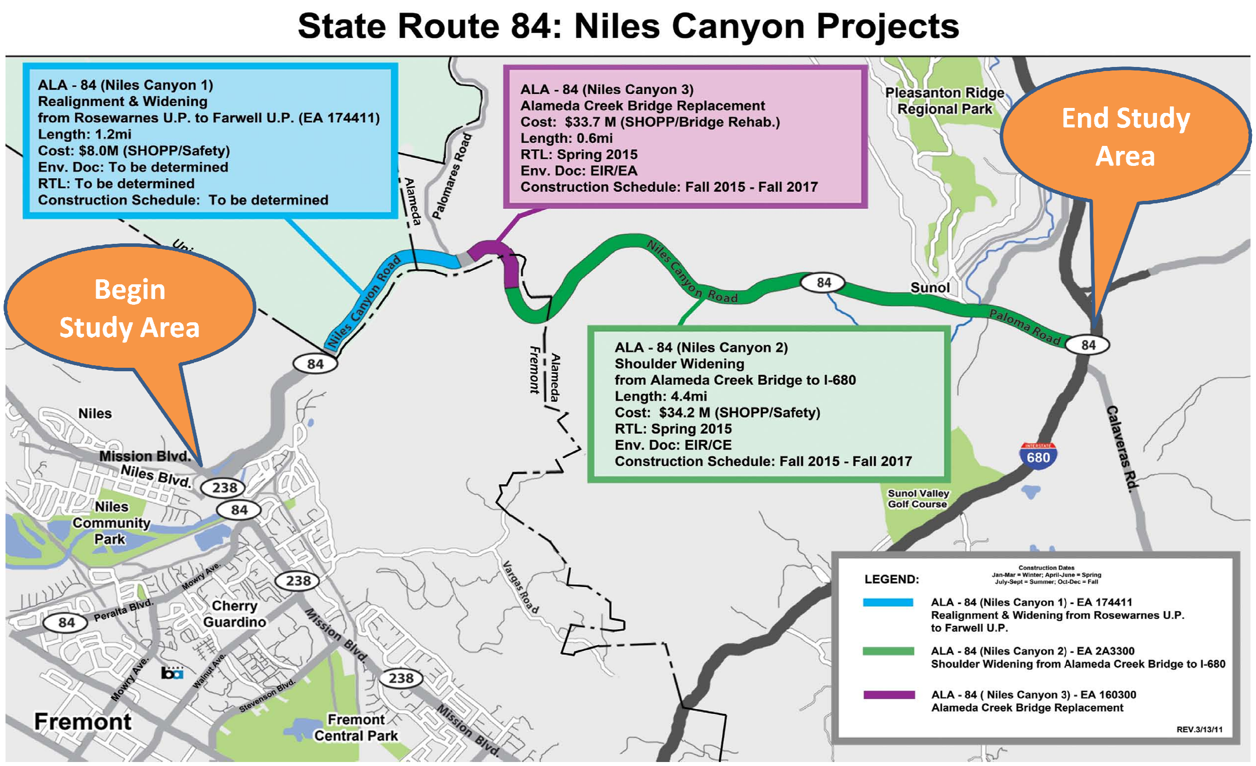


Figure 1: Project Location

The Niles Canyon projects, as originally designed by Caltrans, were opposed by environmental and community groups. These groups are interested in a variety of topics, which can generally be summarized with the following:

- Do the completed interim safety upgrades, such as the centerline rumble strip, negate the need for the proposed Niles 1, 2, and 3 improvements?
- Can the scope of the original projects be reduced while maintaining a reasonable level of safety to minimize the impacts to the recreational, cultural, community, and natural environment resources of the Canyon?
- The water quality of the creek is protected and preserved because it is a drinking water source and to facilitate the restoration of the steelhead trout habitat. Can the improvements be down-scoped to reduce the impact to this natural resource?

In summary, the project stakeholders question if there is a current safety need, and whether context sensitive solutions, such as spot improvements, can be developed to provide the needed safety benefit but with less environmental impact.

EXISTING CORRIDOR FEATURES

The existing condition of the Niles Canyon Road Corridor includes the following features:

- Two-lane conventional highway that leaves the urbanized setting and transitions into a rural setting east of Mission Boulevard.

- Intersections between Mission Boulevard (PM 10.83) and I-680 (PM 17.9) include the following:
  - Old Canyon Road (PM 11.20)
  - Palomares Road (PM 13.00)
  - Kaiser Quarry (15.05)
  - Main Street (PM 17.20)
  - Pleasanton-Sunol Road (PM 17.28)
- The roadbed consists of narrow shoulders (2 to 8 feet in width), especially between the Alameda Creek Bridge and the Alameda Creek BOH Bridge (PM 13.3- 14.32).
- The roadway alignment is typically a curving horizontal alignment; the eastern portion is less curvilinear with more open roadside and generally flatter sideslopes.
- Centerline rumble strips were completed in October 2007 between Old Niles Canyon Road and Pleasanton-Sunol Road.
- The roadway is generally bounded by a steep canyon wall, Alameda Creek, and the railroad.
- The Canyon is a significant natural environment resource within a generally urbanized area; for example, it has variety of cultural/community resources, including:
  - The Niles Canyon Railroad – a historic steam railroad that runs between the towns of Niles and Sunol and was the site of a Charlie Chaplin movie.
  - The canyon carries two historical aqueducts and a historical Water Temple monument near the Pleasanton-Sunol Road Intersection.
  - The scenic roadway supports recreational use, especially on the weekend, from bicyclists, pedestrians, and leisure motor trip drive-bys.
- Regulatory speed is 45 mph; curve warning speed signs to 30-35 mph at spot locations.
- Current Niles Canyon traffic two-way AADT at Palomares Road is approximately 14,000 with 2.5% truck traffic.
- The Niles Canyon two-way AADT is forecasted to grow to 22,250 in the vicinity of Palomares Road by the year 2030.
- Hazardous material trucks are restricted from using the corridor.

The following lists the landmarks within the corridor between Mission Boulevard and I-680:

CO.	CITY	POSTMILE	PT	LENGTH	DESCRIPTION
ALA	FMT	010.830		*P*	MISSION BL VIA NILES CYN
ALA	FMT	011.020			CANYON RD (RT)
ALA	FMT	012.095		00.079	ROSEWARNES UP 33 34
ALA	UNC	012.174		00.643	
ALA		012.817		00.183	
ALA		013.000		00.025	PALOMARES RD
ALA		013.000			NILES CANYON RD AT PALO
ALA		013.025		00.305	FARWELL UP 33 35
ALA		013.330		00.032	ALAMEDA CR33-36;RCHD BR
ALA	FMT	013.362		00.031	
ALA	FMT	013.393		00.535	
ALA	FMT	013.840			AT THE SPOT (LT)
ALA	FMT	013.928		00.206	EAST BRIGHTSIDE TUNNEL
ALA		014.134		00.190	
ALA		014.324		00.188	ALAMEDA CR BOH 33 39
ALA		014.360			OLD NILES CANYON RD(RT)
ALA		014.512		02.421	
ALA		015.050			AT KAISER PLANT (LT)
ALA		016.801			NB OFF TO SUNOL
ALA		016.811			SB ON FR SUNOL
ALA		016.933		00.290	SILVER SPR RD UP 33 42
ALA		017.210			NILES CANYON RD AT MAIN
ALA		017.223		00.059	ARROYO DE LA LAGUNA
ALA		017.282		00.005	
ALA		017.287		00.700	PLEASANTON-SUNOL RD
ALA		017.287			WAT TMPL -PLSNTN-SUNOL
ALA		017.961			RAMPS 680-84

RECENTLY COMPLETED CORRIDOR PROJECTS

The following lists a recently completed corridor project:

- EA 1A700, 04-ALA-84-PM11.1/12.1 & PM13.0/16, install soft median barrier (completed August 2007)

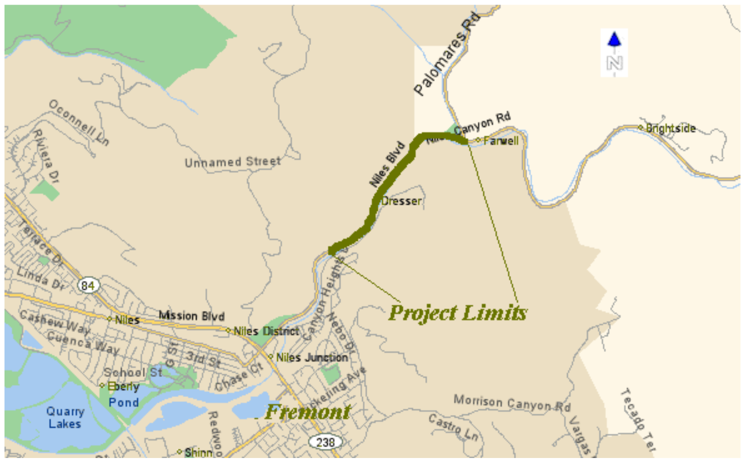
PROJECT DESCRIPTION (ORIGINAL DESIGNS)

The following describes the three projects as originally designed by Caltrans: Niles Canyon 1, 2, and 3.

The VA team used the safety evaluation of the existing corridor to determine safety needs at spot locations and also safety needs that applied on a corridor-wide basis. The team did not rely on the projects as defined by Caltrans to develop the improvements (i.e., countermeasures) to address these safety needs. The use of the three projects served to define the key road features such as stationing and to identify features that might be avoided to reduce environmental impacts, whenever possible.

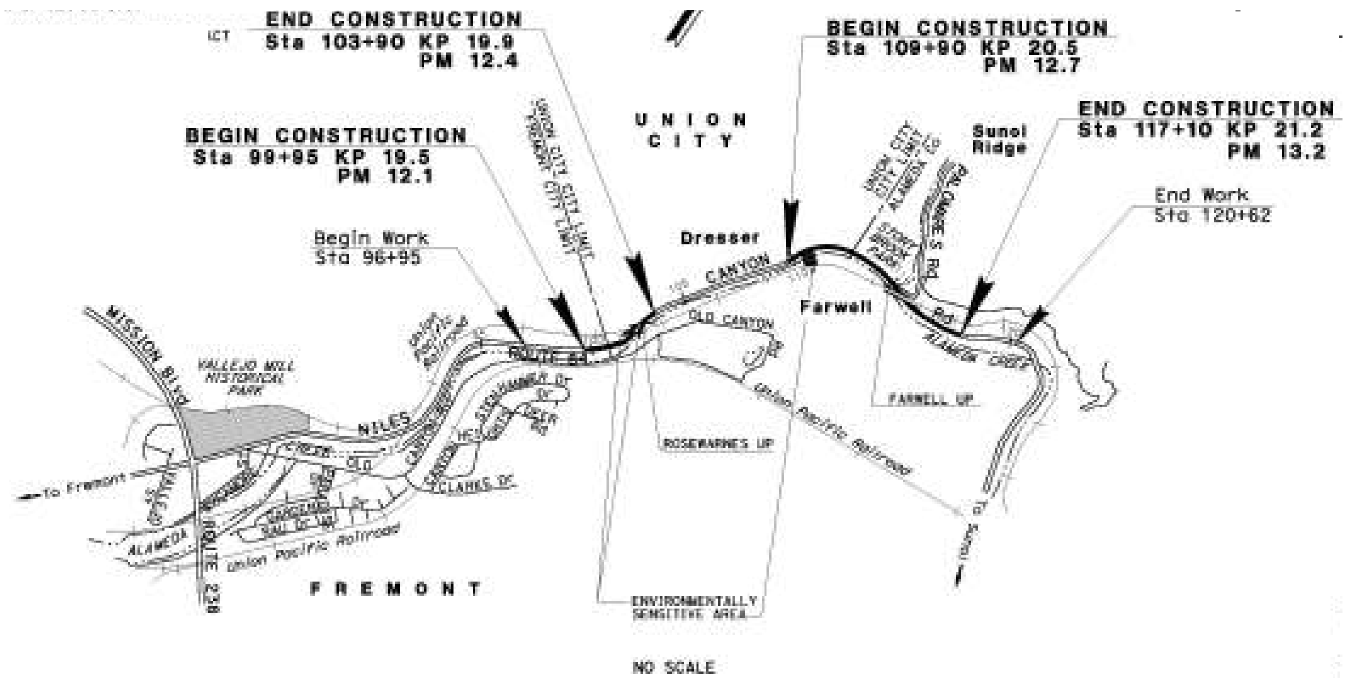
Niles Canyon 1 Project

The Niles Canyon 1 project would have realigned SR 84 curve realignment and widening between the Rosewarnes Underpass and Farwell Underpass in Alameda County (PM 12.1/13.3). In June 2011, the Court of Alameda granted a preliminary injunction to the plaintiffs, the Alameda Creek Alliance, halting all construction activities on the project. In December 2011, the Department terminated the construction contract. The Department is currently evaluating options to restart the project, but at this time no schedule has been set.



The purpose of the Niles Canyon 1 project was to improve traffic safety on SR 84 between the Rosewarnes Underpass and the Farwell Underpass. The Niles Canyon 1 project safety improvement project featured the following:

- Widened shoulders to meet current standards
- Realign the northbound direction around the existing pier at the Rosewarnes Underpass (Bridge No. 33-0034)
- Lowering of the roadway pavement to meet vertical clearance requirements at the Rosewarnes and Farwell Underpasses
- Constructing a left turn pocket at Palomares Road, shift Palomares Road towards the west
- Constructing centerline and shoulder rumble strips
- Other improvements included roadway widening, retaining walls, rock anchors (with rock netting), a new bridge at Stonybrook Creek to improve fish passage, AC overlay, concrete barrier, rock slope protection, erosion control, and environmental mitigation



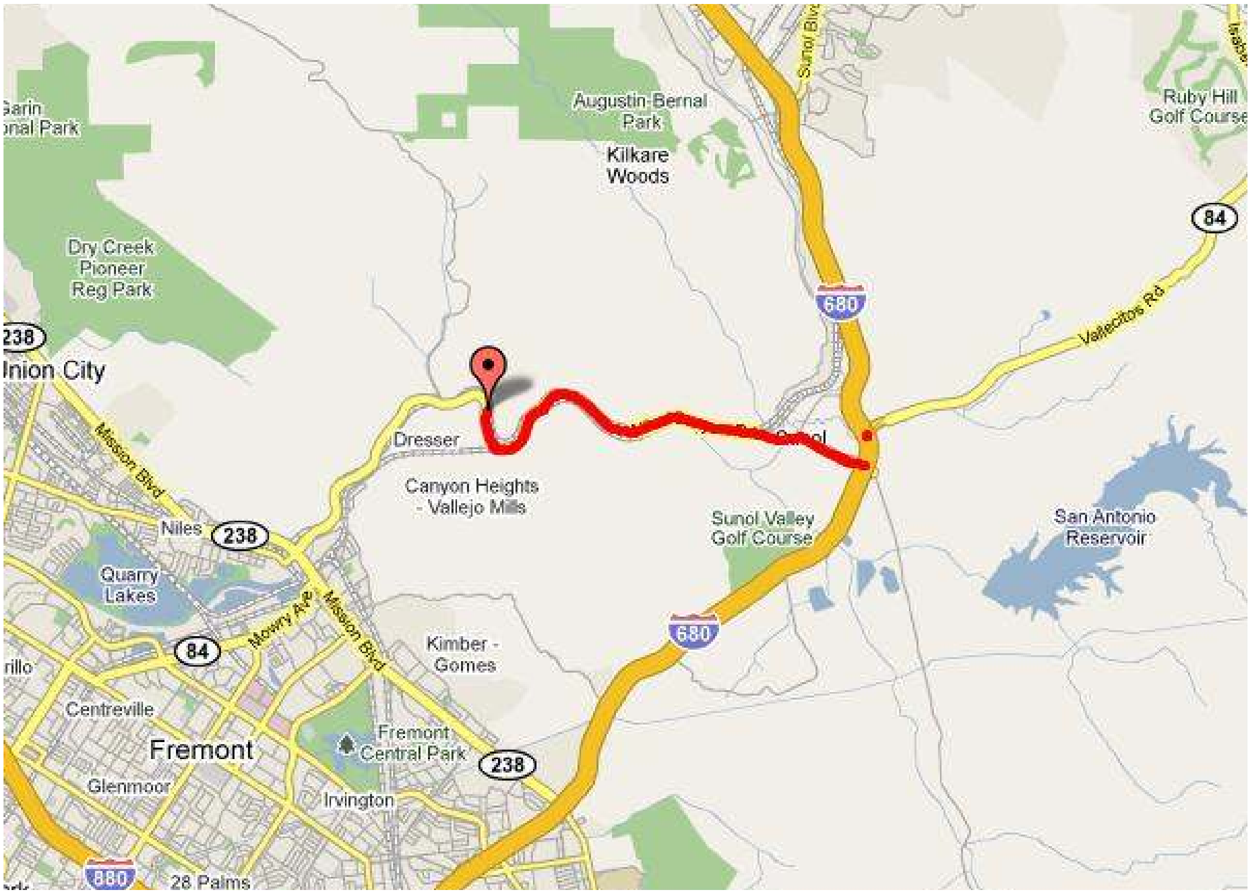
Construction Cost $ 8.0 M
Right-of-Way Cost $ 1.6 M
$ 9.6 M (2010)

Schedule

- Approved PSR 11/2/2001
- Approved FONSI 6/30/2006
- Start Construction 01/15/11
- End Construction 12/2011 - Contract terminated

Niles Canyon 2 Project

The SR 84 Niles Canyon 2 project is a safety improvement project from just east of the Alameda Creek Bridge to I-680 (PM 13.6/18.0).



The purpose of the Niles Canyon 2 project is to provide safety improvements to reduce the number of head-on cross-centerline and run-off-the-road-type accidents, as well as to improve sight distance on this segment of SR 84 in Niles Canyon.

This 4.4-mile project proposes to widen shoulders and improve sight distance to meet current conventional highway standards on SR 84 in Niles Canyon between the Alameda Creek Bridge (PM 13.6) and the SR 84/I-680 separation (PM 18.0) in Alameda County. This safety improvement project will construct:

- Standard width shoulders
- Centerline and shoulder rumble strips
- Retaining walls, concrete barrier, guard rail, drainage facilities, utility relocations, erosion control, advanced warning signs, and environmental mitigation

Simulated view of rock cut looking west towards Fremont

Three bridges within the project limits - the Alameda Creek Bridge and Overhead (Br No 33-0039), Silver Springs Underpass Bridge (Br No 33-0042), and Arroyo De La Laguna Bridge (Br No 33-0043) - will remain as is and are excluded from the project scope.

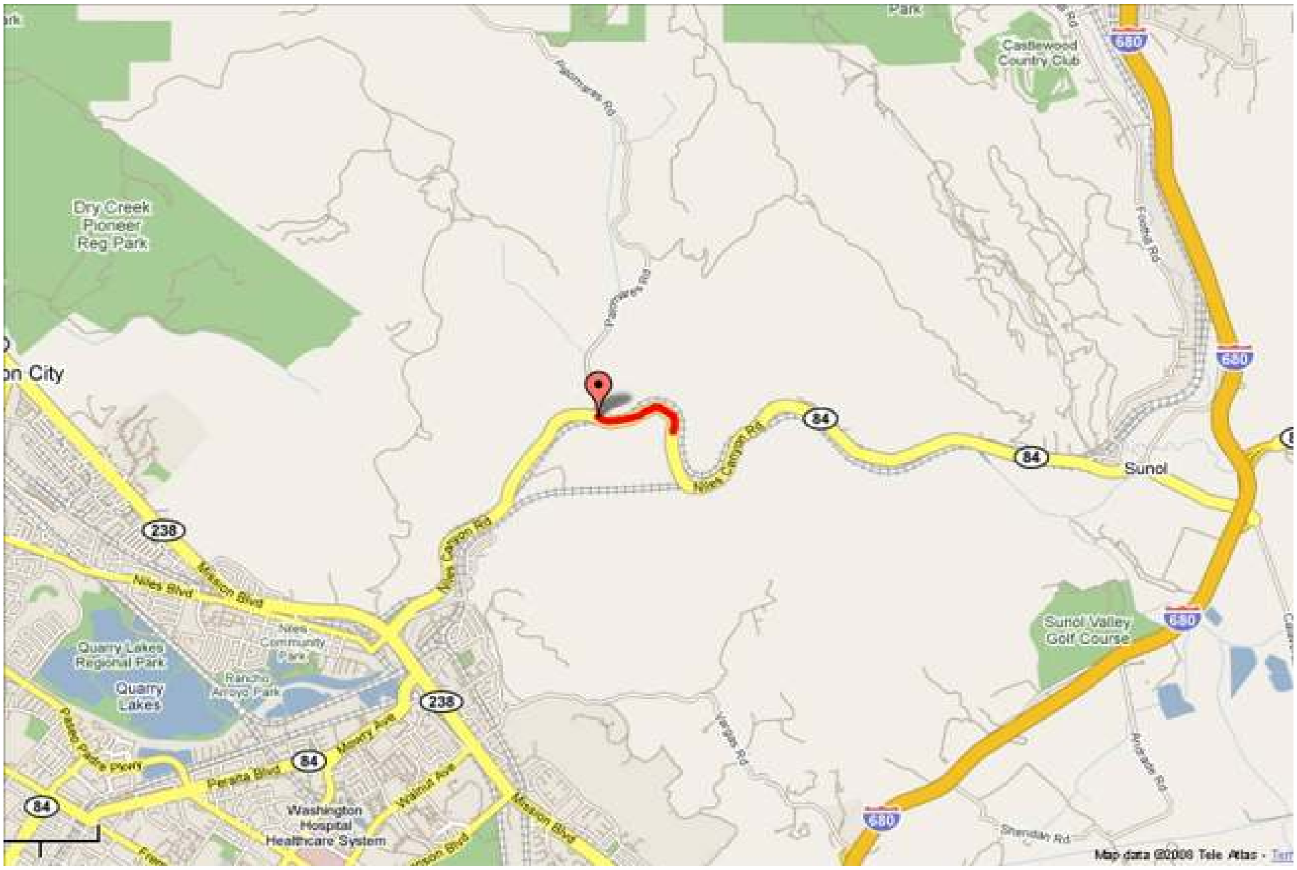
Construction Cost	$ 34.2 M
Right-of-Way Cost	$ 1.8 M
	$ 36.0 M (2010)

Schedule:

- Approved PSR 2/28/2005
- Target Draft Env Doc Fall 2012
- Target Final Env Doc Spring 2013
- Target Final Design Spring 2015
- Target Right-of-Way Cert Spring 2015
- Target Start Construction Fall 2015
- Target End Construction Fall 2017

Niles Canyon 3 Project

The SR 84 Niles Canyon 3 project is a safety improvement project to the Alameda Creek Bridge (PM 13.0/13.6).



The existing Alameda Creek Bridge has non-standard shoulders and bridge railing, poor sight distance, is not adaptable to stage removal and widening, and is considered functionally obsolete. The purpose of the proposed project is to correct these deficiencies and improve traffic safety by replacing the existing bridge over Alameda Creek with a new bridge structure.

The project proposes to replace the Alameda Creek Bridge (#33-36) on SR 84 in Niles Canyon. The existing bridge will be replaced with a 410-foot-long bridge with one lane in each direction, centerline and shoulder rumble strips, and standard width shoulders. The project will construct two retaining walls approximately 800 feet and 950 feet in length on the east side of the bridge. The existing bridge and roadway approaches will be removed and the area will be used for environmental mitigation.

SR 84 at Alameda Creek Bridge – Simulated view of new bridge looking east toward Sunol

Construction Cost	$ 33.7 M
Right-of-Way Cost	$ 0.3 M
	$ 34.0 M (2010)

Target Schedule:

- Approved PS 12/31/2003
- Draft Env Doc Fall 2012
- Final Env Doc Summer 2013
- Final Design Spring 2015
- Right-of-Way Cert Summer 2015
- Start Construction Fall 2015
- End Construction Fall 2017

INFORMATION PROVIDED TO THE QRSA TEAM

The following project documents were provided to the QRSA team for their use during the study:

- Ala 84 Niles Canyon 1999-2010 TSAR Summary and Details
- Ala 84 Niles Canyon 3-yr accident rates between 2001 and 2010
- Ala 84 Niles Canyon Truck AADT from 1996-2010

- Niles Canyon 1 – Final Project Report
- Niles Canyon 1 – Final Negative Declaration
- Niles Canyon 1 – PS&E plan set and Cross-Sections
- Niles Canyon 2 – PSSR
- Niles Canyon 2 – Draft Environmental Impact Report/Environmental Assessment
- Niles Canyon 2 – Draft Project Report
- Niles Canyon 3 – PSSR
- Pleasanton-Sunol Road Intersection Analysis (Roundabout and Signalize Intersection)

Note: The information presented in this section of the report may have been excerpted either in part or in full from the documents/information provided to the QRSA team listed above.

PROJECT ANALYSIS

PROJECT ANALYSIS

SUMMARY OF ANALYSIS

The following analysis tools were used to study the project:

- Site Visit Observations
- Project Stakeholder Issues
- Function Analysis
- Roadside Safety Audit Safety Issues
- Existing Conditions Road Safety Review
- Countermeasures Evaluation
- Countermeasures Strategies Evaluation

SITE VISIT OBSERVATIONS

The ERS expert documented the site visit observation along the corridor for safety issues. The following are some of the highlights of the site visit made in May 2012:

- Speed
    - 85^{th} percentile appears to be slightly above the average with an expectation of greater speeds east of the Alameda Creek BOH
    - Several horizontal curves with low speeds exist within the corridor
    - Passing zone west of Rosewarnes
- Roadside Barrier
    - Conditions exist within the corridor that impact effectiveness of metal beam guard rails (i.e., W-beam as referenced in the Road Safety Review Report) and concrete barriers
    - Bridge railing on the Alameda Creek BOH may not be crash worthy
- Roadside Hazards
    - Minimum CRZ available well below the AASHTO Roadside Design Guide guidelines
    - Throughout the corridor fixed objects are observed within the CRZ
    - Key hazards within the CRZ include the following: fixed objects (poles, trees, electrical installations, etc.), Rosewarnes Underpass, aggressive roadside slopes, shoulder erosion and deterioration
- Positive guidance issues exist throughout the corridor, such as:
    - Sign clutter at several locations
    - Signing for nighttime conditions, including the Pleasanton-Sunol Road Intersection

- Sign panels covered by overgrown vegetation were observed
  - Driver confusion between the mainline and exit lanes at the Silver Springs Underpass exit

- Main Street T intersection confusion between one-way stop versus three-way stop. Intersection operations concerns exist throughout the corridor as follows:
  - Mission Boulevard and Old Canyon Road Intersections have wide open paved areas and other concerns
  - Limited sightlines and skew angle concerns at the Palomares Road Intersection caused by the Farwell Underpass abutment
  - Kaiser Quarry intersection's left turn lane and the nearby at-grade crossing have operational concerns
  - End of queue concerns caused by intersection operations at the Main Street and Pleasanton-Sunol Road Intersections

- Alignment concerns consist of the following:
  - The Kaiser Quarry intersection has limited sightlines caused by the crest vertical curve and appears to have adverse superelevation
  - Lateral sightline obstructions exist on the curvilinear segments of the corridor caused by vegetation and backslopes that limit the sightlines to bicycles and disabled vehicles

- Cross section elements have the following concerns:
  - Shoulder discontinuities throughout the corridor reduce opportunities to accommodate maintenance vehicles, disabled vehicles, bicycles, and speed enforcement
  - Heavy trucks appear to off-track into the flush median at the low-speed curve locations

- Accommodating bicycles concerns include the following:
  - Niles Canyon Road is growing in popularity with both advanced and recreational bicyclists
  - The roadway alignment and cross section elements are an impediment to the accommodation of bicyclists at many locations within the corridor

For more details see the Road Safety Review Report in the *Appendix* of this report.

