ACCIDENT COUNTERMEASURES: LITERATURE REVIEW

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ABSTRACT

The Accident Countermeasures Research project provides information about the accident reductions that could be expected under New Zealand conditions if particular accident countermeasures are implemented. To achieve this objective, international literature on the effects of accident countermeasures, especially that which examined the impacts of countermeasures on specific accident types and on accident severity, was reviewed. The literature originated from 11 countries, with Australia, USA, the United Kingdom and New Zealand providing the highest number of publications. Particular emphasis was given to information relating to the last five years, but earlier information was also assembled if it was readily available.

An overview of the work undertaken in the project, the project findings, and summaries of the information available in the literature are supplied. Full listings of the information collected from the 207 publications reviewed, a full list of references, and one-page summaries of the publications that provide countermeasure statistics by severity and/or by manoeuvre, and the methodology used, are presented.

Abstracts, articles and reports about the effectiveness of accident countermeasures were collected and entered into a database file. Accident countermeasures were then categorised according to thirteen categories called *features*, further subdivided into categories called *treatments*, and then into *area type* which identifies their location. Information about the effectiveness of various accident countermeasures was extracted from the publication. Each value of the percentage change in accidents, related to a particular feature-treatment combination, was entered into a second database, and summarised.

1. INTRODUCTION

This report presents the findings of the Accident Countermeasures Research Project conducted by Travers Morgan (NZ) Ltd on behalf of Transit New Zealand.

The objective of this project is to provide information about the accident reductions that could be expected under New Zealand conditions by implementing particular accident countermeasures. To achieve this objective, international literature on the effects of accident countermeasures, concentrating on that published in the last five years, was reviewed. The focus was on studies that examined the impacts of countermeasures on specific accident types and, where appropriate, on accident severity.

The report consists of an overview of the work undertaken in the project, the project findings, and summaries of the extent of information available in the literature. The appendices contain full listings of the information collected from the articles, a full list of references, and one page summaries of the more relevant references.

Travers Morgan acknowledge the assistance contributed by many people during the project, and particularly by the Ministry of Transport, Land Transport Division (Bill Frith, Colette Kraus and the library staff).

2. METHODOLOGY

The first stage of the project involved collecting abstracts, articles and reports about the effectiveness of accident countermeasures. Relevant literature was identified and obtained from the following main sources:

- A comprehensive computerised database search (from the Australian Transportation Research Information Service, "Information Edge Pty Ltd — A venture of the State Library of NSW") provided 352 pages of abstracts;
- Material held by Transit New Zealand (David Silvester), Wellington, New Zealand;
- Material held by Colette Kraus (private collection), Wellington, New Zealand;
- Discussions with selected individual researchers in New Zealand and Australia;
- Material held in Travers Morgan's libraries in Wellington and Sydney;
- Ministry of Transport, Land Transport Division library, Wellington, New Zealand.

This literature search resulted in a collection of 207 publications (articles and reports). The details of each publication were entered into a database file using the information fields shown in Table 2.1.

The second stage of the project involved categorising accident countermeasures. Thirteen categories, called *features*, of accident countermeasures were identified. Each feature was then further subdivided into categories called *treatments*. For example, one feature is accident countermeasures applied to intersections, and one treatment within that feature is accident countermeasures applied to the roundabout type of intersection. The *area type* is the third category applied to features and treatments to identify their location, i.e. rural or urban. The complete list of features and treatments is provided in Appendix A.

The third stage of the project involved extracting information about the effectiveness of various accident countermeasures from the publications. Each value of the percentage change in accidents, related to a particular feature—treatment combination, was entered into a second database. This database was structured using the information fields shown in Table 2.2.

The information within this database was then summarised for feature, treatment and area type to create a summary table of effectiveness of accident countermeasures (see Section 3).

Table 2.1 Database structure used to categorise publications.

Field Name	Field Description
ID NUMBER	A unique identification number
AUTHOR	The surnames and initials of author
TITLE	The title and subtitle
SOURCE	The publication details
YEAR	The year and month (if available) of publication
COUNTRY	The country of publication(1)
COMMENT	The library source

Notes: (1) Country is identified by the following codes:
AUS — Australia, CA — Canada, FRA — France, GER — Germany, ISR — Israel, JAP — Japan, NET — Netherlands, NZ — New Zealand, SOU — South Africa, SWE — Sweden, UK — United Kingdom, USA — United States of America

Table 2.2 Database structure used to categorise information from publications.

Field Name	Field Description
AREA_TYPE	Rural (R), Urban (U) or Did Not Specify (*)
FEATURE	Feature code
TREATMENT	Treatment code
RF1_NUMBER	Identification number of the original source of the information
RF2_NUMBER	Identification number of the secondary source of the information, i.e. the information was obtained from the secondary source which quoted the primary source. A -1 indicates that this field is not applicable.
REDUCTION	Percentage reduction in the overall accident rate (percentage increases are indicated by a minus sign)
RDN_SEVERE	Percentage reduction in accident type by severity
RDN_VEHCLE	Percentage reduction in accident type by vehicle type
RDN_MANUVR	Percentage reduction in accident type by manoeuvre
RDN_OTHER	Percentage reduction in accident type by any other category
COMMENTS	A more detailed description of the countermeasure and the conditions in which it was applied

3. OVERVIEW OF FINDINGS

A summary of the results on the effectiveness of different treatments is presented in Table 3.1. The first three columns indicate the treatment, feature, and area type over which the information has been summarised. A full listing of treatments and features, and their codes, is given in Appendix A. The column headed "No. of Publications" identifies the number of publications in the literature that provide a figure for the overall reduction in accidents. The column "% Accident Reduction" contains this percentage reduction. The last four columns provide accident reduction percentages by accident category. The abbreviation for the particular accident type is followed by the percentage reduction in accidents and, in parentheses, the number of publications that contain figures for that type of accident, e.g. C = casualty; 15 = % reduction; (1) = number of publications.

Appendix B gives a summary of the accident reduction results for the individual references, and Appendix C gives full details of references. References that contain countermeasure statistics by severity and/or by manoeuvre were particularly useful. Appendix D contains one page summaries of those publications that provide such statistics, and includes the methodology used in those research projects.

The presence of many blank cells in Table 3.1 indicates that most publications lack information about the various categories of accident. Table 3.2 shows the number of countermeasure records that were available for each accident reduction category.

The literature surveyed for this project originated from 11 countries, with Australia, USA, the United Kingdom and New Zealand providing the highest number of publications. Table 3.3 lists the countries and the numbers of articles and countermeasure records that originated from these 11 countries.

Table 3.4 shows the year of publication of the literature researched for the survey. 56% of the publications were published after 1984 and 27% were published in the years 1986 to 1988. 60% of the countermeasure statistics were published after 1984 and 31% were published in the years 1986 to 1988. Particular emphasis was given in the literature search to information relating to the last five years, but earlier information was also assembled if it was readily available.

Table 3.1 Summary of effectiveness of accident countermeasures.

Code*	Feature Treatment	Area Type[1]	No. of publications	% Accident Reduction	% Reduction by Severity[2]	% Reduction by Vehicle Type[3]	% Reduction by Manoeuvre[4]	% Reduction by Other Category[5]
A1	**Area-wide** Blackspot treatments	*	3	30 to 41	C 15(1) I 46(1)			
		R	3	0 to 69	C 69(1)			
		U	1	30	C 30 (1)			
A2	**Area-wide** LATM	*	1	65	C 30 to 41(4)			
		R	0					
		U	18	0 to 77	S 45 to 50(2) I 10 to 70(8) C 16 to 60(3)	P 5 to 43(4) B 16 to 39(3) MB 16(1)	RT 40(1)	
A3	**Area-wide** Street closures	*	2	77				
		R	0					
		U	3	17 to 81		P 55(1)		
A4	**Area-wide** Parking controls	*	1	26				
		R	0					
		U	3	-18 to 70			ROR 50(2)	
D1	**Delineation** Line marking	*	2	8 to 60			ROR 34(1)	W 10(1)
		R	12	0 to 62	C 3 to 30(2)		ROR 34 to 50(2) HO 1(1)	
		U	6	2 to 65		CR 62(1) MB 72(1)	ROR 20 to 85(3)	W 67(1) N 65(1)
D2	**Delineation** Guide posts	*	0					
		R	5	0 to 60				N 41 to 60(2)
		U	2	25 to 67				
D3	**Delineation** RRPMs (edge)	*	1	68			ROR 30(1)	
		R	2	15 to 16				
		U	0					

* Codes for Feature (A, B, C, etc.) and Treatment (1, 2, 3, etc) — see Appendix A.

1 Area Type : Rural (R), Urban (U), Did not specify (*).

2 Severity: Fatality (F), Casualty (C), Serious (S), Injury (I), Property Damage Only (PDO).

3 Vehicle Type: Pedestrian (P), Car (CR), Motorbike (MB), Bicycle (B), Truck or bus (TB).

4 Manoeuvre: Head-on (HO), Rear-end (RE), Ran-off-road or single vehicle or hit fixed object (ROR), Right-turn (RT), Left-turn (LT), Side-swipe (SS), Vehicle-to-vehicle (VV).

5 Other category: Wet surface (W), Night or dark (N), Frozen or icy surface (ICE).

LATM Local area traffic management RRPM Raised reflectorised pavement marker - Negative reduction

Table 3.1 continued

Code*	Feature Treatment	Area Type[1]	No. of publications	% Accident Reduction	% Reduction by Severity[2]	% Reduction by Vehicle Type[3]	% Reduction by Manoeuvre[4]	% Reduction by Other Category[5]
D4	**Delineation** RRPMs (centre)	* R U	2 2 2	6 to 68 12 to 15 5 to 15	C 15 to 20(2) I 10 to 50(2)	P -36(1)	HO 70 to 75(3) SS 27(2) RE 7(1) ROR -7(1) ROR 0 to 18(1) HO 0 to 18(1)	N 88(1) N 0 to 25(3) N 0(1)
G1	**Geometry** Minor realignment	* R U	3 4 5	26 to 70 0 to 90 3 to 100	F 32(2) I 15(2)			
G2	**Geometry** Major realignment	* R U	0 3 4	0 to 30 25 to 80	C 34(1)			
H1	**Hazards** Crash cushions	* R U	0 0 1	8	F 75(2) S 75(2) C 35(1)			
H2	**Hazards** Frangible poles	* R U	0 1 1	0 30	S 30 to 60(1) I 30(1)			
H3	**Hazards** Relocate poles	* R U	4 4 3	13 to 100 0 30 to 100	F 60(1) I 20(1) PDO -20(1)			

* Codes for Feature (A, B, C, etc.) and Treatment (1, 2, 3, etc) — see Appendix A.

1 Area Type : Rural (R), Urban (U), Did not specify (*).

2 Severity: Fatality (F), Casualty (C), Serious (S), Injury (I), Property Damage Only (PDO).

3 Vehicle Type: Pedestrian (P), Car (CR), Motorbike (MB), Bicycle (B), Truck or bus (TB).

4 Manoeuvre: Head-on (HO), Rear-end (RE), Ran-off-road or single vehicle or hit fixed object (ROR), Right-turn (RT), Left-turn (LT), Side-swipe (SS), Vehicle-to-vehicle (VV).

5 Other category: Wet surface (W), Night or dark (N), Frozen or icy surface (ICE).

RRPM Raised reflectorised pavement marker - Negative reduction

Table 3.1 continued

Code*	Feature Treatment	Area Type[1]	No. of publications	% Accident Reduction	% Reduction by Severity[2]	% Reduction by Vehicle Type[3]	% Reduction by Manoeuvre[4]	% Reduction by Other Category[5]
H4	**Hazards** Remove trees	* R U	0 3 0	0	F 50(1) C 24(1) I 25(1) PDO -20(1)			
H5	**Hazards** Widen squeezepoints	* R U	2 1 2	19 to 47 19 to 52 10 to 44	F 38(1) I 19(1) C 30(1)			
H6	**Hazards** Guardrails	* R U	0 1 4	 30 10 to 65	 C 10(1) F 32(1) I -2(1) PDO 0(1)		 ROR 100(1)	
I1	**Intersections** Modify channelisation	* R U	10 1 10	-117 to 41 13 -164 to 54	C 43(1) C -32(1)		SS 25(1)	
I2	**Intersections** Painted channelisation	* R U	0 0 4	 10 to 20			 RT 22(1)	
I3	**Intersections** Add lanes	* R U	3 6 8	22 to 39 0 to 40 8 to 54			 RE 10 to 60(2) HO 70(1) RT 0 to 50(2) LT -770(1) SS 10 to 60(2)	

* Codes for Feature (A, B, C, etc.) and Treatment (1, 2, 3, etc) — see Appendix A.

1 Area Type : Rural (R), Urban (U), Did not specify (*).

2 Severity: Fatality (F), Casualty (C), Serious (S), Injury (I), Property Damage Only (PDO).

3 Vehicle Type: Pedestrian (P), Car (CR), Motorbike (MB), Bicycle (B), Truck or bus (TB).

4 Manoeuvre: Head-on (HO), Rear-end (RE), Ran-off-road or single vehicle or hit fixed object (ROR), Right-turn (RT), Left-turn (LT), Side-swipe (SS), Vehicle-to-vehicle (VV).

5 Other category: Wet surface (W), Night or dark (N), Frozen or icy surface (ICE).

← Negative reduction

Table 3.1 continued

Code*	Feature Treatment	Area Type[1]	No. of publications	% Accident Reduction	% Reduction by Severity[2]	% Reduction by Vehicle Type[3]	% Reduction by Manoeuvre[4]	% Reduction by Other Category[5]
I4	**Intersections** Roundabouts	* R U	7 0 16	25 to 95 0 to 95	F 90(1) C 25 to 81(5) I 50 to 66(2) PDO 66(1) S 60 to 80(1) I 66(1)		RT 80(1)	
I5	**Intersections** Staggered T	* R U	1 4 5	47 to 84 0 to 80 28 to 99	C 80(1)		RT 100(1) RE 80(1)	
I6	**Intersections** Control changes	* R U	24 1 20	-24 to 55 61 -74 to 100	F 50(1) C 6 to 55(6) S 13(1) I 7 to 73(5) I 77(1) C 6(1) I -900 to 81(5)	P 39(1) P 5 to 39(4)	RE -200 to 55(8) HO -157 to 84(4) RT -52 to 77(7) LT -157 to 85(4) ROR -33(1) SS -74(1) RE 48(1) RT 75(1) LT 25(1) RE -98 to 90(9) RT 10 to 83(9) LT -66 to 20(5) ROR -4(1)	
I7	**Intersections** Traffic Islands	* R U	1 0 4	58 0 to 10				
L1	**Lighting**	* R U	3 2 12	-7 to 58 14 to 75 -39 to 81	I 84(1) F 40(1) I 19 to 60(2) PDO 25(1) F 48 to 65(1) C 22(1) I 0 to 30(3) PDO 15(1)	 P 16 to 72(3) CR 63(1)	 ROR 63(1)	N 30 to 43(2) N 30 to 77(6) W 63(1)

* Codes for Feature (A, B, C, etc.) and Treatment (1, 2, 3, etc) — see Appendix A.

1 Area Type : Rural (R), Urban (U), Did not specify (*).

2 Severity: Fatality (F), Casualty (C), Serious (S), Injury (I), Property Damage Only (PDO).

3 Vehicle Type: Pedestrian (P), Car (CR), Motorbike (MB), Bicycle (B), Truck or bus (TB).

4 Manoeuvre: Head-on (HO), Rear-end (RE), Ran-off-road or single vehicle or hit fixed object (ROR), Right-turn (RT), Left-turn (LT), Side-swipe (SS), Vehicle-to-vehicle (VV).

5 Other category: Wet surface (W), Night or dark (N), Frozen or icy surface (ICE).

- Negative reduction

Table 3.1 continued

Code*	Feature Treatment	Area Type[1]	No. of publications	% Accident Reduction	% Reduction by Severity[2]	% Reduction by Vehicle Type[3]	% Reduction by Manoeuvre[4]	% Reduction by Other Category[5]
M1	Medians Install	*	3	28 to 77				
		R	3	20 to 65	C 7(1)			
		U	3	12 to 100			ROR 82(1)	ICE 100(1)
M2	Medians Safety fence	*	3	13 to 61	F 23(1) S 18(1) I 10(1)		ROR 5 to 100(1)	
		R	1	0	C 9 to 27(2)			
		U	1	4 to 24	F 20(2) I 23(1)	P 82(1) MB 71(1)	ROR 74(1) VV 52(1)	N 72(1)
M3	Medians Widen	*	3	32 to 42	C 22 to 38(2) PDO 31 to 35(2)			
		R	0					
		U	0					
M4	Medians Close	*	2	5 to 59				
		R	0					
		U	1	-39 to 75			HO 100(1) RE 50(1) RT 100(1) SS 50(1)	
N1	Lanes Turning	*	2	11 to 35			RE83(1)	
		R	3	15 to 60				
		U	1	40			RE 20(1)	
N2	Lanes Passing	*	3	25 to 38	C 29(1)		HO 58(1) LT 72(1)	
		R	8	10 to 37				
		U	2	10 to 25				

* Codes for Feature (A, B, C, etc.) and Treatment (1, 2, 3, etc) — see Appendix A.

