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TRAFFIC CALMING ON MAJOR ROADS: THE A47 TRUNK ROAD AT THORNEY, CAMBRIDGESHIRE

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CONTENTS

EXECUTIVE SUMMARY

Research is being undertaken to assess the effectiveness of traffic calming measures at reducing the speed of traffic in villages and small communities on major roads. The work follows on from the VIllage SPeed Control Working Group (VISP) study of traffic calming in villages. In this earlier study, a range of techniques was assessed, from gateway signing only, through measures both at the gateway and within the village (mainly signing and/or contrasting road surface treatments), to physical restrictions such as pinch points. The success of many of these schemes in reducing speeds was limited, especially those schemes lacking physical measures or any measures in the village itself.

Changes to legislation, together with special authorisation procedures, now enable local authorities to install a wide range of measures at localities which include, for example, villages on trunk and other major roads which carry high traffic flows. The aim of the current study is to assess the effectiveness of more comprehensive schemes intended to increase the likelihood of reducing 85th percentile speeds at least to the speed limit in the village, for example by the inclusion of physical measures. It includes an assessment of the environmental effects of the traffic calming measures introduced.

Two schemes have been selected for study, in villages on routes with over 8000 vehicles per day and with heavy goods vehicles forming at least 10 per cent of the total. One of these is Thorney on the A47 trunk road in Cambridgeshire, and is the subject of this report. The other, at Craven Arms on the A49 trunk road in Shropshire, is the subject of a separate report (Wheeler et al, 1996).

The scheme at Thorney was introduced during 1995. The speed limit was unchanged at 30mph. A variety of measures was installed on the approaches and within the village. On each main road approach, prominent signing warning of the traffic calming scheme was installed in advance of gateway features which comprise a raised Imprinted brick-patterned contrasting surface within a slight narrowing. A two-way chicane was installed inside each gateway.

In the village, two mini-roundabouts were installed, one within a part-time 20mph speed limit. One of the mini-roundabouts was later removed following complaints of noise from nearby residents. The part-time 20mph speed limit uses variable message signing displaying the lower speed limit when children go to and from a nearby school. Near the school entrance, a zebra crossing was installed and near the village centre, GATSO speed camera equipment was introduced and some junction remodelling was carried out.

'Before' and 'after' monitoring comprised the measurement of vehicle speeds, flows, journey times and traffic noise. A survey of public opinions on the scheme and measurements of ground-borne vibration were carried out after the scheme was installed.

Mean and 85th percentile speeds fell by 9mph at the gateways and by up to 15mph at the chicanes. Within the village, reductions were up to 12mph within the part-time 20mph speed limit when in force, though 85th percentile speeds still exceeded 20mph, and 30mph elsewhere. Speed camera installation had little additional effect, with a further speed reduction of no more than 1mph at the site itself and 2mph at the gateways.

Vehicle noise levels were measured at a number of points. The reductions in speed at the traffic calming measures resulted in reductions in maximum noise levels for both light and heavy vehicles. However, the change in the noise characteristics of light vehicles travelling over the *Imprint* surfacing at the gateway site may be perceived as annoying to residents living in the vicinity. Noise reductions were smallest in the village centre where the presence of a nearby signal junction may have had some influence. Both daytime and nighttime traffic noise levels fell by 3-5 dB(A) except in the village centre, where there was little change.

Thorney lies on Fenland peat deposits, prone to transmitting ground-borne vibration induced by passing traffic. Vibration measurements were taken at a dwelling close to one gateway, an example of a 'worst case' location where vehicles were crossing the raised surface treatment at relatively high speed. Peak levels of ground-borne vibration, slightly exceeding the mean threshold level for human perception, were measured in the building structure near ground level. During a subjective assessment, vibration was felt by the side of the road at the mini-roundabout when heavy goods vehicles mounted the central island.

Public reaction to the scheme was unfavourable; almost all residents who took part in the survey would have preferred a bypass. This is not altogether surprising given that there had been an active campaign for a bypass and that the New Roads Programme had recently been announced, excluding Thorney from having a bypass in the foreseeable future. The mini-roundabout was particularly disliked, mainly because drivers did not negotiate the roundabout well owing to lack of space, often clipping the domed central island. Three-quarters of residents perceived an increase in noise, mostly blaming the surface treatment at the gateways and the zebra crossing, and the mini-roundabout, where noise from body rattle, braking and acceleration may have been generated. Two-thirds of residents noticed vibration

from HGVs and thought that speeds had not been reduced enough, in spite of some encouraging measured reductions. On the other hand, over half of residents thought it was safer for pedestrians after implementation, and over three-quarters thought the speed camera installation was useful in spite of its small additional effect on observed speeds.

Although there were some substantial speed reductions, it would seem that the traffic calming scheme on the A47 at Thorney has only been only partly successful in reducing 85th percentile speeds to the 30mph speed limit. Public opinion was largely against the scheme; detailed design changes might alleviate some of the problems mentioned by the residents. However, their reactions to the scheme highlight the dilemma for the traffic calming engineer who is attempting to reduce accidents by measures that influence vehicle speed without causing unwanted safety and environmental side effects. The measures that are the most effective are generally the ones that have the most impact and hence are the most unpopular.

With regard to the impact of the traffic calming scheme on vehicle noise, there is a discrepancy between the measured changes and the perceptions of residents which will be investigated further in future studies. At the time of writing, further speed measurements have been made at Thorney to assess the longer term impact of the scheme. The overall effect on injury accidents will be assessed when sufficient time has elapsed for a meaningful 'after' analysis period. The results of these surveys will be presented in an overall report of schemes included within this project.

Reference

WHEELER A H, ABBOTT P G, GODFREY N S, LAWRENCE D J and PHILLIPS S M (1996). Traffic calming on major roads: the A49 trunk road at Craven Arms, Shropshire. TRL Report 212. Transport Research Laboratory, Crowthorne.

TRAFFIC CALMING ON MAJOR ROADS: THE A47 TRUNK ROAD AT THORNEY, CAMBRIDGESHIRE

ABSTRACT

Changes to legislation, together with special authorisation procedures, now enable local authorities to install a wide range of traffic calming measures at localities including villages on trunk and other major roads. In 1994, research began on the effectiveness of these measures on busy roads with a significant proportion of heavy goods vehicles. Thorney, on the A47 trunk road in Cambridgeshire, was one of two sites to be chosen initially for the study. The village speed limit is unchanged at 30mph; the measures include a gateway and chicane on each approach, with a part-time 20mph speed limit (past a school), a raised zebra crossing, a mini-roundabout, speed cameras, a refuge and kerb build-outs at adjacent junctions in the village itself. 'Before' and 'after' measurements of vehicle speeds, journey times and traffic noise were carried out, followed by a public opinion survey and ground vibration monitoring. The results are presented in this report. Although a number of measured speed reductions were substantial, most residents expressed reservations about the scheme.

1. INTRODUCTION

A traffic calming scheme has been introduced on the A47 trunk road at Thorney in Cambridgeshire as part of a research project to assess the effectiveness of traffic calming measures at reducing the speed of traffic in villages and small communities on major roads.

The work follows on from previous studies of traffic calming in villages. In 1991 the Secretary of State for Transport announced a joint study, between the County Surveyors' Society, the DOT, and the Scottish and Welsh Offices, of ways to reduce speeds in villages. The VIllage SPeed Control Working Group (VISP) was established to undertake the study by investigating the costs, benefits and effectiveness of suitable speed reducing measures. TRL was commissioned by the DOT's Driver Information and Traffic Management (DITM) Division to provide the research input to VISP.

In the VISP study, villages distributed across Great Britain on a range of road types with different traffic levels, were selected for 'before' and 'after' monitoring of speeds and traffic flows. Measures ranged from gateway signing only, through measures both at the gateway and within the village (mainly signing and/or contrasting road surface treatments), to physical restrictions such as pinch points. The initial results, together with conclusions and recommendations, were published as an overview by the Working Group (County Surveyors' Society/Department of Transport, 1994), and in detail by TRL (Wheeler, Taylor and Barker, 1994). Long-term results, with an examination of injury accident occurrence, were included in Wheeler and Taylor (1995). Further sites in Devon and Gloucestershire outside the VISP project were also studied (Wheeler, Taylor and Payne, 1993).

These studies showed that measures could be installed which reduce vehicle speeds but that any reductions obtained are short lived if measures are modest (e.g. simple gateway signing/marking) or not repeated within the village. The speed reductions broadly mirrored the hierarchy of schemes; gateways comprising striking visual measures or physical measures produced greater benefits, further enhanced (10mph reduction or more in 85th percentile speed) when accompanied by repeated physical measures in the village. Measures such as these seem more likely to reduce 85th percentile speeds to the set speed limit.

Changes to legislation, together with special authorisation procedures, now enable local authorities to install a wide range of measures at localities which include, for example, villages on trunk and other major roads which carry high traffic flows. In 1994, a new project was started to study the effectiveness of traffic calming measures in villages on busy routes (e.g. villages on routes with over 8000 vehicles per day and heavy vehicles forming at least 10 per cent of the total). The aim of this project is to study more comprehensive schemes intended to increase the likelihood of reducing 85th percentile speeds at least to the speed limit in the village, for example by the inclusion of physical measures. It is also intended to study other innovative techniques on these routes. Extensive monitoring at selected schemes is to be carried out: not only to assess the effect of schemes on speeds and traffic flows, but also to study the effect, particularly of physical measures, on traffic noise and ground vibration. Some opinion surveys will also be conducted.

Two schemes have initially been chosen for this study. One of these, at Thorney on the A47 trunk road in Cambridgeshire, is the subject of this report. The other is at Craven Arms on the A49 trunk road in Shropshire and is the subject of a separate report (Wheeler *et al*, 1996).

2. VILLAGE LOCATION AND CHARACTERISTICS

Thorney lies 13km east of Peterborough City Centre; the location of the village is shown in Fig 1. The A47 trunk road

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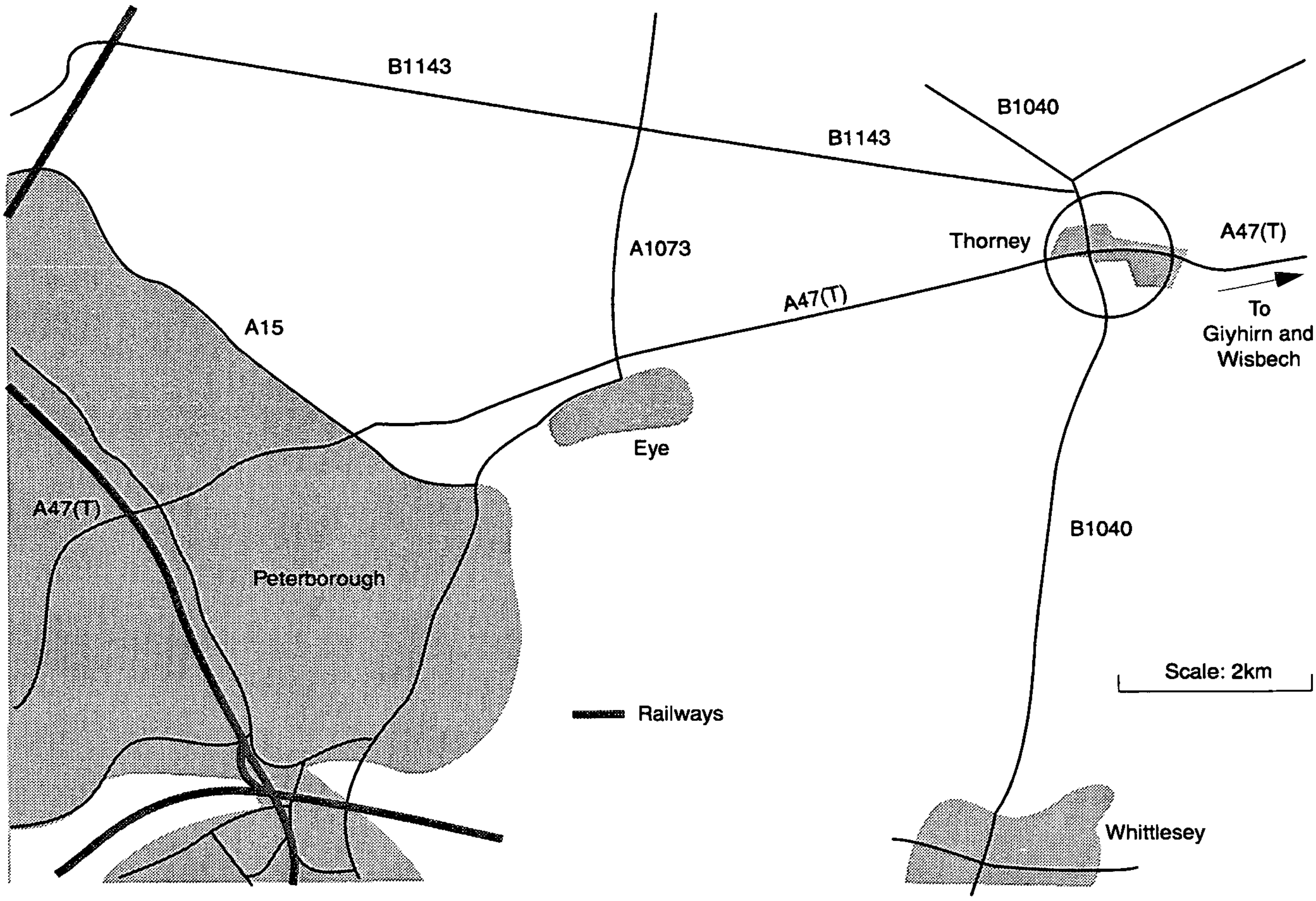


Fig. 1 Location plan for Thorney

forms part of a route linking the Midlands with Norwich, the rest of Norfolk and its coastal resorts and ports. The population of Thorney was 2218 in 1991. Before traffic calming measures were installed, there was a two-way mean traffic flow on the A47 through the village of about 13,000 vehicles per day, of which at least 20% were heavy goods vehicles.

The A47 in the vicinity of Thorney is a two-lane single carriageway, which is subject to the national 60mph speed limit outside the village. Within the village, the speed limit remains after scheme installation at 30mph for a distance of 1650m. Near the centre of the village is a signal-controlled four-way junction with the B1040.

Fig 2 shows six photographs of the A47 through Thorney taken prior to scheme installation. The western approach to the 30mph speed limit is straight, but much of the road within this speed limit has a curved alignment especially to the east of the village centre. There is a bend on the eastern approach about 200m in advance of the gateway, following a fairly straight section 1km long. The road is level throughout and street lighting is provided within the 30mph limit.

Much of the main road within the village is built-up on both sides, except west of the traffic signals and within 400m of the eastern end of the 30mph limit, where development is on one side only. With the exception of the centre, the village has an open aspect with frontages, with front gardens, mostly well away from the carriageway edge. There are also wide verges in places. Either side of the traffic signals, the frontages face on to the footway. Most of the development is residential, with a school in the eastern part of the village.

Before scheme installation, the carriageway width was mostly between 7.5m and 8.0m, with minimum and maximum widths of 6.75m and 9.5m. Other than the junction with the B1040, there are several other junctions with residential roads.

(a) site of the east gateway (cf Fig 7)

(b) site of chicane inside east gateway, looking west (cf Fig 11, top)

(c) site of Sandpit Road mini-roundabout, looking west (cf Fig 18, bottom)

(d) site of speed camera installation, looking west

(e) site of kerb realignment near junction with Church Street in village centre, looking east (cf Fig 20, top)

(f) site of the west gateway (cf Fig 8)

Fig 2. Thorney before scheme installation

3. THE MEASURES

The scheme was designed by Cambridgeshire County Council on behalf of the Highways Agency. A number of constraints were imposed on the design. The measures had to cater for wide loads, as the A47 is a designated abnormal load route; therefore a 6m wide path had to be available throughout the scheme. Because of the high volume of goods vehicles passing through the village, the measures were designed not to impede these vehicles unduly. In addition, the amount of vertical deflection (for raised features) had to be kept to a minimum. The village is a conservation area and the number and scale of the measures was also restricted by conservation interests.

Scheme installation took 5 months and was completed, except for two features implemented at a later date, in May 1995 at a cost of £486,000. It was intended to achieve a target 85th percentile speed of 30mph through the village. The locations of the measures relative to the village layout are shown in Fig 3, and an overall plan of the main road showing the measures in more detail is given at Fig 4. The measures comprise the following:

- gateway treatment at both ends of the village featuring prominent signing, contrasting surface treatment and slight narrowing of the carriageway;
- a chicane a short distance inside each gateway;
- a part-time 20mph speed limit past the school, using variable message signs, introduced June 1995;
- a pedestrian crossing with contrasting surface treatment each side;
- a mini-roundabout at two junctions (with Sandpit Road and with Woburn Drive);
- GATSO speed camera installation, commissioned November 1995;
- kerb alterations at three junctions (the junction with Gas Lane, a junction 50m to the west of Gas Lane, and at a drive to Thorney Park) providing a 'sheltered' bus bay on each side of the carriageway;
- centre hatching west of these junctions incorporating a right-turn lane to Church Street;
- a pedestrian refuge west of the traffic signals.

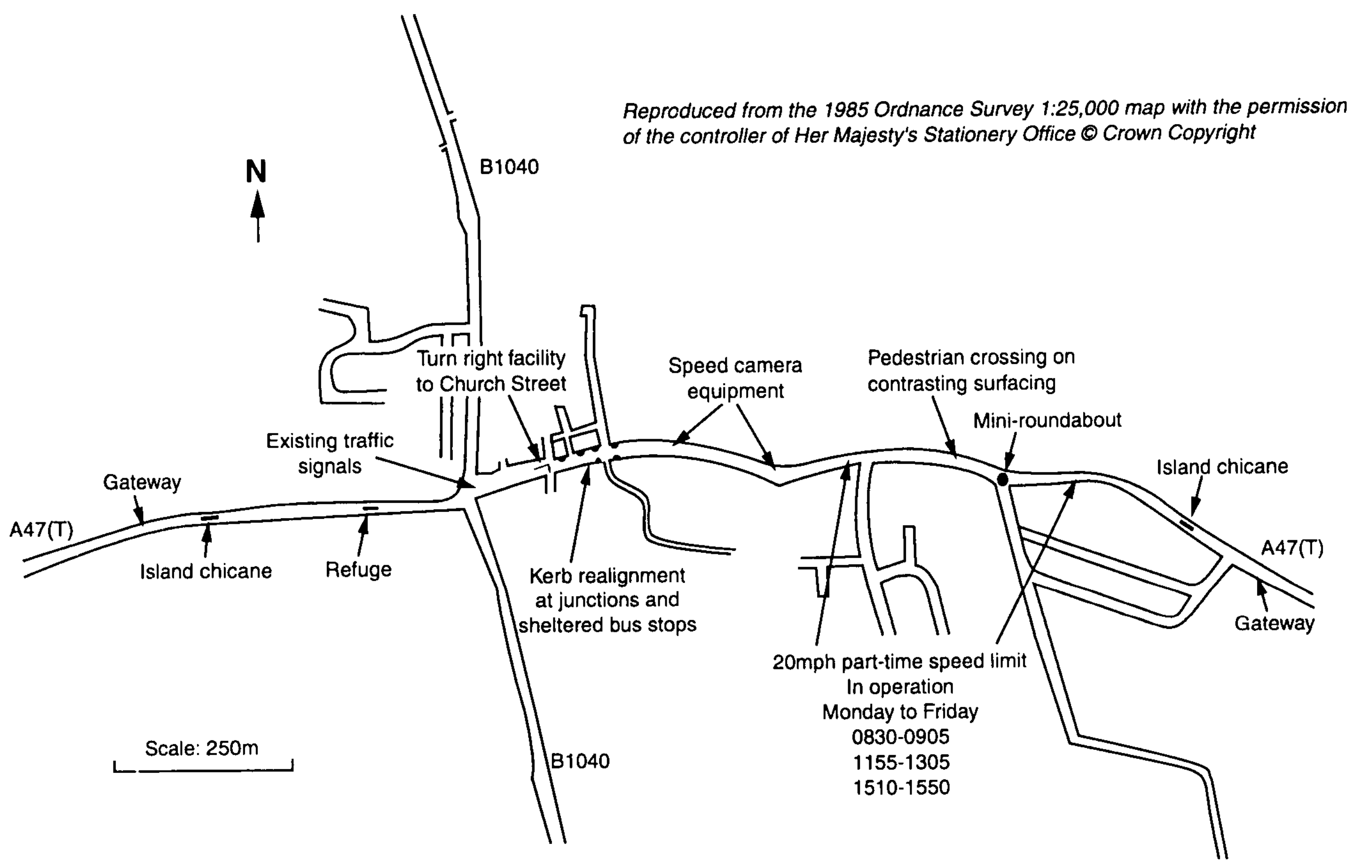


Fig. 3 Location plan of the measures

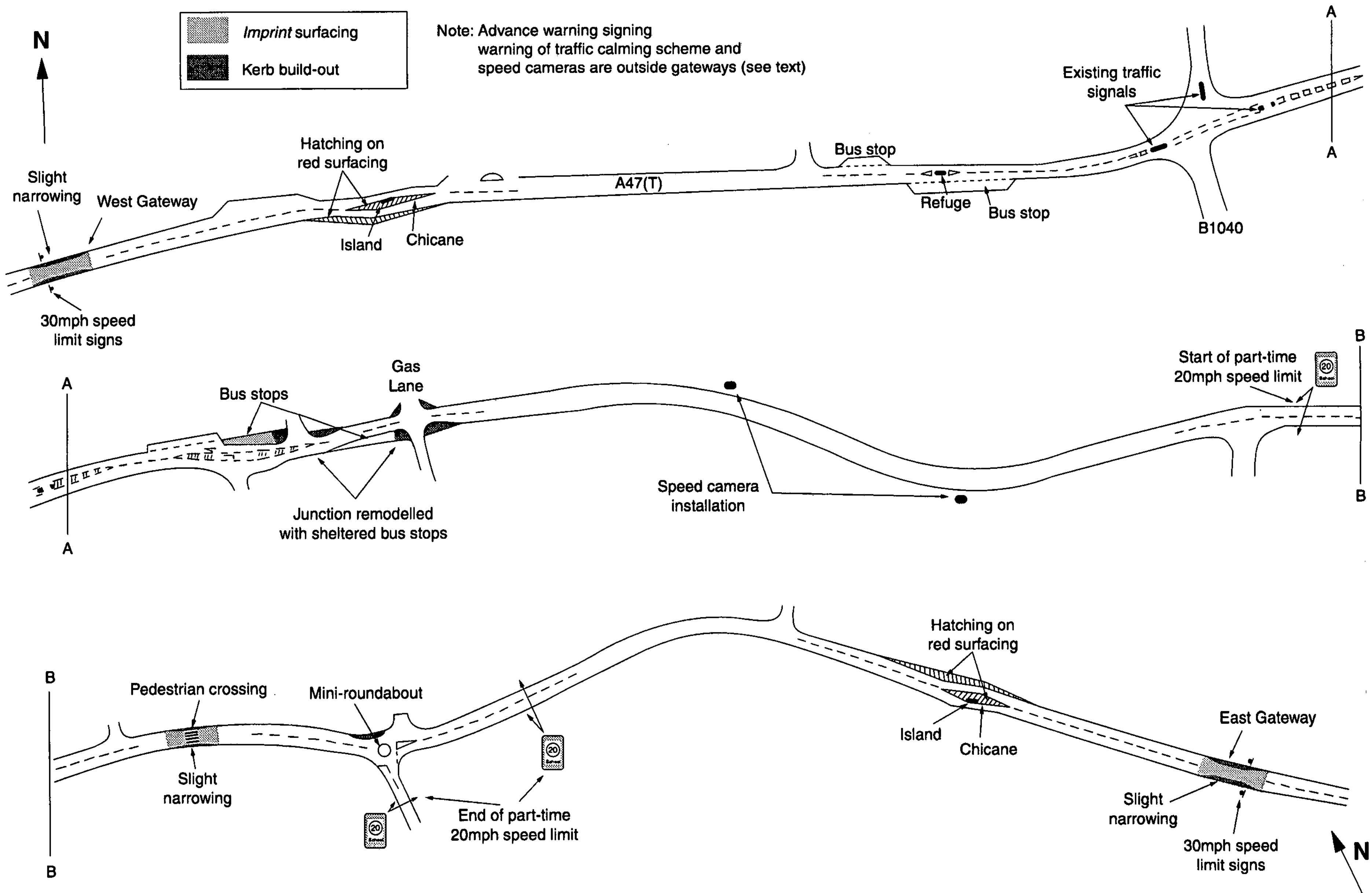


Fig. 4 The measures

Since the village is a conservation area, it was chosen to paint all street furniture (e.g. sign poles, lighting columns, guardrails and speed camera housings) black.

3.1 THE GATEWAYS

Both gateways are essentially of the same design. The measures associated with the gateways were installed in advance of, and at, the start of the 30mph speed limit. In the order encountered by *inbound* traffic, the measures comprise:

1. a 'Road Narrows' warning sign on each side of the carriageway (Fig 5);
2. a sign assembly on each side of the carriageway incorporating further 'Road Narrows' signing, village nameplates and advance warning of traffic calming (Fig 6);
3. at the gateway itself, slight narrowing and 30mph speed limit signing both on each side of the carriageway (Figs 7 and 8) with contrasting surface treatment (Fig 9).

A plan of one of the gateways is shown in Fig 10.

On the inbound approach to the west gateway, marker posts were installed on the nearside between the 'Road Narrows' signing (1) and the sign assemblies (2).

The 'Road Narrows' signs are 900mm in size; a speed camera warning sign was later added to the nearside one. Each sign assembly, mounted on a 2m high by 1m wide backing board, comprises a further 900mm 'Road Narrows' warning sign at the top, the village nameplate in the middle and a blue plate with the message 'TRAFFIC CALMED ZONE' at the bottom. External illumination is provided at the base.

At the gateway itself, the carriageway is narrowed from 7.3m to 6m. The 6m width, to cater for wide loads, extends for a distance of 8m, with a flared entry and exit each 8m long. The total length of the gateway is thus 24m. The build-outs, of equal width on each side of the carriageway, feature Redland Trief kerbing, which has a profile designed to minimise damage to any vehicle colliding with it. The 600mm diameter speed limit signs are positioned on each side of the carriageway at the start of the minimum width section. Each roundel is mounted on black plastic strips (Glasdon *Chevroflex*) similar to those in places used for backing chevron signs on bends. Four reflector posts define the offside of the flared entry to the narrowing for each direction of travel. A 'Keep Right' bollard is positioned on the nearside of the flared entry for outbound traffic.

The contrasting surface treatment at each gateway is dark red in colour and extends for the 24m length of the narrowing. The material used is known as *Imprint*, supplied by Prismo. Marketed as a low-cost alternative to block paving, it is a hot-applied thermoplastic material laid directly on concrete or black-top surfaces and then imprinted using a suitable former to give a brick, block or cobbled pattern. A brick pattern was adopted at Thorney. It can be laid to almost any preformed shape as a relatively thin layer, i.e. less than 30mm. At Thorney it has a maximum thickness of 20mm, with a 2m long 'ramp' to this thickness in both directions. It is claimed that the material can be applied year round with minimal site preparation and disruption to traffic. It is also claimed that the material is resistant to deformation by a daily flow of HGVs similar to that at Thorney, and performs as well as rolled asphalt in this respect. The skidding resistance in the shorter and longer term was considered acceptable for application at Thorney. In the wet, the grooves provide drainage.

At the east gateway, a footway on the north side of the carriageway was diverted to make room for the speed limit sign and its backing. Pedestrian deterrent paving was laid between the footway and the Trief kerbing.

3.2 THE CHICANES

The chicanes are encountered 90m and 100m inside the east and west gateway respectively (Figs 11 and 12). The chicanes differ somewhat in layout (Fig 13), but both cater for two-way traffic, have a slightly angled central island, hatching on a red background and realignment of the carriageway edge to provide horizontal deflection.