PROJECT STAKEHOLDER ISSUES

Over the course of the study, the following summarizes opposition to the Niles Canyon (1, 2, and 3) projects as explained to the VA team:

- The Niles Canyon 1 project was cancelled by an injunction filed by the Alameda Creek Alliance.

- The Niles Canyon 2 and Niles Canyon 3 environmental document preparation was voluntarily delayed by Caltrans due to similar concerns.

- Recent collision data (SWITRS) that has been made available at the request of the stakeholders indicates that traffic volumes/safety rates have gone down.

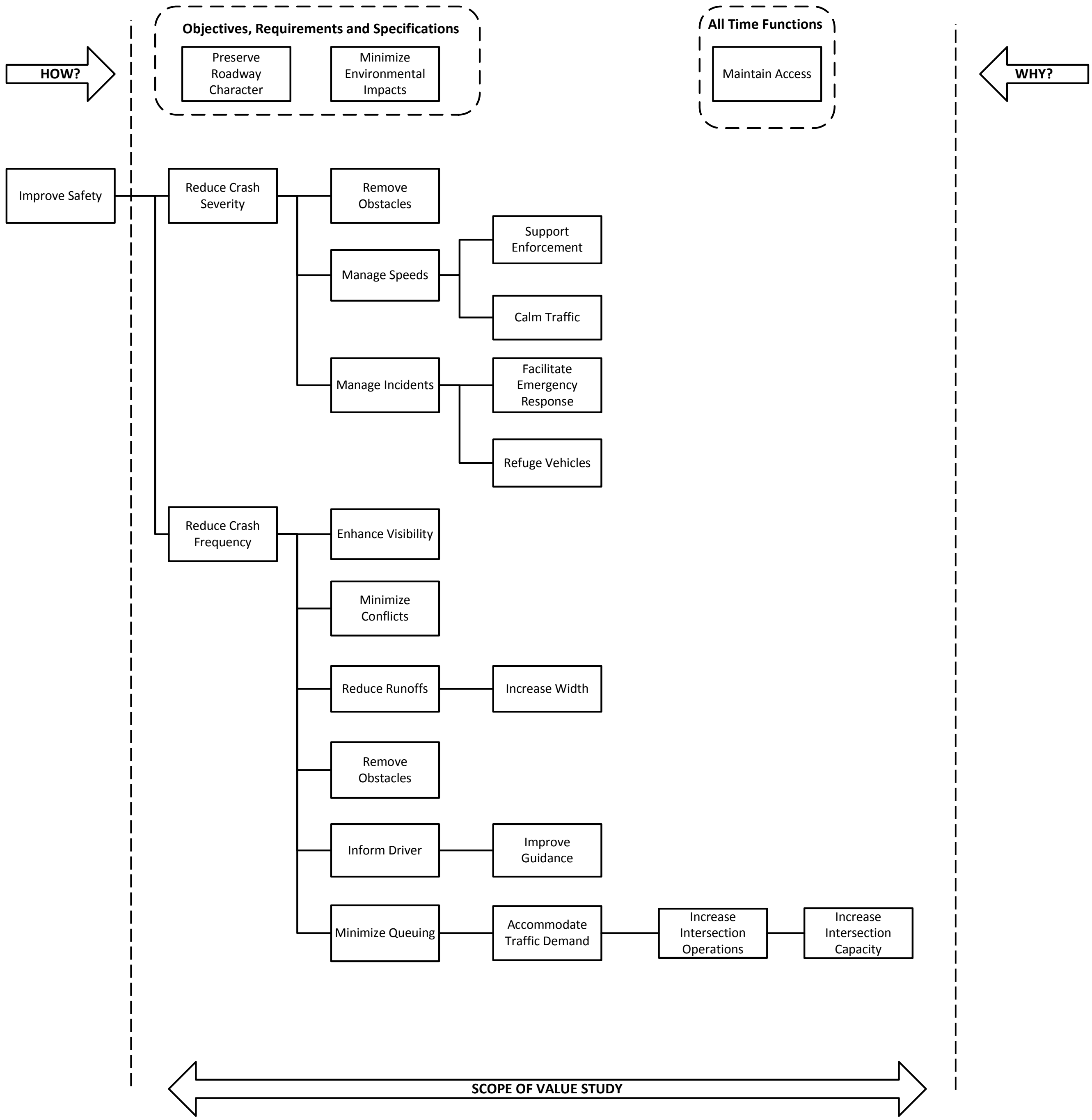
- Do the completed interim safety upgrades, such as the centerline rumble strip, negate the need for the proposed Niles 1, 2, and 3 improvements?
- Stakeholders have expressed a desire that speed management measures be implemented to reduce the critical operating speed within the corridor. Some related topics on this issue include:
  - A perception that wider shoulders generate increased speeds that lead to increased vehicle collisions and increased animal road kill
  - Could more law enforcement benefit speed management
- Over a long period of time the water quality of the Creek has been improved facilitating the restoration of the steelhead trout habitat and bay area drinking water source. Some incidental concerns by the stakeholders related to the Niles Canyon 1, 2, and 3 projects include:
  - Tree removal impacts to water quality
  - Increased roadway runoff volume and higher creek water temperature
- Creek cross sectional reduction on water quality. Stakeholders perceive that the Niles Canyon 1, 2, and 3 projects may change the character of the Canyon as it relates to the road's current feel (rural, winding, and scenic). As an example, some stakeholders expressed the desire to limit the use of retaining walls to reduce the visual impact/reduce the loss of rural feel in the project design.
- Some of the environmental resources that exist in the corridor include:
- Drinking water supply for the East San Francisco Bay cities
  - Species at Risk/Habitat Loss such as those that impact the following:
    - California Red-Legged Frog
    - Alameda Whipsnake
  - Consideration of wildlife crossing to reduce road kill of species at risk.
  - Cultural resources concerns within the corridor include:
    - Community was concerned with the loss of Eucalyptus trees at The Spot, an abandoned old campground between Alameda Creek Bridge and the Alameda Creek BOH Bridge
    - Historic steam railroad (Niles Canyon Railroad) on the uphill side
    - Two abandoned historical aqueducts:
      - Niles Canyon Aqueduct (also referred to as the Secret Sidewalk)
      - Vallejo Aqueduct (built in mid 1800's)
    - Historical Water Temple Monument – built circa 1910
    - Preserving of Alameda Creek as it currently exists would contribute to the corridor's Scenic Road status

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 analysis provided a greater understanding of the total project and how the project's performance, cost, time, and risk characteristics are related to the various functions identified.

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



ROADSIDE SAFETY AUDIT SAFETY ISSUES

The RSA team, from their site visit and analysis, identified 35 safety issues that were turned over to the VA team for further analysis, evaluation, and development. The following list identifies these issues:

Existing Condition Safety Issue
Vegetation is blocking signage and encroaching on roadway
Interchange at Sunol (signage and wayfinding for through traffic is not clear)
Traffic back-ups from the Main Street and Pleasanton intersections extend to the Sunol interchange underpass. Sightlines to the end of queue are limited.
Stop sign on eastbound approach to the Pleasanton Road intersection is not obvious at night
Bicycle safety and accommodation
Signage clutter
Passing zone west of Rosewarnes promotes high-speed approach to tight radius curves
Rosewarnes curves
Palomares intersection (sight distance, skew, signage)
Intersection at Old Canyon Road - wide uncontrolled expanse of pavement - skew angle
Variable consistency in type of pavement markers
Rock falls near Rosewarnes
Reflectivity of signage at Rosewarnes and Palomares flashing beacons
Lighting of key areas (intersections, Rosewarnes Underpass, Palomares)
Reflective markings on Rosewarnes Underpass piers
Superelevation deficiencies (Rosewarnes curves)
Flashing beacon location at Palomares Road intersection, Reflectivity of signage at flashing beacon
Rock wall presents a roadside hazard
Edgeline delineation is faded and inconsistent
Roadside barrier height, deflection distances, inconsistencies, end treatments
Limitations in areas for enforcements and maintenance pullouts
Missing chevrons on low-speed curves
Eucalyptus trees encroaching on roadway
Bridge railing (non-standard design, condition, transition to approach railing)
Headwalls in northeast quadrant at quarry intersection
At-grade rail crossing located in very close proximity to quarry intersection with SR 84
Shoulder widths are not consistent
Pavement edge drop-offs
Sight distance is limited at the quarry intersection due to a crest vertical curve
K-rail at Sims Park may direct an impacting vehicle into trees and utility poles
Sidewalks are provided at the Sunol Underpass - no continuity is provided
Retroreflectivity of pavement markings and delineators
Lack of consistency of curve signage
Speed management on approaches to intersections and low-speed curves
Limited clear zone provisions (fixed objects, critical side slopes)

Safety Issues without specific countermeasures addressed in the VA report include the following:

Existing Condition Safety Issue
Intersection at Old Canyon Road - wide uncontrolled expanse of pavement - skew angle
Variable consistency in type of pavement markers
At-grade rail crossing located in very close proximity to quarry intersection with SR 84
Pavement edge drop-offs
Retro-reflectivity of pavement markings and delineators
Interchange at Sunol (signage and wayfinding for through traffic is not clear)
Signage clutter
Reflectivity of signage and Rosewarnes and Palomares Road flashing beacon
Edge line delineation is faded and inconsistent
Missing chevrons on low-speed curves
Sidewalks are provided at the Sunol Underpass - no continuity is provided
Lack of consistency of curve signage

All other safety issues have been identified in the *Safety Improvement Countermeasures* section of this report.

EXISTING CONDITIONS ROAD SAFETY REVIEW

The VA team's ERS expert reviewed the site, analyzed available collision data, and identified safety needs within the SR 84 corridor between Mission Boulevard and I-680. As elaborated in the Road Safety Review, five spot locations were prioritized as needing attention along the corridor.

SPOT LOCATIONS

The following prioritized, top five, list of treatment locations were identified in the Road Safety Review Report (see the *Appendix* of this report for more detail).

1. Rosewarnes Underpass and its approaches (includes passing zone to the east):

    - A number of road safety issues were identified by the road safety audit. Some of these observations have been identified as having very high and high collision risk.
    - The collision diagrams identify a cluster of collisions at this location. The majority of these collisions involve personal injury.
    - Collision rate for fatal and injury collisions exceeds the state-wide average.
    - Collision rate for all collisions exceeds the state-wide average.
    - This location was highlighted in the severity-weighted collision rate analysis.
    - Predicted collision rate exceeds the state-wide average.

2. Low-speed curve in the vicinity of "The Spot":

- A number of road safety issues were identified by the road safety audit. Some of these observations have been identified as having very high and high collision risk.
- The collision diagrams identify a cluster of collisions at this location. The majority of these collisions involve personal injury.
- Collision rate for fatal and injury collisions exceeds the state-wide average.
- Collision rate for all collisions exceeds the state-wide average.
- This location was highlighted in the severity-weighted collision rate analysis.
- Predicted collision rate exceeds the state-wide average.

3. Palomares intersection/Farwell underpass and their approaches (includes vicinity of church access):

- A number of road safety issues were identified by the road safety audit. Some of these observations have been identified as having very high and high collision risk.
- The collision diagrams identify a cluster of collisions at this location. The severity of collisions at this location appears high, as the majority of reported collisions involve personal injury.
- Collision rate for fatal and injury collisions exceeds the state-wide average.
- Collision rate for all collisions exceeds the state-wide average.
- Intersection collision rate for Palomares Road exceeds the state-wide average for fatal and injury related collisions.
- This location was highlighted in the severity-weighted collision rate analysis.
- Predicted collision rate exceeds the state-wide average.

4. Main Street and Pleasanton-Sunol Road Intersections:

- A number of road safety issues were identified by the road safety audit. Some of these observations have been identified as having very high and high collision risk.
- The collision diagrams identify a cluster of low severity collisions between these intersections and several injury related collisions at the Pleasanton-Sunol Road Intersection.
- Collision rate for fatal and injury collisions exceeds the state-wide average.
- Collision rate for all collisions exceeds the state-wide average.
- Intersection collision rate for Main Street exceeds the state-wide average for all collisions.

- The intersection collision rate for Pleasanton-Sunol Road exceeds state-wide averages for fatal and injury, and all collisions.
- Predicted collision rate exceeds the state-wide average.

5. Alameda Creek Bridge:

- A number of road safety issues were identified by the road safety audit. Some of these observations have been identified as having a high collision risk.
- The collision diagrams identify a cluster of collisions in the vicinity of this structure. The majority of collisions at this location involve hit objects. Rollover, sideswipe, and broadside collisions were also reported. Collision severities involve both injury and property-damage-only collisions.
- Collision rate for fatal and injury collisions exceeds the state-wide average.
- Collision rate for all collisions exceeds the state-wide average.
- Predicted collision rate exceeds the state-wide average.

OTHER ISSUES

In addition to the spot locations identified above, there are a number of corridor-wide road safety issues that were identified as part of the Prioritized Road Safety Audit Findings and Collision Pattern Analysis lines of evidence that require careful consideration. These include:

Accommodation of Bicycles: Collision data for the study period indicates 2% of reported collisions involved cyclists. Stakeholders have reported that bicycling on this section of roadway is gaining popularity. Of particular concern was a statement that indicated this route is gaining popularity with less skilled recreational riders. This is a significant concern as portions of the existing roadway do not have shoulders wide enough to safely accommodate cyclists and many curvilinear sections of the road have limited sightlines. Collisions involving a cyclist and a vehicle operating at a speed of 48 mph will likely result in severe injury or fatality.

Roadside Design Issues: These issues include inadequate clear zone provisions, the presence of roadside hazards, and barrier deficiencies. A review of the reported collision history for the study period indicates that collisions involving the roadside (37% hit objects and 15% overturn) appear to have the greatest impact on the facility’s road safety performance.

Shoulder Discontinuities: These shoulder discontinuities can adversely impact the recovery of vehicles that lose control and depart the roadway and limit opportunities to accommodate disabled vehicles, bicycles, and police enforcement.

Vegetation: Vegetation is obstructing existing warning signs and creating lateral sightline obstructions at horizontal curves. This is of particular concern at locations that exhibit a reduced shoulder width as sightlines to a disabled vehicle or cyclist may be restricted.

For detailed information on the evaluation of the existing corridor's safety need, refer to the Road Safety Review Report in the *Appendix* of this report.

COUNTERMEAUSURES EVALUATION

The VA team's ERS expert quantified the safety benefit for every developed countermeasure. The chart on the following pages identifies the tradeoff between safety benefit versus environmental impact for each of the countermeasures developed in the short-term, medium-term, long-term, and community vision categories.

ID No.	Idea Description	Annual Collision Reduction using 2012 Horizon Year		Environmental Impacts
		2012	Comments	
Short-Term Countermeasures				
AN-2	Install active warning system to alert motorists to bikes on roadway	0.03		Minimal environmental impacts
AN-5	Install sharrows on shoulders or lane edges at select locations to demonstrate potential bicycle usage	-	Although this measure offers no measureable change in collision frequency, it could be combined with the activated warning system in AN-2 to potentially improve likelihood of achieving a road safety benefit.	Minimal environmental impacts
C-1	Install friction treatment to pavements at low-speed curves and in icy areas	0.19		Minimal environmental impacts
AN-3	Install warning signs for roadway narrowing and shoulder reduction	-	No measureable change in collision frequency is expected.	Minimal environmental impacts
IO-8	Install mirrors at Palomares Road to view westbound traffic	0.03		Minimal environmental impacts
IO-9	Relocate flashing beacon at Palomares Road further to the east	-	Consider modifying signage at the existing location.	Minimal environmental impacts
IO-11	Install ITS elements at Palomares Road to signal drivers of approaching vehicles	-	No measureable change in collision frequency is expected.	Minimal environmental impacts
IO-17	Lighting of key areas	0.14		Minimal environmental impacts
P-1	Eliminate passing zone adjacent to low-speed curves	0.22		Minimal environmental impacts
R-5	Install steel mesh netting on slopes in rock fall areas	-	Not quantified. Potential for decrease in collision likelihood.	Potential aesthetic/visual impacts to scenic corridor Disturbs the uplands habitat
R-12	Address guard rail and k-rail end treatments	-	Although there is no change in collision likelihood associated with this safety improvement, there will be a reduction in the resulting collision severity.	Minimal environmental impacts

ID No.	Idea Description	Annual Collision Reduction using 2012 Horizon Year		Environmental Impacts
		2012	Comments	
Short-Term Countermeasures				
R-14	Upgrade roadside protection appurtenances	-	Although there is no change in collision likelihood associated with this safety improvement, there will be a reduction in the resulting collision severity.	Minimal environmental impacts
R-15	Relocate select fixed objects immediately adjacent to roadway	0.15	Approximate annual collision cost reduction = $54,800.	Potential impacts relative to tree removal Cultural impacts relative to Eucalyptus tree removal (community resource) Native species could to be replanted in the vicinity (but offset from the travelway) in support of Niles' Canyon endemic
SIMA-1	Install reflective material on underpass abutments	0.27		Minimal environmental impacts
SIMA-2	Install reflective material on curbs and rock walls adjacent to roadway	0.43		Minimal environmental impacts
SIMA-3	Install dynamic active warning device for queuing conditions	0.13		Minimal environmental impacts
SPMA-2	Install speed feedback sign and longitudinal pavement markings at low-speed curves	0.42	Reduction calculated for both SPMA-2 and SPMA-3	Minimal environmental impacts
SPMA-3	Narrow lane widths to 11 feet and reapportion to shoulder			
Medium-Term Countermeasures				
Rosewarnes UP Countermeasures				
R-4	Relocate the pier adjacent to the WB lane at Rosewarnes Underpass	0.84		Aesthetic impacts relative to retaining structure Potential impacts to historical railroad Potential impacts to upland trees and habitat Opportunity to use vacated area for water catchment/treatment Potential temporary impacts to creek habitat during construction Requires temporary shut down of the railroad to accommodate construction

ID No.	Idea Description	Annual Collision Reduction using 2012 Horizon Year Analysis Results 2012	Comments	Environmental Impacts
Medium-Term Countermeasures				
Rosewarnes UP Countermeasures				
R-9	Bifurcate the roadway at Rosewarne Underpass with new viaduct constructed to the south	-0.21	The avoidance of head-on and side swipe collisions provided by the installation of the median barrier does not compenstate for the increased collision potential associated with the introduction of the median barrier and crashworthy end-treatments.	Requires constructing roadway into creek Reduced impacts to historic railroad Historic railroad can remain operational throughout construction
RO-1	Construct tunnel into slope at Rosewarnes and realign roadway accordingly	0.19		Increased impacts to upland trees and habitat Requires less temporary shut down of the railroad to accommodate construction Increased opportunity to use vacated area for water catchment/treatment Potential impacts to historic aqueduct in vicinity of Rosewarnes
Farwell UP / Palomares Road Intersection				
IO-2	Realign Palomares Road to join church driveway	0.05		Right of way acquisition required Potential impacts to church property Potential impacts to Stoneybrook Creek (steelhead trout habitat) Potential tree removal Reclamation of existing Palomares Road for permeable area improves water quality
IO-5	Relocate the railroad abutment at Farwell Underpass to improve sight distance	0.18		Impacts to historic railroad Requires temporary closure of the railroad
Alameda Creek Bridge				
C-2 (A)	Correct superelevation at low-speed curves	0.07	Collision reduction is combined from C-2(A) and C-2(B)	Minimial impacts as fill and AC would be accomplished within existing footprint
ACB-2	Replace Alameda Creek Bridge	0.37		Requires placing new piers in Alameda Creek, but removes pier from active channel

ID No.	Idea Description	Annual Collision Reduction using 2012 Horizon Year		Environmental Impacts
		2012	Comments	
Medium-term Countermeasures				
Alameda Creek Bridge BOH				
ALCRB0-1	Remove curb on Alameda Creek Bridge OH	0.17	Results in a significant reduction in collision severity (60% -92% fatal &30%-92% injury collisions	Aesthetic impacts relative to bridge rail, however, see-through railing is proposed to mitigate visual impacts Impacts to historic structure (Alameda Creek BOH)
Pleasanton-Sunol Road / Main Street Intersections / End of Queue				
IO-1	Construct a roundabout at the intersection of SR-84 and Sunol/Pleasanton	0.29	Benefit obtained from reduction in rear-ends associated with the existing road's end of queue condition	Potential impacts to historic Water Temple gates Potential tree removal Potential impacts to fruit stand (access, potential relocation) ROW acquisition Pedestrian accommodation issues
IO-15	Install signalized intersection at Pleasanton-Sunol Road	-0.52	Signalized intersection has increased collision potential as compared to a roundabout. The end of queue provides same benefit as the roundabout countermeasure.	Potential tree removal Reduced ROW acquisition
Speed Management				
SPMA-4/ SW-3	Provide widened locations at strategic spacing to accommodate enforcement and pull overs	0		Minimial impacts as fill and AC would be accomplished within existing footprint Minor impacts relative to increased runoff potential from increasing
Long-Term Countermeasures				
RO-3	Widen roadway to provide roadway cross-section of 12' lanes, 8' shoulders, and spot widening for CRZ	1.31		Not evaluated for environmental impacts.
IO-13	Correct superelevation and vertical sight distance at Quarry road intersection	0.02		Not evaluated for environmental impacts
QI-1	Extend the EB left turn pocket at the Quarry intersection	0.01		Not evaluated for environmental impacts
Community Vision				
AN-4	Separate non-motorized traffic to off-roadway trail system	Not quantified		Not evaluated for environmental impacts
AN-6	Provide bike path adjacent to railroad grade	Not quantified		Not evaluated for environmental impacts
RE-1	Designate Niles Canyon as a park and install toll booths on each end	Not quantified		Not evaluated for environmental impacts

COUNTERMEASURE STRATEGIES EVALUATION

Every countermeasure, not just those identified within the strategies shown below, should be carefully reviewed by the PDT. The ultimate decision on whether to pursue a countermeasure must be made upon further study by the District based on cost, environmental, and other factors before deciding which countermeasure is to be implemented.

The information provided below provides an overview of how to organize select countermeasures within similar time frames- i.e. short-term, medium-term, long-term. The selection of the countermeasure category was mainly based on safety benefit, except in the case of the Rosewarnes Underpass and Palomares Road/Farwell Underpass in the medium-term category. At those locations, the selection of the team's preferred countermeasures, were also predicated on minimizing the environmental impacts to the Alameda Creek banks.

Safety Improvement Strategy: Short-Term

These countermeasures are shorter term measures that improve safety with less environmental impact, and address features such as improved positive guidance, removing/ protecting roadside hazards, better identification of roadside hazards, minor intersection improvements, and upgrading roadway appurtenances. The following short-term countermeasures were assembled into a preferred strategy, from the perspective of the QRSA team:

- AN-2 Install active warning system to alert motorists to bikes on roadway
- AN-5 Install sharrows on shoulders or lane edges at select locations to demonstrate potential bicycle usage
- C-1 Install friction treatment to pavements at low-speed curve locations
- IO-8 Install mirror on the Farwell Underpass pier to alert vehicles at the Palomares Road Intersection
- IO-11 Install ITS elements at Palomares Road to signal drivers of approaching vehicles
- IO-17 Lighting of key areas (Rosewarnes Underpass, Palomares Road Intersection/Farwell Underpass)
- P-1 Eliminate passing zone adjacent to low-speed curves
- R-5 Install steel mesh netting on slopes in rockfall areas
- R-12/R-14 Upgrade roadside protection appurtenances and address guard rail and K-rail end treatments
- R-15 Relocate select fixed objects immediately adjacent to roadway
- SIMA-1 Install reflective material on underpass abutments
- SIMA-2 Install reflective material on curbs and rock walls adjacent to roadway
- SIMA-3 Install dynamic active warning device for queuing conditions
- SPMA-2/3 Install speed feedback sign and transverse pavement markings at low-speed curves

The following were not selected for inclusion in the preferred strategy for short-term countermeasures as it showed little to no safety benefit:

- IO-9 Modify flashing beacon at Palomares Road to indicate intersection is further to the east

The following table identifies the safety benefit organized by spot location for the short-term countermeasures preferred by the team. This table takes into account combined safety benefit of all the countermeasures (see the *Appendix* of this report for additional information).

Short-Term Countermeasures						
Location	**Countermeasures Applied**	**Annual Collision Frequency (2012)**		**Collision Rate (per mvm)**		**% Collision Reduction**
		Before	**After**	**Before**	**After**	
Rosewarnes underpass	- Lighting of key areas (IO-17) - Install active warning system to alert motorists to bikes on roadway (AN-2) - Install friction treatment to pavements at low-speed curves and in icy areas (C-1) - Install reflective material on underpass abutments (SIMA-1) - Install speed feedback sign and longitudinal pavement markings at low-speed curves; narrow lane widths to 11 feet and reapportion to shoulder (SPMA-2&3)	0.41	0.30	1.33	0.97	27%
Between Rosewarnes underpass & Palomares Rd	- Install reflective material on curbs and rock walls adjacent to roadway (SIMA-2) - Eliminate passing zone adjacent to low-speed curves (P-1)	1.85	1.48	1.10	0.88	20%
Palomares Rd & Farwell underpass	- Install mirrors at Palomares Road to view westbound traffic (IO-8) - Lighting of key areas (IO-17) - Install active warning system to alert motorists to bikes on roadway (AN-2) - Install friction treatment to pavements at low-speed curves and in icy areas (C-1) - Install reflective material on underpass abutments (SIMA-1) - Install speed feedback sign and longitudinal pavement markings at low-speed curves; narrow lane widths to 11 feet and reapportion to shoulder (SPMA-2&3)	1.44	1.03	1.95	1.40	28%
Between Farwell underpass & Alameda Creek Bridge	- Install reflective material on curbs and rock walls adjacent to roadway (SIMA-2)	1.93	1.75	1.30	1.18	9%
Alameda Creek Bridge to Alameda Creek BOH	- Install active warning system to alert motorists to bikes on roadway (AN-2) - Install friction treatment to pavements at low-speed curves and in icy areas (C-1) - Install speed feedback sign and longitudinal pavement markings at low-speed curves; narrow lane widths to 11 feet and reapportion to shoulder (SPMA-2&3)	6.49	6.00	0.95	0.88	8%
East of Alameda Creek BOH (0.2 miles)	- Install reflective material on curbs and rock walls adjacent to roadway (SIMA-2)	0.82	0.74	0.72	0.65	9%
Between Silver Springs UP and Pleasanton-Sunol intersection	- Install dynamic active warning device for queuing conditions (SIMA-3)	1.29	1.16	0.74	0.67	10%
	Total collision frequency	**14.23**	**12.47**			
		Δ	**1.76**			

Table 1: Quantitative Road Safety Analysis of Short-Term Countermeasure Strategy (2012)

Safety Improvement Strategy: Medium-Term

The following countermeasures were implemented for the medium-term preferred strategy, from the perspective of the team:

Rosewarnes Underpass Spot Improvements

- RO-1 Realign Road and Construct Tunnel into Slope at the Rosewarnes Underpass

Palomares Road/ Farwell Underpass Spot Improvements

- IO-2 Realign Palomares Road to join church driveway

Alameda Creek Bridge Spot Improvements

- ACB-2 Replace Alameda Creek Bridge to upgrade the approach curves

Low-Speed Curve Located Between Alameda Creek and Alameda Creek BOH Bridges Soft Improvement East of The Spot

- C-2 Correct superelevation at low-speed curve between the two project bridges
- C-3 Widen roadway curve east of Alameda Creek Bridge to accommodate off-tracking

Alameda Creek Bridge BOH Spot Improvements

- ALCRB0-1 Remove curb on Alameda Creek Bridge BOH

Pleasanton-Sunol Road/SR 84 Intersection

- IO-1 Construct a roundabout at the intersection of SR 84 and Pleasanton-Sunol Road

Facilitate Corridor Enforcement

- SPMA-4/SW-3 Provide widened locations at strategic spacing to accommodate enforcement and pullovers

The Phase 2 countermeasures listed below were not selected for the following reasons:

- R-4: Relocate the Pier Adjacent to the westbound lane at Rosewarnes Underpass

  This countermeasure was not selected as it had the greatest impact to the historic Niles Canyon Railroad.

