TRANSPORT RESEARCH LABORATORY

Changes in accident frequency following the introduction of traffic calming in villages

Prepared for Charging and Local Transport Division, Department of the Environment, Transport and the Regions

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CONTENTS

Executive Summary

In 1994, the then County Surveyors Society and the Department of Transport, with the Welsh Office, the Scottish Office and TRL, published the results of the Village Speed Reduction Study (VISP). This study was of the effectiveness of different measures at reducing speeds on main roads through villages. It considered a range of treatments, at 'gateways' and within villages, a number of which resulted in substantial reductions in traffic speeds. Subsequently TRL was commissioned by what is now the Charging and Local Transport Division of the Department of the Environment, Transport and the Regions to monitor the broader application of speed reducing measures to villages on more major roads, particularly trunk roads, and more extensive measures were used in these situations. The principal report of this latter work, detailing the effects of the measures on speeds, including a very preliminary review of the effects on accidents, was published in 1999.

Many villages tend to have a perceived, rather than a real, safety problem. Consequently, numbers of accidents are often small and it was not possible to carry out a robust study of accidents in the timescales of either the VISP study or the study of villages on major roads, because the After period was too short. However, reductions in traffic speed can generally be expected to lead to reductions in accidents and it is important to know whether accident reductions have indeed been brought about. The work programme was therefore extended to include a wider study of the impact on accidents of traffic calming measures in villages. This included more recent After accident data for the schemes in the VISP study and those on the more major roads studied subsequently, and data for an additional sample of villages not previously studied by TRL in which measures had been installed for at least 2 years.

In total, 56 village traffic calming schemes located throughout Great Britain were studied. The majority had been installed during the period 1991-93 and the remainder between 1994 and 1997. The villages have a range of size, main road class and traffic flow and are mostly subject to a 30 or 40 miles/h speed limit. The schemes feature measures ranging from just minor gateway features to measures involving physical restrictions (e.g. chicanes, narrowings, mini-roundabouts and road humps) in the village and/or at the gateways.

Injury accident data were obtained from TRL's STATS19 database, for the period up to the end of 1998. Additional data for 1999 were obtained for schemes installed the most recently. The data covered an *average* of 7 years before, and 5 years after, scheme implementation, yielding for analysis a total of over 1,400 accidents occurring within the gateways or village speed limits. The accidents were classified by severity and type, and the villages themselves were grouped by the type of measures installed, by traffic flow and by the speed reduction achieved.

However the schemes were grouped, all injury accidents (i.e. all severities) and KSI accidents (those involving fatal/ serious injury) in each group have been reduced, the majority of the reductions being statistically significant. Across all villages, all accidents and KSI accidents were reduced by about one quarter and one half respectively. These changes substantially improve on national trends for accidents on all roads (excluding motorways), which, taking the average Before and After periods as 1986-93 and 1994-98 respectively, show a 7% reduction in all accidents and a 27% reduction in KSI accidents, when adjusted to allow for the corresponding change in total road length. (No substantial changes in traffic flow in excess of those occurring naturally from national trends were reported at the sites studied.) Together the figures suggest that the schemes have themselves brought about an overall reduction in injury accidents of between one fifth and one quarter, and a reduction in accidents involving fatal and serious injury of between one third and one half. The proportion of KSI accidents reduced from 28% of the total to 18% (compared with 22% to 17% nationally on all roads excluding motorways).

The higher the speed reductions in the village - generally commensurate with the use of more extensive measures - the greater the reduction in accidents. Accident reductions did not, however, appear to vary systematically with the level of traffic flow through the villages. Statistically significant reductions occurred for different accident types. The size of reduction did not vary greatly between types, but there was a suggestion that accidents involving vulnerable road users had reduced more than vehicle-only accidents.

About two-fifths of accidents to vulnerable road users involved children aged under 16 before and after scheme installation. Child pedestrian accidents involving fatal/ serious injury were reduced by three-quarters and child cyclist accidents were halved regardless of severity.

The reduction in KSI and slight injury accidents across the whole sample of 56 villages represents an annual saving of at least £2 million (at least £36,000 per scheme), at 1998 prices. The average annual rate of return was estimated to be at least 0.62 for the VISP schemes and at least 0.39 for the major road schemes.

The accident reductions reported here were achieved in most cases by introducing measures aimed at reducing speeds to below the *existing* 30 or 40 miles/h speed limit. They are of similar magnitude to those reported in Suffolk villages following the widespread introduction of 30miles/h speed limits on roads previously with a 60 or 40 miles/h limit, but where speeds often remained higher than the new speed limit.

1 Introduction

In 1994, the then County Surveyors Society and the Department of Transport, with the Welsh Office, the Scottish Office and TRL, published the results of the Village Speed Reduction Study (VISP). The results appear as an overview in County Surveyors' Society/Department of Transport (1994) and in detail as TRL Report PR85 (Wheeler, Taylor and Barker, 1994). The study was of the effectiveness of different measures at reducing speeds on main roads through villages. It considered a range of treatments, at 'gateways' and within villages, a number of which resulted in quite considerable reductions in traffic speeds. Longer-term results, with an examination of injury accident occurrence, were included in Wheeler and Taylor (1995).

Subsequently TRL was commissioned by what is now the Charging and Local Transport Division of the Department of the Environment, Transport and the Regions to monitor the broader application of speed-reducing measures to villages on more major roads, particularly trunk roads, and more extensive measures were used in these situations. The principal report of this latter work, detailing the effects of the measures on speeds, including a very preliminary review of the effects on accidents, was published as TRL Report 385 (Wheeler and Taylor, 1999).

Many villages have more of a perceived problem than a real safety problem. Consequently, numbers of injury accidents are often small and it was not possible to carry out a robust study of accidents in the timescales of either the VISP or the subsequent study of villages on major roads, because the After period was too short. However, reductions in traffic speed can generally be expected to lead to reductions in accidents (Taylor, Lynam and Baruya, 2000) and it is important to know whether accident reductions have indeed been brought about. The work programme was therefore expanded to include a wider study of the impact on accidents of traffic calming measures in villages. This included the schemes in the VISP study, those on the more major roads studied subsequently, and an additional sample of villages not previously studied by TRL (with one exception) at which measures had been installed for at least 2 years.

2 The villages studied

A total of 56 village traffic calming schemes were studied. This comprised the 24 VISP schemes installed during 1992-93, nine major road schemes which were installed during 1995-97, and an additional 23 schemes which were installed during 1991-97.

2.1 Selection of villages

The VISP schemes were originally selected to include:

- A broad geographic spread (across Great Britain).
- A range of village size, main road class and traffic flow.
- A range of speed reducing measures (from enhanced signing and marking to physical measures such as road narrowing).

The main selection criteria for the major road schemes were:

- A two-way daily flow of through traffic of at least 8,000 vehicles per day.
- At least 10% of the flow comprising heavy vehicles.
- The inclusion of more extensive and/or substantial measures than the schemes typical of the VISP study.

Like the VISP schemes, the additional schemes have a range of main road classification (including trunk roads) and feature a similar range of measures and traffic flow to both the other groups.

2.2 Village characteristics and measures employed

The key characteristics of the villages are given in Tables 1 and 2. Traffic flows are averages of the Before and After flows through the village centre. The schemes are classified by their measures into 8 groups as below and are based on the VISP categories A-F (Wheeler, Taylor and Barker, 1994), with 2 additional categories for schemes employing significant physical measures, which were absent from the VISP group:

No measures in village

A gateway signing, minor marking;

B gateway signing, significant markings/coloured surface/ minor narrowing;

C physical measures at gateway.

Measures in village (not physical - but including islands)

D no gateway;

E gateway with significant signing/marking plus advance measures;

F physical measures at gateway.

Physical measures in village (significant horizontal/ vertical deflection)

G gateways without physical measures, including those with advance measures;

H physical measures at gateway.

All but 7 villages were subject to a 30 or 40 miles/h speed limit before the schemes were introduced. At 10 villages, speed limits were reduced as part of the scheme. At 2 villages, the limit remained at 60 miles/h.

More details of the measures used are given in Appendix A. TRL reports PR85 and TRL385 (Wheeler, Taylor and Barker, 1994; Wheeler and Taylor, 1999) contain full details, plans and photographs of the VISP schemes and the major road schemes respectively.