1 Area Type : Rural (R), Urban (U), Did not specify (*).

2 Severity: Fatality (F), Casualty (C), Serious (S), Injury (I), Property Damage Only (PDO).

3 Vehicle Type: Pedestrian (P), Car (CR), Motorbike (MB), Bicycle (B), Truck or bus (TB).

4 Manoeuvre: Head-on (HO), Rear-end (RE), Ran-off-road or single vehicle or hit fixed object (ROR), Right-turn (RT), Left-turn (LT), Side-swipe (SS), Vehicle-to-vehicle (VV).

5 Other category: Wet surface (W), Night or dark (N), Frozen or icy surface (ICE).

- Negative reduction

Table 3.1 continued

Code*	Feature Treatment	Area Type[1]	No. of publications	% Accident Reduction	% Reduction by Severity[2]	% Reduction by Vehicle Type[3]	% Reduction by Manoeuvre[4]	% Reduction by Other Category[5]
N3	**Lanes** Parking	* R U	0 1 0	 13 to 44			HO 50 to 60(1) ROR 27 to 53(1) RE 17 to 69(1)	
N4	**Lanes** 4-lane	* R U	1 1 0	34 35	C 43(1)		HO 70(1)	
N5	**Lanes** Flatten sideslope	* R U	0 5 1	 2 to 20 2			 ROR 2(1)	
N6	**Lanes** Widen shoulder	* R U	0 6 1	 0 to 49 16 to 40	 C 6(1)		 ROR 48(1)	
N7	**Lanes** Seal shoulder	* R U	1 5 0	0 20 to 75	 F 60 to 70(1)		ROR 0(1) ROR 28 to 61(2)	
N8	**Lanes** Widen lanes	* R U	0 6 6	 9 to 40 10 to 46	C 70(1) C 19 to 43(3)			

* Codes for Feature (A, B, C, etc.) and Treatment (1, 2, 3, etc) — see Appendix A.

1 Area Type : Rural (R), Urban (U), Did not specify (*).

2 Severity: Fatality (F), Casualty (C), Serious (S), Injury (I), Property Damage Only (PDO).

3 Vehicle Type: Pedestrian (P), Car (CR), Motorbike (MB), Bicycle (B), Truck or bus (TB).

4 Manoeuvre: Head-on (HO), Rear-end (RE), Ran-off-road or single vehicle or hit fixed object (ROR), Right-turn (RT), Left-turn (LT), Side-swipe (SS), Vehicle-to-vehicle (VV).

5 Other category: Wet surface (W), Night or dark (N), Frozen or icy surface (ICE).

\- Negative reduction

Table 3.1 continued

Code*	Feature Treatment	Area Type[1]	No. of publications	% Accident Reduction	% Reduction by Severity[2]	% Reduction by Vehicle Type[3]	% Reduction by Manoeuvre[4]	% Reduction by Other Category[5]
N9	**Lanes** Bus bay	*	0					
		R	0					
		U	1	46		MB 67(1) TB 68(1)	ROR 47(1) VV 48(1)	ICE 100(1)
N10	**Lanes** Bus lane	*	0					
		R	0					
		U	0			P 19(1) TB 52(1)		
N11	**Lanes** Cycle path	*	1	82				
		R	0					
		U	2	-5 to 100				
P1	**Pedestrian** Zebra crossings	*	0					
		R	0					
		U	8	-175 to 100		P 30(2)		
P2	**Pedestrian** Refuges	*	1	12			RE 89(1)	
		R	0					
		U	7	-27 to 90	I 52(1)	P -13 to 86(5) B 25(1)	RE 83(1)	
P3	**Pedestrian** Signals	*	0					
		R	0					
		U	5	3 to 85		P 24 to 25(3)	RE 6(1) RT -33(1) SS -33(1)	

* Codes for Feature (A, B, C, etc.) and Treatment (1, 2, 3, etc) — see Appendix A.

1 Area Type : Rural (R), Urban (U), Did not specify (*).

2 Severity: Fatality (F), Casualty (C), Serious (S), Injury (I), Property Damage Only (PDO).

3 Vehicle Type: Pedestrian (P), Car (CR), Motorbike (MB), Bicycle (B), Truck or bus (TB).

4 Manoeuvre: Head-on (HO), Rear-end (RE), Ran-off-road or single vehicle or hit fixed object (ROR), Right-turn (RT), Left-turn (LT), Side-swipe (SS), Vehicle-to-vehicle (VV).

5 Other category: Wet surface (W), Night or dark (N), Frozen or icy surface (ICE).

- Negative reduction

Table 3.1 continued

Code*	Feature Treatment	Area Type[1]	No. of publications	% Accident Reduction	% Reduction by Severity[2]	% Reduction by Vehicle Type[3]	% Reduction by Manoeuvre[4]	% Reduction by Other Category[5]
P4	Pedestrian Bridges	* R U	0 0 1	 39		P 71(1) CR 42(1) TB 38(1) MB 80(1)		
R1	Resurfacing Accident spots	* R U	0 2 0	 0				
R2	Resurfacing Skid resistant	* R U	1 8 5	60 5 to 75 14 to 72	 C -10 to 25(3) C 25(1)		HO 76(1)	W 67(1) W 20(1) W 15 to 85(4)
R3	Resurfacing Upgrade	* R U	0 0 0		 F 43(1) I 39(1) PDO 39(1) F 15(1) I 38(1) PDO 48(1)			
S1	Signs Warning/ Advisory	* R U	1 7 6	17 9 to 50 14 to 82	 C 8 to 60(2)		RT 80(1) RE 15(1) ROR 91(1)	
S2	Signs Chevrons	* R U	0 0 2	 30 to 70				

* Codes for Feature (A, B, C, etc.) and Treatment (1, 2, 3, etc) — see Appendix A.

1 Area Type : Rural (R), Urban (U), Did not specify (*).

2 Severity: Fatality (F), Casualty (C), Serious (S), Injury (I), Property Damage Only (PDO).

3 Vehicle Type: Pedestrian (P), Car (CR), Motorbike (MB), Bicycle (B), Truck or bus (TB).

4 Manoeuvre: Head-on (HO), Rear-end (RE), Ran-off-road or single vehicle or hit fixed object (ROR), Right-turn (RT), Left-turn (LT), Side-swipe (SS), Vehicle-to-vehicle (VV).

5 Other category: Wet surface (W), Night or dark (N), Frozen or icy surface (ICE).

- Negative reduction

Table 3.1 continued

Code*	Feature Treatment	Area Type[1]	No. of publications	% Accident Reduction	% Reduction by Severity[2]	% Reduction by Vehicle Type[3]	% Reduction by Manoeuvre[4]	% Reduction by Other Category[5]
S3	Signs Advance direction	* R U	0 0 2	 39 to 75				
S4	Signs Upgrade signs	* R U	 1 1	 25 8		 P 0(1) B 36(1) MB 10(1) CR 9(1)		
W1	Works Lighting	* R U	0 0 0		I 66(1)			
X1	Rail Crossings Lights	* R U	1 1 1	68 88 -145 to 100	F 86(1) I 65(1) C 86(1)			
X2	Rail Crossings Gates	* R U	0 1 0	 64	 C 51 to 80(2)			

* Codes for Feature (A, B, C, etc.) and Treatment (1, 2, 3, etc) — see Appendix A.

1 Area Type : Rural (R), Urban (U), Did not specify (*).

2 Severity: Fatality (F), Casualty (C), Serious (S), Injury (I), Property Damage Only (PDO).

3 Vehicle Type: Pedestrian (P), Car (CR), Motorbike (MB), Bicycle (B), Truck or bus (TB).

4 Manoeuvre: Head-on (HO), Rear-end (RE), Ran-off-road or single vehicle or hit fixed object (ROR), Right-turn (RT), Left-turn (LT), Side-swipe (SS), Vehicle-to-vehicle (VV).

5 Other category: Wet surface (W), Night or dark (N), Frozen or icy surface (ICE).

- Negative reduction

Table 3.2 Extent of information according to accident reduction category.

Reduction by Category	Number of counter-measure records	Percentage of total records [1] %
Overall	410	78
Severity	117	22
Vehicle type	33	6
Manoeuvre	76	14
Other category	42	8
Total number of records	529[2]	100

Notes: (1) Percentages do not add to 100 because records may contain more than one category of countermeasure.

(2) Numbers do not add to 529 for reason given in (1).

Table 3.3 Availability of information by country of publication.

Country of Publication	Number of counter-measure records	Counter-measure records %	Number of publications	Publications %
Australia	200	38	54	26
USA	125	24	62	30
UK	50	9	29	14
New Zealand	31	6	18	9
Sweden	28	5	8	4
Other[1]	26	5	12	6
Not Specified	69	13	24	12
Total records	529	100	207	100

Notes: (1) Canada, France, Germany, Israel, Japan, Netherlands.

Table 3.4 Extent of information by year of publication.

Year of Publication	Number of counter-measure records	Counter-measure records %	Number of publications	Publications %
pre 1980	68	13	30	15
1980-1984	129	24	42	20
1985	60	11	17	8
1986	55	10	23	11
1987	62	12	16	8
1988	45	9	17	8
1989	14	3	12	6
1990	47	9	17	8
1991	24	5	13	6
1992	4	1	2	1
Not specified	21	4	18	9
Total records	529	100	207	100

APPENDIX A.

LIST OF FEATURES AND TREATMENTS USED IN ACCIDENT COUNTERMEASURES, AND CODES

APPENDIX A. LIST OF FEATURES AND TREATMENTS USED IN ACCIDENT COUNTERMEASURES, AND CODES

Feature Code	Treatment Code	DESCRIPTION OF FEATURE Description of Treatment
A		AREA-WIDE SCHEMES
	1	Blackspot treatments
	2	Traffic calming/LATM[1]
	3	Street closures
	4	Parking controls
D		DELINEATION
	1	Edge and centre line markings
	2	Reflectorised guide posts
	3	Raised pavement markers — edge
	4	Raised pavement markers — centre
G		GEOMETRY
	1	Minor realignment
	2	Major realignment
H		ROADSIDE HAZARDS
	1	Crash cushions
	2	Frangible poles
	3	Relocate poles
	4	Remove trees
	5	Widen narrow squeeze points; Remove obstacles
	6	Guardrails
I		INTERSECTIONS
	1	Modify channelisation
	2	Painted channelisation
	3	Add lanes
	4	Roundabouts
	5	Staggered T; Replace 4-legs
	6	Control changes
	7	Traffic islands
L		LIGHTING
	1	Modify/install street lighting
M		MEDIANS/MULTI-LANE
	1	Install raised/painted medians
	2	Upgrade/install safety fences
	3	Widen medians
	4	Close medians

[1] LATM Local area traffic management

Appendix A List of Features and Treatments used in Accident Countermeasures, and Codes (continued)

Feature Code	Treatment Code	DESCRIPTION OF FEATURE Description of Treatment
N		SHOULDERS AND LANES
	1	Turning lanes
	2	Climbing/passing/overtaking acceleration/deceleration lanes
	3	Widen for parking breakdown
	4	Short 4-lane sections
	5	Flatten batters/sideslopes
	6	Widen shoulders
	7	Seal/improve shoulders
	8	Widen traffic lanes
	9	Bus bays
	10	Bus transit lanes
	11	Cycle paths
P		PEDESTRIAN FACILITIES
	1	Zebra crossings
	2	Pedestrian refuges/Median protection
	3	Pedestrian signals
	4	Pedestrian bridges
R		RESURFACING
	1	Specific accident spots
	2	Skid resistant treatments
	3	Upgrade
S		SIGNS
	1	Warning/advisory
	2	Chevrons
	3	Advance directions/reassurances
	4	Upgrade signs
W		WORK IN PROGRESS
	1	Lighting
X		RAIL LEVEL CROSSINGS
	1	Flashing lights
	2	Boom gates/bells/lights

APPENDIX B.

ACCIDENT REDUCTION RESULTS OBTAINED FROM INDIVIDUAL REFERENCES

APPENDIX B. ACCIDENT REDUCTION RESULTS OBTAINED FROM INDIVIDUAL REFERENCES

Explanatory Notes for Column Headings

Feature Code } Codes for features and treatments are listed and
Treatment Code} defined in Appendix A.

Area Type Code Codes for area types are given in Table 3.1.
R = rural; U = urban; * = did not specify

% Reduction Reduction in accident numbers following the implementation of the accident countermeasure.

Reduction by Severity Kinds of severity are:
fatality; casualty; serious; injury; property damage only.

(%) = percentage reduction in accidents according to these five degrees of severity, following implementation of the accident countermeasure.

Reduction by Vehicle Type Kinds of object involved are:
pedestrian; car; motorbike; bicycle; truck or bus.

(%) = percentage reduction in accidents according to object involved, following implementation of the accident countermeasure.

Reduction by Manoeuvre Kinds of manoeuvre are:
head-on; rear-end; ran-off-road or single vehicle or hit fixed object; right turn; left turn; side-swipe; vehicle-to-vehicle.

(%) = percentage reduction in accidents related to these seven kinds of manoeuvres, following implementation of the accident countermeasure.

Reduction by Other Category

Other categories of information on causes of accidents include:

Kind of surface: wet; frozen or icy; dry.

Kind of road: arterial; local distributor; residential access; straight; curved; distances.

Time: night; dark; day.

(%) = percentage reduction in accidents related to these kinds of conditions, following implementation of the accident countermeasure.

Comments Information concerning the accident countermeasures obtained from the specific publication reviewed (given by the Reference No.).

Year Year of publication of that specific publication.

Country Where publication was published.

Reference No. Number allocated to each publication reviewed for this project. Appendix C lists all references used in this project, in numerical order.

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
A	1	*	41	Injury (46).				Blackspot treatments.	1987	AUS	150
A	1	*	33					Blackspot treatments - Intersections all types.	1990	AUS	41
A	1	*	30	Casualty (15).				Blackspot program.	1988	AUS	33
A	1	R	69					Blackspot treatments - Non-Metropolitan intersections.	1990	AUS	41
A	1	R	0					Blackspot treatments - Non-Intersection locations.	1990	AUS	41
A	1	R	0					Blackspot treatments - Non-Intersection locations.	1990	AUS	41
A	1	R		Casualty (69).				Black-spot treatments at intersections.	1990	AUS	44
A	1	U	30					Blackspot treatments - Metropolitan intersections.	1990	AUS	41
A	1	U		Casualty (30).				Black-spot treatments at intersections.	1990	AUS	44
A	2	*	65					Roundabout (part of area traffic management).	1984	AUS	172
A	2	*		Casualty (41).				Accident black-spot treatments.	1987	AUS	150
A	2	*		Casualty (33).				Black-spot treatments at intersections.	1990	AUS	44
A	2	*		Casualty (40).				Blackspot treatments.	1986		157
A	2	U	10					4 new roundabouts, 3 new pedestrian-actuated crossings, 11 right-turn prohibited crossings.	1981		47
A	2	U	10-20	Casualty (up to 60).				Local area traffic management schemes.	1989	AUS	161
A	2	U		Injury (10-25).				Area-wide low cost engineering measures.	1989	UK	194
A	2	U	20					Urban traffic management.	1986	UK	173
A	2	U	77					Street closure.	1984	AUS	36
A	2	U	10-15		Pedestrian (>15).			Applied to main road - roundabouts, signals and turn bans.	1985	AUS	162
A	2	U	50					Road closures and roundabouts.	1984		17
A	2	U	60					* Improvement in safety noticed by residents (not a reduction in accidents).	1980	AUS	26
A	2	U	10		Pedestrians (14), Bicycle (39).		* Arterial (9), Local Distributor (9), Residential Access (21).	Urban Safety Project - Area-Wide Schemes * Road types.	1988	UK	111
A	2	U	10					Area-wide schemes.	1988	UK	111
A	2	U		Injury (60).				Traffic calming. Redesigning streets to reduce traffic speeds.	1991	GER	99

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
A	2	U		Injury (70).				Traffic calming - Danish schemes.	1991	UK	79
A	2	U	31	Injury (44), Serious (50).				Traffic calming - German schemes.	1991	UK	79
A	2	U	0	Injury (23).				Traffic calming.	1990	UK	80
A	2	U	13					Traffic calming.	1991	UK	179
A	2	U		Injury (50).				Reclassification and reconstruction of residential roads.			110
A	2	U		Injury (15).				Reclassification and reconstruction of traffic arteries.			110
A	2	U		Serious (45), Injury (10).				Speed reduction by area-wide 30 km/h limit with frequent local ramps and narrowings.			110
A	2	U		Casualty (27,44,45).	Pedestrian (43), Child (66), Cycle (16).			Traffic calming.	1991		147
A	2	U	15-40					Traffic calming.	1989	UK	144
A	2	U	50					Traffic calming.	1985	NET	87
A	2	U	13		Pedestrian (5), Cycle (33), Motorcycle (16).	Right-turn (40).		Road closures, turning bans and one-way streets.	1990	UK	112
A	2	U	40					Local area traffic management schemes.	1988	AUS	188
A	2	U	25					Reclassified and reconstructed the road infrastructure in two districts.	1991	HOL	98
A	2	U		Casualty (16).				Change status of streets from ordinary streets (50km/h) to play-areas and quiet-streets.	1990	SWE	53
A	2	U	40					Area-wide traffic calming measures in six West German cities.	1990	SWE	16
A	3	*	77					Street closure.	1985		158
A	3	*	77					Street closures.	1984	AUS	172
A	3	U	73-81					Street closures.	1984	AUS	172
A	3	U	17		Pedestrians (55).			Created pedestrian mall - New Plymouth central.	1976	NZ	91
A	3	U	50					Ring road and mall system - Hastings.	1984	NZ	174
A	4	*	26					Parking control.	1984	AUS	172
A	4	U	32			Fixed object (50).			1975	USA	120
A	4	U	32			Fixed object (50).			1986	UK	173
A	4	U	-18-70					Parking control.	1984	AUS	172
D	1	*	60					Delineator.	1987	JAP	163
D	1	*					Wet edge-line related (10).	8-in (20cm) edgeline on a 24ft (7.3m) pavement.	1990		108