- Countermeasure R-9 Bifurcate the roadway at Rosewarnes Underpass with new viaduct constructed to the south

  This countermeasure was not selected due to its lower safety benefit and negative impacts to water quality

- IO-5: Relocate the Railroad Abutment at Farwell Underpass to Improve Sight Distance

  This countermeasure had the greatest impact to the historic Niles Canyon Railroad.

- IO-15: Install Signalized Intersection at Pleasanton-Sunol Road.

  This countermeasure was not selected for the strategy because it had a lower safety benefit and unlike the roundabout, did not contribute to speed management within the vicinity of Sunol; it also was found to have a lower level of service.

The following table identifies the safety benefit organized by spot location for the medium-term countermeasures preferred by the team. This table takes into account combined safety benefit of all the countermeasures.

Medium-Term Countermeasures							
Location	Countermeasures Applied	Annual Collision Frequency (2012)		Collision Rate (per mvm)		% Collision Reduction
		Before	After	Before	After	
Rosewarnes underpass	- Construct tunnel into slope at Rosewarnes and realign roadway accordingly (RO-1)	0.30	0.11	0.97	0.37	62%
Palomares Rd & Farwell underpass	- Realign Palomares Road to join church driveway (IO-2)	1.03	0.98	1.40	1.33	5%
Alameda Creek Bridge	- Replace Alameda Creek Bridge (ACB-2)	1.87	1.42	0.27	0.21	24%
Low Speed curve in the vicinity of "The Spot"	- Widen roadway at low speed curve at the Spot to accommodate off-tracking (C-3) - Correct superelevation at low-speed curves (C-2)	0.40	0.31	1.39	1.07	23%
Alameda Creek BOH	- Remove curb on Alameda Creek BOH and upgrade rail (ALCRBO-1)	0.83	0.66	0.79	0.63	20%
Between Silver Springs UP and Pleasanton - Sunol intersection	- Construct a roundabout at the intersection of SR-84 and Sunol-Pleasanton (IO-1)	1.16	0.87	0.67	0.50	25%
	Total collision frequency	5.59	4.36			
		Δ	1.24			

Table 2: Quantitative Road Safety Analysis of Mid-Term Countermeasure Strategy (2020)

Safety Improvement Strategy: Long-Term & Community Vision

The long-term road safety and community vision countermeasures were not organized into strategies, as these countermeasures are long-term measures and subject to significant need and change over time. They were also not evaluated as a bundled strategy as the need for their implementation is not a high priority, and in many cases involves a long-term regional approach to their implementation.

Location	Mileage	Collision Rate Reduction (ACC/MVM)	
		Short-Term	Medium-Term
Rosewarnes UP & Approaches	0.055	27%	62%
Between Rosewarnes UP & Palomares Road	0.300	20%	5%
Palomares Rd / Farwell UP & Approaches	0.132	28%	24%
Between Farwell UP & Alameda Creek Br.	0.273	9%	-
Alameda Creek Bridge	0.300	-	24%
Alameda Creek Bridge to Alameda Creek Bridge BOH	0.956	8%	23%
East of Alameda Creek Bridge (0.2 miles)	0.209	9%	-
Alameda Creek Bridge BOH	0.193		20%
Between Silver Springs UP & Pleasanton-Sunol Intersection	0.318	10%	25%
Aggregating the impact at the Spot Locations	**2.74**	**12%**	**22%**

Table 3: Corridor Safety Benefit (2012) for Short-Term and Medium-Term Countermeasures

Table 3, above, locates the spots within the corridor, where the short-term countermeasures (Table 1) and medium-term countermeasures (Table 2) are concentrated. This table summarizes the safety benefit, expressed in percentage, for a particular location.

For example, at Rosewarnes Underpass and Approaches location, Table 4 shows:

- The short-term countermeasures reduce the collision rate by 27%.
- The medium-term countermeasures reduce the collision rate by an additional 62%.
- The countermeasures are applied to a 0.055-mile roadway segment.

The sum benefit, within these nine concentrated locations, a distance of only 2.74 miles out of the total corridor's 7.1 miles, is as follows:

- The short-term countermeasures are reduced by 12%.
- There is an additional 22% collision rate reduction for the medium-term countermeasures.

The countermeasures developed and evaluated in this study should not be considered the end of the search for good project solutions. The analysis of them, in fact, should stimulate improvements to them, or new ideas that may better address safety benefit, reduce environmental impacts, simplify construction or reduce capital investment.

The short-term and medium-term countermeasures should only be taken as suggestions, at this point in time, as they represent one of many ways to improve the safety at the prioritized locations identified by the safety need analysis

IDEA EVALUATION

IDEA EVALUATION

The ideas generated were carefully evaluated, and project-specific attributes were applied to each idea to assure an objective evaluation.

EVALUATIVE CRITERIA

The following are key evaluative criteria identified for this project and used to assist the VA team in evaluating the ideas:

- Highway Safety
- Natural Environment
- Human Environment
- Maintainability
- Constructability

The QRSA team enlisted the assistance of the stakeholders and project team (when available) to develop these attributes so that the evaluation would reflect their specific requirements.

EVALUATION PROCESS

The QRSA team generated and evaluated ideas on how to perform the various project functions using other approaches. The idea list was grouped by function or major project element. Each idea was evaluated with respect to the functional requirements of the project. Performance, cost, time, and risk may also have been considered during this evaluation.

Each idea was evaluated using a simple “Dismiss” or “Develop” according to the opinion of the QRSA Team, based on whether the safety benefits outweighed the impacts to the other evaluative criteria. Rationale for dismissal is also included for each item not carried forward into development. The following Overall Rating codes were used to evaluate each idea.

DEV: *Develop as a Countermeasure*

DIS: *Dismiss Idea- do not carry forward as a Countermeasure*

ABD: *Already Being Done*

IDEA SUMMARY

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

Idea Code	Creativity Target
ACB	Alameda Creek Bridge
ALCRBO	Alameda Creek BOH

Idea Code	Creativity Target
AN	Accommodate Non-Motorists
C	Highway Curves

Idea Code	Creativity Target
EE	Environmental Enhancement
IO	Intersection Operations
P	Passing Lanes
QI	Quarry Intersection (Kaiser)
R	Roadside

Idea Code	Creativity Target
RE	Recreation
SIMA	Signage Markings
SPMA	Speed Management
SW	Shoulder Width

This idea summary below includes additional information related to how each idea improves or degrades the elements of performance, cost, time (schedule), and risk. Only those elements where the idea differs from the baseline concept are included in this summary.

ACB-1: **Widen Alameda Creek Bridge and realign roadway to improve sight distance of approaches**

Overall Rating: **DIS**

General comments: Need to address this in a wider "swoop" that includes both curves at each end of the bridge.

ACB-2: **Replace Alameda Creek Bridge**

Overall Rating: **DEV**

General comments: This concept would improve the existing condition's the bridge's geometry that includes two tight curves in a broken-back configuration.

ACB-3: **Realign roadway to the north at east approach of Alameda Creek Bridge**

Overall Rating: **DIS**

General comments: Does not address the root problem - the reduced speed curve.

ALCRBO-1: **Remove curb on Alameda Creek BOH and upgrade rail**

Overall Rating: **DEV**

General comments: Given the standard bridge rail is as wide as the existing curb and rail, the amount of additional width provided is minimal. However, the safety benefits of the standard bridge rail would still improve safety.

AN-1: **Color contrast the shoulders**

Overall Rating: **DIS**

General comments: Color would have to be selected based upon acceptability for scenic highways. This treatment would be valid for short stretches only, to bring attention to changed conditions - not a good corridor-wide approach.

AN-2: **Install active warning system to alert motorists to bikes on roadway**

Overall Rating: **DEV**

General comments: None.

AN-3: **Install warning signs for roadway narrowing and shoulder reduction**

Overall Rating: **DIS**

General comments: Too many signs would be required due to variation in road widths. "Share the Road" signs are already in place. Would create sign clutter and with the high number of locations where this would occur would not be very effective. There is no expected reduction in collision frequency.

AN-4: **Separate non-motorized traffic to off-roadway trail system**

Overall Rating: **DEV**

General comments: Idea is a long-term consideration due to environmental impacts.

AN-5: **Install sharrows on shoulders or lane edges at select locations to demonstrate potential bicycle usage**

Overall Rating: **DEV**

General comments: Key locations would be between Alameda Creek Bridge and Alameda Creek BOH.

AN-6: **Provide bike path adjacent to railroad grade**

Overall Rating: **DEV**

General comments: Consider this concept to relocate (some) bicyclists and pedestrians off the roadbed.

AN-7: **Close the roadway in select locations during weekends for recreational use**

Overall Rating: **DIS**

General comments: Not a prerogative for a public road, private road has this option.

C-1: **Install friction treatment to pavements at low-speed curves and in icy areas**

Overall Rating: **DEV**

General comments: This is an alternative to increasing the super-elevation rate.

C-2: **Correct superelevations at low-speed curves**

Overall Rating: **DEV**

General comments: May increase speeds through the curves.

C-3: **Widen roadway at curve east of Alameda Creek Bridge to accommodate off-tracking**

Overall Rating: **DEV**

General comments: This is an alternative to increasing the curve radius to compensate for truck trailers that may off-track into the opposing lanes.

C-4: **Flatten the curve east of Alameda Creek Bridge**

Overall Rating: **DIS**

General comments: Both curves need to be addressed simultaneously and the existing curves exist in a broken-back configuration.

EE-1: **Install mechanical treatment of runoff prior to discharge to Alameda Creek**

Overall Rating: **DIS**

General comments: Conflicts with local water permitting policies. May conflict with Caltrans regulations on water treatment. Requires maintenance on treatment measures. Maintenance issues make this nonviable.

IO-1: **Construct a roundabout at the intersection of SR-84 and Sunol/Pleasanton**

Overall Rating: **DEV**

General comments: This concept is intended to address intersection safety issues and the end of queue issues under the Silver Spring UP.

IO-2: **Realign Palomares Road to join church driveway**

Overall Rating: **DEV**

General comments: This would increase the sight distance to the intersection obstructed by the Farwell UP bridge abutment.

IO-3: **Realign Palomares Road to east under railroad tracks**

Overall Rating: **DIS**

General comments: Would cause mainline rear-end potential. Very little room to accommodate the roundabout (would require footprint toward the creek) and hard to keep the grades across the roundabout under 4%).

IO-4: **Revise Palomares Road Intersection to allow right-out and left-in movements only**

Overall Rating: **DIS**

General comments: A dog-bone configuration doesn't seem to be warranted as the backup from the Pleasanton-Sunol Road would not likely stretch back to Main Street.

IO-5: **Relocate the railroad abutment at Farwell Underpass to improve sight distance**

Overall Rating: **DEV**

General comments: This would increase the restricted sight distance caused by the Farwell UP abutment, especially as it relates to the Palomares Road intersection.

IO-6: **Revise Palomares Road alignment to "square-up" the intersection with SR-84**

Overall Rating: **DIS**

General comments: Would trade rear-end collisions for side collisions in an area with limited sight distance.

IO-7: **Install roundabout at Palomares Road**

Overall Rating: **DIS**

General comments: Would create long back-ups west and east of Rosewarnes creating large rear-end potentials over long periods of time. Also questionable feasibility in the grades of the roundabout (need to be less than 4%).

IO-8: **Install mirrors at Palomares Road to view westbound traffic**

Overall Rating: **DEV**

General comments: Helps address the restricted sight distance caused by the Farwell UP abutment.

IO-9: **Relocate flashing beacon at Palomares Road further to the east**

Overall Rating: **DEV**

General comments: The existing location may be confused with the location of the church driveway.

IO-10: **Construct two roundabouts at adjacent intersections in Sunol**

Overall Rating: **DIS**

General comments: The option to use the church driveway is the better option, especially in light of the fact that the railroad is a cultural resource.

IO-11: **Install ITS elements at Palomares Road to signal drivers of approaching vehicles** — Overall Rating: **DEV**

General comments: ITS would be installed on SR-84 to warn WB traffic of vehicles entering at Palomares Road.

IO-12: **Install a "jug-handle" configuration for EB direction at Palomares Road Intersection** — Overall Rating: **DIS**

General comments: Hard to enforce and the eliminated movements are very low volumes.

IO-13: **Correct superelevation and vertical sight distance at quarry road intersection** — Overall Rating: **DEV**

General comments: The current geometrics seem to be deficient and may benefit from the proposed upgrades.

IO-14: **Relocate Water Temple gates away from intersection** — Overall Rating: **Combine**

General comments: Combined with other countermeasures.

IO-15: **Install signalized intersection at Pleasanton-Sunol Road** — Overall Rating: **DEV**

General comments: This concept is intended to address intersection safety issues and the end-of-queue issues under the Silver Springs UP (mutually exclusive with roundabout at this location). Roundabout may have improved intersection safety benefit over the signalized intersection.

IO-16: **Construct acceleration lane in WB direction at Palomares Road Intersection** — Overall Rating: **DIS**

General comments: Dismissed- this causes Alameda Creek impacts and does not address the intersection sight distance deficiency at this intersection for all the Palomares Road/SR-84 movements.

IO-17: **Lighting of key areas (Rosewarnes Undercrossing, Palomares Road Intersection/ Farwell UP)** — Overall Rating: **DEV**

General comments: This would provide nighttime safety benefits.

P-1: **Eliminate passing zone adjacent to low-speed curves**

Overall Rating: **DEV**

General comments: This could reduce head-on collision potential.

QI-1: **Extend the EB left turn pocket at the quarry intersection**

Overall Rating: **DEV**

General comments: The existing left-turn pocket should be investigated for greater storage and current bay taper standards.

R-1: **Implement one-way traffic control at Rosewarnes underpass**

Overall Rating: **DIS**

General comments: Not feasible. Would have great impacts on the creek and the uphill rock slope area.

R-2: **Realign roadway at Rosewarnes underpass to be normal to the railroad alignment**

Overall Rating: **DIS**

General comments: Cannot achieve without significant impact to both the creek banks and the upland rock slopes.

R-3: **Shave the pier adjacent to EB lane at Rosewarnes Underpass**

Overall Rating: **DIS**

General comments: Does not significantly change the offset distance from the edge of travelway.

R-4: **Relocate the pier adjacent to the EB lane at Rosewarnes Underpass**

Overall Rating: **DEV**

General comments: This concept would increase the sight distance currently restricted by the Rosewarnes UP abutment location.

R-5: **Install steel mesh netting on slopes in rockfall areas**

Overall Rating: **DEV**

General comments: Addressed rock fall in the roadbed – "hit object" potential.

R-6: **Install retaining structures on slopes in rockfall areas**

Overall Rating: **DIS**

General comments: R-5 can address collision potential without environmentally impacting the uplands area.

R-7: **Apply grout coating to slopes in rockfall areas**

Overall Rating: **DIS**

General comments: Other countermeasures (such as netting) are less invasive and similarly effective.

R-8: **Continue maintenance programs on slopes in rock fall areas**

Overall Rating: **ABD**

General comments: Already being done.

R-9: **Bifurcate the roadway at Rosewarnes Underpass with new viaduct constructed to the south**

Overall Rating: **DIS**

General comments: Impacts the creek with very little to no safety benefit.

R-10: **Install urban-style drainage and fill/pave side ditches at select locations**

Overall Rating: **DIS**

General comments: Rock nets would provide similar benefit without introducing a roadside hazard.

R-11: **Offset the centerline to one direction to improve sight distances**

Overall Rating: **DIS**

General comments: Rock nets would provide similar benefit without introducing less uphill.

R-12: **Address guard rail and k-rail end treatments**

Overall Rating: **DEV**

General comments: Review the current end treatments for effectiveness.

R-13: **Provide roadway cross section with 20' clear recovery zone including 8' shoulders**

Overall Rating: **DIS**

General comments: Consider countermeasures with less impact - i.e., select areas for std CRZ.

R-14: **Upgrade roadside protection appurtenances**

Overall Rating: **DEV**

General comments: Review the current roadside protection appurtenances for effectiveness.

R-15: **Relocate select fixed objects immediately adjacent to roadway**

Overall Rating: **DEV**

General comments: Review select objects within close proximity of the edge of travel way to reduce “hit object” collision potential.

RE-1: **Designate Niles Canyon as a park and install toll booths on each end**

Overall Rating: **DEV**

General comments: Consider as a long-term planning concept that may fit the community vision.

RO-1: **Construct tunnel into slope at Rosewarnes and realign roadway accordingly**

Overall Rating: **DEV**

General comments: This concept would increase the sight distance currently restricted by the Rosewarnes UP abutment location.

RO-2: **Upgrade non-standard bridge rails on Alameda Creek Bridge**

Overall Rating: **DIS**

General comments: Main issue is the alignment not the hazard of the curb/ non-safety railing type.

RO-3: **Widen roadway to provide roadway cross-section of 12' lanes, 8' shoulders, and spot widening for CRZ**

Overall Rating: **DEV**

General comments: This concept would be to provide standard CRZ and should be considered as a long-term solution (i.e., not driven by current safety need).

SIMA-1: **Install reflective material on underpass abutments**

Overall Rating: **DEV**

General comments: Reduces the collision potential of vehicles striking the underpass abutments.

SIMA-2: **Install reflective material on curbs and rockwalls adjacent to roadway**

Overall Rating: **DEV**

General comments: Reduces the collision potential of vehicles striking the curbs and walls.

SIMA-3: **Install dynamic active warning device for queuing conditions**

Overall Rating: **DEV**

General comments: This is a way to manage the active queue and reduce the end-of-queue rear-end collision potential.

SPMA-1: **Install tubular centerline delineators at Rosewarnes**

Overall Rating: **DIS**

General comments: Due to the curvilinear alignment, confined cross section and close proximity of the bridge abutments, the use of flexible delineators in the median is not recommended. This treatment may create a shy zone in the median that could result in drivers encroaching closer to the bridge abutments.

SPMA-2: **Install speed feedback sign and longitudinal pavement markings at low-speed curves**

Overall Rating: **DEV**

General comments: This concept is intended to address vehicles approaching the curves at higher rates of speed and may reduce the potential for roadway runoffs and other collision types.

SPMA-3: **Narrow lane widths to 11 feet and reapportion to shoulder**

Overall Rating: **DEV**

General comments: Similarly to SPMA-2, this concept can be used effectively to manage vehicular speed concerns.

SPMA-4: **Provide widened locations at strategic spacing to accommodate enforcement and pull overs**

Overall Rating: **DEV**

General comments: This is a speed management strategy.

SW-1: **Reduce pull out widths to discourage parking and pedestrian use along roadway**

Overall Rating: **DIS**

General comments: Vehicles need the pullout areas. The team understood that previous pull-out areas with parking and illegal dumping have been addressed in the past.

SW-2: **Stabilize/Harden the unpaved shoulders**

Overall Rating: ABD

General comments: Already being done.

SW-3: **Pave the existing unpaved shoulders at select locations**

Overall Rating:
DEV

General comments: Consider this to provide additional enforcement areas.

STUDY PROCESS

STUDY PROCESS

OVERVIEW

This is the third of three pilot studies employing combined Road Safety Audit / Value Analysis processes:

- Smith River, US-101 (November 2010)
- Yol-16 (March 2012)
- Ala-84, Niles Canyon 1, 2 and 3 Projects (May 2012)

This study, the Ala-84 safety improvement project, entailed the following three-pronged approach:

1. **Road Safety Audit (RSA) Workshop.** This workshop is carried out by a team consisting of Road Safety Experts, Traffic Operations Specialists, Highway Engineers, and selected other specialists. The workshop starts with a Kick-off Meeting, followed by a field investigation to evaluate the site under various traffic conditions and to identify surrounding land uses and road user types. An examination of historical collision data is also conducted as part of the audit to obtain details on the current road safety performance characteristics of the facility. All of this information is then used by the Audit Team to identify potential road safety risks. Road safety issues identified by the Audit Team, along with a description of the types of countermeasures that may be considered to improve safety performance, are then handed off to the VA Team members for consideration.

2. **Explicit Road Safety (ERS) Analysis.** Based on findings from the RSA, the explicit road safety experts quantify the project's safety need and provide prioritization guidance with regard to the safety issues identified by the RSA Team. This information is a critical input to the VA workshop as it identifies key road safety elements and the likely areas where road safety value might be gained. Using a variety of analytical tools and techniques, the Explicit Road Safety Experts also provided measures of the relative change in road safety performance that may be achieved from the implementation of the RSA's proposed countermeasures.

3. **VA Workshop.** While it is essential that safety be considered explicitly, it is not the only factor that will influence the final selection of countermeasures. With the project safety quantification in hand, the VA workshop completes the process by assessing the countermeasures and assembling them into project strategies with the input of additional disciplines, such as maintenance personnel, environmental planners, construction engineers, etc. The Value Methodology (VM) is a systematic approach to problem solving based on function analysis and supported by value metrics. Value metrics allows the study findings to be quantified in terms of the relationship of project performance to project resources. The VA study facilitated the input of a wide array of stakeholders, which in many cases included conflicting interests.

The Quantitative Road Safety Analysis is achieved by integrating the RSA, ERS and VM processes. The QSRA resulted in the following outcomes:

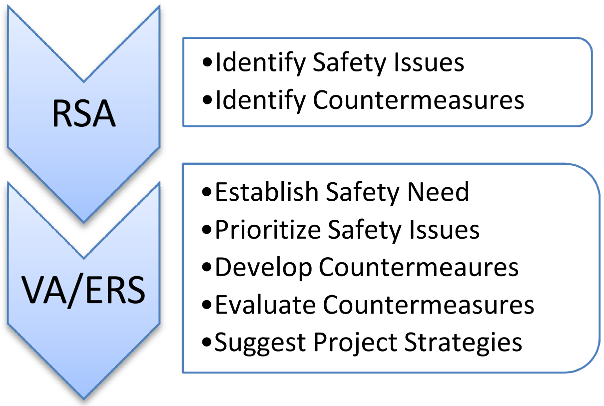


Figure 2: Quantitative Road Safety Analysis Study Process Outcomes

ROADSIDE SAFETY AUDIT PROCESS

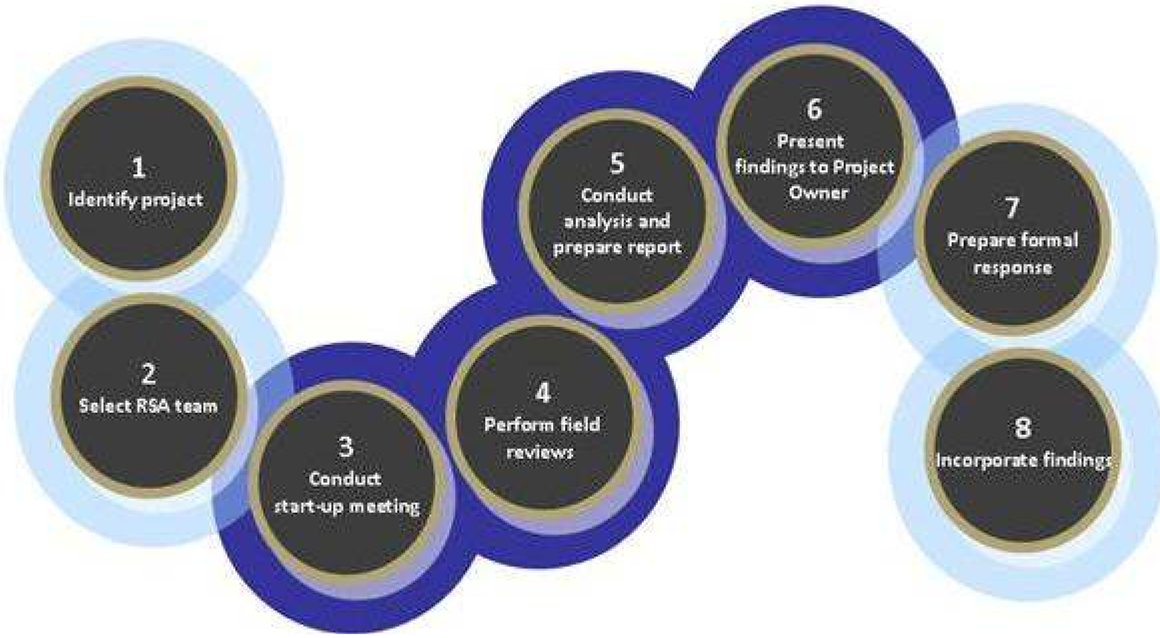
A Roadside Safety Audit is the formal safety performance evaluation of an existing or future road or intersection by an independent, multidisciplinary team. The RSA team:

- Conducts a proactive review of observed and potential safety issues to reduce risk
- Considers all environmental conditions
- Considers the safety of all road users

Roadside Safety Audits observe and identify the following:

- Road user characteristics
- Surrounding land uses
- Varying conditions

RSAs typically employ an eight-step process described below:



For more information on this process, see the separate RSA report.

VM PROCESS

A systematic approach, the Value Methodology, is used in the VA study. The key procedures followed were organized into three distinct parts: (1) Pre-Study Preparation, (2) VA Study, and (3) Post-Study Procedures.

PRE-STUDY PREPARATION

In preparation for the VA study, the team leader reviews critical aspects of the project and areas for improvement. In the week prior to the start of the VA study, the VA team reviews the documents provided by the designer to become better prepared for the study. In addition, performance attributes and requirements are initially identified that are relevant to the project.

VA STUDY

The Value Methodology (VM) Job Plan is followed to guide the teams in the consideration of project functionality and performance, potential schedule issues, high cost areas, and risk factors in the design. These considerations are taken into account in developing alternative solutions for the optimization of project value. The Job Plan phases are:

- Information Phase
- Function Phase

- Speculation Phase
- Evaluation Phase
- Development Phase
- Presentation Phase

Information Phase

At the beginning of the VA study, the design team presents a more detailed review of the design and the various systems. This includes an overview of the project and its various requirements, which further enhances the VA team's knowledge and understanding of the project. The project team also responds to questions posed by the VA team.

The project's performance requirements and attributes are discussed, and the performance of the baseline concept is evaluated.

Function Phase

Key to the VM process is the function analysis techniques used during the Function Phase. Analyzing the functional requirements of a project is essential to assuring an owner that the project has been designed to meet the stated criteria and its need and purpose. The analysis of these functions in terms cost, performance, time and risk is a primary element in a VA study, and is used to develop alternatives. This procedure is beneficial to the VA team, as it forces the participants to think in terms of functions and their relative value in meeting the project's need and purpose. This facilitates a deeper understanding of the project.

Speculation Phase

The Speculation Phase involves identifying and listing creative ideas. During this phase, the VA team participates in a brainstorming session to identify as many means as possible to provide the necessary project functions. Judgment of the ideas is 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 team, 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.

Evaluation Phase

The purpose of the Evaluation Phase is to systematically assess the potential impacts of ideas generated during the Speculation Phase relative to their potential for value improvement. Each idea is evaluated in terms of its potential impact relative to project evaluative factors, such as: safety benefit, constructability, maintainability, and environmental impacts.

