

# North Carolina Project Development Crash Reduction Factor Information

[http://www.ncdot.org/doh/preconstruct/traffic/safety/Resources/project\\_guide/regionalfactors.pdf](http://www.ncdot.org/doh/preconstruct/traffic/safety/Resources/project_guide/regionalfactors.pdf)

Revised October 4, 2010

Countermeasure	Crash Pattern Affected -- Site Specification	Percent Reduction	Date -- Study -- Reference
<b>1. Traffic Signals</b>			
1.1 Install a Traffic Signal	Total Crashes	22	April 01 -- WPRFC Meeting Handout -- Reference 1, 2
	"OR"		
	Total Angle Crashes	65	April 01 -- WPRFC Meeting Handout -- Reference 13
	<b>3-leg Urban Intersection</b> (Injury includes fatality and injury crashes)		
	Total Injury Crashes	14	November 05 -- NCHRP Digest 299 -- Study 4
	"OR"		
	Total Right-Angle Injury Crashes	34	November 05 -- NCHRP Digest 299 -- Study 4
	Total Rear-End Injury Crashes	-50	November 05 -- NCHRP Digest 299 -- Study 4
	<b>4-leg Urban Intersection</b> (Injury includes fatality and injury crashes)		
	Total Injury Crashes	23	November 05 -- NCHRP Digest 299 -- Study 4
"OR"			
Total Right-Angle Injury Crashes	67	November 05 -- NCHRP Digest 299 -- Study 4	
Total Rear-End Injury Crashes	-38	November 05 -- NCHRP Digest 299 -- Study 4	
<b>3-Leg and 4-Leg Rural Intersection</b>			
Total Crashes	44	November 09 -- CMF Web -- Reference 9	
"OR"			
Total Angle Crashes	77	November 09 -- CMF Web -- Reference 9	
1.2 Upgraded Traffic Signals	Total Crashes	22	April 01 -- WPRFC Meeting Handout -- Reference 1, 11
	"OR"		
	Total Fatal Crashes	38	April 01 -- WPRFC Meeting Handout -- Reference 1, 11
	Total Non-Fatal Injury Crashes	22	April 01 -- WPRFC Meeting Handout -- Reference 1, 11
Total PDO Crashes	23	April 01 -- WPRFC Meeting Handout -- Reference 1, 11	
1.3 Add Protected Left-Turn Phase	Total Crashes	25	April 01 -- WPRFC Meeting Handout -- Reference 8
	"OR"		
	Total Left-Turn Crashes	70	April 01 -- WPRFC Meeting Handout -- Reference 13
1.4 Add Protected Permissive Left-Turn Phase	Total Crashes	10	April 01 -- WPRFC Meeting Handout -- Reference 13
	"OR"		
Total Left-Turn Crashes	40	April 01 -- WPRFC Meeting Handout -- Reference 13	
1.5 Change from Permitted or Permitted-Protected to Protected	<b>Urban</b> Total Left-Turn Crashes on Treated Approach	99	November 09 -- CMF Web -- Reference 9
1.6 Pretimed to Actuated	Total Crashes	20	April 01 -- WPRFC Meeting Handout -- Reference 8
1.7 Closed Loop Signal System	Total Crashes	15	April 01 -- WPRFC Meeting Handout -- Reference 13
1.8 Improve Signal Timing	Total Crashes	15	March 05 -- WPRFC Email -- ITE Safety Briefs
1.9 Replace 8-inch Signal Heads with 12-inch Signal Heads	Total Crashes	3	January 10 -- CMF Web -- Reference 15
	"OR"		
Total Angle Crashes	42	January 10 -- CMF Web -- Reference 15	
1.10 Long Vehicle Detection	Total Crashes	10*	September 06 -- WPRFC Email -- Subjective based on 6 B&A analyses
1.11 Provide Advanced Dilemma Zone Detection for Rural High Speed Approaches Major ADT 10900 to 43300	<b>Rural - 4-Leg</b> Total Injury Crashes (Injury includes fatality and injury crashes)	39	November 09 -- CMF Web -- Reference 30
1.12 Signal Back Plates	Total Crashes	5*	September 06 -- WPRFC Email -- Subjective based on committee opinion
	"OR"		
Total Right Angle Crashes	20	April 01 -- WPRFC Meeting Handout -- Reference 13	
1.13 Queue Detection - Ramp Locations	Total Crashes	30*	April 06 -- WPRFC Email -- Subjective based on committee opinion
1.14 Flashing Yellow Arrow	Total Crashes	22*	June 07 -- WPRFC Email -- Subjective based on committee opinion

1.15	Install Shoulder Mounted "Be Prepared to Stop" Signs	Total Crashes	30*	June 07 -- WPRFC Email -- Subjective based on committee opinion
1.16	Left Turn Yield Blank Out Sign	Total Crashes	15*	December 07 -- WPRFC Email -- Subjective based on committee opinion
1.17	Signal Removal	None	None*	May 08 -- WPRFC Email -- Subjective based on committee opinion
1.18	Install Signalized Superstreet at Intersection that is currently Signal Control	Total Crashes	51*	June 10 -- WPRFC Email -- Subjective based on committee opinion