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
D	1	*	8			Out of control (34).		Installation of edge-lines on 650km of roads.	1992	NZ	124
D	1	R	up to 40					Edgelining.	1983	UK	94
D	1	R		Casualty (3).					1987	USA	58
D	1	R	60					UK & US	1981	USA	93
D	1	R	8			Single vehicle (34), Head-on (1).			1986	AUS	123
D	1	R	19					Pavement edge marking.	1960	USA	131
D	1	R	18					100 mm wide.	1988	AUS	140
D	1	R	15					Edgeline - highway or curve,	1985		158
D	1	R	0					Motorways.	1984	UK	196
D	1	R	8					Glassbeads in the centre & edge.	1985	AUS	191
D	1	R	0					Effect of 8-in.-wide edgelines on run-off-road & related accidents on three rural two-lane roads.		USA	3
D	1	R	62					Edge-lines.	1990	AUS	69
D	1	R	30	Casualty (20-30).			Road positioning (85).	End-to-end white lining.	1992	UK	2
D	1	R	15-45				Straight sections (15), Curves (45).	Painted edgeing on curves.	1981		95
D	1	R				Run-off-road (50).		Continuous edge lines.	1986	AUS	125
D	1	U	46					Pavement edge marking.	1962	USA	8
D	1	U	2-15			Run-off-road (20-25).			1975	USA	120
D	1	U	65					No passing lines.	1975	USA	120
D	1	U	2-15			Run-off-road (20-25).			1986	UK	173
D	1	U	33					Pavement markings - install ghost island.	1986	UK	173
D	1	U	65				Pass (85).	No passing lines.		USA	28
D	1	U			Car (62), Motorcycle (72),	Ran-off-road (85), Speed: > 70km/h (71), Upward slope (62), Downward slope (74).	Night (65), Surface: wet (67).	Delineator.	1987	JAP	163
D	2	R	60				Night fatalities (60).		1988	AUS	140
D	2	R	30						1988	AUS	140
D	2	R	25					Guideposts - highway.	1985		158
D	2	R	32					Guideposts - curves.	1985		158
D	2	R	0-60					Post mounted delineators.	1990	AUS	69
D	2	R					Night (41).	Corner cube reflective delineators.	1983	AUS	154
D	2	U	25-67					Post delineation.	1989		46
D	2	U	25-67					Post delineation,	1984	AUS	36
D	3	*	68					Reflective raised pavement markers on edge-line.	1983		13
D	3	*				Night run-off-road (30).		Large delineators more effective than small ones.	1980	USA	145
D	3	R	16						1988	AUS	140

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
D	3	R	15					Raised reflective pavement markers.	1985		158
D	4	*	68					Reflective raised pavement markers on centre line.	1983		13
D	4	*				Head-on (75).	Night (88).	Retroreflective raised pavement markers on undivided 4-laned arterial roads.	1986	AUS	125
D	4	*				Head-on (70), Side-swipe (27).		Retroreflective raised pavement markers.	1985	AUS	127
D	4	*	6		Pedestrian (-36).	Rear-end (7), Head-on (70), Side-swipe (27), Hit object (-7).		Four-lane roads treated with RRPMs with four white markers simulating a 3-metre strip.	1992	NZ	124
D	4	R				Single vehicle and head-on (up to 18).		Raised reflective pavement markers.	1985	AUS	198
D	4	R					Night (0).	Reflective raised pavement markers. 100km/h roads.	1991	NZ	9
D	4	R	15				Night (25).	RPMs.	1980	AUS	176
D	4	R		Injury (50).				Winding sections of road.		NZ	1
D	4	R		Injury (10).				Straight sections of road.		NZ	1
D	4	R					Night (22).	RPMs.	1982	USA	200
D	4	R		Casualty (15-20).		Head-On and Side-Swipe (dramatic reduction).		RRPMs.	1990	AUS	69
D	4	R		Casualty (15).				Raised reflective pavement markers.	1983	AUS	154
D	4	R	12					Sections on highways treated with RRPMs - within 500 metres of low speed curves.	1992	NZ	124
D	4	U	5-15					RRPMs,	1975	USA	120
D	4	U	5-15					RRPMs.	1984	AUS	36
D	4	U					Night (0).	Reflective raised pavement markers.	1991	NZ	9
G	1	*	26-42					Realign short section.	1984	AUS	172
G	1	*	33					Horizontal and vertical alignment changes to improve stopping sight distances.	1987	USA	70
G	1	*	60-70					Increase curve radius from 100m to 400m.	1988	GER	105
G	1	R	15					500-700m/300-500m.	1990	SWE	81
G	1	R	0					Super/cross fall.	1988	AUS	140
G	1	R	40-90					Minor upgrading of an isolated curve or section of highway.	1985	AUS	169
G	1	R	76					Transitional to circular alignment on 3 acute, accident-prone bends.	1990	UK	170
G	1	U	50-85					Superelevation.	1975	USA	120
G	1	U	30					Improve visibility.	1986	UK	173
G	1	U	3-100					Realign short section.	1984	AUS	172

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
G	1	U	95					Reconstruction of short lengths of road on new line.	1984	UK	184
G	1	U	80					Improved alignment of bends.	1984	UK	184
G	1	U					Sight distance: reduced from > 700ft to < 300ft (50).	Sight distance.	1984	USA	139
G	1	U		Fatal (32), Injury (15).				Low cost engineering measures on local and heavily trafficked roads.			110
G	1	U		Fatal (32), Injury (15).				Low cost engineering measures on local and heavily trafficked roads.	1991		147
G	2	R		Casualty (34).					1987	USA	58
G	2	R	30					500m - 1500m radius.	1990	SWE	81
G	2	R	0					GT 600m.	1988	AUS	140
G	2	R	25					Re-construct highway.	1985		158
G	2	U	50-80					Realignment.	1975	USA	120
G	2	U	25-50					Reconstruct.	1975	USA	120
G	2	U	50-80					Realignment.	1986	UK	173
G	2	U	25-50					Reconstruct.	1986	UK	173
H	1	U		Casualty (35).					1987	USA	58
H	1	U		Fatal & Serious (75).				Crash cushion - extremely effective in reducing fatals where object removal is impossible.	1973	USA	189
H	1	U	8	Fatal & Serious (75).					1990	UK	170
H	2	R	0						1988	AUS	140
H	2	U		Serious (estimated 30-60).				Breakaway poles.	1984	USA	205
H	2	U		Injury (30).				Sign/luminaire supports when breakaway supports are used.	1980	USA	113
H	2	U	30					Signs & light poles.	1987	USA	71
H	3	*	13					Relocate poles to 1m.	1988		62
H	3	*	60					Relocate poles to 2.5m.	1988		62
H	3	*	80					Relocate poles to 3m.	1988		62
H	3	*	100					Relocation of utility poles from curbside to a 6ft offset.	1986	USA	103
H	3	R	0						1988	AUS	140
H	3	R	0					Within 2ft.	1984	USA	203
H	3	R	0					Within 5ft.	1984	USA	203
H	3	R	0					Within 10ft.	1984	USA	203
H	3	R		Fatal (60), Injury (20), Property damage only (-20).				Relocate traffic sign posts.	1977	USA	86
H	3	U	30					To 1.5m.	1988		62
H	3	U	80					To 3m.	1988		62

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
H	3	U	100					Service poles moved back to building line - Petone.	1984	NZ	174
H	4	*				Hit tree (39).		Removal of trees within 4.6m of roadway.	1972	AUS	50
H	4	R		Casualty (24).					1987	USA	58
H	4	R	0					Large tree.	1988	AUS	140
H	4	R	0					All trees.	1988	AUS	140
H	4	R	0						1988	AUS	84
H	4	R		Fatal (50), Injury (25), Property damage only (-20).				Remove trees.	1977	USA	86
H	5	*	19	Fatal (38), Injury (19).				Hazard elimination.	1987		55
H	5	*	47					Widened bridges.	1972	AUS	50
H	5	R		Casualty (30).					1987	USA	58
H	5	R	19-52					General roadside improvements, removing obstacles (eg. trees, utility poles).	1988	USA	207
H	5	U	13-44				5ft (13), 10ft (25), 15ft (35), 20ft (44).	Roadside recovery distance (outside edge of shoulder to the nearest roadside obstacles).	1986	USA	206
H	5	U	10-12					Remove obstruction.	1986	UK	173
H	5	U				Car v. rock (decrease).		Remove large rocks decorating a median - Wellington.	1979	NZ	92
H	6	R		Casualty (10).					1987	USA	58
H	6	R	30					Guardrail.	1985		158
H	6	U	10-50					Guardrails at bridge.	1984	AUS	36
H	6	U	10-50					Guardrails at bridge.		USA	28
H	6	U	30					Guardrails inside curves.		USA	28
H	6	U	65					Guardrails outside curves.		USA	28
H	6	U	increase			Barrier penetration/vaulting head-on (100).		Longitudinal barriers (concrete safety shape). Reduce severity: Increase frequency.		USA	45
H	6	U		Fatal (32), Injury (-2), Property damage only (0).				Guardrail installation.	1977	USA	86
I	1	*	40					New signals and channelisation.	1985		158
I	1	*	16					Modify signals & channelisation.	1985		158
I	1	*	41					New channels at signalised intersection (including signal modifications).	1984	AUS	172
I	1	*	-69					Modify channels at signalised intersection.	1984	AUS	172

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
I	1	*	6					Modify channelisation.	1984	AUS	172
I	1	*	17-22			Side-Swipe (25).		New channelisation.	1984	AUS	172
I	1	*	-117-28					Modify channelisation.	1984	AUS	172
I	1	*	37					Other channelisation at junction.	1985	SWE	23
I	1	*	0					Channelisation with raised islands in 3-way junctions.	1981	SWE	19
I	1	*	15					Left-turn channelisation - left-turn lanes with raised islands.	1981	SWE	19
I	1	*		Casualty (43).				Channelisation of unsignalised intersections.	1972	AUS	50
I	1	R	13	Casualty (-32)*				Altered channelisation or lighting at 3-way and 4-way (*) junctions.		SWE	22
I	1	U	10-20					3- and 4-way intersection - secondary road island and left-turn lane, kerbstone channelisation.	1984	SWE	20
I	1	U	17					New channelisation.	1985		158
I	1	U	15					Add right-turn channelisation at signals with phase.	1975	USA	120
I	1	U	36					Add right-turn channelisation at signals without phase.	1975	USA	120
I	1	U	70					Add right-turn channelisation unsignalised with kerb.	1975	USA	120
I	1	U	15					Add right-turn channelisation, unsignalised painted.	1975	USA	120
I	1	U	35-47					New channels at signalised intersection (including signal modifications).	1984	AUS	172
I	1	U	-137--1					Modify channelisation.	1984	AUS	172
I	1	U	10-32					New channelisation: 10-24% in SA, 12-32% in WA.	1984	AUS	172
I	1	U	-164-47					Modify channelisation: -164--70% in SA, 9-47% in WA.	1984	AUS	172
I	1	U	-66-54					Modify signals and channelisation: -30--10% in SA, and -66-54% in WA.	1984	AUS	172
I	2	U	17						1984	SWE	20
I	2	U	20					3-way intersection.	1990	SWE	81
I	2	U	10					4-way intersection.	1990	SWE	81
I	2	U				Right-turn (22).			1989	AUS	161
I	2	U	18					Pavement markings through intersection.	1986	UK	173

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
I	3	*	22					Additional lanes at non-signalised intersection.	1984	AUS	172
I	3	*	36					Left-turn lane at 4-way junction - kerbstone.	1985	SWE	23
I	3	*	39					Left-turn lane at 3-way junction - road marking.	1985	SWE	23
I	3	R	25						1987	USA	58
I	3	R				Rear-end & side-swipe (10), left-turn (increase), right-turn (0).		Turning lanes in uncontrolled approaches of intersections on 2-lane highways: Paved shoulders.	1986		118
I	3	R				Rear-end & side-swipe (60), left-turn (-770), right-turn (50).		Turning lanes in uncontrolled approaches of intersections on 2-lane highways: Unpaved shoulders.	1986		118
I	3	R				Head-on/Cross-path (70).			1988	AUS	140
I	3	R	0					Summary statement.	1988	AUS	140
I	3	R	20-25					Painted right-turn lanes.	1989	AUS	161
I	3	R	30					Painted right-turn lanes.	1989	AUS	161
I	3	R	40					Right-turn lane.	1985		158
I	3	R	20					Left-turn lanes at 3-way junctions marked by painting.	1987		190
I	3	U	10-20					3- and 4-way intersection - secondary road island and left-turn lane, kerbstone channelisation.	1984	SWE	20
I	3	U	35					Uncontrolled approach.	1989	USA	117
I	3	U	54					Signalised approach.	1989	USA	117
I	3	U	22						1985		158
I	3	U	27					Add RT lane and signal.	1975	USA	120
I	3	U	39					Add RT lane without signal.	1975	USA	120
I	3	U	8-36					Additional lanes at non-signalised intersection.	1984	AUS	172
I	3	U	10					Right-turn or left-turn lanes.	1987	JAP	163
I	4	*		Fatal (90), Injury (66), Property Only (66).				Roundabout installation.		AUS	155
I	4	*	57			Right-Angle (80), Rear-End (increase), Side-Swipe (increase).		Roundabout.	1984	AUS	172
I	4	*	31					Roundabout at junction.	1985	SWE	23
I	4	*	81					Blackspot treatments - New roundabouts.	1990	AUS	41
I	4	*		Casualty (25).				Replacing signals with a roundabout.	1990	AUS	42
I	4	*		Casualty (81).				New roundabouts.	1990	AUS	44
I	4	*	60	Casualty (78).				Blackspot treatment - roundabout program.	1988	AUS	33

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
I	4	*	37	Casualty (42).				Signals compared with roundabouts.	1989	AUS	85
I	4	*		Injury (50-60).				Install roundabout at an identified blackspot.	1986	UK	185
I	4	*	25					4-arm roundabouts v. signalised junctions.	1984	UK	115
I	4	*		Casualty (74).				Construction of roundabouts.	1982		153
I	4	*	60-95					Roundabouts.	1991	AUS	178
I	4	U	0						1988	AUS	30
I	4	U	50						1990	SWE	81
I	4	U	57						1985		158
I	4	U	50-60					Install roundabout.	1986	UK	173
I	4	U	52-62						1984	AUS	172
I	4	U	35-95					Roundabout (part of area traffic management).	1984	AUS	172
I	4	U		Injury (decrease).				Install small roundabout.	1984	AUS	172
I	4	U	50					Provision of roundabouts.	1984	UK	184
I	4	U	40	Serious injury (60-80).				Roundabouts.	1985	UK	138
I	4	U	41	Injury (66).				Medium to high volume roundabouts (avg > 1 accident p.a.).	1990	AUS	148
I	4	U	0					Low volume roundabouts (avg < 1 accident p.a.).	1990	AUS	148
I	4	U	62					Roundabouts.	1982	AUS	149
I	4	U	50					Roundabouts at 4-way junctions.	1987		190
I	4	U	decrease	Fatal, serious & minor (decrease).	Vehicles from: different roads (decrease), same roads (decrease).			Changes to roundabouts.	1986	NZ	66
I	4	U	85					Mini-roundabout replaced traffic signals - Napier.	1985	NZ	88
I	4	U	0					Mini-roundabout replaced traffic signals - Palmerston North.	1985	NZ	88
I	4	U	47					Install small roundabout.	1981	AUS	48
I	4	U	75					3 mini-roundabouts installed - Blenheim.	1985	NZ	89
I	5	*	47-84		Right-Angle (100), Rear-End (80).			Convert cross intersection to T junction.	1984	AUS	172
I	5	R	0						1988	AUS	140
I	5	R	0-40					Replace 4 -way junction with two staggered 3-way junctions: Left staggering is more favourable.	1988	SWE	21
I	5	R	80	Casualty (80).				Conversion of cross-road intersections to staggered 'T junctions.	1983	AUS	119
I	5	R	50-80					Conversion of rural cross intersection to staggered T.	1991	AUS	178

