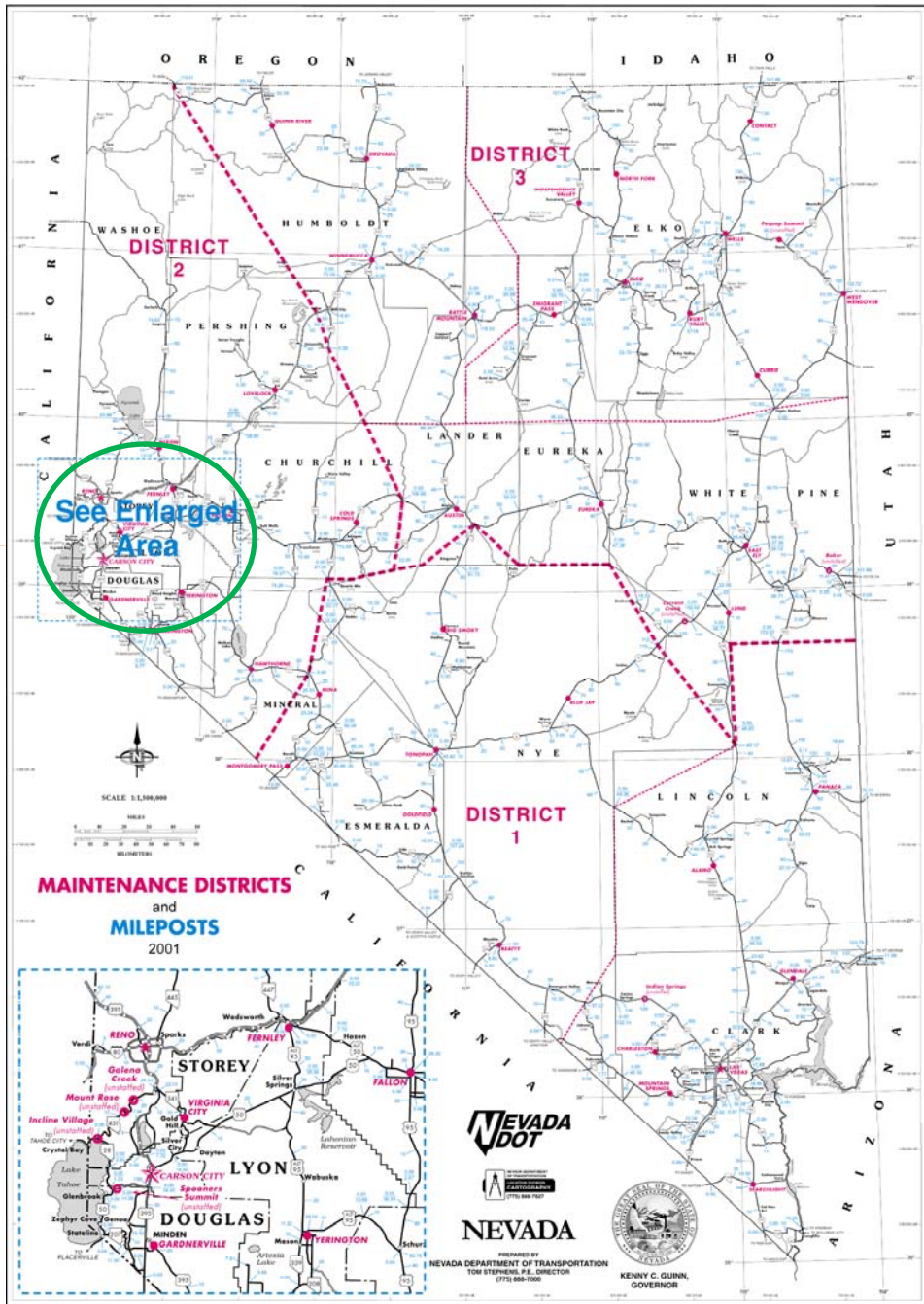
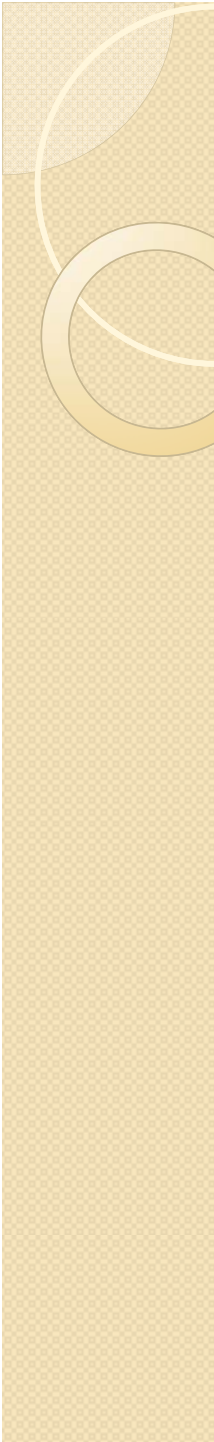


Analysis of Automated Wind Controls, and Related Operational Procedures, Algorithms, and Infrastructure

Jae Pullen, PE (NDOT)
Mike Fuess, PE, PTOE (NDOT)
John Grant, PE (Transcore)

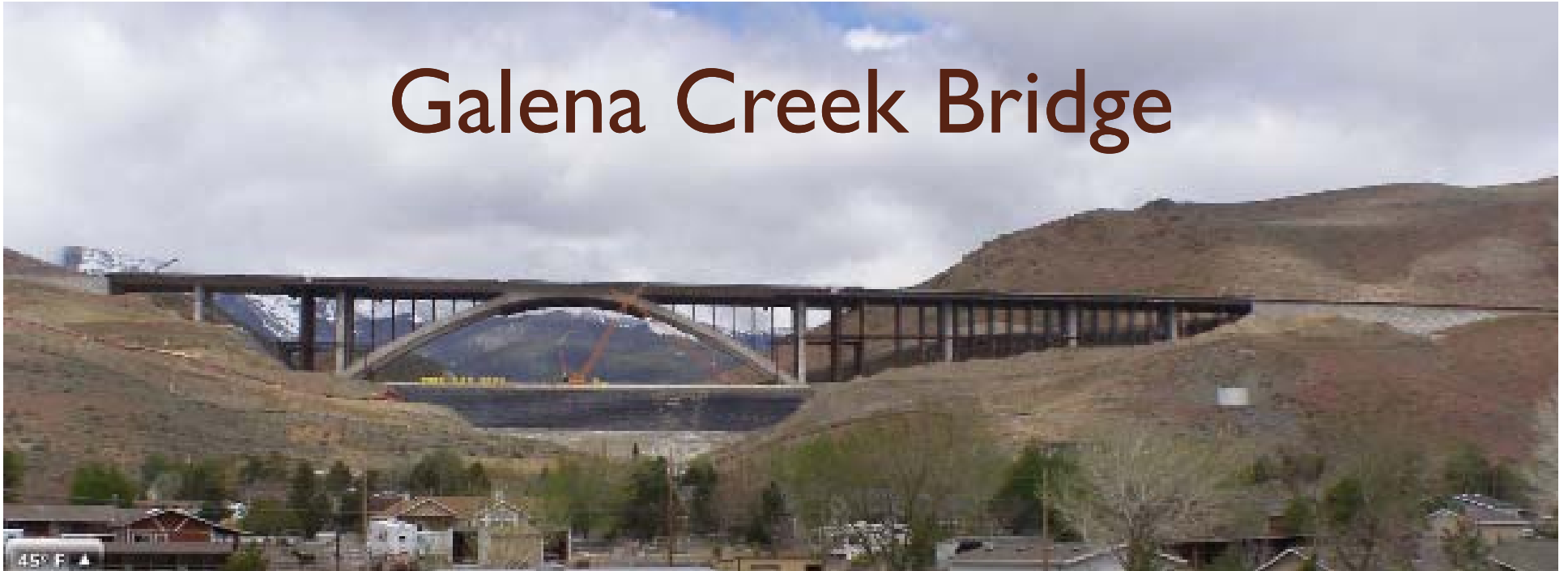




Pleasant & Washoe Valley



Galena Creek Bridge

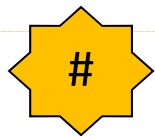


Video ~ December 19, 2008

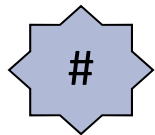




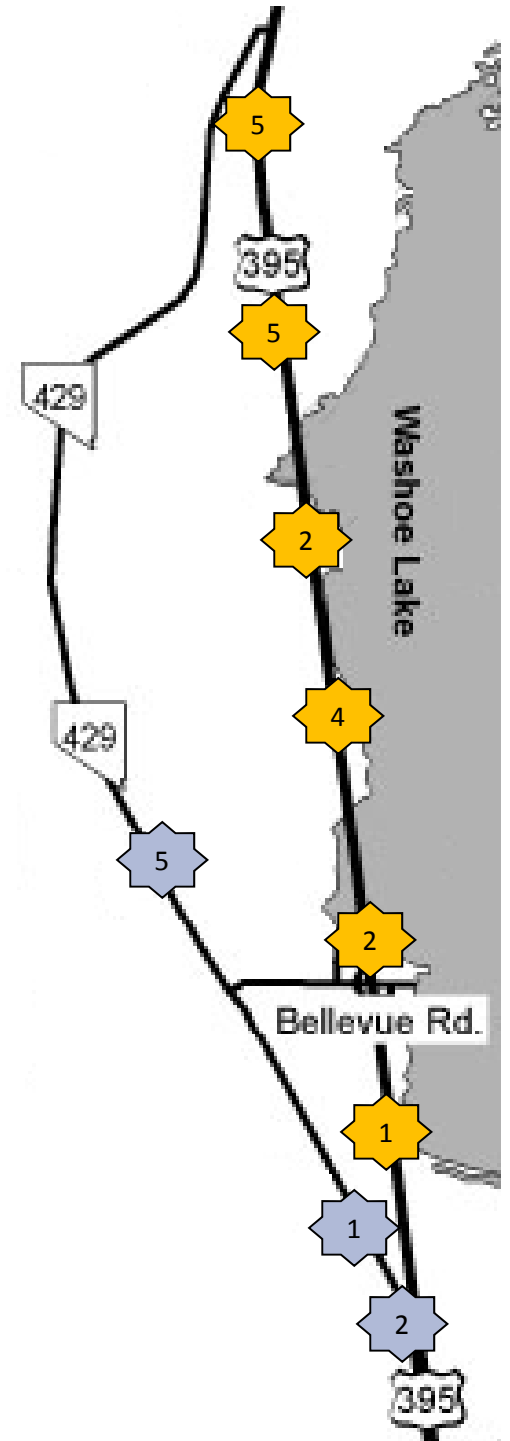
Crash History (1994 – 2009)