The dimensions of the chicanes are as follows:

	Eastern chicane	Western chicane
Island	1.2mx 6.0m	1.2m x 12.0m
Minimum lane width between hatching	3.0m	3.0m
Deflection of nearside edge line		
inbound traffic	2.0m	1.6m
outbound traffic	1.9m	2.8m
Total length of feature	41.6m	52.2m

The Trief-kerbed islands have associated centre hatching, two internally illuminated 'keep left' bollards of the circular type, reflective marker posts and a 'hatpin' type lighting column. There is also hatching on the nearside of the carriageway for outbound traffic. All hatching is bounded by solid white line and is on a red background. The minimum lane width is provided by realignment of the carriageway edge on both sides together with the hatching and edge lining.

Fig.5 The approach to the east gateway (top) and west gateway (bottom); the 'road narrows' signing indicates carriageway narrowing at the gateway

Fig.6 Advance signing on the approach to the east gateway (identical signing is used at the west gateway)

Fig.7 East gateway, showing narrowing with Trief kerbing, speed limit roundels fixed to *Chevroflex* plastic strips and *Imprint* surface treatment

Fig.8 West gateway

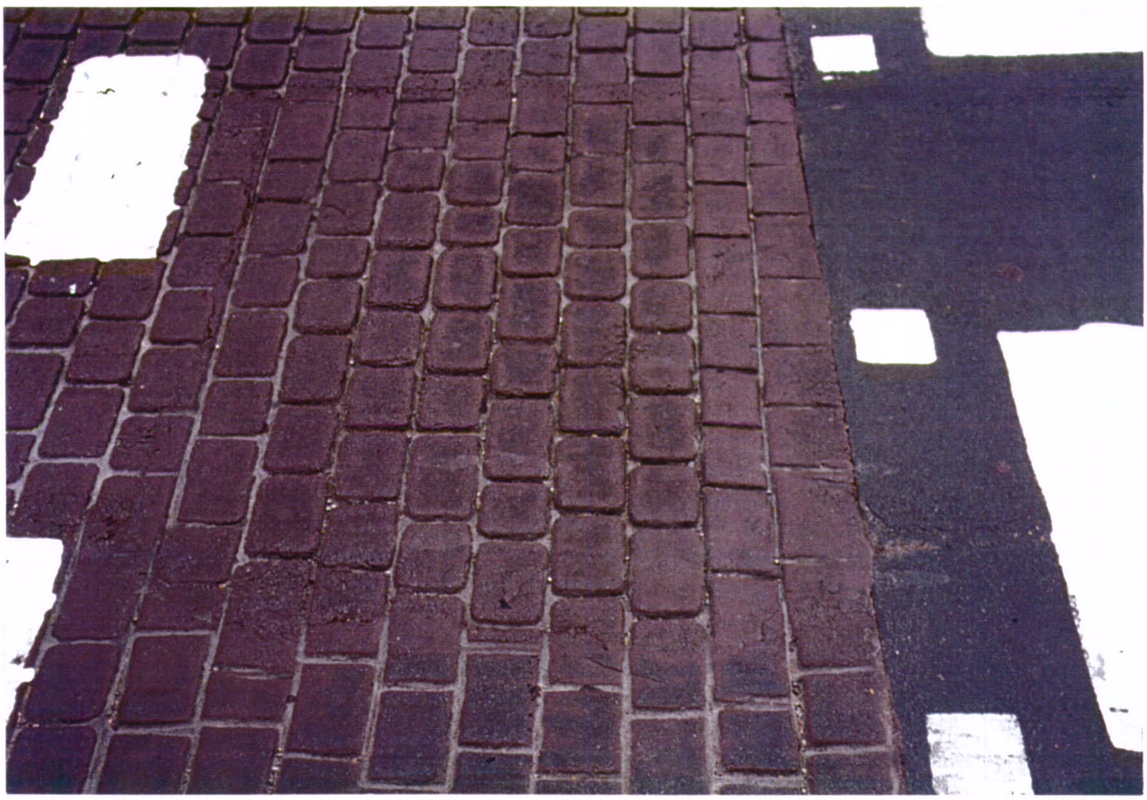


Fig.9 *Imprint* surfacing used at the gateways and each side of the zebra crossing within the village (that at the crossing is shown)

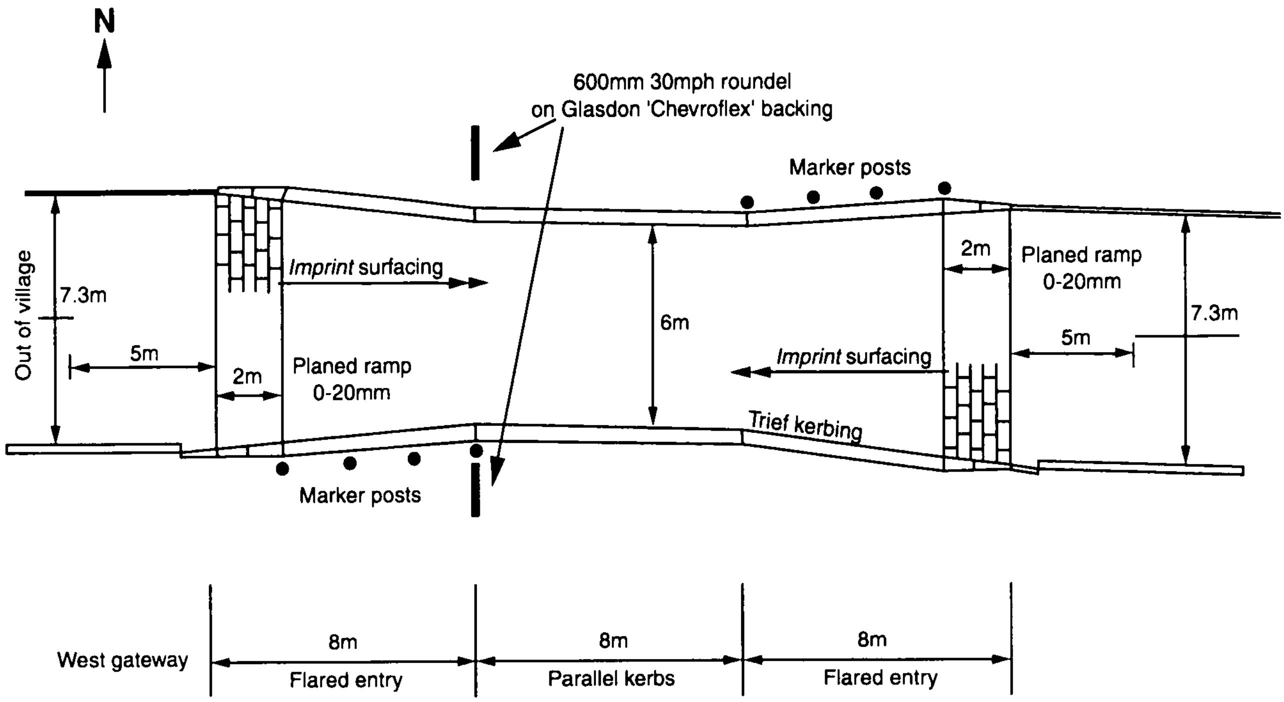


Fig. 10 Plan of gateway (both gateways have the same dimensions and features)

It is necessary for wide loads entering the village to negotiate the chicanes by passing their islands on the 'wrong' side, where the required 6m width is available. At the western chicane, the outbound lane including the hatching is of sufficient width to allow passage, but at the eastern chicane, the black bollards on the outbound side can be removed and the footway overridden. For this reason, the footway is strengthened to carriageway standards.

3.3 PART-TIME 20MPH SPEED LIMIT

Travelling inbound, a part-time 20mph speed limit starts about 160m beyond the eastern chicane. This had been programmed as part of a national experiment and was incorporated into the current scheme. This extends over a distance of 252m past a school access. The speed limit operates on Monday to Friday at each end of the school day and during the lunch period from 0830 to 0905, 1155 to 1305 and 1510 to 1550.

For this purpose, a pair of remotely operated variable message signs (VMS) were erected at each end of this length of road, and in Sandpit Road for drivers about to join the main road. When the speed limit is in force, a '20' roundel with 'School' underneath shows, and an amber light flashes in each corner (Fig 14, top). When the 20mph speed limit is not required, the signs display the 'Children' sign with 'School' underneath (Fig 14, bottom). When each sign displays the '20' roundel, the reverse side shows a '30' roundel for traffic leaving the 20mph limit (Fig 15) - at other times, this display is blank. The signs are switched automatically.

3.4 PEDESTRIAN CROSSING

A zebra crossing was installed about 20m west of the school access (Fig 16); a plan of the crossing is shown in Fig 17. Where the crossing was installed, the carriageway width was reduced from 7.5m to 6m over a distance of 12m. This was achieved by trapezoidal build-outs 750mm wide on both sides of the carriageway; these are flared for 5m at each end. Guard rails were erected along the length of the build-outs and 'keep right' square bollards were installed between the guard railing and the kerb to increase the conspicuity of the build-out. The crossing was installed on *Imprint* surfacing as used at the gateways; this treatment extends for 22m with the crossing halfway along. On each approach, the surface treatment is dark red, and is ramped for 2m, over which distance the thickness of the *Imprint* increases from 6mm to 20mm. At the crossing itself, the surface treatment is black, but without the brick pattern. The crossing is within the part-time 20mph speed limit but was introduced prior to the commencement of the speed limit operation.

Since the completion of 'after' monitoring at Thorney, complaints from nearby residents about noise generated by the *Imprint* surfacing has led to the removal of the surface patterning. However, this has lowered the skidding resistance, and it is hoped to treat this with an anti-skid compound when funds permit.

Fig.11 Chicane, eastern end of village, looking inbound (top) and outbound (bottom)

Fig.12 Chicane, western end of village, looking inbound (top) and outbound (bottom)

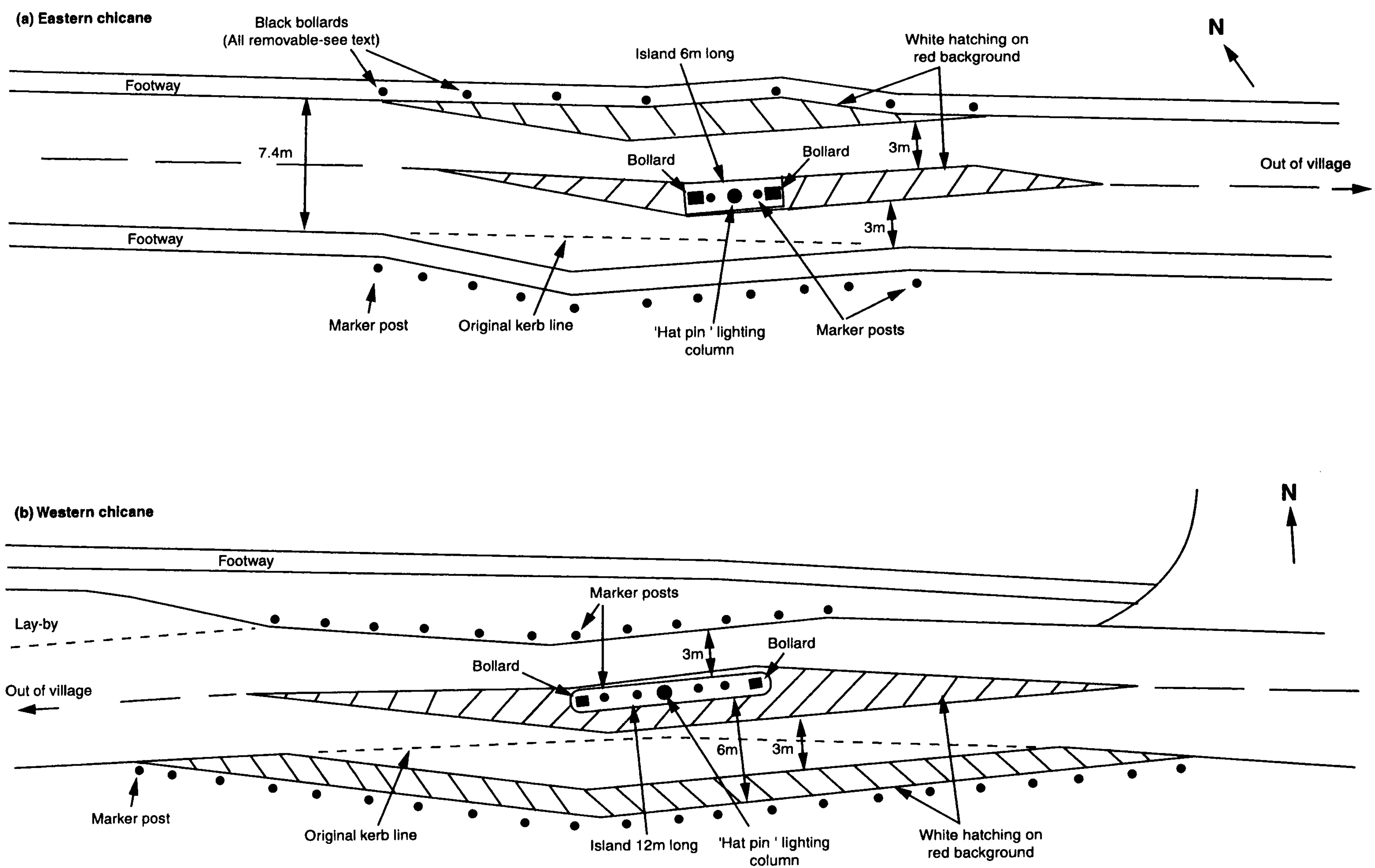


Fig. 13 Plans of chicanes

Fig.14 Variable message signing (looking west) indicating part-time 20mph speed limit past the school; speed limit in operation (top) and not in operation (bottom)

Fig.15 Reverse of variable message 20mph speed limit sign when on (looking west)

Fig.16 Zebra crossing within carriageway narrowing, showing *Imprint* surfacing each side of crossing (looking east)

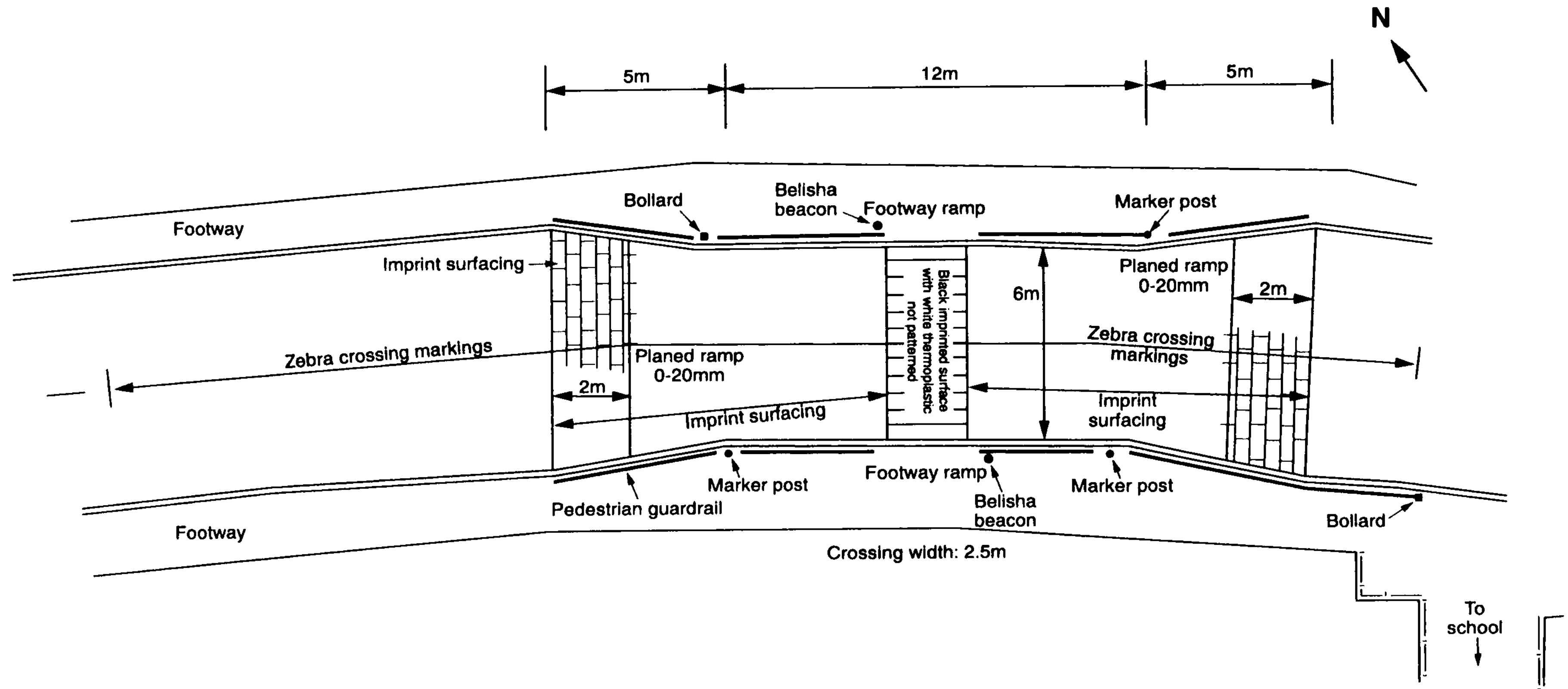


Fig. 17 Plan of zebra crossing and associated features

3.5 MINI-ROUNDABOUTS

Mini-roundabouts, with domed 4m diameter central islands, were installed at the junctions with Sandpit Road and Woburn Drive. The former lies within the part-time 20mph speed limit. The latter, close to the western end of this speed limit, was soon removed following complaints from nearby residents about noise, mainly at night, generated by HGVs allegedly crossing or 'clipping' the domed islands. The Sandpit Road mini-roundabout remains at the time of writing, though there was some pressure for its removal also. This mini-roundabout is shown in Fig 18 and as a plan in Fig 19. Here, deflection for eastbound traffic is provided by a nearside build-out, of maximum width 2m, on the immediate approach to the roundabout (Fig 18, top). Westbound traffic is deflected by a splitter island and the offset central island (Fig 18, bottom). This photograph also shows how clipping of the central island can easily occur.

3.6 SPEED CAMERA INSTALLATION

GATSO speed camera equipment was commissioned in November 1995. The site of installation is shown in Fig 2d. Housings were installed on both sides of the carriageway about midway between the western end of the part-time 20mph speed limit and the remodelled junctions described below. The A47 through Thorney is part of a speed camera route between Giyhirn (11km to the east) and Eye (6km to the west); speed camera warning signs have been erected at intervals along this length of road, and are to be extended eastwards to Wisbech.

3.7 JUNCTION REMODELLING AND RIGHT-TURN LANE

In the centre of the village, between 80m and 210m east of the signalled junction with the B1040, junction remodelling was carried out and centre hatching installed to provide some horizontal deflection to main road traffic. These features are shown in Fig 20 and on a plan at Fig 21. Kerb realignment was carried out at the junctions with Gas Lane (Fig 20, top) and with another road 50m to the west (nearly opposite the junction with Church Street), and each side of a drive to Thorney Park opposite Gas Lane (Fig 20, bottom). The previous kerb line was built out on both corners by 3m at the latter two locations, narrowing the main carriageway to 6.5m. The kerb works also provide shelter for the bus bays installed each side of the main road. These bays are surfaced with grey *Imprint*. The centre hatching, also shown in Fig 20 (top), was installed to the west of Gas Lane, incorporating a right-turn lane into Church Street.

3.8 PEDESTRIAN REFUGE

A pedestrian refuge 1.2m wide and 6m long was installed opposite a bus bay, about 100m west of the junction with the B1040. It is shown in Fig 22, with a plan at Fig 23. The refuge has internally illuminated bollards of the circular type and a 'hatpin' type lighting column.

4. SCHEME MONITORING

Monitoring of the scheme's effectiveness was carried out through 'before' and 'after' observations of the following:

1. traffic flows;
2. vehicle speeds;
3. vehicle journey times through the village;
4. traffic noise.

Monitoring of ground-borne vibration was carried out in the 'after' period only. A survey of public opinions on the scheme was also carried out after time had been allowed for residents to get accustomed to the measures. Accident data and information on emergency services' reactions were also obtained.

The data collection procedures and results are described in the following sub-sections.

4.1 TRAFFIC FLOWS

4.1.1 Data collection

Two-way traffic flows (unclassified by vehicle type) were recorded before, and 7 weeks after, scheme implementation[1], and again following commissioning of the speed camera equipment. The data were collected on both approaches (i.e. at the gateway sites) with automatic data loggers using loop detectors. This equipment also recorded vehicle speeds (see Section 4.2.1). The data yielded daily (24 hour) flows in each direction over at least one week.

Before and after scheme installation, a manual classified traffic count in each direction was carried out at the east gateway over the period 1000-1800. These counts were taken from video recordings to be used for journey time monitoring (see Section 4.3). The vehicle classifications were:

cars/light goods vehicles;
goods vehicles over 1.5 tonnes unladen (HGVs)*;
motorcycles;
buses (including coaches);
pedal cycles.

* Including vans with two sets of double wheels on the rear axle

[1] i.e. without the commissioned 20mph variable message speed limit signs and the speed camera equipment and its signing.

Fig.18 Sandpit Road mini-roundabout looking east (top) and west (bottom)

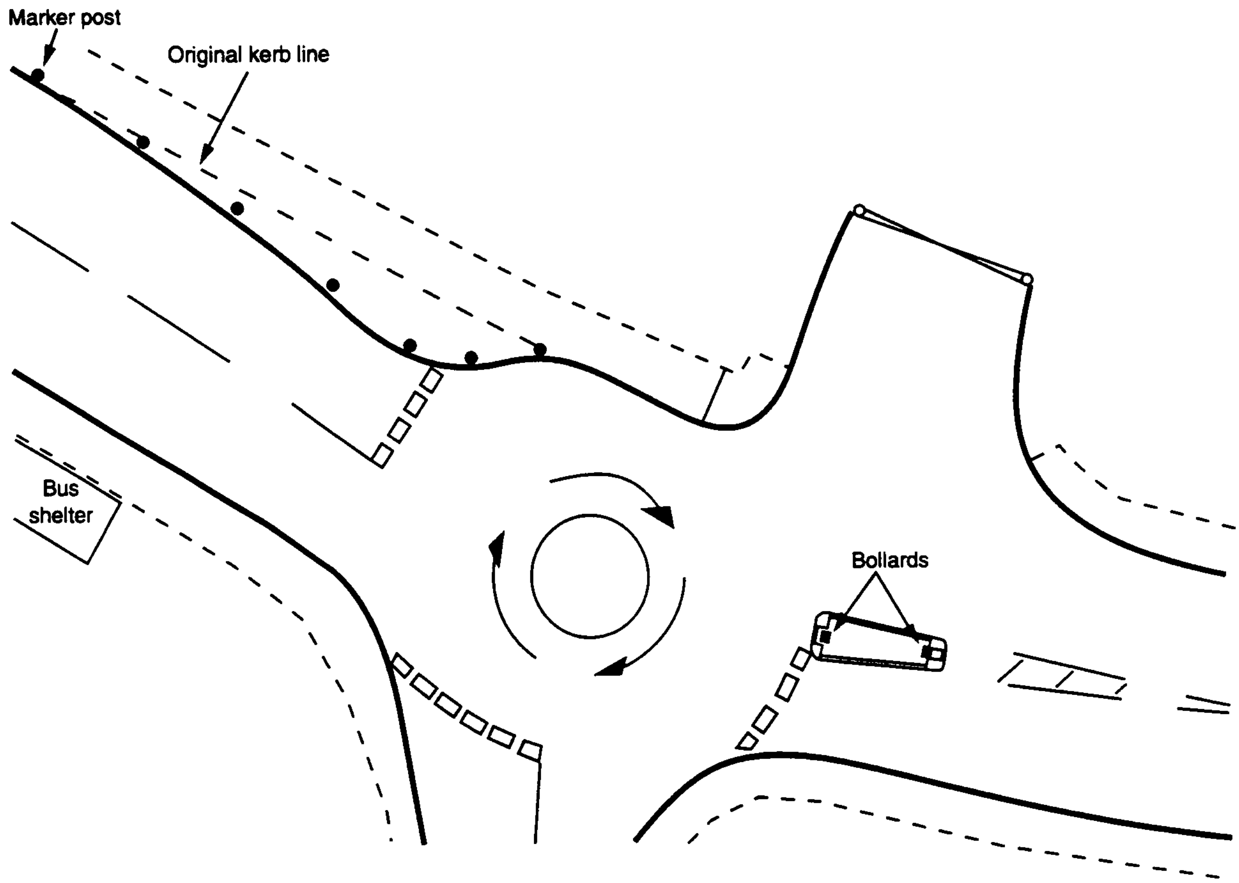


Fig. 19 Plan of mini-roundabout at junction with Sandpit Road

The dates of the counts were as follows:

Before scheme installation

automatic count:	7-13 November 1994
manual classified count:	19 April 1994.

After scheme installation

automatic count:	22-28 June 1995; 24-30 November 1995 (after speed camera installation);
manual classified count:	22 June 1995.

4.1.2 Results

In Table 1, mean 'before' (November 1994) and 'after' (November 1995) two-way traffic flows are shown for the following periods:

7 days;
weekdays (Monday-Friday);
weekend;
Monday-Thursday;
Friday.

The flows measured in June 1995 (not shown) were higher than those observed in November 1994, by an amount broadly consistent with seasonal fluctuations. The mean daily two-way flows in November 1994 and November 1995 were broadly similar to each other. This indicates that the traffic calming scheme had little effect on traffic flows.

At the east gateway, the mean two-way flow over 7 days was 12,400 vehicles/day in both November 1994 and November 1995. At the west gateway, the flows were 13,600 in November 1994 and 13,900 in November 1995. Friday was the busiest day of the week.

The difference in flow between gateways is likely to be due to traffic movements to and from the B1040 and other points within Thorney.

The 8 hour manual two-way counts at the east gateway, classified by vehicle type, are shown in Table 2. Light vehicles include cars, light goods vehicles (LGVs) and motorcycles; heavy vehicles are HGVs (as defined in Section 4.1.1) and buses. The proportions of light vehicles and heavy vehicles changed little between the 'before' and 'after' periods (April 1994 and June 1995 respectively). They were respectively 77.6% and 22.3% in the 'before' period and 78.5% and 21.5% in the 'after' period.