<b>2. Flashing Beacons</b>				
2.1	Intersection Warning Flasher	Total Crashes	30	April 01 -- WPRFC Meeting Handout -- Reference 8, 13
	<u>2-lane at 2-lane Rural Intersection</u>			
	Total Crashes		12	November 06 -- NCDOT Study
	"OR"			
	Injury Crashes (Injury crashes are B and C level)		9	November 06 -- NCDOT Study
	Severe Injury Crashes (Severe injury crashes are K and A level)		40	November 06 -- NCDOT Study
	"OR"			
	Frontal Impact Crashes		9	November 06 -- NCDOT Study
	"OR"			
	"Ran Stop Sign" Crashes		26	November 06 -- NCDOT Study
2.2	Upgrade Overhead Warning Flasher Actuated Vehicles Entering	Total Crashes	25*	June 06 -- WPRFC Email -- Subjective based on committee opinion

3. Turn Lanes				
3.1 Left Turn Lane at an Intersection	<b>Without Signal</b>			
	Total Crashes	35	April 01 -- WPRFC Meeting Handout -- Reference 13	
	"OR"			
	Total Left-Turn Crashes	50	April 01 -- WPRFC Meeting Handout -- Reference 13	
	<b>With Signal</b>			
	Total Crashes	25	April 01 -- WPRFC Meeting Handout -- Reference 13	
	"OR"			
	Total Left-Turn Crashes	45	April 01 -- WPRFC Meeting Handout -- Reference 13	
		<b>Major Road Application</b>		
	<b>3-leg Rural Stop Sign controlled</b>	<b>1 Approach</b>	<b>Both Approaches</b>	
	Total Crashes	44		November 05 -- NCHRP Digest 299 -- Study 2
	"OR"			
	Total Left Turn-Same Road and Rear-End Slow or Stop Crashes	62		November 05 -- NCHRP Digest 299 -- Study 2
	<b>3-leg Urban Stop Sign controlled</b>			
	Total Crashes	33		November 05 -- NCHRP Digest 299 -- Study 2
	<b>4-leg Rural Stop Sign controlled</b>			
Total Crashes	28	48	November 05 -- NCHRP Digest 299 -- Study 2	
"OR"				
Total Left Turn-Same Road and Rear-End Slow or Stop Crashes	37	60	November 05 -- NCHRP Digest 299 -- Study 2	
<b>4-leg Urban Stop Sign controlled</b>				
Total Crashes	27	47	November 05 -- NCHRP Digest 299 -- Study 2	
"OR"				
Total Left Turn-Same Road and Rear-End Slow or Stop Crashes	26	45	November 05 -- NCHRP Digest 299 -- Study 2	
<b>4-leg Urban Signal controlled</b>				
Total Crashes	10	19	November 05 -- NCHRP Digest 299 -- Study 2	
"OR"				
Total Left Turn-Same Road and Rear-End Slow or Stop Crashes	13	24	November 05 -- NCHRP Digest 299 -- Study 2	
<b>3-leg Urban Signal controlled</b>				
Total Crashes	7		November 05 -- NCHRP Digest 299 -- Study 2	
<b>3-leg Rural Signal controlled</b>				
Total Crashes	15		November 05 -- NCHRP Digest 299 -- Study 2	
<b>4-leg Rural Signal controlled</b>				
Total Crashes	18	33	November 05 -- NCHRP Digest 299 -- Study 2	
3.2 Right Turn Lane at an Intersection	Total Crashes	25	April 01 -- WPRFC Meeting Handout -- Reference 13	
	"OR"			
	Total Right-Turn Crashes	50	April 01 -- WPRFC Meeting Handout -- Reference 13	
		<b>Major Road Application</b>		
	<b>4-leg Rural and Urban Stop Sign controlled</b>	<b>1 Approach</b>	<b>Both Approaches</b>	
Total Crashes	14	26	November 05 -- NCHRP Digest 299 -- Study 3	
<b>4-leg Rural and Urban Signal controlled</b>				
Total Crashes	4	8	November 05 -- NCHRP Digest 299 -- Study 3	
3.3 Dual Left Turn Lanes	Total Injury Crashes (Injury includes fatality and injury crashes)	29	February 06 -- WPRFC Email -- NCHRP 500	
	Total PDO Crashes	26	February 06 -- WPRFC Email -- NCHRP 500	
3.4 Increase Turn Lane Length	Total Crashes	15	April 01 -- WPRFC Meeting Handout -- Reference 13	
3.5 Extend Acceleration Lane by approx. 98 ft (30 m)	Total Crashes	11	November 09 -- CMF Web -- Reference 2	
3.6 Extend Deceleration Lane by approx. 98 ft (30 m)	Total Crashes	7	November 09 -- CMF Web -- Reference 2	
3.7 Provide Long Ramp Instead of Shortramp	Total Crashes	38	November 09 -- CMF Web -- Reference 4	
3.8 Provide Short Ramp Instead of Directional Loop Ramp	Total Crashes	30	November 09 -- CMF Web -- Reference 4	