Number of confirmed
crashed on US-395



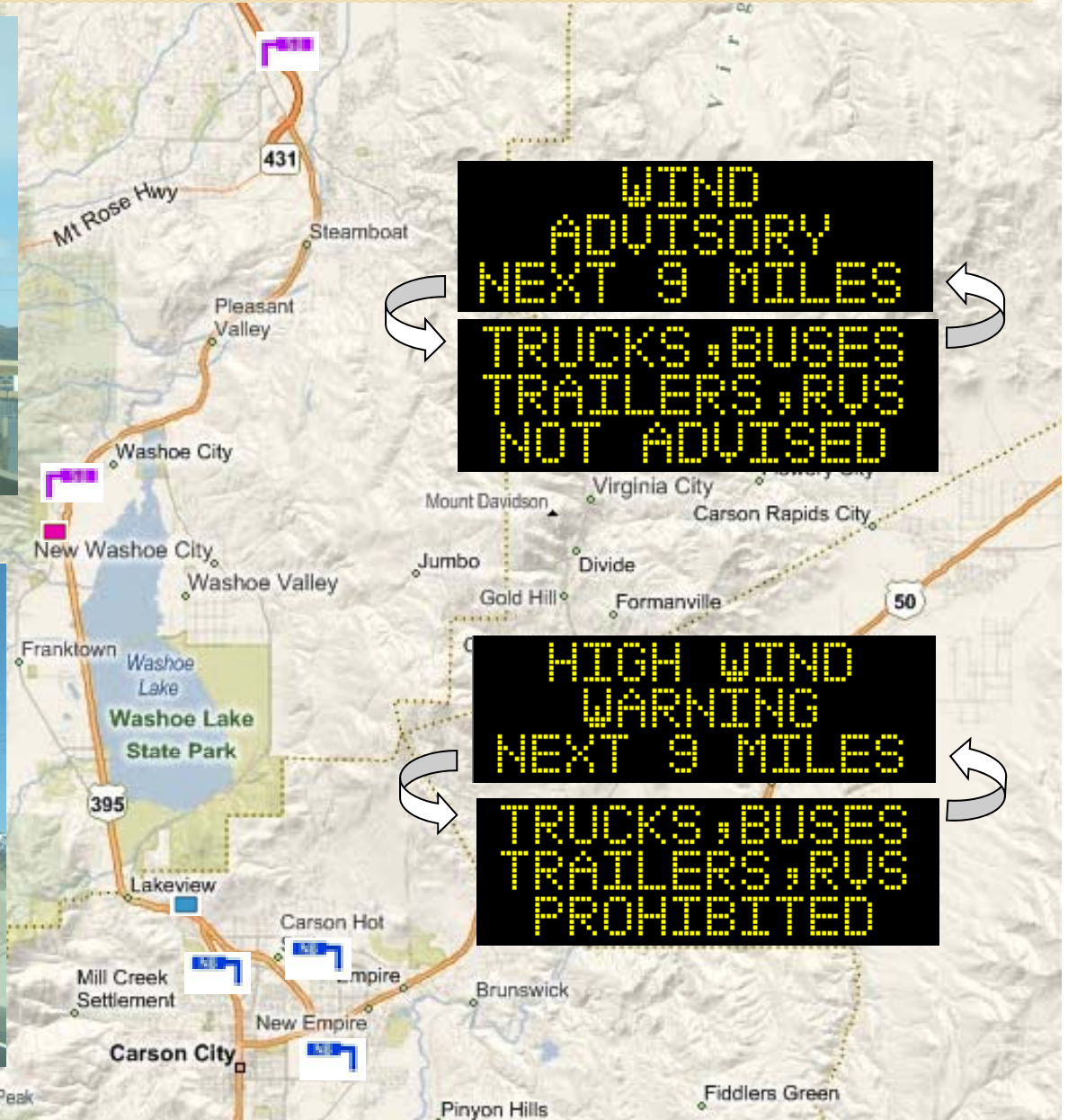
Number of confirmed
crashed on SR-429



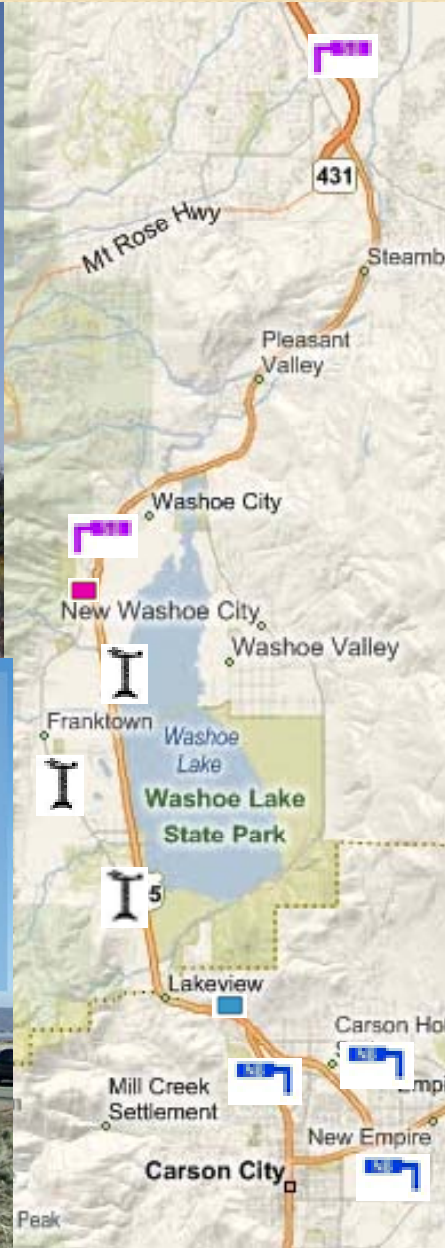
Existing Automated System

- Developed in the mid 1990s
- Experimental and state of the art at the time
- Includes RWIS, DMS and static signs
- Automated activation of DMS signs
- Notification of prohibition at Washoe Valley but does not advise detour route
- Alternate routes may not be intuitive to motorists not familiar with the area

- Dynamic Message Signs (DMS) & Static Signs



- Road Weather Information System (RWIS)





Existing Wind Thresholds

Wind Type	No Controls	Not Advised	Prohibited
Sustained	0 — 14 mph	15 — 29 mph	> 30 mph
Gusting	0 — 19 mph	20 — 39 mph	> 40 mph



Reasons for a New Study

- Existing system was experimental in the mid 1990s
- Apparent lack of compliance with system
- Recent increase in accidents
- Recent complaints from industry and local residents
- I580 extension under construction with a segment that might be windier than Washoe Valley

Goals of Study

- Assess wind warning system and recommend improvements
- Assess motorist & CDL awareness of the existing wind warning system
- Assess motorists & CDL reactions to the wind warning messages
- Assess suitability of alternate routes
- Coordinate with stakeholders and seek to achieve buy in with solutions

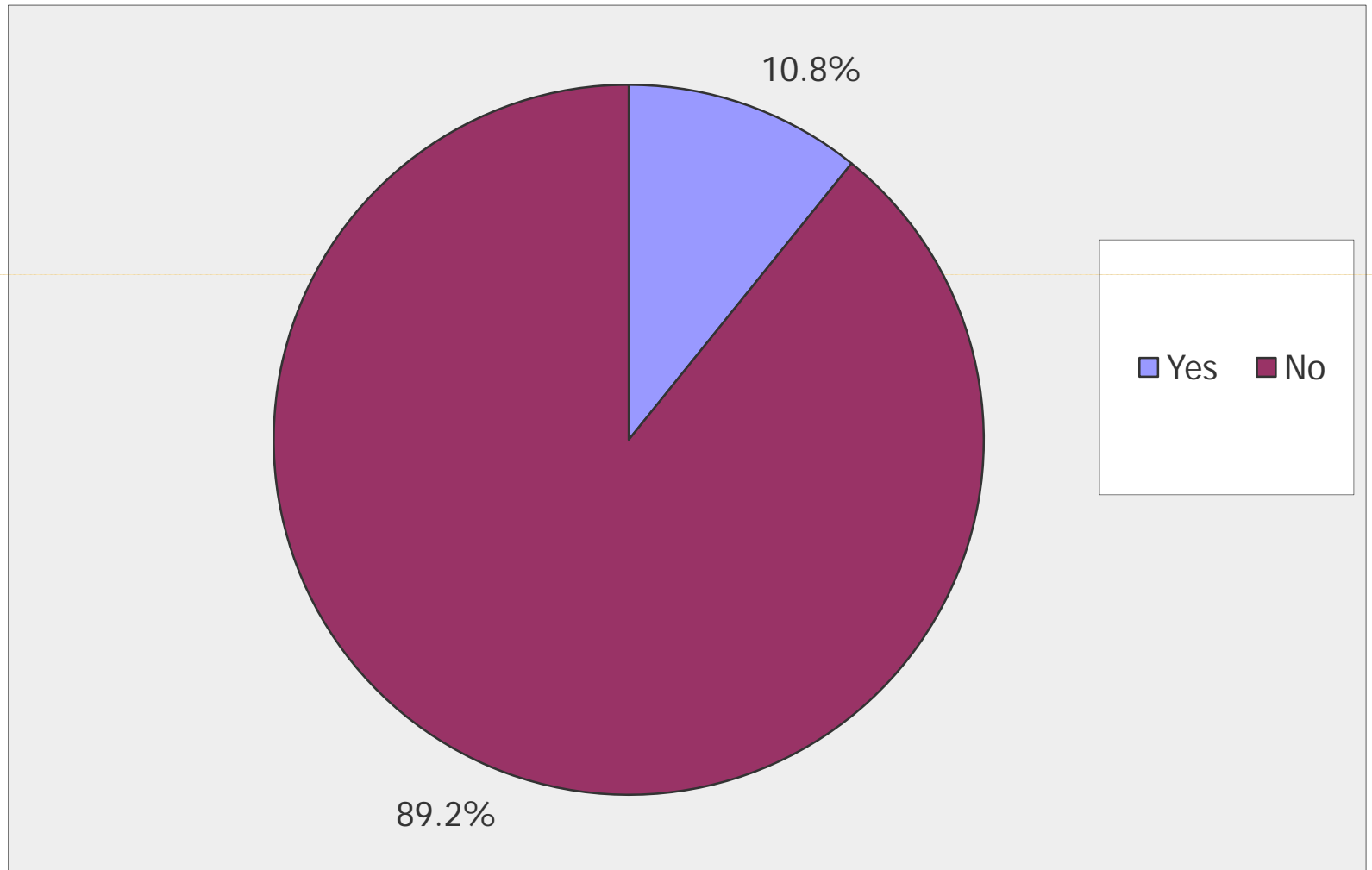
Literature Research

- Many systems rely on the NDOT study from the 1990s
- Lots of good national and international info available
- Made apparent each segment needs to be analyzed separately to determine custom thresholds for advisory and prohibition

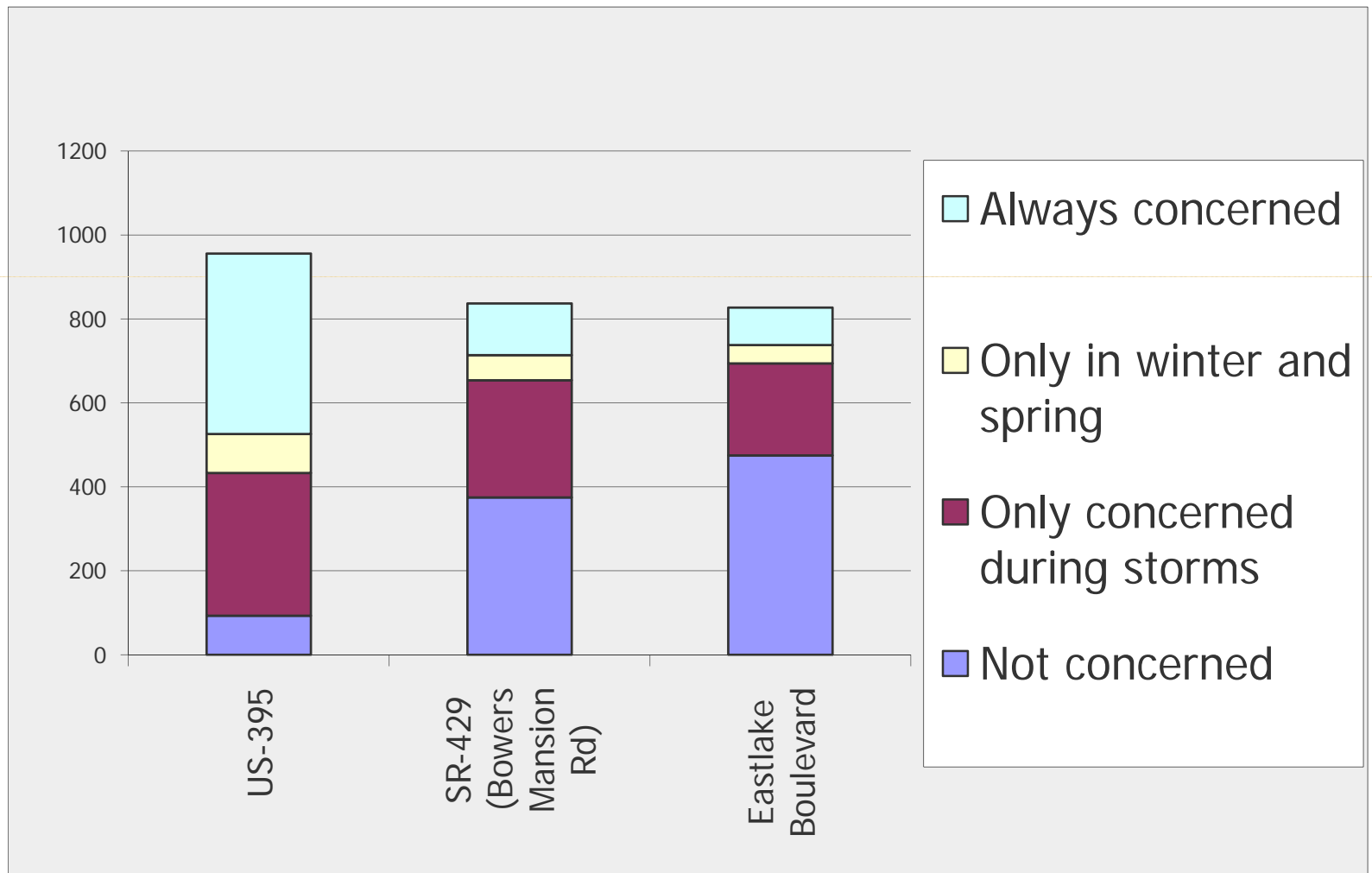
Public outreach

- Public open house
- Stakeholder meetings
- Public survey
- Press releases on study effort

