Enhancing Value With Road Safety Analysis Within Value Engineering Studies

CSVA Conference 2012

Calgary, Alberta

October 24, 25

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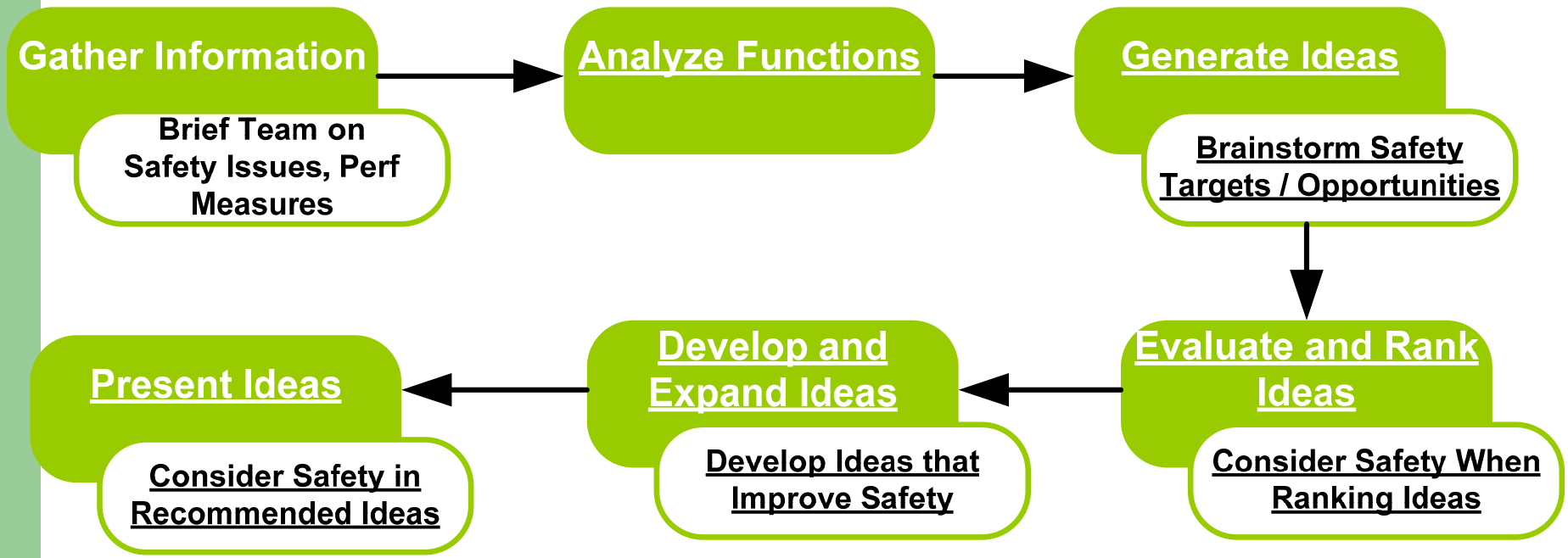
Presentation Outline

- *Levels of Road Safety Analysis (RdSafAn)– Qualitative, Semi-Quantitative, Quantitative*
- *How to integrate RdSafAn within the Value Methodology?*
- *Sample application of Quantitative RdSafAn within a VA Study*

Levels of RdSafAn within a VE Study

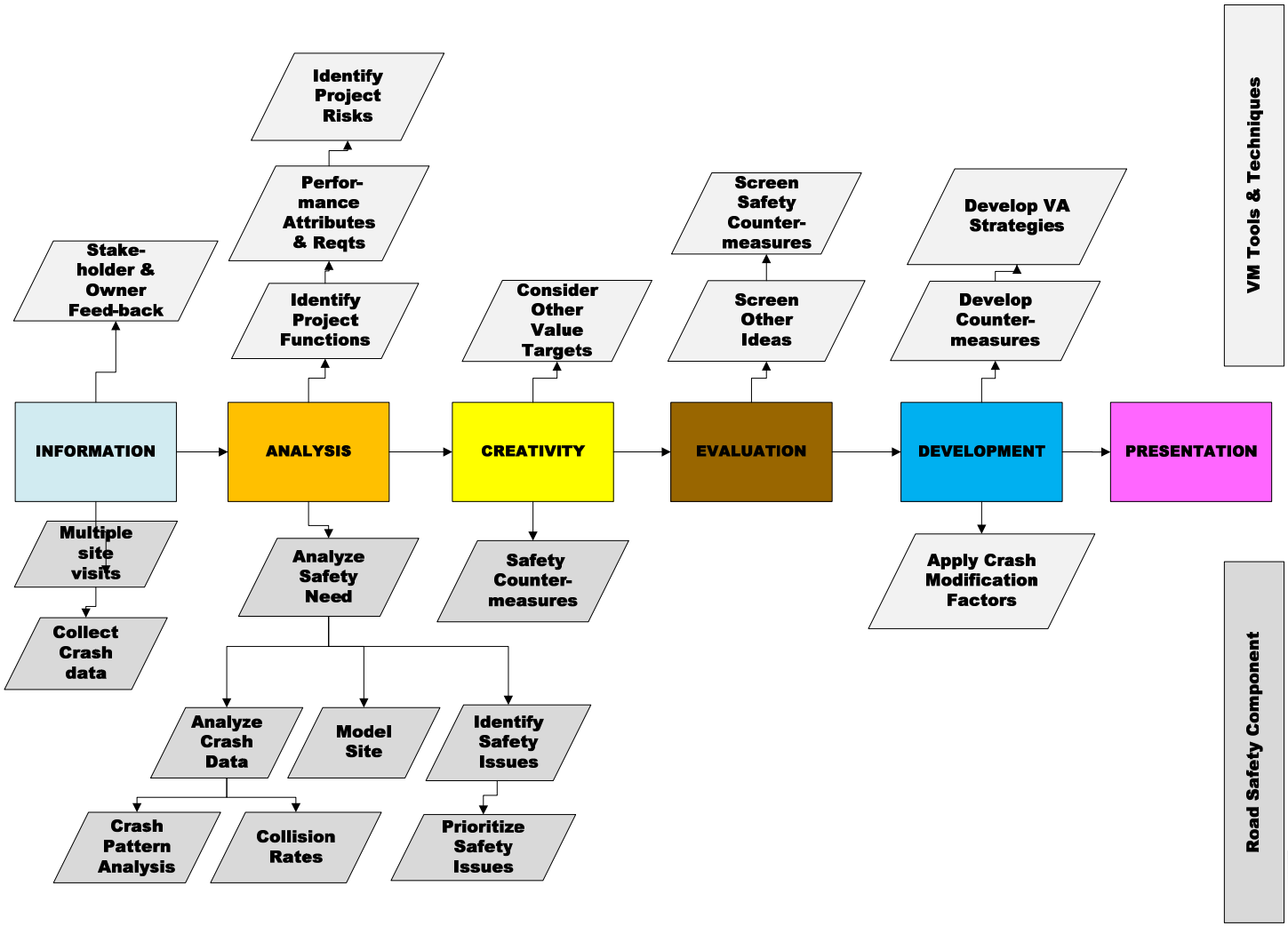
- Qualitative
  - Little to no quantitative road safety analysis applied
  - Relies heavily on field observations (i.e. combine with RSA)
  - Semi-Quantitative
  - Mix of quantitative and qualitative tools.
  - Can be carried out with or without a Road Safety Audit
  - Quantitative
  - Uses quantitative methods to analyze safety.
  - Can be carried out with or without a Road Safety Audit