3.9 Provide Straight Ramp Instead of Cloverleaf Ramp	Total Crashes	45	November 09 -- CMF Web -- Reference 4
3.10 Continuous Left Turn Lane	Total Crashes	30	April 01 -- WPRFC Meeting Handout -- Reference 3
3.11 Install TWLTL (Two-Way Left Turn Lane) on Two Lane Road	Total Crashes "OR"	20	January 10 -- CMF Web -- Reference 20
	Total Rear End Crashes	39	January 10 -- CMF Web -- Reference 20
3.12 Install TWLTL (Two-Way Left Turn Lane) on Two Lane Road	<u>Rural</u> Total Crashes "OR"	36	January 10 -- CMF Web -- Reference 20
	Total Rear End Crashes	47	January 10 -- CMF Web -- Reference 20
3.13 Positive Offset for New Left Turn Lanes	Total Crashes	10*	April 07 -- WPRFC Email -- Subjective based on November 2004
3.14 Positive Offset for Existing Left Turn Lanes	Total Crashes	37*	April 07 -- WPRFC Email -- Subjective based on 2 B&A analyses
3.15 Introducing Zero or Positive Offset Left-Turn Lane on Crossing Roadway	<u>Urban - Signalized</u> Total Angle Crashes	26	November 09 -- CMF Web -- Reference 7
3.16 Stripe for Turn Lane within Existing Roadway	Total Crashes	26*	March 05 -- WPRFC Email -- Subjective based on committee opinion
3.17 Introduce Painted Left-Turn Channelization	<u>Rural - Multilane - 4-Leg - Stop Controlled</u> Total Crashes "OR"	33	November 09 -- CMF Web -- Reference 6
	Total Rearend and Sideswipe Crashes	39	November 09 -- CMF Web -- Reference 6
3.18 Introduce Raised/Curb Left-Turn Channelization	<u>Rural - Multilane - 4-Leg - Stop Controlled</u> Total Crashes "OR"	13	November 09 -- CMF Web -- Reference 6
	Total Rearend and Sideswipe Crashes	25	November 09 -- CMF Web -- Reference 6

<b>4. Pavement Widening</b>			
4.1 Widening for an Additional Lane	Total Crashes	10*	March 07 -- WPRFC Meeting -- Subjective based on committee opinion
4.2 Pavement Widening	Total Crashes "OR"	22	April 01 -- WPRFC Meeting Handout -- Reference 2
	Total Fatal Crashes	40	April 01 -- WPRFC Meeting Handout -- Reference 2
	Total Non-Fatal Injury Crashes	15	April 01 -- WPRFC Meeting Handout -- Reference 2
	Total PDO Crashes	25	April 01 -- WPRFC Meeting Handout -- Reference 2
4.3 Widen or Improve Shoulder	Total Crashes "OR"	8	April 01 -- WPRFC Meeting Handout -- Reference 1, 2
	Total Fatal Crashes	22	April 01 -- WPRFC Meeting Handout -- Reference 1, 2
	Total Non-Fatal Injury Crashes	13	April 01 -- WPRFC Meeting Handout -- Reference 1, 2
	Total PDO Crashes	12	April 01 -- WPRFC Meeting Handout -- Reference 1, 2
	<u>Rural 2-lane</u> Total Crashes "OR"	18	April 01 -- WPRFC Meeting Handout -- Reference 2
	Total Fatal Crashes	48	April 01 -- WPRFC Meeting Handout -- Reference 2
	Total Non-Fatal Injury Crashes	8	April 01 -- WPRFC Meeting Handout -- Reference 2
	Total PDO Crashes	23	April 01 -- WPRFC Meeting Handout -- Reference 2
	<u>Urban 2-lane</u> Total Crashes	26	April 01 -- WPRFC Meeting Handout -- Reference 2
	4.4 Removal of Objects from Clear Zone	Total Fatal Crashes	32*
Total Non-Fatal Injury Crashes		45*	August 08 -- WPRFC Email -- Subjective based on committee opinion
4.5 Increase Distance to Roadside Obstacle from around 1 m to around 5 m	<u>Rural</u> Total Crashes	22	November 09 -- CMF Web -- Reference 2

<b>4.6 Increase Distance to Roadside Obstacle from around 5 m to around 9 m</b>	<b>Rural</b> Total Crashes	44	November 09 -- CMF Web -- Reference 2
<b>4.7 Flatten Sideslope from 1V:3H to 1V:4H</b>	<b>Rural</b> Total Non-Fatal Injury Crashes Total PDO Crashes	42 29	November 09 -- CMF Web -- Reference 2 November 09 -- CMF Web -- Reference 2
<b>4.8 Flatten Sideslope from 1V:4H to 1V:6H</b>	<b>Rural</b> Total Non-Fatal Injury Crashes Total PDO Crashes	22 24	November 09 -- CMF Web -- Reference 2 November 09 -- CMF Web -- Reference 2
<b>4.9 Add Passing Lanes (Two-Lane Roads)</b>	<b>One-Way</b> (single direction of travel) Total Crashes	25	November 05 -- NCHRP Digest 299 -- Study 11
	<b>Two-Way</b> (short four-lane sections) Total Crashes	35	November 05 -- NCHRP Digest 299 -- Study 11