Fig.20 Kerb realignment to create horizontal deflection to traffic: kerb build-outs and sheltered bus bay opposite junction with Church Street, looking east (top) and similar features on other side of carriageway at drive to Thorney Park, looking east (bottom)

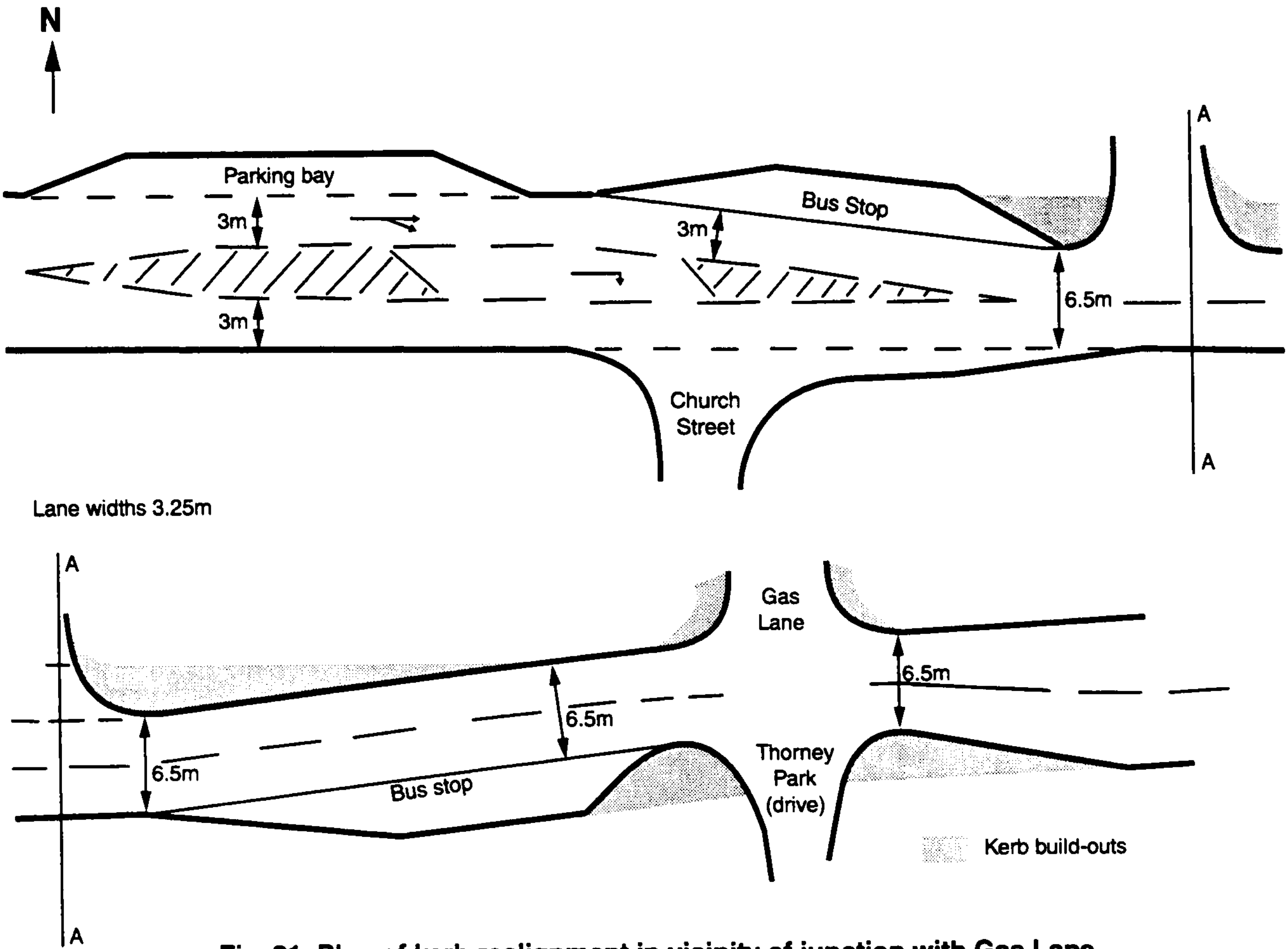


Fig. 21 Plan of kerb realignment in vicinity of junction with Gas Lane

TABLE 1

'Before' and 'after' two-way flows at gateway sites (all vehicles)

Location and period	24 hour two-way flow Before 11.94	After 11.95	Change (%) 11.94 - 11.95
East gateway			
7 day	12426	12408	- 0.1
weekday	13210	12952	- 2.0
weekend	10566	11047	+ 4.5
Monday-Thursday	12864	12710	- 1.2
Friday	14397	13921	- 3.3
West gateway			
7 day	13640	13877	+ 1.7
weekday	14488	14587	+ 0.7
weekend	11521	12101	+ 5.0
Monday-Thursday	14178	14375	+ 1.4
Friday	15730	15436	- 1.9

Fig.22 Refuge adjacent to bus bay to west of junction with B1040 (looking east)

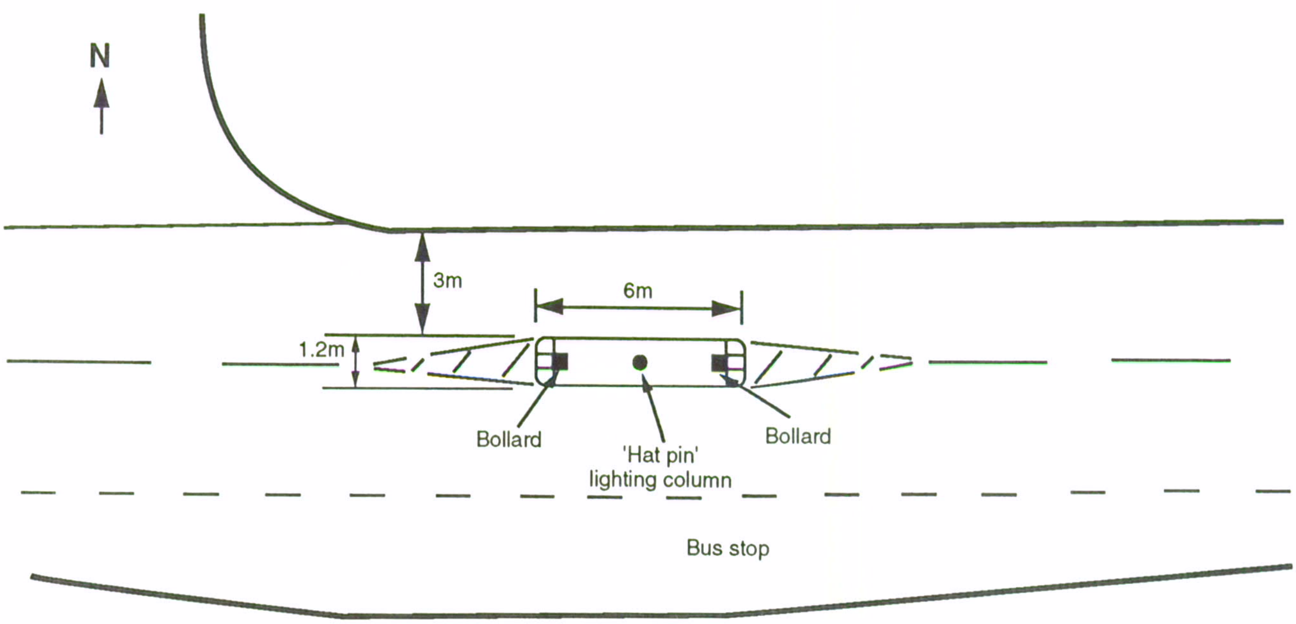


Fig. 23 Plan of refuge

TABLE 2

Flow composition (8 hour manual counts at the east gateway)

	Before (19.4.94) Two-way	Before (19.4.94) Percentage	After (22.6.95) Two-way	After (22.6.95) Percentage
Cars/LGVs	5137	77.3	5496	77.6
Motorcycles	22	0.3	64	0.9
HGVs	1451	21.8	1469	20.8
Buses	32	0.5	49	0.7
Pedal cycles	0	0.0	0	0.0
totals	6642	100	7078	100

4.2 VEHICLE SPEEDS

4.2.1 Data collection

Speed monitoring (both directions) was carried out at 9 positions (Fig 24) - just inside each gateway (by automatic speed measurement) and at 7 positions in the village (using radar guns). 'After' monitoring began about 7 weeks after scheme implementation.

The monitoring positions were:

western approach:	just inside the gateway/30mph speed limit (site 1);
within village:	at the chicane inside the west gateway* (site 2);
	at the pedestrian refuge west of the junction with the B1040 (site 3);
	at the speed camera site (site 4);
	at the western end of the part-time 20mph speed limit (site 5);
	at the zebra crossing within the part-time 20mph speed limit (site 6);
	125m outside the eastern end of the part-time 20mph speed limit and 40m from the inbound end of the eastern chicane (site 7);
	at the chicane near the east gateway* (site 8);
western approach:	just inside the gateway, i.e. just inside the 30mph speed limit (site 9);

* speeds were measured adjacent to the island of the chicane.

The radar speed monitoring was carried out as far as possible in off-peak periods for free-flowing vehicles. At each position, the speeds of 100 light vehicles and 100 HGVs (as defined in Section 4.1.1) were collected on *three* successive Wednesdays and Thursdays respectively during the 'before' period. This method ensured that the data would be more robust by allowing for week to week variability. During the 'after' period, the same procedure was followed, except that monitoring was carried out on *two* successive Tuesdays and Wednesdays[2]. At sites 5 and 6, at the start of, and within, the part-time 20mph speed limit, monitoring was carried out when the 20mph variable message signs were, and were not, activated. When the signs *were* activated, it was not always possible, however, to record the speeds of 100 free-flowing vehicles in the time available.

Further radar data were collected at the speed camera site about 3-4 weeks after commissioning. Automatic speed measurements were also repeated at the gateways following the erection of speed camera signing.

The monitoring dates were as follows:

Before scheme installation

Gateways (sites 1 and 9):	7-13 November 1994 (all vehicles).
Within village (sites 2-8):	*light vehicles:* 19, 26 April, 3 May 1994 (sites 3, 5, 6, 7); 5, 12, 19 October 1994 (sites 2, 4, 8);
	heavy vehicles: 20, 27 April, 4 May 1994 (sites 3, 5, 6, 7); 6, 13, 20 October 1994 (sites 2, 4, 8).

2 At site 7, 200 speeds were recorded on a Tuesday and Wednesday (this size of sample is likely to be more robust than a sample of 100).

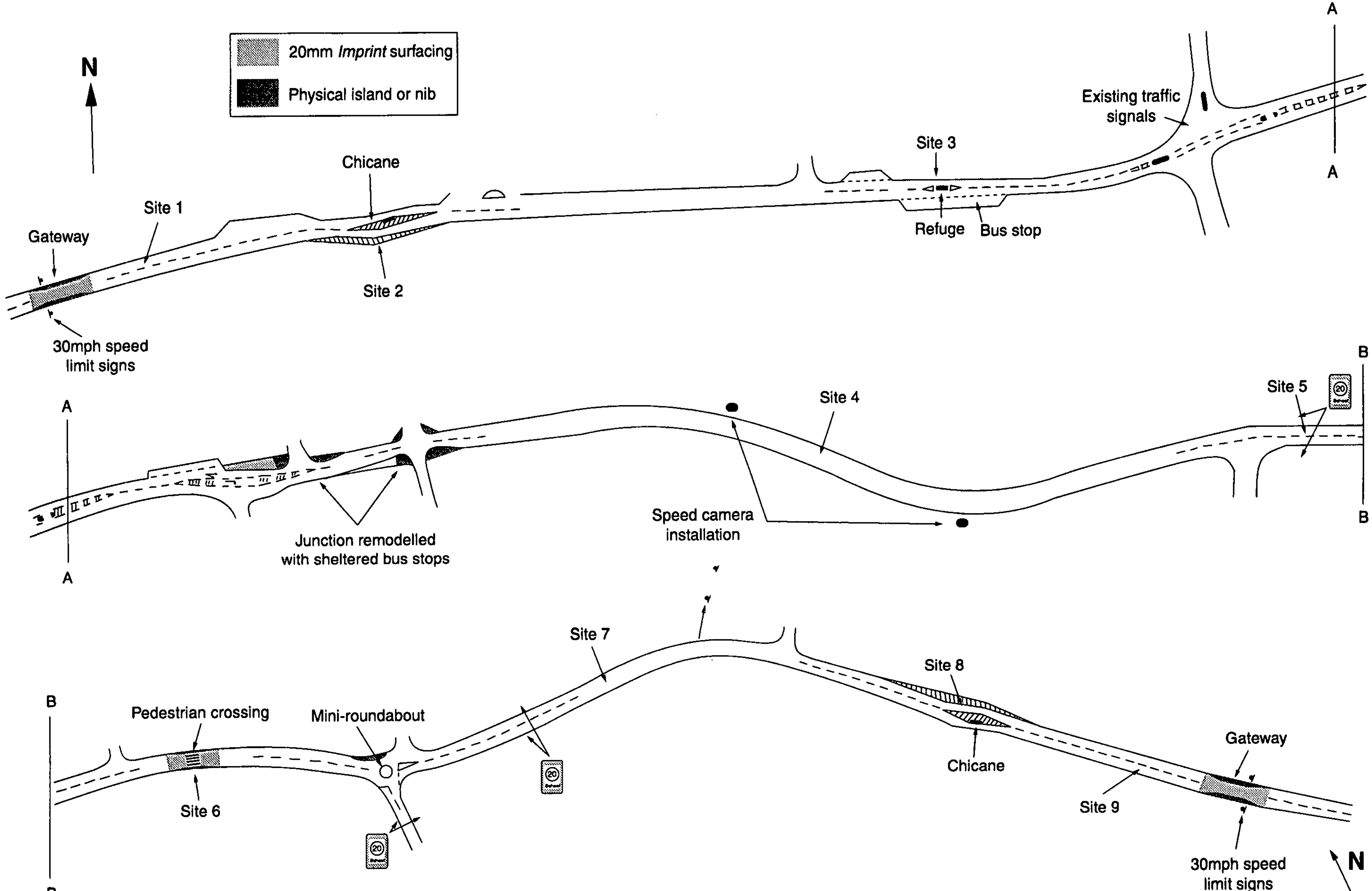


Fig. 24 Speed monitoring positions

After scheme installation

Gateways (sites 1 and 9): 22-28 June 1995 (all vehicles);

24-30 November 1995 (after speed camera installation).

Within village (sites 2-8): *light vehicles:* 4, 11, 18 July 1995;

28, 29 November 1995 (after speed camera installation);

heavy vehicles: 5, 12, 19 July 1995; 28, 29 November 1995 (after speed camera installation).

The weather was fair throughout.

At the gateways, 7 complete days of data were collected. Speeds of all vehicles (unclassified by type) in each direction were recorded. From these data, mean and 85th percentile speeds were calculated for the following:

seven days;
Monday to Friday;
Saturday and Sunday;
daytime (0700-1900);
nighttime (1900-0700).

4.2.2 Results

4.2.2.1 Speed changes on the village approaches

Table 3 shows 'before' and two sets of 'after' mean and 85th percentile speeds just inside the gateway for inbound and outbound traffic. The second set of 'after' results shows the effect, if any, of the subsequent installation of the speed camera equipment in the village and associated signing on the village approaches. Speeds are shown for 7 day, weekday and weekend periods, together with speeds for daytime (0700-1900) and nighttime (1900-0700) periods over 7 days.

Before scheme installation, 7 day inbound mean speeds were 42mph and 46mph at the east and west gateways respectively. Corresponding 85th percentile speeds were 49mph and 53mph. At the east gateway, speeds were similar in both directions, but at the west gateway outbound speeds were 3-4mph lower than inbound speeds. At the weekend, mean and 85th percentile speeds were 2-4mph higher than on weekdays. At night, mean and 85th percentile speeds were 4-7mph higher than during the day at the west gateway. At the east gateway, the difference was 2-3mph.

(a) Speed changes without the speed cameras Every 'before'/'after' change in mean and 85th percentile speed shown in Table 3 was statistically significant at at least the 0.1% level (using the two tailed t-test). The overall (7 day) mean speed of *inbound* traffic fell by 9mph at both gateways, to 33mph and 37mph at the east and west gateway respectively; the weekend changes were 1-3mph more than the weekday changes, with weekend reductions of at least 10mph. 'After' mean speeds were thus only about 1mph higher at the weekend than on weekdays. *Inbound* mean speeds at night, up to 5mph higher than daytime speeds during the 'before' period, fell by 7-9mph, suggesting that the gateways were almost as effective at night as during the day. The 'before' inbound mean speed at night had been 50mph at the east gateway.

At the west gateway, *outbound* mean speeds in all periods fell by a similar amount to inbound speeds, but at the east gateway, outbound speed reductions (typically 4-5mph) were about half of those inbound.

At both gateways, *inbound* 85th percentile speeds over the 7 day period fell by 8-9mph, to 40mph and 44mph at the east and west gateway respectively. 'Before'/'after' changes in these 85th percentile speeds were 2-3mph higher at the weekend than on weekdays, with weekend reductions of up to 11mph. Again, this resulted in 'after' 85th percentile speeds only 1mph higher at the weekend than on weekdays. As with mean speeds, nighttime 85th percentile *inbound* speeds were several mph higher than daytime speeds during the 'before' period and fell by 8-9mph. The 'before' inbound 85th percentile speed at night had been 58mph at the east gateway.

Changes in *outbound* 85th percentile speeds showed a similar pattern to that of mean speeds.

(b) Speed changes after speed camera installation The apparent additional effect of the speed camera equipment and its signing is shown in Table 3. *Inbound* mean speeds (over 7 days) were reduced by a further 2mph, to 31mph at the east gateway and to 36mph at the west gateway, a total reduction of 11mph on speeds prior to the installation of any measures. The further reductions were similar during weekdays, the weekend and during the day. At night, however, mean speeds fell by a further 3-4mph to 33mph and 37mph at the east and west gateways respectively, down 11mph and 13mph on mean speeds before scheme installation.

There was little further overall reduction in *outbound* mean speeds at the west gateway, but at the east gateway, where with no speed cameras the reduction had only been 4mph outbound, there was a further reduction of 4mph.

Inbound 85th percentile speeds (over 7 days) were further reduced by 3mph, to 37mph at the east gateway and to 41mph at the west gateway, a total reduction of 12mph on speeds before scheme installation. The further reductions

TABLE 3

Speeds at the gateways (mph)

Location and direction	Mean speed Before 11.94	After 6.95	After[1] 11.95	Change 11.94-6.95	Change 11.94-11.95	85th percentile speed Before 11.94	After 6.95	After[1] 11.95	Change 11.94-6.95	Change 11.94-11.95
West gateway (site 1)										
Eastbound/inbound										
7 days	46.1	37.3	35.7	- 8.8	-10.4	53.3	44.4	41.3	- 8.9	-12.0
weekdays	45.2	37.1	35.4	- 8.1	- 9.8	52.2	44.1	41.1	- 8.1	-11.1
weekend	48.9	38.0	36.7	-10.9	-12.2	56.2	45.1	41.9	-11.1	-14.3
daytime[2]	45.1	36.3	35.4	- 8.8	- 9.7	51.8	43.0	40.7	- 8.8	-11.1
nighttime[3]	50.2	41.1	37.4	- 9.1	-12.8	58.4	48.9	43.9	- 9.5	-14.5
Westbound/outbound										
7 days	43.4	34.4	33.9	- 9.0	- 9.5	49.5	40.0	40.0	- 9.5	- 9.5
weekdays	43.0	34.1	33.4	- 8.9	- 9.6	48.9	39.8	39.5	- 9.1	- 9.4
weekend	44.9	35.3	35.2	- 9.6	- 9.7	51.2	40.4	41.1	-10.8	-10.1
daytime[2]	42.8	33.8	33.2	- 9.0	- 9.6	48.4	39.0	39.0	- 9.4	- 9.4
nighttime[3]	46.6	36.9	36.5	- 9.7	-10.1	54.1	43.0	43.5	-11.1	-10.6
East gateway (site 9)										
Westbound/inbound										
7 days	42.3	33.3	31.1	- 9.0	-11.2	48.9	40.5	37.1	- 8.4	-11.8
weekdays	41.8	33.0	30.7	- 8.8	-11.1	48.1	40.2	36.7	- 7.9	-11.4
weekend	43.9	34.0	32.3	- 9.9	-11.6	50.6	41.0	38.0	- 9.6	-12.6
daytime[2]	42.0	32.3	30.7	- 9.7	-11.3	48.4	39.2	36.6	- 9.2	-11.8
nighttime[3]	43.7	36.9	32.8	- 6.8	-10.9	51.3	44.3	39.1	- 7.0	-12.2
Eastbound/outbound										
7 days	42.7	38.2	34.6	- 4.5	- 8.1	48.7	44.6	40.5	- 4.1	- 8.2
weekdays	42.2	37.7	34.3	- 4.5	- 7.9	48.2	44.3	40.2	- 3.9	- 8.0
weekend	44.3	39.2	35.6	- 5.1	- 8.7	50.3	45.2	41.4	- 5.1	- 8.9
daytime[2]	42.3	37.5	34.3	- 4.8	- 8.0	48.1	43.7	40.1	- 4.4	- 8.0
nighttime[3]	44.2	40.7	36.2	- 3.5	- 8.0	50.9	47.8	42.8	- 3.1	- 8.1

Notes:

[1] after installation of GATSO speed camera and associated signing

[2] daytime: 07h-19h;

[3] nighttime: 19h-07h.

The number of observations ranged from 7521 (nighttime) to 51,942 (over 7 days)

during weekdays, the weekend and during the day were again similar. As with mean speeds, 85th percentile *inbound* speeds at night fell by a further 5mph, to 39mph and 44mph at the east and west gateways respectively, down 12mph and nearly 15mph on the speeds before scheme installation. There was no further overall reduction in outbound 85th percentile speeds at the west gateway, but at the east gateway, there was a further reduction of up to 4mph.

Note that the reduced speeds at the gateways were still 7-11mph above the 30mph target speed.

4.2.2.2 Speed changes within the village

Table 4 shows the 'before' and 'after' mean and 85th percentile speeds within the village for light vehicles and HGVs in each direction. These speeds were calculated by combining the three 'before' and the two 'after' samples respectively. During the 'before' period, the mean speed of light vehicles ranged from 33mph in the central part of the village to 47mph near the western end of the village where one of the chicanes was installed. Corresponding 85th percentile speeds were in the range 38-54mph.

TABLE 4

Speeds in the village (mph)

location, direction, vehicle type	mean speed before 4/5.94[1] 11.94[2]	mean speed after[3] 7.95	mean speed after[4] 11.95	mean speed change b-a	85th percentile speed before 4/5.94[1] 11.94[2]	85th percentile speed after[3] 7.95	85th percentile speed after[4] 11.95	85th percentile speed change b-a
site 2 (western island chicane)								
eastbound/inbound (light)	47.4	33.4	...	-14.0	54.0	38.8	...	-15.2
westbound/outbound (light)	43.3	33.6	...	- 9.7	48.7	38.4	...	-10.3
eastbound (heavy)	42.6	27.6	...	-15.0	47.5	32.4	...	-15.1
westbound (heavy)	38.5	29.9	...	- 8.6	42.7	33.9	...	- 8.8
site 3 (pedestrian refuge)								
eastbound (light)	37.8	30.5	...	- 7.3	43.9	34.5	...	- 9.4
westbound (light)	38.2	33.0	...	- 5.2	42.8	36.9	...	- 5.9
eastbound (heavy)	36.7	27.9	...	- 8.8	41.4	30.9	...	-10.5
westbound (heavy)	34.9	29.8	...	- 5.1	38.7	33.3	...	- 5.4
site 4 (speed camera site: no camera or housing installed but the other measures in place)								
eastbound (light)	35.4	32.6	...	- 2.8	39.6	36.3	...	- 3.3
westbound (light)	34.0	31.7	...	- 2.3	38.0	35.1	...	- 2.9
eastbound (heavy)	33.9	29.8	...	- 4.1	37.1	32.5	...	- 4.6
westbound (heavy)	32.6	29.6	...	- 3.0	35.6	33.0	...	- 2.6
site 4 (speed camera site: after camera installation)								
eastbound (light)	35.4	...	31.3	- 4.1 (-1.3[5])	39.6	...	34.8	- 4.8 (- 1.5[5])
westbound (light)	34.0	...	30.5	- 3.5 (-1.2$_5$)	38.0	...	33.9	- 4.1 (- 1.2[5])
eastbound (heavy)	33.9	...	30.1	- 3.8 (+0.3[5])	37.1	...	32.9	- 4.2 (+ 0.4[5])
westbound (heavy)	32.6	...	29.3	- 3.3 (-0.3[5])	35.6	...	31.8	- 3.8 (- 1.2[5])
site 5 (west end of part-time 20mph speed limit: signs OFF)								
eastbound (light)	36.9	32.7	...	- 4.2	41.8	36.7	...	- 5.1
westbound (light)	34.6	30.9	...	- 3.7	39.3	34.8	...	- 4.5
eastbound (heavy)	35.1	29.7	...	- 5.4	38.7	32.9	...	- 5.8
westbound (heavy)	33.5	27.3	...	- 6.2	37.4	30.4	...	- 7.0
site 5 (west end of part-time 20mph speed limit: signs ON)								
eastbound (light)	36.9	27.5	...	- 9.4 (-5.2[6])	41.8	32.6	...	- 9.2 (- 4.1[6])
westbound (light)	34.6	27.4	...	- 7.2 (-3.5[6])	39.3	31.7	...	- 7.6 (- 3.1[6])
eastbound (heavy)	35.1	25.5	...	- 9.6 (-4.2[6])	38.7	29.5	...	- 9.2 (- 3.4[6])
westbound (heavy)	33.5	24.6	...	- 8.9 (-2.7[6])	37.4	28.2	...	- 9.2 (- 2.2[6])
site 6 (pedestrian crossing within part-time 20mph speed limit: signs OFF)								
eastbound (light)	36.3	29.6	...	- 6.7	40.7	34.0	...	- 6.7
westbound (light)	32.9	26.1	...	- 6.7	37.8	30.1	...	- 7.7
eastbound (heavy)	34.0	27.7	...	- 6.3	37.7	31.3	...	- 6.4
westbound (heavy)	32.1	24.3	...	- 7.8	35.6	27.2	...	- 8.4
site 6 (pedestrian crossing within part-time 20mph speed limit: signs ON)								
eastbound (light)	36.3	25.4	...	-10.9 (-4.2[6])	40.7	30.2	...	-10.5 (- 3.8[6])
westbound (light)	32.9	23.2	...	- 9.7 (-3.0[6])	37.8	26.9	...	-10.9 (- 3.2[6])
eastbound (heavy)	34.0	22.7	...	-11.3 (-5.0[6])	37.7	26.6	...	-11.1 (- 4.5[6])
westbound (heavy)	32.1	20.5	...	-11.6 (-3.8[6])	35.6	24.3	...	-11.3 (- 2.9[6])
site 7 (between site 6 and eastern island chicane)								
eastbound/outbound (light)	38.7	33.9	...	- 4.8	43.9	37.7	...	- 6.2
westbound/inbound (light)	42.2	31.0	...	-11.2	49.4	35.5	...	-13.9
eastbound (heavy)	36.1	31.1	...	- 5.0	40.1	34.4	...	- 5.7
westbound (heavy)	39.5	24.7	...	-14.8	45.1	28.5	...	-16.6
site 8 (eastern island chicane)								
eastbound/outbound (light)	43.0	37.1	...	- 5.9	48.1	42.4	...	- 5.7
westbound/inbound (light)	42.8	32.3	...	-10.5	49.0	37.7	...	-11.3
eastbound (heavy)	37.6	30.7	...	- 6.9	41.5	34.1	...	- 7.4
westbound (heavy)	38.9	24.8	...	-14.1	44.4	29.3	...	-15.1

1 'Before' monitoring carried out during 4.94 and 5.94 at sites 3, 5, 6 and 7 (total of 300 observations in each sample)
2 'Before' monitoring carried out during 11.94 at sites 2, 4, and 8 (total of 300 observations in each sample)
3 Total number of observations in each sample ranged from 160 to 300
4 This 'after' monitoring was carried out following speed camera installation (total of 400 observations in each sample)
5 Additional speed reduction with the speed camera installation
6 Additional speed reduction with the part-time 20mph speed limit in force

With the measures introduced, speeds were reduced at all seven monitoring positions, and every change in mean speed was statistically significant at at least the 0.1% level (using the two tailed t-test).

(a) At the chicanes (sites 2 and 8). Inbound speed reductions at these sites were among the largest in the village (part of these reductions obviously being due to the gateways just encountered). At site 2, at the western end of Thorney, the mean speed of inbound light and heavy vehicles decreased by 14mph and 15mph respectively. The corresponding 85th percentile speeds of both light and heavy vehicles fell by 15mph.

At site 8, at the eastern end of the village, the inbound mean speed of light and heavy vehicles fell by 10mph and 14mph respectively; corresponding 85th percentile speeds fell by 11mph and 15mph.

In spite of these encouraging reductions, the only 85th percentile inbound speed to be reduced to 30mph or less at the chicanes was that of HGVs at the eastern chicane.

Compared with inbound speed reductions, reductions in outbound mean and 85th percentile speeds at the chicanes were typically 5mph smaller for light vehicles and 6-8mph smaller for HGVs.

(b) At the pedestrian refuge (site 3). Speed reductions at this site were greater eastbound than westbound, although 'before' speeds were similar in each direction. The mean speeds of light and heavy vehicles fell by 5mph westbound and 7-9mph eastbound. Eighty-fifth percentile speed reductions were 5-6mph westbound and 9-10mph eastbound, with 'after' speeds in the range 30-37mph.

(c) At the speed camera site (site 4). Prior to installation of this equipment, speed reductions were the smallest in the village (mean speeds of light and heavy vehicles down by 2-3mph and 3-4mph respectively). This was probably due to the absence of other measures in the vicinity, exacerbated by the removal of the mini-roundabout at the junction of Woburn Drive to the east (see Section 3.5). About 150m to the west, the kerb realignment at and near the junction of Gas Lane (see Section 3.7) provided only modest horizontal deflection. After commissioning, the mean speed of light vehicles fell by only a further 1mph and HGVs were hardly affected.