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
I	5	U	47					Convert X to T.	1985		158
I	5	U	42-85					Stagger X-roads.	1986	UK	173
I	5	U	47					Change X to T.	1984	AUS	36
I	5	U	28-99					Convert a cross intersection to a T junction: 28-66% in SA, and 69-99% in WA.	1984	AUS	172
I	5	U	60					Staggering of cross roads.	1984	UK	184
I	6	*	14					Modify signals.	1985		158
I	6	*	19					New signals.	1985		158
I	6	*	40					New signals and channelisation.	1985		158
I	6	*	16					Modify signals and channelisation.	1985		158
I	6	*	14					Modify signals.	1984	AUS	172
I	6	*	19			Right-Angle (64), Rear-End (55).		New signals.	1984	AUS	172
I	6	*	-29					Signal coordination.	1984	AUS	172
I	6	*	40-46					New signals and channelisation.	1984	AUS	172
I	6	*	-20--6					Modify signals and channelisation.	1984	AUS	172
I	6	*	24					New signals and channel modifications.	1984	AUS	172
I	6	*	14					Substitute "Give Way" signs with "Stop" signs.	1987	NZ	65
I	6	*		Casualty (6).		Right-Against (34), Rear-End (-28).		Traffic signal coordination along 10 routes.	1986	AUS	83
I	6	*		Casualty (20).				Traffic signal coordination along 10 routes - Summary of 4 articles.	1986	AUS	83
I	6	*	43	Injury (73).	Pedestrian (39).	Right-angle (77), Rear-end (18), Fixed-object (-33).		All-way stop conversion.	1984	CAN	142
I	6	*	22					Traffic signal at junction.	1985	SWE	23
I	6	*		Injury (58).		Cross-traffic (84), Right against (-52), Rear-end (31).	Other (i.e. not pedestrian, cross-traffic, right against or rear-end) (66).	New traffic signal installation.	1987	AUS	135
I	6	*	52					Blackspot treatments - New intersection signals.	1990	AUS	41
I	6	*	33					Blackspot treatments - Remodelled intersection signals.	1990	AUS	41
I	6	*	19	Injury (17).		Head-on and Left-turn (-50), Rear-end (-53), Right-angle (57), Other (34).		Newly installed traffic signals and geometric improvement in 35 out of 102 locations.	1990	USA	49
I	6	*	15	Injury (7).		Head-on and Left-turn (-75), Rear-end (-64), Right-angle (52), Other (32).		Newly installed traffic signals.	1990	USA	49

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
I	6	*	-23	Fatal (50), Injury (20).		Rear-end (-200), Head-on and Left-Turn (-157), Sideswipe (-74), Angle (51), Other (39).		Signal installation in 29 urban and rural areas in Michigan.	1959	USA	168
I	6	*	increase	reduction.		Right-angle (reduction), Rear-end (increase).		Signalisation.	1975	USA	100
I	6	*		Severe (13).		Left-turn (85), Rear-end (-33).		Multiphase signals v. two-phase signals.	1979	USA	4
I	6	*		Casualty (53).				New intersection signals.	1990	AUS	44
I	6	*		Casualty (33).				Signal remodelling.	1990	AUS	44
I	6	*		Casualty (44).				Right-turn phase installation at intersections.	1990	AUS	44
I	6	*	16-21	Injury (12-17).				Traffic signal coordination along 10 routes - Summary of 4 articles.	1976	AUS	121
I	6	*	20					Stop signs at intersections.	1972	AUS	50
I	6	*	4					Give Way signs at intersections.	1972	AUS	50
I	6	*	32					Provision of traffic signals at intersections.	1972	AUS	50
I	6	*		Injury (40).				Install traffic signals at an identified blackspot.	1986	UK	185
I	6	*		Casualty (55).				Installation of intersection signals.	1982		153
I	6	*	40-55					Installation of traffic signals.	1991	AUS	178
I	6	*	40-55					Remodelling of traffic signals (especially to provide right turn phase).	1991	AUS	178
I	6	R	61	Injury (77).		Left-turn (25), Right-angle (75), Rear-end (48).		Conversion to all-way stop control: Summary of articles.	1981	USA	15
I	6	R	increase			Rear-end (increase).		Signalisation.	1976	USA	73
I	6	U	17-100					Install traffic signals.	1984	AUS	32
I	6	U	20-70					Provide right-turn phase.	1984	AUS	32
I	6	U	11-80					Modernise signals.	1984	AUS	32
I	6	U			Pedestrians (10).	Rear-end (10), Right-ang. (10), Right-turn (10), Left-turn (10).		Signalisation - improve timing.	1975	USA	120
I	6	U				Rear-end (10).		Signalisation - large lens.	1975	USA	120
I	6	U				Rear-end (90).		Signalisation - remove signal.	1975	USA	120
I	6	U	10-52					Modify signals: 10-18% in SA, 20-52% in WA.	1984	AUS	172
I	6	U	12-26					New signals: 12-26% in SA, 14-26% in WA.	1984	AUS	172
I	6	U	-74-16					Signal coordination.	1984	AUS	172
I	6	U	32-60					New signals and channelisation: 35-45% in SA, 32-60% in WA.	1984	AUS	172

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
I	6	U	10-38					New signals and channel modifications.	1984	AUS	172
I	6	U	20					Install traffic signals.	1984	AUS	172
I	6	U	increase		Pedestrian (decrease).			Intro : Yield sign, Stop sign & replace . Yield sign with Stop sign; During daylight: Not signif.	1985	ISR	146
I	6	U	40-60	Injury (50-80).				Conversion to all-way stop control; Summary of articles.	1986	USA	56
I	6	U	47	Injury (71).	Pedestrian (39).	Right angle (72), Rear end (13), Left turn (20).		Conversion to all-way stop control.	1986	USA	56
I	6	U	54	Injury (81).		Right angle (83), Rear end (33), Fixed object (-4).		Conversion to all-way stop control.	1976		52
I	6	U	up to 50					Traffic signals at 4-way junctions.	1987		190
I	6	U			Pedestrian (5).			Install traffic signals at 3-leg intersections.	1976	NZ	101
I	6	U	0			Rear-end (increase), vehicles from different roads (decrease).		Changes to traffic signals - 3-leg junctions.	1986	NZ	66
I	6	U	decrease	Fatal, serious & minor (decrease).		Vehicles from: different roads (decrease), same roads (increase).		Changes to traffic signals - 4-leg junctions.	1986	NZ	66
I	6	U	decrease	Fatal, serious & minor (decrease).		Vehicles from: different roads (decrease), same roads (decrease).		Signing of uncontrolled 4-leg intersections.	1986	NZ	66
I	6	U	0	Decrease.				Signing of uncontrolled 3-leg intersections.	1986	NZ	66
I	6	U	small					Install traffic signals at 4-leg intersections.	1982		164
I	6	U		Injury (-900).				Give-way priority swapped - New Plymouth.	1985	NZ	88
I	6	U	increase					T changed to 'X' & priority change - Gisborne.	1985	NZ	88
I	6	U				Right-turn (75).		All arrow phase v. full green + R T arrow - Hutt Valley/Porirua; High speed areas SH1 & SH2.		NZ	90
I	6	U	40					Uncontrolled 4-leg intersection signalised.	1985	NZ	67
I	6	U		Casualty (6).		Right-against (34), Rear-end (28).		Traffic signal coordination; included a right-turn phase.	1986	AUS	83
I	6	U	25			Right-angle (63), Rear-end (19), Left-turn (-35), Other (27).		Mast-mounted v. post-mounted signal heads.	1991	USA	12
I	6	U				Rear-end (small).		Reduce frequency of vehicular stops.		USA	11

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
I	6	U	47	Injury (71).	Pedestrian (39).	Right-angle (72), Rear-end (13), Left-turn (20).		Convert intersection control from two-way to all-way stop control.		USA	107
I	6	U	-33			Rear-end (-98), Right-angle (45), Left-Turn (-66), Other (-46).		Signal installation in 52 areas in Michigan.	1964	USA	38
I	6	U	50			Right-angle (75).		Signal installation overhead on two major roadways.	1967	USA	114
I	7	*	58					Secondary road island at 4-way junction - kerbstone.	1985	SWE	23
I	7	U	0-10					3- and 4-way intersection - secondary road island.	1984	SWE	20
I	7	U	10					Traffic islands.	1987	JAP	163
I	7	U	10					Traffic islands at 4-way junctions.	1987		190
I	7	U	0					Small central islands with repeated Give Way signs - Blenheim.	1985	NZ	88
L	1	*	45					New street lighting.	1984	AUS	172
L	1	*	-7					Upgrade street lighting.	1984	AUS	172
L	1	*	58					Street lighting (general).	1984	AUS	172
L	1	*					Dark (43).	Lighting at junction.	1985	SWE	23
L	1	*		Injury (84).				Lighting.	1990		108
L	1	*					Dark (>= 30).	Illumination at 3-way juncs. High ratio of 2ndary road traffic or raised islands in primary road.	1981	SWE	19
L	1	R	14-75	Injury (19-60)				Installation or improvement of road lighting.	1987	FRA	34
L	1	R	30	Fatal (40), Injury (35), Property (25).				Installation or improvement of road lighting: Summary statement.	1987	FRA	34
L	1	U	5-10					3- and 4-way junctions.	1984	SWE	20
L	1	U		Casualty (22).					1987	USA	58
L	1	U					Night (up to 30).		1980		59
L	1	U	75					New lighting at intersection.	1975	USA	120
L	1	U	50					Upgrade lighting at intersection.	1975	USA	120
L	1	U	30				Night (40-75).	Add lighting.	1986	UK	173
L	1	U					Night (up to 30).		1985	AUS	162
L	1	U	16-74					New street lighting.	1984	AUS	172
L	1	U	-39-25					Upgrade street lighting.	1984	AUS	172
L	1	U	35-81					Street lighting (general).	1984	AUS	172
L	1	U	14-53	Fatal (48-65), Injury (21-23).	Pedestrian (32-67).			Installation or improvement of road lighting.	1987	FRA	34
L	1	U	58						1987	JAP	163

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
L	1	U			Pedestrian (72), Car (63).	Speed: 50-70km/h (67), > 70km/h (74), Upward slope (59), Downward slope (69), Single vehicle (63).	Night (77), Surface: wet (63).	Road lighting.	1987	JAP	163
L	1	U	10				Night (30).	Lighting at 4-way junctions.	1987		190
L	1	U		Injury (30).				Public lighting.	1986	NET	159
L	1	U	9		Pedestrian (16).			Relighting roads.	1985	UK	63
L	1	U	11	Injury (0), Property (15).			Day (4), Night (39).		1976	USA	14
M	1	*	77					Median installation.	1984	AUS	172
M	1	*	28					Centre barrier.	1987	JAP	163
M	1	*		Fatal (reduced from 7 to 2.5%), Serious injury (reduced from 21 to 17%), Minor (increased).				Motorway median barriers.	1991	NZ	10
M	1	*	40					Install 3.7m wide median on 18km length of highway.	1972	AUS	50
M	1	R		Casualty (7).					1987	USA	58
M	1	R	23						1988	AUS	140
M	1	R	65					Barrier line.	1985		158
M	1	R	20-50					Road duplication and/or provision of median on rural roads.	1991	AUS	178
M	1	U	12-30					Painted/raised medians.	1975	USA	120
M	1	U	12-30					Painted/raised medians.	1986	UK	173
M	1	U	37-100					Median installation.	1984	AUS	172
M	1	U			Motorcycle (increased).	Speed: > 70km/h (58), Upward slope (61), Downward slope (increased), Single vehicle (82).	Frozen surface (100).	Centre barrier.	1987	JAP	163
M	2	*	14					Safety bars.	1984	AUS	172
M	2	*	61					Guard Rail.	1987	JAP	163
M	2	*	13	Fatal (23), Serious (18), Slight (10).		Onto (5), Rebound (100), Through (59).	Median (57), Non-median (3).	Safety fences.	1988	UK	167
M	2	R		Casualty (27).				Upgrade.	1987	USA	58
M	2	R		Casualty (9).				New.	1987	USA	58
M	2	R	0						1988	AUS	140
M	2	U		Fatal (20).					1989	AUS	161
M	2	U		Injury (23).				Safety barriers on dual carriage ways.	1989	AUS	161
M	2	U	4-24					Safety bars.	1984	AUS	172
M	2	U			Pedestrian (82), Single vehicle (74), Vehicle-to-vehicle (52), Motorcycle (71).	Speed: > 70km/h (93), Upward slope (72), Downward slope (66), Single vehicle (74), Vehicle-Vcle (52).	Night (72), Surface: frozen (decreased), dry (62).	Centre barrier.	1987	JAP	163
M	2	U		Fatal (20).				Safety barriers on dual carriage ways.	1988	UK	133

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
M	3	*	33	Casualty (22), Property (35).				Wide raised v. painted medians.	1986	AUS	160
M	3	*	42					Wide v. narrow medians.	1986	AUS	160
M	3	*	32	Casualty (38), Property (31).				Wide v. painted medians.	1986	AUS	160
M	4	*	59					Close median.	1985		158
M	4	*	5-59					Median closure.	1984	AUS	172
M	4	U				Head-on (100), Rear-end (50), Right-ang. (100), Side-swipe (50), Right-turn (100).		Close median opening.	1975	USA	120
M	4	U	-39-75					Median closure; 43-75% in SA, -39-49% in WA.	1984	AUS	172
N	1	*	11-35					3-lane 2-way left-turn lane design v. 2-lane undivided highway.	1986	USA	75
N	1	*	19-35					5-lane 2-way left-turn lane design v. 2-lane undivided highway.	1986	USA	75
N	1	*				Rear-end (83).		Free flowing left-turn slips.	1986	AUS	129
N	1	R	15					Left-turn lane.	1985		158
N	1	R	25-60					Right-turn bay.	1984	AUS	36
N	1	R	15					Left-turn lane.	1984	AUS	36
N	1	U	40			Rear-end (20).		Right-turn bay.	1986	UK	173
N	2	*	38	Casualty (29).		Head-on (58), Left-turn (72),		Passing lanes.		USA	78
N	2	*	25						1987	AUS	182
N	2	*	25					Installation of passing lane on 2-lane highway.	1988	USA	77
N	2	R	25					Climbing lanes.	1990	SWE	81
N	2	R	25					Overtaking lanes.	1988	AUS	140
N	2	R	25					Overtaking lanes.	1985		158
N	2	R	10					Acceleration lane.	1985		158
N	2	R	25					Passing lanes on existing two-lane highways: Greater reductions in rolling and mountainous terrain.	1987	USA	76
N	2	R	30					Turnouts/Passing Bay.	1990	AUS	69
N	2	R	25-27					Addition of . overtaking lane to . 2-lane highway.	1984	AUS	29
N	2	R	25-30					Rural overtaking lanes.	1991	AUS	178
N	2	U	10					Acceln/decceln lane.	1986	UK	173
N	2	U	25					Passing lane.		CAN	180
N	3	*				Head-on (50-60), Hit-object (27-53), Rear-end (17-69)		Pavement widening.	1977	USA	151

Feature Treatment Area			% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
N	3	R	13-44				Increase distance by 5ft (13), 8ft (21), 10ft (25), 12ft (29), 15ft (35), 20ft (44).	Increase roadside clear - recovery distance.	1987	USA	71
N	4	*	34	Casualty (43).		Head-on (70).		Short 4-lane sections.		USA	78
N	4	R	35						1988	AUS	140
N	5	R				Single vehicle (2).		3:1 sideslope compared to 2:1 sideslope.	1988	USA	207
N	5	R	2-20				Change to: 3:1 (2), 4:1 (7), 5:1 (11), 6:1 (15), > 7:1 (20).	Sideslope flattening from 2:1.	1987	USA	71
N	5	R	6-19				Change to: 4:1 (6), 5:1 (10), 6:1 (14), > 7:1 (19).	Sideslope flattening from 3:1.	1987	USA	71
N	5	R	4-14				Change to: 5:1 (4), 6:1 (9), > 7:1 (14).	Sideslope flattening from 4:1.	1987	USA	71
N	5	R	4-10				Change to: 6:1 (4), > 7:1 (10).	Sideslope flattening from 5:1.	1987	USA	71
N	5	R	6					Sideslope flattening from 6:1 to > 7:1.	1987	USA	71
N	5	U	2					3:1 Sideslopes compared with 2:1 sideslopes.	1986	USA	206
N	6	*	reduce	reduces.				Increasing carriageway width until width range of around 9m.	1988	GER	105
N	6	R		Casualty (6).					1987	USA	58
N	6	R	0						1988	AUS	140
N	6	R	10					Widen shoulder.	1985		158
N	6	R	12						1986	USA	204
N	6	R	39			Run-off-road (48).		Pavement widening.	1978	USA	5
N	6	R	16-49				Widen each side by 2ft (16), 4ft (29), 6ft (40), 8ft (49).	Paved shoulder widening.	1987	USA	71
N	6	R	13-43				Widen each side by 2ft (13), 4ft (25), 6ft (35), 8ft (43).	Unpaved shoulder widening.	1987	USA	71
N	6	U	16-40					Widening paved shoulders of 0 to 12ft: by 2ft (16), 4ft (29), 6ft(40).	1986	USA	206
N	7	*	0			Run-off-road (0).		Painted diagonal striping of the shoulder.	1978	USA	5
N	7	R		Fatal (60-70).				Seal shoulders. For straight and curved roads.	1984	AUS	6
N	7	R	30					Surface road shoulder.	1985		158
N	7	R	28			Run-off-road (28).		Improved shoulders on 2-lane highways.	1978	USA	5