<b>5. Pavement Enhancements</b>			
<b>5.1 Shoulder Rumble Strips</b>	Total Crashes	29	April 01 -- WPRFC Meeting Handout -- Reference 3
	<b>Rural and Urban Freeways</b> (Injury includes fatality and injury crashes) Total Single-Vehicle Run-Off-Road Crashes "OR" Total Injury Single-Vehicle Run-Off-Road Crashes	18 13	November 05 -- NCHRP Digest 299 -- Study 17 November 05 -- NCHRP Digest 299 -- Study 17
	<b>Rural Freeways</b> (Injury includes fatality and injury crashes) Total Single-Vehicle Run-Off-Road Crashes "OR" Total Injury Single-Vehicle Run-Off-Road Crashes	21 7	November 05 -- NCHRP Digest 299 -- Study 17 November 05 -- NCHRP Digest 299 -- Study 17
<b>5.2 Implement Shoulder Widening in Conjunction with Shoulder Rumble Strip Installation on Freeways</b>	<b>Principal Arterial Freeway or Expressway</b> Total Crashes "OR" Total Run Off Road Crashes	19 13	November 09 -- CMF Web -- Reference 27 November 09 -- CMF Web -- Reference 27
<b>5.3 Add Centerline Rumble Strips</b>	<b>Rural 2-lane Roads</b> (Injury includes fatality and injury crashes) Total Crashes "OR" Total Frontal/Opposing-Direction Sideswipe Crashes "OR" Total Injury Crashes "OR" Total Injury Frontal/Opposing-Direction Sideswipe Crashes	14 21 15 25	November 05 -- NCHRP Digest 299 -- Study 18 November 05 -- NCHRP Digest 299 -- Study 18 November 05 -- NCHRP Digest 299 -- Study 18 November 05 -- NCHRP Digest 299 -- Study 18
<b>5.4 Centerline Rumble Strips on Rural 5-Lane Curb and Gutter Crossover</b>	Total Crashes	29*	December 08 -- WPRFC Email -- Subjective based on committee opinion
<b>5.5 Skid Treatments (overlay)</b>	Total Crashes "OR" Total Fatal Crashes Total Non-Fatal Injury Crashes Total PDO Crashes  Total Wet Crashes "OR" Total Wet Injury Crashes (Injury includes fatality and injury crashes)	27 29 16 32  63 57	April 01 -- WPRFC Meeting Handout -- Reference 2 April 01 -- WPRFC Meeting Handout -- Reference 2 April 01 -- WPRFC Meeting Handout -- Reference 2 April 01 -- WPRFC Meeting Handout -- Reference 2  April 01 -- WPRFC Meeting Handout -- Reference 10 April 01 -- WPRFC Meeting Handout -- Reference 9
<b>5.6 Increased Pavement Friction</b>	Total Crashes "OR" Total Wet Road Crashes "OR" Total Rear End Crashes "OR" Total Single Vehicle Crashes	24 57 17 30	November 09 -- CMF Web -- Reference 18 November 09 -- CMF Web -- Reference 18 November 09 -- CMF Web -- Reference 18 November 09 -- CMF Web -- Reference 18

<b>5.7 Skid Treatments (groove pavement)</b>	Total Crashes	14	April 01 -- WPRFC Meeting Handout -- Reference 2
	"OR"		
	Total Non-Fatal Injury Crashes	12	April 01 -- WPRFC Meeting Handout -- Reference 2
	Total PDO Crashes	15	April 01 -- WPRFC Meeting Handout -- Reference 2
	Total Wet Injury Crashes (Injury includes fatality and injury crashes)	61	April 01 -- WPRFC Meeting Handout -- Reference 9
<b>5.8 Resurface Pavement with Groove Pavement (GP)</b>	Total Wet Road Crashes	50	April 10 -- CMF Web -- Reference 22
<b>5.9 Safety Edge</b>	None	None*	October 08 -- WPRFC Email -- Subjective based on committee opinion
<b>5.10 Spot Specific Water Removal such as Drop Inlets, Drainage Grates, and Debris Removal</b>	Total Wet Crashes	63*	April 10 -- WPRFC Email -- Subjective based on committee opinion
	"OR"		
	Total Wet Injury Crashes (Injury includes fatality and injury crashes)	57*	April 10 -- WPRFC Email -- Subjective based on committee opinion

<b>6. Sight Distance</b>			
<b>6.1 Horizontal Realignment</b>	Total Fatal Crashes	66	April 01 -- WPRFC Meeting Handout -- Reference 1
	Total Non-Fatal Injury Crashes	43	April 01 -- WPRFC Meeting Handout -- Reference 1
<b>6.2 Vertical Realignment</b>	Total Crashes	40	April 01 -- WPRFC Meeting Handout -- Reference 13
<b>6.3 Improve Skew Angle</b>	Total Crashes	40	April 01 -- WPRFC Meeting Handout -- Reference 13
<b>6.4 Improve Sight Distance Triangles - Remove Objects</b>	Total Crashes	25	February 2005 -- WPRFC Phone Call -- Low Cost Workshop
	"OR"		
	Total Fatal Crashes	66	February 2005 -- WPRFC Phone Call -- Low Cost Workshop
	Total Non-Fatal Injury Crashes	20	February 2005 -- WPRFC Phone Call -- Low Cost Workshop
<b>6.5 Increase Triangle Sight Distance</b>	<b>4-Leg</b>		
	Total Non-Fatal Injury Crashes	48	November 09 -- CMF Web -- Reference 2
	Total PDO Crashes	11	November 09 -- CMF Web -- Reference 2
<b>6.6 Channelization - Parking Area Sight Distance Issues</b>	Total Crashes	25*	April 06 -- WPRFC Email -- Subjective based on committee opinion
<b>6.7 Improve Superelevation through a Curve</b>	Total Crashes	40*	March 10 -- WPRFC Email -- Subjective based on committee opinion

<b>7. Guardrail</b>			
<b>7.1 New or Upgraded Guardrail</b>	Total Injury Crashes (Injury includes fatality and injury crashes)	47	November 05 -- NCHRP Digest 299 -- Study 19
	Total PDO Crashes	-50*	March 06 -- WPRFC Email -- Subjective based on committee opinion
	<b>Rural 2-lane</b>		
	Total Fatal Crashes	50	April 01 -- WPRFC Meeting Handout -- Reference 2
	Total Non-Fatal Injury Crashes	12	April 01 -- WPRFC Meeting Handout -- Reference 2
	Total PDO Crashes	18	April 01 -- WPRFC Meeting Handout -- Reference 2
	<b>Rural 4-lane Undivided</b>		
	Total Fatal Crashes	44	April 01 -- WPRFC Meeting Handout -- Reference 2
	Total Non-Fatal Injury Crashes	23	April 01 -- WPRFC Meeting Handout -- Reference 2
	Total PDO Crashes	44	April 01 -- WPRFC Meeting Handout -- Reference 2
	<b>Rural 4-lane Divided</b>		
	Total Fatal Crashes	46	April 01 -- WPRFC Meeting Handout -- Reference 2
	Total Non-Fatal Injury Crashes	13	April 01 -- WPRFC Meeting Handout -- Reference 2