3 Methodology

3.1 Contact with local highway authorities

All relevant local highway authorities were contacted for supplementary information for each village to support the

Table 1 Village characteristics — VISP and Major road schemes

Village	*Main road*	*Local highway authority*	*Imple-mentation date (month/ year)*	*Speed limit in miles/h (Before/ After)*	*24 hour two-way flow (thousands)*	*Measures (see text, Section 2.2 and Appendix A)*
VISP schemes						
Hartley Wintney	A30	Hants	1/93	30	15	A-G[2]
Matfield	B2160	Kent	9/92	30	6	A
Billingford	B1145	Norfolk	8/92	30	3	B
Crimond	A952	Aberdeen	4/93	40	5	B
Dairsie	A91T	Fife	3/93	30	8	B
Hermitage	B4009	W Berks	3/93	40&30	3	B
Sanquhar	A76T	D&G[1]	12/92	30	5	B
South Warnborough	B3349	Hants	5/93	30	8	B
Bloxham	A361	Oxon	3/92	40&30	10	D-B[2]
Crondall	C46	Hants	2/93	30	3	C
Halberton	C769	Devon	6/92	30	5	C-H[2]
Jersey Marine	B4290	Neath/PT[1]	12/92	30	8	C
Bigrigg	A595T	Cumbria	4/93	40	13	D
Long Preston	A65T	N Yorks	5/93	30	10	D
North Frodingham	B1249	E Riding	5/92	40	2	D
Temple Sowerby	A66T	Cumbria	2/93	40	10	D
Burland	A534	Cheshire	4/93	30	4	E
Contin	A835T	Highland	3/93	30	3	E
Gisburn	A59T	Lancs	11/92	40	9	E
Ludford	A631	Lincs	2/93	30	4	E
Roade	A508	Northants	8/93	30	9	E
Tunstall	A683	Lancs	10/92	60	2	E
Middleton	A614	E Riding	5/92	30	4	F
Stratton-on-the-Fosse	A367	Somerset	9/92	30	6	H
Major road schemes						
Copster Green	A59T	Lancs	9/95	40	11	E
Hayton	A1079T	E Riding	8/95	60/40	17	E
West Wellow	A36T	Hants	10/96	50/40	17	E
Craven Arms	A49T	Salop	5/95	40/30	9	G
Thorney	A47T	Cambs	6/95	30	13	G
Great Glen	A6T	Leics	4/96	30	17	B-E[2]
Dorrington	A49T	Salop	9/96	30	9	E
Pant	A483T	Salop	3/97	40/30	8	E
Costessey	C162/ C171	Norfolk	7/97	30/20	6	H

[1]*D&G = Dumfries & Galloway; Neath/PT = Neath & Port Talbot*

[2]*Two classification letters indicate modification of scheme at a later stage*

injury accident data to be extracted from TRL's STATS19 database (see section 3.2).

Where possible, the following information was obtained:

VISP and major road schemes

- Any modification to measures since scheme installation, with date.
- Significant changes to traffic flow (other than trends over time), with date.

Additional schemes

- Measures and Before/After speed limit(s).
- Date of scheme implementation.
- Subsequent modifications, if any, with date.
- An indication of traffic flow, with any significant changes.

3.2 Collection of accident data

Accidents occurring on the main road (including at junctions) between the position of the gateways (or speed limit terminal signs if no gateways were introduced) were included in the analysis.

At least 5 years of Before data were extracted for each village, by making the start date for extraction 5 years prior to the earliest of all the implementation dates of the schemes. This start date was 1 January 1987 for the VISP/ major road villages and 1 January 1986 for the additional villages, yielding over 10 years of Before data for a number of more recent schemes.

Data to 31 December 1998 were available, giving at least 5 years of After data for schemes installed before 1994. For the more recent major road schemes, 1999 data were obtained from the relevant highway authorities in order to obtain as long an After period as possible. Up to 9 months data were available at the time of writing, providing After periods mainly between 2 and 4 years for these schemes.

Table 2 Village characteristics — additional schemes

Village	*Main road*	*Local highway authority*	*Imple-mentation date (month/ year)*	*Speed limit in miles/h (Before/ After)*	*24 hour two-way flow (thousands)*	*Measures (see Section 2.2 and Appendix A)*
Eaton Socon/Ford	B1428	Cambs	6/92	60/30	11[1]	G
Fen Ditton	B1047	Cambs	6/92	30	14[1]	G
Soham	A142	Cambs	6/92	30	7[1]	H
Cottenham	B1049	Cambs	1/94	30	9[1]	H
Offords	B1043	Cambs	6/92	30	4[1]	H
Highnam/Maidenhall	B4215	Glos	10/96	30	9[1]	G
Maisemore	A417	Glos	3/92	30	6[1]	A
Brasted	A25	Kent	11/93	30	14	G
Sarre	A28/253	Kent	7/93	40/30	9	H
Cowan Bridge	A65T	Lancs	8/95	60/40	6	E
Rufford	A59T	Lancs	4/94	40	9	E
Crick	A428	Northants	3/91	30	2	B
West Haddon	A428	Northants	3/91	30	2	G
Byfield	A361	Northants	3/91	30	4	G
East Challow	A417	Oxon	11/93	30	8	E
Nuneham Courtenay	A4074	Oxon	7-10/93	40	17	E
Tiddington	A418	Oxon	7/92	60/50	13	D-E
Glangrwyney	A40T	Powys	6/93	30	10	E
Bubbenhall	A445	Warwicks	4/97	60	7	E
Ettington	A422	Warwicks	4/97	30	5	E
Ryton	A445	Warwicks	4/97	30	5	G
Birdham	A286	W Sussex	3/92	40&30	11	D
Sonning	B478/ B4446	Wokingham	6/96	30/20	N/A[2]	H

[1]12 hour flow
[2]N/A not available

3.3 Data analysis

A total of 1,401 injury accidents across the 56 villages were available for analysis. The accidents were classified by:

- Severity, i.e. slight injury, and those involving fatal and serious injury (KSI accidents).
- Type (i.e. junction; non-junction; multi-vehicle; single vehicle; involving a pedestrian; involving a cyclist; involving a child pedestrian (under 16 years); involving a child cyclist (under 16 years)).

The villages and their accident data were grouped by:

- Measures installed (as shown in Section 2.2), i.e.:
  - Schemes with gateways but without measures in the village (types A-C).
  - Schemes with or without gateways *and* non-physical measures in the village (types D-F).
  - Schemes with physical measures in the village and gateways with or without physical measures (types G, H).
  - Sub-division of these main categories as also shown in Section 2.2 (types A, B, …, H).
- Two-way 24 hour traffic flow through the village (average of Before and After flows), i.e.:
  - <4,000;
  - 4,000-7,999;
  - 8,000-11,999;
  - 12,000 or more.
- Average 85th percentile speed reduction in the village centre (this information was only available for the VISP and major road schemes), i.e.:
  - 0-2 miles/h;
  - 3-4 miles/h;
  - 5-6 miles/h;
  - 7 miles/h or more.

All the above classifications were devised such that a reasonably even number of villages fell into each category.

4 Results

Tables 3 and 4 show the Before and After accident frequencies per year for each village by severity. Tables 5, 7, 9 and 11 show annual *aggregate* accident frequencies for villages classified by study group, measures installed, traffic flow and speed reduction respectively. Table 13 shows annual accident frequencies by accident type aggregated over all villages.

The calculation of the average annual accident frequencies across a number of sites can either be weighted or un-weighted. Giving each site equal weight assumes that site average accident frequencies are similarly based, have been calculated to similar precision and that all sites have equal importance. This may distort the overall average if some sites are based on very little data or are perhaps atypical. Weighting sites by the number of years of data used to calculate the site average figure is likely to give a

more reliable figure. This approach has been adopted within this study. (It may be noticed that within some of the tables presented in this report the overall average or total figures are not the simple average/total of the other table entries; this is due to the use of weighted figures.)

Statistical tests on the Before to After changes in accident frequency were carried out by calculating whether or not the After accident frequency was within the 95% confidence limits for the expected value of the Poisson distribution based on the Before accident frequency (see Appendix B for details of the statistical testing carried out). If it did not, it could be concluded that the After frequency was statistically significantly different from before scheme installation.