Integrating RdSafAn into the Value Methodology

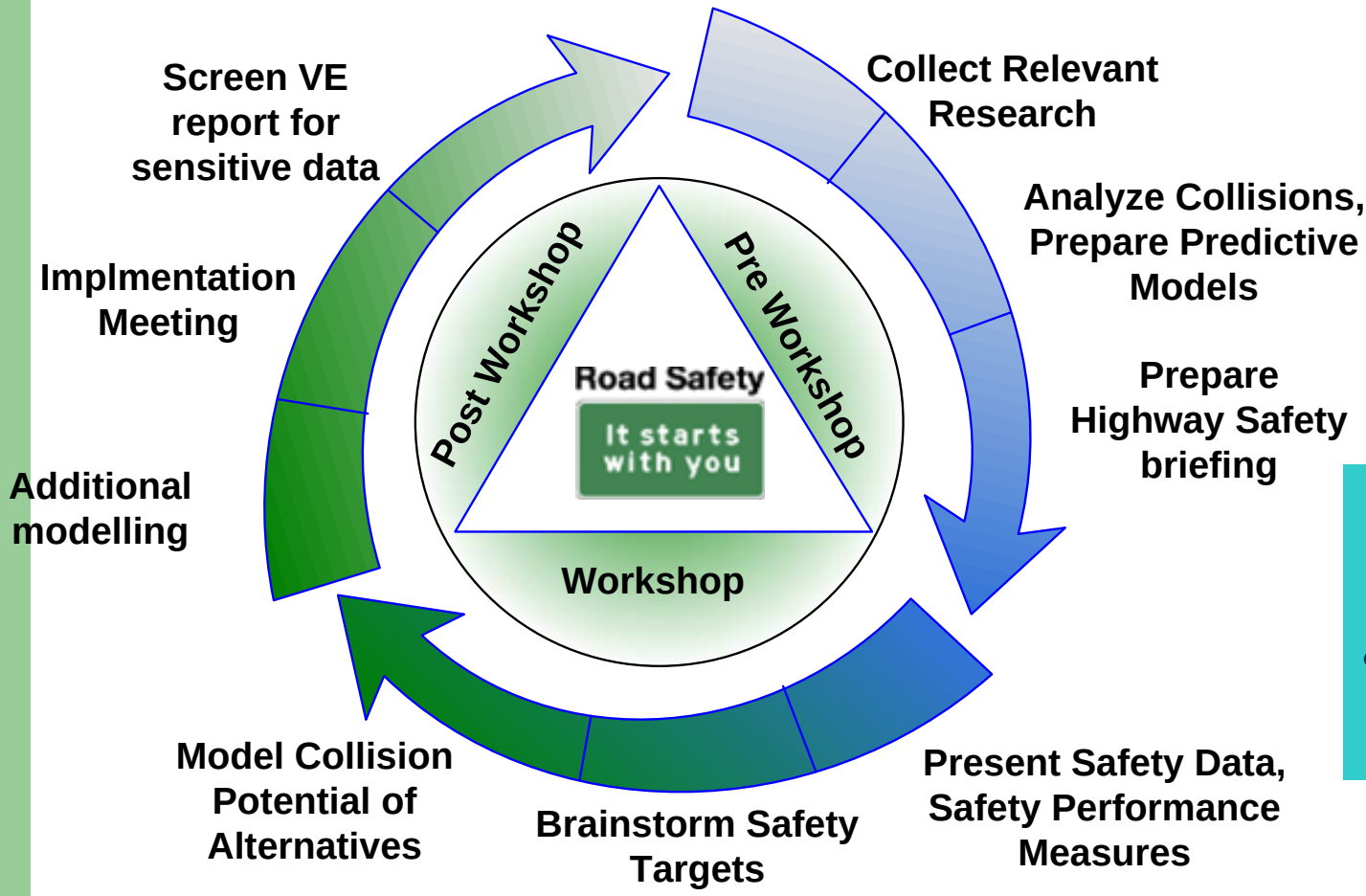


Source: Steve Holmes

Integrated Value Management Road Quantitative Safety Analysis Processes



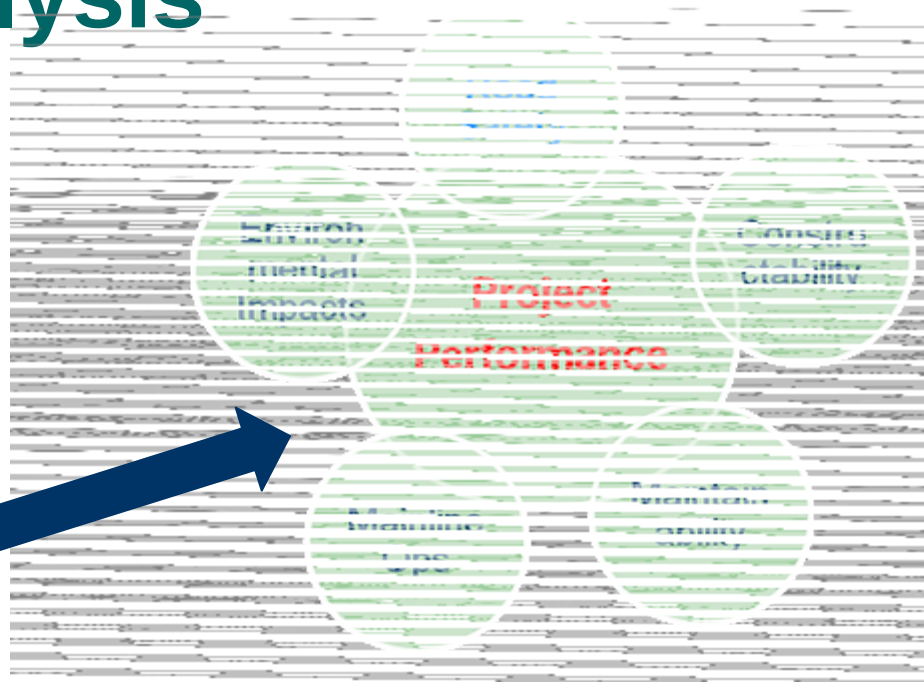
RdSafAn Activities in a Value Engineering Study