<b>7.2 New Median Barrier</b>	Total Fatal Crashes	63	April 01 -- WPRFC Meeting Handout -- Reference 1
	Total Non-Fatal Injury Crashes	10	April 01 -- WPRFC Meeting Handout -- Reference 1
	Total PDO Crashes	-25*	April 01 -- WPRFC Meeting -- Subjective based on committee opinion
	<b><u>Rural 4-lane Divided</u></b>		
	Total Fatal Crashes	93	April 01 -- WPRFC Meeting Handout -- Reference 2
	<b><u>Rural</u></b>		
	Total Fatal Crashes	75	April 01 -- WPRFC Meeting Handout -- Reference 2
	<b><u>Urban 4-lane Undivided</u></b>		
	Total Non-Fatal Injury Crashes	63	April 01 -- WPRFC Meeting Handout -- Reference 2
	<b><u>Urban 4-lane Divided</u></b>		
Total Fatal Crashes	84	April 01 -- WPRFC Meeting Handout -- Reference 2	
<b><u>Urban</u></b>			
Total Fatal Crashes	72	April 01 -- WPRFC Meeting Handout -- Reference 2	
<b><u>Principal Arterial - Divided Highway</u></b>			
Total Fatal Injury Crashes	43	November 09 -- CMF Web -- Reference 2	
Total Non-Fatal Injury Crashes	30	November 09 -- CMF Web -- Reference 2	
Total PDO Crashes	-24	November 09 -- CMF Web -- Reference 2	
<b>7.3 Bridge Guardrail</b>	<b><u>Bridge Approach Guardrail</u></b>		
	Total Fatal Crashes	55	April 01 -- WPRFC Meeting Handout -- Reference 4
	Total Non-Fatal Injury Crashes	20	April 01 -- WPRFC Meeting Handout -- Reference 4
	Total PDO Crashes	-50	April 01 -- WPRFC Meeting Handout -- Reference 4
<b>7.4 Bridge Replacements</b>	Total Crashes per Year	22	November 02 -- NCDOT Study
	"OR"		
	Total Injury Crashes per Year (Injury includes fatality and injury crashes)	32	November 02 -- NCDOT Study
	PDO Crashes per Year	13	November 02 -- NCDOT Study

<b>8. Delineation</b>			
<b>8.1 Markings &amp; Delineation</b>	Total Crashes	21	April 01 -- WPRFC Meeting Handout -- Reference 1, 2
	"OR"		
	Total Fatal Crashes	15	April 01 -- WPRFC Meeting Handout -- Reference 1, 2
	Total Non-Fatal Injury Crashes	6	April 01 -- WPRFC Meeting Handout -- Reference 1, 2
	Total PDO Crashes	26	April 01 -- WPRFC Meeting Handout -- Reference 1, 2
<b>8.2 Introduce Stop Ahead Pavement Markings</b>	<b><u>Rural - 3-Leg</u></b>		
	Total Crashes	60	November 09 -- CMF Web -- Reference 21
	<b><u>Rural - Unspecified</u></b>		
	Total Crashes	56	November 09 -- CMF Web -- Reference 21
<b>8.3 Apply Converging Chevron Pattern Markings on Roadway Segments</b>	<b><u>Rural</u></b>		
	Total Crashes	19	November 09 -- CMF Web -- Reference 28
<b>8.4 Warning Signs - General</b>	Total Crashes	25	April 01 -- WPRFC Meeting Handout -- Reference 13
<b>8.5 Advance Static Curve Warning Signs</b>	Total Non-Fatal Injury Crashes	30	November 09 -- CMF Web -- Reference 2
	Total PDO Crashes	8	November 09 -- CMF Web -- Reference 2
<b>8.6 Provide Static Combination Horizontal Alignment / Advisory Speed Signs</b>	Total Non-Fatal Injury Crashes	13	November 09 -- CMF Web -- Reference 2
	Total PDO Crashes	29	November 09 -- CMF Web -- Reference 2
<b>8.7 Install a Solar Powered Flasher on an existing Curve Warning Sign with Advisory Speed Plate</b>	Total Crashes	5*	June 07 -- WPRFC Email -- Subjective based on committee opinion
<b>8.8 Changeable Curve Speed Warning Signs</b>	<b><u>Rural Principal Arterial</u></b>		
	Total Truck Crashes	71	November 09 -- CMF Web -- Reference 3
<b>8.9 Changeable Speed Warning Signs for Individual Drivers</b>	Total Crashes	46	November 09 -- CMF Web -- Reference 2

