Countryside Traffic Measures Group: A traffic calming scheme at Charlwood, Surrey

Prepared for Charging and Local Transport Division,

Department for Transport, Local Government and the Regions

A H Wheeler, J V Kennedy, G Harris, R E Stait, G J Davies and J M Green

TRL Report 501

First Published 2001
ISSN 0968-4107

This report has been produced by TRL Limited, under/as part of a Contract placed by the Department for Transport, Local Government and the Regions. Any views expressed are not necessarily those of the Department.

TRL is committed to optimising energy efficiency, reducing waste and promoting recycling and re-use. In support of these environmental goals, this report has been printed on recycled paper, comprising 100% post-consumer waste, manufactured using a TCF (totally chlorine free) process.

CONTENTS

Page

Executive Summary

Introduction

The Countryside Traffic Measures Group (CTMG) was set up in 1997 by the Countryside Agency and the Department for Transport, Local Government and the Regions (DTLR) to support the planning and implementation by local authorities of innovative rural traffic management schemes. Under this initiative, local authorities were invited to propose schemes forming part of their traffic and transport strategies, which were designed to integrate sensitively into the local environment. The DTLR's Charging and Local Transport Division commissioned TRL to monitor the effectiveness of a selection of schemes being progressed within the CTMG initiative. The chosen schemes were located in Surrey, Norfolk, Suffolk, Hampshire, Devon and Cumbria but for various reasons, those in Hampshire, Devon and Cumbria were not pursued. This report describes the monitoring of a traffic calming scheme in Surrey at the village of Charlwood, which lies just to the north west of London Gatwick Airport.

The scheme

The scheme is an element of the Dorking Rural Box scheme, which forms part of Surrey County Council's Strategic Traffic Area Reduction (STAR) initiative. The Dorking Rural Box is bounded by the A24, A25, A217 and A264 and suffers from London commuter traffic, and traffic to and from Gatwick Airport. The proposal was to reduce through traffic, encouraging it to use the peripheral main roads, and thereby improve conditions for non-motorised road users such as walkers, cyclists and horse riders. This would be achieved by introducing an area-wide 40 miles/h speed limit with perimeter gateways; there would be 30 miles/h limits on village approaches and 20 miles/h limits with traffic calming measures in village centres. Following the introduction of the area-wide speed limit, Charlwood was the first village to be traffic-calmed, in November 1999.

The measures initially proposed in Charlwood were 30 miles/h gateways and a 20 miles/h speed limit with narrowings and speed tables through the village centre. Following public consultation, the speed tables were rejected in favour of granite setts (or a similar surface treatment) and widened footways throughout the 20 miles/h speed limit. In the event, grey imprinted surfacing simulating stone setts was used as it would be easier to install. Shortage of funding led to the village centre measures being cut back, with the imprinted surfacing installed over a shorter distance. The existing 30 miles/h limit was retained and the 20 miles/h speed limit was not implemented. Completion of the scheme was postponed, and as it was uncertain whether this would be within the timescale of the TRL project, monitoring of the reduced scheme went ahead.

The scheme as implemented in November 1999 was as follows. The gateways comprised *imitation gates, 30 miles/h signing and carriageway roundels. Rumble strips* or *simulated narrowing* (fencing and hatched edge markings) were installed at and/or just inside the gateway. In the village centre, the main features were continuous *grey imprinted surfacing* with *footway widening / carriageway narrowing*, an *informal pedestrian crossing*, comprised of cream imprinted surfacing, and a *change in priority at a junction*. Later additional measures included *patches of grey imprinted surfacing* to highlight two hitherto untreated junctions on the main road through the village, and two further *informal pedestrian crossings.*

Monitoring

Monitoring comprised automatic speed/flow measurements over seven days before and after scheme installation at three of the gateways and within the village. Flows were also measured on a route that could be used to avoid the scheme. Before and After noise and air quality monitoring were conducted, together with a public opinion survey on the scheme as implemented in November 1999. Further speed/flow monitoring within the village was carried out following the completion of the additional measures in November 2000.