Once each idea is fully evaluated, it is given a rating system of Develop/ Dismiss as explained as follows.

Develop	An idea is developed when in the subjective opinion of the VA team it has greater potential to provide benefits than impacts.
Dismiss	An idea is dismissed when in the subjective opinion of the VA team it has less potential to provide benefits of the concepts in relationship to its impacts.

Ideas found to have the greatest potential for value improvement, were further developed, and are documented in the *Countermeasures* section of this report.

Development Phase

During the Development Phase, the highly rated ideas are expanded and developed into countermeasures. The development process employed on this study was limited to project evaluative factors that include safety benefits relative to the existing conditions and impacts to the environment. This analysis is prepared as appropriate for each countermeasure. Each countermeasure describes the existing conditions and proposed changes and includes sketches and calculations, as appropriate.

Presentation Phase

The VA study concludes with a preliminary presentation of the VA team's assessment of the project. The presentation provides an opportunity for the owner, project team, and stakeholders to preview the alternatives and develop an understanding of the rationale behind them.

POST-STUDY PROCEDURES

A *Preliminary VA Study Report* is prepared after the completion of the workshop. This report summarizes the activities and results of the VA study. Once this report has been reviewed by the owner and project team, an implementation meeting is held in order to determine the disposition of the countermeasures presented therein. An implementation plan is developed for those accepted countermeasures, detailing actions, responsibilities, and key milestones for integrating them into the project. Countermeasures that are rejected include a summary of the reasons for their rejection. A *Final VA Study Report* is prepared once the implementation results are finalized.

EXPLICIT ROAD SAFETY PROCESS

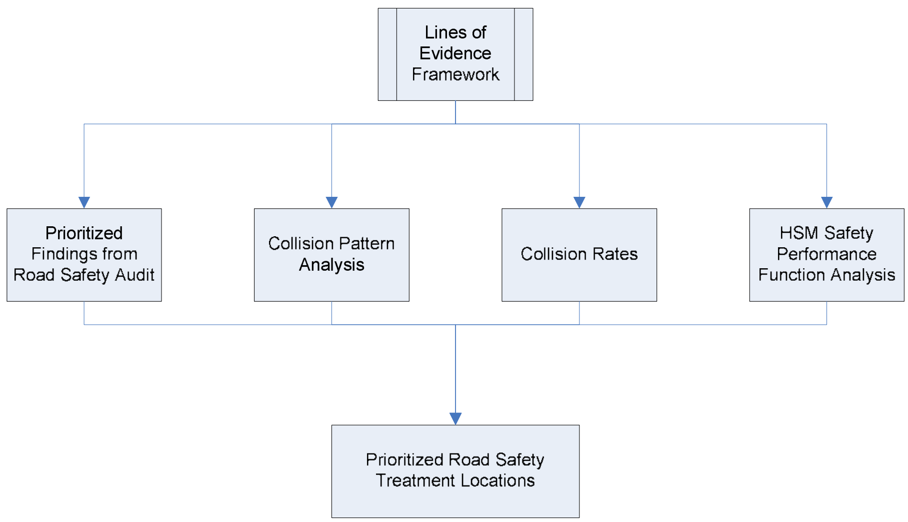
The focus of the explicit road safety analysis was to concentrate only on road safety issues only. The explicit road safety process employed on this study quantified and assessed:

1. The corridor's road safety need
2. The safety benefit of each of the suggested improvements (countermeasures)
3. The safety benefit of the combination of countermeasures bundled into project strategies

For this study the explicit road safety experts were requested to build on information provided as part of a Road Safety Audit of the corridor, conducted by the Federal Highway Administration. In the explicit road safety analysis, issues identified in the road safety audit were examined using quantitative analysis techniques to help the owner support design decisions. While it is essential that safety be considered explicitly during this process, it is not the only factor that will influence the final selection of project countermeasures.

<u>Safety Need</u>

The explicit road safety process employed on this study relied on four lines of evidence to identify the safety needs as described by the figure below.



Lines of evidence framework

The following summarizes the methods employed in the above lines of evidence

- Prioritized Findings from Road Safety Audit: Prioritizes the risk levels associated with each of the road safety issues identified by the RSA team based on a methodology drawn from the Australian Road Safety Audit Guide using collision frequency and severity.
- Collision Pattern Analysis: Examines crash causes and contributing factors using current, available collision data
- Collision Rate: Identifies locations on the facility likely to benefit from safety improvement, a sliding window methodology was applied to the collision rate analysis using current, available collision data
- HSM Safety Performance Functions: Predicted collision frequencies along the corridor were identified using Safety Performance Functions (SPF)

Safety Benefit of Countermeasures/Strategies

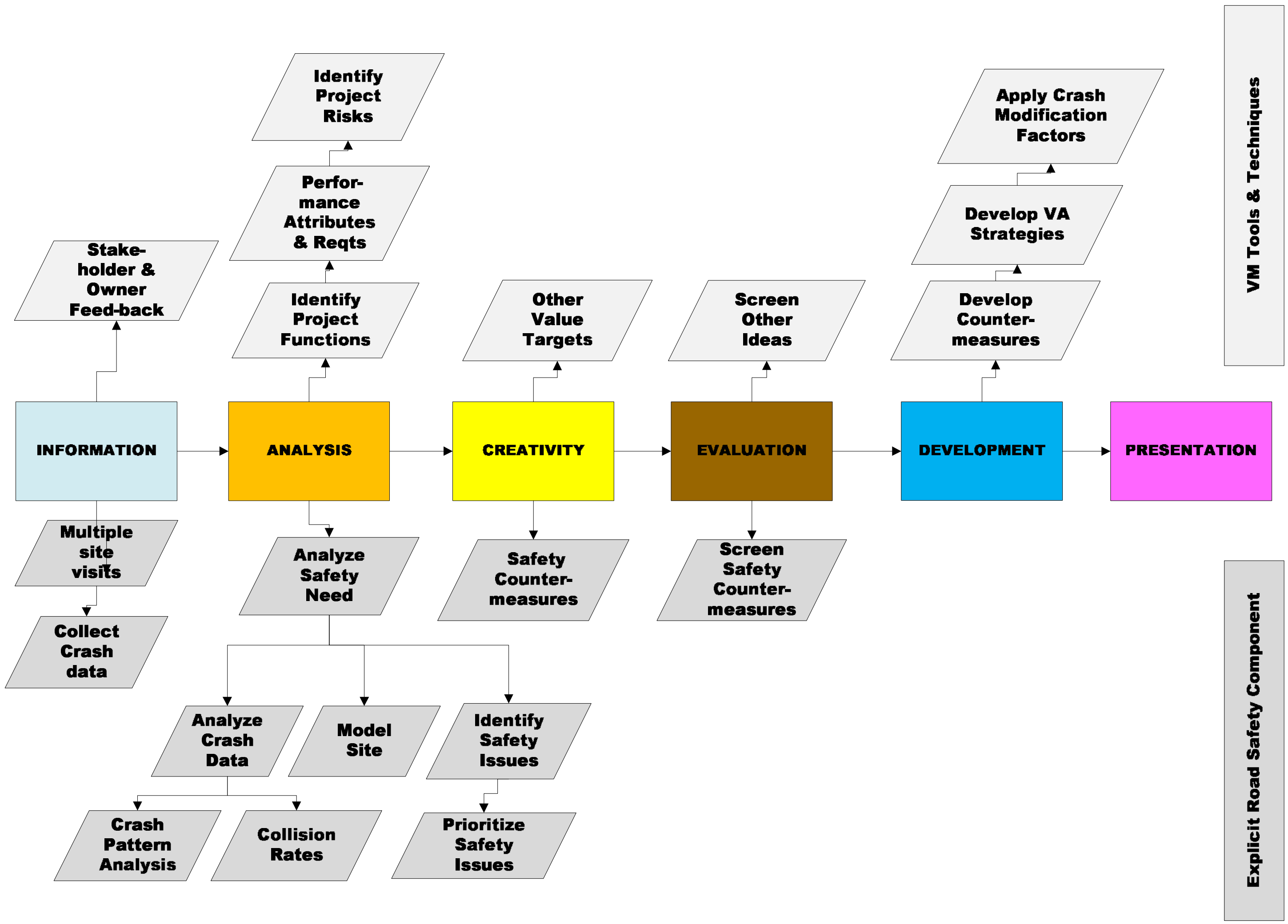
The explicit road safety expert next measures the safety benefit for each of the countermeasure developed to address the safety needs. Finally the countermeasures were organized into strategies based on safety benefit and environmental impact. These strategies were then assessed for safety benefit by the explicit road safety analysis.

INTEGRATED VM-EXPLICIT ROAD SAFETY PROCESSES

The Value Methodology was integrated with the Explicit Road Safety process in order to support the goals of the study to identify the corridor's safety needs and then to quantify the safety benefits of the countermeasures that addressed these needs. Some of the most important features of the combined processes include:

- Explicit Road Safety allows the identification and focus of safety in a VA study
- Explicit Road Safety Injects safety topics throughout all the VA job plan processes
- Provides quantification of safety need within the corridor
- Measures the safety benefit for the proposed countermeasures

The figure on the following page shows the VM job plan (see colored boxes in the middle of the figure) with the typical VM tools and techniques above and the Explicit Road Safety tools and techniques below.



Integrated VM-Explicit Road Safety Processes

CONFERENCE ROOMS

Kick Off & Presentation: 39550 Liberty St, Fremont (Niles Conference room)., Fremont, CA
Workshop Locations: Livermore Construction Office 3049 Independence Dr, Suite I, Livermore, CA
Presentation/ Dry Run Meeting: Caltrans District 4, 111 Grand Ave, Oakland- Room 15-230

PROJECT STAKEHOLDER ACTIVITY

(CITY OF FREMONT- NILES COFERENCE ROOM)

MONDAY, MAY 7, 2012

9:00 AM -11:30 PM **Kick-Off Meeting**

- Attended by all available stakeholders (RSA/VA Team, Caltrans staff, Stakeholders)
- Introductions (15 minutes)
- Overview of Agenda RSA/VA Process (15 minutes)
- Stakeholder Issues & Concerns (60 minutes)
- Break-out Session (60 minutes)

WEDNESDAY, MAY 9 (LIVERMORE CONSTRUCTION OFFICE)

1:00	RSA team prepares for Value Metrics Meeting
2:00 PM	VA team, RSA team and Key Project Development staff meet to establish Value Metrics (Project Performance Attributes and Requirements) - based on feedback from Owner and Stakeholders..
5:00 PM	Adjourn

THURSDAY, MAY 10 (LIVERMORE CONSTRUCTION OFFICE)

8:00 AM	Brainstorm Ideas based on Performance Attributes
10:00 AM	Evaluate New Non-Safety Ideas
12:00 PM	Lunch Break
1:00 PM	Alternative Development (VA Focus)
5:00 PM	Adjourn for the day

FRIDAY, MAY 11 (LIVERMORE CONSTRUCTION OFFICE)

8:00 AM	Alternative Development (continued)
12:00 PM	Lunch Break
1:00 PM	Alternative Development (continued)
3:00 PM	Review Application of Safety Quantification of Alternatives & Offsite Assignments
4:00 PM	Adjourn for the day

INTERIM PERIOD:
Offsite Alternative Development (part time continued development)

MONDAY, MAY 21, 2012 (CALTRANS DISTRICT 4- ROOM 13-220)

8:00	Team Review of Alternatives
12:00 PM	Lunch Break
1:00 PM	Develop VA Strategies
5:00 PM	Adjourn for the day

TUESDAY, MAY 22, 2012 (CALTRANS DISTRICT 4- ROOM 12-820)

8:00 AM	VA Team Meets
9:00 AM	Dry Run/ Feedback of Presentation to Stakeholders (**ROOM 15-230**)
12:00 PM	Lunch Break
1:00 PM	Carry out Value Metrics / Quantify Safety Improvement of VA Strategies
5:00 PM	Adjourn for the day

WEDSNESDAY, MAY 23, 2012

(CALTRANS DISTRICT 4- ROOM 12-923)

8:00 AM	Carry out Value Metrics / Quantify Safety Improvement of VA Strategies (continued)
11:00 AM	Travel to Fremont
12:00 PM	Lunch Break

STUDY FINDINGS PRESENTATIONS

WEDNESDAY, MAY 23, 2012 **(CALTRANS DISTRICT 4- ROOM 15-230**

9:30 -11:30 AM ***Presentation* to *Caltrans District 4 Management***

FRIDAY, JUNE 1, 2012 **(FHWA OFFICES, SACRAMENTO)**

9:00 -11:00 AM ***Presentation* to *FHWA/ Caltrans HQ Management***

Topics:

- Review the list of RSA/VA safety issues identified
- Review the Explicit Highway Safety analysis of corridor safety need
- Identify countermeasures developed for the safety issues
- Review the reduction of safety achieved by the countermeasure

MEETING ATTENDEES

Niles Canyon/State Route 84

QRSA Study

2012 May											
7	**8**	**9**	**10**	**11**	**21**	**22**	**23**	**1**	**NAME**	**POSITION/ROLE**	**ORGANIZATION**
X									Dan Reasor	Member	ACASC
X									Sandi Rivera		ACCDA
X		X							Jana Weldon	Senior Planner	Alameda County
X									Chris Miley	Supervisor's Aide	Alameda County
X									Paul Keener	Senior Transportation Planner	Alameda County Public Works Agency
X									Art Canrea		Alameda County Public Works Agency
X									Evan Buckland		Alameda County Water District
X					X				Cris Pena	Water Supply	Alameda County Water District
X									Rosie Walsh		Alameda Creek Alliance
X									Anne Chavez		Alameda Creek Alliance
X									John Cant		Alameda Creek Alliance
X									Martha Martin		Alameda Creek Alliance
X									Rocky Fernandez	District Director	Assembly Member Bob Wieckowski
		X	X	X					Oliver Iberien	Environmental	Caltrans
					X	X	X		Valerie Shearer	Environmental Analysis	Caltrans
							X		Ghulam Popal	Design	Caltrans
							X		Mary Smith	Env. Planning/Arch. History	Caltrans
							X		John Yeakel	Biology & Permits	Caltrans
							X		Saif Mamoon	Traffic	Caltrans
							X		Qi Leu	Design	Caltrans
							X		Tony Wong	Design	Caltrans
							X		Traci Ruth	Public Affairs	Caltrans
X		X	X	X					Frank Guros	Construction	Caltrans
X									Mark Zabaneh	District 4 Deputy District Director	Caltrans
		X	X	X			X		Mike Thomas	Design/Geometrics	Caltrans
X									Cristina Ferraz	District Division Chief - PM - East	Caltrans
X									Melanie Brent	Environmental Analysis	Caltrans
X		X	X	X	X	X	X		Keith Suzuki	Landscape Architecture	Caltrans
X							X		Jerry Ma	Project Design	Caltrans
X							X		Emily Tang	Senior Transportation Engineer	Caltrans
X							X		Roland Au-Yeung	Traffic	Caltrans
X									Jerry Champa	HQ Traffic Operations	Caltrans
								X	Robert Peterson	HQ Traffic Safety	Caltrans
X		X					X	X	Troy Tusup	HQ VA Manager	Caltrans
		X	X	X	X	X	X		Jayson Imai	Civil Engineer	City of Fremont
X									Jim Pierson	Public Works Director	City of Fremont
X									Tom Ruaril	City Engineer	City of Union City
		X	X	X					Michael Renk	Engineer	City of Union City
X	X	X	X	X	X	X	X	X	Geoff Millen	Road Safety Engineer	Delphi MRC
X	X	X							Keith Harrison	CSS/Human Factors	FHWA
			X	X	X	X	X	X	Jeff Holm	Highway Design	FHWA
X	X	X							Dave Cohen	Highway Safety	FHWA
X	X	X							Craig Allred	RSA Team Leader	FHWA
X									Wynn Kageyanu		Fremont Freewheelers Bicycle Club
X									Ann Rice	Treasurer	Friends of Coyote Hills
X									Bruce Cates		Local Ecology and Agriculture Fremont
X		X					X		Ron Kiaaina	Project Manager	Project Manager, District 4

MEETING ATTENDEES

Niles Canyon/State Route 84

QRSA Study

2012 May									NAME	POSITION/ROLE	ORGANIZATION
7	8	9	10	11	21	22	23	1			
X									Michelle Powell		Save Niles Canyon
X									Marsha Squires		Save Niles Canyon
X									Mike Dubinsky		Save Niles Canyon
X									Alicia Keiser		Save Niles Canyon
X									Shashana Chittle		Save Niles Canyon
X									Elka Rose Hadley		Save Niles Canyon
X									Roel Brown		Save Niles Canyon
X									Tom Browne		Save Niles Canyon
X									Mavis Brown		Save Niles Canyon
X									Jay Shellen		Save Niles Canyon
X									Virginia Cummins		Save Our Hills
X									Conover Smith	Citizen	Save Our Sunol
X									Jim O'Laughlin	Vice President	Save Our Sunol
X									Alex Kobayashi		Senator Ellen Corbett
X									Lynn Ragghianti		Sierra Club ACA
X									Yvonne West		Sierra Club/Save Niles Canyon
X									Bob Frillman		Sunol Citizens Advisory Committee
X	X	X	X	X	X	X	X		Mark Watson	Assistant VA Team Leader	Value Management Strategies
X	X	X	X	X	X	X	X	X	George Hunter	VA Team Leader	Value Management Strategies
X									Dennis Chittle	Citizen	
X									Jorva West	Citizen	
X									Ernie Rodriguez	Community Member	
X									Theresa DeAnda	Niles Resident	
X									Dorothy Bradley	Resident of Niles	
X									Connie DeGrange	Citizen	
X									Art Martinez	Citizen	
									Tim Craggs	Caltrans	Traffic Operations
									Peter Pangilinau	FHWA	California TE
									Ken Kochevar	FHWA	FHWA Safety & Design TL

APPENDIX

Route 84 Niles Canyon Highway: Road Safety Review for a Quantitative Road Safety Analysis Study

An explicit highway safety analysis of proposed road safety improvements identified as part of a Road Safety Audit conducted on Route 84 between Mission Boulevard and Highway 680.

August 31, 2012

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APPENDIX A: Comments from a road safety field review of the study area conducted by representatives from Delphi-MRC and VMS.

1 Introduction

1.1 Background

This report has been prepared as a background document for a Quantitative Road Safety Analysis (QSRA) study, an integrated Road Safety Value Analysis process, being conducted by Value Management Strategies Inc. in cooperation with Delphi-MRC in which explicit highway safety analysis tools and techniques have been used to assess proposed road safety improvements identified as part of a formal road safety audit conducted by a team of road safety specialist from the Federal Highway Administration on Route 84 – Niles Canyon Highway between Mission Boulevard and Highway 680.

The goals of this analysis were as follows:

1. Provide prioritization guidance on the road safety issues identified as part of an independent FHWA Road Safety Audit.

2. Provide prioritization guidance with regards to treatment locations within the corridor.

3. Where possible, provide quantitative estimates of expected levels of road safety improvement associated with countermeasures developed to address the road safety concerns identified.

1.2 The focus of our review

Our analysis addresses road safety issues only. In carrying out the work, we have reviewed plans and documents supplied by Caltrans, assessed relevant background literature, and conducted a field reconnaissance of the study area.

This analysis builds on information provided as part of a Road Safety Audit of the existing Route 84 study area conducted by the Federal Highway Administration. A road safety audit is formal and independent safety review of a roadway's safety performance by an experienced team of safety specialists that addresses the safety of all road users. In explicit road safety analysis, issues identified in the road safety audit are examined using quantitative analysis techniques to help road agencies support design decisions.

In this analysis, we do not attempt to deal with the question of cost-effectiveness. Readers of this memo should recognize that road design decisions necessarily encompass and must be influenced by the need to provide cost-effective overall solutions to design problems. While it is essential that safety be considered explicitly during this process, it is not the only factor that will influence the final overall resolution of the design challenge under consideration.

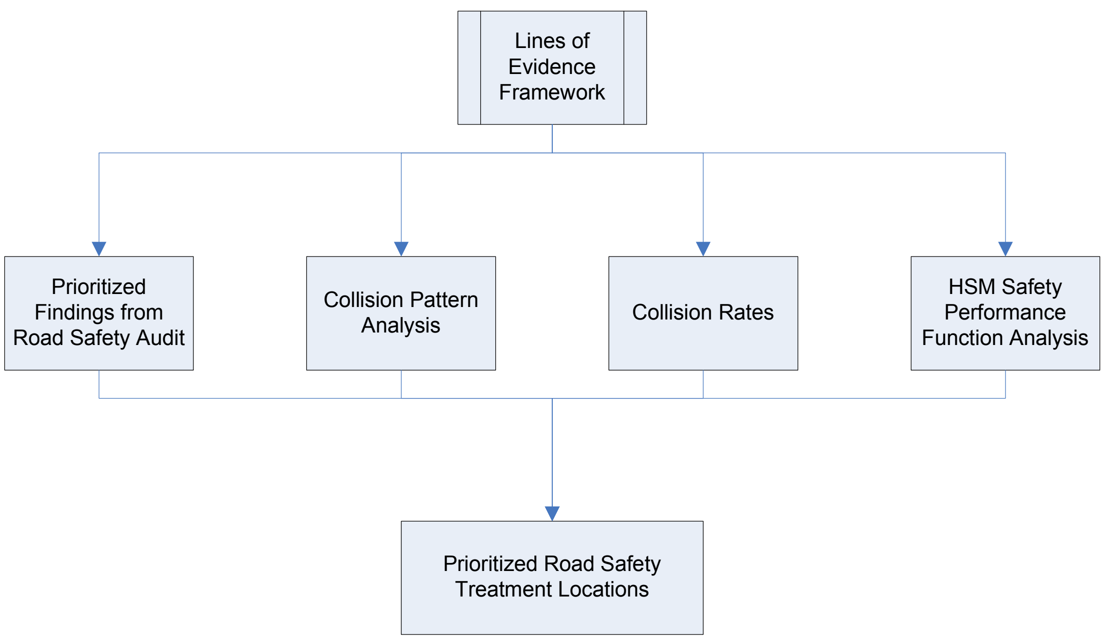
2 Current road safety performance

2.1 Background

In carrying out this work, an assessment of the existing road safety performance of the study area was conducted based on a "lines of evidence" approach. This approach examines the safety performance of the study area using a range of tools and techniques and assesses these first individually, and then as a whole. Where lines of evidence "overlap" and point to a common conclusion regarding a particular element of the roadway or location, that conclusion is strengthened by the independence of the indicators and the multiplicity of their occurrence as well as the independence of the individual investigators pursuing the different approaches to the analysis.

Our lines of evidence framework examined the performance of the Route 84 study area using four distinct examination methods as illustrated in Figure 1, below. Findings from a synthesis of the lines of evidence are used to prioritize risk levels associated with the safety concerns identified and to prioritize locations within the study area for road safety improvement.

Figure 1: Lines of evidence framework



2.2 Prioritized findings from road safety audit - Line of evidence

2.2.1 Overview

A road safety audit of existing roadway conditions within the Route 84 study area was conducted by an independent team of specialists for the Federal Highway Administration. This field audit was an important part of the overall analysis effort, as it provided expert opinion and insight into the observed road safety characteristics of the facility including:

- Driver workload issues such as user task loads and information requirements
- Traffic operations characteristics including, but not limited to, operating speeds, the presence of speed differentials, passing operations and other aspects of the operating environment;
- Highway and roadside design characteristics, compliance with generally accepted design and operations practices, maintenance conditions and other matters.

In this line of evidence, issues identified as part of the road safety audit were prioritized based on their potential level of road safety risk. This information was then used to identify locations within the study area that appear to offer the greatest potential for road safety improvement.

2.2.2 Independent road safety audit issues

The following table provides a summary of road safety issues associated with existing conditions within the Route 84 study area as identified by the independent road safety audit team. To help supplement the findings of the FHWA road safety audit team, road safety observations noted during a field review conducted by members of the QRSA team were provided to the FHWA team for consideration. A summary of these comments is included in Appendix A of this report.

Table 1: Summary of existing roadway issues from a road safety audit

Existing Condition Safety Issue
Vegetation is blocking signage and encroaching on roadway
Intercahange at Sunol (signage and wayfinding for through traffic is not clear)
Traffic back-ups from Main Street and Pleasanton intersections extend to the Sunol interchange underpass. Sightlines to the end of queue are limited.
Stop sign on eastbound approach to Pleasanton Road intersection is not obvious at night
Bicycle safety and accommodation
Signage clutter
Passing zone west of Rosewarnes promoteds high-speed approach to tight radius curves.
Rosewarnes curves
Palomares Intersection (sight distance, skew, signage)
Intersection at Old Canyon Road - wide uncontrolled expanse of pavement - skew angle
Variable consistency in type of pavement markers
Rock falls near Rosewarnes
Reflectivity of signage at Rosewarnes and Palomares flashing beacons
Lighting of key areas (intersections, Rosewarnes underpass, Palomares)
Reflective markings on Rosewarnes underpass piers
Superelevation deficiencies (Rosewarnes curves)
Flashing beacon location at Palomares Road intersection, Reflectivity of signage at flashing beacon
Rock wall presents a roadside hazard
Edgeline delineation is faded and inconsistent
Roadside barrier height, deflection distances, inconsistencies, end treatments
Limitations in areas for enforcements and maintenance pullouts
Missing chevrons on low-speed curves
Eucalyptus trees encroaching on roadway
Bridge railing (nonstandard design, condition, transition to approach railing)
Headwalls in northeast quadrant at quarry intersection
At-grade rail crossing located in very close proximity to Quarry intersection with Route 84
Shoulder widths are not consistent
Pavement edge drop-offs
Sight distance is limited at the Quarry intersection due to a crest vertical curve
K-rail at Sims Park may direct an impacting vehicle into trees and utility poles
Sidewalks are provided at the Sunol underpass - no continuity is provided
Retroreflectivity of pavement markings and delineators
Lack of consistency of curve signage
Speed management on approaches to intersections and low speed curves
Limited clear zone provisions (fixed objects, critical side slopes)

2.2.3 Prioritization of road safety audit issues

The methodology used to prioritize the risk levels associated with each of the road safety issues identified by the Road Safety Audit team is adapted from the Australian

Road Safety Audit Guide[1] and is based on establishing two criteria associated with a specific deficiency:

1) Frequency that the deficiency is likely to cause a collision

2) Severity of the collision that would result from the deficiency

The general rating scheme to define each of these two rating criteria is defined in the following two tables.

Figure 2: Frequency that the deficiency is likely to lead to a collision

Frequency	Description
Frequent (F)	Once or more per week
Probable (P)	One or more per year (< week)
Occasional (O)	Once every 5 to 10 years
Improbable (I)	Less often than once every 10 years

Figure 3: Likely severity of a collision resulting from the deficiency

Severity	Description
Catastrophic (C)	Likely Multiple Deaths
Serious (S)	Likely Death or Serious Injury
Minor (M)	Likely Minor Injury
Limited (L)	Likely Trivial Injury or Property Damage Only

The two rating criteria defined above are combined into an overall priority rating based on the matrix in the table below. The risk level is color coded and has been carried through this report to identify the level of risk associated with each of the deficiencies recorded in our audits.

Figure 4: Level of Risk

	Frequent	Probable	Occasional	Improbable
Catastrophic	Very High	Very High	Very High	High
Serious	Very High	Very High	High	Medium
Minor	Very High	High	Medium	Low
Limited	High	Medium	Low	Low

The four risk categories defined in Table 4 can generally be tied to the following treatment categories:

[1] Austroads, "Road Safety Audit" Second Edition, 2002. Section 6.8, p.42 .