<b>8.10 Changeable Queue Warning Signs</b>	<u>Principal Arterial Freeway and Expressway</u> Total Rear-End Non-Fatal Injury Crashes Total Rear-End PDO Crashes	16 -16	November 09 -- CMF Web -- Reference 2 November 09 -- CMF Web -- Reference 2
<b>8.11 Installing Long Vehicle Detection that would Actuate Flashers on Several Truck Warning Signs that are currently Installed</b>	Total Crashes	10*	July 07 -- WPRFC Email -- Subjective based on committee opinion
<b>8.12 Install a Detection Warning System with CCTV's, Warning Signs with Flashers, and DMS's</b>	Total Crashes	25*	May 08 -- WPRFC Email -- Subjective based on committee opinion
<b>8.13 Reduce Regulatory Speed Limit in Curve</b>	None	None*	May 08 -- WPRFC Email -- Subjective based on committee opinion
<b>8.14 Replace Engineer Grade Signs with High Intensity Signs along a Corridor</b>	Total Crashes	5*	July 08 -- WPRFC Email -- Subjective based on committee opinion
<b>8.15 "Watch for Slow or Stopped Traffic" Signs</b>	Total Crashes	25*	October 08 -- WPRFC Email -- Subjective based on committee opinion
<b>8.16 Regulatory Sign to Enforce Truck Network Restrictions</b>	Total Crashes	15*	March 10 -- WPRFC Email -- Subjective based on committee opinion
<b>8.17 Actuated Advanced Flasher at Official Use Crossover</b>	Public Use Crossover Crashes	75*	March 10 -- WPRFC Email -- Subjective based on committee opinion
<b>8.18 Transversable Delineator Posts at Official Use Crossover</b>	Public Use Crossover Crashes	80*	March 10 -- WPRFC Email -- Subjective based on committee opinion
<b>8.19 Install Warning Signs on Waterway To Prevent Distracted Drivers</b>	Total Crashes	25*	June 10 -- WPRFC Email -- Subjective based on committee opinion

<b>9. Intersection Enhancements</b>			
<b>9.1 Limited Movement Crossovers</b>	Total Crashes	37*	April 07 -- WPRFC Email -- Subjective based on 12 B&A analyses
<b>9.2 Install Concrete Island to Prohibit Left Turns from Side Street, but Allow Left Turns from Mainline</b>	Total Crashes	37*	September 07 -- WPRFC Email -- Subjective based on committee opinion
<b>9.3 Replace Direct Left-Turns with Right-Turn/U-Turn</b>	<u>Principal Arterial</u> Total Crashes	20	November 09 -- CMF Web -- Reference 8
<b>9.4 Install J-Turn Intersection</b>	<u>Rural - 4-lane Divided Principal Arterial at Undivided Major Collector Two-Way Stop Controlled</u>		
4-Leg - Major ADT 10670 to 11240, Minor ADT 14	Total Crashes	92	November 09 -- CMF Web -- Reference 5
4-Leg - Major ADT 45000 to 47600, 55 MPH	<u>4-lane Divided Principal Arterial Freeway or Expressway at Two-Way Stop Controlled</u> Total Angle Crashes	92	November 09 -- CMF Web -- Reference 5
4-Leg - Major ADT 45000 to 47600, 55 MPH	"OR" Total PDO Crashes	64	November 09 -- CMF Web -- Reference 5
4-Leg - Major ADT 16900 to 20000, 55 MPH	<u>4-lane Divided Principal Arterial Freeway or Expressway at Two-Way Stop Controlled</u> Total Crashes	61	November 09 -- CMF Web -- Reference 5
4-Leg - Major ADT 16900 to 20000, 55 MPH	"OR" Total Non-Fatal Injury Crashes	80	November 09 -- CMF Web -- Reference 5
4-Leg - Major ADT 28600 to 29200, 55 MPH	<u>Suburban - 4-lane Divided Principal Arterial Freeway or Expressway at Two-Way Stop Controlled</u> Total Crashes	70	November 09 -- CMF Web -- Reference 5
4-Leg - Major ADT 28600 to 29200, 55 MPH	"OR" Total Angle Crashes	64	November 09 -- CMF Web -- Reference 5
4-Leg - Major ADT 45000 to 47600, 55 MPH	<u>4-lane Divided Principal Arterial at Two-Way Stop Controlled</u> Total Crashes	50	November 09 -- CMF Web -- Reference 5
<b>9.5 Concrete Island - Channelization</b>	Total Crashes	25	March 07 -- NCDOT Project Development Webpage -- Reference 13
<b>9.6 Install Island Down 5-Lane Crosssection (approximately 1.5 miles long)</b>	Total Crashes (not within 150 feet of the intersections along the section)	90*	July 07 -- WPRFC Email -- Subjective based on committee opinion