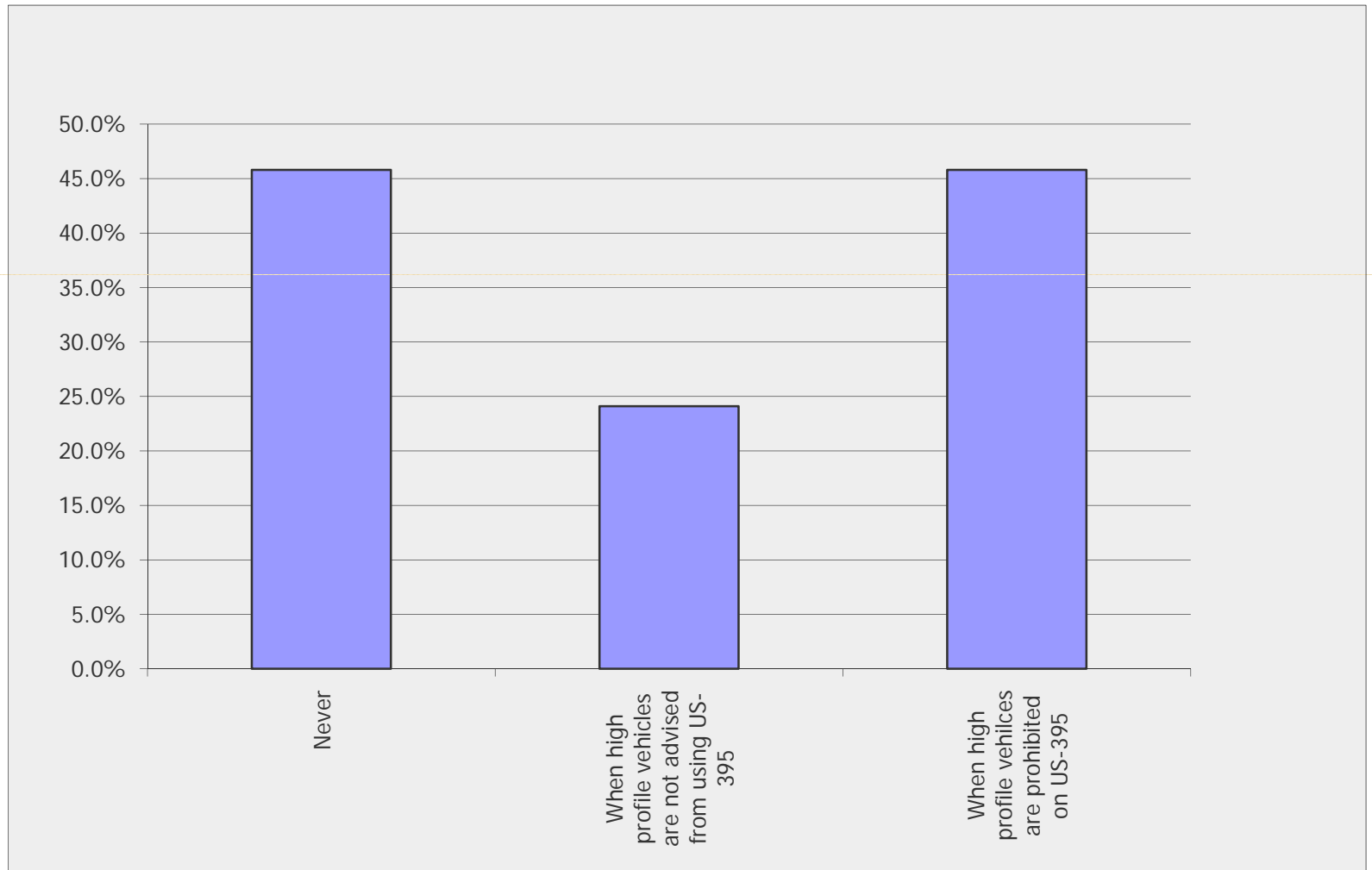
Survey Question 2; Do you have a Commercial Drivers License (CDL)?





Survey Question 4; How concerned are you about HIGH WINDS when traveling through Washoe Valley?



Survey Question 6; Have you ever used SR-429 (Bowers Mansion Road) as a detour route during HIGH WIND EVENTS?
Please check all that apply.




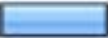
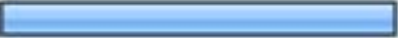
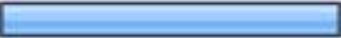



Survey Question 7; Do you feel SR-429 (Bowers Mansion Road) is a safer detour route for US-395?

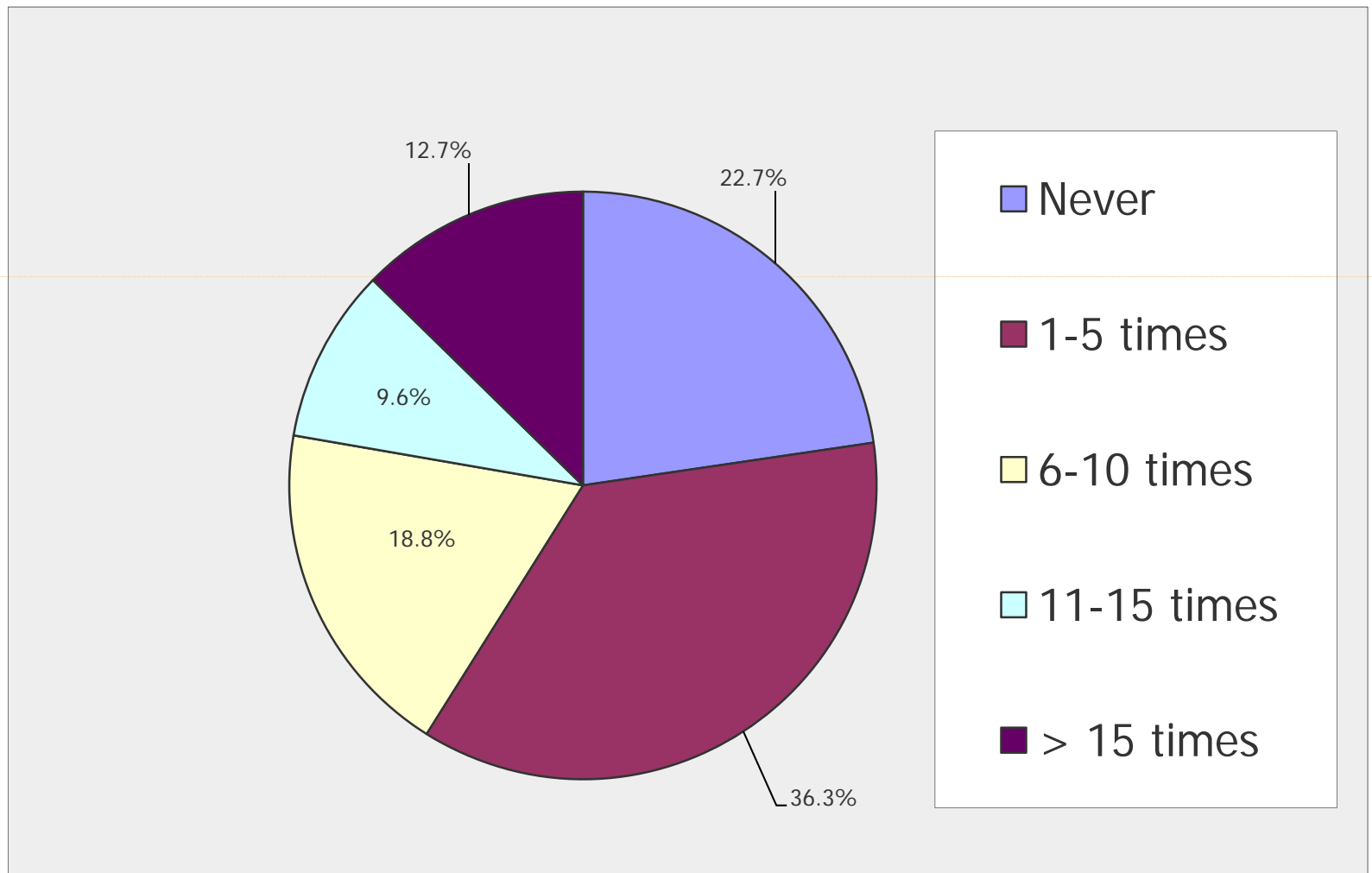
	Response Percent	Response Count
Yes 	77.3%	692
No 	22.7%	203
Comments:		241
	<i>answered question</i>	895
	<i>skipped question</i>	88

“With respect to wind, it is safe at the north end of the valley; but the middle section is just as bad as US-395”
 “People go slower on SR-429, driver’s expectations is 55 MPH, not 75 MPH”

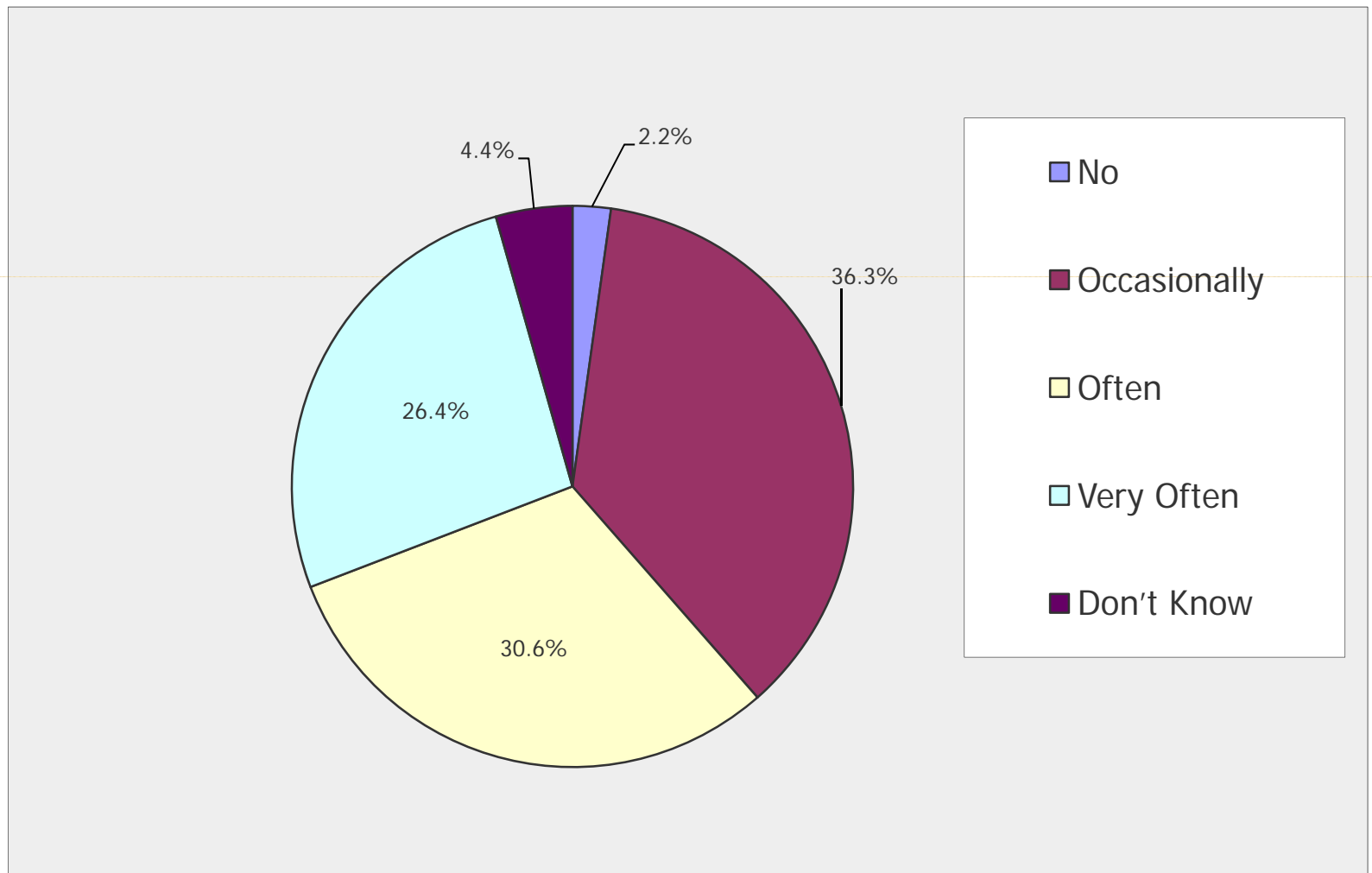
10. Why do you think drivers of high profile vehicles ignore high wind warnings and prohibitions? Please check all that apply.