Eighty-fifth percentile speeds of light and heavy vehicles at site 4 prior to speed camera installation were down by no more than 5mph. The additional effect of the speed camera installation was again a further reduction of only 1mph, with eastbound HGVs unaffected. Even with the camera equipment in place, 85th percentile speeds were still 2-5mph above the speed limit.

(d) At the western end of the part-time 20mph speed limit (site 5). Here, the mean speeds of light and heavy vehicles were down by 4mph and 5-6mph respectively without the 20mph speed limit in force. When this speed limit was operating, there was a further reduction of 3-5mph for light vehicles and 3-4mph for HGVs, giving a total reduction of about 9mph on 'before' speeds.

Without sign activation at site 5, 85th percentile speeds of light and heavy vehicles were down by up to 5mph and 7mph respectively. With the 20mph speed limit in operation, there was a further reduction of up to 4mph and 3mph for light and heavy vehicles respectively, giving a total reduction of up to 9mph on 'before' speeds. This resulted in 85th percentile speeds of about 32mph for light vehicles and about 29mph for HGVs, well above the 20mph target speed. Vehicles entering the 20mph speed limit (eastbound) were travelling at the higher speeds, having not encountered any other speed reducing measures for some distance (see notes above for site 4).

(e) At the zebra crossing within the part-time 20mph speed limit (site 6). The mean speeds of light and heavy vehicles without sign activation were down by 7mph and 6-8mph respectively. When the 20mph speed limit was operating, there was a further reduction of up to 4mph for light vehicles and up to 5mph for HGVs, giving a total reduction of 10-12mph on 'before' speeds.

Without sign activation at site 6, 85th percentile speeds of both light and heavy vehicles were down by up to 8mph. With the 20mph speed limit operating, there was a further reduction of up to 4mph for light and heavy vehicles, giving a total reduction of 11mph on 'before' speeds. This resulted in 85th percentile speeds of 27-30mph for light vehicles and 24-27mph for HGVs, again well above the desired speed. The higher speeds were again in the eastbound direction, probably for the reason mentioned above.

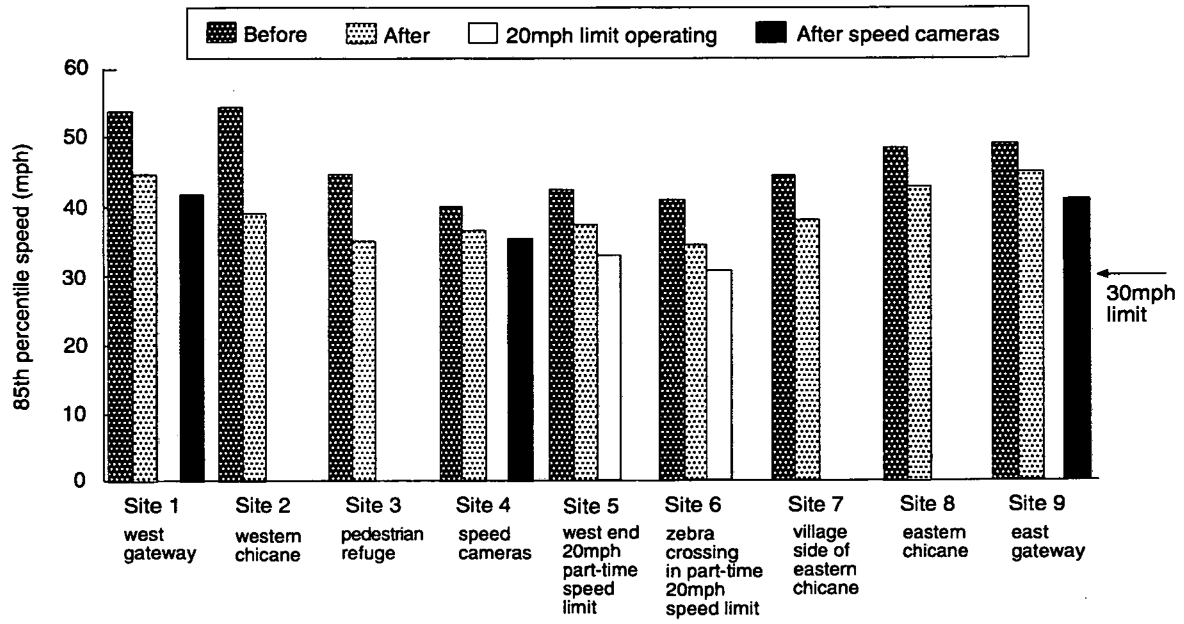
It was noticed on a site visit that opposing large HGVs at site 6 occasionally had to slow considerably to pass each other on the zebra crossing, possibly due to the combination of the reduced width of 6.5m and the relocation of the crossing to a site where there is a slight bend. (At the original site of the crossing, immediately outside the school entrance, the carriageway is straight.) The presence of the guard rails could also be a factor. This phenomenon is also supported by anecdotal evidence.

(f) At site 7, there was a marked difference in the speed changes for eastbound and westbound traffic. The mean speed of light vehicles fell by 5mph and 11mph in these directions respectively; the corresponding reductions for HGVs were 5mph and 15mph. The larger reductions westbound were partly because the speeds in this direction were measured about 50m downstream of the exit of the eastern chicane, whereas eastbound traffic had not encountered any measures for about 170m. Moreover, westbound mean and 85th percentile speeds at this site before scheme installation were about 3mph higher than eastbound speeds.

The 85th percentile speed of light vehicles fell by 6mph eastbound and 14mph westbound. Corresponding reductions for HGVs were 6mph and 17mph, the latter being the largest observed at any point in the village.

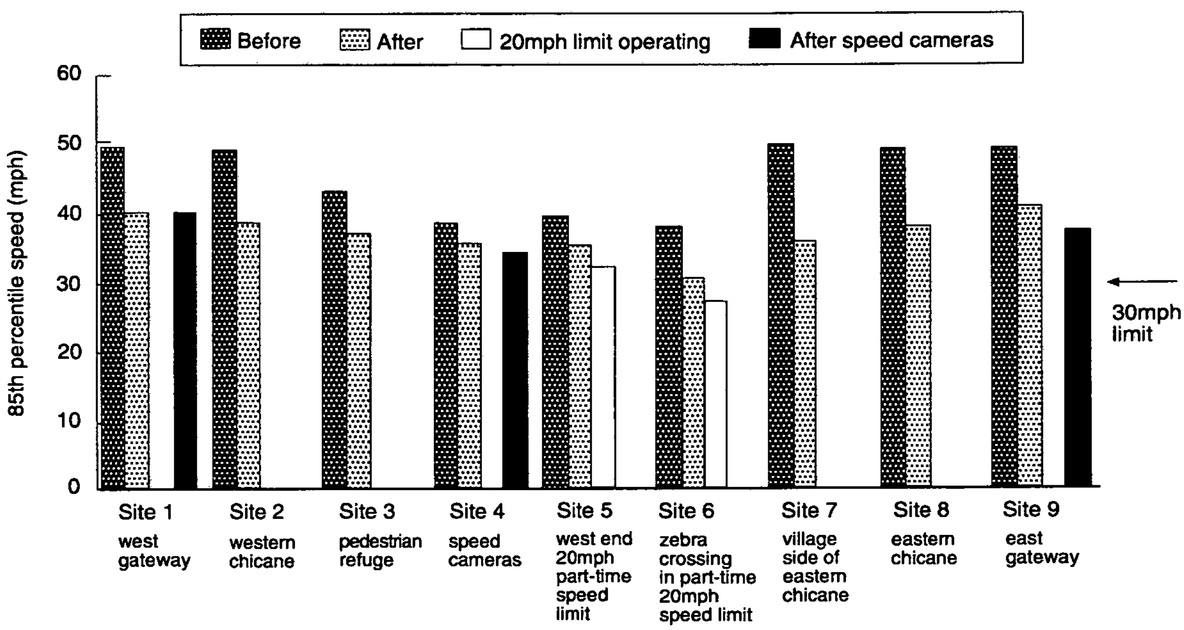
4.2.2.3 Speed profile through the village

Fig 25 shows graphically the 85th percentile speed changes in each direction of travel at all 9 monitoring positions. It should be noted that the 85th percentile speeds at sites 1 and 9 and those at sites 2-8 are not directly comparable, because of the collection of data at sites 1 and 9 by automatic data logger for *all* vehicles, and elsewhere by radar gun for *light vehicles only*. Additional bars, representing the results of additional monitoring of the speed camera installation and signing (sites 1, 4 and 9) and the part-time 20mph speed limit when in force (sites 5 and 6), are shown. The charts



*7-day speeds of ALL vehicles at Sites 1 and 9; radar speeds of light vehicles only at Sites 2 to 8

Fig. 25(a) A47(T) Thorney - speed profile
Eastbound, Before and After



*7-day speeds of ALL vehicles at Sites 1 and 9; radar speeds of light vehicles only at Sites 2 to 8

Fig. 25(b) A47(T) Thorney - speed profile
Westbound, Before and After

show that speed changes and additional changes were similar in each direction, except at the chicanes and the east gateway.

Fig 25 helps to emphasize the fact that overall, even with reductions of up to 15mph and the presence of speed cameras, the target 85th percentile speed of 30mph or below was only achieved at the zebra crossing within the part-time 20mph speed limit (site 6). (In the eastbound direction, this was only achieved when the 20mph speed limit was operating.) Elsewhere, to achieve the target speed, a further reduction, in addition to the existing reductions, of 4-5mph at the speed camera site, 8-12mph at the chicanes, and up to 8mph elsewhere in the village would be required for light vehicles. For HGVs (see Table 4), the target speed was achieved at the eastern chicane and downstream of it (inbound), and in the part-time 20mph speed limit (always when at 20mph, partially when not). Elsewhere in the village, a further reduction of up to 4mph (2-3mph at the speed camera site) would be required in addition to the existing reduction.

4.3 VEHICLE JOURNEY TIMES THROUGH THE VILLAGE

4.3.1 Data collection

An overall effect of the measures on traffic can be assessed by calculating vehicle journey times through the length of the village. At each end of the village speed limit, the number plates of vehicles travelling in each direction were recorded on video, before and after scheme installation. Four cameras were used, two for each direction of travel. The cameras were positioned as discreetly as possible. Dates of filming and the periods analysed are shown below:

'before':	Tuesday 19 April 1994;
'after':	Thursday 22 June 1995.
Eastbound:	1000-1100, 1200-1300, 1400-1500, 1600-1700.
Westbound:	1100-1200, 1300-1400, 1500-1600, 1700-1800.

The video tapes were scanned such that data files were compiled containing the following information:

- camera position number;
- class of vehicle (light or heavy);
- registration number;
- time of day vehicle passed camera (hours, minutes, seconds).

From this information, it was possible to match the registration numbers of those vehicles which passed both ends of the speed limit and thus calculate their journey times. To avoid the inclusion of vehicles which might have parked or stopped in circumstances other than being within the traffic stream, those taking more than 5 minutes to pass through the village were excluded. Vehicles travelling eastbound between 1000 and 1100 were also excluded because white lining was being carried out during this period at the western end of the village.

4.3.2 Results

For each direction, the times taken to travel between the ends of the speed limit (distance 1650m) in Thorney are summarised in Table 5 and presented graphically in Figs 26 and 27. The bar charts present the percentage of vehicles taking less than 60sec, between 60sec and 240sec in 10sec increments, and more than 240sec (but less than 300sec).

Before scheme installation, the mean journey time through the village was around 2min 20sec in each direction. Afterwards, the mean journey time increased by 18sec westbound but by only 4sec eastbound. The reason for the very small increase eastbound is unclear, since most observed speed changes were similar in both directions (Section 4.2.2.3).

The bar charts both show a shift towards the longer journey time ranges during the 'after' period, but for eastbound traffic, it is only slight. The bar chart for westbound traffic (Fig 27) shows a somewhat flatter distribution, but the chart for eastbound traffic (Fig 26) shows a slightly narrower distribution centred on 10-20sec longer journey times in the 'after' period. In this direction, 53% of the sample of vehicles took up to 140sec in the 'before' period, compared to 42% in the 'after' period. Westbound, the equivalent 'before' and 'after' percentages were 65% and 33%.

4.4 VEHICLE AND TRAFFIC NOISE

4.4.1 Background

A noise monitoring survey before and after scheme installation in Thorney was carried out to assess the overall change in the noise exposure outside residential properties. The level of noise from traffic is dependent on the total volume, percentage of heavy vehicles and speed of the traffic. Whilst the scheme was not expected to change the volume and composition of the traffic it was anticipated that the reduction in speed would result in a reduction in traffic noise. However, vehicle noise can be influenced by other factors such as driver behaviour and mode of vehicle operation, which may alter the character of the sound, e.g. by drivers adopting a more aggressive style. Under these circumstances, the anticipated reduction in overall traffic noise levels may, therefore, lead to an increase in annoyance from local residents.

Vehicle and traffic noise measurements were taken in Thorney to quantify the change in the noise climate after the introduction of the scheme. Vehicle noise measurements involve recording the noise from individual vehicles as they pass significant features. The results can be used to

TABLE 5

Mean journey times between the ends of the village speed limit

Direction	Time (seconds) and sample sizes Before	After	Change	Standard deviation (seconds) Before	After
Eastbound	141.8 (941)	145.6 (1430)	+ 3.8 (+3%)	23.17	21.30
Westbound	136.2 (1065)	154.3 (1356)	+18.1 (+29%)	28.54	25.29

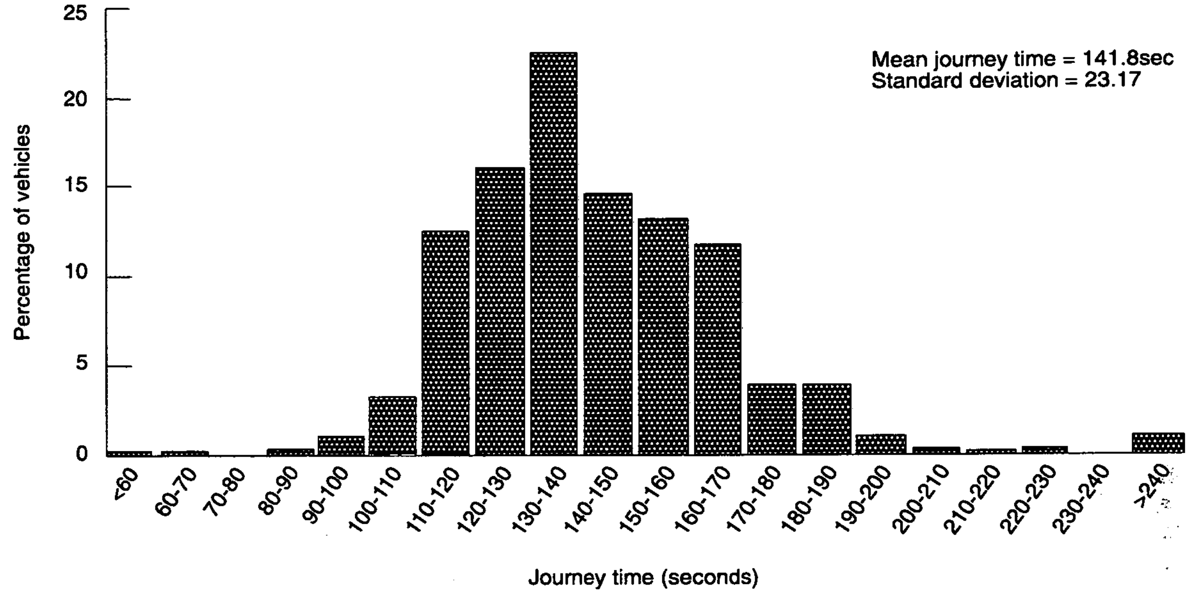


Fig.26(a) A47(T) Thorney - Journey times between gateway sites
Eastbound, Before

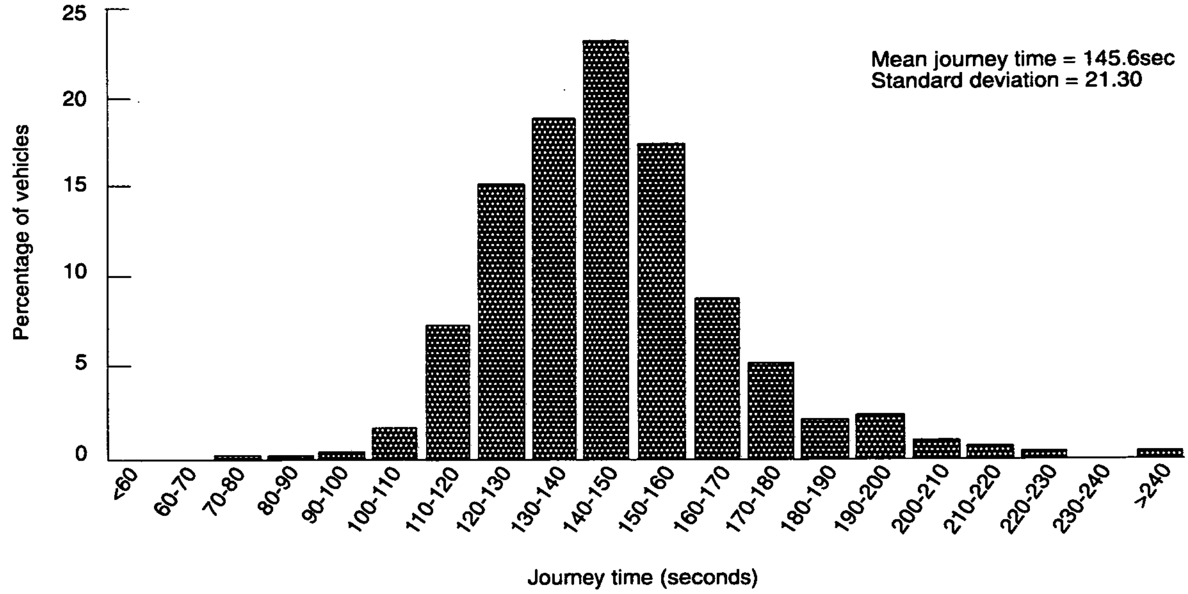


Fig.26(b) A47(T) Thorney - Journey times between gateway sites
Eastbound, After

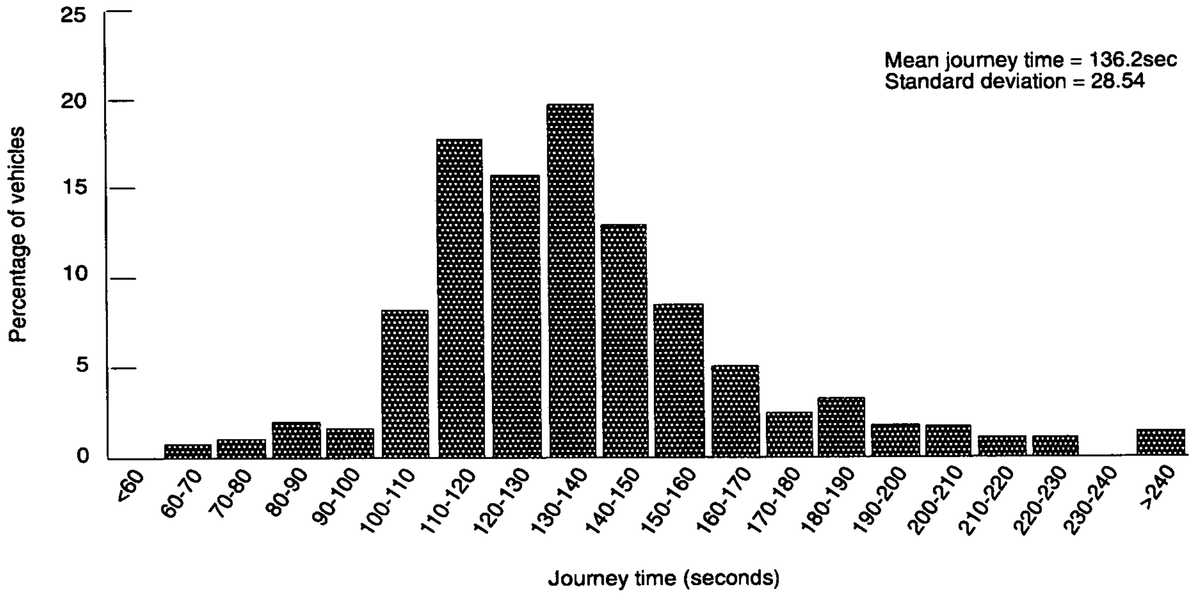


Fig.27(a) A47(T) Thorney - Journey times between gateway sites
Westbound, Before

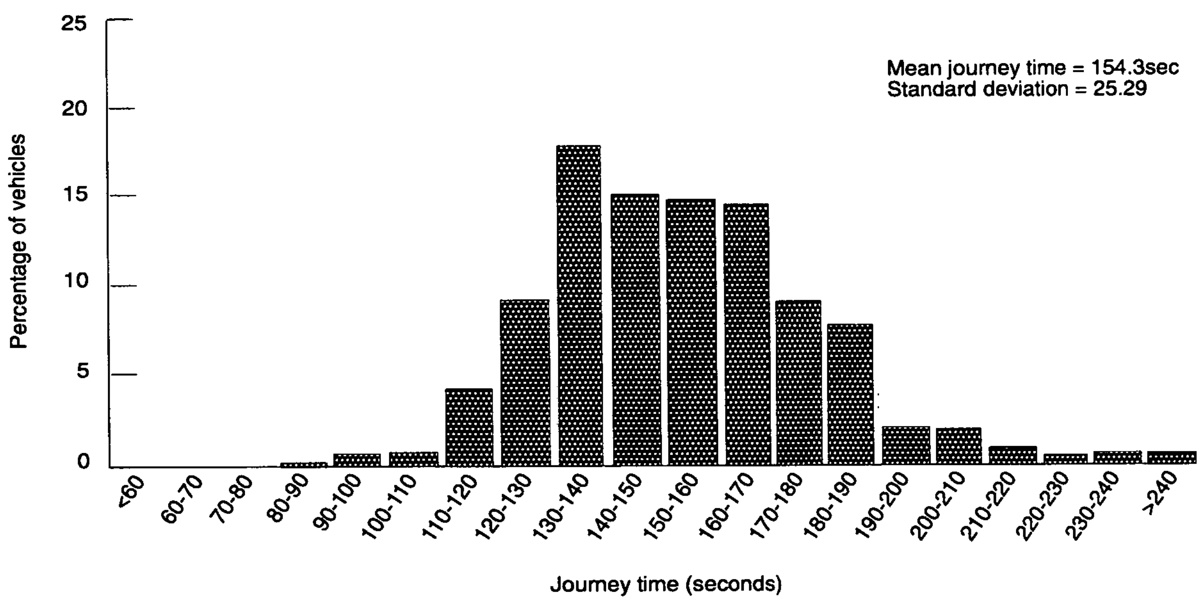


Fig.27(b) A47(T) Thorney - Journey times between gateway sites
Westbound, After

monitor the variability of noise throughout the scheme, and to identify areas or measures that may signify a noise nuisance. Traffic noise measurements assess the exposure to noise outside residential properties, and have been shown to correlate directly with scales of annoyance (Baughan and Huddart, 1993). The two methods are described in the following sections.

4.4.2 Location of measurement sites

Noise measurement sites were selected to represent three different traffic conditions while satisfying the practical and acoustical requirements of the measurement methods. The three conditions were identified as: gateway to the village, residential area of the village, and the village centre. A schematic plan of the village, indicating the position of the noise measurement sites and the major traffic calming features, is shown in Fig 28.

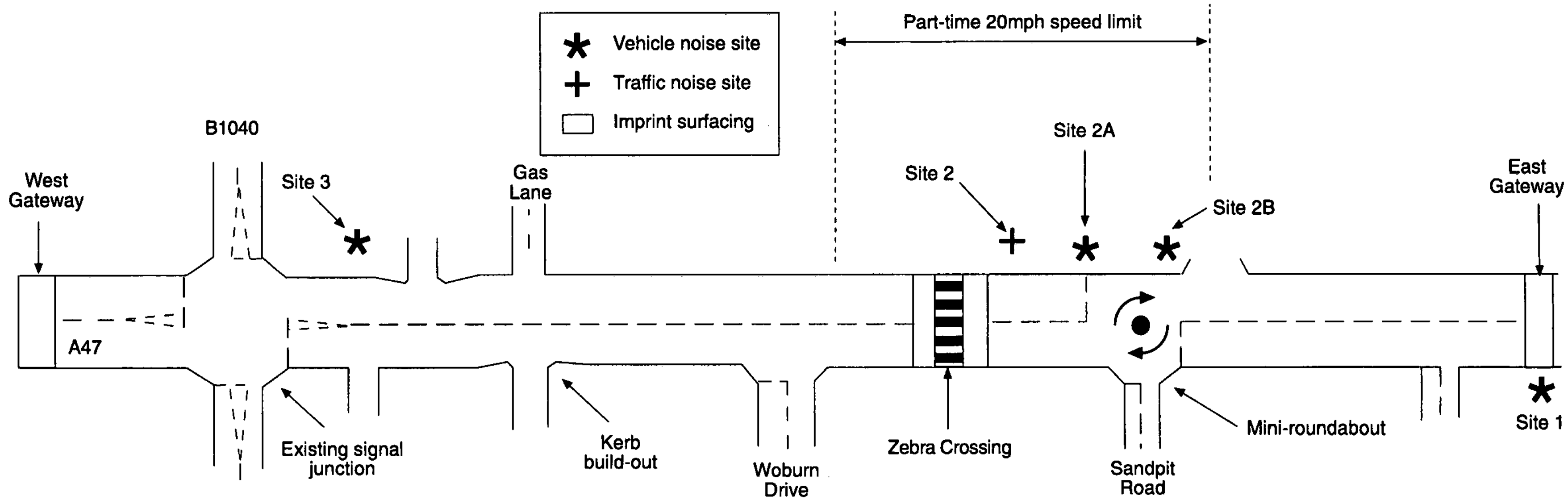


Fig 28. Location of traffic and vehicle noise measurement sites, Thorney

Traffic noise was measured at one site in the village, which is shown as site 2 on the plan. This site was located at a semi-detached house in a residential area in the eastern part of the village, and was within the proposed part-time 20 mph speed limit (described in Section 3.3). The location of the survey site was selected to ensure that the microphone was not screened from the traffic by large walls or hedges and was close to where a vehicle noise measurement could also be carried out. Security of the monitoring equipment and the effects of other noise influences were considered before final site selection, although it was realised that noise from a near-by school may affect the recorded noise levels.

Vehicle noise measurements were carried out at 3 sites: a gateway, in the residential area of the village and in the village centre. The gateway site (site 1) was located alongside the westbound lane at the east gateway. In the residential area, it was proposed to measure vehicle noise adjacent to the 24 hour traffic noise site. However, due to physical restrictions, this type of measurement could not be performed and a new site about 15 metres away was chosen, site 2A. Following the introduction of the scheme, this site was unsuitable for monitoring because the installation of a new mini-roundabout had significantly altered the road layout. A further site, site 2B, was selected as close as possible to site 2A. It was not anticipated that the relocation of this measurement site would have substantially affected the results. The village centre site (site 3) was located in the most built-up part of the village about 70m east of the signal controlled junction of the A47 and the B1040. Table 6 summarises the type of measurement undertaken at each site before and after scheme installation.

4.4.3 Measurement method

'Before' and 'after' measurements were carried out on 19-20 April 1994 and 27-29 June 1995 respectively.

4.4.3.1 Vehicle noise

The Statistical Pass-by (SPB) method was used to measure vehicle noise at the 3 sites before and after scheme installation. Essentially, the SPB method involves measuring the noise level and speed of individual vehicles and then applying statistical methods to determine a relationship between noise level and speed for vehicles of similar type. This relationship can then be used to compare vehicle noise levels at typical speeds in the 'before' and 'after' situations. A full description of the methodology for the SPB technique can be found in Appendix A.