Figure 5: Treatments for each Risk Level

Risk Level	Suggested Treatment Approach
Very High	Must be corrected.
High	Should be corrected or the risk significantly reduced, even if the treatment cost is high.
Medium	Should be corrected or the risk significantly reduced, if the treatment cost is moderate, but not high.
Low	Should be corrected or the risk reduced, if the treatment cost is low.

The application of this methodology to the specific issues identified by the Road Safety Audit Team is summarized in the following table:

Table 2: Risk evaluation of road safety audit issues

Existing Condition Safety Issue	Frequency	Severity	Risk
Vegetation is blocking signage and encroaching on roadway	P	M	H
Intercahange at Sunol (signage and wayfinding for through traffic is not clear)	O	L	L
Traffic back-ups from Main Street and Pleasanton intersections extend to the Sunol interchange underpass. Sightlines to the end of queue are limited.	P	S	VH
Stop sign on eastbound approach to Pleasanton Road intersection is not obvious at night	O	S	H
Bicycle safety and accommodation	P	S	VH
Signage clutter	O	L	L
Passing zone west of Rosewarnes promoteds high-speed approach to tight radius curves.	P	S	VH
Rosewarnes curves	P	S	VH
Palomares Intersection (sight distance, skew, signage)	P	S	VH
Intersection at Old Canyon Road - wide uncontrolled expanse of pavement - skew angle	O	M	M
Variable consistency in type of pavement markers	I	S	M
Rock falls near Rosewarnes	P	L	M
Reflectivity of signage at Rosewarnes and Palomares flashing beacons	O	L	L
Lighting of key areas (intersections, Rosewarnes underpass, Palomares)	P	L	M
Reflective markings on Rosewarnes underpass piers	P	S	VH
Superelevation deficiencies (Rosewarnes curves)	O	M	M
Flashing beacon location at Palomares Road intersection, Reflectivity of signage at flashing beacon	O	L	L
Rock wall presents a roadside hazard	P	M	H
Edgeline delineation is faded and inconsistent	O	L	L
Roadside barrier height, deflection distances, inconsistencies, end treatments	P	S	VH
Limitations in areas for enforcements and maintenance pullouts	O	L	L
Missing chevrons on low-speed curves	O	L	L
Eucalyptus trees encroaching on roadway	O	S	H
Bridge railing (nonstandard design, condition, transition to approach railing)	O	S	H
Headwalls in northeast quadrant at quarry intersection	I	S	M
At-grade rail crossing located in very close proximity to Quarry intersection with Route 84	I	S	M
Shoulder widths are not consistent	P	M	H
Pavement edge drop-offs	O	M	M
Sight distance is limited at the Quarry intersection due to a crest vertical curve	P	M	H
K-rail at Sims Park may direct an impacting vehicle into trees and utility poles	I	M	L
Sidewalks are provided at the Sunol underpass - no continuity is provided	I	M	L
Retroreflectivity of pavement markings and delineators	O	M	M
Lack of consistency of curve signage	O	L	L
Speed management on approaches to intersections and low speed curves	P	S	VH
Limited clear zone provisions (fixed objects, critical side slopes)	P	S	VH

2.2.4 Very High risk items

With respect to road safety issues and priorities for action along Route 84, the following very high risk priorities were identified:

- Traffic queues from Main Street and Pleasanton/Sunol intersections: Intersection operations at the Main Street and Pleasanton intersections create eastbound traffic queues during both AM and PM peak periods that extend back to the Sunol interchange underpass. Roadway geometry, terrain and the closed structure configuration at the Sunol underpass limit sightlines to the end of queue. This creates a significant risk for high-speed end-of-queue collision.

- Bicycle safety and accommodation: The Niles Canyon Highway is a popular destination for cyclist and discussions with members of the public and representatives from local municipalities suggest cycling volumes can be expected to increase significantly with time. Obstructed sightlines on horizontal curves, narrow structures at Alameda Creek, Rosewarnes and Farwell, and shoulder discontinuities throughout the facility present a significant risk to cyclists. Bicycle related collisions involving vehicle operating speeds of 48 miles per hour are very likely to result in serious injury or fatality.

- Passing zone west of Rosewarnes: A passing zone located to the west of Rosewarnes may promote high-speed approaches into tight radius curves located at each end of the passing zone.

- Rosewarnes underpass and approaches: The Rosewarnes underpass and its approaches exhibit a low-speed horizontal alignment, reduced shoulder width and a roadside hazard (bridge pier) located adjacent to the travel lane. This creates a significant risk for a fixed object collision.

- Palomares Intersection (sight distance, skew, signage): Sightlines at the Palomares intersection are severely limited by the Farwell underpass located just east of the intersection. This creates an elevated risk of rear-end, sideswipe and broadside type collisions. With a 48 mile/hour operating speed on Route 84, these collisions will likely involve serious injury.

- Reflective markings on Rosewarnes underpass piers: The Rosewarnes underpass piers are not fully delineated. A result, the pier is difficult to see in the shadows of the structure and during night driving conditions. This issue contributes to an increase risk of fixed object collision.

- Roadside inconsistencies (barrier height, deflection distance and end treatments): Barrier inconsistencies can reduce the effectiveness of barrier installations and contribute to increased collision severity.

- Speed management on approaches to intersections and low speed curves: The tendency for drivers to carry excessive speed through the study area may contribute to increases in both collision severity and likelihood. Findings from the evaluation of historical collision data indicate that fatal and injury related collisions are over-represented a several locations throughout the study area. Of particular concern are locations with low-speed horizontal curves and locations with that exhibit a constrained cross section. Examples include: the low-speed curve in the vicinity of “The Spot”, the low-speed curve at the west end of the Alameda Creek Bridge, Rosewarnes Underpass, and the Palomares intersection/Farwell underpass.

- Limited clear zone provisions (fixed objects, critical side slopes): Roadside design effects are well defined and understood in the literature. More aggressive and non-conforming roadsides, minimal clear zones can all contribute to greater collision frequencies and severities. A review of the collision data for the facility suggests the roadside is a key contributor to the current road safety performance.

2.2.5 High risk items

Seven high risk priorities were also identified as follows:

- Vegetation blocking signage and encroaching on roadway: Vegetation is creating sightline obstructions to warning signs and lateral sightline obstructions at horizontal curves. This can contribute to an increased risk of rear-end collision with a disabled or stopped vehicle or a bicycle.
- Stop sign on eastbound approach to Pleasanton Road intersection is not obvious at night: Poor conspicuity of a stop sign increases the risk of driver violating the intersection stop control. This type of violation can result in significant collision severity.
- Rock wall presents a roadside hazard: Sections of the facility exhibit a rock retaining wall that does not appear to be crashworthy. An errant vehicle impacting this wall may be tripped, snagged or vaulted. These collision types are typically associated with increased collision severity. The lengthy section of these walls also increases the likelihood of collision.
- Eucalyptus trees encroaching on roadway: Trees located adjacent to the travel lane present a significant roadside hazard to errant vehicles. At a 48 mile/hour operating speed, a vehicle impacting these trees will likely result in severe injury.
- Bridge railing (nonstandard design, condition, transition to approach railing): Bridge railing and the barrier transition to Alameda Creek BOH do not appear to be crash tested technologies. The effectiveness of these barriers during a collision may be limited.
- Shoulder widths are not consistent: Discontinuities in the available shoulder width reduce opportunities to accommodate maintenance vehicles, disabled vehicles and speed enforcement. They also result in a reduced margin for driver error as the recoverable area for errant vehicles is reduced.
- Sight distance is limited at the Quarry intersection: A crest vertical curve limits sightlines to this intersection and contributes to an increased risk of intersection related collision types (rear-end, sideswipe, broadside).

2.2.6 So what does this mean?

The road safety issues identified by the independent Audit Team, and the results of the prioritization exercise appear to highlight specific locations within the study area that exhibit an increased level of road safety risk. These locations include:

- **Rosewarnes underpass and its approaches (includes passing zone to east):**
  - ➢ Very high road safety risk levels associated with roadside hazards (pier), positive guidance, the presence of a passing zone and speed management, roadway geometry, and the accommodation of bicycles.
  - ➢ High road safety risk levels associated with shoulder discontinuities.
- **Vicinity of Palomares intersection and Farwell underpass:**
  - ➢ Very high road safety risk level associated with intersection sightlines, speed management and the accommodation of bicycles.
  - ➢ High road safety risk levels associated with shoulder discontinuities.
- **Low-speed curve east of "The Spot"[2]:**
  - ➢ Very high road safety risk level associated with the accommodation of bicycles, and speed management.
  - ➢ High road safety risk level associated with shoulder discontinuities, sightline limitations created by vegetation and the roadside hazard presented by the Eucalyptus trees.
- **Alameda Creek Bridge:**
  - ➢ Very high road safety risk level associated with speed management and the accommodation of bicycles.
  - ➢ High road safety risk levels associated with shoulder discontinuities.
- **Alameda BOH**:
  - ➢ Very high road safety risk level associated with the accommodation of bicycles.
  - ➢ High road safety risk levels associated with shoulder discontinuities and non-standard bridge railing.
- **Kaiser Quarry intersection:**
  - ➢ High road safety risk level associated with limited sightlines created by crest vertical curve.

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[2] The Spot is a previously active campground located between the Alameda Creek Bridge and the Alameda Creek BOH.

- **Main Street and Pleasanton/Sunol intersections:**
  - ➢ Very high road safety risk level associated with intersection operations and vehicle queues that extend into high-speed driving environments.
  - ➢ High road safety risk level associated with visibility of intersection traffic control during night time operations

Several issues identified by the road safety audit that apply corridor wide were also highlighted by the prioritization exercise. These include:

Corridor-wide: Intolerable risk items

- Bicycle safety and accommodation.
- Roadside barrier inconsistencies (barrier height, deflection distance and end treatments.
- Limited clear zone provisions (fixed objects, critical side slopes.

Corridor-wide: High risk items

- Vegetation blocking signage and encroaching on roadway.
- Shoulder widths discontinuities.

2.3 Collision pattern analysis – Line of evidence

2.3.1 Background

Collision pattern analysis consists of an evaluation of the available collision data and can be particularly useful in examining crash causes and contributing factors. The collision diagrams and statistical summaries produced in the course of this analysis provided both a visual and quantitative representation of collision types and – in addition to being useful at the diagnostic stage of the safety review –also provided valuable clues as to the most appropriate candidate countermeasures that should be considered for addressing safety challenges.

Discussions with Caltrans representatives indicate that a two foot flush median treatment was applied to the Route 84 as a countermeasure to address concerns associated with head-on collisions on the facility. The installation of this treatment was completed in October 2007. As a result, collision data supplied by Caltrans for the period from November 2007 to September 2010 was used to ensure the impact of this important road safety improvement was reflected in our analysis.

Although more recent collision data was available for a section of Route 84 between Palomares Road and Highway 680, collision data for the same period was not available for the section of Route 84 between Mission Boulevard and Palomares Road. To ensure a balanced approach to this analysis, this portion of the data set was not used as it may bias the results for a portion of the facility.

2.3.2 Findings

- A total of 84 collisions were reported in the study area between November 2007 and September 2010. These included 2 fatal collisions (2%), 46 injury related collisions (55%) and 36 PDO collisions (43%). The frequency and proportion of fatal and injury related collisions on this facility is significant.

- Fatal collisions were reported in the vicinity of the Rosewarnes underpass and the low-speed curve near "The Spot".

- A summary of reported collision types is provided below. Based on these frequencies, collisions involving the roadside (37% hit objects and 15% overturn) appear to have the greatest impact on the facility's road safety performance.

Table 3: Reported collision types – Nov. 2007 to Sep. 2010

Collision Type		
31	37%	Hit object
16	19%	Broadside
13	15%	Overturn
12	14%	Rear-end
5	6%	Sideswipe
3	4%	Animal
2	2%	Head-on
2	2%	Bicycle
84	100%	

- When vehicle type is examined:

  - 82% of reported collisions involved passenger cars, pickup trucks and single unit trucks.

  - 2% involved heavy trucks and construction equipment. This level of collision involvement is consistent with their portion of the overall vehicle mix on the facility.

  - 14% involved motorcycles. Discussions with stakeholders indicate that Niles Canyon is a popular route for motorcyclists. The level of motorcycle involvement in collisions is significant as motorcycle collisions typically involve increased collision severity.

  - 2% involved cyclists. Stakeholders have reported that bicycling on this section of roadway is gaining popularity. Of particular concern was a statement that indicated this route is gaining popularity with less skilled recreational riders. This is significant concern as portions of the existing roadway do not have shoulders wide enough to safely accommodate cyclists and may curvilinear sections of the road have limited sightlines. Also, collision between a cyclist and a vehicle operating at a speed of 48 miles/hour will likely result in severe injury or fatality.

Table 4: Collision vehicle type – Nov. 2007 to Sep. 2010

Vehicle type		
81	65%	Auto/station wagon
21	17%	Pickup/single unit truck
17	14%	Motorcycle
1	1%	Truck tractor combinations
1	1%	Emergency vehicle
1	1%	Construction equipment
2	2%	Bicycle
124	100%	

- A review of the collision plots indicates increased collision frequency at the following locations:
  - **Intersection of Mission Boulevard and Route 84.** Collisions reported on the approaches to this intersection include several broadsides, one rear-end and one collision involving a bicycle.
  - **Rosewarnes underpass and its approaches (includes passing zone to east).** The severity of collisions at this location appears high as most of the reported collisions involve personal injury. One fatal collision was also reported at this location. Most of the reported collisions appear to involve hit object and rollover collision types
  - **Vicinity of the Palomares intersection and Farwell underpass.** The severity of collisions at this location appears high as the majority of reported collisions involve personal injury. Hit object collisions appear to be most prevalent on the approaches. A bicycle and sideswipe collision was also reported at this location.
  - **West end of the Alameda Creek Bridge.** The majority of collisions at this location involve hit objects. Rollover, sideswipe and broadside collisions were also reported. Collision severities included both injury and property damage only collisions.
  - **Low-speed curve located in the vicinity of "The Spot".** The severity of collisions at this location appears high as the majority of reported collisions involve personal injury. One fatal collision was also reported at this location. Most of the collisions at this location involved hit objects.
  - **Main Street and Pleasanton/Sunol Road intersections.** Collision severity appears lower at this location as the majority of reported collisions involve property damage only. This may be the result of lower operating speeds in this area. Collision types reported at these locations appear to be related to intersection operations. These include broadside and rear-end collisions.

The following figures present all of the collisions reported between November 2007 and September 2010 in a linear format based on the Caltrans post mile reference system.

Figure 6: Collision frequencies by severity – Nov. 2007 to Sep. 2010 (Caltrans mile post linear referencing)

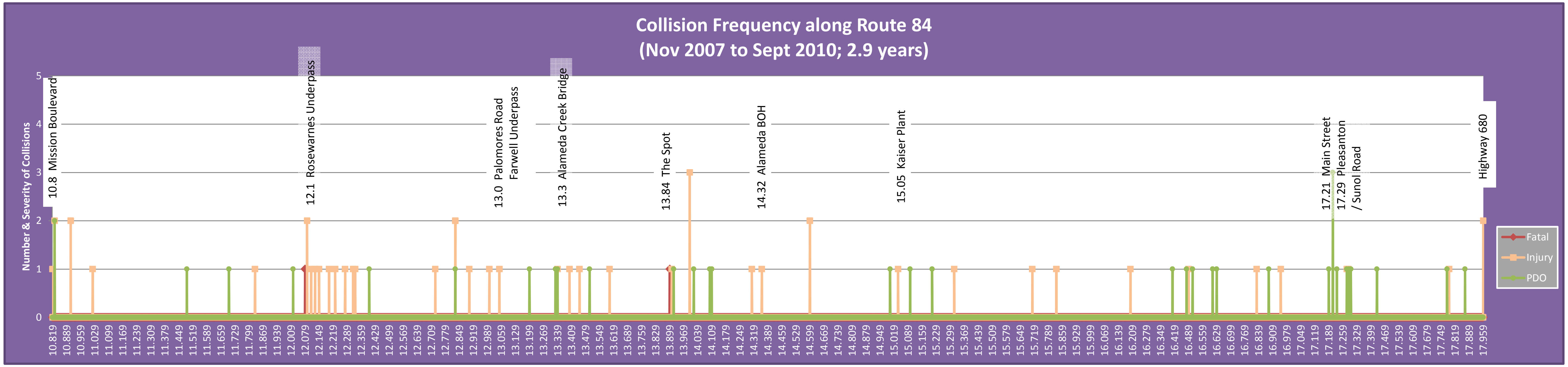


Figure 7: Collision frequency by severity – Nov. 2007 to Sep.2010 Aerial plot (Caltrans mile post linear referencing)

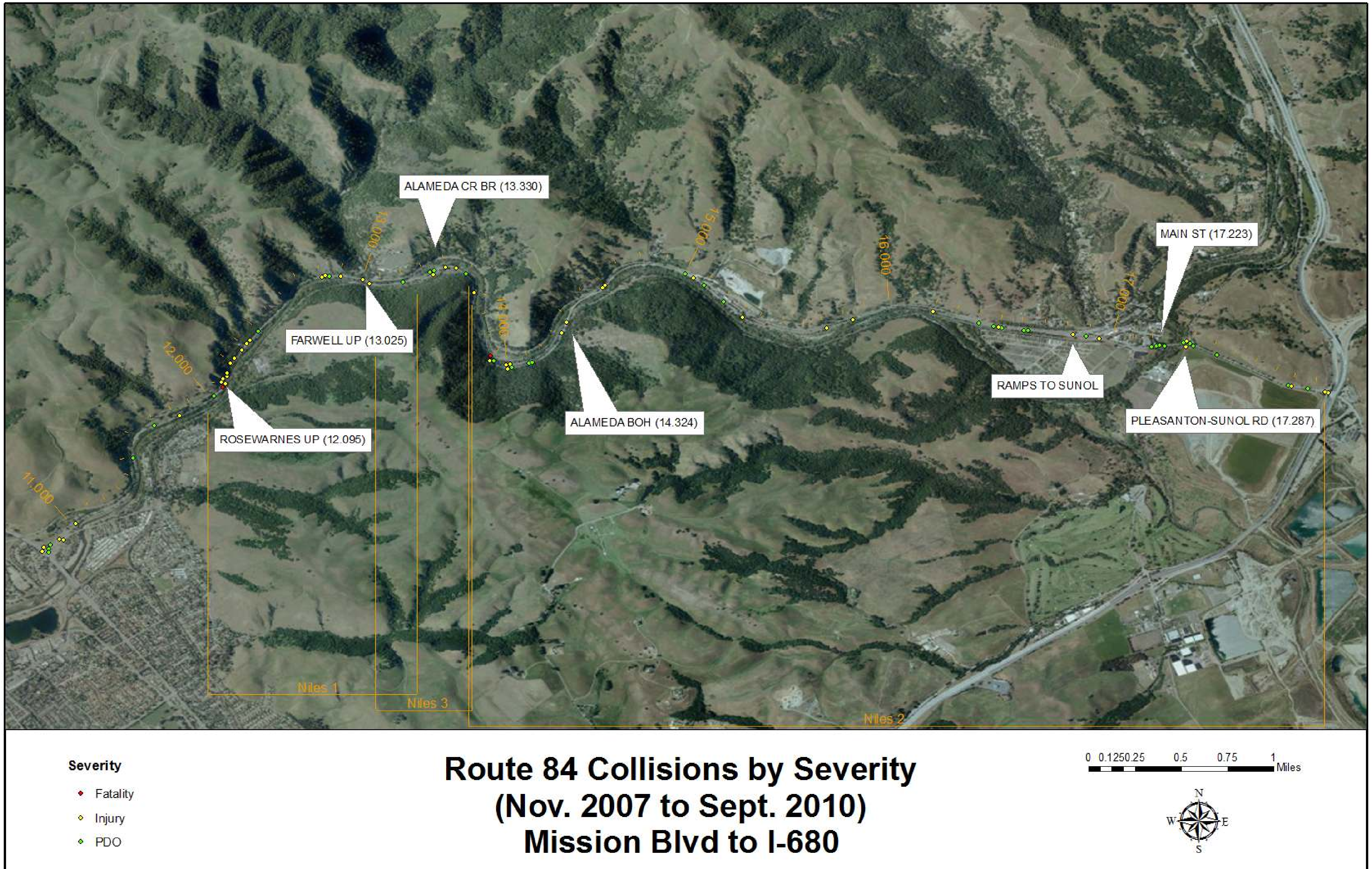
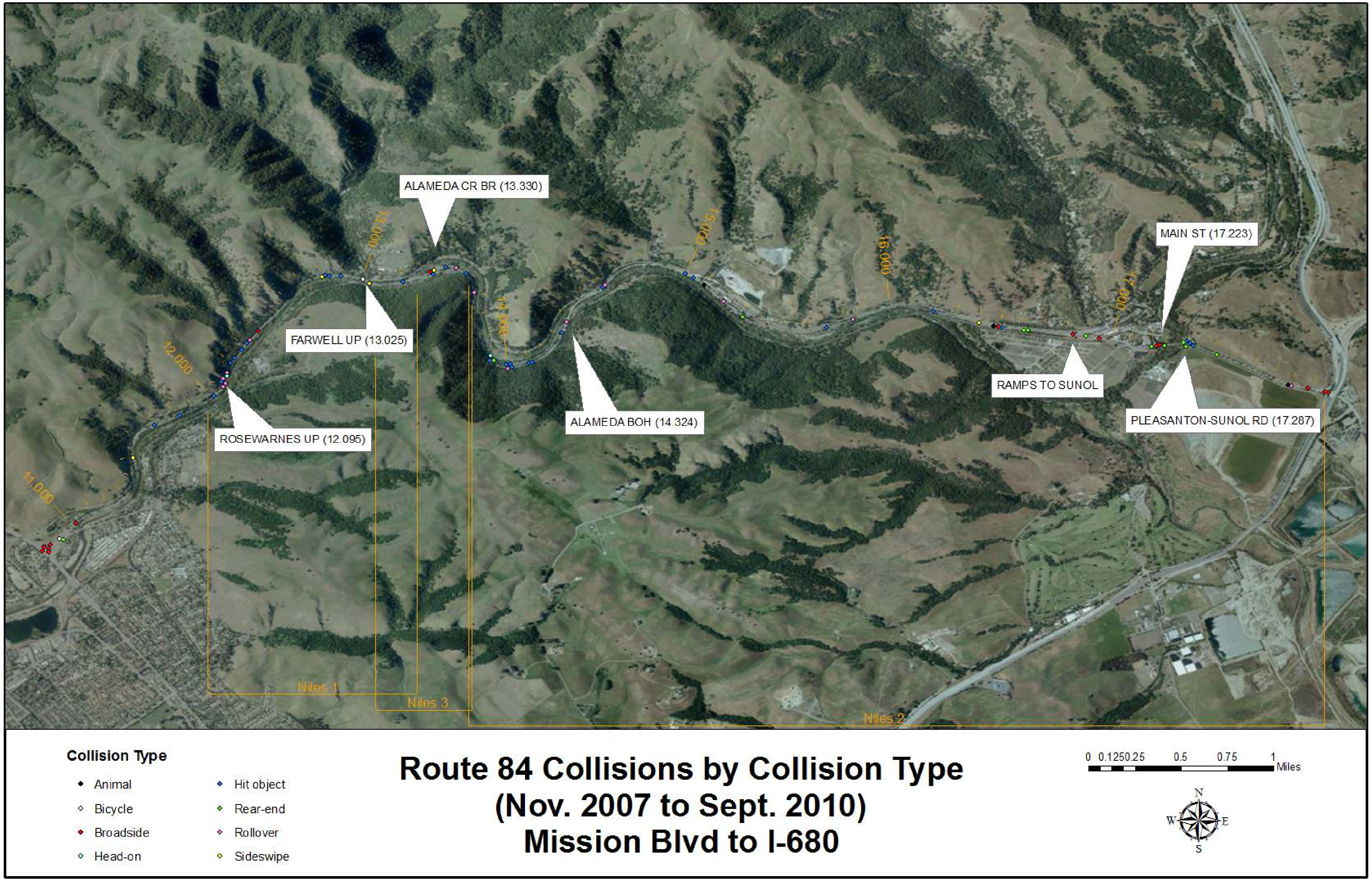


Figure 8: Collision frequency by collision type – Nov. 2007 to Sep.2010 Aerial plot (Caltrans mile post linear referencing)



2.4 Collision rates – Line of evidence

2.4.1 Overview

Collision rate has long been used as a relative comparison between similar highway segments. The collision rate performance measure normalizes the frequency of collisions with the exposure, measured by traffic volumes and segment length. When calculating collision rates, traffic volumes are reported as million entering vehicles for intersections and million vehicle miles travelled for roadway segments. As a measure of how a particular facility is operating from a road safety standpoint, the resulting collision rates are compared to state-wide average collision rates for similar facilities.

2.4.2 Collision rates on roadway segments

To identify locations on the facility which are likely to benefit from safety improvement, a sliding window methodology was applied to the collision rate analysis. In the sliding window analysis a window 0.1 mile in length was moved along the roadway for its entire length. The roadway was screened for performance measures that included:

- Fatal collision rate
- Fatal and injury collision rate
- All severities collision rate (fatal, injury and Property-Damage-Only)

As the window was moved along the roadway, the various collision rates were calculated and compared to state-wide average rates. The results of this analysis are summarized in the figures on the following pages where the state average collision rate is represented by a horizontal red line.

As part of this review, Equivalent Property Damage Only collision rates were also determined. This method assigns weighting factors to collisions by severity (fatal, injury and PDO) to standardize the collision rate. Weighting factors were determined using collision cost values typically applied by the State for benefit-cost analysis (Fatal = $4,400,000, Average Injury = $101,600, PDO = $2,500).

This analysis identifies specific locations within the study area that appear to provide the greatest opportunity for road safety improvement. These locations include:

- **Rosewarnes underpass and its approaches (includes passing zone to east):** Over-represented in fatal, injury, and all collisions. Also displays an over-representation based on severity weighted collision rate.
- **Vicinity of the Palomares intersection and Farwell underpass:** Over-represented in injury and all collisions. This over-representation may be partially due to comparing the Palomares Road intersection safety performance to the state average collision rate for roadway segments. In section 2.4.3 of this report the performance of the Palomares Road intersection is compared to state–wide average collision rates for similar intersections.
- **Vicinity of the Alameda Creek Bridge:** Over-represented in injury and all collisions.

- **Low-speed curve located in the vicinity of "The Spot":** Over-represented in fatal, injury and all collisions. Also displays an over-representation based on severity weighted collision rate.

- **Vicinity of the Alameda BOH:** Over-represented in injury collisions.

- **Approach to the Sunol interchange (vicinity on and off ramps):** Over-represented in all collisions.

- **Between the Main Street and Pleasanton/Sunol Road intersections:** Over-represented in injury and all collisions. This over-representation may be partially due to comparing the Main Street and Pleasanton/Sunol Road intersection safety performance to the state average collision rate for roadway segments. In section 2.4.3 of this report the performance of the Main Street and Pleasanton/Sunol Road intersections are compared to state–wide average collision rates for similar intersections.