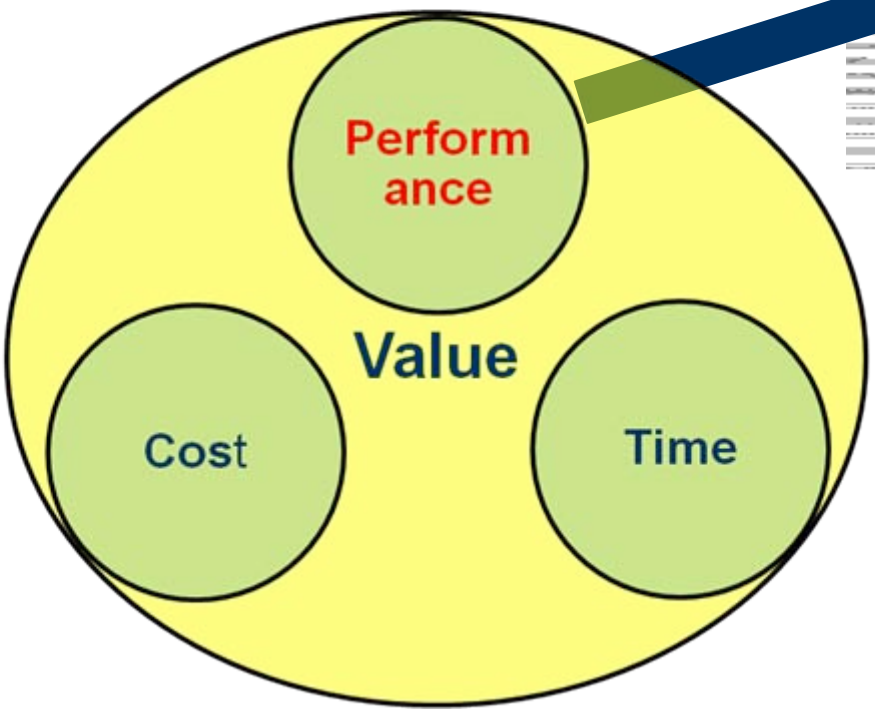


- Highway Safety Expert
- Human Factors Expert

Source: Steve Holmes-MTO

Integrating Value Metrics & Road Safety Analysis





$$V_F = \frac{P}{(C + S)}$$

Quantifying Safety using a Risk-Based Approach

- Risk management approach with the identification of risk feature (i.e. collision vector)
- Assessment of potential “impact”:
  - 0 to 1 scale reflecting collision severity
- Assessment of “likelihood” of occurrence
  - 0 to 1 scale reflecting likelihood
- Development of a quantitative index:

Risk Index = Impact x Likelihood

Source

delphi MRC

SCAV CSVA

Some comments on Risk Index

- Subjective, based on expert judgement
  - Supported by accepted quantitative & performance-based safety analysis techniques
- Relative differences are key
  - Lower values are “more safe”
  - Higher values are “less safe”

Source delphi MRC

SCAV CSVA

Sample Assessment – Baseline Concept

QEW - Highway 403 Preliminary Design Risk Analysis	
	Baseline
	Risk Index
Alternative >>>	Calculated
Risk element	
Speed & Speed Differentials	0.28
Gap search & lane change	0.35
Interchange configuration	0.20
Accommodation of heavy vehicles	0.12
HOV lane entry/exit points	0.20
Lane balance and continuity	0.42
Driver workload	0.16
Average Risk Index	0.25

Driver workload and operational complexity

The following conditions in the current design contribute to the driver workload and operational complexity:

- The congestion and speed differentials observed at key fwy-fwy merge and diverge points
- Closely spaced interchanges, successive ramps and weaving sections appear to contribute to increased congestion, vehicle conflicts and operational complexity.

Sample Assessment – Design & VE Concepts

	Baseline	Design Alternative 1	VE Scenario 1	VE Scenario 2
	Risk Index	Risk Index	Risk Index	Risk Index
Alternative >>>	Calculated	Calculated	Calculated	Calculated
Risk element				
Speed & Speed Differentials	0.28	0.32	0.28	0.26
Gap search & lane change	0.35	0.25	0.30	0.30
Interchange configuration	0.20	0.20	0.27	0.25
Accommodation of heavy vehicles	0.12	0.12	0.12	0.12
HOV lane entry/exit points	0.20	0.20	0.24	0.24
Lane balance and continuity	0.42	0.30	0.36	0.36
Driver workload	0.16	0.25	0.20	0.18
Average Risk Index	0.25	0.23	0.25	0.24
Equivalent Performance Rating (0-10)	5.03	5.16	4.97	5.06

Design Alternative 1 (Section 2-2B)	
Collision Vector	**Comments**
Speed & Speed Differential	The following locations may demonstrate an increased risk of speed differential: Eastbound QEW/403 diverge - similar to base case Eastbound 403/Ford Drive diverge - similar to base case Eastbound QEW on-ramp from Ford Drive - worse than base case Northbound 403 on-ramp from Ford Drive - similar to base case Northbound 403 truck lane - similar to base case Minimun radius curves on QEW/403 connectors (two curves eliminated) - better than base case Westbound QEW access/egress to HOV at Winston Churchill - similar to base case Northbound and southbound 403 at Dundas ramps - similar to base case Northbound and southbound 403 between Dundas and QEW - better than base case Potential for speed differentials on westbound QEW due to weave created between Ford Drive and Winston Churchill - worse than base case Potential for speed differential on eastbound QEW due to weave created between Ford Drive and Winston Churchill - worse than base case
	The QEW west to 403 North and 403 north to QEW west connectors consist of 550 m and 600 m radii. These minimum radius curves are consistent with 110 km/h. Operating speeds through this section will likely be in excess of 110 km/h - Similar to base case
	The elongated configuration of the Ford Drive eastbound off-ramp may promote increased operating speeds on the approach to the ramp terminal - Similar to base case

STATE ROUTE 84 / NILES CANYON

Case Study Integrated Value Analysis/ Quantitative Road Safety Analysis Study

Study Team

Jeff Holm	FHWA
Frank Guros	Caltrans Construction
Valerie Shearer	Caltrans Env. Planning
Oliver Iberien	Caltrans Env. Planning
Keith Suzuki	Caltrans Landscape Arch.
Mike Thomas	Caltrans HQ Design
Jana Weldon	Alameda County
Cris Pena (Part-time)	Alameda County Water District
Jayson Imai	City of Fremont
Michael Renk	City of Union City
Geoff Millen	Delphi MRC
George Hunter	VMS
Mark Watson	VMS

State Route 84 / Niles Canyon Study Area

Study Approach

Road Safety Audit (RSA) Workshop

- Field Observations & Collision Data
  - Identify Safety Issues
    - Identify Countermeasures