		Response Percent	Response Count
They don't believe the prohibition is warranted.		77.0%	656
They don't think they'll get caught by law enforcement.		71.7%	611
Inadequate notifications.		20.7%	176
Status updates are insufficient.		13.6%	116
Drivers are pressured by managers to meet schedule.		51.9%	442
Financial loss due to delay is greater than the risk of being ticketed or involved in an accident.		44.5%	379
No other option because warning was too late and there is no place to park or turn-around.		25.1%	214
	Other (please specify)		170
answered question			852
skipped question			131

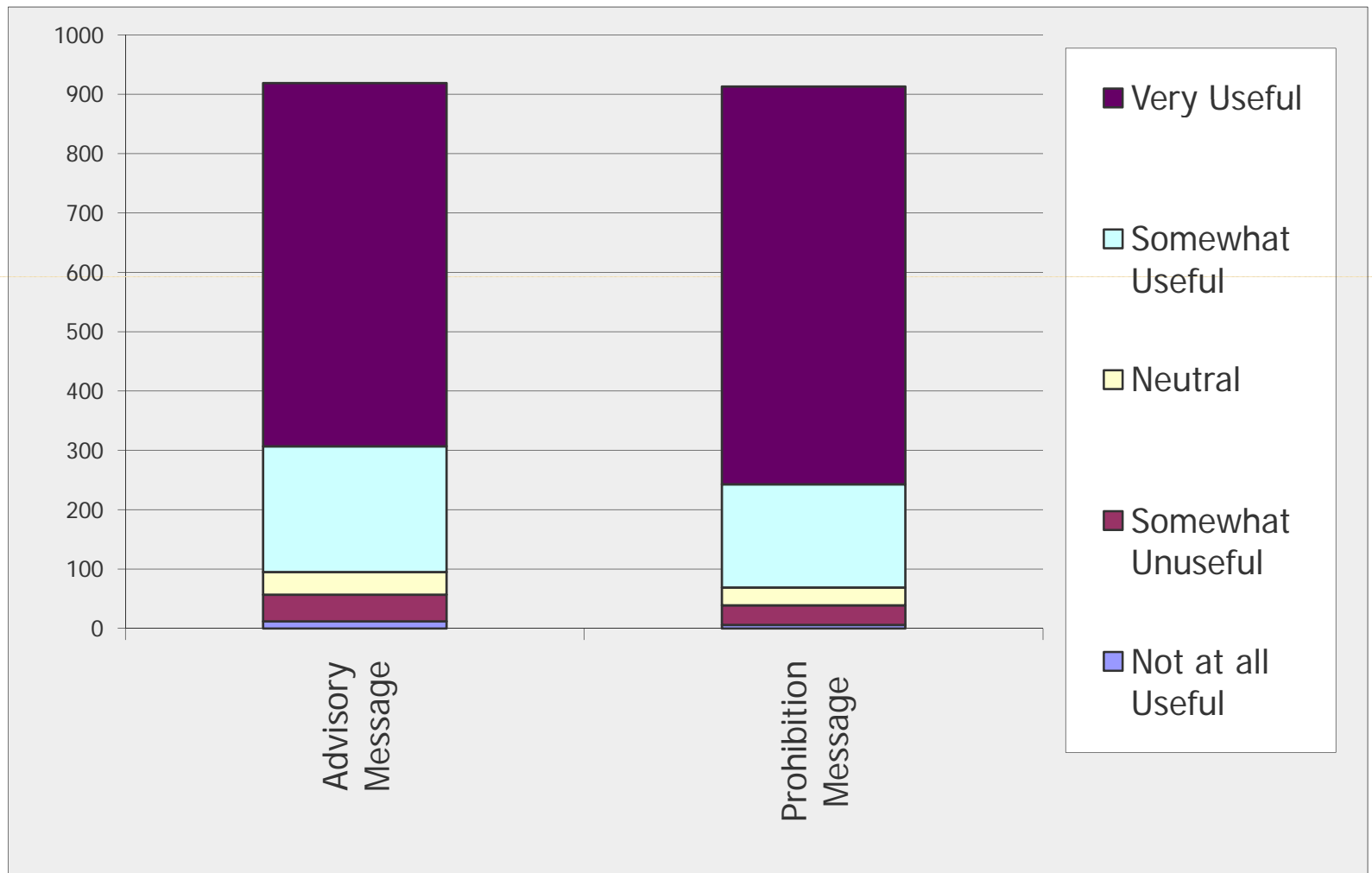
Survey Question 8; On average how often are you impacted by HIGH WIND prohibitions over a typical year?



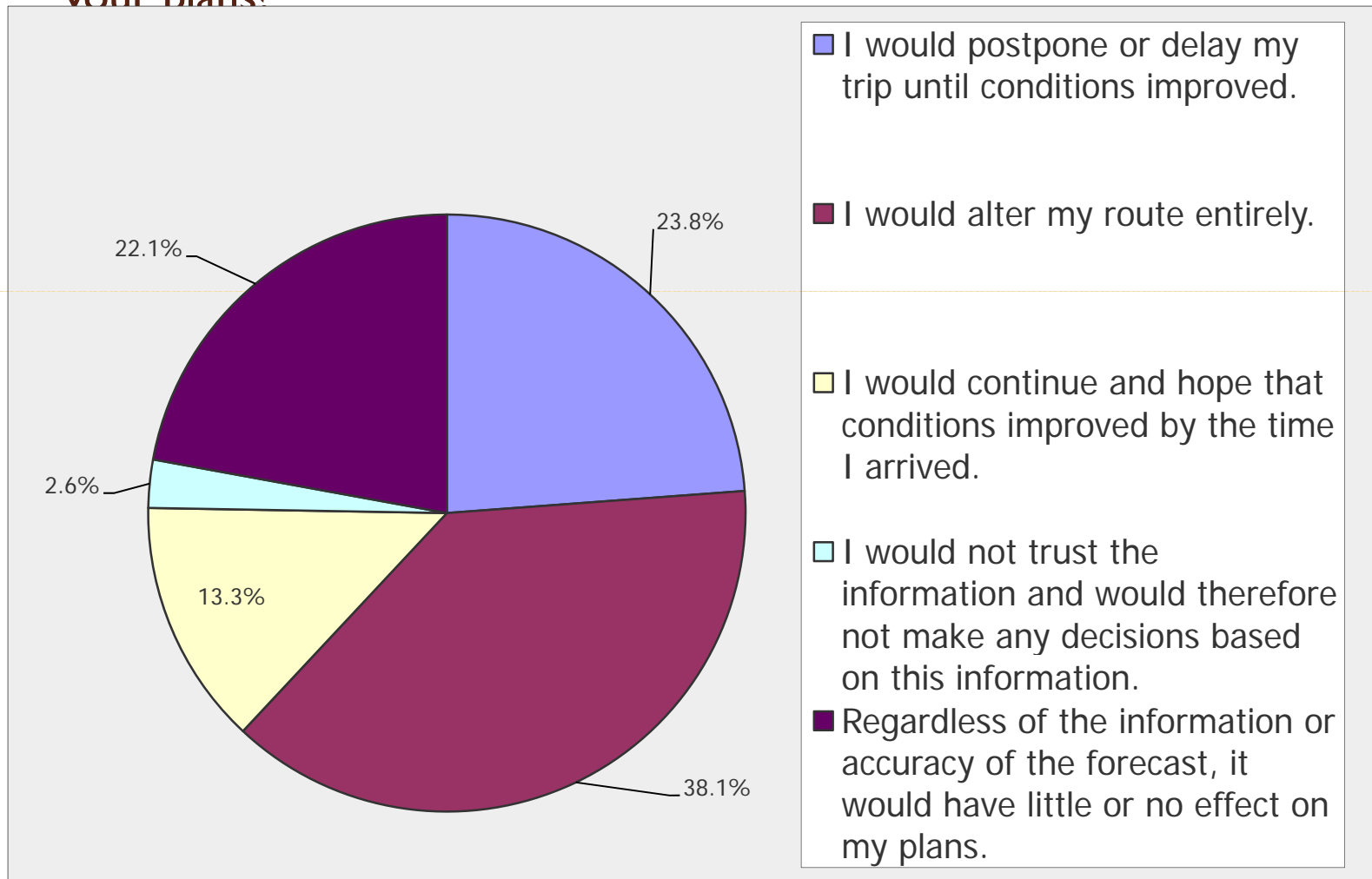
Survey Question 9; Do drivers of High Profile Vehicles (10 feet or more in height) ignore the high wind warnings or prohibition?



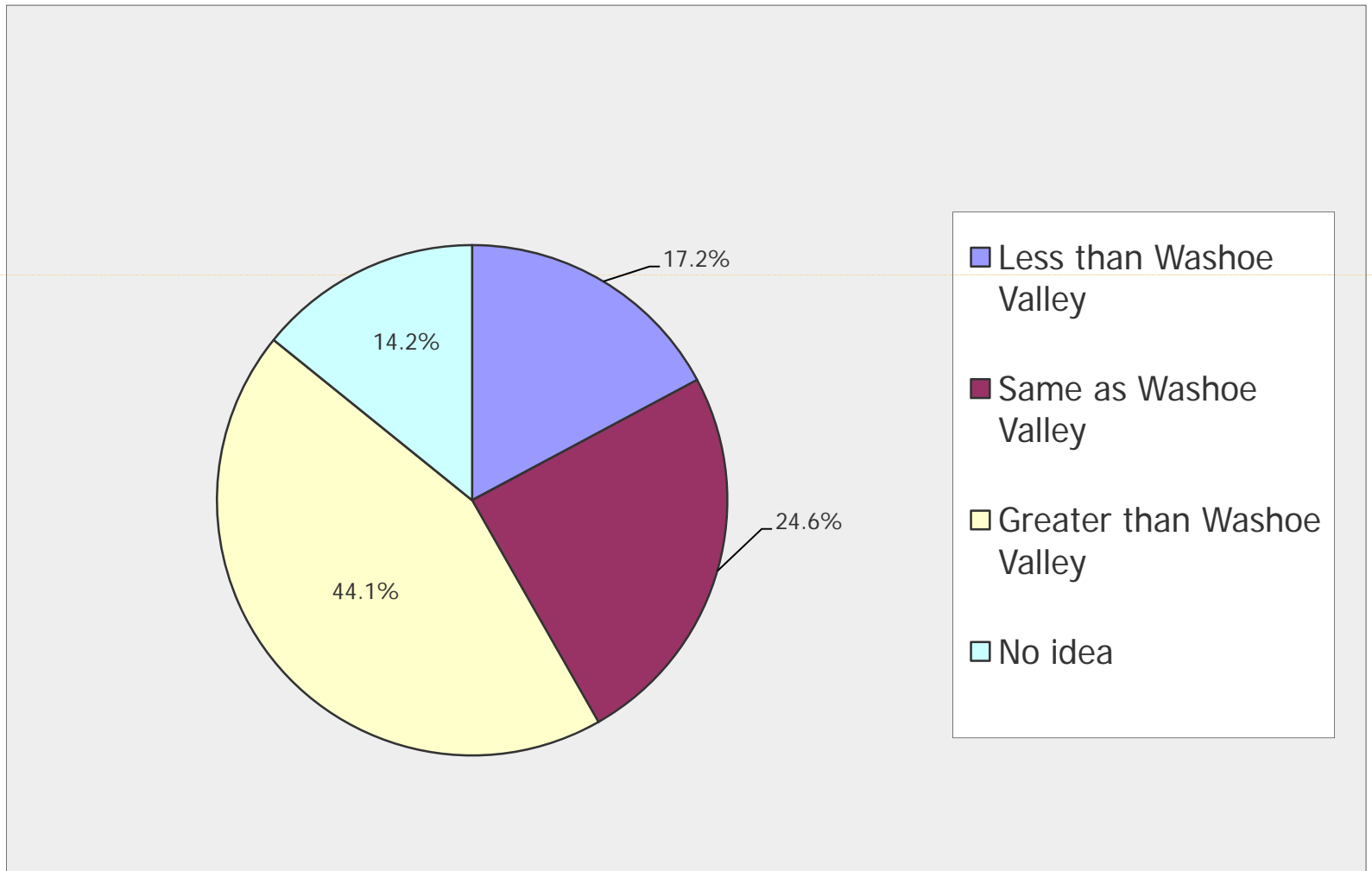
Survey Question 12; How clear are these existing electronic changeable messages?



Survey Question 15; If unfavorable forecasts were received at your specified location to warn motorists of high winds or driving prohibitions in the Washoe Valley, how likely would you be to alter your plans?