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
N	7	R				Run-off-road (61).		Diagonal grooving of right shoulder at 30m intervals.	1978	USA	5
N	7	R	23-33					Improve/stabilize 2-lane road shoulders.	1974	USA	61
N	7	R	20					Paved 0.9 to 1.2m paved shoulders.	1974		82
N	7	R	70-75					Rural road, sealed shoulders.	1991	AUS	178
N	8	*	decrease					Increase bridge width.	1966		25
N	8	*		Casualty (70).				Freeways and dual carriageways v. 2-lane highways.	1984	AUS	29
N	8	R		Casualty (19).					1987	USA	58
N	8	R	25					Lane widening.	1985		158
N	8	R	30					Improve to dual carriageway.	1985		158
N	8	R	16-29					Low traffic (16) and high traffic (29).	1986	USA	204
N	8	R	20-30					Increasing lane width up to 3.4 metres, especially where traffic and accident levels are high.	1985	AUS	169
N	8	R	9	Casualty (22).				Widening lanes on 2-lane rural highways.	1981	USA	116
N	8	R	12-40				Widen by 1ft (12), 2ft (23), 3ft (32), 4ft (40).	Lane widening.	1987	USA	71
N	8	R		Casualty (43).				Pavement widening.	1972	AUS	50
N	8	U	45					Widen 7-13m.	1990	SWE	81
N	8	U	35					Widen 7-13m.	1990	SWE	81
N	8	U	20					Widen 7-9m.	1990	SWE	81
N	8	U	12-40					Widening 10-ft lanes by: 1ft (12), 2ft (23), 3ft (32), 4 ft (40).	1986	USA	206
N	8	U	10-15					General widening.	1986	UK	173
N	9	U	46						1987	JAP	163
N	9	U			Motorcycle (67), Truck (68).	Speed: 50-70km/h (65), Single vehicle (47), Vehicle-to-vehicle (48).	Surface: frozen (100).	Bus bay.	1987	JAP	163
N	10	U			Pedestrian (19), Bus (52).			Contraflow bus lanes.	1984	USA	104
N	11	*	82					Cycle way.	1984	AUS	172
N	11	U	-5-100					Cycle way.	1984	AUS	172
N	11	U	0					Footways converted to joint cycle-pedestrian lanes.	1989	UK	195
P	1	U	-66		Pedestrian (30).				1986	UK	173
P	1	U	-66		Pedestrian (30).				1984	AUS	36
P	1	U	-8-50					School pedestrian crossing.	1984	AUS	172
P	1	U	-175-43					Zebra crossing.	1984	AUS	172

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
P	1	U	-97-100					Zebra crossing with channelisation.	1984	AUS	172
P	1	U	21					School pedestrian crossing.	1984	AUS	172
P	1	U	-66					Zebra crossing.	1984	AUS	172
P	1	U	16					Zebra crossing with channelisation.	1984	AUS	172
P	2	*			Pedestrian (86).	Rear-end (89).		Raised concrete pedestrian islands replaced zebra crossings on 4-laned arterial roads.	1986	AUS	125
P	2	*	12					Replace zebra crossings with raised concrete pedestrian islands.	1978	AUS	126
P	2	U			Pedestrian (30-38).				1986	UK	173
P	2	U			Pedestrian (30-38).			Pedestrian refuge.	1984	AUS	36
P	2	U	up to 75						1972	SOU	18
P	2	U	28-48					Pedestrian refuge islands.	1984	AUS	172
P	2	U	-27-73					Pedestrian protection.	1984	AUS	172
P	2	U	38					Pedestrian refuge islands.	1984	AUS	172
P	2	U	23					Pedestrian protection.	1984	AUS	172
P	2	U	24	Injury (52) - pedestrian (50) - cycle (25).	Pedestrian (-13).			Pedestrian refuges.	1990	UK	177
P	2	U			Pedestrian (80).	Rear-end (83).		Replace zebra crossings by concrete islands.	1987	AUS	130
P	2	U	30-90					Pedestrian facilities.	1991	AUS	178
P	3	U	3-13		Pedestrians (25).			Add pedestrian signals.	1975	USA	120
P	3	U	3-13		Pedestrians (25).			Add pedestrian signals.	1986	UK	173
P	3	U	32-46					New pedestrian signals.	1984	AUS	172
P	3	U	39		Pedestrian (24).	Rear-End (6), Side-Swipe (-33), Right-Angle (-33).		New pedestrian signals.	1984	AUS	172
P	3	U	85					Signalisation - pedestrian phase.	1988	USA	40
P	3	U				Rear-end (increase).		Pedestrian signals replaced crossing - Upper Hutt.	1985	NZ	88
P	4	U	39						1987	JAP	163
P	4	U			Pedestrian (71), Car (42), Truck (38), Motorcycle (80).	Speed: < 30km/h (56), 50-60km/h (increased), Downward slope (62), Single Vehicle (increased).		Pedestrian bridge.	1987	JAP	163
R	1	R	0					Accident spot on major road.	1988	AUS	140
R	1	R	0					Accident spot on minor road.	1988	AUS	140
R	2	*					Wet (67).	Pavement grooving.	1990	USA	197

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
R	2	*	60		Hit object (76).			Resurface with bituminous concrete planer - increase skid resistance.	1991	AUS	122
R	2	R		Casualty (17).					1987	USA	58
R	2	R	0					In Vic/Spec. Treatment.	1988	AUS	140
R	2	R	18					Summary statement.	1988	AUS	140
R	2	R	25-75					Pavement resurfacing - overseas experience.	1990	AUS	69
R	2	R	5-10					Pavement resurfacing - Australian experience.	1990	AUS	69
R	2	R	5	Casualty (-10).			Wet (20), Dry (up to -15).	Resurfacing.	1987	USA	37
R	2	R	40					Skid-resistant road surface treatments.	1982	USA	57
R	2	R	6					Skid-resistant road surface treatments.	1986	AUS	156
R	2	R	5-25					Skid-resistant overlays.	1991	AUS	178
R	2	U	14-72					Modernised signals.	1984	AUS	32
R	2	U	42					Resurfacing.	1975	USA	120
R	2	U					Wet weather (85).	Road grooving.	1971	USA	54
R	2	U	45				Wet roads (80).	Improving slippery surfaces.	1984	UK	184
R	2	U	45				Wet roads (80).	Improving slippery surfaces.	1984	UK	184
R	2	U					Weather: Dry (-10), Wet (15).	Pavement resurfacing; Changes diminish rapidly over time.	1979	USA	201
R	2	U	25	Casualty (25).				Resurfacing.	1987	USA	37
R	3	R		Fatal (43), Injury (39), Property (39)				11,270km of highway upgraded	1985	AUS	162
R	3	U		Fatal (15), Injury (38), Property (48)				11,270km of highway upgraded	1985	AUS	162
S	1	*				Right angle (80).		Installation of STOP sign at hazardous intersections.	1986	AUS	125
S	1	*	17			Rear-end (15).		Small advance-direction signs (stop sign ahead, give way sign ahead, cross road, side jn, T jn).	1991	UK	192
S	1	R		Casualty (8).					1987	USA	58
S	1	R	30					Two lane road - advance warning sign, highway	1985		158
S	1	R	18					Multi-lane road - advance warning sign, highway.	1985		158
S	1	R	35					Two lane roads - advance warning sign, intersections.	1985		158
S	1	R	9					Multi-lane roads - advance warning sign, intersections.	1985		158
S	1	R	50			Speed/lost-control/fixed-object (91).		Flashing beacons on hazardous curve.		USA	97
S	1	R	14-75					Signage - information, warning and regulatory.	1990	AUS	69

Feature	Treatment	Area	% Reduction	Reduction by Severity	Reduction by Vehicle Type	Reduction by Manoeuvre	Reduction by Other Category	Comments	Year	Country	Reference No.
S	1	R	45	Casualty (60).				Advisory speed signs at curves on a highway.	1972	AUS	50
S	1	U	38-48					Minor leg stop control.	1975	USA	120
S	1	U	50					Minor leg give-way sign.	1975	USA	120
S	1	U	20					Warning signs and delineators at intersection.	1975	USA	120
S	1	U	14-20					Warning signs on sections.	1975	USA	120
S	1	U	82					Stop signs at hazardous intersections where there were no signs.	1977	AUS	128
S	1	U	58					Stop signs at hazardous intersections where there were give way signs.	1977	AUS	128
S	2	U	30-70					Chevrons.	1986	UK	173
S	2	U	30-70					Chevrons.	1989		46
S	3	U	39					4-way signs at intersections.	1991	NZ	102
S	3	U	75					Curve warning signs	1975	USA	120
S	4	R	25					Improve signs.	1991	NZ	102
S	4	U	8		Pedestrians (0), Bicycle (36), Motorcycle (10), Car (9).			Road marking & signing.	1985	NZ	24
W	1	*		Injury (66).				Lit roadworks sites.	1990		108
X	1	*	68	Fatal (86), Injury (65).				Rail-Highway Crossing.	1987		55
X	1	R		Casualty (86).					1987	USA	58
X	1	R	88						1988	AUS	140
X	1	U	-145-100					Rail crossing.	1984	AUS	172
X	2	R		Casualty (51).				Upgrade.	1987	USA	58
X	2	R		Casualty (80).				New.	1987	USA	58
X	2	R	64						1988	AUS	140

APPENDIX C.

LIST OF REFERENCES OBTAINED FROM LITERATURE SEARCH

APPENDIX C. LIST OF REFERENCES OBTAINED FROM LITERATURE SEARCH

Explanatory Notes for Column Headings

No. Number allocated to each publication reviewed for this project. They are in numerical order.

Author Surname and initials.

Title of the Article Title is given in full.

Source of the Article Name of journal or book, volume and part numbers, page numbers are supplied if available.

Year Year of publication of that specific publication.

Country Where publication was published.

Comment Place where publication may be viewed or reference number of the publication in which it is referred.

The references do not follow Transit New Zealand style because of formatting constraints. See p.47 for abbreviations used in this Appendix.

Abbreviations used in Bibliographic References, Appendix C

AASHTO	American Association of State Highways and Transportation Officials
ARRB	Australian Road Research Board
ASCE	Associated Society of Civil Engineers
CIE	Commission Internationale d'Eclairage
DOT	Department of Transport
FHWA	Federal Highway Administration, US Department of Transport, Washington DC
IES	Illuminating Engineers Society
IPENZ	Institute of Professional Engineers of New Zealand
ITE	Institution of Transportation Engineers
MOT	Ministry of Transport, Wellington, New Zealand
NAO	National Audit Office
NHMRC	National Health Medical Research Council
NHTSA	National Highway Traffic Safety Association
NRMA	National Roads and Motorists Association, Sydney
NTIS	National Technical Information Service, US Department of Commerce
PTRC	Planning and Transport Research & Computation International Association
PWRI	Public Works Research Institute, Japan
RACV	Royal Automobile Club of Victoria
RCA	Road Construction Authority, Australia
REAAA	Road Engineering Association of Australasia and Asia
RTA	Road Traffic Authority, Australia
SWOV	Institute for Road Safety Research, The Netherlands
T & T	Traffic and Transportation
TandTE	Transport and Traffic Engineering
TEC	Traffic Engineering and Control
TM	Travers Morgan New Zealand
TMA	Travers Morgan Australia
TNZ	Transit New Zealand
TRB	Transportation Research Board, Washington DC
TRR	Transportation Research Record, Washington DC
TRRL	Transport and Road Research Laboratory, Crowthorne, UK
VTI	Swedish Road and Traffic Research Institute

AUS	Australia	NET	Netherlands
CAN	Canada	NSW	New South Wales
FRA	France	NZ	New Zealand
GER	Germany	SOU	South Africa
HOL	Holland	SWE	Sweden
ISR	Israel	UK	United Kingdom
JAP	Japan	USA	United Stated of America

No.	Author	Title of the article	Source of the article	Year	Country	Comment
1		Benefit Cost Analysis For Installing Raised Reflective Pavement Markers on Some Rural State Highways			NZ	At Travers Morgan NZ Ltd (TM).
2		Scottish White Lining Programme Reduces Accidents By One Third	Local Transport Today	1992	UK	At TM.
3	Agent KR	Traffic Control and Accidents at Rural High-Speed Intersections	Transportation Research Record 1160, Washington DC: Transportation Research Board, pp.14-21.		USA	At TM.
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11	Berg WD, Kaub AR and Belscamper BW	Case Study Evaluation of the Safety and Operational Benefits of Traffic Signal Coordination	Transportation Research Record 1057, Transportation Research Board, pp. 58-64.		USA	At TM.
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66	Frith WJ and Harte DS	The Safety Implications of Some Control Changes at Urban Intersections	Accident Analysis and Prevention, Vol.18, No.3, pp. 183-192.	1986	NZ	At TM.
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114	Malo AF	Signal Modernization	Highway Research Board, Special Report 93, Washington DC: Highway Research Board, pp. 96-126.	1967	USA	Referred by 49.
115	Maycock G and Hall RD	Accidents at 4-arm Roundabouts	TRRL Report LR1120.	1984	UK	Referred by 43.
116	McCarthy J, Scruggs JC and Brown DB	Estimating the Safety Benefits for Alternative Highway and/or Operational Improvements	Report No. FHWA/RD-81/179, Federal Highway Administration, Washington DC.	1981	USA	Referred by 13.
117	McCoy P and Malone M	Safety Effects of Left Turn Lanes on Urban Four Lane Roadways	Transportation Research Record 1239, Washington DC.	1989	USA	Referred by 182.
118	McCoy PT and Hoppe WJ	Traffic Operations Study of the Turning Lanes on Uncontrolled Approaches of Rural Intersections	Transportation Research Record 1100.	1986		At TM.

No.	Author	Title of the article	Source of the article	Year	Country	Comment
119	Middleton IH and Strickland TL	Fundamentals of Traffic Engineering Course	Traffic Engineering Division, Road Construction Authority Victoria.	1983	AUS	Referred by 84.
120	Missouri State Highway Commission	Manual of Identification, Analysis and Correction of High Accident Locations		1975	USA	TNZ - Anatole Sergejew - Accident Investigation Workshop (1991).
121	Moore S and Lowrie PR	Further on the Effects of Co-ordinated Traffic Signal Systems on Traffic Accidents	ARRB Proceedings, Vol. 8, Part 5, pp.10-15.	1976	AUS	Referred by 83.
122	Moses P	Things That Go Bump in the Night	Western Roads, pp.5-11.		AUS	At TM.
123	Moses PJ	Edge Lines and Single Vehicle Accidents	Western Roads, pp.6-8.	1986	AUS	At TM. Referred by 182.
124	Moses PJ	Traffic Management in New Zealand 1991 - A Perspective			NZ	At TNZ.
125	Moses, PJ	Combating the Road Toll	Western Roads, pp.4-5.		AUS	At TM.
126	Moses, PJ	Pedestrian Safety - A Comparison of the Pedestrian Safety of Median Islands and Marked Crossings	Western Roads, p.12.		AUS	At TM.
127	Moses, PJ	Cat's Eyes Cost Effective	Western Roads, pp.4-5.		AUS	At TM.
128	Moses, PJ	Regulatory Sign Control at Hazardous Intersections	Western Roads, p.9.		AUS	At TM.
129	Moses, PJ	The Urban Epidemic	Western Roads, pp.12-13.		AUS	At TM.
130	Moses, PJ	Where Have All The Zebras Gone?	Western Roads, pp.15-16.		AUS	At TM.
131	Musick JV	Effect of Pavement Edge Marking on Two-Lane Rural State Highways in Ohio	Highway Research Board Bulletin 266, Washington DC: Highway Research Board.	1960	USA	Referred by 35, 45 and 182.
132	Nairn RJ and Partners Pty. Ltd.	A Review of the Cost-Effectiveness of Road Safety Measures	Road Safety Division, Report Series 10/87.	1987	AUS	At TM.
133	NAO	Department of Transport, Scottish Development Department and Welsh Office: Road Safety	Report by the Controller and Auditor General, National Audit Office, Her Majesty's Stationary Office.	1988	UK	Referred by 161.
134	Nguyen T	Pilot Analysis of a Sample of Low Cost Treatments at Signalised Intersections	Traffic Programs Groups, Australian Department of Transport.	1986	AUS	At TM (abstract only).

No.	Author	Title of the article	Source of the article	Year	Country	Comment
135	Nguyen T, Hodge G and Hall K	The Road Safety Effectiveness of Traffic Signal Installation at 4-Leg Intersections in Victoria	Program Development Group, Australia Ministry of Transport.	1987	AUS	At TM.
136	Nicholas Clark and Associates	Rural Road Accident Literature Review	South Australian Department of Transport, Road Safety Division, Working Paper 2/85.		AUS	At TMA.
137	Nuemann TR, et. al.	Accident Analysis for Highway Curves	Transportation Research Record 923.	1983		Referred by 182.
138	O'Brien A and Richardson E	Use of Roundabouts in Australia	Institute of Transportation Engineers, Compendium of Technical Papers, 55th Annual Meeting, New Orleans.	1985	UK	Referred by 148.
139	Olsen PL et al.	Parameters Affecting Stopping Sight Distance	Washington DC; Transportation Research Board; NCHRP Report 270.	1984	USA	Referred by 45.
140	Pak-Poy and Kneebone Pty Ltd	Road Safety Benefits from Rural Road Improvements	Transport and Communications - Federal Office of Road Safety, Canberra.	1988	AUS	Referred by 183.
141	Pak-Poy and Kneebone Pty Ltd	Roadside Hazards Removal Programme (Draft Report)	Traffic Authority of New South Wales.	1986	AUS	At RTA.
142	Persaud B, Hauer E and Lovell J	The Safety Effect of Conversion to All-Way Stop Control in Philadelpia	Department of Civil Engineering, University of Toronto, Publication No. 84-14.	1984	CAN	Referred by 143.
143	Persaud BN	Are Safety Measures More Effective Where There Are Many Accidents? Do Accidents Migrate? Some Findings on These and Other Issues	Transport Safety Studies Group, Department of Civil Engineering, University of Toronto.	1985	CAN	At TM.
144	Pharaoh T and Russell J	Traffic Calming: Policy and Evaluations in Three European Countries	Occasional Paper 2, South Bank Polytechnic.	1989	UK	Referred by 147.
145	Planning and Research Bureau, Montana Department of Highways	Field Evaluation of Experimental Delineation	Prepared for Federal Highway Administration under Contract DOT-FH-11-8611.	1980	USA	Referred by 13.
146	Polus A	Driver Behaviour and Accident Records at Unsignalized Urban Intersections	Accident Analysis and Prevention, Vol.17, No.1, pp. 25-32.	1985	ISR	At TM.
147	Proctor S	Accident Reduction Through Area-Wide Traffic Schemes	Traffic Engineering and Control, pp. 566-573.	1991		At TM.