Value Analysis (VA)/ Quantitative Road Safety Analysis Workshop

- Establish Safety Need
- Prioritize Safety Issues
- Develop Countermeasures
- Evaluate Countermeasures
- Develop & Evaluate Countermeasure Strategies

Identification of Safety Need drove Study process

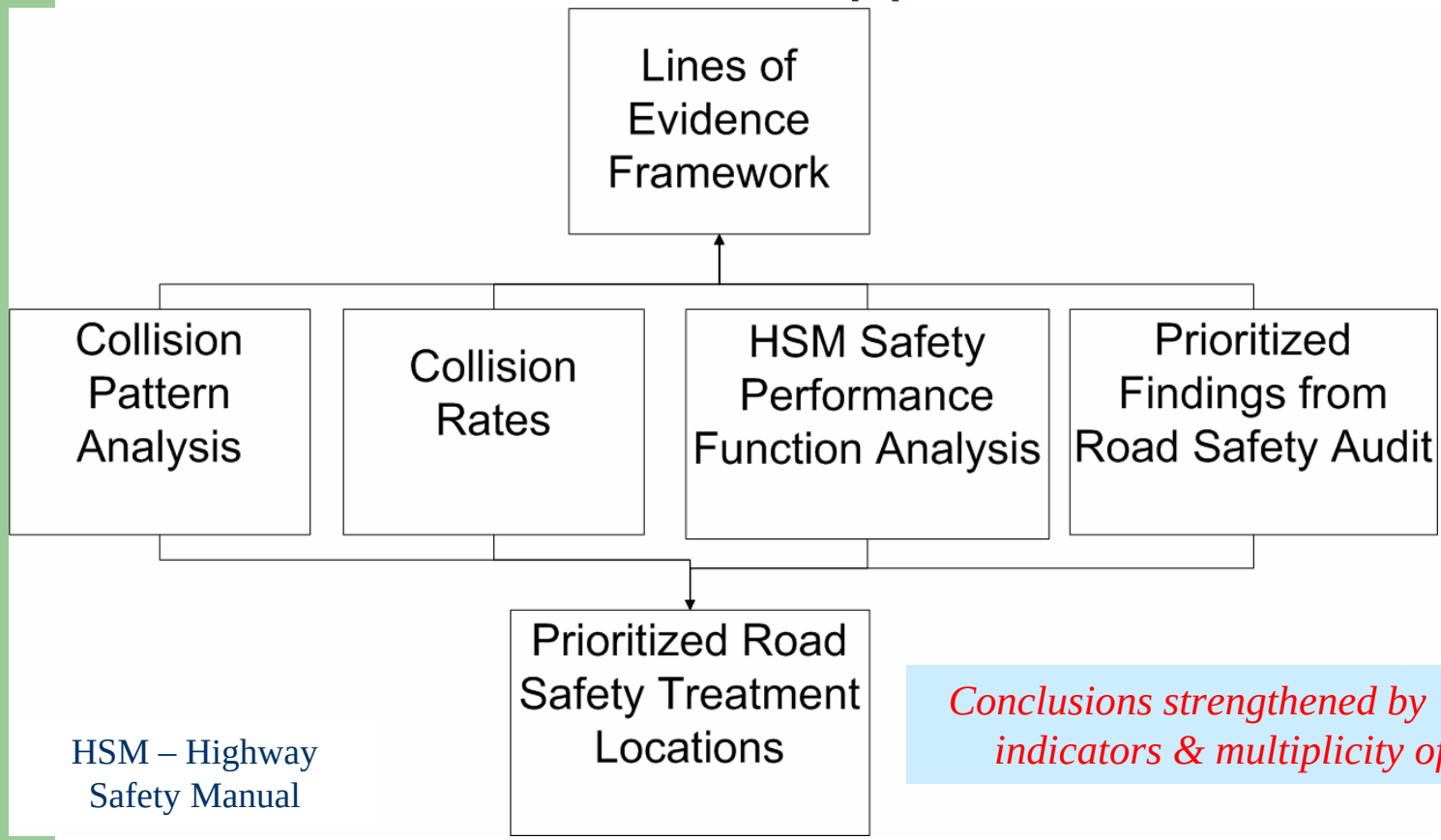
Key Study focus

1. Did the centerline rumble strips installed in 2007 address the corridor safety concerns?

2. If safety improvements are needed – can they be minimized to reduce effects to the recreational, cultural, community and natural environment resources of the Canyon?

Identification of Safety Need

- Assessment of the existing road safety performance
- A “lines of evidence” approach.



HSM – Highway Safety Manual

Conclusions strengthened by independence of the indicators & multiplicity of their occurrence