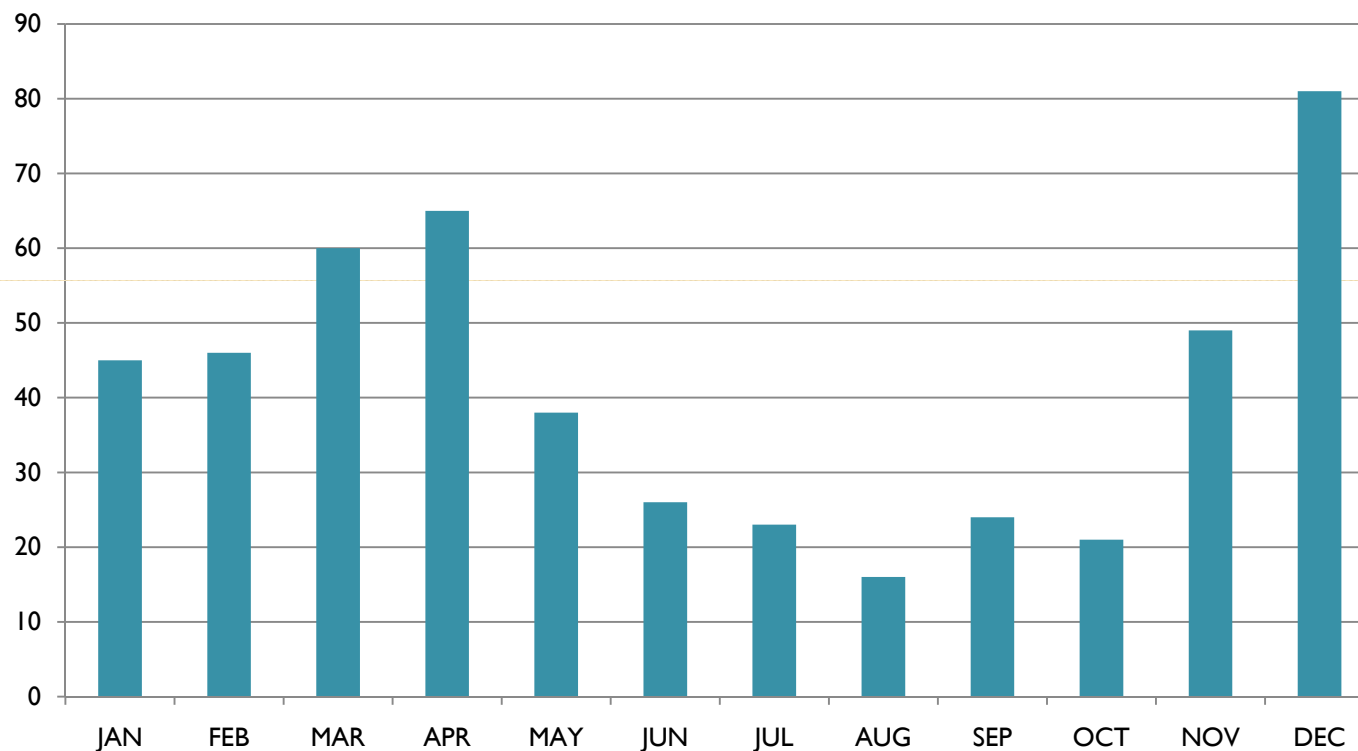
Survey Question 18; How strong do you expect the wind to be on the new US-395 freeway segment between Mt. Rose Highway (SR-431) and Washoe Valley (JCT SR-429)?



Washoe Valley Crash-related Wind Data

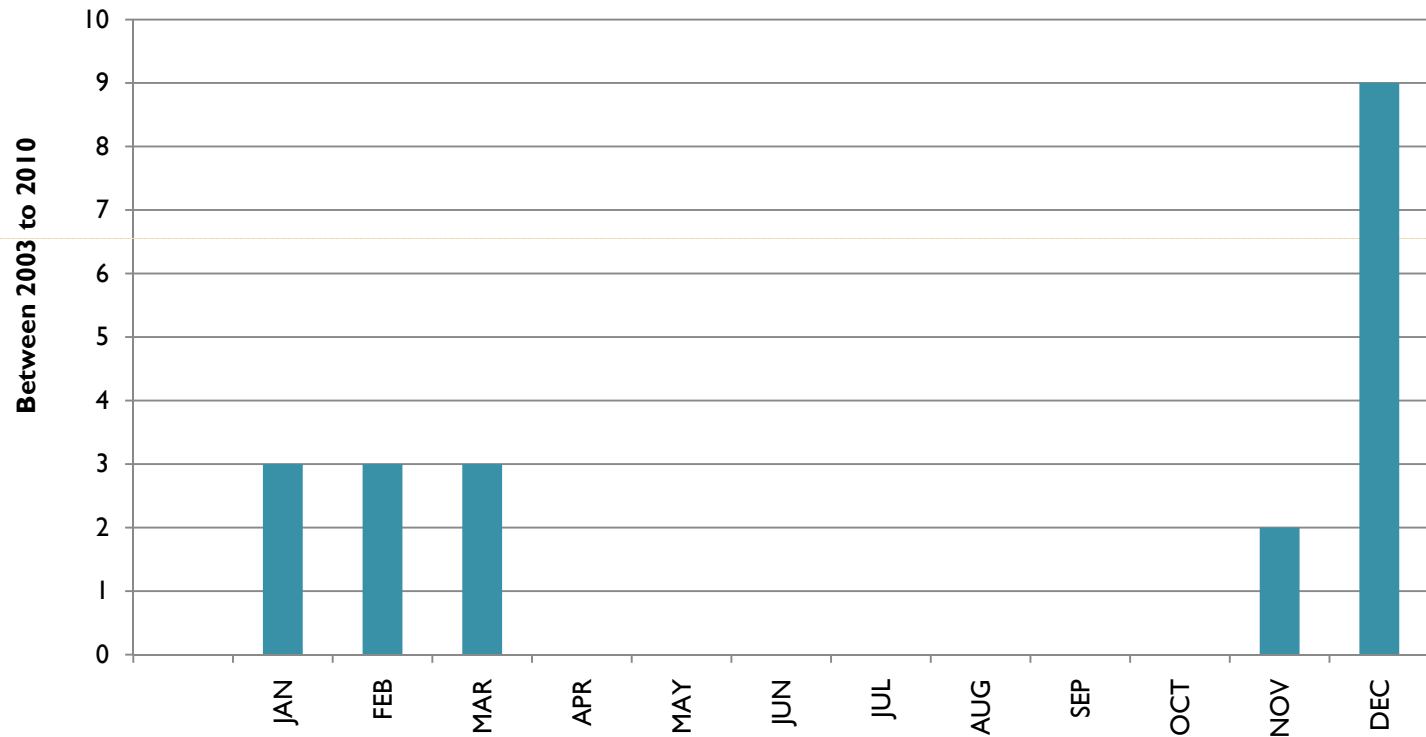
Parameters	Wind Speed (mph)	Wind Direction	Wind Gust Speed (mph)
Average	42	229.8	61.5
Max	59	243.0	91.0
Min	23	206.0	35.0
Standard Deviation	7.8	7.1	9.8

Frequency of Windy Days in Washoe Valley that Exceed Prohibition Criteria, 2003—2010

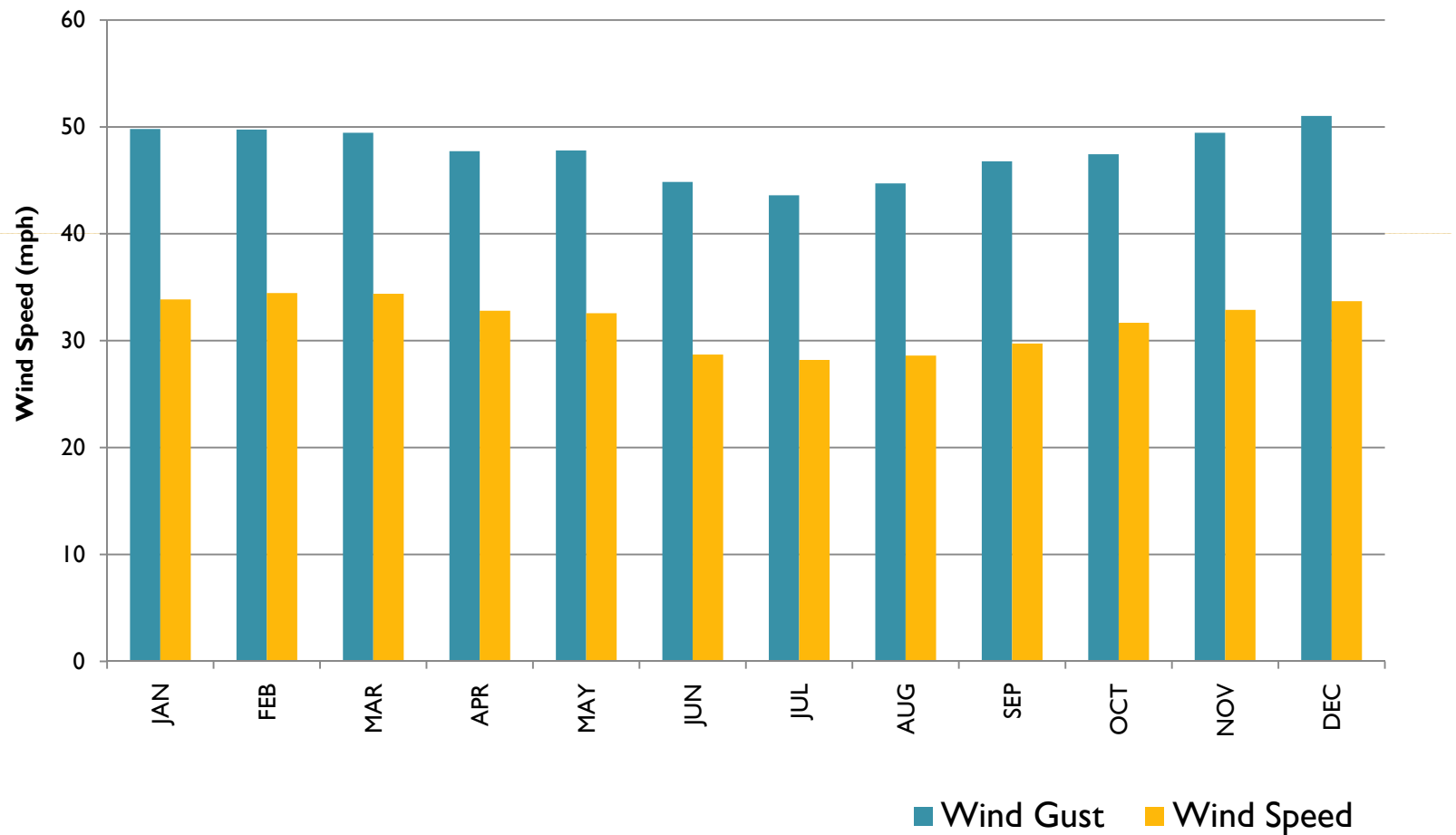


■ Number of 'windy' days (W>30, G>40)

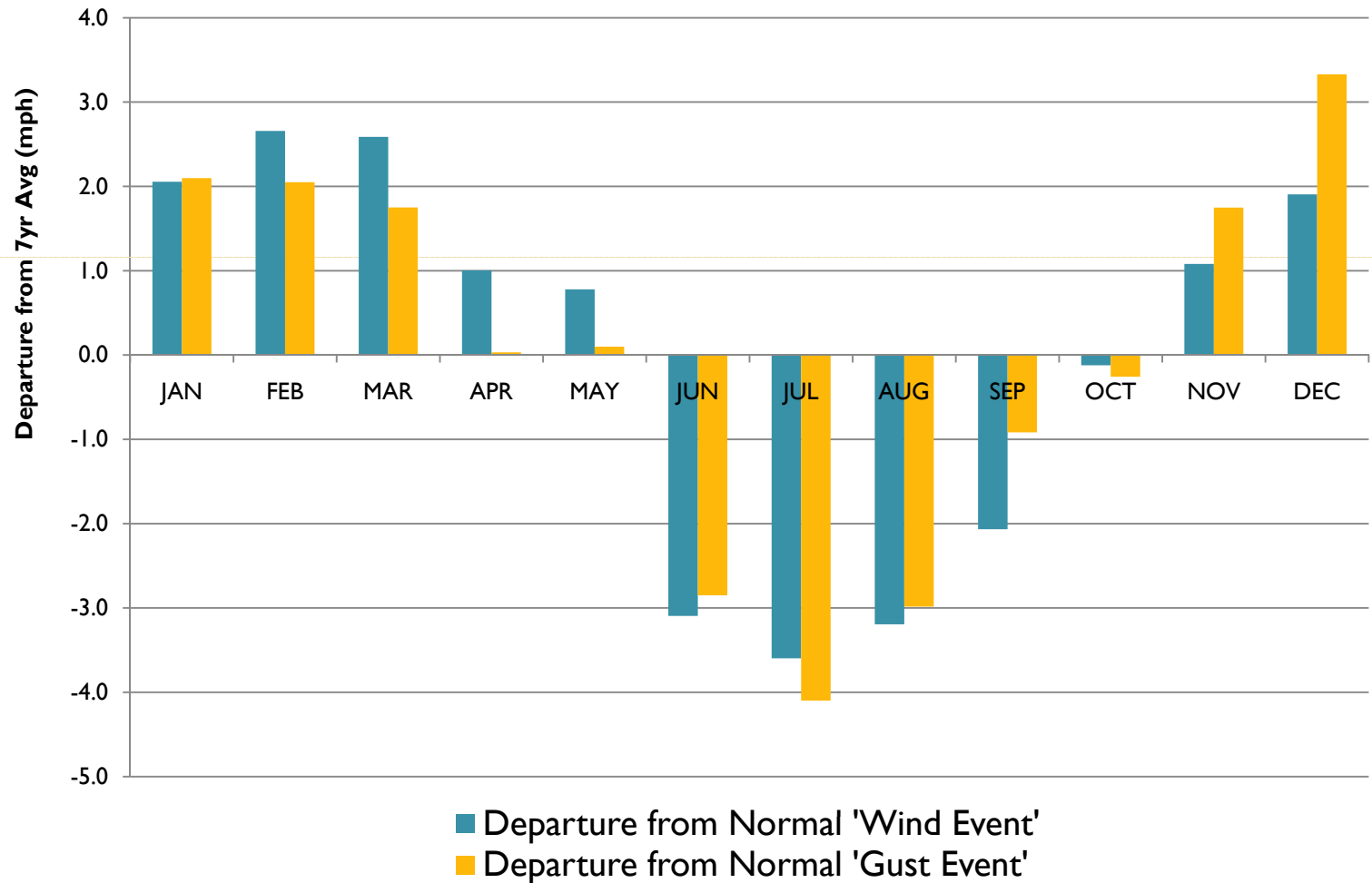
Frequency of Wind Related Crashes in the Washoe Valley by Month 2003-2010