9.7 Install Raised Median ADT 1390 to 51200	<u>Urban - Principal Arterial</u> Total Crashes	71	December 09 -- CMF Web -- Reference 23
	"OR" Total Angle Crashes	55	December 09 -- CMF Web -- Reference 23
9.8 Provide a Median	<u>Urban Principal Arterial</u> Total Non-Fatal Injury Crashes	22	November 09 -- CMF Web -- Reference 2
	Total PDO Crashes	-9	November 09 -- CMF Web -- Reference 2
	<u>Rural Principal Arterial</u> Total Non-Fatal Injury Crashes	12	November 09 -- CMF Web -- Reference 2
	Total PDO Crashes	18	November 09 -- CMF Web -- Reference 2
9.9 Remove Crossover	Total Crashes	90*	March 07 -- WPRFC Meeting on 030107 -- Subjective based on committee opinion
9.10 Roundabout	<u>All Conversions</u> (Injury includes fatality and injury crashes)		
	Total Crashes	40	November 05 -- NCHRP Digest 299 -- Study 1
	"OR" Total Injury Crashes	80	November 05 -- NCHRP Digest 299 -- Study 1
9.11 Convert High-Speed Rural Intersection to Roundabout 3 to 5-Leg - ADT 6030 to 13456, 40-65 MPH	<u>Rural</u> Total Crashes	67	November 09 -- CMF Web -- Reference 12
	"OR" Total Injury Crashes (Injury includes fatality and injury crashes)	89	November 09 -- CMF Web -- Reference 12
9.12 Convert Signalized Intersection to Roundabout	Total Crashes	48	November 09 -- CMF Web -- Reference 11
9.13 Convert Two-Way Stop-Controlled Intersection to Roundabout	<u>Rural - 4-Leg</u> Total Crashes	71	November 09 -- CMF Web -- Reference 11
	<u>Suburban - 4-Leg</u> Total Crashes	78	November 09 -- CMF Web -- Reference 11
	<u>Urban - 4-Leg</u> Total Crashes	29	November 09 -- CMF Web -- Reference 11
9.14 Splitter Island with Additional Stop Sign	Total Crashes	11	April 05 -- WPRFC Email -- Low Cost Workshop
	"OR" Total Right Angle Crashes	36	April 05 -- WPRFC Email -- Low Cost Workshop
9.15 Transverse Rumble Strips	Total Crashes	30	May 05 -- WPRFC Email -- Low Cost Workshop
9.16 4-Way Stop Installation	Total Crashes	47	November 05 -- NCHRP Digest 299 -- Study 7
	"OR"		
	Total Right-Angle Crashes	72	November 05 -- NCHRP Digest 299 -- Study 7
	Total Rear-End Crashes	13	November 05 -- NCHRP Digest 299 -- Study 7
	Total Left-Turn Crashes	20	November 05 -- NCHRP Digest 299 -- Study 7
	Total Pedestrian Crashes	39	November 05 -- NCHRP Digest 299 -- Study 7
"OR" Total Injury Crashes (Injury includes fatality and injury crashes)	71	November 05 -- NCHRP Digest 299 -- Study 7	
9.17 Grade Separation - Flyover	Total Crashes	90*	March 06 -- WPRFC Email -- Subjective based on committee opinion
9.18 Realign Intersection to Change Stop Condition and Install Turn Lanes	Total Fatal Crashes	66*	June 10 -- WPRFC Email -- Subjective based on committee opinion
	Total Non-Fatal Injury Crashes	43*	June 10 -- WPRFC Email -- Subjective based on committee opinion
9.19 Conversion of Four-Leg or Cross Intersections into Two T-Intersections	<u>Urban</u> Total Non-Fatal Injury Crashes	25	November 09 -- CMF Web -- Reference 2
	Total PDO Crashes	10	November 09 -- CMF Web -- Reference 2

10. Pedestrian Enhancements			
10.1 Pedestrian Structure	Pedestrian	85	April 01 -- WPRFC Meeting Handout -- Reference 12
10.2 Crosswalk	Total Pedestrian Crashes	25	April 01 -- WPRFC Meeting Handout -- Reference 13
10.3 Crosswalk - Multiple Improvements	Total Pedestrian Crashes	50*	March 06 -- WPRFC Email -- Subjective based on committee opinion
10.4 Install Raised Medians at Crosswalks	<u>Urban and Suburban Multilane Roads - Marked Crosswalks</u> Total Pedestrian Crashes	46	November 05 -- NCHRP Digest 299 -- Study 20
	<u>Urban and Suburban Multilane Roads - Unmarked Crosswalks</u> Total Pedestrian Crashes	39	November 05 -- NCHRP Digest 299 -- Study 20
10.5 Change Out Standard Pedestrian Heads to Countdown Pedestrian Heads	None	None*	April 08 -- WPRFC Email -- Subjective based on committee opinion
10.6 Hawk Pedestrian Crossing Beacon	<u>Rural 2-lane</u> Total Crashes	12	November 09 -- CMF Web -- Reference 1

## Notes:

Please use all crashes of the correctable type occurring at the location unless otherwise noted.

- \* Subjective data agreed upon by the Crash Reduction Factor Committee until empirical data is established. The subjective data is based off of small samples of Simple Before and After Analyses or are compiled from the experiences and opinions of the Crash Reduction Factor Committee members.

## References:

April 01 -- WPRFC Handout -- Reference 1 FHWA, (1996). The 1996 Annual Report on Highway Safety Improvement Programs. Publication No. FHWA-SA-96-040. USDOT. FHWA. Washington, DC.  
April 01 -- WPRFC Handout -- Reference 2 Highway Safety Evaluation System, FHWA Office of Highway Safety, 1982.  
April 01 -- WPRFC Handout -- Reference 3 "Predicting Accident Reduction Factors for Safety Improvements in the State of Kansas", Mulinazzi, Lee; Kansas University Transportation Center, August 1981  
April 01 -- WPRFC Handout -- Reference 4 "Assessment of Techniques for Cost-Effectiveness of Highway Accident Countermeasures", McFarland, et. Al., TTI; Report No. FHWA-RD-79-53, January 1979.  
April 01 -- WPRFC Handout -- Reference 8 "Development of Accident Reduction Factors", Kentucky Transportation Research Program, March 1985  
April 01 -- WPRFC Handout -- Reference 9 "1981 Annual Report, Pennsylvania Highway Safety Improvement Program, Pennsylvania DOT, September 1981.  
April 01 -- WPRFC Handout -- Reference 10 "Annual Safety Report, FY 1981", New Jersey DOT, August 1981.  
April 01 -- WPRFC Handout -- Reference 11 "Evaluation and Report on the Highway Safety Construction Program", Illinois DOT, August 1981.  
April 01 -- WPRFC Handout -- Reference 12 "Synthesis of Safety Research - Pedestrians", Zeeger, FHWA, June 1991.  
April 01 -- WPRFC Handout -- Reference 13 "Development of Accident Reduction Factors", Kentucky Transportation Center, June 1996.