No.	Author	Title of the article	Source of the article	Year	Country	Comment
148	Richardson E	Accidents at Roundabouts - An Update	Paper presented to the 7th State Conference of the Local Government Engineers' Association of Western Australia.	1990	AUS	At TM.
149	Richardson E	Experience with Road Humps and Roundabouts in Perth	Local Government Engineers' Association of Western Australia Seminar on Area Traffic Management.	1982	AUS	Referred by 148.
150	Richardson G	The Road Safety Effects of Accident Blackspot Treatments	Australian Ministry of Transport.	1987	AUS	At TM.
151	Rinde EA	Accident Rates vs. Shoulder Width	Report CA-DOT-TR-314-1-77-01, California Department of Transportation.	1977	USA	Referred by 84 and 204.
152	Rinde EA and Smith RN	Conventional Road Safety	ITE Journal.	1981		At TM.
153	Road Construction Authority	Road Accident Information	An internal report prepared for the National Association of State Road Authorities National Roads Study.	1982		Referred by 43.
154	Road Construction Authority (RCA)	Submission to the Social Development Committee Inquiry into Road Safety in Victoria		1983	AUS	Referred by 84.
155	Road Safety Bureau, Roads and Traffic Authority, NSW	Guidelines For Crash Reduction at Hazardous Locations	Unpublished.		AUS	At TMA.
156	Road Traffic Authority (RTA)	Road Safety and Traffic Management Programs: A Cost Benefit Analysis		1986	AUS	At RTA.
157	Sach N, Negus BJ and Fox C	The Traffic Facilities Program's Contribution to Road Safety and Performance of the Road Network	Road Traffic Authority, Traffic Management Division.	1986		At TMA.
158	Sanderson JT, Cameron MH and Fildes BN	Identification of Hazardous Road Locations: Procedural Guidelines	Federal Office of Safety, Report CR38, Civic Square, A.C.T.	1985		Referred by 155.
159	Schreuder DA	Public Lighting	Proceedings of the International Workshop "Recent Developments in Road Safety Research", Koninklijk Conservatorium, The Hague.	1986	NET	At TM (abstract only).
160	Scriven RW	Raised Median Strips - A Highly Effective Road Safety Measure	13th ARRB Conference/5th REAAA Conference, Vol. 13, Part 9.	1986	AUS	At TM.

No.	Author	Title of the article	Source of the article	Year	Country	Comment
161	Searles B	Road Safety and Traffic Management - Europe Scandinavia and United Kingdom	NRMA, Sydney.	1989	AUS	At MOT and TMA.
162	Searles B	Overseas Investigations - Road Safety Countermeasures	Traffic and Safety Department, NRMA, ISBN 909932-77-8.	1985	AUS	At TMA.
163	Shimogami T	Efficiency Analysis of Traffic Safety Countermeasures	PWRI Newsletter No.28, pp. 51-57.	1987	JAP	At TM.
164	Short MS, Woelfl GA and Chang CJ	Effect of Traffic Signal Installation on Accidents	Accident Analysis and Prevention, Vol. 18, No. 3, pp. 135-145.	1982		Referred by 66.
165	Sicking DL and Ross HE	Benefit-Cost Analysis of Roadside Safety Alternatives	Transportation Research Record 1065, pp.98-105.	1986	USA	At TM.
166	Simpson D and Brown M	A Review of Recent Department of Transport Accident Based Studies Part I	The Journal of the Institution of Highways and Transportation, pp. 15-20.	1988	UK	At TM.
167	Simpson D and Brown M	A Review of Recent Department of Transport Accident Based Studies Part II	The Journal of the Institution of Highways and Transportation, pp. 26-28.	1988	UK	At TM.
168	Solomon D	Traffic Signals and Accidents in Michigan	Public Roads, Vol. 30, pp. 234-237.	1959	USA	Referred by 49.
169	South Australian Department of Transport	Rural Road Accident Study Literature Review	NHMRC, Road Accident Research Unit and Nicholas Clark and Associates, Working paper 2/85, Part 3, Policy and Research Branch.	1985	AUS	Referred by 132.
170	Stewart D and Chudworth CJ	A Remedy For Accidents at Bends	Traffic Engineering and Control, pp. 88-93.	1990	UK	At TM.
171	Summersgill I	Traffic Management at Major Roadworks on Motorways: Safety Performance in 1982	Proceedings of Seminar M held at the PTRC Summer Annual Meeting, University of Sussex, England, pp. 15-18, Vol. P269.	1985	UK	At TM.
172	Teale G	The Evaluation of the Effectiveness of Low Cost Traffic Engineering Projects	Office of Road Safety, Department of Transport Australia, Report CR22.	1984	AUS	At TMA.
173	The Department of Transport	Accident Investigation Manual	Marsham St, London.	1986	UK	TNZ - Anatole Sergejew - Accident Investigation Workshop (1991).
174	Thomas DC	Traffic Control Measures in a Provincial City	1984 IPENZ Conference.	1984	NZ	Referred by 88.

No.	Author	Title of the article	Source of the article	Year	Country	Comment
175	Thomas IL	Pavement Edge Lines on Twenty-Four Foot Surfaces in Louisiana	Highway Research Board Bulletin 178, Washington DC: Highway Research Board.	1958	USA	Referred by 182.
176	Thompson B	Raised Reflective Pavement Markers on Centre-Lines of 2-Lane, 2-Way Roads - Before and After Study	Inter-Office Memo, R.C A, Victoria.	1980	AUS	Referred by 7.
177	Thompson SJ, Heydon SJ and Charnley CB	Pedestrian Refuge Schemes in Nottingham	Traffic Engineering and Control, pp.118-123.	1990	UK	At TM.
178	Torpey S, Ogden K, Cameron M and Vulcan P	Indicative Benefit/Cost Analysis of Road Trauma Countermeasures - Interim Report for Discussion	Monash University Accident Research Centre.		AUS	At TM.
179	Transport and Road Research Laboratory	..While TRRL Push Continental-Style Environmental 'Woonerfs'	Local Transport Today.	1991	UK	At TM.
180	Transport Canada	Road Safety Annual Report			CAN	TNZ - Anatole Sergejew - Accident Investigation Workshop (1991)
181	Transportation Research Board - National Research Council	Geometrics and Safety Considerations	Transportation Research Record 960, Washington DC.	1984	USA	Referred by 182.
182	Travers Morgan Pty Ltd	Review of Road Safety and Government Investment in Road Improvements	The Australian Roads Outlook Report, Working Papers, Vol.2, Benefits of Roads, National Association of Australian State Road Authorities.	1987	AUS	At TMA.
183	Travers Morgan Pty Ltd	Road Features Safety Assessment	Prepared for the Road Safety Bureau, Roads and Traffic Authority.	1991	AUS	At TM.
184	UK Department of Transport	Accidents Investigation Manual		1984	UK	Referred by 40.
185	UK Department of Transport	The UK Investigation Manual		1986	UK	Referred by 43.
186	Urbanik T and Bonilla CR	California Experience with Inside Shoulder Removals	Transportation Research Record N1122, pp. 37-46, Transportation Research Board.	1987	USA	At TM.
187	US Department of Transportation - Federal Highway Administration	The 1990 Annual Report on Highway Safety Improvements Programs	US Department of Transportation, Washington DC.	1990	USA	Referred by 182.
188	van den Dool D	LATM Design Optimisation: Can We Please Everyone?	NRMA Publication.	1988	AUS	Referred by 161.

No.	Author	Title of the article	Source of the article	Year	Country	Comment
189	Viner JG and Boyer GM	Accident Experience with Impact Attenuation Devices	Washington DC: Federal Highway Administration.	1973	USA	Referred by 45.
190	VTI	Traffic Safety at Junctions	VTI Annual Report.	1987		At TM.
191	WA MRD	Western Australia MRD		1985	AUS	TMA database.
192	Walker CD and Lines CJ	Accident Reductions From Trunk Road Improvements	Research Report 321, Transport and Road Research Laboratory, Department of Transport.		UK	At TM.
193	Walker JS and Pittam SR	Accidents at Mini-Roundabouts: Frequencies and Rates	TRRL, Crowthorne, Berkshire.	1989	UK	Referred by 182.
194	Ward H, Norrie JD, Allsop RE and Sang AP	Urban Safety Project: The Bristol Scheme	TRRL, Crowthorne, Berkshire.	1989	UK	At TM.
195	Williams MC	Injury Accidents to Pedal-Cyclists on Roads With Converted Footways	Transport and Road Research Laboratory, Traffic Engineering and Control.	1989	UK	At TM.
196	Willis PA, Scott PP and Barnes JW	Road Edgelining and Accidents: An Experiment in South-West England	TRRL Laboratory Report 1117, TRRL.	1984	UK	Referred by 182.
197	Wong S	Effectiveness of Pavement Grooving in Accident Reduction	ITE Journal, pp. 34-37.	1990	USA	At TM.
198	Wylde L	Rural Road Accident Study: Summary	Road Safety Division, Working Paper 2/85 Part 2, Department of Transport, South Australia.	1985	AUS	Referred by 84.
199	Yee WCKO and Bell MGH	The Impact on Accidents and Driver Behaviour of Concentric Lane-Markings in Small Roundabouts	Traffic Engineering and Control.	1986	UK	At TM.
200	Zador PL	Effect of Pavement Markers on Night Time Crashes in Georgia	Transportation Research Record.	1982	USA	Referred by 7.
201	Zegeer C, Agent K and Rizenbergs R	Use of Economic Analyses and Dynamic Programming in the Selection of Projects for Resurfacing	Lexington, Kentucky: DOT Division of Research.	1979	USA	Referred by 45.
202	Zegeer CV	Methods for Identifying Hazardous Highway Elements	National Co-operative Highway Research Programs, Transport Research Board.	1986	USA	Referred by 182.
203	Zegeer CV and Cynecki MJ	Determination of Cost Effective Roadway Treatments for Utility Pole Accidents	Transportation Research Record 970, Washington DC.	1984	USA	Referred by 182.

No.	Author	Title of the article	Source of the article	Year	Country	Comment
204	Zegeer CV and Deacon J	Effect of Lane Width, Shoulder Width and Shoulder Type on Highway Safety: A Synthesis of Prior Literature	Washington DC: Transport Research Board, National Research Council State of the Art Report #6.	1986	USA	At TM.
205	Zegeer CV and Parker Jr. MR	Effects of Traffic and Roadway Features on Utility Pole Accidents	Transportation Research Record 970, Washington DC: Transportation Research Board pp. 65-76.	1984	USA	Referred by 45.
206	Zegeer CV, Hummer J, Reinfurt DW, Herf L and Hunter W	Safety Effects of Cross Section Design for Two Lane Roads	Transportation Research Record 1195, Transportation Research Board.	1986	USA	At TM.
207	Zegeer CV, Reinfurt DW, Hunter WW, Hummer J, Stewart R and Herf L	Accident Effects of Sideslope and Other Roadside Features on Two-Lane Roads	Transportation Research Record 1195, Transportation Research Board, pp. 33-47.	1988	USA	At TM.

APPENDIX D.

SYNOPSES OF SELECTED REFERENCES ARRANGED BY TREATMENTS

APPENDIX D. SYNOPSES OF SELECTED REFERENCES, ARRANGED BY TREATMENTS

TABLE D.1 AREA-WIDE SCHEMES - STREET CLOSURES

REFERENCE: Teale, Graeme 1984. The evaluation of the effectiveness of low cost traffic engineering projects. *Australian Department of Transport, Office of Road Safety, Report CR 22.*

REF. NO: 172

TREATMENT: Street closures (part of area traffic management).

LOCATION: South Australia: 71 projects.

STUDY: Before-and-after technique was used. Sites where traffic volumes changed substantially from normal growth patterns were excluded. A separate control group, with all intersections on roads of the same classification, was used to compare the effect of other factors which vary over time. The control group was made as large as possible to minimise the effects of statistical variation within the control group.

COMMENT: Method appears to be sound.

RESULTS: Accident numbers before and after street closures.

Type of Accident	Before	After
Casualty	131.6	34.2
Property damage	304.0	87.4
Total accidents	444.1	119.2

Notes:
1. All accident numbers adjusted to base year 1975 by control factors.
2. Each row has been adjusted by a control factor for this class of accident. The total row is the adjusted value of the total number of accidents, and not the sum of the preceding two rows.

TABLE D.2 DELINEATION

REFERENCE: Shimogami, Tamio 1987. Efficiency analysis of traffic safety countermeasures. *PWRI (Public Works Research Institute) Newsletter* No. 28: 51-57.

REF. NO: 163

TREATMENT: Road delineators installed between 1979 and 1981. Type of delineators is not specified.

LOCATION: 129 sites over 50 km of highway.

STUDY: A before-and-after comparison of accident types over one year. The most probable accident rate is calculated by a regression formula, taking into account specific factors of road and traffic conditions such as average daily traffic volume, width of carriageway, density of traffic entering signalised intersections, and average daily traffic volumes of bicycles and pedestrians.

COMMENT: Using only one year of before-and-after data is suspect. No allowance appears to have been made for bias-by-selection.

RESULTS: Reduction rates in accidents following installation of road delineators.

Accident Type		Reduction Rates %
Accident pattern	Single vehicle	85
Time of day	Night	65
Type of vehicle	Passenger car	62
	Motorcycle	72
Travelling speed	Faster than 70 km/hr	71
Grade	Upward slope	62
	Downward slope	74
Pavement surface	Wet	67
All accident types		60

TABLE D.3 DELINEATION - EDGELINE MARKING

REFERENCE: Moses, P.J. 1986. Edgelines and single vehicle accidents. *Western Roads,* April 1986: 6-8.

REF. NO: 123

TREATMENT: Edgeline widths of 150mm, impregnated with glass beads. Implemented in 1984.

LOCATION: West Australia: over 650km of highways which radiate from Perth.

STUDY: A before-and-after study of out-of-control and head-on accidents.

COMMENT: Study details were not provided.

RESULTS: Accident numbers before and after edgeline marking.

Accident Category	Before	After
All accidents	270	249
Out of control	83	55
Head-on	18	17

TABLE D.4 DELINEATION - RAISED PAVEMENT MARKERS

REFERENCE: Moses, P.J. 1985. Cat's eyes cost effective. *Western Roads,* October 1985: 4-5.

REF. NO: 127

TREATMENT: Raised reflectorised pavement markers (RRPMs) used to complement painted longitudinal lines.

LOCATION: Western Australia: 28 km of major dual and undivided carriageways.

STUDY: A 12-month before-and-after study was conducted.

COMMENT: Using only one year of before-and-after data is suspect. Additional study details were not provided.

RESULTS: Accident numbers before and after delineation, using raised reflectorised pavement markers.

Accident Category	Before	After
Rear-end	502	469
Head-on	33	10
Side-swipe	146	106
Right angle	300	302
Hit object	54	58
Hit pedestrian	11	15
Other	25	43
Total accidents	1071	1003

TABLE D.5 ROADSIDE HAZARDS - GUARDRAIL

REFERENCE: Shimogami, Tamio 1987. Efficiency analysis of traffic safety countermeasures. *PWRI Newsletter* No. 28: 51-57.

REF. NO: 163

TREATMENT: Guardrails installed between 1979 and 1981.

LOCATION: 163 sites over 26 km of highway.

STUDY: A one-year before-and-after comparison. The most probable accident rate is calculated by a regression formula taking into account specific factors of road and traffic conditions such as average daily traffic volume, width of carriageway, density of traffic entering signalised intersections, and average daily traffic volumes of bicycles and pedestrians.

COMMENT: Using only one year of before-and-after data is suspect. No allowance appears to have been made for bias-by-selection.

RESULTS: Reduction rates in accidents following guardrail installation.

Accident Type		Reduction Rates (%)
Accident pattern	Hitting pedestrian	82
	Single vehicle	74
	Vehicle-to-vehicle	52
Time of day	Night	72
Type of vehicle	Motorcycle	71
Travelling speed	Faster than 70 km/hr	93
Grade	Upward slope	72
	Downward slope	66
Pavement surface	Frozen or snowy	decreased
	Dry	62
All accident types		61

TABLE D.6 INTERSECTIONS - CHANNELISATION

REFERENCE: Teale, Graeme 1984. The evaluation of the effectiveness of low cost traffic engineering projects. *Australian Department of Transport, Office of Road Safety, Report CR 22.*

REF. NO: 172

TREATMENT: New and modified channels at signalised and non-signalised intersections.