Line 1: Collision Pattern Analysis

Line 1: Collision Data

- November 2007 to September 2010

Severity		
36	43%	PDO
46	55%	Injury
2	2%	Fatal
84	100%	

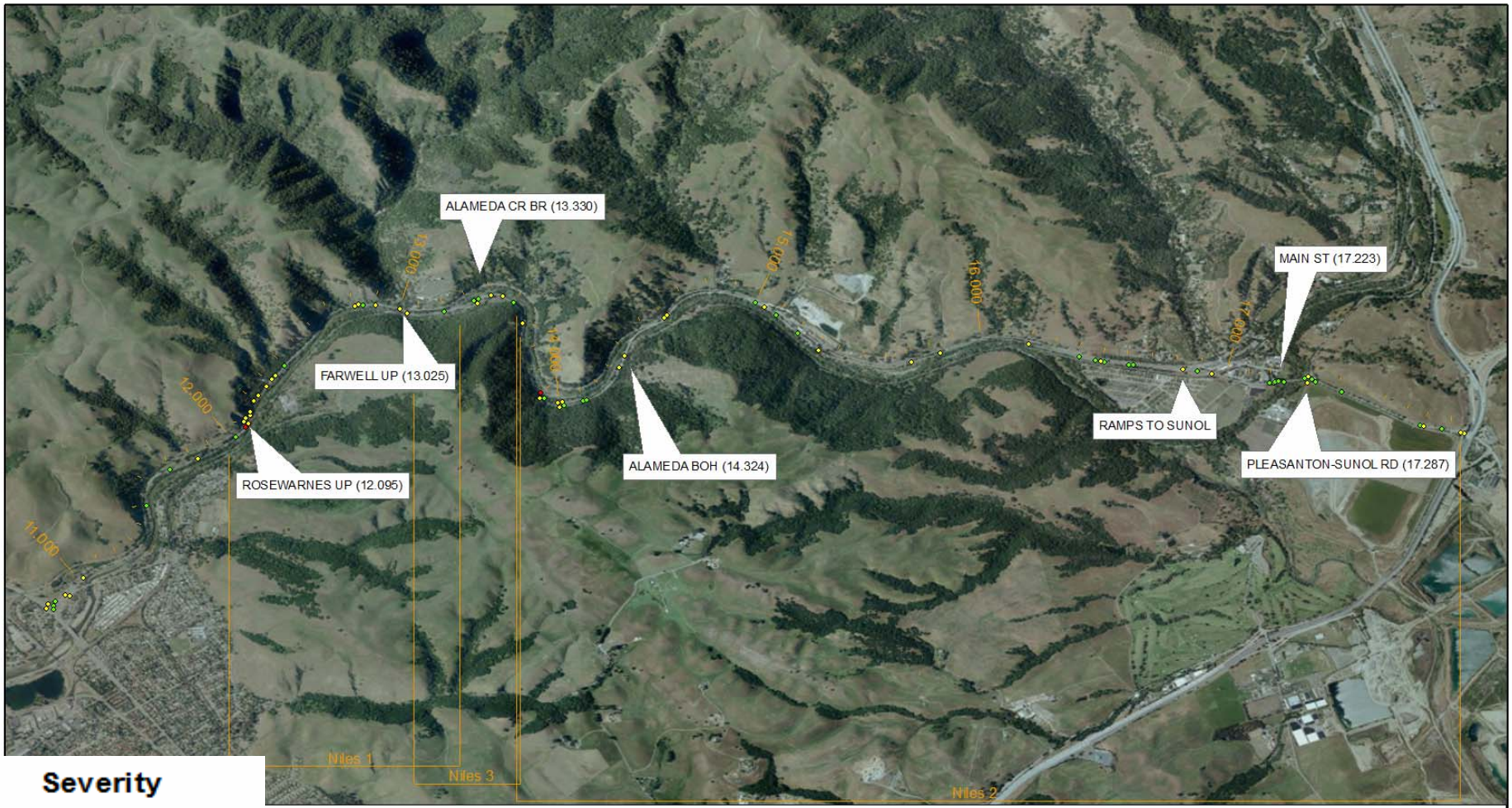
PDO = Property Damage Only

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%	

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%	

Light Condition		
52	62%	Daylight
24	29%	Dark
4	5%	Dark (artificial light)
3	4%	Dusk/dawn
1	1%	Not stated
84	100%	

Line 1: Collision Severity



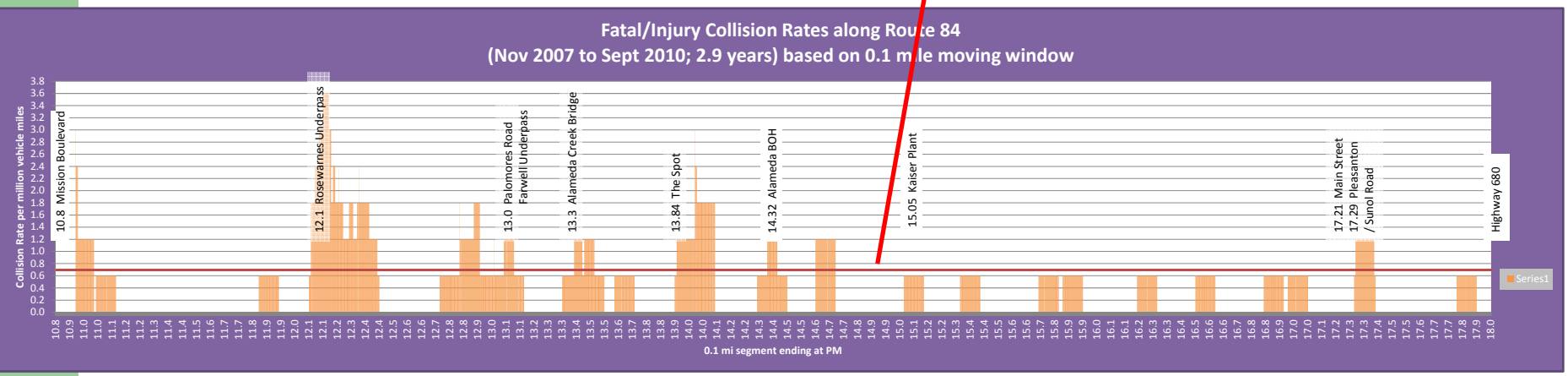
Line 2: Collision Rate Analysis

Line 2: Collision Rate Analysis Methodology

- Mainline Collision Rate:
  - Used Nov 2007- Sept 2010 timeframe
  - Normalized data for Fatality, Injury and PDO using a severity-weighted collision rate
  - Sliding window analysis (0.1 mile frame)
  - Compared to State Mainline Average
- Intersection Collision Data
  - Actual collision rates versus statewide average for similar facility

Line 2: Collision Rate (Mainline)

Mainline Fatality & Injury

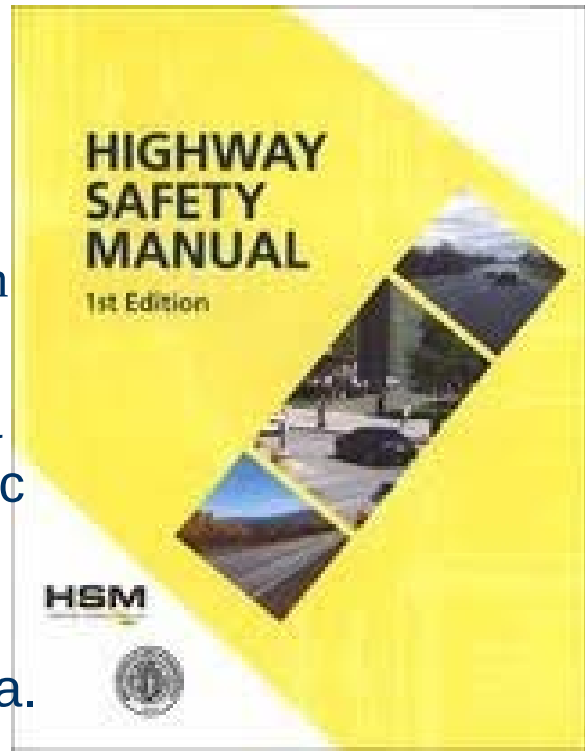


Line 2: Collision Rate (Intersections)