Wind Speed and Gusts During a Prohibition by Month in the Washoe Valley 2003-2010

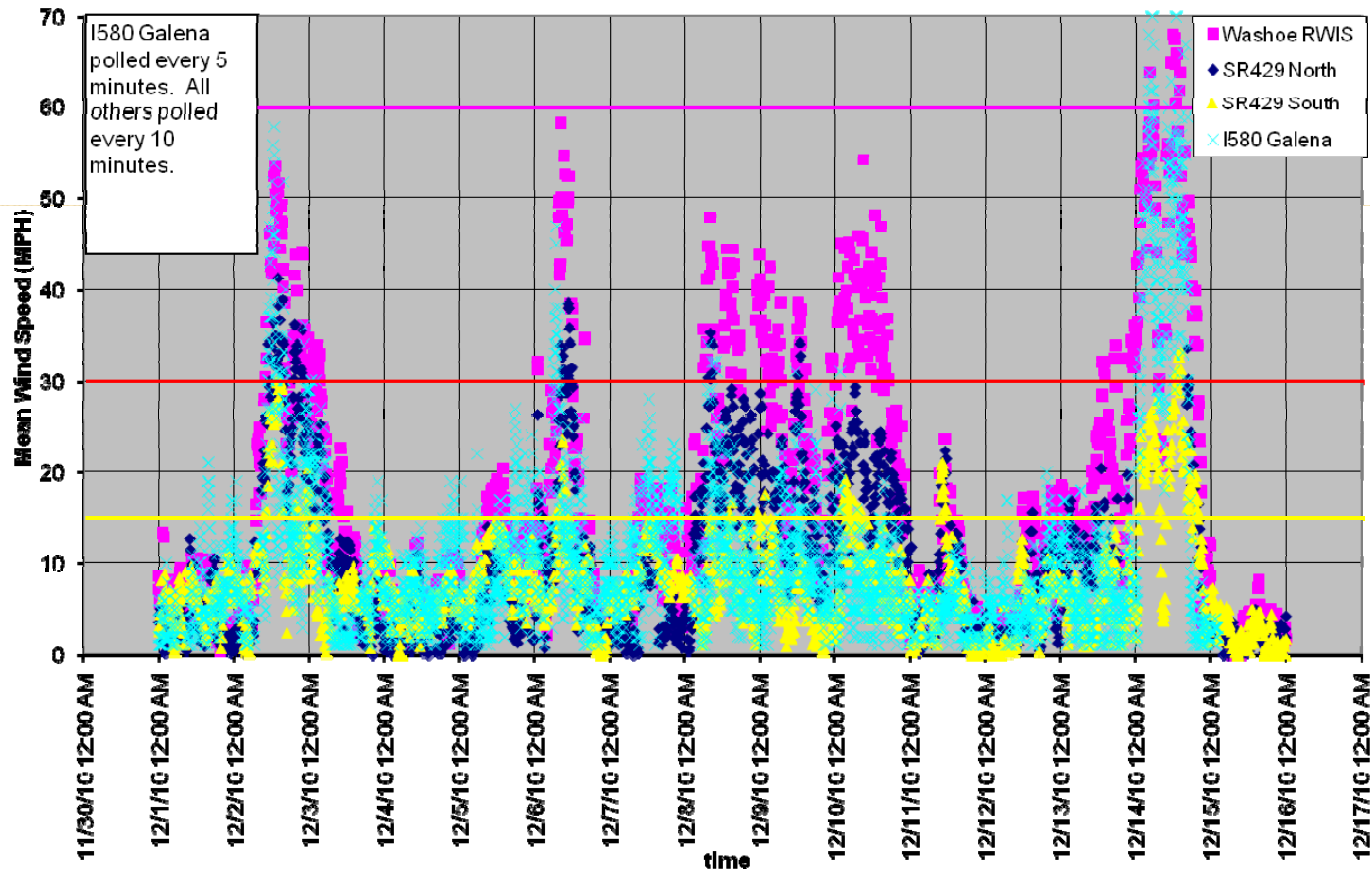


Departure from Ave. Wind and Gust Events by Month During a Prohibition in the Washoe Valley 2003-2010