At each site the measurement microphone was positioned 1.2m above the level of the road surface and 7.5m from the centre of the nearside lane, except at site 3. Here, the microphone could be placed no further than 7.2m from the centre of the lane being monitored owing to the proximity of the frontages to the carriageway edge. The microphone was connected to a noise analyser configured to record the noise level at the moment when the sound level reached a maximum for each individual vehicle pass-by. Vehicles chosen for measurement were judged to be sufficiently separated in the traffic stream so that their noise characteristics were not influenced by other vehicles. Only vehicles travelling in the centre of the lane were selected.

Vehicles chosen for measurement were classified as either 'light' (i.e. all cars and vans with an unladen weight less than 1.5 tonnes) or 'heavy' (all other vehicles with an unladen weight greater than 1.5 tonnes). Speed was measured using portable radar equipment, which was positioned to be as unobtrusive as possible, to reduce the likelihood of altering driver behaviour. As each selected vehicle passed the microphone position, its speed was recorded and vehicle classification noted. Table 7 lists the site details and microphone positions for each of the vehicle noise measurements.

4.4.3.2 Traffic noise

Traffic noise was measured outside one house in the village in both the 'before' and 'after' surveys, for a minimum of 24 hours on each occasion. The chosen site was on the opposite side of the carriageway to the school and, as

TABLE 6

Noise monitoring before and after scheme installation

Site Location	Number	Feature	Measurement type Before	After
East gateway	1	gateway	vehicle noise	vehicle noise
Residential area of village	2	zebra crossing*	24h traffic noise	24h traffic noise
	2A		vehicle noise	-
	2B	mini-roundabout	-	vehicle noise
Village centre	3	no features**	vehicle noise	vehicle noise

* on *Imprint* surface treatment within part-time 20mph speed limit, and near mini-roundabout

** between traffic signals at A47/B1040 junction and junction remodelling at Gas Lane junction previously mentioned, was within the part-time 20mph speed limit. The microphone position is given in Table 8.

At this site, an environmental sound level meter was set up to calculate a variety of noise level indices in each hour. The results were stored in the internal memory of the sound level meter, and then down-loaded to a laptop computer at the end of each measurement session.

A number of noise scales and indices can be used for traffic noise measurements. However, the main index used in the UK for traffic noise, and the index used in Thorney, was $L_{A10,18h}$ dB. This index is derived from noise levels measured in an 18 hour period from 0600 to 2400 outside residential properties. For each of the one-hour periods, the level exceeded for 10 per cent of the time is calculated from the cumulative distribution of the sampled noise levels to give the noise index $L_{A10,1h}$ dB. An arithmetic average of the 18 individual $L_{A10,1h}$ values is then calculated to give the $L_{A10,18h}$ dB. Previous studies have shown that disturbance from traffic noise in the home is correlated with the noise index $L_{A10,18h}$ dB (Morton-Williams, Hedges and Fernando, 1978); this index is used in the UK for assessing the impact of traffic noise from new and altered road schemes (Department of Transport and Welsh Office, 1988) and for the determination of entitlement to statutory sound insulation of dwellings as described in the Noise Insulation (Amended) Regulations (House of Commons, 1988).

4.4.4 Results

4.4.4.1 Vehicle noise

During the analysis of vehicle noise the relation between vehicle speed and noise was produced for each site with 'light' and 'heavy' vehicle events being treated separately. The maximum noise levels of each vehicle were regressed against the logarithm of vehicle speed. The derived noise/speed functions were used to calculate the maximum noise level for a typical vehicle in each category travelling at the average speed[3] for each site, which were then used to represent the average 'before' and 'after' vehicle noise levels. The regression lines together with the corresponding vehicle events recorded during the 'before' and 'after' surveys for both light and heavy vehicles are shown, respectively, in Figs 29 and 30 for site 1, Figs 31 and 32 for sites 2A and 2B, and Figs 33 and 34 for site 3. Summary regression statistics for all of the measurements are shown in Appendix B. Further statistical analysis was carried out to determine whether the regression lines calculated for the 'before' and 'after' situations at each site were statistically significantly different at the 5% level. Where they were not, the data from both the 'before' and 'after' surveys were combined and a regression line for the whole data set determined. The results of the noise monitoring for the two vehicle classes are described below.

TABLE 7

Microphone positions for vehicle noise measurements

Site	Feature	Microphone distance to edge of kerb (m)	Microphone distance to centre of lane (m)	Microphone height above road level (m)
1	East gateway	5.6 (before) 6.0 (after)	7.5	1.2
2A	Residential area	5.3	7.5	1.2
2B	Residential area	5.4	7.5	1.2
3	Village centre	4.7	7.2	1.2

TABLE 8

Details of traffic noise measurements (site 2)

Location	Microphone distance to edge of kerb* (m)	Microphone height above road level (m)
192 Wisbech Road	13.6	2.7

* The microphone was positioned 1m from the most exposed façade of the property

[3] The average speeds used for all the analyses were derived from the speed measurements described in Section 4.2, made at the site or at a nearby location.

(a) Light vehicles

The maximum light vehicle noise levels measured and the average site speeds 'before' and 'after' scheme installation are shown in Table 9. This shows that at each site, the maximum noise levels, as well as the mean speeds, were reduced after scheme installation. At site 1 (east gateway) the maximum noise level at the average speed of each survey was reduced by 6.0 dB(A), with the average speed reduced by 16.9km/h (10.5mph). The regression lines plotted through the data (Fig 29) show that over the speed range studied, the noise/speed regression function was lower after the scheme was introduced. The difference between the 'before' and 'after' functions was found to be significantly different at the 5% level. In the 'after' study the *Imprint* surface treatment may have contributed to the difference in the noise/speed function at this site. Using the 'before' regression line, the estimated reduction in light vehicle noise corresponding to a reduction in mean speed of 16.9km/h was 3.9dB(A). It is therefore concluded that for light vehicles at this site the change in road surface has contributed to the overall reduction in the average light vehicle noise level by 2.1dB(A). However, the change in road surface was confined to a short section of road 24m in length, and therefore, as light vehicles travel over this section of road, it is likely that the variability in noise level from these vehicles may have increased compared with the 'before' situation. Despite the overall benefit in reducing the noise from light vehicles, any such increase in the variability in noise resulting from the *Imprint* surfacing may be perceived as annoying to residents living in the vicinity.

At sites 2A and 2B it was found that the regression lines for the 'before' and 'after' surveys (see Fig 31) were significantly different at the 5% level. Assuming that the 'before' noise/speed function measured at site 2A is a valid estimate of the noise/speed function at site 2B prior to the installation of the mini-roundabout, then the lower level of the 'after' regression line indicates that a reduction in noise has again occurred which is more than that expected from the speed reduction alone. It may be inferred that reductions in light vehicle noise levels at site 2B could have been influenced by the presence of the mini-roundabout. Although there is on average a reduction in vehicle noise, the variability in noise levels in the 'after' situation is likely to be larger, due to the influence of the mini-roundabout on driver behaviour.

Using the regression statistics from the 'before' and 'after' surveys separately at sites 2A and 2B respectively, there was a reduction of 3.8dB(A) in maximum light vehicle noise levels when the part-time 20mph speed limit was *not* in operation. When this speed limit was operating, the 'before'/'after' reduction was 5.0 dB(A). This indicates that when the part-time 20mph speed limit is in operation, light vehicle noise levels on average are reduced by a further 1.2dB(A).

TABLE 9

Before' and 'after' light vehicle noise levels

Site	Before		After		Change in	
	Mean site speed* km/h	Maximum vehicle noise level at mean speed dB(A)	Mean site speed* km/h	Maximum vehicle noise level at mean speed dB(A)	Mean speed* km/h	Maximum noise level dB(A)
East gateway						
1	68.9	78.6	52.0	72.6	-16.9	-6.0
Residential area / Part-time 20mph speed limit						
2A	58.4	76.9				
2B	-	-	47.6 (off)	73.1	-10.8	-3.8
	-	-	40.9 (on)	71.9	-17.5	-5.0
Village centre						
3**	60.8	80.2	49.1	78.3	-11.7	-1.9 (-2.4)

* Derived from the speed measurements observed in Section 4.2.

** The average reduction in noise level using the combined 'before' and 'after' SPB noise/speed function is shown in brackets.

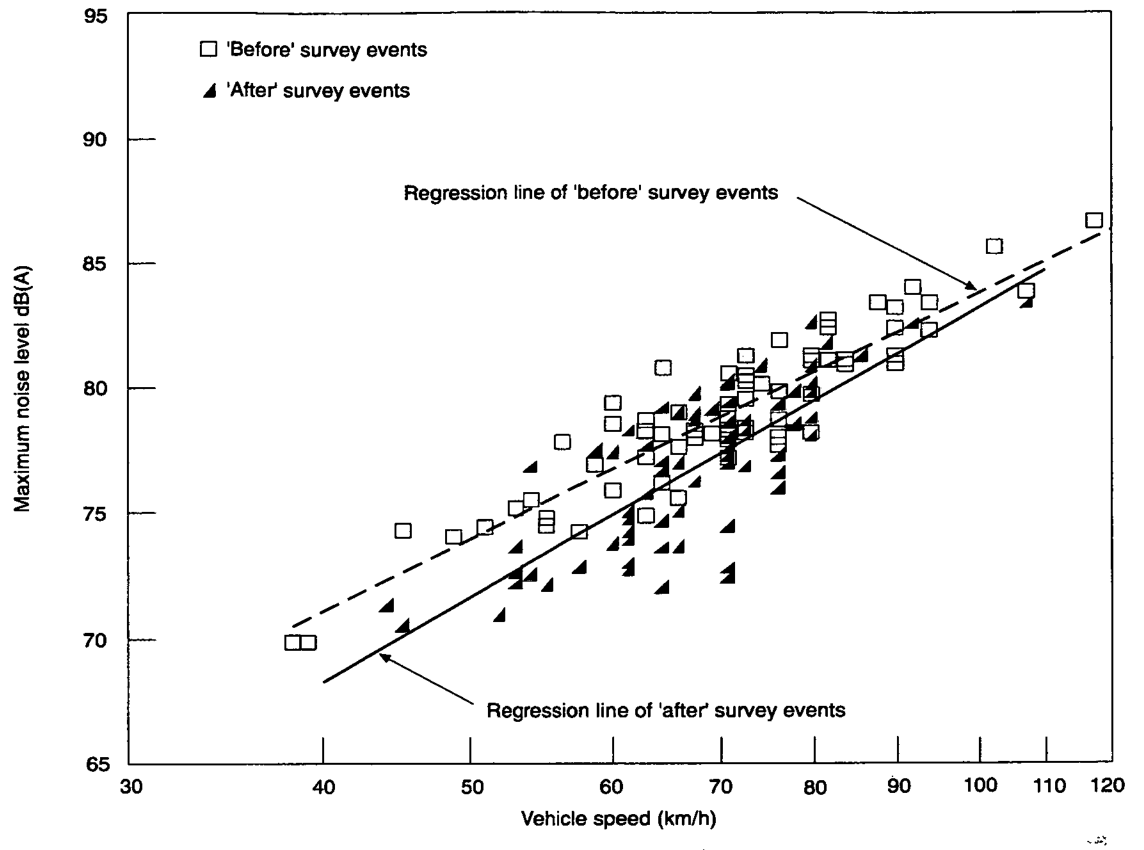


Fig.29 Comparison of light vehicle noise levels and speed before and after installing gateway at site 1
(measured at 7.5m from the centre of the lane)

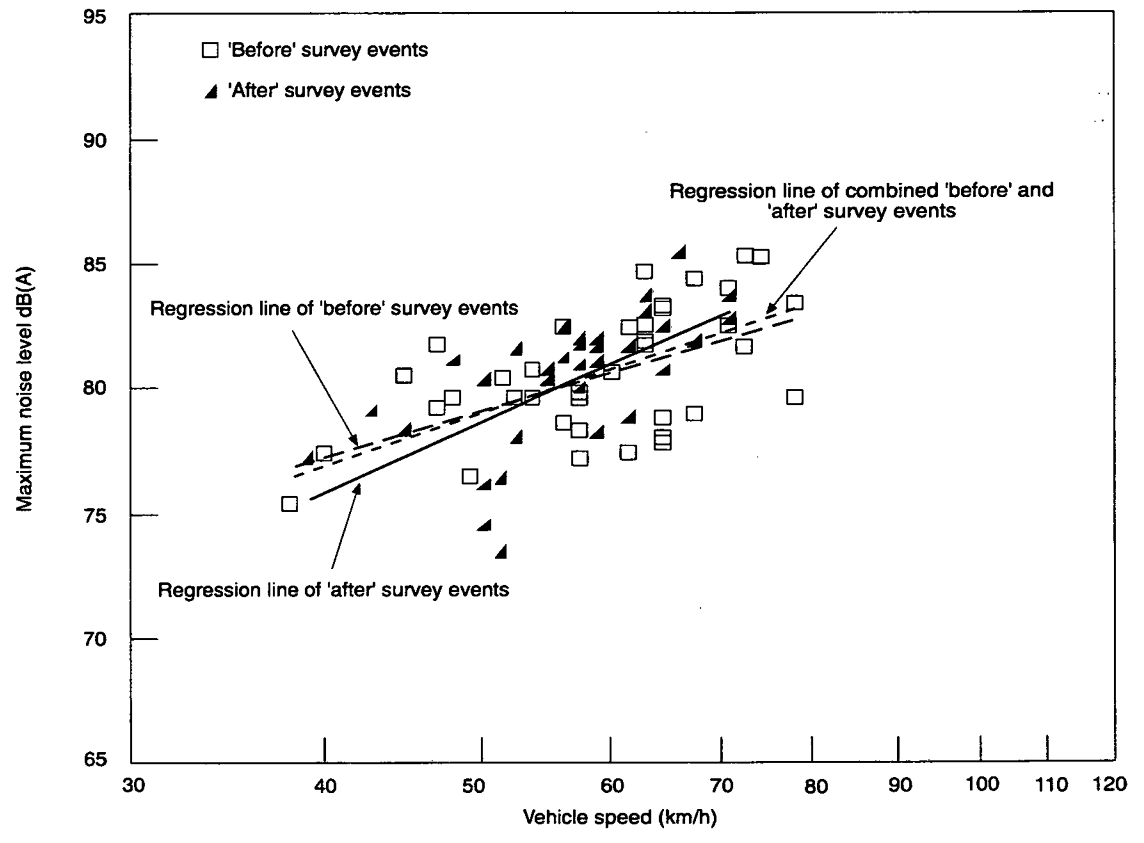


Fig.30 Comparison of heavy vehicle noise levels and speed before and after installing gateway at site 1
(measured at 7.5m from the centre of the lane)

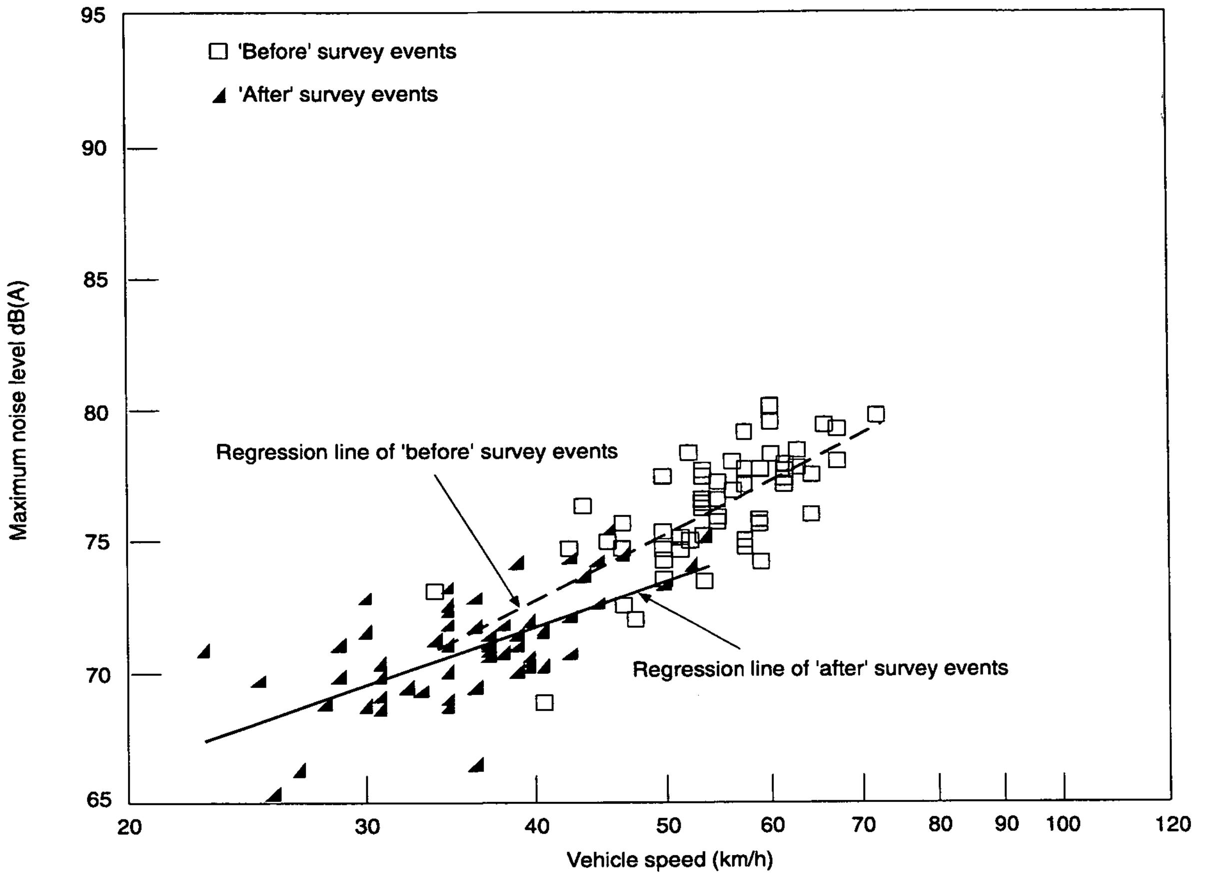


Fig.31 Comparison of light vehicle noise levels and speed before and after scheme installation at sites 2A and 2B
(measured at 7.5m from the centre of the lane)

At site 3, there was a reduction of 11.7km/h in average speed, with a corresponding 1.9 dB(A) reduction in the maximum noise level derived from the 'before' and 'after' noise/speed functions shown in Fig 33. However, further statistical analysis showed that the 'before' and 'after' noise/speed functions were not significantly different and, therefore, indicated that the change in noise level for light vehicles was influenced only by the change in average vehicle speed. The data from the 'before' and 'after' surveys were therefore combined and the noise/speed function derived from the combined data used to obtain a more reliable estimate of the change in noise level at this site. The results from this analysis showed that for a reduction in average speed of 11.7km/h the reduction in noise from light vehicles was 2.4 dB(A).

Maximum noise levels were higher at site 3 than at both the other sites. This may be explained by a combination of factors. The site was in a built-up area and reflections from the façades of the houses behind the microphone (and to a lesser extent from the houses opposite the microphone) would result in higher noise levels than compared with the other sites. In addition, as mentioned above, the microphone at this site was positioned slightly closer to the carriageway than at the other two sites, because of the proximity of the frontage behind. However, the site was not chosen to provide a direct comparison with other sites but rather to determine the 'before'/'after' change.

(b) Heavy vehicles

Maximum heavy vehicle noise levels and the average site speeds before and after scheme installation are shown in Table 10.

Using the 'before' and 'after' survey data separately, the maximum noise levels fell at the gateway (site 1) by 5.1dB(A) for a corresponding reduction in average speed of 22.7km/h (14.1 mph). Fig 30 shows the regression lines through the measured values. However, further statistical analysis showed that the 'before' and 'after' noise/speed functions were not significantly different and, therefore, indicated that the change in noise level for heavy vehicles was influenced only by the change in average vehicle speed. The data from the 'before' and 'after' surveys was therefore combined and the noise/speed function derived from the combined data used to obtain a more reliable estimate of the change in noise level at this site. The results of this analysis showed that for a reduction in average speed of 22.7km/h, the reduction in noise from heavy vehicles was 4.3 dB(A). For heavy vehicles at this site the change in

TABLE 10

'Before' and 'after' heavy vehicle noise levels

Site	Before Mean site speed* km/h	 Maximum vehicle noise level at mean speed dB(A)	After Mean site speed* km/h	 Maximum vehicle noise level at mean speed dB(A)	Change in Mean speed* km/h	 Maximum noise level dB(A)
East gateway						
1**	62.6	81.0	39.9	75.9	-22.7	-5.1 (-4.3)
Residential area / Part-time 20mph speed limit						
2A	54.7	81.7				
2B			44.6 (off)	79.5	-10.1	-2.2
			36.5 (on)	79.5	-18.2	-2.2
Village centre						
3**	59.1	84.3	44.9	83.1	-14.2	-1.2 (+0.3)

* Derived from the speed measurements observed in Section 4.2.
** The average reduction in noise level using the combined 'before' and 'after' SPB noise/speed function is shown in brackets.

the road surface does not appear to have influenced overall noise levels, unlike for light vehicles at this site. This can be explained by the fact that tyre/road surface noise contributes more to overall vehicle noise levels for light vehicles than it does for heavy vehicles.

At sites 2A and 2B, as with light vehicles, it was found that the regression lines in the 'before' and 'after' surveys (see Fig 32) were significantly different at the 5% level. Assuming that the 'before' noise/speed function measured at site 2A is a valid estimate of the noise/speed function at site 2B, prior to the installation of the mini-roundabout, it may be inferred that reductions in heavy vehicle noise levels at site 2B following a reduction in average speed have been significantly influenced by the presence of the mini-roundabout. Again, although there is on average a reduction in vehicle noise, the variability in noise levels in the 'after' situation is likely to be larger, due to the influence of the mini-roundabout on driver behaviour.

The 'before' survey regression line demonstrates that vehicle speed has a major influence on noise levels indicating that drivers were probably travelling in similar gears to each other. However, the 'after' noise/speed function shows speed to have little influence on noise levels (see Table B.2 in Appendix B) indicating that driver behaviour (i.e. choice of gears and mode of operation) was a major factor in determining vehicle noise levels.

Using the regression statistics from the 'before' and 'after' surveys separately at sites 2A and 2B respectively, there was a reduction of 2.2dB(A) in maximum heavy vehicle noise levels when the part-time 20mph speed limit was *not* operating and a similar reduction when this speed limit was operating, despite a reduction in vehicle speed of 8.1km/h.

At site 3, there was a reduction of 14.2km/h in average speed, with a corresponding 1.2dB(A) reduction in the maximum noise level derived from the 'before' and 'after' noise/speed functions shown in Fig 33. However, further statistical analysis showed that the 'before' and 'after' noise/speed functions were not significantly different. The data from the 'before' and 'after' surveys were therefore combined and the noise/speed function derived from the combined data used to obtain a more reliable estimate of the change in noise level at this site. The results of this analysis showed that for a reduction in average speed of 14.2km/h the noise from heavy vehicles *increased* by 0.3dB(A). However, examining the regression statistics in Table B.2 given in Appendix B it is shown that vehicle speed for heavy vehicles at this site is poorly correlated with noise. It can therefore be concluded that average vehicle noise levels for heavy vehicles at this site have not been affected by the traffic calming scheme. It is likely that for heavy vehicles at this site the nearby signal junction influenced the way the vehicles were driven, particularly at speeds below 40km/h were it is likely that vehicles were accelerating away from the junction.

4.4.4.2 Traffic noise

A 24 hour traffic noise measurement was taken at site 2 in the village using the method described in Section 4.4.3.2.

The results from both the 'before' and 'after' traffic noise surveys are given in Table 11. Fig 35 shows the diurnal

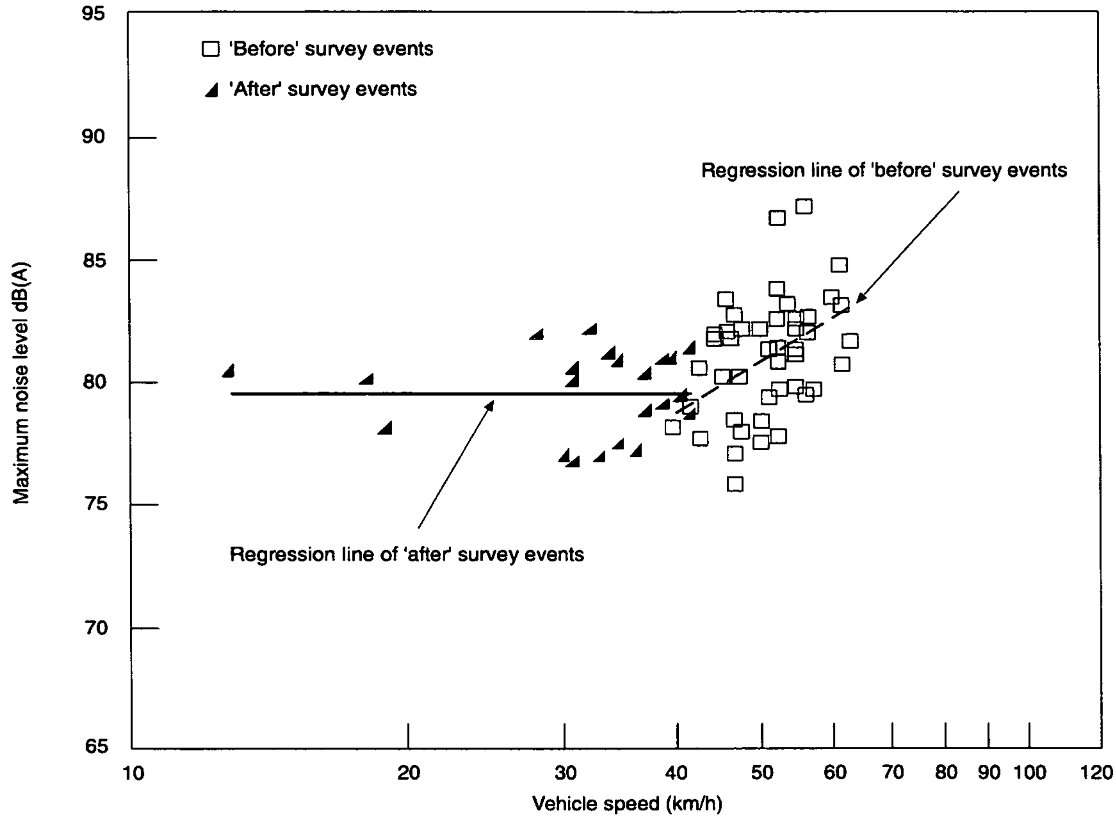


Fig.32 Comparison of heavy vehicle noise levels and speed before and after scheme installation at sites 2A and 2B
(measured at 7.5m from the centre of the lane)

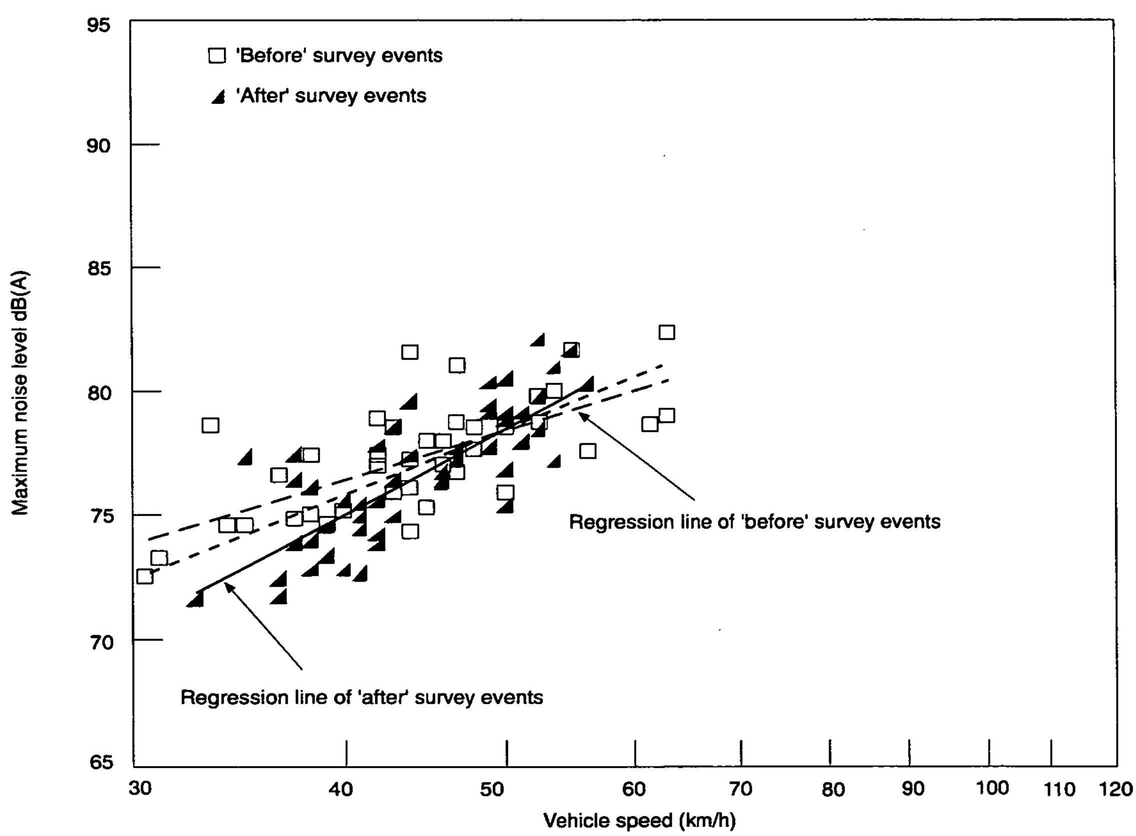


Fig.33 Comparison of light vehicle noise levels and speed before and after scheme installation at site 3
(measured at 7.2m from the centre of the lane)