Figure 9: Sliding window collision rates – Nov. 2007 to Sep. 2010: Fatal collisions (Caltrans mile post linear referencing)

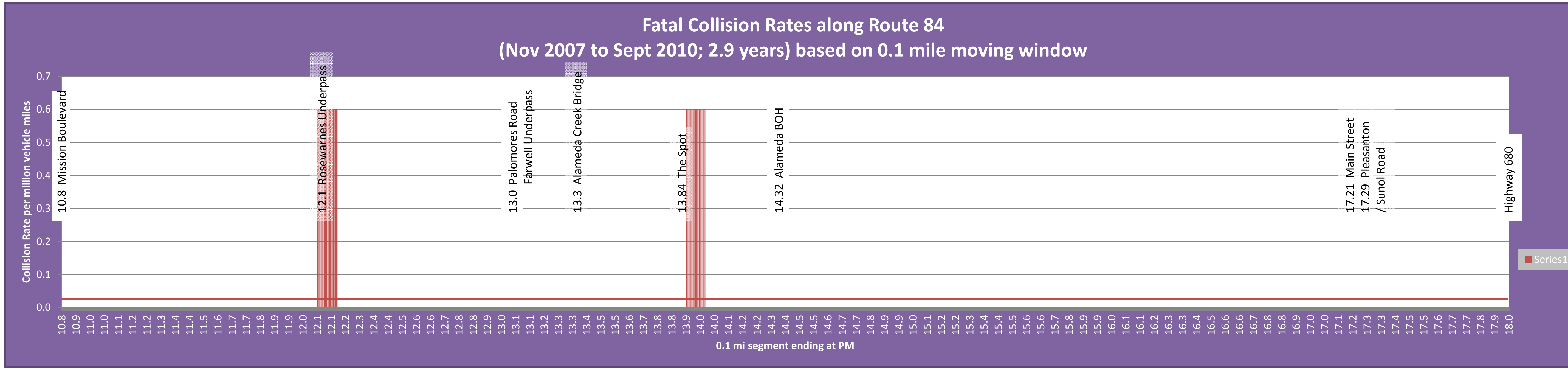


Figure 10: Sliding window collision rates – Nov. 2007 to Sep. 2010: Fatal + Injury collisions (Caltrans mile post linear referencing)

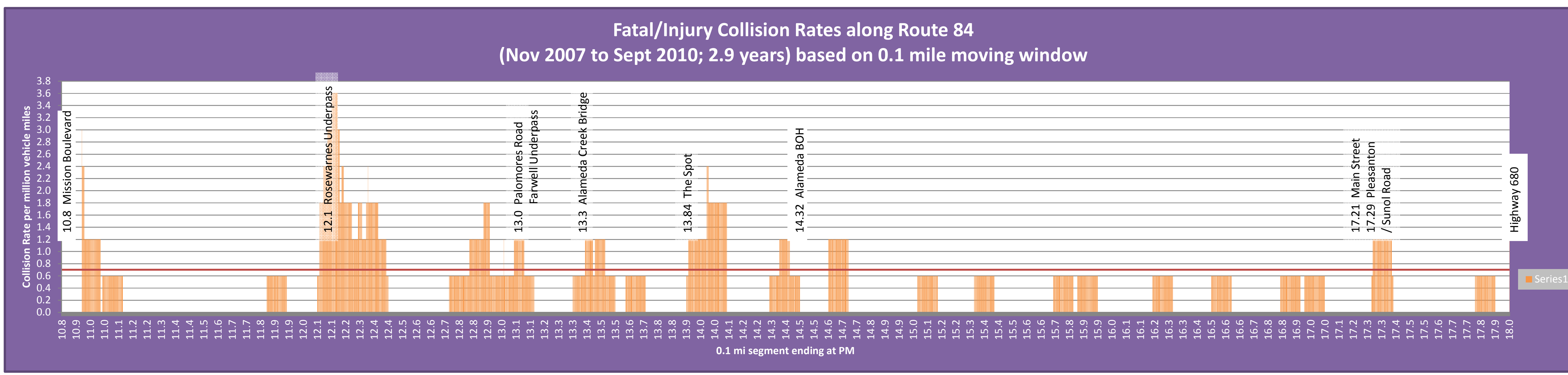


Figure 11: Sliding window collision rates – Nov. 2007 to Sep. 2010: All collisions (Caltrans mile post linear referencing)

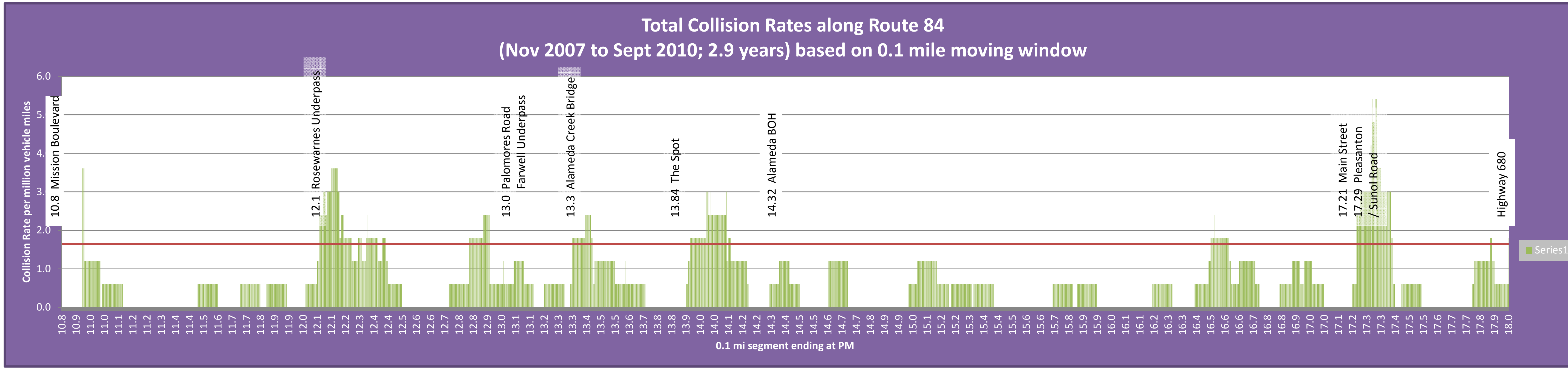
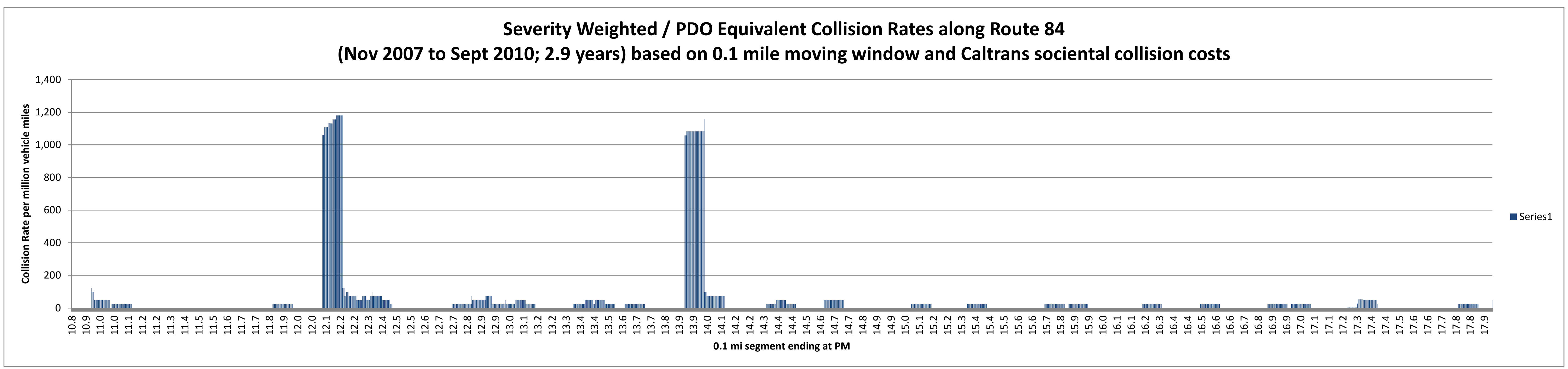


Figure 12: Sliding window severity weighted collision rate – Nov. 2007 to Sep. 2010 (Caltrans mile post linear referencing)



2.4.3 Collision rates at intersections

Collision rates at intersection locations within the study area were also compared to state-wide average intersection collision rates for the period from November 2007 to September 2010. The findings from this analysis are summarized in the following table.

Table 5: Intersection collision rates - Nov. 2007 to Sep. 2010

Intersection	Collisions/Million Vehicles Entering					
	Actual			State Average		
	Fatal	Fatal & Injury	All Collisions	Fatal	Fatal & Injury	All Collisions
Palomares	0.00	0.07	0.07	0.001	0.06	0.15
Main	0.00	0.00	0.30	0.003	0.08	0.20
Pleasanton	0.00	0.16	0.41	0.01	0.13	0.30

The results of this analysis indicate the following:

- **Palomares Road intersection:** The actual collision rate for fatal & injury related collisions is higher than the state-wide average.
- **Main Street intersection:** The actual collision rate for all collisions is higher than the state-wide average.
- **Pleasanton/Sunol Road intersection:** The actual collision rates for fatal & injury and all collisions are higher than the state-wide averages.

Evaluation of the Mission Bouldevard/Route 84 intersection was not conducted as the required traffic volumes were not available at the time of this analysis.

2.5 HSM Safety Performance Functions – Line of evidence

2.5.1 Overview

Safety Performance Functions (SPF) are statistical based models used to estimate average crash frequency for a specific facility type. The advantages associated with these types on models are as follows:

- Regression to the mean bias is addressed as the method concentrates on long term expected average crash frequencies rather than short-term observed crash frequency.
- Reliance on availability of limited crash data for any one site is reduced by incorporating predictive relationships based on data from many similar sites.
- The method accounts for the non-linear relationship between crash frequencies and traffic volume.
- The SPF's in the Highway Safety Manual are based on negative binomial distribution, which is better suited to modeling the high variability of crash data.

The AASHTO Highway Safety Manual contains SPF's for rural two-lane two-way roadways. These SPF's are incorporated into an FHWA toolset called the Interactive Highway Safety Design Model (IHSDM).

The Interactive Highway Safety Design Model (IHSDM) is a suite of software analysis tools for evaluating safety and operational effects of geometric design decisions on highways. It supports design decisions by providing estimates of a highway design's expected safety and operational performance.

IHSDM includes six evaluation modules:

- Crash Prediction Module: estimates the expected frequency crashes on a highway using geometric design and traffic characteristics.
- Design Consistency Module: estimates the magnitude of potential speed inconsistencies to help identify and diagnose safety concerns at horizontal curves
- Intersection Review Module: performs a diagnostic review to systematically evaluate an intersection design for typical safety concerns.
- Policy Review Module: checks highway segment design elements relative to design policy.
- Traffic Analysis Module: estimates operational quality-of-service measures for a highway under current or projected future traffic flows.
- Driver/Vehicle Module: estimates a driver's speed and path along a highway and corresponding measures of vehicle dynamics.

For the purposes of this review, the Crash Prediction Module was applied. The crash prediction module estimates the frequency of crashes expected on a roadway based on its geometric design and traffic characteristics. The crash prediction algorithms consider the effect of a number of roadway segment and intersection variables.

The algorithm for estimating crash frequency combines statistical Safety Performance Functions (SPFs) and crash modification factors. The crash modification factors adjust the SPF (base model) estimates for individual geometric design element dimensions and for traffic control features. The factors are the consensus on the best available estimates of quantitative safety effects of each design and traffic control feature.

The collision prediction algorithm also provides an Empirical Bayes procedure for blending the algorithm estimate with site-specific crash history data. This process was applied using historical collision data from the study area for the period from November 2007 to September 2010. Although the Crash Prediction Module provides a methodology to calibrate the SPF to reflect State roadway, topographic, environmental, and crash-reporting conditions, time and data constraints did not permit the application of this process.

The existing horizontal alignment details were not available for Route 84 between Mission Boulevard and the western limit of the Nile 1 design project. As a result, the IHSDM model prepared as part of this analysis does not include this section of roadway.

2.5.2 Results

Predicted collision frequencies for each geometric segment of the existing roadway alignment were determined using the IHSDM Crash Prediction Module. These frequencies were then normalized using traffic volumes and compared to state-wide average collision rates for similar facilities. The results of this comparison identified portions of the existing facility that are predicted to underperform from a safety perspective based on their geometric and cross sectional features. This comparison is displayed on figures on the following pages.

The results from this predictive analysis indicate that the following locations are expected to exhibit a safety performance worse than the state-wide average.

- Rosewarnes underpass and its approaches (includes passing zone to east)
- Station 11+350 (approximate mile post 12.8 – just west of church driveway in vicinity of Palomares/Farwell)
- Palomares Road, Farwell underpass and their approaches
- Alameda Creek Bridge and its approaches
- Low-speed curve in the vicinity of "the Spot"
- Station 7+800 (approximate mile post 14.6)
- Kaiser Quarry access
- Station 11+800 (approximate mile post 15.3)
- Station 13+800 (approximate mile post 15.7)
- Sunol interchange on and off ramps
- Between the Main Street and Pleasanton intersections

Figure 13: Niles 1 - Predicted collision rates from IHSDM Collision Prediction Module (2012) – Design alignment chainage linear reference

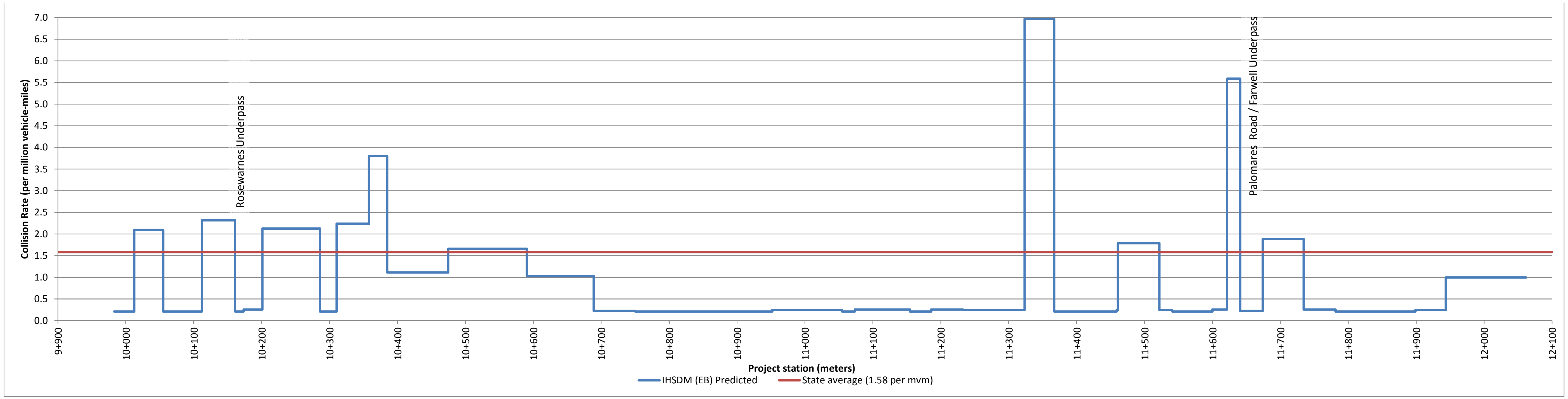


Figure 14: Niles 2 – Predicted collision rates from IHSDM Collision Prediction Module (2012) – Design alignment chainage linear reference

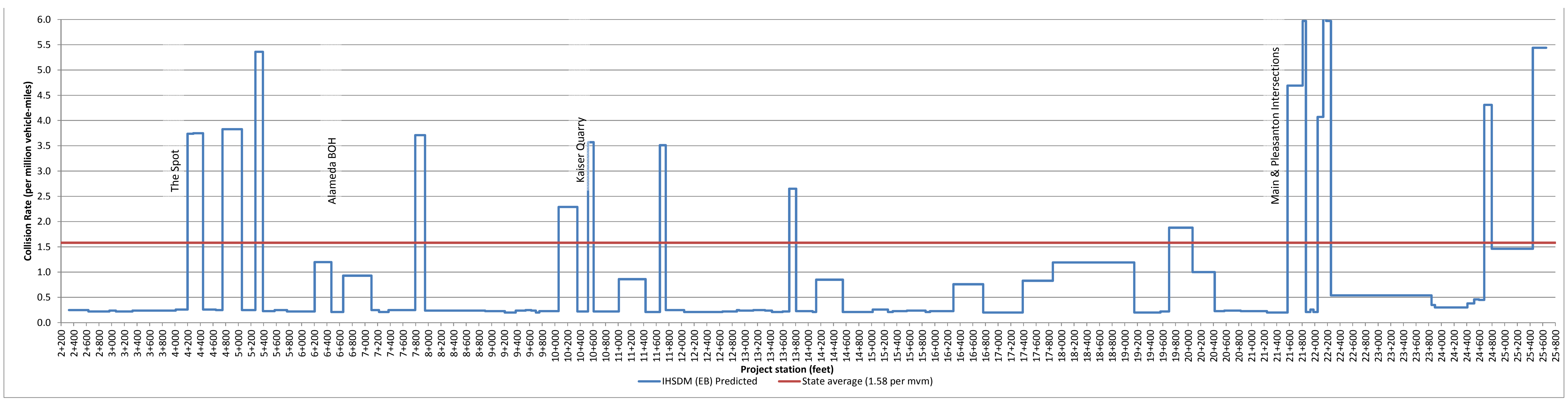
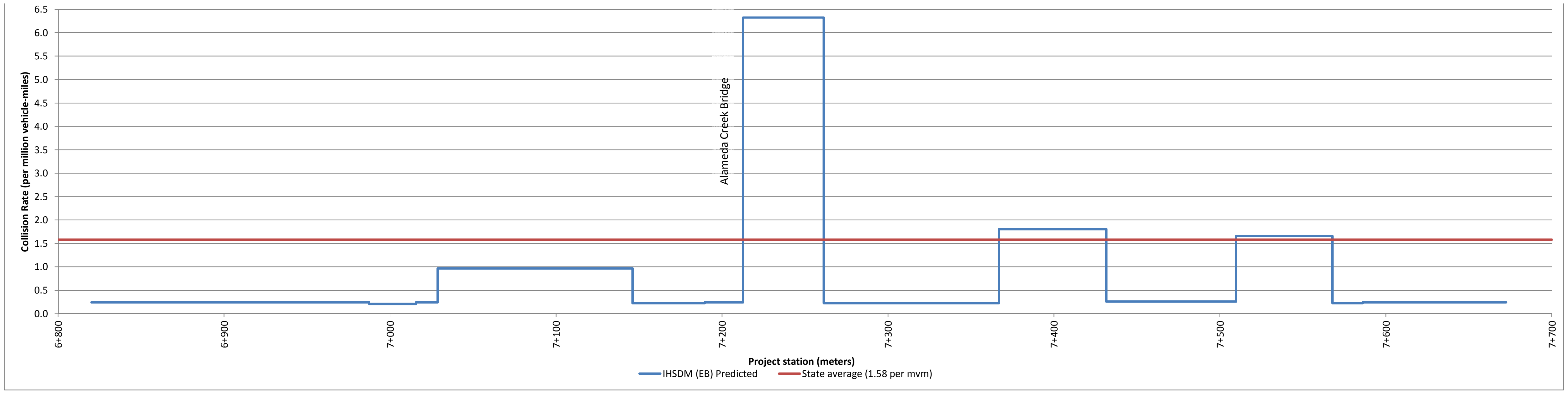


Figure 15: Niles 3 – Predicted collision rates from IHSDM Collision Prediction Module (2012) – Design alignment chainage linear reference



2.6 Prioritization of locations for road safety mitigation

2.6.1 Overview

The work conducted up to this point has focused on documenting the existing road safety characteristics of the facility. In this phase of our analysis, we apply the knowledge gained from this review to provide guidance with regards to prioritizing key locations within the study area for road safety mitigation.

2.6.2 Lines of evidence summary

The following table presents a summary of findings from the lines of evidence evaluation of the existing safety performance the study area. In this table, locations identified by each line of evidence are compared to each other to identify commonalities. Where lines of evidence "overlap" and point to a common conclusion regarding a particular or location, that conclusion is strengthened by the independence of the indicators and the multiplicity of their occurrence as well as the independence of the individual investigators pursuing the different approaches to the analysis.

Table 6: Lines of evidence summary

Location	Lines of Evidence			
	Prioritized RSA Findings	Collision Pattern	Collision Rates	Safety Performance Function
Specific Locations				
Mission Boulevard		X		
Rosewarnes Underpass & Approaches (includes passing zone to east)	X	X	X	X
Station 11+350 (approx. mile post 12.8 - vicinity of church access)	X	X	X	X
Palomares Intersection/Farwell Underpass	X	X	X	X
Alameda Creek Bridge	X	X		X
Low-Speed Curve Near "The Spot"	X	X	X	X
Alameda BOH	X		X	
Station 7+800 (approx. mile post 14.6)			X	X
Kaiser Quarry Intersection	X			X
Station 11+800 (approx. mile post 15.3)				X
Station 13+800 (approx. mile post 15.7)				X
Sunol Interchange on/off ramps				X
Main Street and Pleasanton/Sunol Intersections -queues that extend to Silver Spring UP	X	X	X	X
Corridor Wide Issues				
Roadside Barrier Inconsistencies	X			
Clear Zone Provisions	X	X		
Accommodating Bicycles	X	X		
Shoulder discontinuities	X			
Vegetation limits sightlines	X			

2.6.3 Location prioritization

An examination of the overlapping lines of evidence outlined above identifies a number of key locations within the study area that appear to be under-performing from a road safety perspective. The following prioritized list of treatment locations was identified based on 3 to 4 overlapping lines of evidence (top five locations):

1. Rosewarnes Underpass and its approaches (includes passing zone to east):

    - A number of road safety issues were identified by the road safety audit. Some of these observations have been identified as having very high and high collision risk.
    - The collision diagrams identify a cluster of collisions at this location. The majority of these collisions involve personal injury.
    - Collision rate for fatal and injury collisions exceeds the state-wide average.
    - Collision rate for all collisions exceeds the state-wide average.
    - This location was highlighted in the severity-weighted collision rate analysis.
    - Predicted collision rate exceeds the state-wide average.

2. Low-speed curve in the vicinity of “The Spot”

    - A number of road safety issues were identified by the road safety audit. Some of these observations have been identified as having very high and high collision risk.
    - The collision diagrams identify a cluster of collisions at this location. The majority of these collisions involve personal injury.
    - Collision rate for fatal and injury collisions exceeds the state-wide average.
    - Collision rate for all collisions exceeds the state-wide average.
    - This location was highlighted in the severity-weighted collision rate analysis.
    - Predicted collision rate exceeds the state-wide average.

3. Palomares intersection/Farwell underpass and their approaches (includes vicinity of church access)

    - A number of road safety issues were identified by the road safety audit. Some of these observations have been identified as having very high and high collision risk.

- The collision diagrams identify a cluster of collisions at this location. The severity of collisions at this location appears high as the majority of reported collisions involve personal injury.
- Collision rate for fatal and injury collisions exceeds the state-wide average.
- Collision rate for all collisions exceeds the state-wide average.
- Intersection collision rate for Palomares exceeds the state-wide average for fatal and injury related collisions.
- This location was highlighted in the severity-weighted collision rate analysis.
- Predicted collision rate exceeds the state-wide average.

4. Main Street and Pleasanton/Sunol intersections

- A number of road safety issues were identified by the road safety audit. Some of these observations have been identified as having very high and high collision risk.
- The collision diagrams identify a cluster of low severity collisions between these intersections and several injury related collisions at the Pleasanton/Sunol intersection.
- Collision rate for fatal and injury collisions exceeds the state-wide average.
- Collision rate for all collisions exceeds the state-wide average.
- Intersection collision rate for Main Street exceeds the state-wide average for all collisions.
- The intersection collision rate for Pleasanton/Sunol exceeds state-wide averages for fatal and injury, and all collisions.
- Predicted collision rate exceeds the state-wide average.

5. Alameda Creek Bridge

- A number of road safety issues were identified by the road safety audit. Some of these observations have been identified as having a high collision risk.
- The collision diagrams identify a cluster of collisions in the vicinity of this structure. The majority of collisions at this location involve hit objects. Rollover, sideswipe and broadside collisions were also reported. Collision severities involve both injury and property damage only collisions.

- Collision rate for fatal and injury collisions exceeds the state-wide average.
- Collision rate for all collisions exceeds the state-wide average.
- Predicted collision rate exceeds the state-wide average.

2.6.4 Other issues

In addition to the specific locations identified above, there are a number of corridor-wide road safety issues that were identified as part of the Prioritized Road Safety Audit Findings and Collision Patter Analysis lines of evidence that require careful consideration. These include:

- **Accommodation of bicycles:** Collision data for the study period indicates 2% of reported collisions involved cyclists. Stakeholders have reported that bicycling on this section of roadway is gaining popularity. Of particular concern was a statement that indicated this route is gaining popularity with less skilled recreational riders. This is significant concern as portions of the existing roadway do not have shoulders wide enough to safely accommodate cyclists and may curvilinear sections of the road have limited sightlines. Also, collisions between a cyclist and a vehicle operating at a speed of 48 miles/hour will likely result in severe injury or fatality.

- **Roadside design issues:** These issues include inadequate clear zone provisions, the presence of roadside hazards and barrier deficiencies. A review of the reported collision history for the study period indicates that collisions involving the roadside (37% hit objects and 15% overturn) appear to have the greatest impact on the facility's road safety performance.

- **Shoulder discontinuities:** These shoulder discontinuities can adversely impact the recovery of vehicles that lose control and depart the roadway and limit opportunities to accommodate disabled vehicles, bicycles and police enforcement.

- **Vegetation:** Vegetation is obstructing existing warning signs and creating lateral sightline obstructions at horizontal curves. This is of particular concern at locations that exhibit a reduced shoulder width as sightlines to a disabled vehicle or cyclist may be restricted.

3 Countermeasure identification and assessment

3.1 Overview

All of the work documented thus far in this report has focused on the lines of evidence approach. This provided a quantitative appreciation of the road safety performance of the existing roadway in the study area, as well as some initial guidance as to appropriate countermeasures that might be applied to specific locations.

The purpose of this Section is to provide an overview of the process that was undertaken to quantitatively assess the potential road safety impacts associated with road safety improvement strategies developed to address road safety concerns identified by the independent road safety audit team.

3.2 Countermeasure strategies

Using the list of potential countermeasures identified by the RSA team, the QRSA team developed a short-list of countermeasures for further evaluation. Each of the short-listed countermeasures was then prioritized by the QRSA team into short-term, mid-term and long-term strategies based on their environmental impacts and level of project development effort. The following table presents the prioritised short-list of countermeasures.