LOCATION: South Australia: 21 urban non-signalised intersections where new channelisation was implemented during a four-year period. 2 T-junctions where channels were modified.
Western Australia: 39 signalised and 38 non-signalised intersections where new channelisation was implemented. 2 signalised and 7 non-signalised intersections where channels were modified.

STUDY: Before-and-after technique was used. Sites where traffic volumes changed substantially from normal growth patterns were excluded. A separate control group was used to compare the effects of those factors which vary over time. The control group was made as large as possible to minimise the effects of statistical variation within the control group.

COMMENT: Method appears to be sound.

RESULTS: Accident numbers before and after channelising intersections.

Type of Accident	Signalised Intersections		Non-signalised Intersections	
	Before	After	Before	After
New Channelisation				
Casualty	140.6	103.5	254.6	114.2
Property damage	542.6	426.0	1073.4	546.8
Total	681.6	529.4	1326.8	657.8
Modified Channelisation				
Casualty	4.0	4.9	44.5	16.2
Property damage	24.1	45.7	353.7	117.1
Total accidents	28.5	50.9	400.6	134.6

Notes:
1. All accident numbers adjusted to base year 1975 by control factors.
2. Each row has been adjusted by a control factor for this class of accident. The total row is the adjusted value of the total number of accidents, and not the sum of the preceding two rows.

TABLE D.7 INTERSECTIONS - ADD LANES

REFERENCE: Teale, Graeme 1984. The evaluation of the effectiveness of low cost traffic engineering projects. *Australian Department of Transport, Office of Road Safety, Report CR 22.*

REF. NO: 172

TREATMENT: Provide additional lanes at intersections.

LOCATION: South Australia: 4 sites. At 2 sites the additional lane allowed separation of left and right turners.
Western Australia: 1 site, where a left-turn lane was added to the tail of an urban T-junction.

STUDY: Before-and-after technique was used. Sites where traffic volumes changed substantially from normal growth patterns were excluded. A separate control group was used to compare the effects of those factors which vary over time. The control group was made as large as possible to minimise the effects of statistical variation within the control group.

COMMENT: Method appears to be sound.

RESULTS: Accident numbers before and after adding lanes at intersections.

Type of Accident	South Australia		Western Australia	
	Before	After	Before	After
Casualty	83.8	22.4	30.9	4.9
Property damage	343.5	132.9	106.2	38.8
Total accidents	427.8	156.6	137.2	43.4

Notes:
1. All accident numbers adjusted to base year 1975 by control factors.
2. Each row has been adjusted by a control factor for this class of accident. The total row is the adjusted value of the total number of accidents, and not the sum of the preceding two rows.

TABLE D.8 INTERSECTIONS - ROUNDABOUTS

REFERENCE: Teale, Graeme 1984. The evaluation of the effectiveness of low cost traffic engineering projects. *Australian Department of Transport, Office of Road Safety, Report CR 22.*

REF. NO: 172

TREATMENT: Install roundabouts.

LOCATION: South Australia: 59 isolated roundabouts and 4 roundabouts which formed part of an area traffic management scheme were studied. The sites covered 48 intersections of non-classified roads, 2 country town sites and one city site. The other sites covered low traffic volume-classified urban roads.

STUDY: Before-and-after technique was used. Sites where traffic volumes changed substantially from normal growth patterns were excluded. A separate control group, all non-signalised intersections with four or more legs, was used to compare the effects of those factors which vary over time. The control group was made as large as possible to minimise the effects of statistical variation within the control group.

COMMENT: Method appears to be sound.

RESULTS: Accident numbers before and after installation of roundabouts at intersections.

Type of Accident	Roundabouts		Roundabouts (Part of LATM)	
	Before	After	Before	After
Casualty	208.6	46.3	1.5	1.1
Property damage	487.8	202.5	26.6	4.7
Total accidents	705.3	248.5	28.5	5.8
	Reduction			
Right angle	80%			

Notes:
1. All accident numbers adjusted to base year 1975 by control factors.
2. Each row has been adjusted by a control factor for this class of accident. The total row is the adjusted value of the total number of accidents, and not the sum of the preceding two rows.

TABLE D.9 INTERSECTIONS - STAGGERED T

REFERENCE: Teale, Graeme 1984. The evaluation of the effectiveness of low cost traffic engineering projects. *Australian Department of Transport, Office of Road Safety, Report CR 22.*

REF. NO: 172

TREATMENT: Convert cross intersection to T-junction.

LOCATION: South Australia: 15 urban intersections converted in the period between 1976 to 1978. These sites had relatively low traffic volumes and accident numbers, but accidents were more severe than average.
Western Australia: 2 intersections converted.

STUDY: Before-and-after technique was used. Sites where traffic volumes changed substantially from normal growth patterns were excluded. A separate control group, all non-signalised 4-way intersections, was used to compare the effects of those factors which vary over time. The control group was made as large as possible to minimise the effects of statistical variation within the control group.

COMMENT: Method appears to be sound.

RESULTS: Accident numbers before and after converting intersections to staggered T junctions.

Type of Accident	South Australia		West Australia	
	Before	After	Before	After
Casualty	49.1	2.3	14.1	0.0
Property damage	142.5	26.9	46.1	3.3
Total accidents	193.9	29.4	59.9	3.3
	Reduction		Reduction	
Right angle	Not available		100%	
Rear end			80%	

Notes:
1. All accident numbers adjusted to base year 1975 by control factors.
2. Each row has been adjusted by a control factor for this class of accident. The total row is the adjusted value of the total number of accidents, and not the sum of the preceding two rows.

TABLE D.10 INTERSECTIONS - CONTROL CHANGES

REFERENCE: Bhesania, Russi P. 1991. Impact of mast-mounted signal heads on accident reduction. *Journal of the Institution of Transportation Engineers,* October 1991: 25-29.

REF. NO: 12

TREATMENT: Post-mounted signal heads at six intersections were replaced with mast-mounted signal heads. The controllers were replaced with modern Type 170 controllers. Direct buried cables were removed, and cables were placed in conduits wherever applicable. All-red intervals of one second were added for through-phases. Implemented in 1989.

LOCATION: Kansas City, Missouri, USA: five-hour (7-9 am and 3-6 pm) traffic counts made at six intersections indicated that the total volume of entering traffic during these periods ranged from a low of 13 675 to a high of 17 575.

STUDY: Twelve months of accident data from before-and-after periods for these intersections were reviewed. The before-and-after study periods are reasonably comparable because traffic volumes remained fairly constant and no other changes were implemented during the period.
Chi-square test affirmed that, at 95% confidence level, a statistical reduction in both the number of right-angle accidents and the number of total collisions occurred.

COMMENT: Using only one year of before-and-after data is suspect. The number of sites is small, and the number of changes at once are too many to attribute to signal displays.

RESULTS: Changes in numbers and % of accidents following installation of mast-mounted signals at intersections.

Type of Collision	No. of accidents		% Change
	Before	After	
Right angle	65	24	-63
Rear end	37	30	-19
Left turn	37	50	35
Other	22	16	-27
Total accidents	161	120	-25

TABLE D.11 INTERSECTIONS - CONTROL CHANGES

REFERENCE: Datta, Tapan K., Dutta, Utpal 1960. Traffic signal installation and accident experience. *Journal of the Institution of Transportation Engineers,* September 1990: 39-42.

REF. NO: 49

TREATMENT: Newly installed traffic signals, implemented between 1978 and 1983.

LOCATION: Michigan: 102 locations.

STUDY: Two to three years of accident data for both the before and the after periods were used to determine before-and-after accident rates (the number of accidents per million entering vehicles).
Accident rates, both before and after signal installation for all locations, were compared by two-tailed paired t-tests to determine if there was a statistically significant difference (at a 0.05 significance level) between the before and after periods.

COMMENT: No allowance appears to have been made for bias-by-selection.

RESULTS: Changes in before-and-after accident rates compared by paired t-tests, following control changes at intersections.

Accident Type	All Locations Combined			Locations with No Geometric Changes		
	Mean Accident Rate[1]		% Increase (+) or Decrease (-)	Mean Accident Rate		% Increase (+) or Decrease (-)
	Before	After		Before	After	
All accidents	1.87	1.47	-19.2	1.87	1.58	-15.5
Injury	0.58	0.48	-17.24	0.59	0.28	-52.5
Rear-end	0.32	0.49	+53.0	0.57	0.53	- 7.0[2]
Right-angle	0.56	0.24	-57.1	0.12	0.21	+75.0
Head-on	0.14	0.21	+50.0	0.31	0.51	+64.5
Other	0.80	0.53	-33.8	0.85	0.58	-31.8

Notes: [1] Mean Accident Rate : the mean number of accidents per million entering vehicles.

[2] Means are not significantly different.

TABLE D.12 INTERSECTIONS - CONTROL CHANGES

REFERENCE: Frith, W.J., Harte, D.S. 1986. The safety implications of some control changes at urban intersections. *Accident Analysis and Prevention* 18(3): 183-192.

REF. NO: 66

TREATMENT: Considers no control, simple stop, or give-way signs, roundabouts and signals.
The monthly series covers the period from January 1972 to December 1981.

LOCATION: New Zealand-wide selection (mostly Christchurch) of urban intersections where controls have been changed.

STUDY: Accident counts before and after control changes were collected from a sample of intersections. The study compares proportions of accidents at these intersections to all accidents in the neighbouring urban area in a way that isolates the control change effect from time effects and the local intersection effect. A binomial logit model was used. This method involves modelling the accident counts as a binomial random variable.

COMMENT: A sound study. Discussion on bias-by-selection is presented in paper.

RESULTS: Mean fractional change in monthly accident rate (from pp. 186-190) following control changes at intersections.

Intersection Conversion	Accident Type						
	All	Rear-end	Same road	Different roads	Single vehicle	Fatal & Serious	Minor
Uncontrolled 3-leg to signal control	1.1	3.2[1]	1.3	0.3[1]	1.4	1.2	0.9
Sign-controlled 3-leg to signal control	1.1	2.4	1.3	0.6	1.0	1.1	1.2
Uncontrolled 4-leg to signal control	0.6[1]	—	1.8	0.2[1]	—	1.0	0.5[1]
Sign-controlled 4-leg to signal control	0.7[1]	1.7	1.9	0.3[1]	0.8	0.7[1]	0.6[1]
Uncontrolled & signed 3- & 4-leg to roundabouts	0.4[1]	—	0.1	0.3[1]	—	0.2[1]	0.5[1]
Uncontrolled 3-leg to give-way or stop-sign control	0.9[1]	0.8	1.1	0.8	0.7	0.5[1]	1.1
Uncontrolled 4-leg to give-way sign control	0.3[1]	—	1.5	0.2[1]	—	0.2[1]	0.4[1]
Uncontrolled 4-leg to stop-sign control	0.3[1]	—	0.7	0.2[1]	—	0.2[1]	0.4[1]

Notes: [1]Significant at the 95% level.

TABLE D.13 INTERSECTIONS - CONTROL CHANGES

REFERENCE: Hodge, G.A., Daley, K.F., Nguyen, T.N. 1986. Signal co-ordination in regional areas of Melbourne - a road safety evaluation. *Proceedings of 13th ARRB - 5th REAAA Combined Conference,* 25-29 August 1986, 13(9): 178-190.

REF: NO: 83

TREATMENT: Traffic signal co-ordination using the SCAT (Sydney Co-ordinated Area Traffic) system in dynamic mode. Implemented about 1981 to 1982.

LOCATION: Melbourne: 10 co-ordinated routes. Intersections were either 4- or 3-leg sites, and previously operated under isolated signal control.

STUDY: Only casualty accidents were included in the analysis. A before-and-after analysis technique was adopted. The average before-period was four years and the average after-period was just over two years. Statistical control data were used. To assess the magnitude of bias-by-site selection (regression-to-the-mean), estimates of the number of expected casualty accidents in the after-period were made for all sites.

COMMENT: Method appears to be sound. However, no allowance appears to have been made for bias-by-selection.

RESULTS: Accident numbers and % changes along all linked routes (from p. 183) following control changes at intersections.

Type of Accidents	Signalised Intersections			Between Signalised Intersections			Total		
	E	O	C%	E	O	C%	E	O	C%
Pedestrian	30.3	27	-11^{NS}	44.8	36	-20^{NS}	75.1	63	-16^{NS}
Cross-traffic	36.6	31	-15^{NS}	20.0	21	$+5^{NS}$	56.1	52	-8^{NS}
Right-against	155.4	103	-34^{**}	14.7	10	-32^{NS}	170.1	113	-34^{**}
Rear-end	77.2	87	$+13^{NS}$	87.4	124	$+42^{*}$-	164.6	211	$+28^{*}$-
Other	69.1	43	-38^{**}	144.4	152	$+5^{NS}$	213.5	195	-9^{NS}
All Types	368.6	291	-21^{**}	311.3	343	$+10^{NS}$	679.6	634	-7^{NS}

Notes: 1. E : Expected number of accidents. O : Observed numbers. C = (O-E)/E change in percent (%). Minus sign (-) : indicates a reduction. Plus sign (+) : indicates an increase.

2. NS : statistically not significant at a 0.10 significance level.

3. *_, *, ** : statistically significant at the 0.10, 0.05 and 0.01 levels respectively.

TABLE D.14 INTERSECTIONS - CONTROL CHANGES

REFERENCE: Lovell, J., Hauer, E. 1986. The safety effect of conversion to all-way stop control. *Transportation Research Record* 1068: 103-107. Transportation Research Board, Washington, DC.

REF. NO: 107

TREATMENT: Converted traffic control from 2-way to all-way stop control at both rural and urban intersections.

LOCATION: San Francisco: 49 intersections (existing 1-year before-and-after study).
Philadelphia: 222 intersections (existing 2-year before-and-after study).
Michigan: 10 rural intersections (existing 7-year period study).
Toronto: 79 intersections (new 1973 to 1983 study).

STUDY: Three re-analysed and de-biased (for regression-to-the-mean bias) recent data sets and one newly analysed and assembled set. To assess the magnitude of bias-by-site selection (regression-to-the-mean), estimates of the number of expected casualty accidents in the after-period were made for all sites.

COMMENT: Not applicable to New Zealand because it used 4-way stops in completely different situations to usage in New Zealand.

RESULTS: Most likely percent accident reductions (%) following control changes at intersections.

Accident Type	San Francisco %	Philadelphia %	Michigan %	Toronto %	Combined (%)
Right-angle	84	78	64	48	72
Rear-end	-305	20	19	22	13
Left-turn	33	-	-7	25	20
Pedestrian	66	40	-	42	39
Fixed object	-	-30	-	-	-
Injury	74	74	62	63	71
Total accidents	62	47	59	37	41

TABLE D.15 INTERSECTIONS - CONTROL CHANGES

REFERENCE: Nguyen, T.; Hodge, G.; Hall, K. 1987. The road safety effectiveness of traffic signal installation at 4-leg intersections in Victoria. Program Development Group, Australia Ministry of Transport.

REF. NO: 135

TREATMENT: Changed the mode of traffic control from priority signs (e.g. Give-Way, Stop Signs) to control by traffic signals, at 4-leg intersections. Implemented between 1976 and 1982.

LOCATION: Melbourne Metropolitan area: 82 sites but not in the City of Melbourne.

STUDY: Only casualty accidents were included in the analysis. A before-and-after analysis technique was adopted. Statistical control data were used. To assess the magnitude of bias-by-site selection (regression-to-the-mean), estimates of the number of expected casualty accidents in the after-period were made for all sites.

COMMENT: Method appears to be sound.

RESULTS: Before-and-after studies of accident numbers and % changes following control changes at intersections.

Type of Accidents	Expected Number	Actual Number	Change (%)	Significant
Pedestrian-related accidents	35	49	+39	NS
Cross-traffic accidents	531	83	-84	**
Right-against accidents	88	133	+52	**
Rear-end accidents	76	52	-31	*_
Other	155	53	-66	**
All types of accidents	885	370	-58	**

Notes:
- NS : Not statistically significant at a level of 0.10.
- * : Statistically significant at a level of 0.05.
- ** : Statistically significant at a level of 0.01 or higher.
- *_ : Statistically significant at a level of 0.10.

- \- sign : A reduction in accidents after the treatment was implemented.
- \+ sign : An increase in accidents after the treatment was implemented.

TABLE D.16 INTERSECTIONS - CONTROL CHANGES

REFERENCE: Teale, Graeme 1984. The evaluation of the effectiveness of low cost traffic engineering projects. *Australian Department of Transport, Office of Road Safety, Report CR 22.*

REF. NO: 172

TREATMENT: New, modified and co-ordinated traffic signals.

LOCATION: South Australia: 49 signals modified; 24 new signals installed between 1975 and 1978.
Western Australia: 5 signals modified in 1978 and 1979; 44 new signals installed.

STUDY: Before-and-after technique was used. Sites where traffic volumes changed substantially from normal growth patterns were excluded. A separate control group was used to compare the effects of those factors which vary over time. The control group was made as large as possible to minimise the effects of statistical variation within the control group.

COMMENT: Method appears to be sound.

RESULTS: Accident numbers before and after changes to controls at intersections.

Type of Accident	New Signals		Modified Signals		Signal Co-ordination	
	Before	After	Before	After	Before	After
Casualty	407.6	417.7	690.8	448.0	35.8	14.0
Property damage	2013.9	1883.1	3548.1	2714.7	139.2	70.8
Total accidents	2418.4	2298.4	4227.1	3180.9	173.2	85.1

Notes:
1. All accident numbers adjusted to base year 1975 by control factors.
2. Each row has been adjusted by a control factor for this class of accident. The total row is the adjusted value of the total number of accidents, and not the sum of the preceding two rows.