Sites where significant changes in traffic flow were reported during the study period (due for example to the opening of a new road) were excluded from this study. No changes in flow, other than those occurring naturally due to national trends, were reported at the sites studied, although the local authorities did not always have detailed information on traffic flows. In most cases traffic would be unlikely to have diverted away from the schemes because there was no available alternative route. In the case of the VISP and major road sites, this was specifically established in the original TRL studies of speed changes. In this report it is assumed that flow changes over the study period only reflected national trends and no adjustments to observed accident frequencies have therefore been made.

4.1 Accident changes in individual villages (Tables 3 and 4)

Accident frequencies varied widely between individual villages, particularly before scheme installation. This may be a function of wide-ranging physical characteristics (e.g.

Table 3 VISP and major road schemes: injury accident frequency per year (Statistically significant changes shown in **bold** (outside 95% confidence limits for expected value of Poisson distribution))[1]

			Before				*After*			
Village	*Main road*	*Local highway authority*	*Sl*[2]	*KSI*[3]	*All*	*Y*[4]	*Sl*[2]	*KSI*[3]	*All*	*Y*[4]
VISP schemes										
Hartley Wintney	A30	Hants	4.0	1.3	5.3	6.0	5.2	1.2	6.3	6.0
Matfield	B2160	Kent	1.4	0.4	1.8	5.7	1.7	0.2	1.9	6.3
Billingford	B1145	Norfolk	0.2	0.2	0.4	5.6	0.3	0.0	0.3	6.4
Crimond	A952	Aberdeen	1.0	0.2	1.1	6.3	0.3	0.2	0.5	5.8
Dairsie	A91T	Fife	0.5	0.6	1.1	6.2	0.9	**0.0**	0.9	5.8
Hermitage	B4009	W Berks	2.6	0.8	3.4	6.2	3.1	0.3	3.4	5.8
Sanquhar	A76T	D&G	1.5	0.5	2.0	5.9	0.5	**0.0**	**0.5**	6.1
South Warnborough	B3349	Hants	0.6	0.5	1.1	6.3	0.4	0.7	1.1	5.7
Bloxham	A361	Oxon	4.6	1.9	6.6	5.2	2.9	**0.7**	**3.7**	6.8
Crondall	C46	Hants	0.0	0.0	0.0	6.1	0.2	0.0	0.2	5.9
Halberton	C769	Devon	0.4	0.0	0.4	5.4	0.0	0.0	0.0	6.6
Jersey Marine	B4290	Neath/PT	1.2	0.2	1.4	5.9	0.5	0.2	0.7	6.1
Bigrigg	A595T	Cumbria	1.4	1.0	2.4	6.3	2.4	0.7	3.1	5.8
Long Preston	A65T	N Yorks	0.6	0.9	1.6	6.3	2.5	0.7	**3.2**	5.7
North Frodingham	B1249	E Riding	0.9	0.2	1.1	5.3	0.3	0.2	0.5	6.7
Temple Sowerby	A66T	Cumbria	0.7	1.2	1.8	6.1	1.0	0.5	1.5	5.9
Burland	A534	Cheshire	0.6	0.3	1.0	6.3	0.0	0.0	**0.0**	5.8
Contin	A835T	Highland	0.0	0.2	0.2	6.2	0.0	0.0	0.0	5.8
Gisburn	A59T	Lancs	2.4	0.7	3.1	5.8	2.8	0.6	3.4	6.2
Ludford	A631	Lincs	0.5	0.0	0.5	6.1	0.5	0.0	0.5	5.9
Roade	A508	Northants	3.0	1.2	4.3	6.6	1.8	1.5	3.3	5.4
Tunstall	A683	Lancs	0.0	0.0	0.0	5.8	0.0	0.2	0.2	6.3
Middleton	A614	E Riding	0.0	0.6	0.6	5.3	0.6	0.2	0.8	6.7
Stratton-on-the-Fosse	A367	Somerset	1.2	0.4	1.6	5.7	0.6	0.2	0.8	6.3
Major road schemes										
Copster Green	A59T	Lancs	2.7	1.0	3.7	8.7	2.5	1.0	3.5	4.0
Hayton	A1079T	E Riding	0.8	0.8	1.6	8.6	0.5	**0.0**	0.5	4.0
West Wellow	A36T	Hants	3.3	1.0	4.3	9.8	4.0	**0.4**	4.4	2.3
Craven Arms	A49T	Salop	4.1	1.0	5.0	8.3	2.3	**0.0**	**2.3**	4.4
Thorney	A47T	Cambs	2.7	1.7	4.4	8.4	3.4	**0.2**	3.6	4.2
Great Glen	A6T	Leics	3.4	0.4	3.8	9.3	3.4	0.3	3.7	3.5
Dorrington	A49T	Salop	0.5	0.3	0.8	9.7	0.6	0.3	1.0	3.1
Pant	A483T	Salop	1.0	0.7	1.7	10.2	1.2	**0.0**	1.2	2.6
Costessey	C162/ C171	Norfolk	1.6	0.1	1.7	10.5	0.5	0.5	**0.9**	2.2

[1]*Tests performed on KSI and all accidents only*
[2]*Accidents involving slight injury*
[3]*Accidents involving fatal or serious injury*
[4]*Number of years of accident data*

Table 4 Additional schemes: injury accident frequency per year (Statistically significant changes shown in **bold** (outside 95% confidence limits for expected value of Poisson distribution))[1]

Village	Main road	Local highway authority	Before				After			
			SI[2]	*KSI*[3]	*All*	*Y*[4]	*SI*[2]	*KSI*[3]	*All*	*Y*[4]
Eaton Socon/Ford	B1428	Cambs	12.3	3.3	15.6	6.4	4.1	**0.5**	**4.6**	6.6
Fen Ditton	B1047	Cambs	2.5	0.9	3.4	6.4	2.0	0.2	2.1	6.6
Soham	A142	Cambs	0.2	0.0	0.2	6.4	0.0	0.0	0.0	6.6
Cottenham	B1049	Cambs	3.3	1.1	4.4	8.0	3.4	**0.2**	3.6	5.0
Offords	B1043	Cambs	1.9	0.9	2.8	6.4	0.3	**0.0**	**0.3**	6.6
Highnam/Maidenhall	B4215	Glos	1.5	0.5	2.0	10.8	1.8	**0.0**	1.8	2.3
Maisemore	A417	Glos	0.0	0.8	0.8	6.2	0.9	**0.0**	0.9	6.8
Brasted	A25	Kent	1.7	0.4	2.0	7.8	1.5	0.4	1.9	5.2
Sarre	A28	Kent	2.0	0.4	2.4	7.4	0.4	0.5	**0.9**	5.6
Cowan Bridge	A65T	Lancs	0.9	0.2	1.1	9.6	0.6	0.6	1.2	3.4
Rufford	A59T	Lancs	1.7	1.0	2.7	8.3	2.1	**0.0**	2.1	4.8
Crick	A428	Northants	0.6	0.6	1.2	5.2	0.9	0.1	1.0	7.8
West Haddon	A428	Northants	0.4	0.4	0.8	5.2	0.5	0.1	0.6	7.8
Byfield	A361	Northants	0.2	0.2	0.4	5.2	0.6	0.3	0.9	7.8
East Challow	A417	Oxon	0.6	0.3	0.9	7.8	1.2	0.0	1.2	5.2
Nuneham Courtenay	A4074	Oxon	0.8	0.9	1.7	7.6	1.5	0.4	1.8	5.4
Tiddington	A418	Oxon	2.5	0.9	3.4	6.5	3.2	1.1	4.3	6.5
Glangrwyney	A40T	Powys	0.5	0.9	1.5	7.4	0.4	**0.0**	**0.4**	5.6
Bubbenhall	A445	Warwicks	0.4	0.1	0.5	11.3	0.6	0.0	0.6	1.8
Ettington	A422	Warwicks	0.4	0.3	0.7	11.3	0.0	0.6	0.6	1.8
Ryton	A445	Warwicks	0.4	0.2	0.5	11.3	1.1	1.1	**2.3**	1.8
Birdham	A286	W Sussex	1.8	0.8	2.6	6.2	2.3	0.7	3.1	6.8
Sonning	B478/ B4446	Wokingham	2.7	0.8	3.5	10.4	3.1	**0.0**	3.1	2.6

[1]*Tests performed on KSI and all accidents only*
[2]*Accidents involving slight injury*
[3]*Accidents involving fatal or serious injury*
[4]*Number of years of accident data*

number of junctions, road alignment and length treated) and traffic characteristics (e.g. speed, volume). Annual accident frequencies before scheme installation ranged from none at Crondall (Hampshire) to as many as 15.6 at Eaton Socon/Eaton Ford, two large villages in Cambridgeshire, which now form one settlement. The majority of villages had typically 1-3 accidents per year prior to scheme installation.