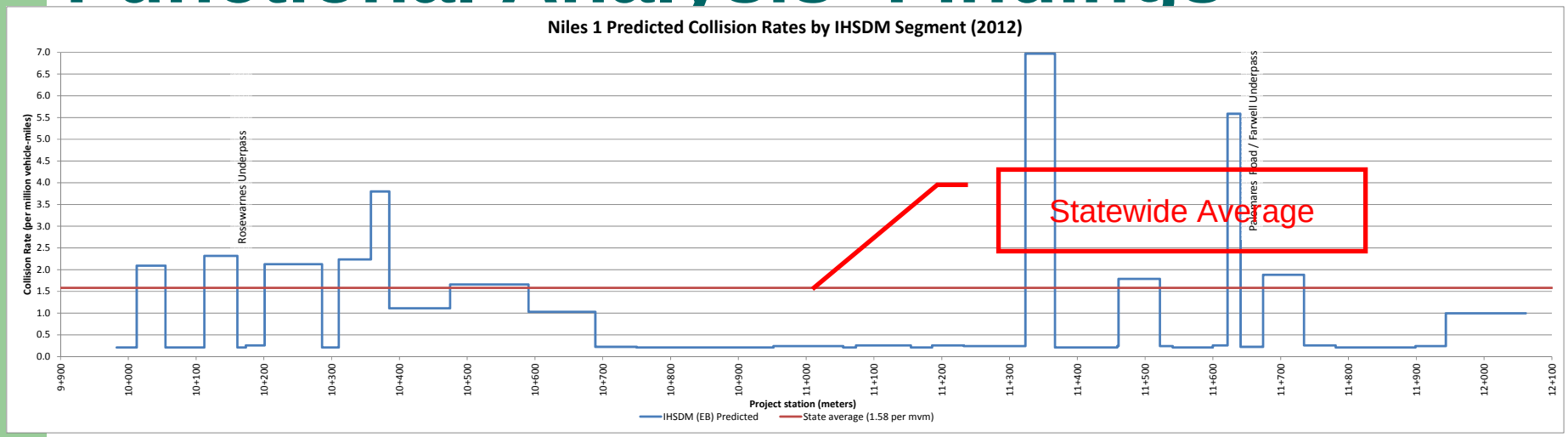
Collisions/Million Vehicles Entering						
Intersection	Actual			State Average		
	Fatal	Fatal & Injury	All Collisions	Fatal	Fatal & Injury	All Collisions
Palomares	0.00	0.07	0.07	0.001	0.06	0.15
Main	0.00	0.00	0.30	0.003	0.08	0.20
Pleasanton	0.00	0.16	0.41	0.01	0.13	0.30

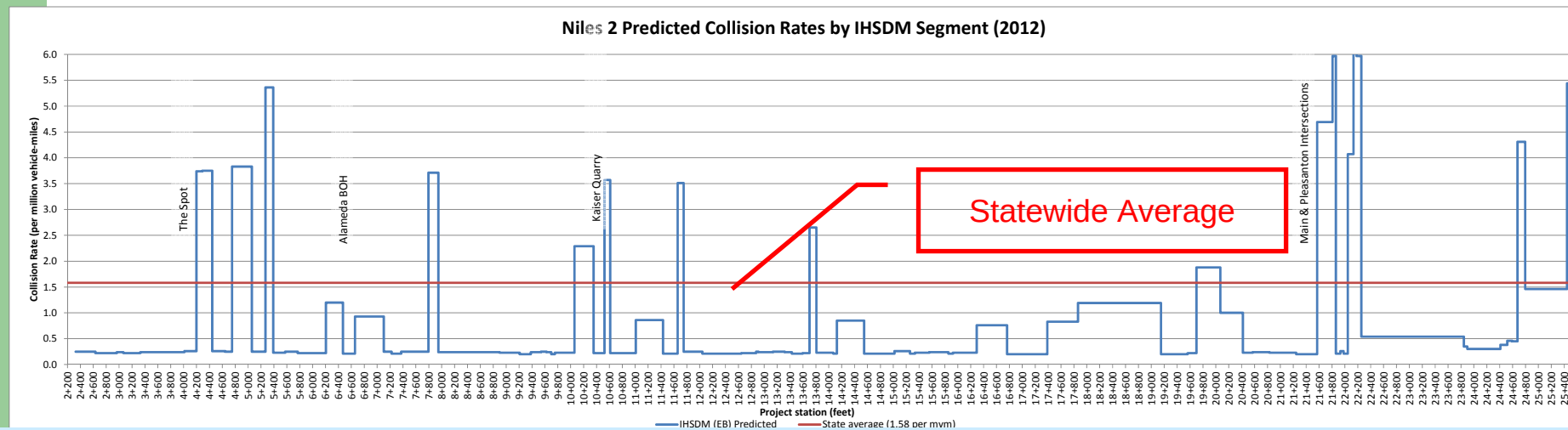
Line 3 – HSM Performance Functional Analysis

- Interactive Highway Safety Design Model (IHSDM).
  - Safety Performance Functions (SPF) are statistical based models used to predict average crash frequency for a specific roadway type.
  - Estimates the expected frequency crashes on a highway based on its geometric design and traffic characteristics.
  - Uses a weighted averaging of the algorithm estimate with project-specific collision history data.



Line 3 – HSM Performance Functional Analysis- Findings





Predictive model based on existing roadway geometry and cross-section and national collision data

Line 4- Prioritization of RSA Issues

- Methodology:
  - Identifies safety concerns with potential level of road safety risk.
  - AustRoads: Australian Road Safety Auditing Guide
  - Prioritize the risk levels associated with each of the road safety concerns by the RSA team
  - Prioritization- based on establishing two criteria associated with each specific issue:
    - Frequency
    - Severity

Line 4- Prioritization of RSA Issues- Risk Criteria

- Frequency

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

- Severity

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

Line 4- Prioritization of RSA Issues- Risk Levels

- 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

- Treatment Priority

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.

Line 4- Prioritization Results

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	O	S	H
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	
Palomares Intersection (sight distance, skew, signage)	P	S	
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 and Rosewarnes and Palomares flashing beacon	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 (Rosewarren curves)	O	M	M
Flashing beacon location at Palomares Road intersection, Reflectivity of signage of flashing beacon	O	L	L
Rockwall presents a roadside hazard	P	M	H

Line 4- Prioritization Results

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	

Safety Need Summary Lines of Evidence

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)				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
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			

Safety Need Priorities- Spot Locations*

- Rosewarnes Underpass (including passing zone)
- Low-speed curve between bridges
- Palomares intersection/Farwell underpass & approaches (includes the vicinity of the church parking lot)
- Main Street & Pleasanton Sunol intersections
- Alameda Creek Bridge

*As indicated and supported on all **Lines of Evidence**

Safety Need- Other Issues

- **Accommodation of Bicycles**
  - 2% of collision
  - High Severity
  - Growing Usage
- **Roadside Design Issues**
  - Roadside Hazards
  - Barrier Deficiencies
  - 57% of collisions
- **Shoulder Discontinuities**
  - Vehicle Roadside Departure
  - Disabled Vehicles, Bicycles and Police Enforcement
- **Vegetation**
  - Obstruction signing
  - Restricting lateral sight lines

Safety Improvement Countermeasures

- 51 Countermeasures identified during RSA and VA brainstorming exercises

- 31 Countermeasures Conceptually Developed:
  - (16) – Short-term implementation
  - (12) – Medium-term implementation
  - (3) – Long-term implementation after monitoring

Short Term Countermeasures Development

Install reflective material on underpass abutments

Install reflective material on curbs & rock walls adjacent to roadway

Vehicle Speed Feedback Sign
(Assembly example shown with W1-2a)

Install speed feedback sign & transverse pavement markings at low speed curves.