TABLE D.17 LIGHTING

REFERENCE: Commission Internationale de l'Eclairage (CIE) 1990. Road lighting as an accident countermeasure. *CIE Technical Report No.* 8/2, final version, September 1990.

REF. NO: 34

TREATMENT: Road lighting.

LOCATION: 15 countries.

STUDY: 62 world-wide lighting and accident studies are rigorously analysed.

COMMENT: Contains the details and data of each of the 62 lighting and accident studies.

RESULTS: 85% of results show lighting to be beneficial; about one third of them have statistical significance.

TABLE D.18 LIGHTING

REFERENCE: Shimogami, Tamio 1987. Efficiency analysis of traffic safety countermeasures. *PWRI Newsletter* No. 28: 51-57.

REF. NO: 163

TREATMENT: Road lighting installed between 1979 and 1981.

LOCATION: 124 sites over 18 km of highway.

STUDY: A one-year before-and-after comparison. The most probable accident rate is calculated by a regression formula taking into account the specific factors of road and traffic conditions such as average daily traffic volume, width of carriageway, density of traffic entering signalised intersections, and average daily traffic volumes of bicycles and pedestrians.

COMMENT: Lighting is applied to more hazardous road segments only. Using only one year of before-and-after data is suspect. No allowance appears to have been made for bias-by-selection.

RESULTS: Reduction rates in accidents following installation of road lighting.

Accident Type		Reduction Rates (%)
Accident pattern	Hitting pedestrian	72
	Single vehicle	63
Time of day	Night	77
Type of vehicle	Passenger car	63
Travelling speed	Faster than 70 km/hr	74
	50-70 km/hr	67
Grade	Upward slope	59
	Downward slope	69
Pavement surface	Wet	63
All accident types		58

TABLE D.19 LIGHTING

REFERENCE: Teale, Graeme 1984. The evaluation of the effectiveness of low cost traffic engineering projects. *Australian Department of Transport, Office of Road Safety, Report CR 22.*

REF. NO: 172

TREATMENT: New and upgraded street lighting.

LOCATION: South Australia: new street lighting at one urban intersection and two rural T-junctions; upgraded street lighting at three sites.

STUDY: Before-and-after technique was used. Sites where traffic volumes changed substantially from normal growth patterns were excluded. A separate control group was used to compare the effects of those factors which vary over time. The control group was made as large as possible to minimise the effects of statistical variation within the control group.

COMMENT: Method appears to be sound.

RESULTS: Accident numbers before and after installation and upgrading of street lighting.

Type of Accident	New Street Lighting		Upgraded Street Lighting	
	Before	After	Before	After
Casualty	14.6	2.1	20.3	4.4
Property damage	79.4	22.4	63.9	41.2
Total accidents	93.3	23.2	84.8	46.4

Notes:
1. All accident numbers adjusted to base year 1975 by control factors.
2. Each row has been adjusted by a control factor for this class of accident. The total row is the adjusted value of the total number of accidents, and not the sum of the preceding two rows.

TABLE D.20 MEDIANS - INSTALL

REFERENCE: Beca Carter Hollings & Ferner Ltd 1991. Evaluation of safety benefits of motorway median barriers. Draft report prepared for Transit New Zealand, June 1991.

REF. NO: 10

TREATMENT: Median barriers installed where traffic volume exceeds 20 000 vehicles per day with a median width less than 6m. 86% of the medians were installed between 1986 and 1991.

LOCATION: New Zealand: motorways.

STUDY: Multivariate linear regression of accidents per kilometre per year for various classes of accidents on each section was undertaken to relate the accident rate to certain parameters (traffic volume, type of median installed, and median width) and whether a median was installed or not. Accident types which had been unaffected by the installation of median barriers were used as a control for non-median barrier-related effects for the before-and-after analysis.

COMMENT: No allowance appears to have been made for bias-by-selection.

RESULTS: Before-and-after log-odds tests of accident reductions following installations of median barriers.

Accident Severity	% Accident Reductions by Accident Type			
	Lane Change	Head On	Lost Control	Other
All	+42	-75	-27	-40
Minor Injury	+55	-56	-21	-32
Serious Injury	+17[a]	-75	-36[a]	-54
Fatal	-14[a]	-87	-39[a]	- 6[a]

Note: [a] Not significant at a 95% level of confidence.

TABLE D.21 MEDIANS - INSTALL

REFERENCE: Scriven, R.W. 1986. Raised median strips - a highly effective road safety measure. *Proceedings of 13th ARRB-5th REAAA Combined Conference* 13(9): 46-53.

REF. NO: 160

TREATMENT: Wide (i.e. sufficient to incorporate sheltered right-turn lanes) raised median strips installed on roads wide enough to accommodate them without reducing the number of traffic lanes. The wide raised medians replaced narrow (1.2m) raised medians and 1.8m painted flush medians.

LOCATION: Marion City, Australia: 1.5 km of urban road.

STUDY: Before-and-after comparison based on 8 years of accident data, 4 before, and 4 after.

COMMENT: Study details were not provided.

RESULTS: Changes in property-only and casualty accident rates[1] by accident type[2], following installations of medians.

Treatment	Property Damage Only					Casualty				
	Accident Type[2]									
	RE	SS	RA	FO	TOT	RE	SS	RA	FO	TOT
Before[3]	12.96	3.05	3.66	0	23.02	2.44	0.46	0.91	0.15	4.88
After[3]	5.93	2.97	1.98	0.71	14.97	1.98	0.56	0.42	0	3.81

Note:
1 Rates are expressed as accidents per 10 million vehicle kilometres of travel per year.
2 Accident type: RE = rear-end; SS = side-swipe; RA = right angle; FO = hit fixed object; TOT = total.
3 Before: medians were 1.8m painted flush medians.
After: medians were wide raised medians.

TABLE D.22 MEDIANS - INSTALL

REFERENCE: Shimogami, Tamio 1987. Efficiency analysis of traffic safety countermeasures. *PWRI Newsletter* No. 28: 51-57.

REF. NO: 163

TREATMENT: Centre barriers installed between 1979 and 1981.

LOCATION: 39 sites over 18 km of highway.

STUDY: A one-year before-and-after comparison. The most probable accident rate is calculated by a regression formula taking into account the specific factors of road and traffic conditions such as average daily traffic volume, width of carriageway, density of traffic entering signalised intersections, and average daily traffic volumes of bicycles and pedestrians.

COMMENT: Using only one year of before-and-after data is suspect. No allowance appears to have been made for bias-by-selection.

RESULTS: Reduction rates in accidents following installation of centre barrier medians.

Accident Type		Reduction Rates %
Accident pattern	Single vehicle	82
Type of vehicle	Motorcycle	increased
Travelling speed	Faster than 70 km/hr	58
Grade	Upward slope	61
	Downward slope	increased
Pavement surface	Frozen	100
All accident types		28

TABLE D.23 MEDIANS/MULTI-LANE - SAFETY FENCE

REFERENCE: Simpson, D.; Brown, M. 1988. A review of recent Department of Transport accident-based studies. Part 2. *Journal of the Institution of Highways and Transportation,* February 1988: 26-28.

REF. NO: 167

TREATMENT: Installation of central reserve safety fences on high-speed all-purpose dual-carriageway roads.

LOCATION: England: a sample of 150km of fenced and 150km of unfenced all-purpose dual carriageways; inter-urban roads, speed limits 60 or 70mph. Included a reasonable sample of high flow roads.

STUDY: Modelled by regression analysis of accidents both with and without fences. Used a generalised linear model formulation (available in GENSTAT).

COMMENT: Method appears to be sound. However, no allowance appears to have been made for bias-by-selection.

RESULTS: Accident rates (per million vehicle kilometres) following installation of central reserve safety fences.

Accident Type	Accident Severity	Accident Rates	
		Fenced	Unfenced
Onto	Fatal	0.07	0.13
	Serious	0.66	0.75
	Slight	1.16	1.59
	Total	1.89	2.47
Rebound	Fatal	0.00	0.02
	Serious	0.25	0.17
	Slight	0.71	0.30
	Total	0.96	0.48
Through	Fatal	0.12	0.29
	Serious	0.39	1.01
	Slight	0.40	1.06
	Total	0.91	2.36
Total median	Fatal	0.19	0.44
	Serious	1.30	1.92
	Slight	2.27	2.96
	Total	3.76	5.32
Non-median	Fatal	0.79	0.77
	Serious	3.79	4.28
	Slight	8.15	8.57
	Total	12.74*	13.62

* from publication

TABLE D.24 MEDIANS - CLOSE

REFERENCE: Teale, Graeme 1984. The evaluation of the effectiveness of low cost traffic engineering projects. *Australian Department of Transport, Office of Road Safety, Report CR 22.*

REF. NO: 172

TREATMENT: Close medians.

LOCATION: South Australia: 3 sites. One site on a busy urban main road (designed to prevent turning manoeuvres), two sites on lower volume unclassified roads (designed to re-define feasible movements and reduce the number of potential conflicts at critical points along the major route).
Western Australia: 1 site.

STUDY: Before-and-after technique was used. Sites where traffic volumes changed substantially from normal growth patterns were excluded. A separate control group, of all non-signalised intersections, was used to compare the effects of those factors which vary over time. The control group was made as large as possible to minimise the effects of statistical variation within the control group.

COMMENT: Method appears to be sound.

RESULTS: Accident numbers before and after closing medians.

Type of Accident	South Australia		Western Australia	
	Before	After	Before	After
Casualty	10.1	4.3	2.4	3.1
Property damage	75.1	53.6	25.1	24.6
Total accidents	84.9	59.1	28.1	27.6

Notes:
1. All accident numbers adjusted to base year 1975 by control factors.
2. Each row has been adjusted by a control factor for this class of accident. The total row is the adjusted value of the total number of accidents, and not the sum of the preceding two rows.

TABLE D.25 SHOULDERS AND LANES - PASSING LANES

REFERENCE: Harwood, D.W., St. John, A.D., Warren, D.L. 1985. Operational and safety effectiveness of passing lanes on two-lane highways. *Transportation Research Record* 1026: 31-39. FHWA, Transportation Research Board, Washington DC.

REF. NO: 78

TREATMENT: Passing lanes and short 4-lane sections were installed to provide increased opportunities for passing slow-moving vehicles on 2-lane highways.

LOCATION: USA: 66 passing-lane and 10 short 4-lane sites.

STUDY: Compares the mean accident rates for the treated and untreated sections of 2-lane highway. Also performed a matched-pair comparison between selected treated and untreated sites. The average length of the accident study period for the 66 passing-lane sites was 3.59 years.

COMMENT: No allowance appears to have been made for bias-by-selection.

RESULTS: Comparison of mean accident rates[1] following installation of passing lanes.

Accident Severity Level	Passing Lane Sections			Short 4-Lane Sections	
	Opposing Passing Prohibited	Opposing Passing Allowed	Untreated Sections	Treated Sections	Untreated Sections
Cross-Centreline					
- Fatal	0.026	0.018	0.026	0.033	0.007
- Injury	0.064	0.043	0.143	0.112	0.323
- PDO[2]	0.043	0.050	0.102	0.045	0.072
Total accidents	0.133	0.111	0.271	0.190	0.402
All Accidents Casualty	0.44[3]		0.83	0.77	1.36

Notes: 1 Mean accident rate is the number of accidents per million vehicle miles.
2 PDO = property damage only.
3 Treated and untreated combined.

TABLE D.26 SHOULDERS AND LANES - BUS BAYS

REFERENCE: Shimogami, Tamio 1987. Efficiency analysis of traffic safety countermeasures. *PWRI Newsletter* No. 28: 51-57.

REF. NO: 163

TREATMENT: Bus bays installed between 1979 and 1981.

LOCATION: 80 sites over 18 km of highway.

STUDY: A one-year before-and-after comparison. The most probable accident rate is calculated by a regression formula taking into account the specific factors of road and traffic conditions such as average daily traffic volume, width of carriageway, density of traffic entering signalised intersections, and average daily traffic volumes of bicycles and pedestrians.

COMMENT: Using only one year of before-and-after data is suspect. No allowance appears to have been made for bias-by-selection.

RESULTS: Reduction rates in accidents following installation of bus bays.

Accident Type		Reduction Rates (%)
Accident pattern	Vehicle to vehicle	48
	Single vehicle	47
Type of vehicle	Cargo truck	68
	Motorcycle	67
Travelling speed	50-70 km/hr	65
Pavement surface	Frozen or snowy	100
All accident types		46

TABLE D.27 PEDESTRIAN FACILITIES - REFUGES

REFERENCE: Teale, Graeme 1984. The evaluation of the effectiveness of low cost traffic engineering projects. *Australian Department of Transport, Office of Road Safety, Report CR 22.*

REF. NO: 172

TREATMENT: Western Australia: pedestrian refuge islands.
South Australia: safety bars (fencing designed to prevent access to the roadway by pedestrians except at designated crossing points).

LOCATION: Western Australia: 26 projects.
South Australia: 57 safety bar projects implemented between the years 1974 and 1978.

STUDY: Before-and-after technique was used. Sites where traffic volumes changed substantially from normal growth patterns were excluded. A separate control group was used to compare the effects of those factors which vary over time. The control group was made as large as possible to minimise the effects of statistical variation within the control group.

COMMENT: Method appears to be sound.

RESULTS: Accident numbers before and after installation of pedestrian refuges.

Type of Accident	Refuge Islands		Safety Bars	
	Before	After	Before	After
Casualty	72.6	34.3	114.9	105.9
Property damage	293.2	126.2	359.6	326.8
Total accidents	364.9	161.0	474.9	427.9

Notes:
1. All accident numbers adjusted to base year 1975 by control factors.
2. Each row has been adjusted by a control factor for this class of accident. The total row is the adjusted value of the total number of accidents, and not the sum of the preceding two rows.

TABLE D.28 PEDESTRIAN FACILITIES - SIGNALS

REFERENCE: Teale, Graeme 1984. The evaluation of the effectiveness of low cost traffic engineering projects. *Australian Department of Transport, Office of Road Safety, Report CR 22.*

REF. NO: 172

TREATMENT: New pedestrian signals.

LOCATION: South Australia: 17 sets of pedestrian signals were installed at end-block locations on major urban arterial roads.

STUDY: Before-and-after technique was used. Sites where traffic volumes changed substantially from normal growth patterns were excluded. A separate control group, of all non-intersection sites, was used to compare the effects of those factors which vary over time. The control group was made as large as possible to minimise the effects of statistical variation within the control group.

COMMENT: Method appears to be sound.

RESULTS: Accident numbers before and after installation of pedestrian signals.

Accident Type	Before	After
Casualty	71.7	53.0
Property damage	360.2	226.0
Total accidents	429.6	277.3
	Before (% of Total)	**After (% of Total)**
Rear end	71.2	66.7
Side swipe	16.0	21.2
Right angle	4.2	5.6
Hit pedestrian	5.4	4.1
Other	3.2	2.4

Notes:
1. All accident numbers adjusted to base year 1975 by control factors.
2. Each row has been adjusted by a control factor for this class of accident. The total row is the adjusted value of the total number of accidents, and not the sum of the preceding two rows.

TABLE D.29 PEDESTRIAN FACILITIES - BRIDGES

REFERENCE: Shimogami, Tamio 1987. Efficiency analysis of traffic safety countermeasures. *PWRI Newsletter* No. 28: 51-57.

REF. NO: 163

TREATMENT: Pedestrian bridges installed between 1979 and 1981.

LOCATION: 55 sites over 10 km of highway.

STUDY: A one-year before-and-after comparison. The most probable accident rate is calculated by a regression formula taking into account the specific factors of road and traffic conditions such as average daily traffic volume, width of carriageway, density of traffic entering signalised intersections, and average daily traffic volumes of bicycles and pedestrians.

COMMENT: Using only one year of before-and-after data is suspect. No allowance appears to have been made for bias-by-selection.

RESULTS: Reduction rates in accidents following installation of pedestrian bridges.

Accident Type		Reduction Rates (%)
Accident pattern	Hitting pedestrian	71
	Single vehicle	increased
Type of vehicle	Passenger car	42
	Cargo truck	38
	Motorcycle	80
Travelling speed	Slower than 30 km/hr	56
	50-70 km/hr	increased
Grade	Downward slope	62
All accident types		39

TABLE D.30 SIGNS - WARNING/ADVISORY

REFERENCE: Janoff, M.S., Graham Hill, J. 1986. Effectiveness of flashing beacons in reducing accidents at a hazardous rural curve. *Transportation Research Record* 1069: 80-82. Transportation Research Board, Washington DC.

REF. NO: 97

TREATMENT: A flashing beacon at a curve, mounted on a pole on the side of the highway. Installed in October 1980.

LOCATION: Texas, USA: a dangerous curve (approx. 45 degrees) on a 4-lane rural high-speed highway.

STUDY: A before-and-after analysis using 22 months of both before-and-after data.

COMMENT: Using only one site is suspect. No allowance appears to have been made for bias-by-selection.

RESULTS: Summary of accident numbers and changes before and after installation of a warning sign.

Type of Accident	No. of Accidents by Time Period		Change	
	Before	After	No.	%
All	14	7	-7	-50
Speed/lost-control, head-on, and fixed-object type	11	1	-10	-91
Other	3	6	+3	+50