The overall injury accident frequency was reduced at 34 of the 56 villages after scheme installation. There was evidence for a statistically significant accident reduction at the following (see numbers in bold type in Tables 3 and 4):

VISP and major road schemes (see Appendix A for scheme details)

All accidents (i.e. all severities)
Sanquhar (Dumfries & Galloway), Bloxham (Oxfordshire), Burland (Cheshire), Craven Arms (Shropshire), Costessey (Norfolk).

KSI accidents (i.e. involving fatal/serious injury)
Dairsie (Fife), Sanquhar (Dumfries & Galloway), Bloxham (Oxfordshire), Hayton (East Riding of Yorkshire), West Wellow (Hampshire), Craven Arms (Shropshire), Thorney (Cambridgeshire), Pant (Shropshire).

Additional schemes (see Appendix A for scheme details)

All accidents
Eaton Socon/Eaton Ford, Offord Cluny/D'Arcy (Cambridgeshire), Sarre (Kent), Glangrwyney (Powys).

KSI accidents
Eaton Socon/Eaton Ford, Cottenham, Offord Cluny/D'Arcy (Cambridgeshire), Highnam/Maidenhall, Maisemore (Gloucestershire), Rufford (Lancashire), Glangrwyney (Powys), Sonning (Wokingham).

At Long Preston (North Yorkshire) and Ryton (Warwickshire), there was a statistically significant increase in the total accident frequency; the result for Ryton, however, relates to an After period of only less than 2 years.

4.2 Accident changes by village study groups (Tables 5 and 6)

There was a statistically significant decrease in accidents of all severities and KSI accidents across all villages and across each of the VISP, major road and additional village groups.

It can be seen that across all villages, KSI accidents have been halved and all accidents have been reduced by a quarter. These changes are substantially ahead of national trends for accidents on all roads (excluding motorways), which, if the average Before period for the study villages is taken as 1986-93 and the After period 1994-98, show a 27% reduction in KSI accidents and a 7% reduction in all

Table 5 Accident frequency[1] summary table for Tables 3 and 4 (Statistically significant changes shown in **bold** (outside 95% confidence limits for expected value of Poisson distribution))

Village group (number of villages in brackets)	*Before*					*After*				
	Slight[2]	*KSI[3]*	*All*	*%KSI*	*Years[4]*	*Slight[2]*	*KSI[3]*	*All*	*%KSI*	*Years[4]*
VISP (24)	29.3	13.2	42.5	31.0	5.9	28.3	**7.9**	**36.2**	21.8	6.1
Major road (9)	19.7	6.8	26.5	25.7	9.3	19.2	**2.7**	**22.0**	12.5	3.3
Additional (23)	37.7	14.7	52.4	28.0	7.8	**32.7**	**6.3**	**39.0**	16.2	5.2
All villages (56)	89.8	35.3	125.2	28.2	7.2	**76.8**	**17.0**	**93.8**	18.1	5.3

[1]Accidents per year for villages combined in each group
[2]Accidents involving slight injury
[3]Accidents involving fatal or serious injury
[4]Mean number of years of accident data for sites combined

Table 6 Percentage changes in injury accident frequency

	Change in injury accident frequency		
Study group	*Slight[1]*	*KSI[2]*	*All severities*
VISP	- 3% NS	-40%	-15%
Major road	- 2% NS	-60%	-17%
Additional	-13%	-57%	-25%
All villages	-15%	-52%	-25%

[1]Accidents involving slight injury
[2]Accidents involving fatal or serious injury
(NS = non-significant change)

accidents. These changes have been adjusted for the corresponding 3% increase in road length which occurred over this time (DETR, 1993, 1999).

Across all villages, the proportion of KSI accidents reduced from 28% of the total to 18% (compared with 22% to 17% nationally on all non-motorway roads). Corresponding reductions for the VISP schemes were from 31% to 22%, for the major road schemes from 26% to 13% (the largest reduction) and for the additional schemes from 28% to 16%. The greater reduction in KSI accidents for the major road and additional villages may have been associated with the fact that both these groups have a larger share of schemes featuring physical measures (Tables 1 and 2).

The large reductions in KSI accidents were offset by the smaller reductions in slight injury accidents (statistically significant for only the additional villages), but still giving statistically significant reductions in all accidents.

4.3 Accident changes by scheme type (Tables 7 and 8)

There were reductions in all accidents and in KSI accidents for each of the main groups, i.e:

- Measures at the gateway but none in the village (Types A, B and C).
- Measures in the village (Types D, E and F)
- Physical measures in the village (Types G and H).

All of these reductions were statistically significant except for the reduction in all accidents for the middle group (Types D, E and F).

Measures at the gateway but none in the village (Types A, B, C)

Across the 14 schemes in this group, the aggregate frequency of all accidents was reduced by 19% (from 25.9 to 21.1 per year), with KSI accidents more than halving (from 7.7 to 3.5 per year). The proportion of KSI accidents at these villages fell from 30% to 17%.

The majority of these schemes (11 out of 14) had more substantial measures at the gateways (minor narrowing, surface treatments and/or more extensive markings with three featuring physical measures) than just signing and minor marking, and therefore contributed largely to the overall changes for the group.

Measures in the village (Types D, E, F)

There were 26 schemes in this group, featuring non-physical measures installed in the village (signing, marking and coloured surfacing, but also including islands in a number of schemes), with or without gateways. Across this group, aggregate KSI accident frequency reduced by 34% (from 15.6 to 10.3 per year). This was offset by an 11% increase in slight injury accidents (from 32.2 to 35.7 per year), contributing to the non-statistically significant change in all accidents.

The proportion of KSI accidents at these villages fell from 33% to 22%. The frequency of KSI and all accidents was reduced by 34% and 4% respectively .

The 19 schemes of Type E (those with gateways featuring significant signing/marking plus advance measures) contributed most to the overall result in this group.

Physical measures in the village (Types G, H)

These 16 schemes, involving physical measures (e.g. chicanes, narrowings, mini-roundabouts, road humps and speed cushions), saw the largest percentage reductions in accidents of the three main groups: all, slight and KSI accidents were reduced by 45%, 37% and 70% respectively, all changes being statistically significant. The proportion of KSI accidents at these villages fell from 23% to 13%.

At the 7 schemes featuring physical measures at the gateways and in the village (Type H), the frequency of both slight and KSI accidents was more than halved.

Table 7 Accident frequency[1] at all villages by scheme type (Statistically significant changes shown in **bold** (outside 95% confidence limits for expected value of Poisson distribution). Statistical tests carried out for the 3 main groups only)

	Before					*After*				
Scheme type[2]	*Slight[3]*	*KSI[4]*	*All*	*%KSI*	*Years[5]*	*Slight[3]*	*KSI[4]*	*All*	*%KSI*	*Years[5]*
Measures at gateway; none in village										
A (3 schemes)	5.4	2.4	7.8	30.4	5.9	7.5	1.3	8.7	14.3	6.4
B (8 schemes)	11.3	5.1	16.4	31.3	5.9	9.4	2.1	11.5	18.1	6.3
C (3 schemes)	1.6	0.2	1.7	10.0	5.8	0.7	0.2	0.8	20.0	6.2
All A, B, C (14 schemes)	18.3	7.7	25.9	29.6	5.9	17.6	**3.5**	**21.1**	16.5	6.3
Measures in village										
D (6 schemes) (no gateway)	8.0	5.1	13.1	38.7	6.1	11.7	3.9	15.6	24.7	6.2
E (19 schemes) with g'way	24.0	10.4	34.4	30.1	8.2	22.3	5.7	28.1	20.5	4.3
F (1 scheme) with gateway	0.0	0.6	0.6	100.0	5.3	0.6	0.1	0.7	20.0	6.7
All D, E, F (26 schemes)	32.3	15.6	48.0	32.6	7.6	35.7	**10.3**	46.0	22.3	4.9
All A-F, i.e. schemes without physical measures in village (40 schemes)	50.6	23.4	74.0	31.7	7.0	53.1	**13.4**	**66.5**	20.2	5.4
Physical measures in village (with gateways)										
G (9 schemes)	24.5	8.0	32.5	24.6	7.8	16.8	2.3	19.1	12.1	5.2
H (7 schemes)	13.5	3.7	17.2	21.5	7.8	6.8	1.2	8.1	15.0	5.0
All G, H (16 schemes)	38.0	11.7	49.7	23.5	7.8	**23.8**	**3.5**	**27.3**	12.9	5.1
Overall	89.8	35.3	125.2	28.2	7.2	**76.8**	**17.0**	**93.8**	18.1	5.3