Short Term Countermeasures

- Install active warning system to alert motorists to bikes on roadway
- Install sharrows on shoulders or lane edges at select locations to demonstrate potential bicycle usage
- Install friction treatment to pavements at low-speed curves and in icy areas
- Modify flashing beacon at Palomares Road to indicate intersection further to the east
- Install mirrors at Palomares Road to view westbound traffic
- Install ITS elements at Palomares Road to signal drivers of approaching vehicles
- Lighting of key areas (Rosewarnes Undercrossing, Palomares Intersection/ Farwell UP)
- Eliminate passing zone adjacent to low-speed curves
- Address guard rail and k-rail end treatments/Upgrade roadside protection appurtenances
- Relocate select fixed objects immediately adjacent to roadway
- Install steel mesh netting on slopes in rockfall areas
- Install reflective material on underpass abutments
- Install reflective material on curbs and rock walls adjacent to roadway
- Install dynamic active warning device for queuing conditions
- Install speed feedback sign and optical bars at low-speed curves
- Narrow lane widths to 11 feet and reapportion to shoulder
- Reduce sign clutter at Old Canyon Road and Palomares Road

Medium Term Countermeasures

- **ROSEWARNES UNDERPASS SPOT IMPROVEMEMENTS**
  - Strategy 1 - Relocate the west abutment at Rosewarnes UP
  - Strategy 2 - Realign Road and Construct Tunnel into Slope at Rosewarnes UP
  - Strategy 3 - Bifurcate around the Pier on the North Side of Alameda Creek at the Rosewarnes UP
- **PALOMARES ROAD/ FARWEL UP SPOT IMPROVEMENTS**
  - Strategy 1 - Realign Palomares Rd to join church driveway
  - Strategy 2 - Relocate the railroad abutment at Farwell UP to improve sight distance
- **ALAMEDA CREEK BRIDGE SPOT IMPROVEMENTS**
  - Replace Alameda Creek Bridge to upgrade the approach curves
- **LOW SPEED CURVE BETWEEN BRIDGES SPOT IMPROVEMENT**
  - Correct superelevation at roadway curve east of Alameda Creek Bridge
  - Widen roadway curve east of Alameda Creek Bridge to accommodate off-tracking
- **ALAMEDA CREEK BOH SPOT IMPROVEMENT**
  - Remove Curb on Alameda Creek Bridge BOH
- **PLEASANTON-SUNOL ROAD/ ALA-84 INTERSECTION SPOT IMPROVEMENT**
  - Strategy 1 - Construct a Signalized Intersection
  - Strategy 2 - Construct a Roundabout
- **FACILITATE CORRIDOR ENFORCEMENT (CORRIDOR WIDE)**
  - Widen locations at strategic spacing to accommodate enforcement and pull-overs