TABLE 11

Measured traffic noise levels at site 2

	Traffic noise levels dB(A) Before	After	Change
Daytime levels (0600-midnight, $L_{A10,18h}$)	75.3	71.8	-3.5
Nighttime levels (midnight-0600, $L_{A10,6h}$)	68.2	64.8	-3.4

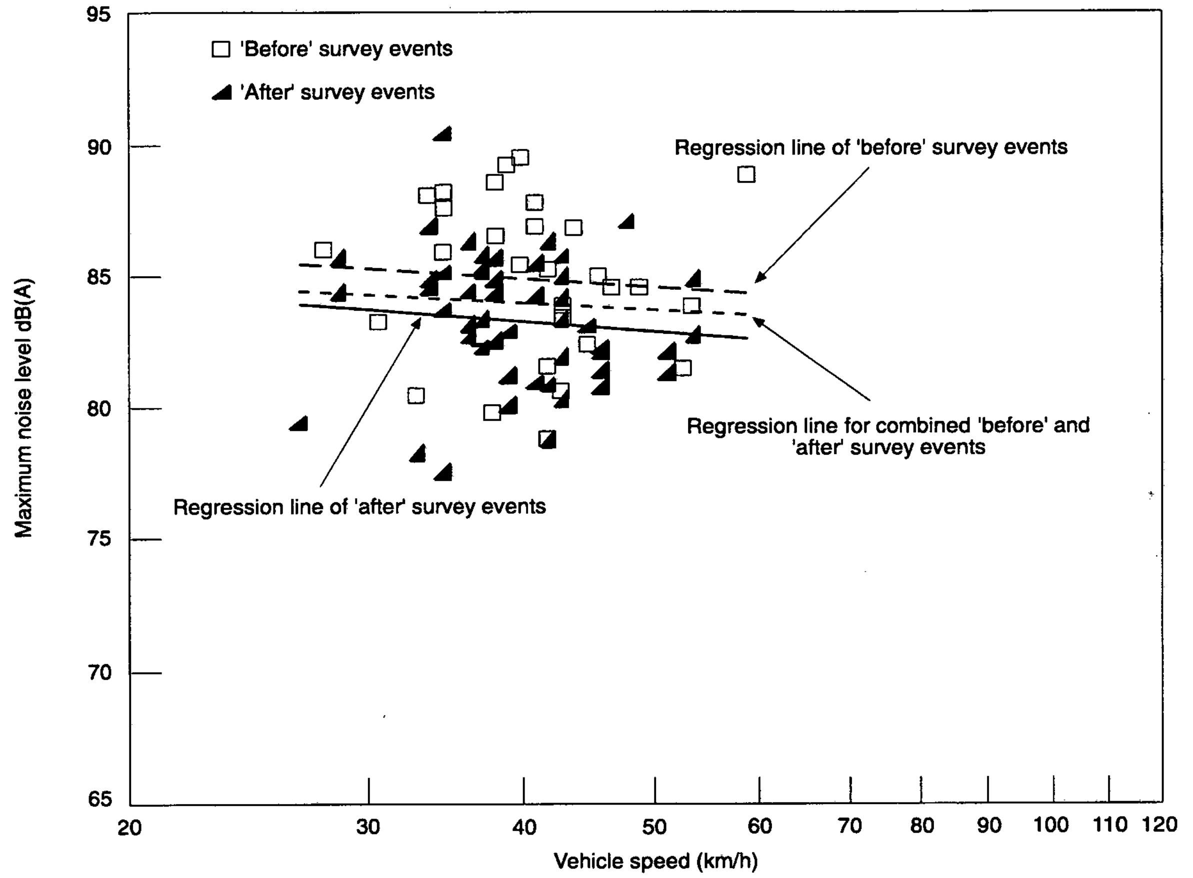


Fig.34 Comparison of heavy vehicle noise levels and speed before and after scheme installation at site 3 (measured at 7.2m from the centre of the lane)

variation in the hourly $L_{A10,1h}$ noise levels measured during both the 'before' and 'after' surveys. Unfortunately during part of these surveys noise levels were not monitored due to equipment failure and therefore noise levels during these periods were extrapolated. It can be seen from Fig 35 that the variation in noise levels during the day is fairly uniform, which allows the extrapolated values to be determined with some confidence. However, there is insufficient data during the periods when the 20mph speed limit is in operation to estimate its influence on traffic noise levels. Overall, it is clear that traffic noise levels have substantially been reduced during the 'after' survey at this site. Table11 shows reductions of 3.5dB(A) and 3.4 dB(A) for the daytime (0600-2400, $L_{A10,18h}$) and nighttime (0000-0600, $L_{A10,6h}$) periods respectively.

Observed traffic flows increased by about 4% between the two measurement periods with no change in traffic composition. The change in flow would result in a small increase in noise of 0.2 dB(A). Consequently, the dominating factor which has influenced the reduction in traffic noise levels has been the reduction in vehicle speeds.

The reduction in traffic noise was consistent with the overall changes in vehicle noise measured at this site. The average reduction in heavy vehicle noise was shown to be about 2 dB(A) (Table 10), whilst light vehicle noise levels were about 4 dB(A) lower (Table 9). These reductions in vehicle noise levels would suggest reductions in overall traffic noise of the order of 3 dB(A), which is in good agreement with the measured values.

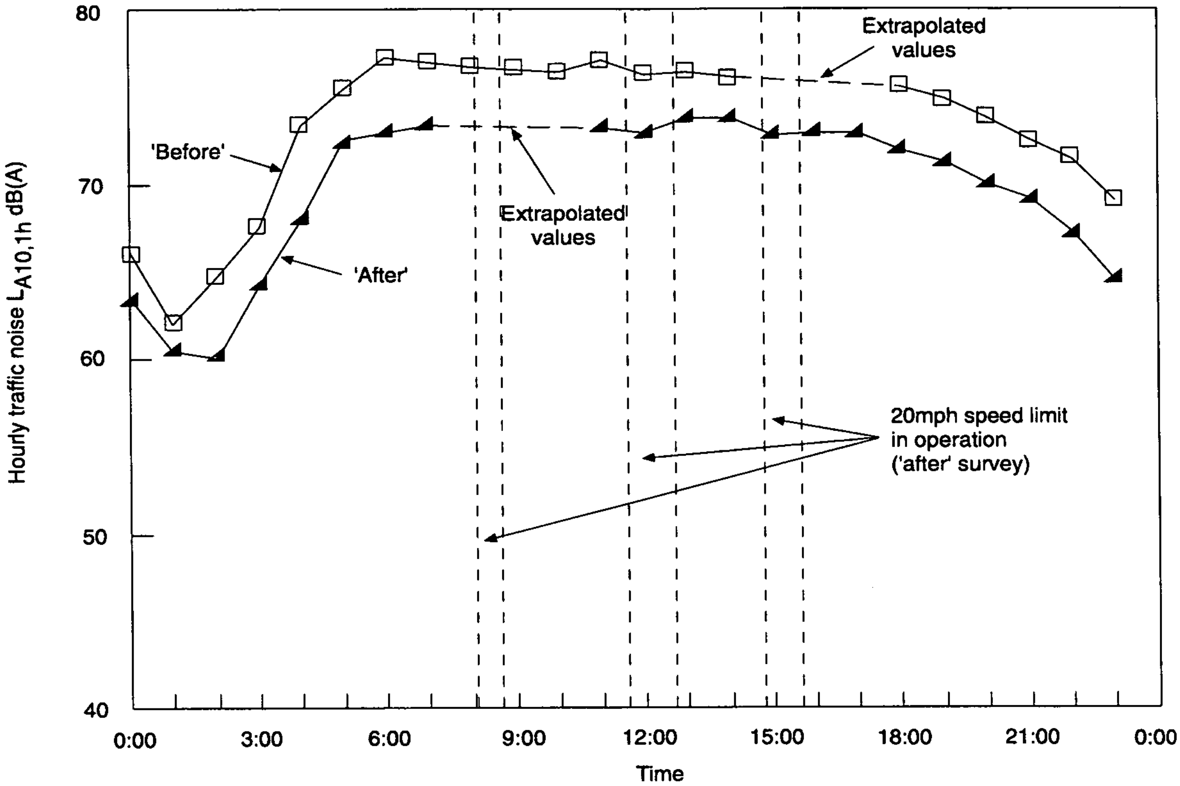


Fig.35 Variation in hourly traffic noise levels from 'before' and 'after' surveys

4.5 GROUND-BORNE VIBRATION

It was considered important to monitor ground-borne vibration since it is known that vehicles traversing undulations in the road surface can lead to the generation of perceptible vibrations (Watts, 1990). This is the result of the dynamic loads imposed on the road surface as the wheels pass over the irregularity. Larger vehicles with stiffer suspension are responsible for the generation of the largest vibrations. Surface and body waves are generated in the underlying soil with the principal component typically in the vertical direction. Dominant frequencies are 10-12 Hz which corresponds to the wheel hop frequency of an HGV's suspension. The size of the effect depends critically on the size of the undulation and the nature of the subsoil. Where there is soft ground of low shear strength then sizeable vibrations can be generated by HGVs traversing relatively modest irregularities in the road. Such vibrations can be perceptible in buildings close to the highway and result in considerable disturbance.

No 'before' survey was carried out. A site visit was made soon after scheme installation to determine subjectively where ground-borne vibration could be a problem. It was occasionally felt at the roadside near both gateways when HGVs crossed on to the slightly raised *Imprint* surface treatment; it was also felt at the mini-roundabout when certain HGVs clipped the domed central island. The zebra crossing (also on *Imprint* surfacing) was also visited but no vibration was felt. The east gateway seemed the most likely feature to be a potential nuisance as approach speeds (from the east) were relatively high and it was considered that vibrations generated at this point would be amongst the highest for the traffic calming scheme as a whole. Moreover, unlike the west gateway, dwellings were nearby. On this basis, measurements were subsequently carried out at the house closest to the gateway, the centre of which was just over 50m away. Measurements were made at the foundations of this house, which are on soft soils containing Fenland peat deposits; it was considered that this ground condition would lead to relatively high vibration levels.

4.5.1 Measurement Method

Vibration measurements were made at 143 Wisbech Road, the name given to this section of the A47. The position of the gateway relative to the property is shown in Fig 36 (site plan). Measurements were made using a triaxial geophone array (Fig 37) attached to the external façade of the property near ground level. The geophones produce signals directly proportional to particle velocity. The maximum amplitude of particle velocity or *peak particle velocity (PPV)* has been widely used to assess the damage potential of vibrations in buildings and has been found to be the best correlated vibration measure with case history data of damage occurrence (New, 1986).

A continuous sample of vibration was recorded during a 15 minute period in each hour between 0900 and 1600. A classified traffic count was also carried out during each

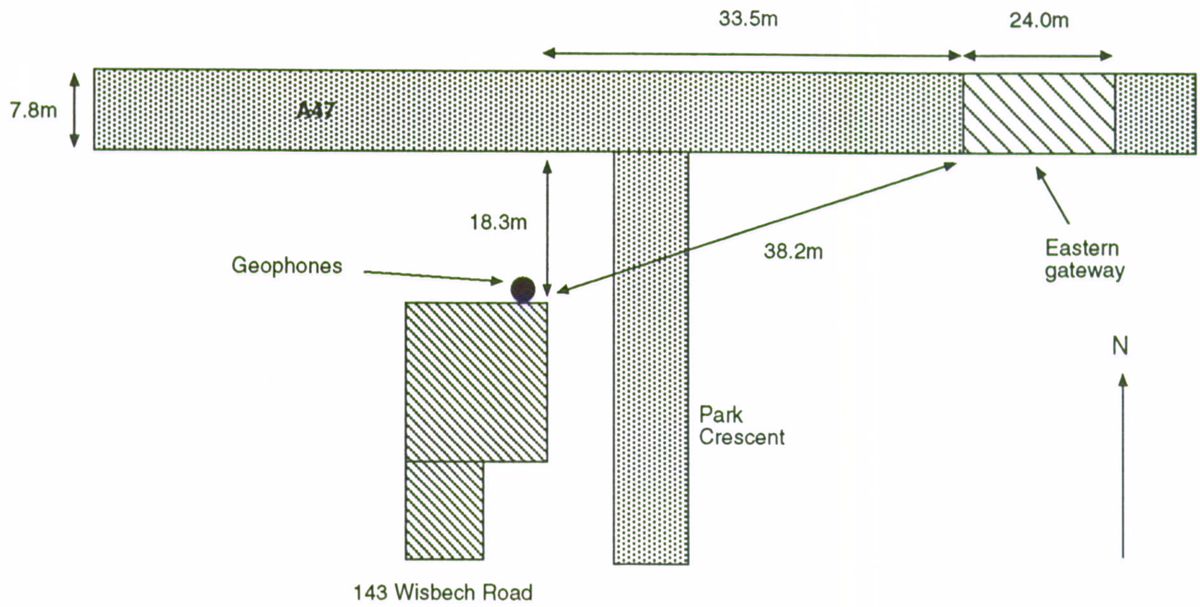


Fig. 36 Site plan of ground-borne vibration measurements at 143 Wisbech Road

Fig.37 Installation of triaxial geophone array attached to wall near ground level

sample period. The classes were light vehicles up to approximately 1.5 tonne gross weight, and HGVs over 1.5 tonne.

4.5.2 Recording and Analysis

Three geophones were mounted on an aluminium cube so that PPVs in 3 orthogonal (vertical, radial and transverse) directions could be measured. The array was bolted to a metal angle bracket attached securely to the brickwork with Plaster of Paris at a height of 0.3m above ground level (Fig 37). The array was located on the front of the house at a point closest to the gateway which was 38m away.

The array was aligned so that in the horizontal plane one geophone was pointed towards the closest point of the A47 to measure the radial component of vibration (R) while the other horizontally mounted geophone measured the transverse component (T). The third geophone measured the vertical component (V). The vibration signals were logged on site by a computer controlled CED 1401 digital interface unit. The system can simultaneously sample up to 16 channels of information and with appropriate software enabled the calculation and listing of PPVs for individual vehicles. In addition it allowed the vibration exposure in each 15 minute sample period to be evaluated for one channel. For this purpose the number of events in a 15 minute period producing vertical PPVs exceeding 0.3 mm/s were logged together with the maximum peak value in each period. This procedure has been used at several other sites in order to quantify vibration exposure (Watts, 1990). It should be noted that 0.3 mm/s is the mean threshold for human perception of continuous sinusoidal vertical vibration. Below 0.3 mm/s it is quite possible that vibrations might be just noticeable by some occupants especially on upper floors since amplification is known to occur but the risk of disturbance and complaints is likely to be low.

From previous work it is known that heavy vehicles produce significantly greater levels of vibration than light vehicles and therefore the vibration measurements of individual vehicles concentrated on heavy vehicles. To assess the effect of the gateway, PPVs were obtained for light and heavy vehicles separately as they travelled through the gateway, and as they passed in front of the house on the smooth road surface.

4.5.3 Results

Table 12 lists the maximum vertical PPVs recorded in each 15 minute period. It can be seen that the maximum vibration recorded in these periods would occasionally exceed the 0.3 mm/s perception threshold level.

Table 13 shows the average and maximum PPVs in each orthogonal direction for light and heavy vehicles as they passed the gateway and as they passed the house. It can be seen that the vertical vibration levels are substantially higher than the levels recorded in the radial and transverse directions. For this reason the analysis concentrated on vertical PPVs. The vertical vibration levels for heavy vehicles were, on average, almost twice as high when crossing the gateway as when passing the front of the house. Vibration levels for light vehicles crossing the gateway and passing the front of the house are both close to background levels and therefore the gateway has no apparent effect.

4.5.4 Discussion

The results of the survey indicate that ground-borne vibration exposure is relatively high with peak levels exceeding the perception threshold of 0.3 mm/s in all the 15 minute sample periods. Although it is unlikely that this level of vibration is unacceptable since it is close to the threshold, some disturbance might be experienced by the occupants especially on upper floors where amplification may occur. Since the surface treatment at the gateway was raised to a maximum of 20mm above the otherwise smooth road surface, it is considered that the soft nature of the soil led to the relatively high levels of vibration experienced. The good condition of the road surface and absence of such defects as poorly backfilled trenches, manhole or drain covers contributed to the relatively low level of vibrations recorded from vehicles passing the front of the house.

In the light of these results the introduction of traffic calming measures involving surface humps or cushions on such soft soils should be carefully considered since it is clear that very modest surface alterations have the potential to cause vibration disturbance.

Generally, heavy vehicles crossing the gateway produced vibration levels double those generated by heavy vehicles passing in front of the house. The highest level recorded from passing traffic was 0.46 mm/s. This can be compared with normal activities such as opening and closing the front door of a house which, in a similar study at Craven Arms on the A49 in Shropshire (Wheeler et al, 1996), produced a peak level of 0.1 mm/s. The small difference in vertical vibration levels between nearside and far-side vehicles crossing the gateway is probably due to the higher speed of vehicles approaching the village than those leaving it.

The peak levels of vibration recorded in this survey are comparable to other sites alongside main roads on soft soils (Watts, 1990). It should be noted that from observations made some years ago, a two-storey cottage nearer the centre of Thorney was exposed to a maximum vertical level of 3.5 mm/s near ground level (Watts, 1988). This is almost

TABLE 12

Maximum recorded vertical PPVs (mm/s) during 15 minute sample periods

Period	Hour beginning 0900	1000	1100	1200	1300	1400	1500	1600
Number of events >0.30 mm/s	3	1	1	4	3	3	2	2
Maximum PPV (mm/s)	0.407	0.307	0.330	0.380	0.457	0.359	0.381	0.385

TABLE 13

PPVs in each orthogonal direction for selected light and heavy vehicles crossing the gateway and in front of the house.

Location	Vehicle category	Direction of travel	Number of events	Vertical Mean	Vertical S.D.	Vertical Max	Radial Mean	Radial S.D.	Radial Max	Transverse Mean	Transverse S.D.	Transverse Max
Gateway	Heavy	Westbound (nearside)	13	0.176	0.080	0.297	0.074	0.029	0.122	0.074	0.030	0.135
	Heavy	Eastbound (far side)	9	0.139	0.055	0.224	0.081	0.038	0.149	0.084	0.037	0.151
	Light	Westbound & Eastbound	3	0.037	0.007	0.045	0.033	0.002	0.035	0.035	0.009	0.046
Normal road surface (close to monitoring site)	Heavy (nearside)	Westbound	8	0.078	0.024	0.114	0.068	0.035	0.145	0.054	0.013	0.076
	Heavy	Eastbound (far side)	6	0.092	0.032	0.133	0.065	0.024	0.101	0.048	0.012	0.062
	Light	Westbound & eastbound	3	0.034	0.005	0.039	0.030	0.003	0.033	0.033	0.002	0.035
Background	-	-	3	0.031	0.004	0.035	0.030	0.001	0.031	0.030	0.003	0.033

Heavy vehicles: gross weight > 1.5 tonne
Background: PPV recorded with no traffic passing
Mean: Mean PPV
S.D.: standard deviation of PPV
nearside: on the nearside of the carriageway relative to the house
far side: on the far side of the carriageway relative to the house

8 times the maximum level resulting from traffic recorded in the current survey and was due to the large size of the irregularity and its proximity. In the current survey, however, the house is about 20m from the closest wheel track and about 50m from the centre of the gateway, resulting in the lower levels recorded.

A recent British Standard (BS7385) places the threshold for directly occurring damage due to impulsive sources at the much higher value of 19 mm/s (British Standards Institution, 1993) although structural fatigue damage due to many repeated cycles of vibration has been observed at the lower level of approximately 3mm/s (Watts, 1990). These levels are much greater than the highest peak level attributable to passing vehicles recorded during the current survey and therefore the risk of such damage is considered negligible.

4.6 PUBLIC OPINION SURVEY

A total of 199 people resident in Thorney were interviewed in their homes during late November/early December 1995, about 6 months after the installation of the main scheme and 3-4 weeks after the commissioning of the speed camera equipment. The aim was to establish people's perceptions of the measures and their effectiveness, or otherwise, in reducing any traffic problems resulting from the main road. Only those respondents who had lived in the village prior to 1995 were eligible for interview. As many homes as possible along the main road were visited, followed by homes elsewhere until the required number of interviews had been conducted.

Section 4.6.1 presents the characteristics of respondents, and Section 4.6.2 summarises the survey results. The questionnaire is reproduced in Appendix C.

4.6.1 Sample profile

Table 14 shows the distribution of respondents by age, sex, location and transportation.

It can be seen that 41% of those questioned were male. Seventy-two per cent of respondents were over 40 years of age and only 5% were under 25; although care was taken in establishing the distribution of properties to be visited, this does not appear to be a very accurate reflection of the actual age distribution of the population of Thorney according to the 1991 Census. The age distribution derived from the Census returns was as follows:

under 16	21%
16-29	19%
30-44	23%
45-59	18%
60+	20%

TABLE 14

Classification of respondents (percentages of total)

		All respondents (200) %
Sex		
	Male	41
	Female	59
Age		
	Under 25	5
	25-39	24
	40-59	29
	60+	43
Property location		
	On main road	50
	Elsewhere	50
Children under 16		
	Yes	30
	No	70
Transportation		
	Drive a car	74
	Drive a van	6
	Drive a lorry	1
	Ride a motorcycle	0
	Ride a pedal cycle	28
	None of these	18

It is likely that fewer people in the younger age groups were available for interview; also, no-one under 16 was interviewed. The nature of the responses between age groups, tested using the χ^2 test, was broadly similar; exceptions, regarding the usefulness of two of the measures, are mentioned in Section 4.6.2.5.

Thirty per cent of the respondents had children under 16. Of those interviewed, 74% were drivers of a car, van or lorry (there were no motorcycle riders), 28% rode a pedal cycle as an alternative or sole means of transport, and 18% had no personal transport.

Fifty per cent of the respondents lived on the main road, but those aged 60 and over were statistically significantly more likely to live elsewhere. Of the 99 respondents in this category, 37 were defined as *living near to 'sensitive' measures* - in this case, because of their designs, the mini-roundabout, the east gateway and the zebra crossing. A further 9 respondents, defined as *previously living near to 'sensitive' measures* lived near the mini-roundabout that was removed. These measures were likely to be controversial in their application on a busy main road, owing to their possible effect on traffic noise and ground-borne vibration, for example. The sources of the noise and vibration are likely to be:

- the slightly raised surface treatment at the gateway and the zebra crossing (see Sections 3.1 and 3.4);
- the domed central island of the existing, and former, mini-roundabout (see Section 3.5).

The length of time interviewees had lived in Thorney was:

0-5 years	43 (22%)
6-10	26 (13%)
11-20	44 (22%)
21-30	30 (15%)
31-50	38 (19%)
Over 50 years	18 (9%)

4.6.2 Results

Responses to each question are presented in turn. Tables show the percentage of interviewees giving each response. For simplicity, although they were computed, results classified by age and sex and whether or not the respondent was a driver have generally not been included in the Tables. Relevant comments have, however, been made where appropriate.

The results for questions 4-7 have been analysed to give 'mean' responses by allocating a score to each response (see Sections 4.6.2.3 - 4.6.2.6). Scores of 1 to 5 were given as follows, where 5 was for the most positive reaction, 3 was for no opinion either way and 1 for the most negative reaction:

- Q.4 (level of satisfaction with changes made): 5 = very satisfied; 1 = very dissatisfied;
- Q.5 (effect of the changes for various groups of people): 5 = very good; 1 = very bad;
- Q.6 (usefulness of the changes made - *4 possible responses only*): 4 = very useful; 2 = of little use; 1 = causes concern;
- Q.7 (agreement with statements regarding the changes): 5 = agree a lot; 1 = disagree a lot.

Tables relating to these questions show the resulting mean scores for: all respondents, those living on the main road, those living away from the main road, and for drivers and non-drivers. Respondents living on the main road are further split into those living near 'sensitive' measures, and those living elsewhere on the main road.

4.6.2.1 Spontaneous recall of problems before the changes (Q.3 and Table 15)

Residents were first asked to think back to any problems caused by the road before the changes to it were made. The main problems recalled are presented in Table 15.

Fifty per cent of respondents made comments related to the volume of traffic; over half of these respondents specifically mentioned the difficulty in crossing the road. Interestingly, only 37% of those living on the main road mentioned these problems compared to 61% of those who lived elsewhere.

Nineteen per cent of respondents mentioned the speed of traffic, in spite of the previously existing 30mph speed limit through the village. Those living away from the main road were most likely to recall this issue, with 31% of these residents mentioning the high speed of traffic compared with 6% of those living on the main road.

Queues and delays, for example at weekends and holiday periods, were mentioned by 10% of respondents. Noise (including being kept awake at night) and the frequency of accidents were each mentioned by 6%, and vibration was mentioned by 4%.

Other problems mentioned were: pollution (3%), near misses between lorries and pedestrians/footways too close to the road (1%) and difficulty emerging from side roads (1%). Seven per cent said there were problems without being specific.

However, 29% of respondents (and 38% of those living on the main road) did not think that there had been any problems before scheme installation.

4.6.2.2 Prompted recall of problems (Q.3A and Table 16)

Respondents were prompted with a number of issues concerning the main road and its traffic which could have caused problems before scheme installation. Of these, the danger to children was the main worry, with 84% of respondents agreeing that it had been a problem. The danger to pedestrians crossing the road (80%), the speed of traffic (74%), the number of lorries (70%), the amount of traffic (69%) and the danger to cyclists (68%) were also endorsed as having been problems before scheme installation. At least half of respondents agreed that danger to pedestrians on the footway (56%), smoke and fumes (54%), danger to motorists (53%) and dust and dirt (50%) were a problem prior to scheme installation. Nearly half of respondents thought that noise (48%) and vibration (47%) had been a problem.

There was a rather greater perception of problems among respondents living away from the main road than those living on it, though for noise and vibration the perception levels were similar.

4.6.2.3 Level of satisfaction with the changes (Q.4 and Table 17)

Respondents were asked about their overall level of satisfaction with the scheme. Seventy per cent of all respondents expressed dissatisfaction, with 27% being fairly dissatisfied and 43% being very dissatisfied. This reaction was strongest for residents living on the main road, with 79% expressing dissatisfaction, especially for those who lived near 'sensitive' measures (defined in Section 4.6.1), for whom 84% were dissatisfied. Only 26% of respondents were satisfied with the scheme.