[1]Injury accidents per year for villages combined in each scheme category
[2]See Section 2.2 for details
[3]Accidents involving slight injury
[4]Accidents involving fatal or serious injury
[5]Mean number of years of accident data for sites combined

Table 8 Percentage changes in injury accident frequency by scheme types

	Change in injury accident frequency					
Scheme type[1]	*Slight[2]*		*KSI[3]*	*All severities*		
A, B, C	-3%	NS	-54%	-19%		
D, E, F	+11%	NS	-34%	- 4%	NS	
All A-F[4]	*+5%*	*NS*	*-43%*	*-10%*		
G, H[5]	-37%		-70%	-45%		

[1]See Section 2.2
[2]Accidents involving slight injury
[3]Accidents involving fatal or serious injury
[4]All schemes without physical measures
[5]Schemes with physical measures
(NS = non-significant change)

Comparison between schemes with and without physical measures

Schemes with physical measures appeared more likely to yield reductions in injury accidents than those without. For example, KSI accidents were reduced by 70% at the schemes with physical measures (types G, H) compared to 43% at the remainder (types A-F). Overall, accidents were nearly halved at the schemes with physical measures but were reduced by only 10% (albeit a statistically significant change) elsewhere.

4.4 Accident changes by traffic flow (Tables 9 and 10)

It is immediately apparent that whatever the flow, KSI accidents were more or less halved, all these changes being statistically significant. The changes in all accidents were less clear cut, due to the fact that these large reductions in KSI accidents were offset by varying changes in slight injury accidents. Slight injury accidents increased in the villages with the lowest and the highest flows (though the changes were not statistically significant), but underwent smaller (but statistically significant) reductions in the villages with medium flows. At the villages with medium flows, all accidents were reduced by about one third.

The proportion of KSI accidents fell most markedly at the villages with the lowest and highest flows.

4.5 Accident changes by speed reduction (Tables 11 and 12)

These results relate only to the VISP and the major road village schemes.

The main finding is that the greater the speed reduction in the village centre, the greater the reduction in all accidents. These reductions were statistically significant except for the schemes yielding the smallest speed reductions (i.e. 2miles/h or less).

The reduction in KSI accidents by speed change was less clear cut, but was still largest for the schemes yielding the highest speed reductions (i.e. 7miles/h or more). For the group of schemes yielding the smallest speed reductions, KSI accidents were halved, but this was offset by a small increase in slight injury accidents. The reductions in KSI accidents were statistically significant except where speeds were reduced by 5-6 miles/h (a group with very few schemes).

The proportion of KSI accidents was remarkably similar across the speed reduction groups before scheme implementation, at just over a quarter. Following scheme implementation the proportion fell to 15% at the schemes with the smallest speed reductions, and to 10% where speed reductions were largest. For the middle groups there was little change.

Table 10 Percentage changes in injury accident frequency by two-way traffic flow

Two-way traffic flow[1]	*Change in injury accident frequency*				
	Slight[2]		*KSI*[3]	*All severities*	
Under 4,000	+5%	NS	-60%	-16%	NS
4,000 - 7,999	-31%		-49%	-35%	
8,000 - 11,999	-18%		-50%	-27%	
12,000 or over	+16%	NS	-43%	- 1%	NS

[1]Average Before/After two-way flow through village centre
[2]Accidents involving slight injury
[3]Accidents involving fatal or serious injury
(NS = non-significant change)

4.6 Accident changes by type of accident (Tables 13 and 14)

There was a statistically significant reduction in all the main accident types regardless of severity, except for slight pedestrian accidents. All types of KSI accidents were halved except for single vehicle accidents, which were reduced by about one third.

All multi-vehicle and junction accidents (all severities) were reduced by just over one fifth and other types were reduced by about one third. There was a slightly greater reduction in the frequency of accidents involving vulnerable road users than in the vehicle only accident frequency. However the proportion of KSI accidents reduced more for vehicle only accidents (from 26% to 16%) than for those involving vulnerable road users (from 32% to 25%).

Accidents involving child pedestrians and cyclists

About two-fifths of accidents to vulnerable road users involved pedestrians and cyclists aged under 16 before and

Table 9 Accident frequency[1] at all villages by traffic flow (Statistically significant changes shown in **bold** (outside 95% confidence limits for expected value of Poisson distribution))

Two-way traffic flow[2] (number of schemes in brackets)	Before					After				
	Slight[3]	KSI[4]	All	%KSI	Years[5]	Slight[3]	KSI[4]	All	%KSI	Years[5]
Under 4,000 (8)	4.9	2.3	7.2	31.7	5.7	5.2	**0.9**	6.1	15.0	6.6
4,000 - 7,999 (17)	12.8	4.5	17.3	26.0	7.3	**8.9**	**2.3**	**11.2**	20.7	5.2
8,000 - 11,999 (20)	43.7	17.6	61.3	28.8	7.4	**36.0**	**8.9**	**44.9**	19.8	5.2
12,000 or over (10)	23.1	9.3	32.5	28.5	7.7	26.8	**5.3**	32.1	16.5	4.9
All villages (56)[6]	89.8	35.3	125.2	28.2	7.2	**76.8**	**17.0**	**93.8**	18.1	5.3

[1]Injury accidents per year for villages combined in each traffic flow category
[2]Average Before/After two-way flow through village centre
[3]Accidents involving slight injury
[4]Accidents involving fatal or serious injury
[5]Mean number of years accident data for sites combined
[6]Including Sonning, for which no flow data were available

Table 11 Accident frequency[1] at all VISP and major road villages by speed reduction (Statistically significant changes shown in **bold** (outside 95% confidence limits for expected value of Poisson distribution))

	Before					*After*				
Speed reduction[2]	*Slight[3]*	*KSI[4]*	*All*	*%KSI*	*Years[5]*	*Slight[3]*	*KSI[4]*	*All*	*%KSI*	*Years[5]*
0-2 miles/h (12 schemes)	13.9	5.8	19.7	29.5	6.2	15.0	**2.7**	17.8	15.4	5.9
3-4 miles/h (9 schemes)	19.0	7.5	26.6	28.2	7.1	17.3	**5.5**	**22.8**	24.1	5.1
5-6 miles/h (5 schemes)	6.3	2.1	8.4	25.5	6.1	**4.2**	1.5	**5.7**	26.5	6.0
7+ miles/h (7 schemes)	12.0	4.8	16.7	28.5	8.2	**8.0**	**0.9**	**8.9**	10.5	4.3
All villages (33)	52.1	20.6	72.8	28.3	6.8	**44.1**	**10.7**	**54.8**	19.5	5.3

[1]Accidents per year for villages combined in each speed reduction category
[2]Average 85th percentile speed reduction in village centre
[3]Accidents involving slight injury
[4]Accidents involving fatal or serious injury
[5]Mean number of years accident data for sites combined

Table 12 Percentage changes in injury accident frequency by 85th percentile speed reduction (VISP and major road schemes only)

	Change in injury accident frequency		
Speed reduction[1]	*Slight[2]*	*KSI[3]*	*All severities*
0-2 miles/h	+ 8% NS	-53%	-10% NS
3-4 miles/h	- 9% NS	-27%	-14%
5-6 miles/h	-33%	-30% NS	-32%
7 miles/h or over	-33%	-80%	-47%

[1]Average 85th percentile speed reduction in village centre
[2]Accidents involving slight injury
[3]Accidents involving fatal or serious injury
(NS = non-significant change)

Table 13 Accident frequency[1] at all villages by accident type (Statistically significant changes shown in **bold** (outside 95% confidence limits for expected value of Poisson distribution))