Table 7: Road safety countermeasures and strategies

ID No.	Idea Description	Strategy
IO-17	Lighting of key areas	Short-term
AN-2	Install active warning system to alert motorists to bikes on roadway	Short-term
AN-5	Install sharrows on shoulders or lane edges at select locations to demonstrate potential bicycle usage	Short-term
C-1	Install friction treatment to pavements at low-speed curves and in icy areas	Short-term
AN-3	Install warning signs for roadway narrowing and shoulder reduction	Short-term
IO-8	Install mirrors at Palomares Road to view westbound traffic	Short-term
IO-9	Relocate flashing beacon at Palomares Road further to the east	Short-term
IO-11	Install ITS elements at Palomares Road to signal drivers of approaching vehicles	Short-term
P-1	Eliminate passing zone adjacent to low-speed curves	Short-term
R-5	Install steel mesh netting on slopes in rockfall areas	Short-term
R-8	Continue maintenance programs on slopes in rock fall areas	Short-term
R-12	Address guard rail and k-rail end treatments	Short-term
R-14	Upgrade roadside protection appurtenances	Short-term
R-15	Relocate select fixed objects immediately adjacent to roadway	Short-term
SIMA-1	Install reflective material on underpass abutments	Short-term
SIMA-2	Install reflective material on curbs and rock walls adjacent to roadway	Short-term
SIMA-3	Install dynamic active warning device for queuing conditions	Short-term
SPMA-1	Install tubular centerline delineators at Rosewarnes	Short-term
SPMA-2	Install speed feedback sign and longitudinal pavement markings at low-speed curves	Short-term
SPMA-3	Narrow lane widths to 11 feet and reaportion to shoulder	Short-term
ALCRBO-1	Remove curb on Alameda Creek BOH and upgrade rail	Mid-term
C-2	Correct superelevations at low-speed curves	Mid-term
IO-1	Construct a roundabout at the intersection of SR-84 and Sunol/Pleasanton	Mid-term
IO-2	Realign Palomares Road to join church driveway	Mid-term
IO-5	Relocate the railroad abutment at Farwell Underpass to improve sight distance	Mid-term
IO-15	Install signalized intersection at Pleasanton-Sunol Road	Mid-term
R-4	Relocate the pier adjacent to the EB lane at Rosewarnes Underpass	Mid-term
R-9	Bifurcate the roadway at Rosewarne Underpass with new viaduct constructed to the south	Mid-term
RO-1	Construct tunnel into slope at Rosewarnes and realign roadway accordingly	Mid-term
SPMA-4	Provide widened locations at strategic spacing to accommodate enforcement and pull overs	Mid-term
C-3	Widen roadway at curve east of Alameda Creek Bridge to accommodate off-tracking	Mid-term
ACB-2	Replace Alameda Creek Bridge	Mid-term
AN-4	Separate non-motorized traffic to off-roadway trail system	Long-term
AN-6	Provide bike path adjacent to railroad grade	Long-term
RE-1	Designate Niles Canyon as a park and install toll booths on each end	Long-term
RO-3	Widen roadway to provide roadway cross-section of 12' lanes, 8' shoulders, and spot widening for CRZ	Long-term
IO-13	Correct superelevation and vertical sight distance at Quarry road intersection	Long-term
QI-1	Extend the EB left turn pocket at the Quarry intersection	Long-term

3.3 Evaluation

The goal of the evaluation process was to quantify the potential road safety benefits associated with each of the countermeasures and strategies developed by the RSA and QRSA teams using a toolset of evaluation techniques. Given the diverse nature of the candidate countermeasures, several different analytical tools were applied to quantify potential road safety benefits.

For the purpose of this analysis the toolsets applied included the following:

- **Highway Safety Manual - Safety Performance Functions and Crash Reduction Factors (CRF):** Using the Crash Prediction Module from the Interactive Highway Safety Design Model (IHSDM) toolset, estimates of expected crash frequency on the existing facility were determined. Crash Reduction Factors from the FHWA's CRF Clearinghouse, AASHTO Highway Safety Manual and the FHWA's Desktop Reference for Crash Reduction Factors were then applied to estimate the level of crash reduction that might be expected after implementing a given countermeasure at a specific site.
- **AASHTO Roadside Safety Analysis Program software (RSAP):** The AASHTO Roadside Safety Analysis Program (RSAP) is a cost-effectiveness analysis procedure for use in assessing roadside safety improvements. The analysis technique used was a before-and-after study approach. The before condition represents the existing condition of a typical road safety risk (i.e. a bridge pier located in close proximity to the driving lane). The after condition was then represented by making changes to the before situation based on the countermeasures identified above (increasing the offset between the bridge pier and the driving lane).
- **Highway Capacity Manual:** The Highway Capacity Manual methodology was applied to assess the operational impacts associated with the implementing a roundabout at the Pleasanton/Sunol intersection.

3.4 Analysis results

Each of the short, mid and long term countermeasures carried forward to the detailed evaluation phase was evaluated using one or a combination of the techniques outlined above to quantify the road safety benefits.

The results of this analysis are shown in the following tables. The tables provide a description of the countermeasure, details on the analysis tool or techniques applied, a discussion on any assumptions or Crash Reduction Factors used, details on application locations, and the resulting impact the countermeasure is expected to have on collision frequency based on projected 2012, 2020 and 2030 traffic volumes.

Table 8: Short-term countermeasures – Estimates of collision reduction for individual treatments

ID No.	Analysis Technique	Discussion	Treatment Locations	Analysis Results Using 2012 Horizon Year
Short-Term Countermeasures				
IO-17	CRF/IHSDM	Lighting at intersections: CRF = 33% reduction in angle collisions (A Simultaneous Equation Model of Crash Frequency By Collision Type for Rural Intersections, Ye etal, 2008 CRF = 20% reduction in all nighttime collision for all severities (NCHRP 617: Crash Reduction Factors for Traffic Engineering and ITS Improvements: State of Knowledge Report, TRB, 2005). Use CRF = 20% Nighttime collisions occurring on the roadway = 37%	Application locations include: Rosewarnes underpass (10+112.259 m to 10+201.006 m) Palomares and Farwell underpass (11+522 m to 11+734.37 m)	Total collision reduction =1.85 x 20% x 37% = 0.14 collisions/year
AN-2	CRF/IHSDM	Due to the limited application of this treatment, no specific reliable CRF's are available. CRF's for the application of flashing beacons in combination with other warning devices (signs, chevrons) suggest that a range of collision reductions from 20% to 70% in target collisions might be appropriate in this case for the proposed treatment. In this case the reduction would apply to only bicycle/vehicle collision. Although this treatment would provide motorists with advanced warning of the presence of cyclists, there are concerns that some cyclists may not active the warning system. Use CRF = 20% Bicycle collisions occurring on the roadway = 2% It should be noted that discussions with stakeholders indicate that bicycle activity is increasing within the study area and that less skilled recreational recreational riders are beginning to use the facility. This change in rider profile may contribute to an increased likelihood of bicycle related collisions.	Application locations include: Rosewarnes underpass (10+112.259 m to 10+201.066 m) Farwell underpass (11+522 m to 11+734.370 m) Between Alameda Creek Bridge and Alameda Creek Bridge BOH (7+190 m to 7+672 m and 2+325 ft to 7+371 ft	Total collision reduction = 8.34 x 20% x2% = 0.03 collisions/year
AN-5	Engineering Judgement/CRF	The MUTCD does not recommend the application of Sharrow on roadways with posted speeds in excess of 35 miles/hour. Operating speeds through this section of the study area appear to be in excess of 35 miles/hour. Although there are no CRF's specific to the application of Sharrows, the literature appears to suggest an increase in collision frequency (both bicycle and vehicle collisions associated with the installation of bike lanes (Bicycle Tracks and Lanes: A before and After Study, Jenson, 2008). This suggests that careful consideration of site context and the appropriateness of the proposed facility for cycling is required. Sharrows would provide motorists with an indication that cyclists may be present on this section of the facility. Based on this discussion, a negligible impact on collision severity and likelihood is expected. However, this measure does support the potnetial improvement associated with the advanced flashing warning devise countermeasure.	Application locations include: Curvilinear section of Route 84 between the Alameda Creek Bridge and the Alameda Creek Bridge BOH Rosewarnes underpass Farwell underpass	Although this measure offers no measureable change in collision frequency, it could be combined with the activated warning system in AN-2 to potentially improve likelihood of achieving a road safety benefit.

ID No.	Analysis Technique	Discussion	Treatment Locations	Analysis Results Using 2012 Horizon Year
Short-Term Countermeasures				
C-1	CRF/IHSDM	NCHRP 617 Crash Reduction for Traffic Engineering and ITS Improvements, Harkey etal 2008. CRF = 24% All collisions CRF = 30% Single vehicle CRF = 57% Wet road collisions One study of a California two-lane road with sharp curves found a 72 percent reduction in wet-pavement accidents, but only 7 percent reduction in dry-pavement accidents. Use CRF = 57% reduction for wet road conditions 4% of corridor collisions occured in wet conditions	Application locations include: Rosewarnes underpass (10+112.259 m to 10+201.066 m) Palomares and Farwell underpass (11+522 m to 11+734 m) West end of Alameda Creek Bridge and through low-speed curves located between the Alameda Creek Bridges (7+190 m to 7+672 m and 2+325 ft to 7+371 ft)	Total collision reduction = 8.34 x 57% x 4% = 0.19 collisions/year
IO-8	CRF/IHSDM	No CRF specific to the installation of mirrors to improve intersection sight distance are available. Restricted sight distance in one quadrant of an intersection can result in a 5% increase in all collisions (Prediction of the expected safety performance of rural two lane highways, FHWA, Harwood etall, 2000). This suggest that the installation of a mirror may offer some small benefit in reducing all collisions. Assume CRF = 2% reduction in all collisions	Palomares intersection (11+522 m to 11+734 m)	Total collision reduction = 1.44 x 2% = 0.03 collisions/year
IO-9	Engineering Judgement	No CRF specific to this situation. Because of the limited sightlines, it is likely that relocating this sign further to the east will increase collision likelihood. Opportunities to improve the current signage should be considered. Options may include adding an "Ahead" tab to the existing sign to improve the guidance offered to drivers.	Palomares intersection	Consider modifying signage at the existing location.
IO-11	CRF/IHSDM	Dynamic message sign CRF = 20% for all (Handbook of Road Safety Measures, Elvik and Vaa, Oxford, UK, 2004. Dynamic advanced intersection warning system CRF = 54% to 70% reduction in all collisions (NCHRP 650: Median Intersection Design for Rural High-Speed Divided Highways, Maze etal, 2010. In order to ensure effectiveness, ITS elements should replace the existing flashing warning sign as the combination of continuous and active warning devices will be confusing to drivers. As there is already a flashing warning " intersection warning" sign in advance of the intersection, the resulting change in collision frequency resulting from changing the sign message will likely be limited.	Westbound approach to Palomares intersection	No measureable change in collision frequency is expected.

<table>
<tr><th>ID No.</th><th>Analysis Technique</th><th>Discussion</th><th>Treatment Locations</th><th>Analysis Results
Using 2012 Horizon Year</th></tr>
<tr><td colspan="5">Short-Term Countermeasures</td></tr>
<tr><td>P-1</td><td>CRF/IHSDM</td><td>This passing zone is bounded by curvilinear alignments at both ends. This is not an appropriate location for passing activity.

Elimination of this passing zone permits the provision of a flush median treatment with centerline rumble strips. It also reduces the risk of high approach speeds into the low speed horizontal curves.

Centerline rumble strips can result in the following improvement: CRF = 37% head-on collisions (NCHRP 641: Guidance for the design and application of shoulder and centerline rumble strips, Torbic etal, 2009).
CRF = 9% - 14% all collisions (NCHRP 641 and Crash Reduction Following Installation of Centerline Rumble Strips on Rural Two-Lane Roads, Persaud, etal, 2003).
Use CRF = 12% reduction in all collisions as this is both a head-on collision and speed management countermeasure.</td><td>A 1600 foot section of Route 84 west of the Rosewarnes underpass (10+358 m to 10+841 m)</td><td>Total collision reduction = 1.85 x 12% = 0.22 collisions/year</td></tr>
<tr><td>R-8</td><td>Current practice</td><td>This program is currently in place.
No change in safety performance. CRF = 0</td><td>Application locations include:
A 600 ft section of Route 84 just east of Rosewarnes
A 1200 ft section of Route 84 in the vicinity of Palomares Road</td><td>Already being conducted. This forms part of the baseline condition.</td></tr>
<tr><td>R-12</td><td>RSAP</td><td>Install crash worth end-treatments at barrier installations. Although replacing blunt end barriers with crashworthy end-treatments will not reduce the likelihood of collision, the resulting severity of the collision will the barrier end will be reduced.
An RSAP analysis suggest the Severity Index resulting from a collision with the barrier end will reduce from 3.90 to 2.55.
<table>
<tr><th rowspan="3">Accident Severity Level</th><th colspan="12">Proportion of Accident Severity Level (%)</th></tr>
<tr><th colspan="12">SI Level</th></tr>
<tr><th>0</th><th>0.5</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th></tr>
<tr><td>PDO1</td><td>0.0</td><td>100.0</td><td>66.7</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td></tr>
<tr><td>PDO2</td><td>0.0</td><td>0.0</td><td>23.7</td><td>71.0</td><td>43.0</td><td>30.0</td><td>15.0</td><td>7.0</td><td>2.0</td><td>0.0</td><td>0.0</td><td>0.0</td></tr>
<tr><td>Slight Injury</td><td>0.0</td><td>0.0</td><td>7.3</td><td>22.0</td><td>34.0</td><td>30.0</td><td>22.0</td><td>16.0</td><td>10.0</td><td>4.0</td><td>0.0</td><td>0.0</td></tr>
<tr><td>Moderate Injury</td><td>0.0</td><td>0.0</td><td>2.3</td><td>7.0</td><td>21.0</td><td>32.0</td><td>45.0</td><td>39.0</td><td>28.0</td><td>19.0</td><td>7.0</td><td>0.0</td></tr>
<tr><td>Severe Injury</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>1.0</td><td>5.0</td><td>10.0</td><td>20.0</td><td>30.0</td><td>27.0</td><td>18.0</td><td>0.0</td></tr>
<tr><td>Fatal</td><td>0.0</td><td>0.0</td><td>0.0</td><td>0.0</td><td>1.0</td><td>3.0</td><td>8.0</td><td>18.0</td><td>30.0</td><td>50.0</td><td>75.0</td><td>100.0</td></tr>
</table>
</td><td></td><td>Although there is no change in collision likelihood associated with this safety improvement, there will be a reduction in the resulting collision severity.</td></tr>
<tr><td>R-14</td><td>General maintenance</td><td>Includes issues associated with barrier mounting height, barrier condition, etc.
Could have a significant impact on collision severity as approximately 52% of collisions on the facility involve the roadside (fixed object and overturn collisions).</td><td>Throughout the study area</td><td>Although there is no change in collision likelihood associated with this safety improvement, there will be a reduction in the resulting collision severity.</td></tr>
</table>

<table>
<thead>
<tr><th>ID No.</th><th>Analysis Technique</th><th>Discussion</th><th>Treatment Locations</th><th>Analysis Results
Using 2012 Horizon Year</th></tr>
</thead>
<tbody>
<tr><td colspan="5">Short-Term Countermeasures</td></tr>
<tr><td>R-15</td><td>RSAP</td><td>RSAP was used to estimate the collision frequency associated with incremental changes in the roadside hazard offset. The results were as follows:
<table>
<tr><th rowspan="2">Treatment</th><th colspan="4">Annual Collision Frequency Reduction</th></tr>
<tr><th>2012</th><th>2020</th><th>2030</th><th>Approximate Annual Collision Cost Reduction</th></tr>
<tr><td>Remove single tree (1 foot in diameter)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>At 4 ft offset from edge of through lane</td><td>0.006</td><td>0.006</td><td>0.007</td><td>$2,000</td></tr>
<tr><td>At 10 ft offset from edge of through lane</td><td>0.002</td><td>0.002</td><td>0.003</td><td>$1,100</td></tr>
<tr><td>At 20 ft offset from edge of through lane</td><td>0.0006</td><td>0.0007</td><td>0.0008</td><td>$400</td></tr>
<tr><td>Remove a row of trees (1 foot in diameter spaced at 35 ft)/ 0.1 mile</td><td></td><td></td><td></td><td></td></tr>
<tr><td>At 4 ft from edge of through lane</td><td>0.033</td><td>0.036</td><td>0.04</td><td>$23,400</td></tr>
<tr><td>At 10 ft from edge of through lane</td><td>0.012</td><td>0.013</td><td>0.015</td><td>$15,300</td></tr>
<tr><td>At 20 ft from edge of through lane</td><td>0.004</td><td>0.004</td><td>0.005</td><td>$7,000</td></tr>
<tr><td>Utility poles</td><td></td><td></td><td></td><td></td></tr>
<tr><td>At 4 ft offset from edge of through lane</td><td>0.006</td><td>0.006</td><td>0.007</td><td>$1,600</td></tr>
<tr><td>At 10 ft offset from edge of through lane</td><td>0.002</td><td>0.002</td><td>0.003</td><td>$900</td></tr>
<tr><td>At 20 ft offset from edge of through lane</td><td>0.0006</td><td>0.0007</td><td>0.0008</td><td>$300</td></tr>
<tr><td>Culvert headwall</td><td>0.008</td><td>0.009</td><td>0.01</td><td>$2,700</td></tr>
<tr><td>Eucalyptus trees at The Spot (20 trees at 10 ft spacing</td><td>0.06</td><td>0.07</td><td>0.08</td><td>$15,400</td></tr>
<tr><td>Electrical transformer</td><td>0.008</td><td>0.009</td><td>0.01</td><td>$1,500</td></tr>
</table>
</td><td>Utility poles = 7 poles at 4 ft
Utility poles = 3 poles at 10 ft
Trees = 3 trees at 4 ft
Tree line at 10 ft = 0.1 mile
Eucalyptus trees
Culvert headwall
Electrical transformer</td><td>Total collision reduction = 0.15 collisions/year

Approximate annual collision cost reduction = $54,800.</td></tr>
<tr><td>SIMA-1</td><td>CRF/IHSDM</td><td>Installing delineators on bridges CRF = 39% to 50% all collisions (Update of Florida Crash Reduction Factors and Countermeasures to Improve the Development of District Safety Improvement Projects, Florida DOT, 2005).

Use CRF = 39% of fixed object collisions at the underpasses.
Fixed object collisions = 37% within corridor</td><td>Application locations include:
Rosewarnes underpass (10+112 m to 10+201 m)
Farwell underpass (11+522 m to 11+734 m)</td><td>Total collision reduction =1.85 x 37% x 39% = 0.27 collisions/year</td></tr>
<tr><td>SIMA-2</td><td>CRF/IHSDM</td><td>CRF's for the installation of general roadside delineators:
CRF = 11% all collisions (Florida DOT)
CRF = 25% night collisions (Florida DOT)
CRF = 34% run-off-road collisions (Florida DOT)
CRF = 8% all fatal and injury collisions (Safety Reviews of Existing Roads: Quantitative Safety Assessment Methodology, Montella, Italy, 2005)

Use CRF =25% of night collisions
Nighttime collisions occurring on the roadway = 37%</td><td>Application locations include:
10+358 m to 10+841 m
11+621 m to 12+061 m
7+794 ft to 8+898 ft</td><td>Total collision reduction = 4.60 x 25% x 37% = 0.43 collisions/year</td></tr>
<tr><td>SIMA-3</td><td>CRF/IHSDM</td><td>Installation of dynamic message sign:
CRF = 20% for all collisions (Handbook of Road Safety Measures, Elvik and Vaa, Oxford, UK, 2004).
CRF = 16% for rear-end injury collisions
CRF = 16% increase in rear-end PDO collisions

Use CRF = 20% of all collisions in eastbound direction only.</td><td>Sunol interchange underpass 19+150 ft to 20+830 ft</td><td>Total collision reduction = 1.29 x 20% x 50% = 0.13 collisions/year</td></tr>
</tbody>
</table>

ID No.	Analysis Technique	Discussion	Treatment Locations	Analysis Results Using 2012 Horizon Year
Short-Term Countermeasures				
SPMA-1	Engineering Judgement	Due to the curvilinear alignment, confined cross section and close proximity of the bridge abutments, the use of flexible delineators in the median is not recommended. This treatment may create a shy zone in the median that could result in drivers encroaching closer to the bridge abutments.		Not recommended
SPMA-2	CRF/IHSDM	Changeable speed warning sign CRF = 41% to 46% all injury collisions (Handbook of Road Safety Measures, Elvik etal, Oxford, UK, 2004). Studies by New York, Mississippi, and Texas show transverse pavement markings can effectively reduce mean speeds, 85th percentile speeds, and speed variance. Initial 85th percentile speed reductions varied from 0 to 5 mi/h. However, their long-term effectiveness is not known. Change in 85th percentile speed: CRF = 5% all collision with a 5 mile/hour reduction in operating speed (WRRSP: Wyoming Rural Road Safety Program, Ksaibati etal, 2009).	Application locations include: Rosewarnes underpass (10+112 m to 10+201 m) Farwell underpass (11+522 m to 11+734 m) West end of Alameda Creek Bridge and through low-speed curves located between the Alameda Creek Bridges (7+189 m to 7+672 m and 2+325 ft to 7+371 ft) The effects of speed management measures diminish as drivers become accustom to the roadway changes. In our opinion, combining the various speed management measure CRF's creates an over-optimistic level of improvement. Therefore we have applied a combined CRF = 5% reduction in all collisions to the locations outline above. The 5% reduction includes speed feedback signs, pavement markings and lane narrowing.	Total collision reduction = 8.34 x 5% = 0.42 collisions/year
SPMA-3	IHSDM/ CRF	Assuming a 12 foot lane width for base case. 11 foot lane CRF = 5% increase in all collisions Assuming a 6 foot shoulder width for the base case. 7 foot lane width CRF = 6.5% decrease in all collisions Increase shoulder width by 1 foot		

Table 9: Medium-term countermeasures – Estimates of collision reduction for individual treatments

ID No.	Analysis Technique	Discussion	Treatment Locations	Analysis Results Using 2012 Horizon Year
Medium-Term Countermeasures				
ALCRBO-1	CRF/IHSDM	Upgrade bridge railing: CRF = 5% to 20% all collisions (Update of Florida Crash Reduction Factors and Countermeasures to Improve the Development of District Safety Improvement Projects, Florida DOT, 2005). CRF = 60% to 92% fatal collisions (Update of Florida Crash Reduction Factors and Countermeasures to Improve the Development of District Safety Improvement Projects, Florida DOT, 2005) CRF = 30% to 92% injury collisions (Update of Florida Crash Reduction Factors and Countermeasures to Improve the Development of District Safety Improvement Projects, Florida DOT, 2005) Use CRF = 20% of all collisions	Alameda Creek BOH (6+205 ft to 7+222 ft)	Total collision reduction = 0.83 x 20% = 0.17 collisions/year . Results in a significnat reduction in collision severity (60% to 92% Fatal and 30% to 92% injury collisions).
C-2	CRF/IHSDM	Improve superelevation: CRF = 28% to 40% all collisions (Update of Florida Crash Reduction Factors and Countermeasures to Improve the Development of District Safety Improvement Projects, Florida DOT, 2005) Improve superelevation (Crash reduction Factors for Traffic Engineering and ITS Improvements: State of Knowledge Report, TRB, 2005). CRF =100(1-(1.06+3(SD-0.02))) for superelevation deficiency greater that 2% - For a 3% deficiency, this results in a CRF = 9% CRF = 100(1-(1.00+6(SD-0.01))) for superelevation deficiency less than 2% Proposed superelevation improvement = 3% Use CRF = 18% for all collisions (average of 28% and 9%)	Low speed curve located between the Alameda Creek Bridges (4+011 ft to 4+289 ft)	Total collision reduction = 0.40 x 18% = 0.07 collisions/year
IO-1	CRF/IHSDM/HCM	Convert a four leg stop controlled intersection to a roundabout CRF = 3% increase in all collisions (NCHRP 572: Roundabouts in the United States, Rodegerdts etal, 2007. NCHRP 672: Roundabouts An Informational Guide also indicates that converting a four-leg stop controlled intersection to a roundabout results in insignificant changes in road safety performance at the intersection (all collisions and Fatal & Injury collisions). Improved traffic operations becomes the key advantage An HCM analysis of traffic volumes at the Pleasanton/Sunol intersection indicates that a roundabout can improve delay and Level of Service at this intersection. It also suggests that the eastbound queue length between Main Street and the Pleasanton intersections is reduced to 6 vehicles (approximately 160 feet). This reduction in queue length will improve traffic operation between Main and Pleasanton and will reduce the risk associated with high-speed end of queue collisions at the Sunol interchange. Although the CRF's suggest no road safety improvement will occur that the Pleasanton intersection, a reduction in rear-end collisions between the Sunol interchange and Main Street appears reasonable. We have assumed a 50% reduction in eastbound collisions in this area.	Sunol interchange underpass 19+150 ft to 20+830 ft	Total collision reduction = 1.16 x 50% x 50% = 0.29 collisions/year

ID No.	Analysis Technique	Discussion	Treatment Locations	Analysis Results Using 2012 Horizon Year
Medium-Term Countermeasures				
IO-2	CRF/IHSDM	Restricted sight distance in one quadrant of an intersection can result in a 5% increase in all collisions (Prediction of the expected safety performance of rural two lane highways, FHWA, Harwood etall, 2000). This suggest that the installation of a mirror may offer some small benefit in reducing all collisions. Assume CRF =5% reduction in all collisions Apply to predicted intersection collisions at Palomares	Palomares intersection (11+522 m to 11+734 m)	Total collision reduction = 1.03 x 5% = 0.05 collisions/year
IO-5	RSAP/CRF	Restricted sight distance in one quadrant of an intersection can result in a 5% increase in all collisions (Prediction of the expected safety performance of rural two lane highways, FHWA, Harwood etall, 2000). Relocating the bridge abutment also reduces the risk of road side related collisions at this location. RSAP indicates a reduction in collision frequency associated with the bridge pier of 94%. Apply this CRF to fixed object portion of the collision histroy (37%) at the pier.	Apply from Farwell underpass and Palomares intersection (11+522 m to 11+734 m)	Sight line collision reduction = 1.03 x 5% = 0.05 collisions/year Pier collision reduction =0.36 x37% x94% = 0.13 collisions/year Total = 0.18 collisions/year
IO-15	CRF/IHSDM/Caltrans Synchro analysis	Caltrans specific CRF's indicates the following: Installation of a new signal CRF = up to 20% reduction in all collisions Signal with left turn phase CRF = up to 35% reduction in all collisions HSM CRF's are as follows: Convert stop control to signal CRF = 5% reduction in all collisions for urban conditions and CRF = 44% reduction in all collision severities for rural condition **One limitation in these CRF's is that they typically apply to the conversion of two-way stop control conditions.** As outlined in NCHRP 672 and NCHRP 572, no road safety benefit is typically experienced at an intersection as a result of conversion from a four-way stop to a roundabout (CRF = -3%). As a roundabout has fewer conflict points than a signalized intersection, **a greater decrease in the level of road safety performance is likely to occur** when converting from a four-leg stop controlled intersection to a signalized intersection then would occur from converting a four-leg stop controlled intersection to a roundabout. NCHRP 572, Rodegerdts et al, 2007 suggests a 48% reduction in all collision types and severities and a 78% reduction in injury related collisions for the conversion of a signalized intersection to a roundabout. It should be noted that the intersection skew angle of east leg of the Pleasanton/Sunol intersection is a concern for high-speed through traffic traversing the intersection. Realignment of the east leg of this intersection should be considered as part of any plans to apply signals at this location. A Synchro analysis of traffic volumes at the Pleasanton/Sunol and Main Street intersections conducted by Caltrans, indicates that signalization of the Pleasanton and Main Street intersection improved traffic operations and Level of Service at these locations. It also indicates that queue lengths on the eastbound approach to these intersections are reduced. This reduction in queue length reduces the risk associated with high-speed end of queue collisions at the Sunol interchange. A reduction in rear-end collisions between the Sunol interchange and Main Street appears reasonable. We have assumed a 50% reduction in eastbound rear-end collisions in this area.	Pleasanton/Sunol Intersection and Sunol interchange underpass 19+150 ft to 20+830 ft	Signal results in reduced safety performance at the intersection when compared to the potential safety performance of a roundabout (48% increase in all collisions and 78% increase in injury related collisions). Collision increase = 1.67 x 48% = 0.81 collisions/year. Improvement associated with high-speed end of queue collisions at Sunol underpass have been estimated as follows: Total collision reduction = 1.16 x 50% x 50% = 0.29 collisions/year Resulting increase in collision frequency = 0.81 - 0.29 = 0.52 colllisions/year