TABLE 15

Spontaneous recall of problems before the changes
(Main comments only)

	All respondents %	Respondents on main road %	Respondents living elsewhere %
Number in sample	*199*	*99*	*100*
No problems	29	38	19
Difficult to cross road due to volume of traffic	29	19	38
Too much traffic/sheer volume	21	18	23
Speeding vehicles	19	6	31
Queues/delays/weekends and holiday periods	10	8	12
General problems (unspecified)	7	7	6
Noise/kept awake at night	6	7	5
Accidents	6	6	5
Vibration	4	5	3

TABLE 16

Prompted recall of problems

	All respondents	Respondents on main road	Respondents elsewhere
Number in sample	*199*	*99*	*100*
	% %	% %	% %
Amount of traffic	y=69, n=29	y=58, n=41	y=81, n=16
Speed of traffic	y=74, n=25	y=65, n=34	y=84, n=16
Number of lorries	y=70, n=28	y=58, n=39	y=82, n=16
Dangerous for motorists	y=53, n=38	y=43, n=46	y=62, n=29
Dangerous for cyclists	y=68, n=20	y=63, n=26	y=74, n=13
Dangerous/difficult for pedestrians to cross the road	y=80, n=17	y=72, n=25	y=88, n= 9
Dangerous for pedestrians using the footway	y=56, n=39	y=46, n=51	y=65, n=28
Dangerous for children	y=84, n=12	y=78, n=18	y=90, n= 6
Too much noise	y=48, n=44	y=47, n=49	y=48, n=39
Ground vibration	y=47, n=46	y=46, n=52	y=48, n=40
Dust and dirt	y=50, n=44	y=46, n=51	y=54, n=37
Smoke and fumes	y=54, n=41	y=48, n=49	y=59, n=32

TABLE 17

Level of satisfaction with the changes made: mean scores

Respondents ***(with number in sample)*** Total	On main road	Near sensitive measures (*)	Away from sensitive measures	Elsewhere	Drivers	Non-drivers
199	*99*	*37 (9)*	*53*	*100*	*129*	*71*
5 = very satisfied, 4 = fairly satisfied, 3 = no opinion either way, 2 = fairly dissatisfied, 1 = very dissatisfied						
2.13	1.82	1.57 (1.22)	2.10	2.43	2.16	2.02

* In brackets: previously near sensitive measures (removed mini-roundabout - see text)

Table 17 shows the mean scores for the overall level of satisfaction with the scheme for various categories of respondent. A mean score of 2.13 (slightly better than "fairly dissatisfied") was recorded. The lowest mean scores were 1.22 for residents living near sensitive measures which were later removed (i.e. the mini-roundabout at the junction with Woburn Drive), and 1.57 for those living near existing sensitive measures. The scores for the other categories of respondents did not exceed 2.43 (for those living away from the main road).

4.6.2.4 Effect of the changes on certain groups of people (Q.5, Table 18)

The interviewees were asked how they thought the changes had affected different groups of people: 53%, 38%, 31%, and 27% of respondents thought the scheme had been quite good or very good for schoolchildren, pedestrians, cyclists and elderly people respectively. On the other hand, 20%, 27%, 21% and 33% respectively thought the scheme had been quite bad or very bad for these groups. Only 8% and 5% of those questioned thought the scheme was quite good

TABLE 18

Effect of the changes on certain groups of people: mean scores

Respondents *(with number in sample)* Total	On main road	Near sensitive measures	Away from sensitive measures	Elsewhere	Drivers	Non-drivers
199	*99*	*37*	*53*	*100*	*147*	*52*
5 = very good, 4 = quite good, 3 = no effect, 2 = quite bad, 1 = very bad						
Pedestrians						
3.06	2.90	2.83	2.94	3.23	3.19	2.71
Drivers						
2.63	2.48	2.44	2.58	2.78	2.67	2.50
Schoolchildren						
3.36	3.23	3.26	3.28	3.49	3.39	3.29
Cyclists						
3.11	3.13	3.43	2.89	3.08	3.04	3.30
Elderly people						
2.83	2.66	2.78	2.64	3.00	2.87	2.70
Shopkeepers						
2.08	1.81	1.90	1.79	2.35	2.09	2.08
Residents on the main road						
1.89	1.80	1.75	1.82	1.99	1.93	1.75

or very good for residents on the main road and shopkeepers respectively, and 62% and 49% thought the scheme was quite bad or very bad for these groups.

The mean scores for the effect of the changes on different groups of people are shown in Table 18 for various categories of respondent. The total mean scores ranged from 3.36 (between "no effect" and "quite good") for the effects on schoolchildren to 1.89 (just below "quite bad") for the effects on residents living on the main road; overall, the scheme was seen as having little better than "no effect" on any single group of people. Respondents who lived on the main road were more likely than those who lived elsewhere to think that the changes had had an adverse effect on the specified groups, except on cyclists. Non-drivers tended to be more negative about the effects of the changes than drivers.

4.6.2.5 Usefulness of the changes made (Q.6, Q.6A, Tables 19-22)

Respondents were asked to assess how useful specific measures were. The most positive reaction was to the speed cameras, which 81% of respondents thought were fairly or very useful. Sixty-one per cent felt the same way about the zebra crossing within a slight narrowing of the carriageway and 59% thought that the part-time speed limit past the school was beneficial. Just over half of the residents (53%) thought that the large blue and yellow signs just outside the 30mph speed limit were either very or fairly useful, though on the other hand, 39% thought that these signs were of little use.

Over 40% of respondents thought the *Imprint* surfacing at the gateways and the zebra crossing was of little use, and almost as many felt the same about the kerb realignment at and around the junction with Gas Lane. A third of respondents thought that the slight road narrowing at the gateways was of little use.

The responses were fairly similar between age groups except that respondents aged 60 or over were more likely, by a statistically significant margin, to (a) think that the part-time 20mph speed limit was useful and (b) express concern about the kerb realignment at and around the junction with Gas Lane.

The measures which caused the most concern were the mini-roundabout, and to a lesser extent the chicanes and the kerb realignment at and near the junction with Gas Lane.

Concern over the mini-roundabout was expressed by 59% of all respondents and 84% of those who lived near to the 'sensitive' measures. Concern such as this had led to the removal of the Woburn Drive mini-roundabout (as mentioned in Section 3.5). Table 19 shows the main concerns

TABLE 19

Main concerns regarding the mini-roundabout

	All respondents %	Respondents on main road %	Respondents living elsewhere %
Number in sample	*118*	*72*	*46*
"Vehicles take no notice of the roundabout"	20	14	30
"Road too narrow/lorries cannot get through"	15	17	13
"People don't always observe the signs/pay attention"	14	11	20
"Too narrow so lorries drive over markings rather than around them"	12	18	2
"People do not give way"	11	13	9
"Noise/for people nearby/kept awake at night"	9	10	9
"Dangerous/will cause an accident"	9	6	15
"Signs are in wrong place"	8	10	4
"Waste of money"	6	8	2

Other comments

"Unsafe on footway"; "island in wrong place"; "no room for buses at bus stop"; "vehicles go on wrong side of road".

TABLE 20

Main concerns regarding the chicanes

	All respondents %	Respondents on main road %	Respondents living elsewhere %
Number in sample	*77*	*42*	*35*
"Road too narrow/lorries cannot get though"	38	36	40
"Vehicles don't slow down/take no notice/still speed"	23	24	23
"Vehicles do not keep to their side of the road"	18	19	17
"Dangerous/will cause an accident"	16	14	17
"Noise/for people nearby/kept awake at night"	12	21	-
"Path is too close to the road/no proper pavement/ feel unsafe"	8	7	9
"Too narrow so lorries drive over markings rather than around them"	6	10	3
"People don't always observe the signs/pay attention"	5	5	6

Other comments

"Waste of money"; "slippery surface/easy to skid in wet weather"; "lot of vibration/uneven surface"; "signs are in wrong place"

expressed. When the 118 respondents concerned about the mini-roundabout were asked what in particular worried them, 60 made comments relating to the layout and positioning of the mini-roundabout: 18 said that the road was too narrow and lorries could not get through and 14 said that lorries drove over the mini-roundabout island and markings (possibly the thermoplastic splitter islands on the approaches) rather than around them. Also, 9 respondents commented on the positioning of the signing, 6 comments were related to being unsafe on the footway in the vicinity, 5 respondents complained about the island being off-centre/in the wrong place, 5 mentioned the lack of room for the bus at the bus stop and 3 said that vehicles did not keep to their side of the road. A total of 59 respondents made

TABLE 21

Main concerns about the kerb realignment at/near the Gas Lane junction

	All respondents %	Respondents on main road %	Respondents living elsewhere %
Number in sample	*64*	*33*	*31*
"Road too narrow/lorries cannot get through"	28	18	39
"Trade has suffered/cannot park outside the shops"	28	39	16
"Waste of money"	11	15	6
"Vehicles do not keep to their side of the road"	8	3	13
"Not enough room for the bus at the bus stop"	5	6	3
"Signs are in the wrong place"	5	3	6

Other comments
"Dangerous/will cause an accident"; "vehicles don't slow down/take no notice/still speed"; "people don't always observe the signs/pay attention"; "path is too close to the road/no proper pavement/feel unsafe"; "too narrow so lorries drive over markings rather than around them"; "eyesore/spoils the village"; "it is off-centre to the road/in the wrong place"; "difficult to cross the road"; "people do not give way".

comments which could relate to drivers' lack of acknowledgement of the presence of the mini-roundabout. For example, 24 said that vehicles took no notice of the roundabout, 17 felt that little or no attention was paid to the signing, 13 said that drivers did not give way and 5 comments related to drivers not reducing speed. Eleven respondents said that noise was a problem for people nearby, mentioning being kept awake at night. This may have been related to HGVs clipping the central island and changing speed (with gear changing, braking and acceleration) as the mini-roundabout was negotiated.

While 39% felt that the chicanes were very or fairly useful, an equal proportion of respondents were concerned about them. Of the 77 respondents who were concerned, 42 lived on the main road and 51 were drivers. The main concerns are shown in Table 20. Over two-thirds of the concerns were related to the layout of the chicanes: 29 respondents said the road was too narrow and lorries could not get through, 14 said that vehicles did not keep to their side of the road (possibly related to cutting across the markings) and 5 respondents specifically mentioned HGVs driving over the markings. Six respondents made comments relating to feeling unsafe on the footway. In spite of the good speed reductions (especially for inbound traffic), 18 respondents claimed that drivers did not reduce speed or took no notice of the chicanes. Nine respondents mentioned a noise nuisance; again this may have been related to HGVs changing speed.

Almost a third (32%) of all respondents were concerned about the narrowing of the main road at the junction with Gas Lane. Only 23% saw any benefit resulting from this alteration. Interestingly, 18 of the 64 respondents who voiced their concern about this measure believed that trade had suffered because parking outside of the shops was no longer possible (Table 21). An equal number were concerned about the lack of carriageway width, especially with regard to HGVs.

Concerns about the other measures were wide-ranging.

Table 22 shows the mean scores for the perceived usefulness of the changes, for various categories of respondent. The majority of these scores were between the "fairly useful" (3) and "of little use" (2) ratings. Although none reached the "very useful" category, the speed cameras achieved the highest score of 3.59 for views by residents away from the main road. The speed cameras also received the highest rating by all respondents (3.39). This was followed by the part-time 20mph speed limit past the school (2.82), the zebra crossing (2.65) and the large blue and yellow signs just outside the gateway (2.61). The mini-roundabout consistently had the lowest rating, ranging from 1.22 for those living near 'sensitive' measures, through 1.50 for other respondents on the main road, to 1.80 for respondents living elsewhere. The kerb realignment at and around the junction with Gas Lane had the next lowest score, ranging from 1.79 for residents living near 'sensitive' measures, through 1.94 for other respondents on the main road, to 1.98 for residents living elsewhere.

4.6.2.6 Agreement with statements regarding the changes (Q.7 and Table 23)

Respondents were asked whether or not they agreed about various statements regarding the changes.

TABLE 22

Usefulness of the changes made: mean scores

Respondents *(with number in sample)* Total	On main road	Near sensitive measures	Away from sensitive measures	Elsewhere	Drivers	Non-drivers
199	*99*	*37*	*53*	*100*	*147*	*52*
4 = very useful, 3 = fairly useful, 2 = of little use, 1 = causes concern						
Blue/yellow gateway signing						
2.61	2.53	2.43	2.60	2.69	2.62	2.58
Slight road narrowing at gateway						
2.30	2.21	2.00	2.29	2.39	2.30	2.31
Imprint surfacing at gateway						
2.16	2.04	1.84	2.14	2.29	2.23	1.96
Chicanes just inside gateways						
2.06	2.00	1.69	2.17	2.11	2.14	1.80
Part-time 20mph speed limit						
2.82	2.60	2.28	2.93	3.02	2.84	2.76
Zebra crossing						
2.65	2.34	1.97	2.62	2.98	2.79	2.24
Imprint surfacing at zebra crossing						
2.11	1.95	1.74	2.15	2.28	2.18	1.89
Mini-roundabout						
1.58	1.38	1.22	1.50	1.80	1.65	1.37
Speed cameras						
3.39	3.19	3.00	3.38	3.59	3.37	3.43
Kerb realignment (Gas Lane)						
1.92	1.86	1.79	1.94	1.98	1.95	1.82
Pedestrian refuge						
2.46	2.36	2.30	2.38	2.55	2.51	2.28

In spite of the negative reactions to parts of the scheme already described, 57% of residents concluded that the changes were necessary, 58% agreed that the road was now safer and easier to cross and 61% agreed that the scheme had reduced speeds (though less than a quarter (24%) thought that they had been reduced enough).

The mean scores for respondents' agreement with statements regarding the changes are shown in Table 23 for various categories of respondent. The scores for residents on the main road, especially those living near 'sensitive' measures, generally suggested a more negative reaction than other respondents to these statements.

The statement "the changes were necessary" had an overall rating close to neutral across all respondents, with a score of 3.08. The score was lower (2.63) for those living on the main road, particularly those living near 'sensitive' measures (2.32).

There was a tendency to disagree with the statements that the measures made it safer for motorists, or to walk on the footway (scoring 2.63 and 2.52 respectively for all respondents). The score for drivers regarding motorists' safety was virtually the same as the overall score of 2.63. Residents on the main road, particularly those living near sensitive measures, were most likely to disagree with both statements.

Opinion was fairly neutral about the statement that the measures made it safer for cyclists, with an overall score of 3.02 and a higher score of 3.26 for non-drivers.

TABLE 23

Agreement with statements regarding the changes: mean scores

Respondents *(with number in sample)* Total	On main road	Near sensitive measures	Away from sensitive measures	Elsewhere	Drivers	Non-drivers
199	*99*	*37*	*53*	*100*	*147*	*52*
5 = agree a lot, 4 = agree a little, 3 = no opinion, 2 = disagree a little, 1 = disagree a lot						
The changes were necessary						
3.08	2.63	2.32	2.85	3.54	3.20	2.75
They make it safer/easier to cross the road						
3.18	2.70	2.59	2.90	3.65	3.24	2.98
They make it safer to walk on the footway						
2.52	2.34	2.19	2.48	2.70	2.55	2.44
They make it safer for motorists						
2.63	2.38	2.25	2.49	2.88	2.64	2.59
They make it safer for cyclists						
3.02	3.08	3.25	2.98	2.96	2.93	3.26
They have reduced speeds						
3.18	2.79	2.59	3.02	3.56	3.19	3.14
They have reduced speeds enough						
2.22	2.04	1.73	2.27	2.41	2.28	2.06
They are frustrating for drivers						
3.53	3.53	3.54	3.50	3.53	3.50	3.62
They should be introduced in other villages						
2.60	2.25	2.26	2.50	2.83	2.72	2.21
They have increased noise						
4.21	4.35	4.54	4.15	4.07	4.19	4.28
House shakes when a lorry goes by						
4.07	4.36	4.49	4.20	3.76	4.08	4.04
They have increased traffic fumes						
4.18	4.26	4.30	4.15	4.09	4.18	4.17
A bypass would have been better						
4.88	4.83	5.00	4.72	4.93	4.86	4.92
Other changes would have been better						
3.25	3.36	3.34	3.24	3.16	3.31	3.05

There was no strong feeling either way that the measures had reduced speeds. Respondents living away from the main road were more likely to agree with the statement (3.56), while the score for those living on the main road was 2.79 and that for those living near 'sensitive' measures was 2.59. There was less agreement that the measures had reduced speeds *enough*, the scores ranging from 1.73 for respondents living close to sensitive measures, to 2.41 for residents living away from the main road. The overall score was 2.22.

There was a slight tendency to agree that the measures were frustrating for drivers (score 3.53) and this varied little between drivers and non-drivers.

All categories of respondent tended to disagree that the measures should be introduced in other villages, the greatest tendency being among non-drivers (2.21) and residents on the main road (2.25). The overall score was 2.60. The opinions of respondents living away from the main road were closest to neutral (2.83).

There was general agreement that the measures had adverse environmental effects (increased noise and traffic fumes, and perceptible vibration in houses from HGVs), with all but one score being at least 4 ("agree a little"). There was consistent agreement that noise had increased, in spite of measured noise reductions (see Section 4.4). A number of possible noise sources, not shown by measurement, could have biased residents' opinions to the negative side:

- HGV body rattle generated by (a) clipping the Sandpit Road mini-roundabout domed island, (b) uneven road surface resulting from the removal of the Woburn Drive mini-roundabout and (c) crossing the slightly ramped boundaries of the *Imprint* surfacing;
- a change in the character of tyre noise, generated by the *Imprint* surfacing;
- more variability in noise, caused by additional braking, acceleration and gear changing from HGVs encountering the mini-roundabout and opposing HGVs having to slow down for each other at the zebra crossing within the narrowed section of carriageway;
- disturbance, of which there is both opinion survey and anecdotal evidence, caused by noise from any of the above sources at night.

Not surprisingly, the strongest opinions concerning increasing noise came from residents living on the main road, with a score of 4.35, increasing to 4.54 for those living near to 'sensitive' measures.

Overall there was slight agreement that houses are shaken by lorries (score of 4.07), with a score of 4.49 for those living close to 'sensitive' measures. This is consistent with ground-borne vibration above the threshold level of perception being measured throughout the monitoring period. Also, ground-borne vibration can be amplified upstairs in a house. In addition, residents' comments on vibration may be related to airborne vibration due to low frequency noise emissions from traffic rather than ground-borne vibration. Low frequency noise can cause light flexible structures such as doors and windows to vibrate; this can generate noise effects which are present as vibration. Airborne vibration was not measured in this study as it can be difficult to measure - this is carried out by attaching an accelerometer to something that is likely to be excited by low frequency noise. This would need to be determined beforehand by asking the occupier or waiting for the effect to occur.

There was general agreement across all categories of respondent with the statement that the measures had increased traffic fumes, ranging from 4.09 for residents away from the main road to 4.30 for residents near 'sensitive' measures. The score was 4.18 for all respondents.

In summary, the opinions of residents on the main road and particularly those living near 'sensitive' measures attracted the highest scores for noise, vibration and traffic fumes.

Ninety-six per cent of residents agreed that a bypass would have been better (score of 4.88). This is unsurprising given that there had been an active campaign for a bypass and that the New Roads Programme had recently been announced, excluding Thorney from having a bypass in the foreseeable future. They were less sure about whether other changes would have been better (score of 3.25). There was little difference in opinion between residents living on or away from the main road on both issues, though those living near 'sensitive' measures were unanimous in their feelings about a bypass, attracting the maximum score of 5.00.

4.6.2.7 The look of the scheme (Q.8, Q.8A, Tables 24 and 25)

Respondents were asked if they had any concerns about the look of the scheme; 61% were unconcerned (Table 24).

Of the 77 people who had concerns (Table 25), 74% said that it spoiled the look of the village and/or countryside and 12% mentioned that it was an eyesore or generally unsightly. Other residents felt that there were too many signs, markings, "lights" and measures or that the scheme was "cluttered" or "messy" (together mentioned by 9% of respondents). Nine per cent of residents no longer felt it was a conservation area. Six per cent of respondents mentioned

TABLE 24

Incidence of concerns regarding the look of the scheme

	All respondents %	Respondents on main road %	Respondents elsewhere %
Number in sample	*199*	*99*	*100*
Yes	39	41	36
No	61	59	64

TABLE 25

Particular concerns regarding the look of the scheme

Comments	%
Number in sample	*77 respondents*
"Spoiled village/spoiled countryside"	74
"Eyesore/unsightly"	12
"Too many signs/markings/lights/measures/cluttered/messy"	9
"No longer a conservation area"	9
"Black metal posts/markings/colourings out of keeping with village"	6
"Villages cannot make alterations to their homes but the Government can do anything"	3
"We have lost security and safety"	1

that various features were out of keeping with the village, i.e. "black metal posts", markings and "colourings". (The 'black posts' referred to the lighting columns and sign poles, which were in fact painted black *because* the village was a conservation area.)

4.6.2.8 Awareness of the changes before they occurred (Q9, Q9A, Tables 26 and 27)

Respondents were then asked if they had heard about the changes prior to scheme installation, and 89% of respondents said that they had been forewarned (Table 26). The remainder (11%) had not been aware of the new scheme until work had actually started.

Table 27 shows that for the 177 respondents who did have prior knowledge of the scheme, the three most common sources of information were public meetings, leaflets and the local papers (for 49%, 48% and 45% of these respondents respectively). A third of respondents found out about the scheme through friends or relatives, 13% mentioned public street notices and 8% had seen a display in the school. Other sources included local TV and radio news (7 respondents), a visit from the council (3%), a display in Station Road and an exhibition (2% each) and a petition in a shop (1%). A greater proportion of residents on the main road than elsewhere heard about the changes through public meetings and leaflets (both about 60% compared with 40%) and through the school display (11% compared with 5%). On the other hand, 41% of residents away from the main road heard about the scheme through friends and relatives compared to 24% of those living on the main road. Otherwise, there was little difference in the pattern of responses between the two categories of respondents.

4.6.2.9 Consultation with the residents about the scheme (Q10, Q10A, Tables 28 and 29)

When asked whether the council or the Department of Transport had asked residents for their views on the plans via leaflets or public meetings, 64% of respondents said they had been consulted in this way (Table 28). Nine per cent claimed that they had not been asked for their opinion and 28%, a relatively high proportion of residents, did not know.

Almost all of the residents who were aware of the council or Department of Transport asking for opinions said that they were consulted before the changes (116 out of 127 respondents). Only two respondents claimed to have been consulted after the event.

Respondents were not wholly satisfied with the consultation regarding the scheme (Table 29): 51% were dissatisfied, 30% had no opinion either way or were unsure and only 21% were satisfied. The resulting mean score was 2.39 (tending towards "fairly dissatisfied").

4.7 REACTION FROM THE EMERGENCY SERVICES

No comments on the scheme have been received from the emergency services.

4.8 ACCIDENTS

There was a total of 26 reported injury accidents on the A47 within the built-up area (i.e. within the 30mph speed limit) of Thorney in the 5 complete years (1990-1994) prior to the introduction of the traffic calming measures. Of these, 1 was fatal and 8 involved serious injury. Ten of the accidents were reported during the last 3 years up to scheme

TABLE 26

Awareness of the changes before they occurred

	All respondents %	Respondents on main road %	Respondents elsewhere %
Number in sample	199	99	100
Yes	89	86	92
No	11	14	8

TABLE 27

How the changes were heard about

	All respondents with prior knowledge of scheme %
Number in sample	*177*
Public meetings	49
Leaflets	48
Local papers	45
From friends/relatives	33
Public notices in the street	13
Display in school	8
Local TV news	5
Visit from the council	3
Local radio news	2
Display in Station Road	2
Exhibition	2
Petition in a shop	1
At work	1
Plans in Town Hall	1

TABLE 29

Level of satisfaction with the consultation regarding the scheme

	All respondents aware of consultation %
Number in sample	*127*
Very satisfied	4
Fairly satisfied	17
No opinion either way	27
Fairly dissatisfied	16
Very dissatisfied	35
Don't know	2

TABLE 28

Consultation with the residents about the scheme

	All respondents	Respondents on main road %	Respondents elsewhere % %
Number in sample	*199*	*99*	*100*
Yes	64	67	61
No	9	10	7
Don't know	28	23	32

installation (May 1992 to April 1995) and can be classified as follows:

nose-to-tail (on main road)	5
nose-to-tail involving a vehicle waiting to turn right off the main road	1
pedestrian	1
pedal cyclist	1
probable red-run at the traffic signals	1
overtaken vehicle hit by overtaking vehicle	1

Three of the nose-to-tail accidents involved a rear-end collision with vehicles queueing for the traffic signals.

Following scheme implementation, 4 injury accidents (all slight) were reported in the 12 month period up to May 1996. The 'after' period is quite short; the change (from 5 per year in the 5 year 'before' period to 4 per year in the 'after' period) is not statistically significant and more time will be needed before a comprehensive accident analysis can be carried out.

5. SUMMARY AND CONCLUSIONS

A traffic calming scheme was implemented in 1995 at Thorney, on the A47 trunk road in Cambridgeshire. The A47 trunk road forms part of a route linking the Midlands with Norwich and the remainder of Norfolk and its coastal resorts and ports. Before the traffic calming measures were introduced, there was a two-way mean traffic flow through Thorney of about 13,000 vehicles per day, of which at least 20% were heavy goods vehicles. The built-up area of the village extends for about 1.6km and the current speed limit (unchanged on scheme installation) is 30mph. The carriageway width is mostly 7.5-8.0m, with a minimum width of 6.75m and a maximum width of 9.5m. A total of 26 injury accidents were reported within the village speed limit during the 5 complete years (1990-1994) prior to scheme installation.

Most of the scheme was introduced in May 1995 with additional features implemented later in the year. The speed limit was unchanged at 30mph. A variety of measures was installed on the approaches and within the village. On each main road approach, prominent signing warning of the traffic calming scheme ahead was installed in advance of gateway features. The gateways comprise 30mph speed limit signing mounted on a black plastic background on each side of the carriageway, together with an area of dark red road surfacing laid as a screed and *Imprinted* to simulate pavers. This surface treatment is slightly raised. The carriageway is slightly narrowed on both sides with Trief kerbing. About 100m inside each gateway a two-way chicane was installed, comprising a slightly angled central island with hatching on a red background beyond each end of it and on the nearside of the outbound carriageway.

In the village, two mini-roundabouts were installed. On the stretch between these, along which there is a school, a part-time 20mph speed limit was introduced in June 1995, using variable-message signs displaying the lower speed limit when children go to and from the school. Outside the school entrance, a zebra crossing within a slight narrowing was installed. On both sides of the crossing, the same *Imprint* surfacing as at the gateways was laid, again slightly raised. Near the centre of the village, GATSO speed camera equipment was commissioned in November 1995 and associated signing was installed on the village approaches. In the village centre, a pedestrian refuge was installed and some junction remodelling involving the installation of kerb extensions narrowing the main carriageway was carried out. One of the mini-roundabouts (near the start of the part-time 20mph speed limit) was removed following residents' opposition before the 'after' monitoring took place.

'Before' and 'after' monitoring comprised measurements of vehicle speeds and flows, journey times through the village and traffic noise. Ground vibration measurements were carried out in the 'after' period only. A public opinion survey was conducted about 6 months after scheme installation. The results are summarised below and conclusions drawn. Further longer-term measurements of vehicle speeds and flow were made in June 1996, 12 months after the initial speed and flow measurements.

5.1 TRAFFIC FLOWS

'Before' and 'after' total vehicle counts were carried out at the gateway sites in November 1994, June 1995 and November 1995, using data loggers connected to inductive loop detectors. The latter counts were carried out after speed camera installation. An 8 hour manual classified count was carried out at the gateway sites in April 1994 and June 1995 as part of the journey time surveys.

At the gateway sites, the mean 24 hour two-way traffic flow over 7 days was little changed between November 1994 and November 1995. In June 1995 the flow was higher by an amount reasonably consistent with seasonal variation.

The manual classified count showed that the proportion of HGVs was 22% during the 'before' period and 21% during the 'after' period.

It would therefore seem that, with no practical alternative route available, the traffic calming scheme has not measurably affected the overall flow of traffic through Thorney, or the number of HGVs.

5.2 VEHICLE SPEEDS AND JOURNEY TIMES

'Before' and 'after' speed monitoring was carried out in April/May/November 1994 and June 1995, with further monitoring carried out in November 1995 following speed camera installation. The monitoring positions were at the gateway sites and at 7 sites within the village: at each chicane and downstream (towards the village) of one of them; near the remaining Sandpit Road mini-roundabout; within the part-time 20mph speed limit; at the speed camera site; and at the pedestrian refuge. At the gateway sites, data were collected by data logger, while elsewhere radar speed readings of free-flowing vehicles were taken. The part-time 20mph speed limit was monitored with the variable message signs on and with them off. In November 1995, data loggers were deployed at the gateways and radar speed readings were carried out at the speed camera site only.