	Before (7.2 years[2])				*After (5.3 years[2])*			
Accident type	*Slight[3]*	*KSI[4]*	*All*	*%KSI*	*Slight[3]*	*KSI[4]*	*All*	*%KSI*
Junction	50.6	19.1	69.7	27.4	**44.8**	**9.6**	**54.5**	17.7
Non-junction	39.3	16.2	55.5	29.2	**32.0**	**7.4**	**39.3**	18.7
All	89.8	35.3	125.2	28.2	**76.8**	**17.0**	**93.8**	18.1
Multi-vehicle[5]	68.3	22.2	90.5	24.5	**60.9**	**9.6**	**70.6**	13.7
Single vehicle[5]	12.5	6.1	18.6	32.8	**8.1**	**3.8**	**11.9**	31.7
All vehicle only	80.7	28.2	109.0	25.9	**69.1**	**13.4**	**82.5**	16.3
Involving a pedestrian	9.1	7.1	16.2	43.6	7.8	**3.6**	**11.3**	31.7
Pedestrians under 16	*3.3*	*3.3*	*6.6*	*50.0*	*3.2*	***0.8***	***4.0***	*19.1*
Involving a cyclist	10.8	2.8	13.6	20.4	**7.0**	**1.3**	**8.3**	15.9
Cyclists under 16	*4.3*	*1.1*	*5.4*	*20.5*	*2.1*	*0.6*	*2.7*	*21.4*
All vulnerable road user	19.9	9.8	29.8	33.0	**14.7**	**4.9**	**19.7**	25.0

[1]Injury accidents per year for villages combined for each accident type
[2]Mean number of years of accident data for all villages combined
[3]Accidents involving slight injury
[4]Accidents involving fatal or serious injury
[5]Including cycle accidents

Table 14 Percentage changes in injury accident frequency by accident type

	Change in injury accident frequency		
Accident type	*Slight*[1]	*KSI*[2]	*All severities*
Junction	-11%	-50%	-22%
Non-junction	-19%	-54%	-29%
Multi-vehicle	-11%	-56%	-22%
Single vehicle	-35%	-38%	-36%
All vehicle only	**-15%**	**-52%**	**-25%**
Involving a pedestrian	-15% NS	-49%	-30%
Involving a child pedestrian	*- 3% NS*	*-77%*	*-40%*
Involving a cyclist	-35%	-52%	-39%
Involving a child cyclist	*-52% NS*	*-49% NS*	*-51% NS*
All vulnerable road user	**-26%**	**-50%**	**-35%**

[1]*Accidents involving slight injury*
[2]*Accidents involving fatal or serious injury*
(NS = non-significant change)

after scheme installation. However, these accidents were all reduced following scheme installation. The largest change was a 77% reduction in KSI child pedestrian accidents, and child pedestrian accidents of all severities were reduced by 40%. Despite the relatively small numbers of accidents involved, these changes were statistically significant. Child pedestrian accidents involving slight injury, however, were virtually unchanged.

Accidents involving cyclists aged under 16 were approximately halved regardless of severity, but these reductions were not statistically significant.

At least three-quarters of the accidents involving child pedestrians before and after scheme installation involved a vehicle going ahead along the main road. About 1 in 7 accidents involved a vehicle going ahead passing a stationary vehicle; there was only a single occurrence of this type of accident after scheme installation.

About 1 in 4 accidents involving child cyclists before scheme installation involved a vehicle emerging on to the main road. About 1 in 5 involved a cyclist either emerging on to the main road or being struck by a vehicle going in the same direction. The proportion of accidents involving an emerging vehicle was little changed after scheme installation but there was only a single occurrence of each of the other types.

4.7 Cost implications

On a non built-up road, the average value of prevention of a KSI accident (at 1998 prices) is £206,875 and for a slight injury accident it is £15,840 (DETR, 1999). (The average figure for a KSI accident was calculated by dividing the value of prevention of all the fatal accidents and the same for all the serious injury accidents occurring on non built-up roads (except motorways) in Great Britain in 1998 by the aggregate number of these accidents.)

Across the whole sample of villages there was a reduction of 18.3 KSI and 13.0 slight injury accidents per year (Table 5). Adjusting for national changes in accidents over the same period (on all roads excluding motorways) this represents a reduction of 8.7 KSI and 14.1 slight injury accidents per year. This equates to an annual saving of £2.02 million or £36,128 per scheme.

The average cost (at 1998 prices) of a VISP and major road scheme was £25,200 and £138,300 respectively (the costs were not known for every additional scheme) although there was a wide range in both these figures. Across the VISP schemes, there was a reduction of 5.3 KSI accidents and 1.0 slight injury accident per year (Table 5), which becomes 1.7 KSI and 1.4 slight accidents, allowing for national accident changes. This is equivalent to an annual saving of £0.37 million (£15,578 per scheme), which equates to an average annual rate of return of 0.62 per scheme. Across the major road schemes, there was a reduction of 4.1 KSI accidents and 0.5 of a slight injury accident per year, which becomes 2.3 KSI and 0.7 slight accidents, allowing for national accident changes. This is equivalent to an annual saving of £0.49 million (£54,100 per scheme), which equates to an average annual rate of return of 0.39 per scheme.

5 Summary and discussion

On the traffic calmed roads through the villages, the frequencies of all injury accidents and accidents involving fatal or serious injury (KSI accidents) have reduced by about one quarter and one half respectively. These changes are substantially ahead of national trends for accidents on all roads (excluding motorways), which, if the average Before and After periods are taken as 1986-93 and 1994-98 respectively, show a 7% reduction in all accidents and a 27% reduction in KSI accidents. (These changes have been adjusted for the corresponding 3% increase in road length between the Before and After periods.)

Making full allowance for these national trends (i.e. assuming they have been brought about by factors other than the introduction of traffic calming schemes – improved education and training for example) the present results would represent an overall reduction in injury accidents of one fifth, and a one third reduction in accidents involving serious or fatal injury. In reality, however, traffic calming schemes have *contributed* to national accident reductions; the present results are therefore best interpreted as:

- between one fifth and one quarter reduction in all injury accidents, and
- between one third and one half reduction in accidents involving serious or fatal injury.

The following results have not been adjusted for national trends in accidents.

Across all villages, the proportion of KSI accidents reduced from 28% of the total to 18% (compared with 22% to 17% nationally).

The overall injury accident frequency reduced at 34 of the 56 villages. The reduction was statistically significant at 9 villages. For 16 villages there was a statistically significant reduction in KSI accidents.

Village study groups

- The overall injury accident frequency reduced most (25%) at the additional sites and least (15%) at the VISP sites.
- The KSI accident frequency reduced most (60%) at the major road sites and least (40%) at the VISP sites.
- The proportion of KSI accidents reduced most at the major road sites (from 26% to 13%).

Scheme type

- The overall injury accident frequency reduced most (45%) at the sites with physical measures in the village, and least (4%) at the sites with non-physical measures in the village.
- The KSI accident frequency reduced most (70%) at the sites with physical measures in the village and least (34%) at the sites with non-physical measures in the village.

Traffic flow

- Accident reductions did not vary systematically with the level of traffic flow through the villages.
- The reduction in overall injury accident frequency was small at high and low flows and larger at average flows.
- The reduction in KSI accident frequency was remarkably constant across flow levels.

Speed reductions

- The overall injury accident frequency reduced most (47%) at the sites where 85th percentile speeds reduced by 7miles/h or more within the village, and least (10%) at the sites where speed reductions were 2miles/h or less.
- The KSI accident frequency reduced most (80%) at the sites with speed reductions of 7miles/h or more, and least (29%) at the sites with medium speed reductions (3-6miles/h).
- The proportion of KSI accidents reduced most at the sites with speed reductions of 7miles/h or more (from 28.5% to 10.5%).

It appears, from the evidence of 33 schemes for which speed data were available, that higher speed reductions are more likely to yield a reduction in the severity of accidents, as well as a reduction in total accidents. Not surprisingly, this is related to the fact that the schemes with more extensive measures (particularly those with physical measures) saw the larger reductions in KSI accidents. However, schemes with smaller speed reductions (e.g. no more than 4miles/h) and lesser measures also seem capable of yielding at least a reduction in accident severity, if not always in total numbers.