ID No.	Analysis Technique	Discussion	Treatment Locations	Analysis Results Using 2012 Horizon Year
Medium-Term Countermeasures				
R-4	IHSDM	Adjust existing condition IHSDM model to include the realignment of Route 84 and cross section changes (8 foot shoulders) at this location. For this analysis, historical collision data was removed from the model in order to obtain the relative percent difference in road safety performance at this location. This relative difference was used as a CRF (CRF = 60%) and applied to the baseline IHSDM model to determine the change in collision frequency.	Rosewarnes underpass	Total collision reduction = 0.30 x 60% = 0.18 collisions/year
R-9	RSAP/CRF	CRF for median barrier installation = 86% to 77% reduction in all collisions and 88% reduction in fatal and injury collisions (Hovey, P. W. and Chowdhury, M., "Development of Crash Reduction Factors." , Ohio Department of Transport,2005). However, these numbers are more applicable to multi-lane divided highways and do not appears reasonable for this situation. associated with the installation of median barrier at this location appears more appropriate. A reduced potential for head-on and side swipe collisions due to the insatallation of median barrier at this location appears more appropriate (assume 100% reduction in this collision type). Percentage head-on and sideswipe collisions for study area = 8% RSAP analysis suggests a 50% increases in roadside related collisions associated with the bification (introduction of median barrier and crashworthy end-treatments). Percentage of roadside related collisions for study area = 52% (fixed object and overturn) All of this appears to suggest an increase in collision frequency and a reduction in collision severity.	Rosewarnes underpass	Decrease in collision frequency due to reduced risk of head-on and sideswipe collisions = (0.30 x 8% x100%) = 0.02 collisions/year Total collision increase =(0.30 x 52% x 150%) = 0.23 collisions/year Resuting incease in collision frequency = 0.23-0.02 = 0.21 collisions/year.
RO-1	CRF/IHSDM	Adjust existing condition IHSDM model to include the realignment of Route 84 and cross section changes (8 foot shoulders) at this location. For this analysis, historical collision data was removed from the model in order to obtain the relative percent difference in road safety performance at this location. This relative difference was used as a CRF (CRF = 62%) and applied to the baseline IHSDM model to determine the change in collision frequency.	Rosewarnes underpass	Total collision reduction = 0.30 x 62% = 0.19 collisions/year
SPMA-4	CRF/IHSDM	Adjust existing condition IHSDM model to reflect an 8 ft paved shoulder at specific locations on the facility	Apply the the following locations: Eastbound 8+898 to 10+060 ft 22+256 to 25+654 ft Westbound 6+205 to 7+103 ft 11+432 to 12+382 ft 16+765 to 19+564 ft	Total collision reduction = 0 collisions/year
C-3	CRF/IHSDM	Widen lane Add 2 feet to sides CRF = 23% Head-on, run-off-road, sideswipes (Update of Florida Crash Reduction Factors and Countermeasures to Improve the Development of District Safety Improvement Projects, Florida DOT, 2005). Applied to 61% of corridor related collisions	Apply to low-speed curve at station 4+011 to 4+289	Total collision reduction = 0.40 x 23% x 61% = 0.06 collisions/year
ACB-2	CRF/IHSDM	Adjust existing condition IHSDM model to reflect an 8 ft paved shoulders on bridge and new horizontal alignment. For this analysis, historical collision data was removed from the model in order to obtain the relative percent difference in road safety performance at this location. This relative difference was used as a CRF (CRF = 24%) and applied to the baseline IHSDM model to determine the change in collision frequency.	Alameda Creek Bridge and its approaches (7+189 to 7+431)	Total collision reduction = 1.54 x 24% = 0.37 collisions/year

Table 10: Long-Term & Community Vision countermeasures – Estimates of collision reduction for individual treatments

ID No.	Analysis Technique	Discussion	Treatment Locations	Analysis Results Using 2012 Horizon Year
Long-Term & Community Vision Countermeasures				
AN-4		Experienced cyclists will likely still travel on Route 84		Not quantified
AN-6		Experienced cyclists will likely still travel on Route 84		Not quantified
RE-1		Will likely contribute to reduced traffic volumes this could contribute to reduced collision frequencies		Not quantified
RO-3	CRF/IHSDM	Adjust the existing condition IHSDM model to reflect 8 ft paved shoulders, 12 ft lanes and an improved roadside condition.		Total collision reduction = 1.31 collisions/year
IO-13	CRF/IHSDM	Flatten crest vertical curve: CRF = 50% fatal and injury collisions CRF = 20% all collisions Use CRF = 20% reduction in all collisions	Applies to crest vertical curve at Quarry (9+700 to 10+060 ft)	Total collision reduction = 0.08 x 20% = 0.02 collisions/year
QI-1	CRF/IHSDM	Install acceleration/deceleration lanes: CRF = 10% all collisions (Development of Accident Reduction Factors, Agent etal, 1996) CRF = 10% all collisions (Update of Florida Crash Reduction Factors and Countermeasures to Improve the Development of District Safety Improvement Projects, Florida DOT, 2005). Use CRF =10% reduction in all collisions in the vicinity of the Quarry intersection.	Applies to Quarry entrance (9+700 to 10+060 ft)	Total collision reduction = 0.08 x 10% = 0.01 collisions/year

3.5 Combined impact of countermeasures

Using results from the quantitative road safety analysis of the proposed countermeasures, short-term and mid-term countermeasure strategies were selected by the QRSA team. These strategies are outlined in the following tables:

Table 11: Short-term countermeasure strategy

ID No.	Idea Description
IO-17	Illumination at key locations
AN-2	Install active warning system to alert motorists to bikes on roadway
AN-5	Install sharrows on shoulders or lane edges at select locations to demonstrate potential bicycle usage
C-1	Install friction treatment to pavements at low-speed curves and in icy areas
IO-8	Install mirrors at Palomares Road to view westbound traffic
IO-11	Install ITS elements at Palomares Road to signal drivers of approaching vehicles
P-1	Eliminate passing zone adjacent to low-speed curves
R-5	Install steel mesh netting on slopes in rockfall areas
R-12	Address guard rail and k-rail end treatments
R-14	Upgrade roadside protection appurtenances
R-15	Relocate select fixed objects immediately adjacent to roadway
SIMA-1	Install reflective material on underpass abutments
SIMA-2	Install reflective material on curbs and rock walls adjacent to roadway
SIMA-3	Install dynamic active warning device for queuing conditions
SPMA-2	Install speed feedback sign and longitudinal pavement markings at low-speed curves
SPMA-3	Narrow lane widths to 11 feet and reaportion to shoulder

APPENDIX A: Comments from a road safety field review of the study area conducted by representatives from Delphi-MRC and VMS.

Table 12: Medium-term countermeasure strategy

ALCRBO-1	Remove curb on Alameda Creek BOH and upgrade rail
C-2	Correct superelevations at low-speed curves
IO-1	Construct a roundabout at the intersection of SR-84 and Sunol/Pleasanton
IO-2	Realign Palomares Road to join church driveway
RO-1	Construct tunnel into slope at Rosewarnes and realign roadway accordingly
SPMA-4	Provide widened locations at strategic spacing to accommodate enforcement and pull overs
C-3	Widen roadway at curve east of Alameda Creek Bridge to accommodate off-tracking
ACB-2	Replace Alameda Creek Bridge

Although implementing several countermeasures might be more effective than just one, it is unlikely the full effect of each countermeasure would be realized when they are implemented concurrently, particularly if the countermeasures are targeting the same crash type. As a result, when multiple countermeasures are implemented at one location, the common practice is to multiply the Crash Modification Factors to estimate the combined effect of the countermeasures.

This process was applied to locations within the corridor to estimate the level of collision reduction that may be achieved through the implementation of the various countermeasure bundles. The following table summarizes the estimated combined impact of proposed countermeasures at key locations within the study area.

Table 13: Quantitative road safety analysis of short-term countermeasure strategy (2012)

Short-Term Countermeasures						
Location	Countermeasures Applied	Annual Collision Frequency (2012)		Collision Rate (per mvm)		% Collision Reduction
		Before	After	Before	After	
Rosewarnes underpass	- Lighting of key areas (IO-17) - Install active warning system to alert motorists to bikes on roadway (AN-2) - Install friction treatment to pavements at low-speed curves and in icy areas (C-1) - Install reflective material on underpass abutments (SIMA-1) - Install speed feedback sign and longitudinal pavement markings at low-speed curves; narrow lane widths to 11 feet and reapportion to shoulder (SPMA-2&3)	0.41	0.30	1.33	0.97	27%
Between Rosewarnes underpass & Palomares Rd	- Install reflective material on curbs and rock walls adjacent to roadway (SIMA-2) - Eliminate passing zone adjacent to low-speed curves (P-1)	1.85	1.48	1.10	0.88	20%
Palomares Rd & Farwell underpass	- Install mirrors at Palomares Road to view westbound traffic (IO-8) - Lighting of key areas (IO-17) - Install active warning system to alert motorists to bikes on roadway (AN-2) - Install friction treatment to pavements at low-speed curves and in icy areas (C-1) - Install reflective material on underpass abutments (SIMA-1) - Install speed feedback sign and longitudinal pavement markings at low-speed curves; narrow lane widths to 11 feet and reapportion to shoulder (SPMA-2&3)	1.44	1.03	1.95	1.40	28%
Between Farwell underpass & Alameda Creek Bridge	- Install reflective material on curbs and rock walls adjacent to roadway (SIMA-2)	1.93	1.75	1.30	1.18	9%
Alameda Creek Bridge to Alameda Creek BOH	- Install active warning system to alert motorists to bikes on roadway (AN-2) - Install friction treatment to pavements at low-speed curves and in icy areas (C-1) - Install speed feedback sign and longitudinal pavement markings at low-speed curves; narrow lane widths to 11 feet and reapportion to shoulder (SPMA-2&3)	6.49	6.00	0.95	0.88	8%
East of Alameda Creek BOH (0.2 miles)	- Install reflective material on curbs and rock walls adjacent to roadway (SIMA-2)	0.82	0.74	0.72	0.65	9%
Between Silver Springs UP and Pleasanton-Sunol intersection	- Install dynamic active warning device for queuing conditions (SIMA-3)	1.29	1.16	0.74	0.67	10%
	Total collision frequency	**14.23**	**12.47**			
		Δ	**1.76**			

Table 14: Quantitative road safety analysis of medium-term countermeasure strategy (2012)

Medium-Term Countermeasures							
Location	Countermeasures Applied	Annual Collision Frequency (2012)		Collision Rate (per mvm)		% Collision Reduction
		Before	After	Before	After	
Rosewarnes underpass	- Construct tunnel into slope at Rosewarnes and realign roadway accordingly (RO-1)	0.30	0.11	0.97	0.37	62%
Palomares Rd & Farwell underpass	- Realign Palomares Road to join church driveway (IO-2)	1.03	0.98	1.40	1.33	5%
Alameda Creek Bridge	- Replace Alameda Creek Bridge (ACB-2)	1.87	1.42	0.27	0.21	24%
Low Speed curve in the vicinity of "The Spot"	- Widen roadway at low speed curve at the Spot to accommodate off-tracking (C-3) - Correct superelevation at low-speed curves (C-2)	0.40	0.31	1.39	1.07	23%
Alameda Creek BOH	- Remove curb on Alameda Creek BOH and upgrade rail (ALCRBO-1)	0.83	0.66	0.79	0.63	20%
Between Silver Springs UP and Pleasanton - Sunol intersection	- Construct a roundabout at the intersection of SR-84 and Sunol-Pleasanton (IO-1)	1.16	0.87	0.67	0.50	25%
	Total collision frequency	**5.59**	**4.36**			
		Δ	**1.24**			

3.6 Long-term countermeasures

The long-term countermeasures and community vision road safety improvements include the following:

Table 15: Long-term countermeasure strategy

ID No.	Idea Description
RO-3	Widen roadway to provide roadway cross-section of 12’ lanes, 8’ shoulders, and spot widening for CRZ
IO-13	Correct superelevation and vertical sight distance at Quarry road intersection
QI-1	Extend the EB left turn pocket at the Quarry intersection

Table 16: Long-term community vision strategy

ID No.	Idea Description
AN-4	Separate non-motorized traffic to off-roadway trail system
AN-6	Provide bike path adjacent to railroad grade
RE-1	Designate Niles Canyon as a park and install toll booths on each end

The long-term and community vision road safety improvements were not evaluated as a bundled strategy as the need for their implementation is not a high priority and in many cases involves a long-term regional approach to their implementation.

3.7 Findings

3.7.1 Short-term strategy

Finding from the analysis of the short-term strategy indicate the following:

- Application of the short-term countermeasure strategy is estimated to reduce the corridor wide collision frequency by 1.76 collisions/year. Key contributors to this reduction include the countermeasures applied between Rosewarnes and Palomares, countermeasures applied in the vicinity of Palomares and Farwell, and countermeasures applied between the Alameda Creek Bridge and Alameda BOH.

- A significant reduction in collision rate (27% to 28%) is predicted in the vicinity of the Rosewarnes underpass and the Palomares Road/Farwell underpass with the implementation of the short-term countermeasures.

- A small reduction in collision rate (8% to 10%) is predicted for the roadway segment located between Alameda Creek Bridge and Alameda BOH, and between the Sunol interchange and Main Street intersection with the implementation of the short-term countermeasures.

3.7.2 Medium-term strategy

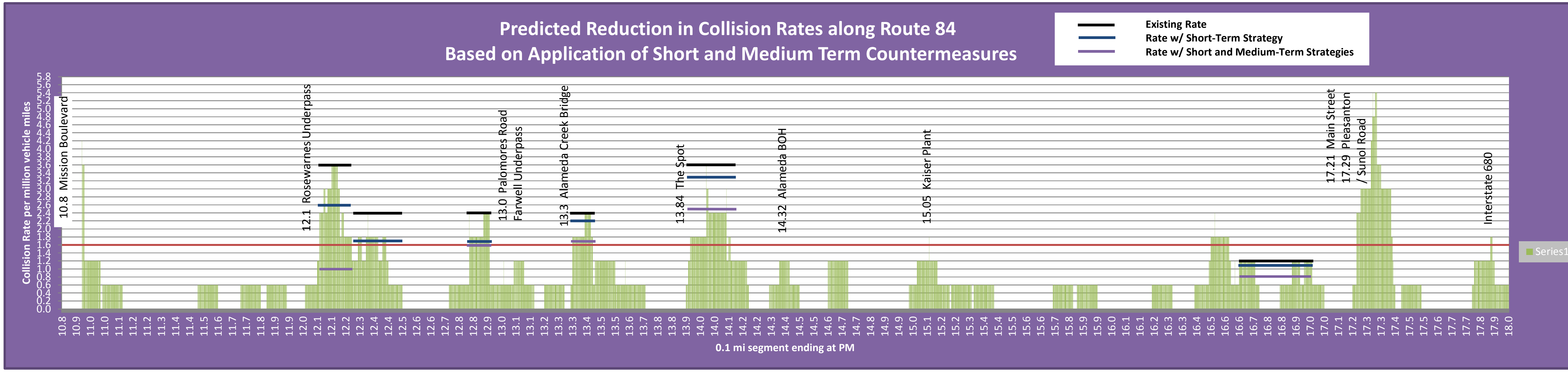
- After implementing the short-term countermeasures, application of the medium-term countermeasure strategy is estimated to reduce the corridor wide collision frequency by an additional 1.24 collisions/year. Key contributors to this reduction include the tunnel at Rosewarnes, replacement of the Alameda Creek Bridge and replacing the stop controlled intersection at Pleasanton with a roundabout.

- A 62% reduction in collision rate is predicted at the Rosewarnes underpass with the introduction of a tunnel as part of the medium-term countermeasures.

- Significant reductions in collision rate (20% to 25%) are also predicted with the application of the medium-term countermeasures at Alameda Creek Bridge, the low-speed curve in the vicinity of The Spot, Alameda BOH, and between the Sunol interchange and Main Street intersection

In order to illustrate the level of change in collision rate that has been estimated from this analysis, the reductions outlined in Tables 13 and 14 of this report were applied to the rolling collision rate diagram for all collision severities from Section 2.4.2 of this report. The results are plotted in the figure below.

Figure 16: Predicted reduction in collision rates for Short-Term and Medium-Term countermeasure strategies – Applied to rolling collision rate diagram for collision data between November 2007 and September 2010.



4 Conclusions

The goal of this report is to provide prioritization guidance on road safety issues identified by the independent FHWA Road Safety Audit and were possible to provide quantitative estimates of expected levels of road safety improvement associated with countermeasures developed to address the road safety concerns identified.

In carrying out this work, an assessment of the existing road safety performance of the study area was conducted using a number of analytical techniques and toolsets. Findings from this analysis identified locations within the study area that appear to offer the greatest potential for road safety improvement. The top five priority locations include the following:

- Rosewarnes Underpass and its approaches (includes passing zone to east)
- Low-speed curve in the vicinity of "The Spot"
- Palomares intersection/Farwell underpass (includes the vicinity of the church access)
- Main Street and Pleasanton intersections
- Alameda Creek Bridge

In addition to the specific locations identified above, there are a number of corridor-wide road safety issues that were identified as part of the Prioritized Road Safety Audit Findings and Collision Patter Analysis lines of evidence that require careful consideration. These include:

- Accommodation of bicycles on the facility as Stakeholders have reported that bicycling on this section of roadway is gaining popularity.
- Roadside design concerns including the adequacy to clear zone provisions, the presence of roadside hazards and barrier deficiencies.
- Shoulder discontinuities that can adversely impact the recovery of vehicles that lose control and depart the roadway and limit opportunities to accommodate disabled vehicles, bicycles and police enforcement.
- Vegetation that obstructs existing warning signs and creating lateral sightline obstructions at horizontal curves.

To address the road safety concerns identified, short-term, medium-term and long-term countermeasure strategies were developed by the QRSA team. Using quantitative road safety analysis techniques, the potential effectiveness of each strategy was determined. The results of this analysis suggest the following:

- Application of the short-term countermeasure strategy is estimated to reduce the corridor wide collision frequency by 1.76 collisions/year. Key contributors to this reduction include the countermeasures applied between Rosewarnes and Palomares, countermeasures applied in the vicinity of Palomares and Farwell, and countermeasures applied between the Alameda Creek Bridge and Alameda BOH.

- The short-term countermeasures appear to offer significant road safety improvement for relatively minor implementation cost and environmental impact.

- Application of the medium-term countermeasures in addition to the short-term countermeasures has the potential to reduce the corridor wide collision frequency by an additional 1.24 collisions/year. This is a combined reduction in collision frequency of 3.0 collisions/year. Key contributors to this reduction include the tunnel at Rosewarnes, replacement of the Alameda Creek Bridge and replacing the stop controlled intersection at Pleasanton with a roundabout.

- Although the road safety improvements associated with the medium-term countermeasures are beneficial, the costs and environmental impacts associated with these countermeasures are significant. Clearly the extent to which the medium-term countermeasures are implemented will need to be evaluated as part of the Caltrans project development and environmental processes.

- The long-term countermeasures should be considered in any future long-term planning studies after the implementation of short and medium-term countermeasures. Discussions with Caltrans suggest the community vision countermeasures will need to be addressed by the regional planning agencies.

In association with

Appendix A: Route 84 Niles Canyon Highway: Road Safety Field Reconnaissance

Findings from a road safety field reconnaissance of existing conditions within the Route 84 study area conducted in support of the VA workshop carried out as part of the QSRA study.

August 31, 2012

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Background

In preparation for the Route 84 - Niles Canyon Highway Value Assessment (VA) workshop, a road safety field reconnaissance was conducted to familiarize key members of the QSRA team with the physical nature of the facility and the current operating characteristics. Both day and night field reviews were conducted within the study area between May 7 and 8, 2012 by the following QSRA team members:

- George Hunter, P.E. Value Management Strategies
- Mark Watson, P.E, Value Management Strategies
- Geoff Millen, P. Eng., Delphi-MRC

This review provided an insight into the interaction of roadway geometry and the collision performance of the roadway including:

- Driver workload issues such as user task loads and information requirements.
- Traffic operations characteristics including, but not limited to, operating speeds, the presence of speed differentials, intersection operations and other aspects of the operating environment.
- Highway and roadside design characteristics, compliance with generally accepted design and operations practices, maintenance conditions and other matters.

1.2 Focus of this review

Our review addresses road safety and operational issues only. In carrying out our work, we conducted a field review of the study corridor to observe existing traffic operations.

We have examined the various issues upon which we provide comment from a road safety and operational perspective only, and do not attempt to deal with the question of cost-effectiveness. Readers of this report should recognize that road design and operational decisions necessarily encompass and must be influenced by the need to provide cost-effective overall solutions to design problems. While it is essential that safety be considered explicitly during the process – as is the intent with this review - it is not the only factor that will influence the final overall resolution of the road safety questions under consideration.

2 OBSERVATIONS

2.1 Speed

- Based on field observations, free flow 85th percentile operating speeds on this facility were estimated to be approximately 48-50 miles/hour. These speeds exceed the 45 mile/hour posted speed. It was noted that operating speeds to the east of Alameda BOH appeared to be higher. This may be the result of the less curvilinear alignment and open cross section.

- Several horizontal curves within the study area are posted with speed advisory tab signs. In some instances, the advisory speeds are as low as 25 miles/hour. These inconsistencies in horizontal alignment can contribute to increased speed differential and result in an increased risk of collision. Of particular concern are the low-speed curves at the Rosewarnes and Farwell Underpasses, west end of the Alameda Creek Bridge and just west of “The Spot”.

- A passing zone located to the west of Rosewarnes may promote high-speed approaches into tight radius curves located at each end of the passing zone.

2.2 Roadside barrier

- A review of the existing roadside barrier installations identified the following concerns:

  - The mounting height of the W-beam channel appears low at locations throughout the facility. This may reduce the barrier effectiveness upon impact.

  - Blunt end barrier sections were observed at locations within the study area. Relocating the blunt end beyond the clear zone, burying the blunt end in a backslope or protecting the blunt end with a crash-worth end-treatment may be potential countermeasures.

- The W-beam installations at the Alameda Creek BOH do not appear to be connected to the bridge railing. This may reduce the effectiveness of the W-beam transition to the structure upon impact.

- The bridge railing at the Alameda BOH does not appear to be a technology that complies with NCHRP-350 or MASH testing requirements.

- Fixed objects are located within the W-beam deflection distance and within the gating zone of some end-treatments. This will likely reduce the barrier effectiveness during an impact.

2.3 **Roadside hazards**

- Based on the observed operating speeds, a minimum clear zone provision ranging from 20.0 ft. to 28.0 ft. appears appropriate. These clear zone dimensions are based on the guidance and best practices contained in the AASHTO Roadside Design Guide.

- Throughout the study area, fixed objects including utility poles, electrical installations, trees and culvert headwalls were observed within the required clear zone. These present a hazard to vehicles encroaching on the roadside and should be removed, made breakaway or considered for barrier protection.

- The close proximity of the bridge pier to the travel lane at the Rosewarnes Underpass is of particular concern. The pier exhibits evidence of past impacts.

- Aggressive roadside slopes were observed throughout the facility. Features included critical slopes, rock outcrops, slopes with rough surfaces that may affect an errant vehicles ability to recover and retaining walls that present a tripping or vaulting hazard to errant vehicles.

- Shoulder erosion and deterioration has created a pavement edge drop-off at several locations throughout the study area.

2.4 **Positive guidance**

- Sign clutter was observed at several locations within the study area. This can reduce sign effectiveness and may cause drivers to overlook key warnings information. The figure below provides an example from the eastbound lanes of Route 84 just east of the Mission Boulevard intersection.

- During nighttime driving conditions, the overhead warning signs on the approaches to the Rosewarnes Underpass and the Palomares intersection are difficult to see. This may be an issue associated with sign sheet reflectivity or the absence of illumination on these signs. In addition, sightlines to the overhead sign on the eastbound approach to Rosewarnes are obstructed by vegetation.

- Warning signs are obstructed by vegetation growth. Discussions with Caltrans maintenance staff indicated that vegetation is cut back annually; however, this operation has not yet been conducted on this facility.

- On the eastbound approach to the Silver Springs underpass, the exit ramp appears to be the through movement for traffic continuing on Route 84. Limited visibility to the underpass structure created by a crest vertical curve on the approach may be contributing to this phenomenon. The provision of enhances positive guidance at this location should be considered.

- Painted bars delineating the “Keep Clear” zone at the Main Street intersection gives the appearance of a stop bar and a three-way stop controlled intersection. This was particularly confusing at night.

- During the nighttime review, the eastbound stop sign at the Pleasanton/Sunol intersection was not obvious as the illumination at this intersection is limited.

2.5 **Intersection operations**

- Intersection operations at the Main Street and Pleasanton intersections create eastbound traffic queues during both AM and PM peak periods that extend back to the Silver Springs underpass. Roadway geometry, terrain and the closed structure configuration at this underpass limit sightlines to the end of queue. This creates a significant risk for high-speed end-of-queue collision.

- Sightlines at the Palomares Road intersection are severely limited to the west by the Farwell underpass abutment. This creates a challenge for drivers turning both left and right from this intersection. The intersection skew also creates challenges for drivers turning right onto Route 84 as these vehicles entre the intersection at a low intersection skew angle.

- The Mission Boulevard intersection consists of a wide expanse of uncontrolled pavement. In addition, the eastbound through lane is oriented with the left turn lane from the opposing direction. This is an unusual configuration.

- Issues observed at the Old Canyon Road intersection included the following:
  - ➢ The wide throat width at this intersection may promote increased speed for vehicles turning right from Route 84 onto Old Canyon Road. Positive control should be considered at this intersection.

- The short distance between the Old Canyon Road intersection with Route 84 and Old Canyon Road intersection with Sycamore may result in vehicle entering this intersection at unusual orientations. Positive control should be considered at this intersection.

- Issues observed at the Kaiser Quarry intersection included the following:

  - The eastbound left-turn lane is not fully visible due to the crest curve and the deceleration lane appears short for the operating speeds observed.

  - An at-grade rail crossing of the Kaiser Quarry access road is located in very close proximity to the intersection. A heavy truck stopped at the intersection could be caught straddling the tracks as a train approaches.

2.6 **Alignment**

- A crest vertical curve at the Kaiser Quarry intersection limits the available sightlines on the approaches to this intersection. Skid marks were observed in both the eastbound left-turn lane and the eastbound acceleration lane.

- The pavement cross-fall on Route 84 at the Kaiser Quarry intersection appears to be sloping the wrong way.

- Vegetation growth and backslopes are creating lateral sightline obstructions on curvilinear sections of the facility. This limits the available sight distance to bicycles and disabled vehicles.

2.7 **Cross section elements**

- Shoulder discontinuities were observed throughout the facility. These discontinuities reduce opportunities to accommodate maintenance vehicles, disabled vehicles, bicycles, and speed enforcement. They also result in a reduced margin for driver error as the recoverable area for errant vehicles is reduced.

- Heavy trucks appear to off-track into the flush median at the low-speed curve locations.

2.8 **Accommodating bicycles**

- The Niles Canyon Highway is a popular destination for cyclist and discussions with members of the public and representatives from local municipalities suggest cycling volumes can be expected to increase significantly with time. Obstructed sightlines on horizontal curves, narrow structures at Alameda Creek, Rosewarnes and Farwell, and shoulder discontinuities throughout the facility present a significant risk to cyclists. Bicycle related collisions involving vehicle operating speeds of 48 miles per hour are very likely to result in serious injury or fatality.

- Of particular concern is a comment made by a municipal stakeholder that suggests this route is gaining popularity with less skilled recreational riders. This facility presents a high-risk environment for cyclists. As a result, this may not be a facility where Caltrans should be promoting cycling or providing cyclists with a false sense of security through the provision of signs and pavement markings. The provision of an alternative route or segregated facility may the more appropriate.

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