(WPRFC -- W-Project Reduction Factor Committee)

November 05 -- NCHRP Digest 299 -- Study 1 Install Roundabout -- Persaud, Retting, Garder, and Lord; 2001  
November 05 -- NCHRP Digest 299 -- Study 2 Add Exclusive Left-Turn Lane -- Harwood, Bauer, Potts, Torbic, Richard, Kohlman-Rabbani, Hauer, and Elefteriadou; 2002  
November 05 -- NCHRP Digest 299 -- Study 3 Add Exclusive Right-Turn Lane -- Harwood, Bauer, Potts, Torbic, Richard, Kohlman-Rabbani, Hauer, and Elefteriadou; 2002  
November 05 -- NCHRP Digest 299 -- Study 4 Install a Traffic Signal -- McGee, Taori, and Persaud; 2003  
November 05 -- NCHRP Digest 299 -- Study 7 Convert to All-Way Stop Control -- Lovell and Hauer; 1986  
November 05 -- NCHRP Digest 299 -- Study 11 Add Passing Lanes (Two-Lane Roads) -- Harwood, Council, Hauer, Hughes, and Vogt; 2000  
November 05 -- NCHRP Digest 299 -- Study 17 Add Shoulder Rumble Strips -- Griffith; 1999  
November 05 -- NCHRP Digest 299 -- Study 18 Add Centerline Rumble Strips -- Persaud, Retting, and Lyon; 2003  
November 05 -- NCHRP Digest 299 -- Study 19 Install/Upgrade Guardrail -- Elvik and Vaa; 2004  
November 05 -- NCHRP Digest 299 -- Study 20 Install Raised Medians at Crosswalk -- Zegeer, Stewart, Huang, and Lagerwey; 2001

November 09 -- CMF Web -- Reference 1 Safety Effectiveness of the HAWK Pedestrian Treatment - 2009  
November 09 -- CMF Web -- Reference 2 Handbook of Road Safety Measures - 2004  
November 09 -- CMF Web -- Reference 3 An Evaluation of Dynamic Curve Warning Systems in the Sacramento River Canyon - 2000  
November 09 -- CMF Web -- Reference 4 Revision of the Hand Book of Road Safety Measures - 2007  
November 09 -- CMF Web -- Reference 5 The J-Turn Intersection: Design Guidance & Safety Experience - 2009  
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November 09 -- CMF Web -- Reference 7 Right-Angle Crash Occurance at Signalized Intersections - 2007  
November 09 -- CMF Web -- Reference 8 Right Turns Followed by U-Turns Versus Direct Left Turns: A Comparison of Safety Issues - 2001  
November 09 -- CMF Web -- Reference 9 Accident Modification Factors for Traffic Engineering and ITS Improvements - 2008  
November 09 -- CMF Web -- Reference 10 Safety Effects of Left-Turn Phasing Schemes at High-Speed Intersections - 2007  
November 09 -- CMF Web -- Reference 11 NCHRP Report 572: Applying Roundabouts in the United States - 2007  
November 09 -- CMF Web -- Reference 12 Crash Analysis of Roundabouts at High-speed Rural Intersections - 2009  
November 09 -- CMF Web -- Reference 13 An Evaluation of the Safety Effects of Modifying Late Night Flash Signal Operations in North Carolina - 2009  
November 09 -- CMF Web -- Reference 14 Guidelines for the Use of No U-Turn and No-Left Turn Signs - 1994  
January 10 -- CMF Web -- Reference 15 Evaluation of the Safety Effectiveness of Selected Treatments at Urban Signalized Intersections - 2008  
December 09 -- CMF Web -- Reference 16 Evaluation of the Safety Effectiveness of Selected Treatments at Urban Signalized Intersections - 2008  
January 10 -- CMF Web -- Reference 17 Safety Effects of a Targeted Skid Resistance Improvement Program - 2008  
November 09 -- CMF Web -- Reference 18 Crash Reduction Factors for Traffic Engineering and ITS Improvements - 2008  
November 09 -- CMF Web -- Reference 19 Crash Reduction Following Installation of Centerline Rumble Strips on Rural Two-Lane Roads - 2003  
January 10 -- CMF Web -- Reference 20 Safety Evaluation of Installing Center Two-Way Left-Turn Lanes on Two-Lane Roads - 2008  
November 09 -- CMF Web -- Reference 21 Safety Effectiveness of STOP AHEAD Pavement Markings - 2008  
April 10 -- CMF Web -- Reference 22 Safety Performance of Experimental Pavement Types in California Using Before-and-After Comparisons - 2010  
December 09 -- CMF Web -- Reference 23 Correlating Access Management to Crash Rate, Severity, and Collision Type - 2008  
November 09 -- CMF Web -- Reference 24 Evaluation of the Effectiveness of Shoulder Rumble Strips on Rural Multi-lane Divided Highways In Minnesota - 2004  
November 09 -- CMF Web -- Reference 25 The Effectiveness and Use of Continuous Shoulder Rumble Strips - 1998  
November 09 -- CMF Web -- Reference 26 Safety Evaluation of Rolled-In Continuous Shoulder Rumble Strips Installed on Freeways - 1999  
November 09 -- CMF Web -- Reference 27 Analysis of Accident Reduction Factors on California State Highways - 2000  
November 09 -- CMF Web -- Reference 28 A Review of Two Innovative Pavement Patterns that Have Been Developed to Reduce Traffic Speeds and Crashes - 1996  
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