Accident type

- There was a slightly greater reduction in the overall frequency of accidents involving vulnerable road users (35%) than for those involving vehicles only (25%).
- The KSI accident frequency was roughly halved for all accident types except single vehicle accidents which were reduced by about one third.
- The proportion of KSI accidents reduced more for vehicle only accidents (from 26% to 16%) than for those involving vulnerable road users (from 33% to 25%).
- Accidents involving vulnerable road users aged under 16 were reduced following scheme installation. Child pedestrian accidents involving fatal/serious injury were reduced by three-quarters and child cyclist accidents were halved regardless of severity.

All of the above results are assumed to have been unaffected by changes in traffic flow other than in respect of national trends. Sites where other significant changes in traffic flow were reported during the study period (due for example to the opening of a new road) were excluded.

Cost implications

For the VISP and major road schemes (which had known installation costs), the reduction in accidents (slight injury and fatal/serious) represents an annual saving of approximately £15,500 and £54,000 per scheme respectively (at 1998 prices), allowing for national reductions in accident frequencies. Taking average scheme costs (albeit averages of wide-ranging figures) into account, this equates to an average annual rate of return of 0.62 per VISP scheme and 0.39 per major road scheme. (Again, these can be considered as *minimum* figures because the schemes and others like them will themselves have contributed to national reductions in accidents.) From the evidence available, it seems that the higher cost schemes may have a lower rate of return in terms of accident savings in monetary terms than lower cost schemes.

The reduction in KSI and slight injury accidents across the whole sample of 56 villages represents an annual saving of at least £2 million (at least £36,000 per scheme), at 1998 prices.

Comparison with accident changes in Suffolk villages

Between 1994 and 1996 Suffolk County Council introduced 30miles/h speed limits within all village communities where there was a desire for such a limit. (The previous limit was 60 miles/h in some cases and 40 miles/h in others.) The initiative was accompanied by extensive local publicity. Compared to the surrounding 'control' area, all injury accidents were found subsequently to have reduced by 20% (Suffolk County Council, 1999), but 85th percentile speeds generally remained well above the new speed limit (Jeanes, 1997). The present accident reduction result, which is similar in magnitude to the Suffolk result, relates largely to villages in which there was *already* a 30 or 40 miles/h speed limit, which remained unchanged, and at which other measures were introduced to reduce 85th percentile speeds to this limit. The implication is that if measures had been introduced in Suffolk *in addition to* the reduction in the posted speed limits, even greater accident reductions may have resulted.

6 Acknowledgements

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Appendix A: Summary of measures installed

A.1 VISP villages (over period 1991-99)

Bigrigg (Cumbria): Pelican crossing in village (no gateways).

Billingford (Norfolk): *one gateway only* - enhanced signing, red surface, narrowing by edge lines. Fibre optic 30miles/h speed limit reminder sign added on each approach 5/99.

Bloxham (Oxfordshire): Rumble strips before start of 40miles/h limit (one approach); speed camera in village (temporary).

Burland (Cheshire): *gateways* - enhanced signing with vehicle-actuated lights and red surfacing; *village* - red patches with speed limit roundels.

Contin (Highland): *gateways* - enhanced signing, coloured surface, narrowing by centre hatching and edge lines, speed limit roundels; *village* – speed limit roundels.

Crimond (Aberdeenshire): *gateways* - enhanced signing, red surface, narrowing by centre hatching and 'dragon's teeth' markings. No measures in village.

Crondall (Hampshire): *gateway (one only)* - enhanced signing, pinch point with outbound priority. No measures in village.

Dairsie (Fife): *gateways* - enhanced signing, red surface, narrowing by edge lines, textured bands in advance of gateways, speed limit roundel. No measures in village.

Gisburn (Lancashire): *gateways* - enhanced signing; also narrowing, advance warning signs at one gateway; *village* - mini-roundabout, islands.

Halberton (Devon): *gateways* - red/white surface, narrowing by island and hatching, speed limit roundel. One-way working narrowings and advisory 20miles/h sign added 4/98.

Hartley Wintney (Hampshire): *gateway (one only)* - enhanced signing, narrowing by kerb extensions and hatching. Mini-roundabouts introduced 9/96; footway widening and environmental enhancements 10/98.

Hermitage (West Berkshire): *gateway (one only)* - enhanced signing, red/grey surface, pinch effect.

Jersey Marine (Neath & Port Talbot): *gateways* – narrowing with outbound priority, weight restriction, advance warning signs. No measures in village.

Long Preston (North Yorkshire): Pelican crossing in village with warning signs (no gateways).

Ludford (Lincolnshire): *ahead of gateways* - advance warning signs on one approach, yellow bars on other; *gateways* - enhanced signing; *village* - speed limit repeater signs/markings.

Matfield (Kent): *gateways* - enhanced signing. No measures in village.

Middleton (East Riding of Yorkshire): *gateways* - narrowing by hatching and island; *village* - edge lines, mini-roundabout with cobbled area, centre hatching and islands in village.

North Frodingham (East Riding of Yorkshire): Hatching, footway extensions and sheltered parking (no gateways).

Roade (Northamptonshire): *gateways* - enhanced signing, illumination; *village* - mini-roundabout, red surface either side of zebra crossing and edge lines.

Sanquhar (Dumfries & Galloway): *one approach only: ahead of gateway* - centre hatching; white bar and school markings; *gateway* - enhanced signing, red/grey surface, speed limit roundels inside it. Island added 1995. No measures in village.

South Warnborough (Hampshire): *one approach only: ahead of gateway* – rumble strips, warning signing, slight narrowing by kerbs and markings; *gateway* – enhanced signing.

Stratton-on-the-Fosse (Somerset): *ahead of gateways* **–** warning signing; *gateways* – one-way working narrowing with outbound priority; *village* – one-way working narrowings.

Temple Sowerby (Cumbria): *gateways* - Enhanced signing; *village* - pedestrian refuge.

Tunstall (Lancashire): *gateways* - enhanced signing, buff bar markings; *village* - group of buff bar markings at intervals.

A.2 Major road villages (over period 1994-99)

Copster Green (Lancashire): *ahead of gateways* – coloured bars, 'road narrows' signing; *gateways* – signing/ marking/coloured surfacing, narrowing; *village* – centre hatching, pedestrian refuges.

Costessey (Norfolk): *ahead of one gateway* – vehicle-actuated 30miles/h sign; *gateways (numbering 3)* – 20mph zone signing, narrowing, speed cushion (at 2 gateways), mini-roundabout just ahead of third gateway; *village* – speed cushions, narrowings (one-way working), flat-top hump outside school. Reduction in speed limit from 30 to 20 miles/h.

Craven Arms (Shropshire): *ahead of gateways* – countdown signing; *gateways* – dragon teeth, signing/ marking/coloured surfacing; *village* – coloured patches, centre hatching on coloured background, pedestrian refuges, speed limit roundels; mini-roundabouts and speed cushions in centre. Reduction in speed limit from 40 to 30 miles/h.

Dorrington (Shropshire): *ahead of gateways* – countdown signing; *at gateways* - dragon teeth, signing/ marking/coloured surfacing; *village* – coloured patches, centre hatching on coloured background, speed limit repeaters, part-time (portable) speed cameras.

Great Glen (Leicestershire): *gateways* – dragon teeth, signing/marking/coloured surfacing; *village* – speed camera added 8/97.

Hayton (East Riding of Yorkshire): *ahead of gateways* – coloured patches, other signing; *gateways* - signing/ marking/coloured surfacing; *village* – centre hatching on coloured background, islands, pedestrian refuge. Reduction in speed limit from 60 to 40 miles/h.

Pant (Shropshire): *gateways* - dragon teeth, signing/ marking/coloured surfacing; *village* – coloured patches, centre hatching on coloured background, speed limit roundels, part-time (portable) speed cameras. Reduction in speed limit from 40 to 30 miles/h.

Thorney (Peterborough City Council[1]): *ahead of gateways* – speed camera signing, 'traffic calming ahead' signing; *gateways* – coloured textured surfacing, narrowing; *village* – two-way chicanes, part-time 20mph speed limit past school, speed cameras, pedestrian refuges, pedestrian crossing, mini-roundabout, kerb realignment at junction providing mild horizontal deflection.

West Wellow (Hampshire): *gateways* - signing/marking/ coloured surfacing; *village* – coloured surfacing, speed limit roundels, speed limit repeaters, enlarged island. Reduction in speed limit from 50 to 40 miles/h.