Mean and 85th percentile speeds fell by 8-9mph at the gateways, though 85th percentile speeds were still up to 14mph above the speed limit. There was a further reduction of 2-3mph with the presence of speed camera signing on the village approaches. Prior to installation of the camera equipment, speed reductions in the village ranged from 3mph at the speed camera site to 15mph inbound at the chicanes and downstream (in the same direction) of the eastern chicane. At the speed camera installation following commissioning, speeds were further reduced by only 1mph. The target 85th percentile speed of 30mph within the village was achieved, mainly by HGVs, at only a few locations. These were:

1. at the eastern chicane (westbound/inbound);
2. downstream of the eastern chicane (westbound);
3. at the zebra crossing within the part-time 20mph speed limit (when not operating);
4. near the Sandpit Road mini-roundabout.

When the part-time 20mph speed limit was operating, 85th percentile speeds within the limit were still 27-30mph for light vehicles and 24-27mph for HGVs, even though reductions were up to 11mph.

It is not known which of the measures employed on the approach to, and at, the gateways contributed most to the reduction in speeds. Approaching the gateways, the blue and yellow signs warning of traffic calming and road narrowing arguably have more visual impact than the gateway itself, where the dull-coloured *Imprint* surfacing is inconspicuous until it is encountered. Speeds were further reduced at the chicanes 100m inside the gateways. Once through the chicanes, speeds continued to fall until after the next measure was encountered (the zebra crossing within the part-time 20mph speed limit or the pedestrian refuge, depending on the direction of travel). Thereafter, speeds began to rise in both directions between the pre-existing traffic signals in the village centre and the Sandpit Road mini-roundabout. On this comparatively long stretch, a second mini-roundabout had been removed, with a consequent wide spacing between the remaining mini-roundabout and the remodelled Gas Lane junction. Moreover, during the initial 'after' monitoring, the speed camera equipment on this stretch had yet to be installed.

Journey times through the village (between each end of the village speed limit) were calculated by matching registration numbers on video taken at the gateway sites over an 8 hour period. The times at which the vehicles passed each gateway site were subtracted to obtain the journey time. After the scheme was introduced, the mean journey time increased by 18sec westbound (29% increase) but by only 4sec eastbound (3% increase).

5.3 NOISE MEASUREMENTS

'Before' and 'after' vehicle and traffic noise measurements were carried out at the east gateway, in a residential part of the village (within the part-time 20mph speed limit), and in the village centre, the most built-up area.

5.3.1 Vehicle noise

Reductions in the maximum vehicle noise occurred at all three sites, except for heavy vehicles in the village centre (site 3) where noise levels were unchanged.

The greatest change occurred at the gateway, site 1, where changes of 6 dB(A) and 4.3 dB(A) for light and heavy vehicles respectively were measured. Although the change in noise levels for both vehicle categories at this site was predominantly due to the change in speed [17km/h (10mph) and 23 km/h (14mph) for light and heavy vehicles, respectively] it was shown that the change in road surface to *Imprint* surfacing provided an additional reduction in light vehicle noise level of 2.1dB(A). However, this type of surfacing, confined to a short section of road, would provide fluctuations in the noise emission levels from light vehicles which may be perceived as annoying to residents living in the vicinity.

In the residential area (site 2A/2B), light and heavy vehicle noise levels were reduced by 3.8 dB(A) and 2 dB(A) respectively. It is estimated that when the part-time 20mph speed limit is in operation noise levels are reduced for light vehicles by a further 1.2 dB(A). However, 'after' heavy vehicle noise levels were found to be largely insensitive to speed and consequently are expected to remain roughly constant between the on and off periods. It was also indicated that vehicle noise emission levels were influenced by the presence of the mini-roundabout, particularly for heavy vehicles. It is therefore, possible that the characteristics of the noise in terms of levels at different frequencies may have changed which may be perceived as annoying to residents living in the vicinity.

There were much smaller changes in the centre of the village (site 3). 'After' vehicle noise levels for heavy vehicles remained about the same, whilst light vehicle noise levels were reduced by 2.4dB(A). The presence of the nearby signal junction may have influenced noise levels, particularly for heavy vehicles, which may have been accelerating away from the junction.

5.3.2 Traffic noise

Traffic noise levels measured outside a house at site 2 were reduced by about 3.5 dB(A) during both the daytime (0600-2400) and nighttime (0000-0600) periods. This reduction is equivalent to that expected if the traffic flow were reduced to approximately half its existing level. The reduction is consistent with the observed reductions in vehicle noise levels.

It can be expected that traffic noise levels adjacent to the east gateway (site 1) would have been reduced by at least 5 dB(A) based upon the reductions in vehicle noise. However, using the same method of approximation, it is unlikely that a significant change in traffic noise occurred in the centre of the village, near to site 3, after scheme installation.

5.4 GROUND-BORNE VIBRATION

No 'before' survey was carried out. As a result of a subjective assessment at various sites in the village, the east gateway, with its slightly raised *Imprint* surfacing, was chosen as a suitable location for measurements, which were carried out at a house about 50m away. At this locality approach speeds (from the east) were relatively high and it was considered that vibrations generated at this point would be amongst the highest for the traffic calming scheme as a whole. The area is on soft soils containing peat deposits and thus relatively high vibration levels were considered likely. Results from this 'worst case' location enable the maximum likely vibration effects of measures with changes of road surface to be gauged for the scheme as a whole.

From the measurements made the following conclusions can be drawn:

1. The peak levels of ground-borne vertical vibration in the building structure near ground level exceeded the perception threshold of 0.3 mm/s in every 15 minute measurement period, and were in the range 0.31 to 0.46 mm/s.

2. Although it is unlikely that the measured level of vibration at the house is unacceptable since it is close to the threshold, some disturbance might be experienced upstairs where amplification may occur.

3. Since the surface treatment at the gateway was raised to a maximum of 20mm above the otherwise smooth road surface, it is likely that the soft ground conditions led to the relatively high levels of vibration experienced. The absence of road surface defects and manhole covers contributed to the relatively low level of vibrations recorded from vehicles passing immediately in front of the house.

4. A recent British Standard (BS7385) places the threshold for damage due to ground vibration at the much higher value of 19 mm/s. However structural fatigue damage due to longer-term exposure to vibration has been observed at 3mm/s. These levels are much greater than the highest peak level attributable to passing vehicles recorded during the current survey and therefore the risk of such damage is considered negligible.

5. The results suggest that the introduction of traffic calming measures involving surface humps or cushions on soft ground conditions should be carefully considered since very modest surface alterations clearly have the potential to cause vibration disturbance.

5.5 PUBLIC OPINION SURVEY

A public opinion survey, of 199 local residents, took place in November 1995, about 6 months after the introduction of the measures. Forty-one per cent of the respondents were male, 72% were 40 years old or over, 50% lived on the main road and 74% were drivers (there were no motorcycle riders). Nearly 90% of respondents knew beforehand that measures were to be installed, but only 57% thought that changes were necessary.

The main problems before scheme installation were thought to be the difficulty in crossing the road because of the volume and speed of traffic, but nearly 30% of respondents did not recall any problems. Although measured speed reductions were encouraging at least in the outer parts of the village, over three-quarters of respondents thought speeds had not been reduced enough after implementation. This may be a reflection of the more disappointing speed reductions in the centre of the village. Nearly 60% of respondents thought it was safer to cross the road after implementation, but only 30% thought it was safer to walk on the footway. Only 33% and 37% thought the scheme was safer for motorists and cyclists respectively.

When asked about their level of satisfaction with the scheme, 70% of the residents expressed dissatisfaction. The reaction was fairly similar whether the residents lived on, or away from, the main road. Only 26% of respondents were satisfied with the scheme.

When asked about specific measures, 81% of respondents thought that the speed cameras were useful, and over half thought the same about the blue and yellow signing in advance of the gateways, the part-time 20mph speed limit and the zebra crossing. On the other hand, the blue and yellow signing and the *Imprint* surfacing at the zebra crossing were each thought to be of little use by about 40% of respondents. The mini-roundabout caused the most concern of any of the measures, expressed by nearly 60% of respondents. Comments were mixed, the main ones implying that it was ignored by drivers and difficult for HGVs to negotiate because of the restricted space to manoeuvre. One in 11 of the respondents concerned about the mini-roundabout mentioned noise nuisance and being kept awake at night.

Although the chicanes were effective in reducing speeds, nearly 40% of respondents were concerned about them. The main criticisms were that the road was too narrow, HGVs could not get through, and there were claims implying they do not reduce speed. A third of respondents were also concerned about the kerb realignment at the Gas Lane junction, again in connection with the available lane or carriageway width, with an equal concern about not being able to park outside the shops and the consequent loss in trade. This feature was also thought to be of little use by nearly 40% of respondents.

There was fairly strong agreement about the environmental effects of the measures - that they had increased traffic noise and traffic fumes, and that there was perceptible vibration in houses from HGVs. The lack of satisfaction with the scheme overall was reflected in respondents' strong agreement that a bypass, for which there had recently been an active campaign, would have been better. This appeared to be preferred to the option of other changes, as residents were fairly non-committal about the latter, but this is likely to be because the bypass issue was uppermost in their minds.

Negative comments about the scheme were made more strongly by those living on the main road than elsewhere, particularly by those living close to 'sensitive' measures (the mini-roundabout, the east gateway and the zebra crossing). Those living on the main road were also more likely to think there had been no problems prior to scheme installation.

Responses were broadly similar between age groups, except that older respondents (aged 60 and over) were more likely to think that the part-time 20mph speed limit was useful, and to express concern about the kerb realignment at and around the junction with Gas Lane.

5.6 ACCIDENTS

A total of 26 injury accidents (1 fatal and 8 involving serious injury) were reported on the A47 within the built-up area (i.e. within the 30mph speed limit) of Thorney in the 5 full years prior to the introduction of the traffic calming measures. Ten accidents were reported during the last 3 years before installation. In the 12 month period since scheme installation, 4 injury accidents have been reported. More time is needed before any conclusions about the safety benefit of the scheme can be drawn.

5.7 DISCUSSION

The traffic calming scheme on the A47 at Thorney has yielded encouraging speed reductions in the outer parts of the village and in the part-time 20mph speed limit past the school, but it mostly has not met the objective of reducing 85th percentile speeds to the 30mph speed limit, even at the speed camera site. The large speed reductions, for example at the chicanes, were from fairly high 'before' speeds. The scheme has not, on the whole, achieved public acceptability.

About three-quarters of the people interviewed expressed dissatisfaction with the scheme. Many people thought that vehicle speeds had not been reduced enough, and the overall impression was that the bypass originally planned would have been much preferred to traffic calming measures[4], although the speed camera installation was accepted by most residents, even though it had little additional effect on observed speeds. Their main concerns were about the mini-roundabout in particular; a second mini-roundabout had been removed soon after scheme installation. Other measures that were capable of reducing speeds to levels at or below the 30mph limit (e.g. the chicanes) also attracted criticism. Detailed design changes might alleviate some of the problems mentioned by the residents. However, their reactions to the scheme highlight the dilemma for the traffic calming engineer who is attempting to reduce accidents by measures that influence vehicle speed without causing unwanted safety and environmental side effects. The measures that are the most effective are generally the ones that have the most behavioural and environmental impact and are likely to be the most unpopular.

With regard to the impact of the traffic calming scheme on vehicle noise, there is a discrepancy between the measured changes and the perceptions of residents. These measurements generally show a decrease or no change. However, the responses from the residents suggest that noise has increased. This discrepancy could be caused by a number of factors associated with perception and measurement of noise:

1. Location of measurements. Due to cost considerations, noise measurements were made at just three sites, while the residents' survey included people living throughout the village. However, two of the measurement sites were chosen to reflect likely 'worst case' locations, the third being away from any measures.

[4] In fact, traffic calming measures would have been installed whether or not a bypass was built - it is very likely, that with reduced traffic flow, speeds would have increased in the bypassed village. A bypass would have allowed more severe traffic calming measures to be installed with the removal of design constraints mentioned earlier.

2. Questionnaire design. For cost reasons, the questionnaire was fairly brief and responses were sought to specific questions about increased noise. It may be that the residents were influenced by the way in which the questions were put. A more detailed survey would be needed to resolve this point.

3. Although overall traffic noise levels were reduced at two sites and little changed at the third, it is possible that residents living alongside the A47 close to certain measures might have found certain aspects of the noise intrusive. The measures blamed for increased noise nuisance by some residents were principally the gateways, the zebra crossing, the chicanes and the mini-roundabout. Variations in tyre noise generated by the *Imprint* surfacing at the gateways and zebra crossing, together with variations in heavy vehicle noise (such as body rattle, braking, acceleration and gear changing) at both these measures, as well as at the chicanes and mini-roundabout, might have constituted a nuisance.

4. Isolated noise events, particularly at night, might have had greater impact on people's perception of changes in noise nuisance than the measured changes in the levels of traffic noise. In the longer term, further research may be needed to investigate this issue.

Given the soft ground on which Thorney lies, the perception of vibration in houses at Thorney may be associated with two factors (although the second is not associated with ground conditions):

1. Residents' reaction reflecting amplified vibration effects felt upstairs, given that measured vibration at ground level was only just above the level of perception at the monitoring site near the east gateway.

2. Airborne vibration due to low frequency noise (caused by noise emissions from vehicle engines and exhausts) rather than ground-borne vibration. Further analysis of the noise data is needed to establish whether low frequency noise levels have increased since the traffic calming scheme was introduced.

Generally speaking, people's perception of increased noise and vibration may be influenced by concerns about other aspects of the scheme. A more detailed questionnaire would help to resolve this point.

6. ACKNOWLEDGEMENTS

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APPENDIX A: NOISE MEASUREMENTS - THE STATISTICAL PASS-BY METHOD

The Statistical Pass-by Method was initially developed at TRL for road surface noise surveys (Franklin, Harland and Nelson, 1979). The technique is used by researchers in many other countries and has become an internationally accepted method for measuring the influence of road surfaces on vehicle and traffic noise levels (International Standards Organisation, 1995).

The method requires the simultaneous measurement of the maximum noise level and speed of individual vehicles in the traffic stream. A typical measurement site layout is shown in Fig A.1. The traffic population is categorised into 'light' vehicles, which include all cars and vans with an unladen weight less than 1.5 tonnes, and 'heavy' vehicles. Under normal conditions, approximately 50 vehicles from each category are selected for measurement.

From this data set, a regression of noise against the logarithm of vehicle speed is performed for both vehicle groups. The general relation between the maximum sound level ($L_{A,max}$) and the speed of a passing vehicle has been shown to take the form (Harland,1974):

$$L_{A,max} = a + b \, log_{10} V \text{ dB(A)}$$

where

V = speed of the vehicle (km/h)

a = the constant term

b = the slope of the regression line

The regression lines calculated are then used to determine the noise levels at suitable reference speeds. These levels are used to compare the sites studied. This method has been found to give results for surface noise surveys which are repeatable to within 1.0dB(A) when using the vehicle sample size indicated.

All noise measurements should be taken when the road is dry and during light wind conditions, i.e. wind speeds less than 10 m/s. To further minimise the effects of any turbulence due to wind, all measurements should be conducted with a microphone fitted with a standard foam windshield. The microphone system and recording level are calibrated both prior to, and following, each measurement session using a precision 1 kHz tone calibrator. The maximum and minimum air temperatures during each of the monitoring sessions are also recorded.

In the analysis, the acoustic data are combined with the vehicle speed and classification data. The maximum noise levels for each vehicle event are regressed against the logarithm of the vehicle speed using the general relation given above.

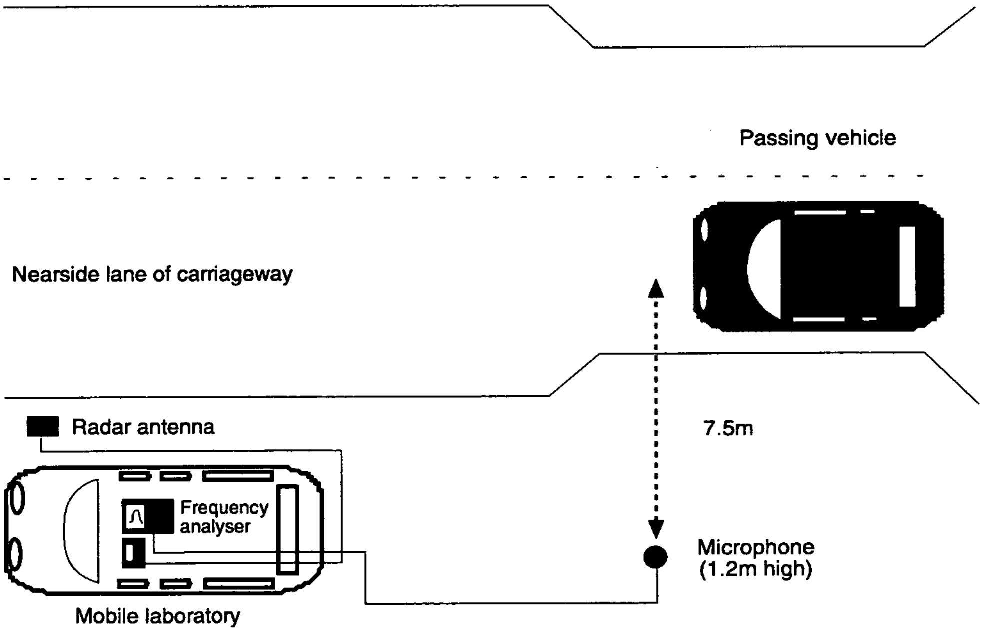

Fig.A1 Site layout for vehicle noise measurements

APPENDIX B:
REGRESSION ANALYSIS OF VEHICLE NOISE AND SPEED

TABLE B.1

Regression analysis of vehicle noise and speed for light vehicles

Site	Constant (a)	Regression analysis statistics* Slope (b)	Correlation (r^2)	Standard deviation dB(A)
Before				
1	20.11	31.85	0.84	1.25
2A	31.32	25.83	0.50	1.53
3	43.51	21.96	0.47	1.70
After				
1	8.51	37.32	0.61	1.96
2B	43.19	17.82	0.44	1.57
3	19.73	34.64	0.61	1.66

* Regression analysis of maximum noise level, $L_{A,max}$ dB(A) and the logarithm of vehicle speed, V km/h, takes the form :

$$L_{A,max} = a + b \log_{10} V \text{ dB(A)}$$

where	constant	=	the constant term a
	slope	=	the slope of the regression line b
	correlation	=	the square of the correlation coefficient, r
and	standard deviation	=	residual standard deviation

TABLE B.2

Regression analysis of vehicle noise and speed for heavy vehicles

Site	Constant (a)	Regression analysis statistics Slope (b)	Correlation (r^2)	Standard deviation dB(A)
Before				
1	46.67	19.12	0.33	2.11
2A	43.51	21.96	0.19	2.19
3	90.61	-3.54	0.01	3.02
After				
1	30.00	28.70	0.41	2.08
2B	79.59	-0.08	0.00	1.75
3	89.24	-3.70	0.01	2.48

APPENDIX C

(6), card 1

Questionnaire number ☐ ☐ ☐ ☐ (7-10)

Date ☐☐ ☐☐ ☐☐ (11-16)

TRAFFIC CALMING ON MAJOR ROADS THROUGH VILLAGES: QUESTIONNAIRE

Village: **THORNEY (A47T, Cambridgeshire)**

Good morning/afternoon/evening. My name is ______________________ and I work for the Transport Research Laboratory. We are carrying out a survey for the Department of Transport about people's opinions of traffic passing through the village.

	ROUTE
Q.1 How long have you lived in this village?	
WRITE IN: ________ years ________ months	(17-20)
IF NOT RESIDENT IN THE VILLAGE BEFORE 1995 DO NOT CONTINUE WITH THE INTERVIEW	Q.2

	CODE	ROUTE
Q.2 Recently some changes were made on the main road to slow traffic going through through the village. Are you aware of this? **RING CODE NUMBER**	(21)	
Yes	1	Q.3
No	2	Discontinue interview

Q.3 Thinking back before these changes were made, did the main road through the village and its traffic cause any problem in the village?
PROBE FULLY AND WRITE IN BELOW

(22-23)

(24-25)

(26-27)

Q.3A So, could I just check to see whether any of the following things were a problem before the changes were made
SHOW CARD 'A' AND READ OUT. RING *YES (1), NO (2) OR DON'T KNOW (9)* FOR EACH

	Yes	No	Don't know
Amount of traffic (28)	1	2	9
Speed of traffic (29)	1	2	9
Number of lorries (30)	1	2	9
Dangerous for motorists (31)	1	2	9
Dangerous for cyclists (32)	1	2	9
Dangerous/difficult for pedestrians to cross the road (33)	1	2	9
Dangerous for pedestrians using the footway (34)	1	2	9
Dangerous for children (35)	1	2	9
Too much noise (36)	1	2	9
Ground vibration (37)	1	2	9
Dust and dirt (38)	1	2	9
Smoke and fumes (39)	1	2	9

ROUTE: Q.4

Q.4 Now I would like to ask you about how the changes have affected things. How satisfied are you overall with the changes that have been made in the village? **SHOW CARD 'B' AND READ OUT**	CODE (40)	ROUTE
Very satisfied	1	
Fairly satisfied	2	
No opinion either way	3	
Fairly dissatisfied	4	
Very dissatisfied	5	
Don't know	9	Q.5

Q.5 Can you tell me, for the following groups of people, whether the changes have been a good thing, a bad thing, or have had no effect? **SHOW CARD 'C1'**

READ OUT ITEMS BELOW AND SHOW CARD 'C2'

	Very good	Quite good	No effect	Quite bad	Very bad	Don't know
Pedestrians (41)	1	2	3	4	5	9
Drivers (42)	1	2	3	4	5	9
Schoolchildren (43)	1	2	3	4	5	9
Cyclists (44)	1	2	3	4	5	9
Old people (45)	1	2	3	4	5	9
Shopkeepers (46)	1	2	3	4	5	9
Residents on the main road (47)	1	2	3	4	5	9

ROUTE: Q.6

Q.6 How useful do you consider each of the changes that have been made in the village?
SHOW CARD 'D' AND PHOTOS

ITEM NUMBER		Very useful	Fairly useful	Of little use	Causes concern	Don't know/ no opinion
(1)	Large blue & yellow signs just outside 30mph speed limit (48)	1	2	3	4	9
(2)	Slight road narrowing at 30mph speed limit signs (49)	1	2	3	4	9
(3)	Different road surface at 30mph speed limit signs (50)	1	2	3	4	9
(4)	Chicanes a short distance inside speed limit (51)	1	2	3	4	9
(5)	Part-time 20mph speed limit past school (52)	1	2	3	4	9
(6)	Zebra crossing within slight narrowing of the road (53)	1	2	3	4	9
(7)	Different road surface either side of the zebra crossing (54)	1	2	3	4	9
(8)	Mini-roundabout at the junction with Sandpit Lane (55)	1	2	3	4	9
(9)	Speed cameras (56)	1	2	3	4	9
(10)	Main road narrowing at the junction with Gas Lane (57)	1	2	3	4	9
(11)	Pedestrian island at western (Peterborough) end of village (58)	1	2	3	4	9

ROUTE:

For each item ringed '4' in Q.6, ask Q.6A
If none, go to Q.7

Q.6A What is your particular concern about the.....?
READ OUT FIRST ITEM RINGED '4' IN Q.6 AND WRITE IN ITEM NUMBER IN BOX PROVIDED
PROBE FULLY AND WRITE IN ANSWER
REPEAT FOR ALL ITEMS RINGED '4' IN Q.6, REMEMBERING TO ENTER THE ITEM NUMBER EACH TIME

ENTER ITEM NUMBER

☐ (59) (60) (61)

(62) (63)

☐ (64) (65) (66)

(67) (68)

☐ (69) (70) (71)

(72) (73)

☐ (74) (75) (76)

(77) (78)

☐ (11) CARD 2

(12) (13)

(14) (15)

☐ (16)

(17) (18)

(19) (20)

☐ (21) (22) (23)

(24) (25)

CONTINUED ON NEXT PAGE

Q.6A (CONTINUED FROM PREVIOUS PAGE)

ENTER ITEM NUMBER

☐ (26) (27) (28)

(29) (30)

☐ (31) (32) (33)

(34) (35)

☐ (36) (37) (38)

(39) (40)

☐ (41) (42) (43)

(44) (45)

Q.7 Now I am going to read out some things people have said about the changes. For each one please tell me whether you agree a little, agree a lot, disagree a little, or disagree a lot. **SHOW CARD 'E1'**

READ OUT ITEMS BELOW AND SHOW CARD 'E2'

	Agree a lot	Agree a little	No opinion	Disagree a little	Disagree a lot	D/K
The changes were necessary (46)	1	2	3	4	5	9
They make it safer/easier to cross the road (47)	1	2	3	4	5	9
They make it safer to walk on the footway (48)	1	2	3	4	5	9
They make it safer for motorists (49)	1	2	3	4	5	9
They make it safer for cyclists (50)	1	2	3	4	5	9
They have reduced speeds (51)	1	2	3	4	5	9
They have reduced speeds enough (52)	1	2	3	4	5	9
They are frustrating for drivers (53)	1	2	3	4	5	9
They should be introduced in other villages (54)	1	2	3	4	5	9
They have increased noise (55)	1	2	3	4	5	9
House shakes when a lorry goes by (56)	1	2	3	4	5	9
They have increased traffic fumes (57)	1	2	3	4	5	9
A bypass would have been better (58)	1	2	3	4	5	9
Other changes would have been better (59)	1	2	3	4	5	9

(FOR LAST ITEM) If you agree, what changes would you suggest? **WRITE IN BELOW** (60) (61)

(62) (63)

ROUTE: Q.8

Q.8 Do you have any concerns about the look of the scheme?	CODE (64)	ROUTE
Yes	1	Q.8A
No	2	Q.9

Q.8A If so, what? **PROBE FULLY AND WRITE IN BELOW**

(65) (66)

(67) (68)

(69) (70)

Q.9

Q.9 Did you hear about the changes before they occurred?	CODE (71)	ROUTE
Yes	1	Q.9A
No	2	Q.10

Q.9A If yes, how?
READ OUT ITEMS BELOW AND SHOW CARD 'F', PLEASE RING ALL THAT APPLY

	(72)	
From friends/relatives	1	
Local papers	2	
Local TV news	3	
Local radio news	4	
Public meetings	5	
Visit from the Council	6	
Leaflets	7	
Public notices in the street	8	
Other **(WRITE IN BELOW)**	9	
	(73) (74)	Q.10

Q.10 Did the council or Department of Transport ask people, eg on a leaflet or in a public meeting, what they thought about the plans?	CODE (75)	ROUTE
Yes	1	Q.10A
No	2	Q.12
Don't know	9	Q.12
Q.10A If so, when did they do it?	(76)	
READ OUT: Before the changes	1	
After the changes	2	
Both	3	Q.11

Q.11 How satisfied were you with the consultation? Were you:	CODE (77)	ROUTE
READ OUT: Very satisfied	1	
Fairly satisfied	2	
No opinion either way	3	
Fairly dissatisfied	4	
Very dissatisfied	5	Q.12

CLASSIFICATION

Q.12

	CODE (78)		CODE CARD 3 (11)
(i) Sex **(BY OBSERVATION)**		(iv) Do you have any children under 16?	
Male	1	Yes	1
Female	2	No	2
(ii) What was your age last birthday?	(79)	(v) Do you do any of the following? **(RING ALL THAT APPLY)**	(12)
Under 25	1	Drive a car	1
25-39	2	Drive a van	2
40-59	3	Drive a lorry	3
60 +	4	Ride a motorcycle	4
		Ride a pedal cycle	5
		None of these	6
(iii) Live on or off the main road? **(BY OBSERVATION)**	(80)		
On main road	1		
Elsewhere	2		

THANK YOU VERY MUCH FOR YOUR HELP

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