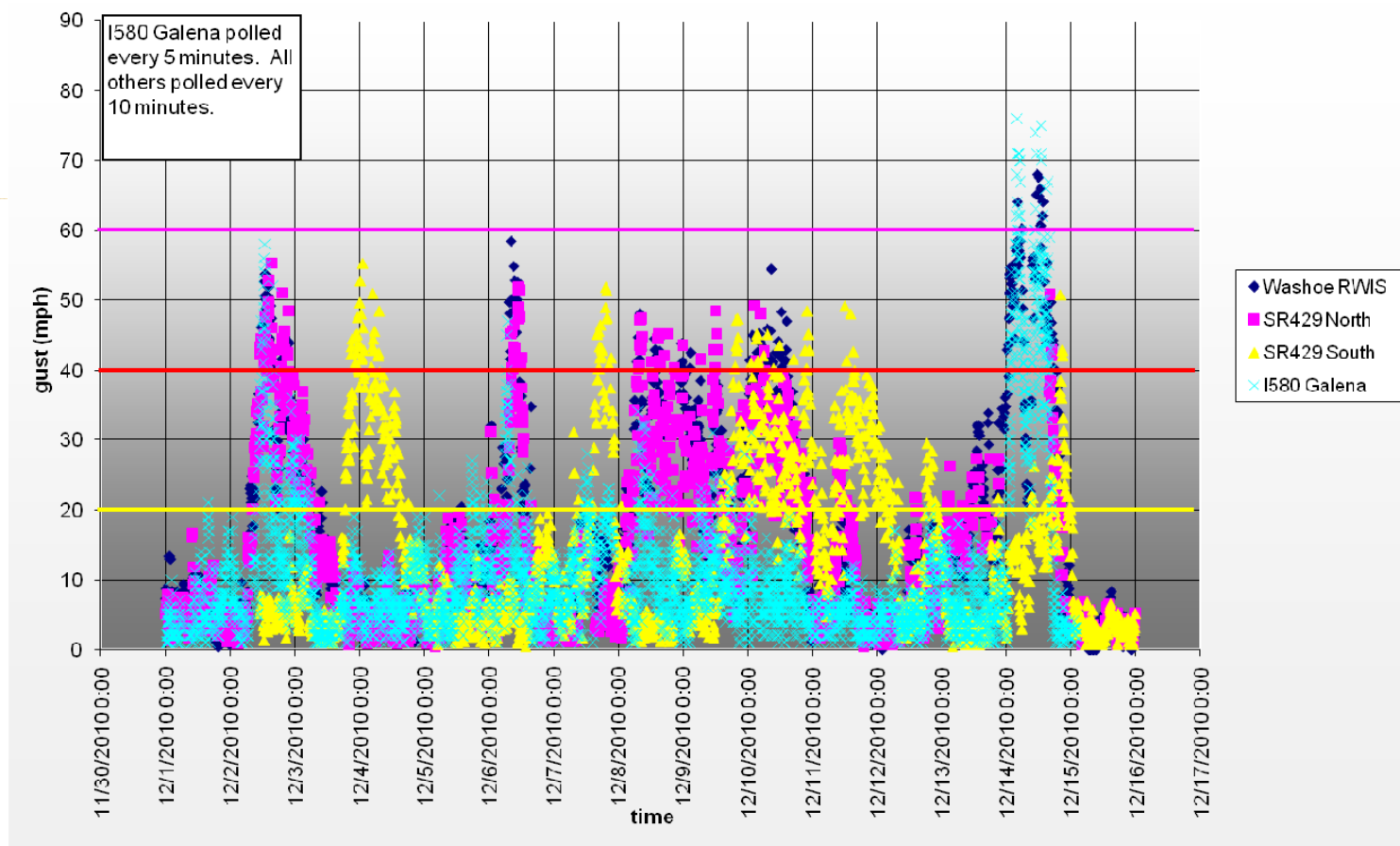
Mean Wind Speed 12/01/10-12/15/10

Washoe Valley Mean Wind Speed



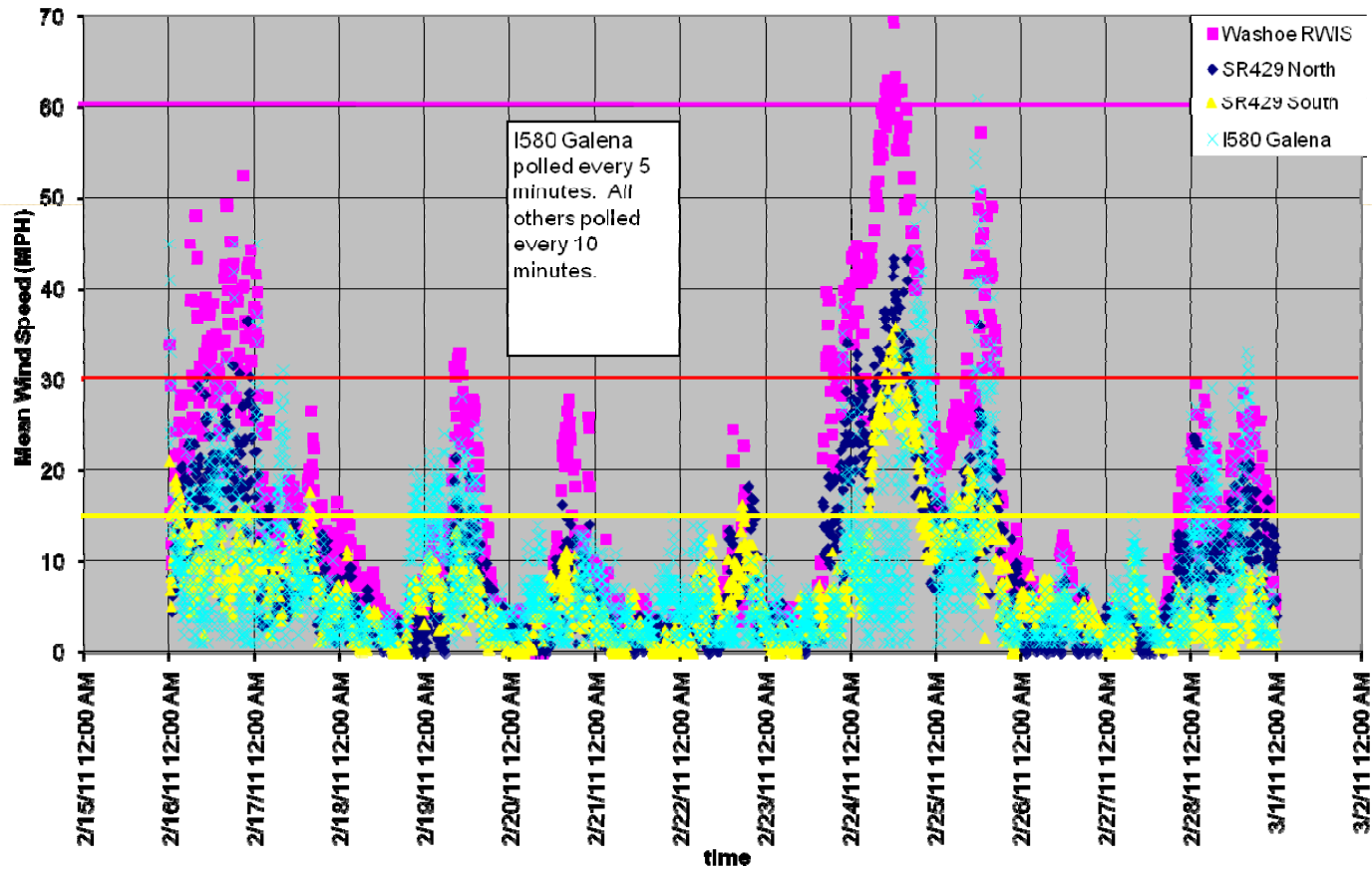
Gust Wind Speed 12/01/10-12/15/10

Washoe Valley Wind Gusts



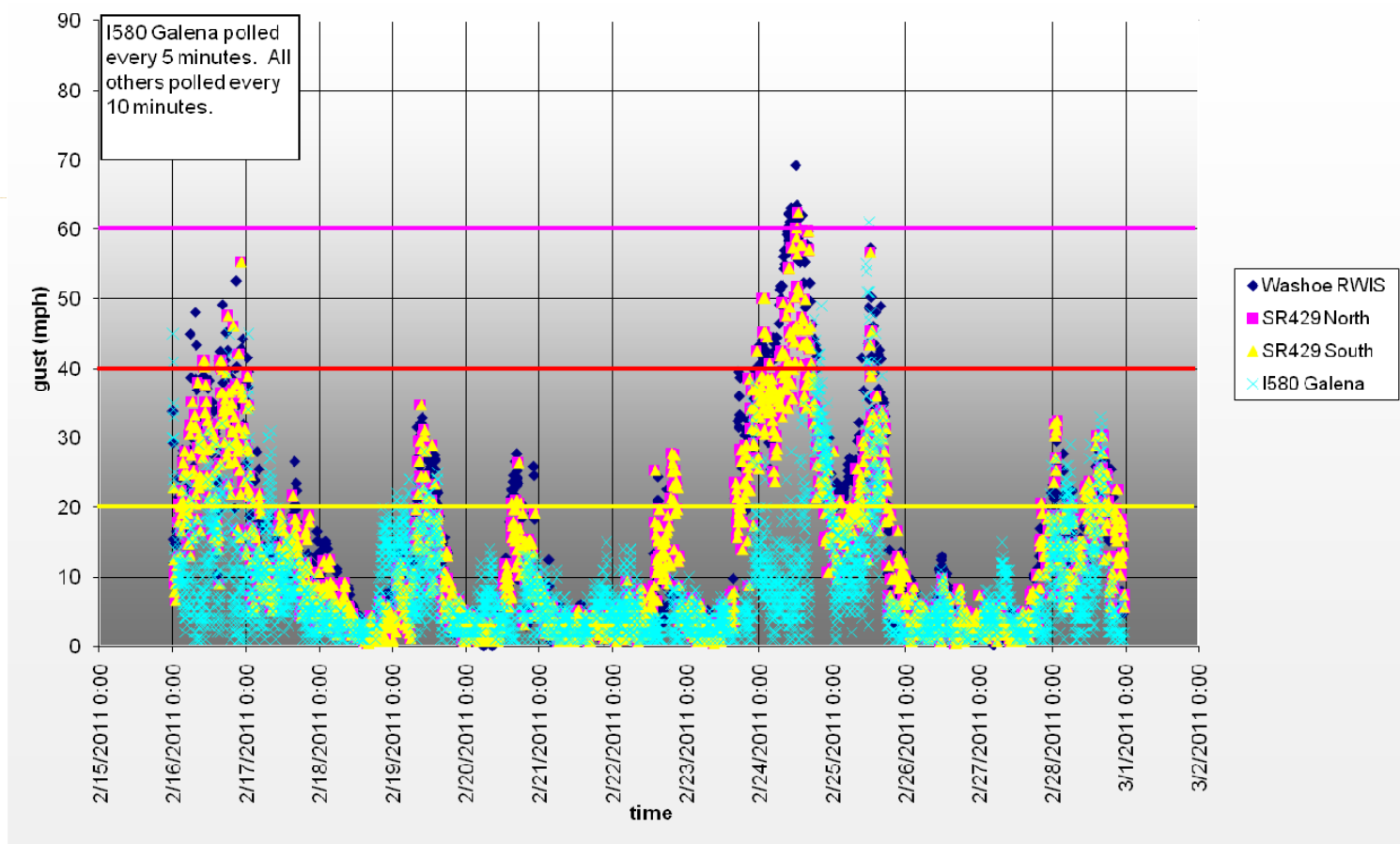
Mean Wind Speed 02/16/11-02/31/11

Washoe Valley Mean Wind Speed



Wind Gust Speed 02/16/11-02/31/11

Washoe Valley Wind Gusts



User Costs

- ~ \$100k cost to industry for every hour US395 is closed
- In 2007, we experienced 500 hours of prohibition on US395
- If we would have closed US395 in 2007 instead of detour, we would cost industry more than \$45M

Consultant Findings

- Every road segment requires its own analysis for maximum truck throughput
- Significant opportunity for ITS applications to allow more high profile vehicles through
- More wind data leads to better algorithms and better forecasting
- Public wants better info well before Washoe Valley

Consultant Findings Continued

- Need credibility in order to achieve compliance
- Better information and options improve compliance
- Trucking industry concerns appear to conflict with residential concerns

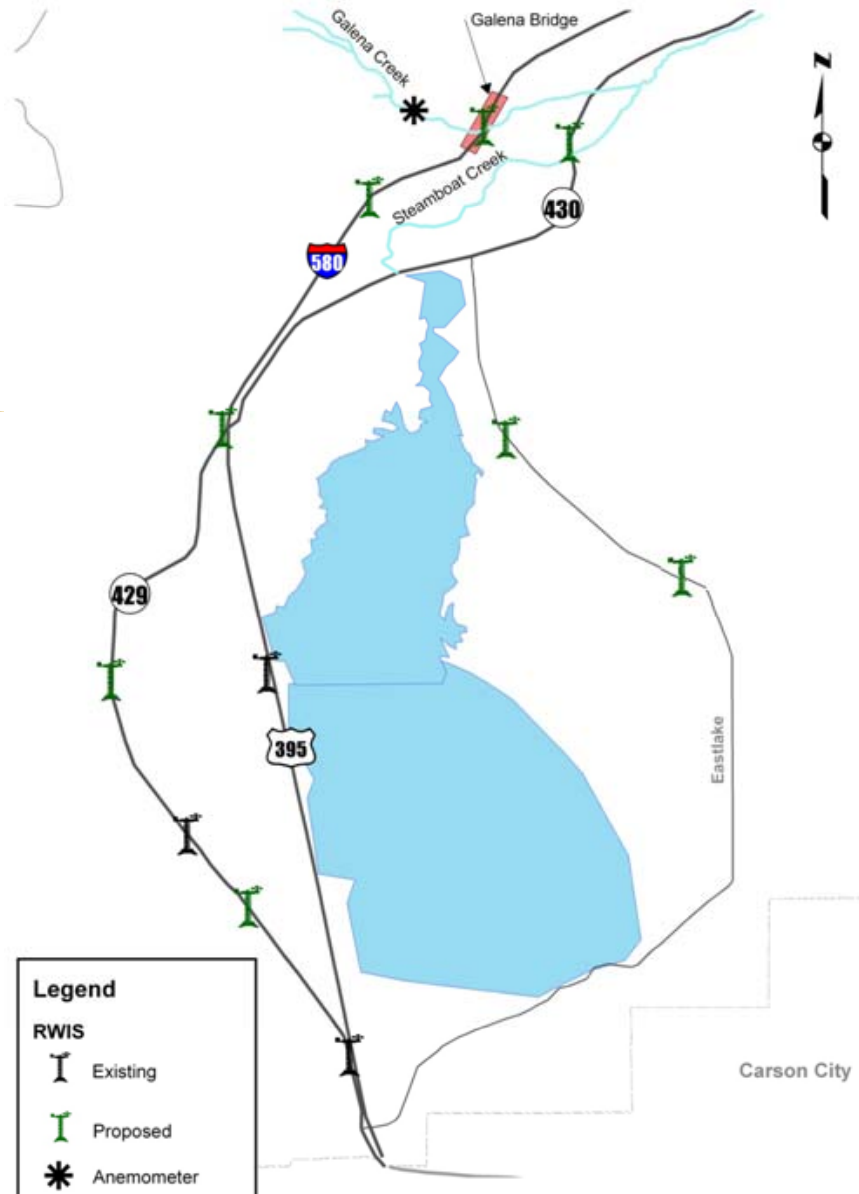
Proposed Improvements

- Change philosophy regarding factor of safety
- Increase system complexity to allow more users through
- Increase range of notification
- Diversify media used for motorist information
- Accommodate parking during wind events

Proposed New Thresholds

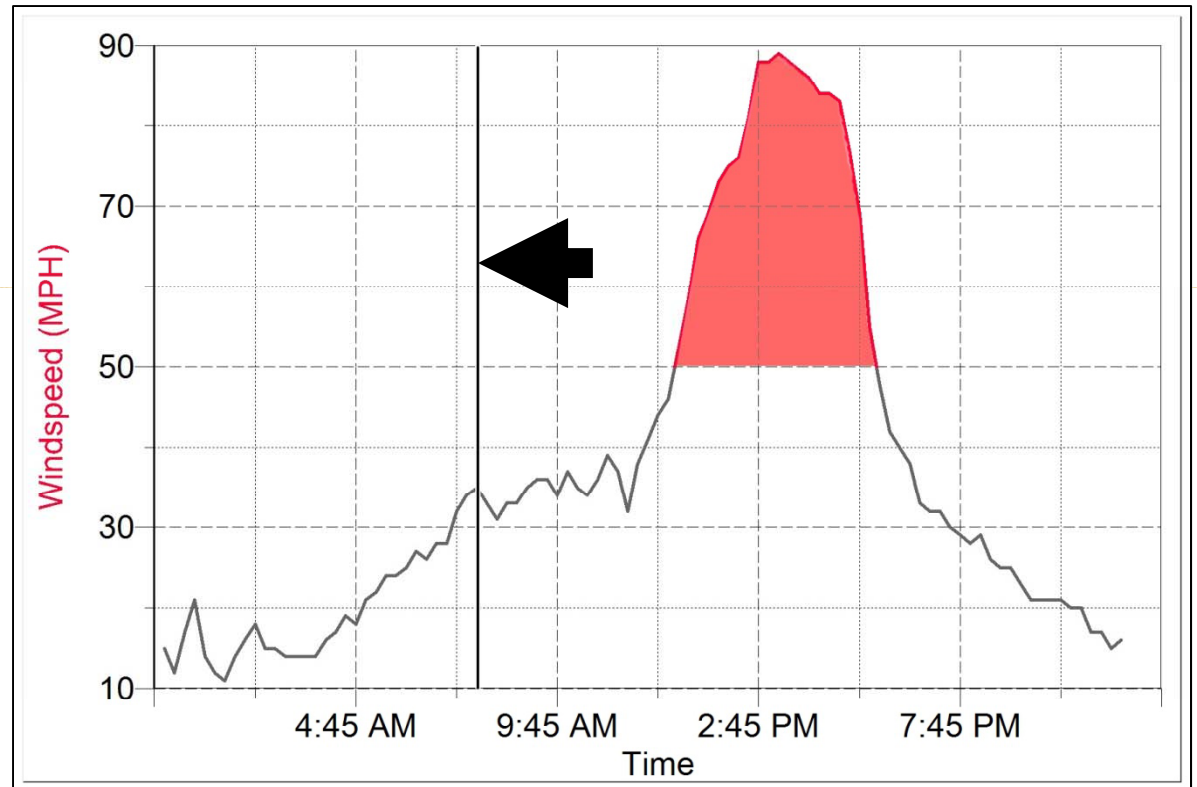
US-395			SR-429/Eastlake Blvd		I-580	
Wind Direction		Action	Actual or Forecasted Wind Speed (MPH)	Action	Actual or Forecasted Wind Speed (MPH)	Action
10 to 80 degrees or 190 to 260 degrees	260 to 10 degrees or 80 to 190 degrees					
Actual or Forecasted Wind Speed (MPH)						
Dry Pavement						
< 35	< 35	Continue to monitor	< 30	Continue to monitor	< 20	Continue to monitor
35 < wind speed < 50	35 < wind speed < 60	Issue wind warnings (HAR/DMS)	30 < wind speed < 45	Issue wind warnings (HAR/DMS)	20 < wind speed < 40	Issue wind warnings (HAR/DMS)
50 < wind speed < 60	60 < wind speed < 70	Reduce HPV speed limit to 45 mph	45 < wind speed < 55	Reduce HPV speed limit to 45 mph	40 < wind speed < 50	Reduce HPV speed limit to 45 mph
> 60	> 70	Activate HPV prohibition	> 55	Activate HPV prohibition	> 50	Activate HPV prohibition
Wet Pavement						
< 35	< 35	Continue to monitor	< 30	Continue to monitor	< 20	Continue to monitor
35 < wind speed < 40	35 < wind speed < 45	Issue wind warnings (HAR/DMS)	30 < wind speed < 35	Issue wind warnings (HAR/DMS)	20 < wind speed < 30	Issue wind warnings (HAR/DMS)
40 < wind speed < 50	45 < wind speed < 55	Reduce HPV speed limit to 45 mph	35 < wind speed < 40	Reduce HPV speed limit to 45 mph	30 < wind speed < 35	Reduce HPV speed limit to 45 mph
> 50	> 55	Activate HPV prohibition	> 40	Activate HPV prohibition	> 35	Activate HPV prohibition