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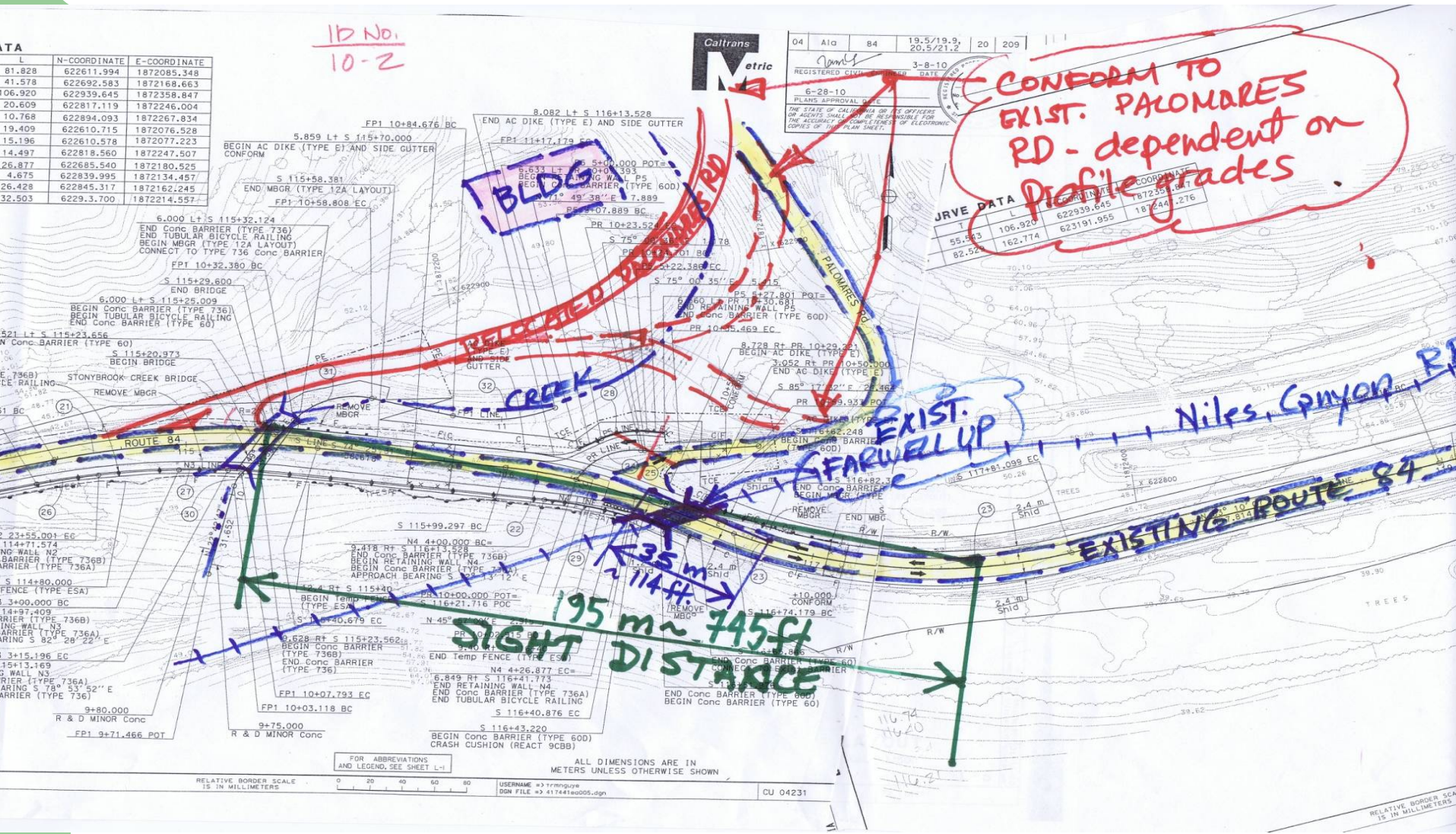
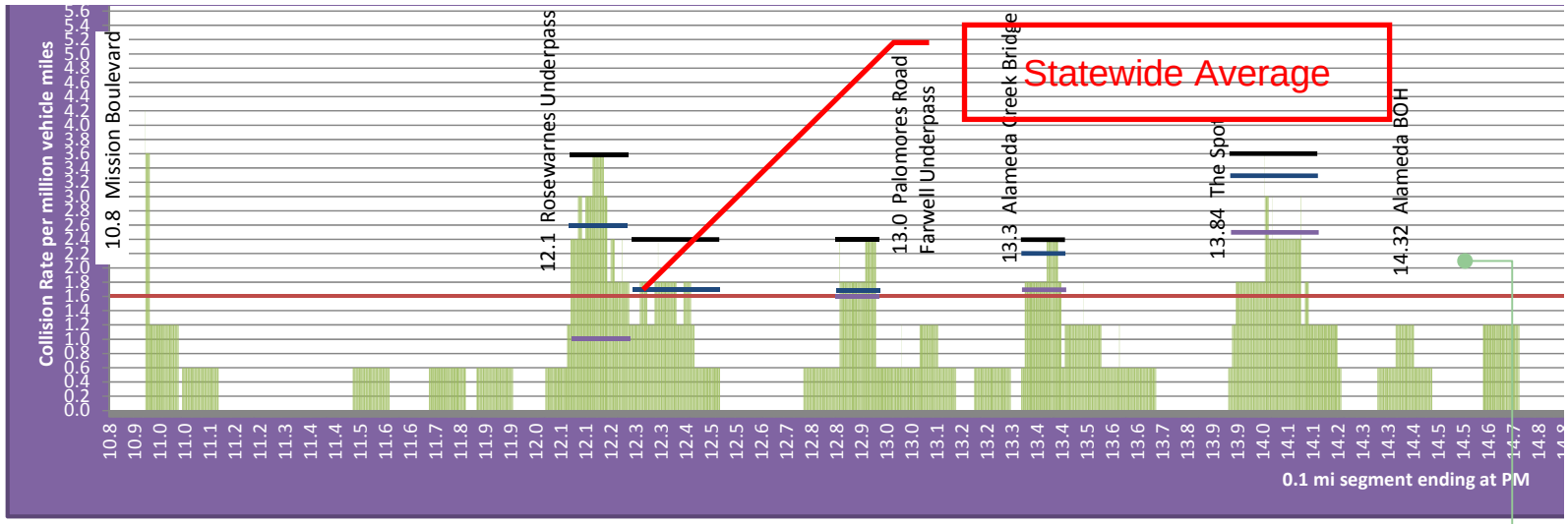
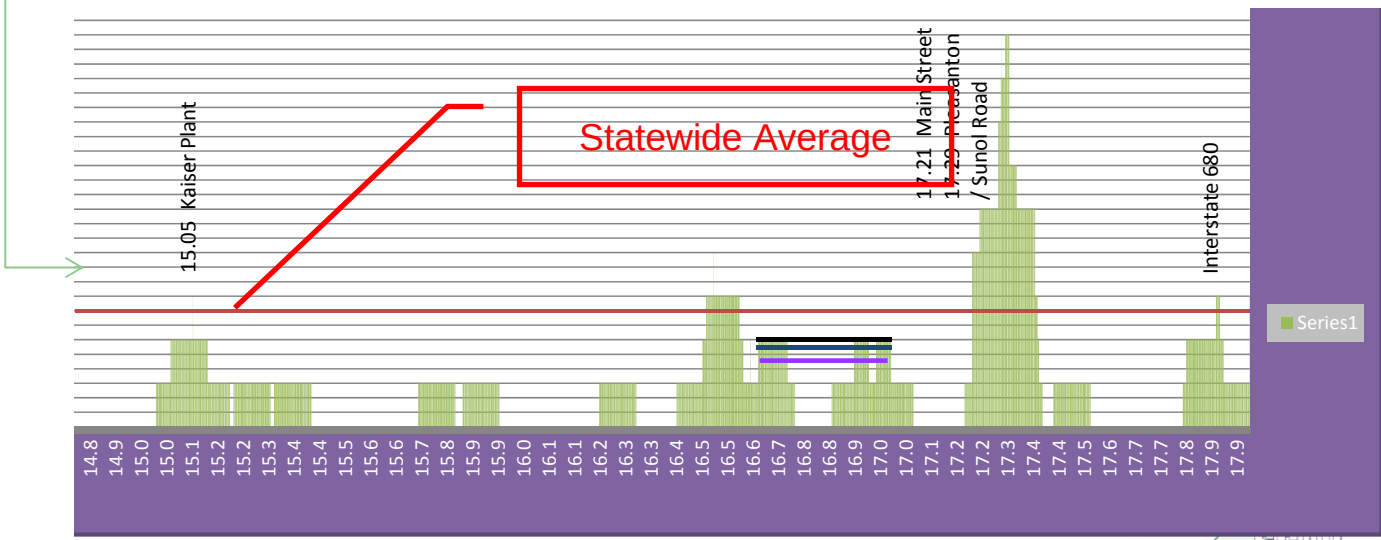
Palomares Rd - Existing Conditions

Proposed Countermeasure-Realign Palomares Rd



Safety Benefit





LEGEND

- Existing Condition
- Short Term Reduction
- Medium Term Reduction

Countermeasures' Safety Benefit

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%**

Corridor collision reduction (applied to 7.1 mile corridor): 10%

Collision rate reduction measurements based an accidents per million-vehicle miles

Monitoring Roadway Performance

- Caltrans will work with stakeholders to scope new projects to enhance safety on this highway. Funding for the new projects will be from the safety program.
- Current traffic data after 2007 (post rumble strip installation) shows that the highway no longer on the 2-3 lane monitoring report.
  - However, that does not mean safety improvements are not warranted. The findings from the RSA and VA teams indicate that there is a history of fatal and injury collisions occurred at spot locations along the highway.

Long Term Countermeasures

- Widen roadway to provide roadway cross-section of 12-foot lanes, 8-foot shoulders, and spot widening for clear recovery zone
- Correct superelevation and vertical sight distance at Quarry Road intersection
- Extend the eastbound left-turn pocket at the Quarry intersection

Summary of Study Findings

- Safety improvements are warranted at specific locations
  - Collision rates are above state-wide average in select locations after installation of median rumble strips
  - Select corridor-wide improvements warranted:
    - Accommodation of Bicycles
    - Roadside Design Issues
    - Shoulder Discontinuities
    - Vegetation
- Consider implementing short and medium-term countermeasures
- Monitor roadway safety performance after project implementation of short & medium-term countermeasures
- Based on monitoring results, consider implementation of long-term countermeasures

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Questions & Comments