A.3 Additional villages (over period 1991-98)

Eaton Socon/Eaton Ford (Cambridgeshire): *gateways* - one-way working road narrowing (one end), roundabout, 'traffic calmed zone' signing (other end); *village* - mini roundabouts, chicanes, islands, two-way working road narrowings, sheltered parking, pelican crossings. Reduction in speed limit from 60 to 30 miles/h.

Fen Ditton (Cambridgeshire): two-way working road narrowings and chicanes.

Offord Cluny/Offord D'Arcy (Cambridgeshire): road humps, one-way working road narrowings (one scheme).

Soham (Cambridgeshire): one-way working road narrowings, mini-roundabouts and road humps.

Cottenham (Cambridgeshire): *gateways* - one-way working road narrowing, mini-roundabout; *village* - road humps, mini-roundabouts, islands and sheltered parking.

Highnam/Maidenhall (Gloucestershire): *gateways* - prominent signing, speed limit roundel; *village* - painted speed limit roundels, mini-roundabout.

Maisemore (Gloucestershire): *gateways* - prominent signing including red/white bars under each village nameplate, reflective marker posts; SLOW marking; *village* - edge lines, centre hatching.

Brasted (Kent): *gateways* - prominent signing, block paved surfacing, chicane at one gateway; slight narrowing at other; *village* - chicanes, coloured surfacing, block paved and widened footways with parking bays, refuge, zebra crossing.

Sarre (Kent): *gateways* - refuge with hatch and SLOW markings; *village* - new and widened footways, half-chicane, refuges, new signing, mini-roundabout, surface treatment, general environmental enhancement. Reduction in speed limit from 40 to 30miles/h.

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[1]*Local highway authority formerly Cambridgeshire*

Cowan Bridge (Lancashire): *ahead of gateways* – red bar markings; *gateways* - prominent signing and speed limit roundel; *village* - islands, centre hatching. Reduction in speed limit from 60 to 40 miles/h.

Rufford (Lancashire): *ahead of gateways* - rumble areas and central hatching (latter on one approach only); *gateways* - prominent signing and refuge; *village* - refuges, central hatching, right turn lanes.

Crick (Northamptonshire): *gateways* - prominent signing with red/white horizontal bars below village nameplates, coloured surfacing.; *village* - none.

West Haddon (Northamptonshire): *gateways* - as Crick; *village* - mini-roundabouts with centre and side hatching (latter provides sheltered parking), one-way working narrowing.

Byfield (Northamptonshire): *ahead of gateways* – rumble strips; *gateways* - as Crick; *village* - coloured surfacing throughout, mini-roundabouts.

East Challow (Oxfordshire): *ahead of gateways* **–** rumble strips; *gateways* - prominent signing with red/white horizontal bars below village nameplates, coloured surfacing; *village* - coloured patches.

Nuneham Courtenay (Oxfordshire): *gateways* - white field gates on verges at south gateway and white vertical planking (as at VISP site Roade) at north gateway, both carrying signing; coloured surfacing at both gateways; *village* - speed camera.

Tiddington (Oxfordshire): *gateways* - field gates on verges; *village* - refuge, double white lines, speed camera. Reduction in speed limit from 60 to 50 miles/h prior to measures.

Glangrwyney (Powys): *ahead of gateways* – countdown signs; *gateways* – speed limit roundels and signing; *village* - central hatching.

Bubbenhall (Warwickshire): *ahead of gateways* – rumble strips; *gateways* - village name and 'slow' plates on backing board incorporating flashing amber lights activated by vehicles, with coloured surfacing; *village* - red patches, school crossing sign with flashing amber lights, school crossing patrol (operative during school arrival and leaving times).

Ettington (Warwickshire): *ahead of one gateway* – rumble strips; *gateways* - prominent signing, coloured surfacing; *village* - coloured patches, refuge, one-way working road narrowing, zebra crossing.

Ryton (Warwickshire): *ahead of gateways* – rumble strips; *gateways* - prominent signing; *village* - mini-roundabout, one-way working road narrowing.

Birdham (West Sussex): refuges (no gateways).

Sonning (Wokingham): *ahead of gateways* - 30miles/h and 40miles/h 'buffer' speed limits with kerb realignment and splitter island at start of 30miles/h limit; *gateways* - narrowing with 20miles/h zone signing, *village* - humps and road narrowing. Reduction in speed limit from 30 to 20 miles/h.

Appendix B: Statistical testing of accident data

The number of accidents occurring per year over a number of years is known to follow a Poisson distribution, which represents the occurrence of isolated events in a continuum of time.

The general term of a Poisson series may be written as $e^{-m}m^i/i!$ (i = 0, 1, 2, …). For any given value c and $\alpha <$ 0.05, we may determine two values of m, say $m_A(c \mid \alpha) < m_B(c \mid \alpha)$, such that

$$\sum_{i=c}^{\infty} \frac{e^{-m_A} m^i{}_A}{i!} = \alpha, \sum_{i=0}^{c} \frac{e^{-m_B} m^i{}_B}{i!} = \alpha \qquad [1]$$

The terms $m_A(c)$ and $m_B(c)$ can be determined from a table of percentage points of the χ^2-distribution, or calculated thus:

$$m_B(c \mid \alpha) = 0.5\chi_1^2, \text{ where } Q(\chi_1^2 \mid \nu) = \alpha, \nu = 2(c + 1), \qquad [2]$$

$$m_A(c \mid \alpha) = 0.5\chi_2^2, \text{ where } 1 - Q(\chi_2^2 \mid \nu) = \alpha, \nu = 2c, \qquad [3]$$

where c = the number of Before accidents occurring over the whole observation period and Q = upper and lower percentage points of the χ^2-distribution and ν = the number of degrees of freedom and m_A and m_B are the lower and upper 95% confidence limits for the Before accidents. If the After accident rate falls outside of the confidence interval then one can be 95% confident that there has been a change in the accident rate

Example

The frequency of KSI accidents (i.e. those involving fatal or serious injury) across all 56 villages studied has fallen from 35.3 to 17.0 per year. The average Before period across all villages was 7.2 years, during which 255 KSI accidents were reported. This gives 512 and 510 degrees of freedom (ν in Equations [2] and [3] respectively) and a corresponding χ^2 statistic of 576.6 and 449.3 for upper and lower 95% confidence limits respectively. The upper and lower confidence limits based on the total number of Before accidents is 288.3 and 224.7 ($0.5\chi^2$ in Equations [2] and [3] respectively). Dividing these values by the length of the Before period in years, they become 39.9 and 31.1. The After accident frequency value of 17.0 per year falls outside these confidence limits, thus we can conclude that there has been a statistically significant reduction in accident frequency across all villages.

Abstract

A study has been conducted by TRL for the Department of the Environment, Transport and the Regions to investigate the effect on injury accident occurrence of the installation of traffic calming schemes in 56 villages. Over 1,400 accidents were analysed based on average Before and After periods for the sample of 7 years and 5 years respectively. The villages are mostly subject to a 30 or 40 miles/h speed limit and feature a variety of schemes ranging from gateway features only to physical restrictions in the village, that have resulted in a range of speed reductions.

On the traffic calmed roads through the villages, accidents of all severities and particularly fatal/serious accidents have undergone significant reductions, substantially ahead of national trends. The report presents these aggregate results, and also examines the changes in accidents by type of scheme; accident type; traffic flow levels; and changes in traffic speed.

Related publications

TRL421 *The effects of drivers' speed on the frequency of road accidents* by M C Taylor, D A Lynam and A Baruya. 2000 (price £35, code H)

TRL401 Interactive fibre optic signing at a rural crossroad (B1149 Felthorpe, Norfolk) by M A Winnett (TRL), E Woodgate (TRL) and N Mayhew (Norfolk CC). 1999 (price 35, Code H)

TRL385 *Traffic calming in villages on major roads: final report* by A H Wheeler and M C Taylor. 1999 (price £35, code H)

TRL364 *A traffic calming scheme at Costessey, Norfolk* by A Wheeler, G Harris, L Chinn, M Taylor and P Abbott. 1998 (price £25, code E)

TRL313 *Traffic calming - an assessment of selected on-road chicane schemes* by I A Sayer, D I Parry and J K Barker. 1998 (price £25, code E)

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