Proposed RWIS



Wind Warning DSS

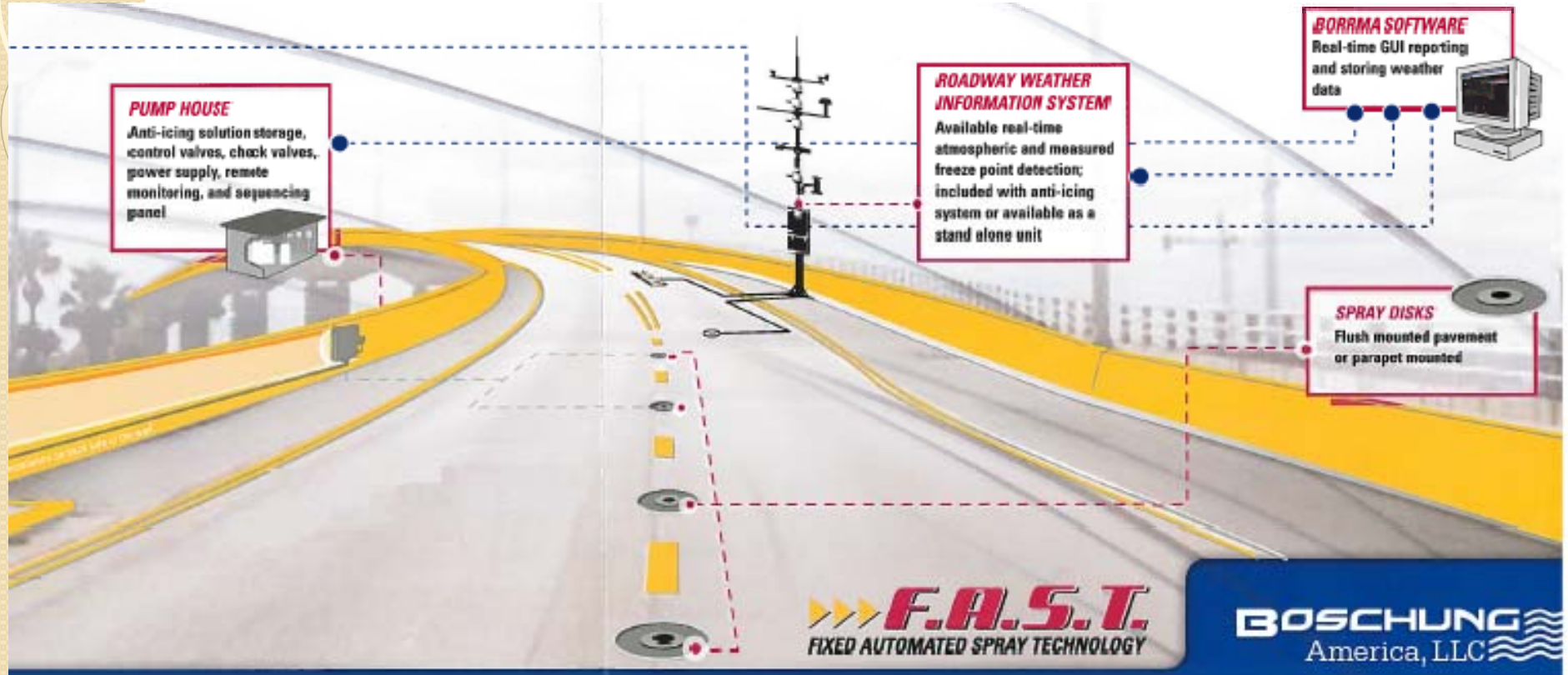
- Processed forecast, Met QC
- DSS updates hourly with new data
- Continuous scrolling
- End user sets thresholds
- End user sets layers



NorthWest WeatherNet, Inc



Anti-icing System



- Galena Forest Bridge
- Steamboat Hills Bridge
- Browns Creek Bridge
- Galena Creek Bridge

Real Time motorist Information

ROUTE	WIND SPEED*	GUST SPEED*	STATUS**
US-395	XX MPH	XX MPH	CLOSED TO HPV
I-580	XX MPH	XX MPH	WIND ADVISORY
SR-429	XX MPH	XX MPH	CLOSED TO HPV
EASTLAKE BLVD.	XX MPH	XX MPH	OPEN
CONDITIONS FORECAST SCROLL***			

* **XX** is a changeable message sign that will display wind and gust speeds

** **CLOSED TO HPV** is a changeable message sign that will display the closure/warning status on various routes. Messages shown are suggestions.

*** This is a changeable message sign that will allow a scrolling message to provide conditions forecast updates to motorists.

Wind Deflectors




Wind Speeds with Windscreens

- Galena Creek Bridge
- 1:40 scale
- Windscreen: 3m high from bridge deck



- Tested the winds speeds for existing bridge rail; solid, 20% and 50% Porosity windscreens (up to 2 screens)

WIND 
UREF = 1.0

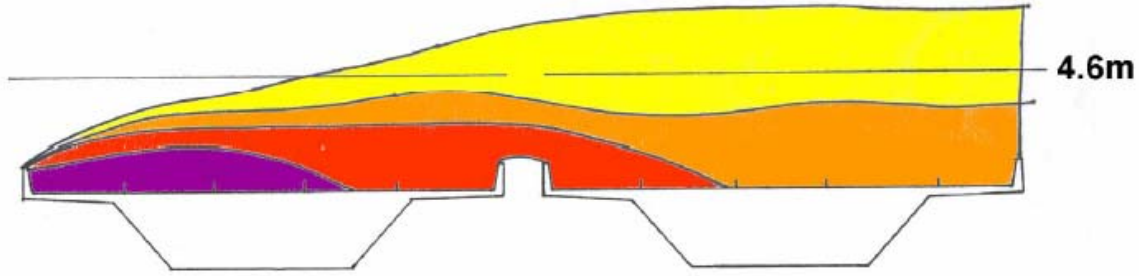


FIGURE 6: No Windscreens - Angle 0°

WIND 
UREF = 1.0

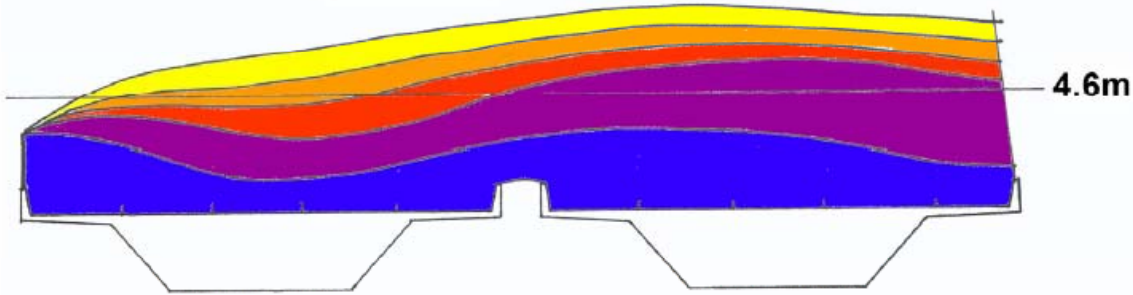


FIGURE 7: One 3m Solid Windscreen - Angle 0°

WIND 
UREF = 1.0

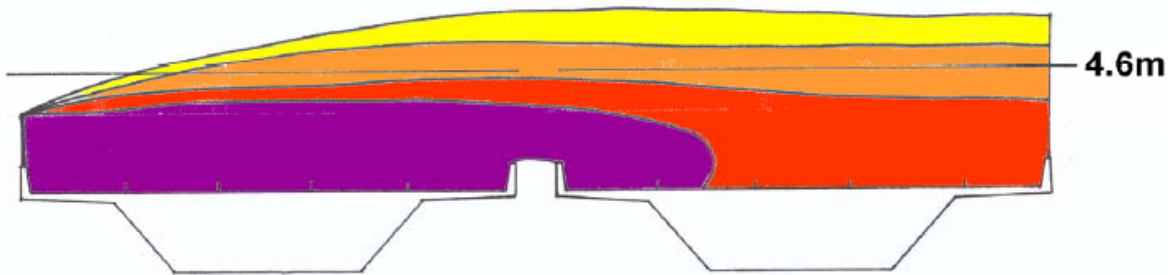
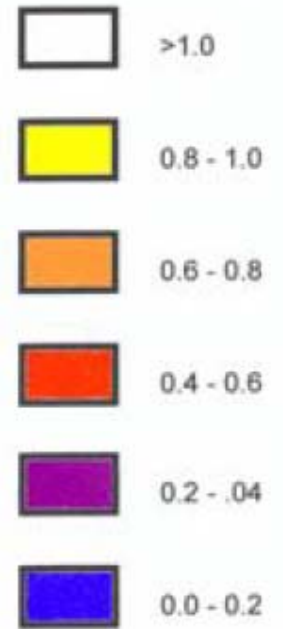
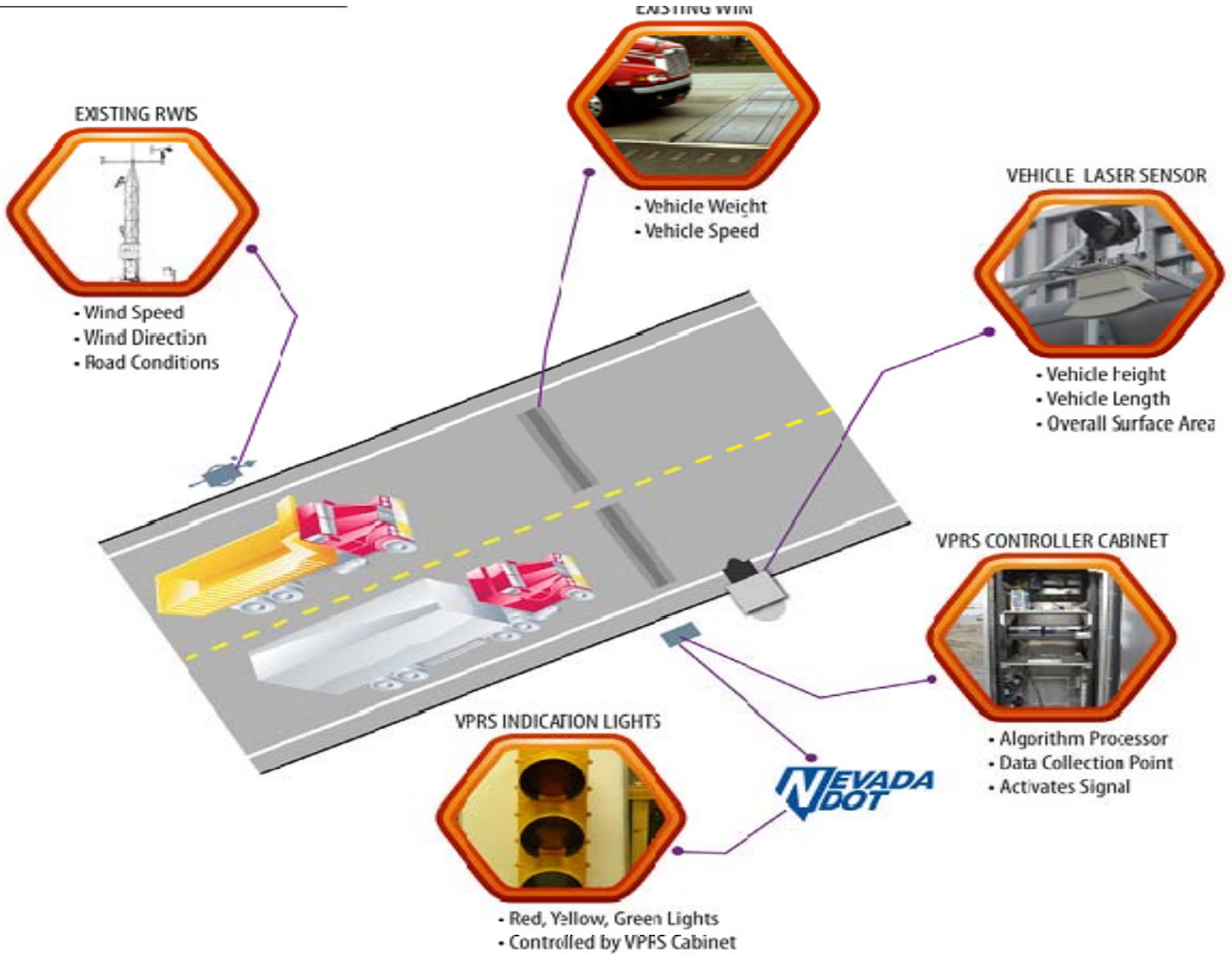


FIGURE 19: One 3m 50% Porous Windscreen - Angle 0°





Questions?



TRANSCORE • WEATHER SOLUTIONS GROUP • NORTHWEST WEATHERNET, INC. • AIT • RLA SOLUTIONS

WIND WARNING STUDY FOR US-395 & I-580 IN WASHOE & PLEASANT VALLEYS

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