Results

Traffic speeds and flows

With the November 1999 measures, the inbound mean speed at the *gateways* dropped by between 3 and 5 miles/h to between 30 and 33 miles/h, and outbound speeds dropped by between 1 and 3 miles/h. The mean speed in the village centre on the *imprinted surfacing* dropped by 5 miles/h to 23 miles/h, although some of this decrease may have been due to the *change in priority at the junction*. The mean speed in the centre of the village away from the imprinted surfacing was little changed at about 32 miles/h. At the junctions treated with *patches of imprinted surfacing* in November 2000, however, this speed was reduced to about 28 miles/h.

There was a 7% decrease in traffic through the centre of the village (from about 6,000 vehicles per day), but no change on a possible diversion route. At the junction where the priority had changed, however, traffic on the former minor arm *increased* by 7%, possibly because it had become easier to turn right from this arm. Following the implementation of the additional measures, village centre traffic increased slightly but was still 4% below the Before levels.

Vehicle noise

Before and After measurements were made alongside the *imprinted surfacing* and a set of *rumble strips*. Despite the reduction in mean speed, the changes in noise level from light vehicles measured at these sites would be imperceptible to residents. The reduction in power train noise (from the engine, engine ancillaries, transmission and exhaust) was possibly offset by an increase in noise generated by the interaction of the tyres and the imprint pattern. The noise from vehicles passing over the *imprinted surfacing* had a noticeable character.

Alongside the *rumble strips*, neither the noise from heavy vehicles nor their speeds changed to any degree. Alongside the *imprinted surfacing*, heavy vehicle noise was reduced by 2.8 dB(A), coinciding with a large reduction in mean speed. However, this speed reduction must be partly attributed to a change in monitoring position for the After survey, resulting from the reduction in the length of surface treatment originally proposed.

Traffic noise

Before and After measurements were made alongside a set of *rumble strips*. The influence of aircraft was removed from the noise record in order to estimate the changes in traffic noise. When the effects of changes in traffic flow and composition were also taken into account, total noise exposure levels were shown not to have increased.

Air quality measurements

From the air quality measurements, there was no evidence to suggest that the scheme had affected local air quality. Concentrations measured before scheme installation were already well below the current Air Quality Standards.

Public opinions

The public opinion survey was carried out on the scheme as implemented in November 1999. It showed that the *imprinted surfacing* was considered to increase safety and to improve the appearance of the village, but was thought to be noisy. There was general agreement that the *footway widening / carriageway narrowing* on the section with the imprinted surfacing was effective in improving safety for those on foot. However, the carriageway narrowing may have been the reason why safety was not thought to have been improved for cyclists. Speeds were not considered to have been reduced enough.

The *change in priority at the junction* and the *informal pedestrian crossing* were considered to improve safety. Opinion was divided on the effectiveness of the *gateways*, *carriageway roundels* and *rumble strips*. The *fencing* was not thought to be effective. Most thought these features did not affect the appearance of the village, but those who disliked them commented that they were out of keeping in a rural village.

Accidents

The After periods were too short to assess the effect of the scheme on safety. The majority of the Before accidents occurred on the eastern approach to the village, on a series of bends.

Conclusions

Overall, the success of the scheme as monitored in meeting CTMG objectives was mixed. Most of the measures were not visually obtrusive, but the imprinted surfacing was noisy. There were reasonable speed reductions at the gateways and on the continuous imprinted surfacing near the village centre, but initially there was little change elsewhere in the village. The two additional patches of imprinted surfacing installed in November 2000 led to a useful speed reduction, with mean speeds there falling just below the 30 miles/h limit.

The slight reduction in traffic through the village may possibly be attributed to the implementation of peripheral gateways into the Dorking Rural Box and the introduction of an area-wide 40 miles/h speed limit within it.

It is possible that the scheme might reduce bend accidents on the eastern approach to the village, as it is likely that these were speed related, with drivers losing control in the majority of cases. Resurfacing might have improved skidding resistance on this section but may encourage higher speeds.

The absence of vertical and horizontal deflections will have limited the speed reductions achieved. The relatively high speeds that still occur at the eastern end of the village suggest that a 20 miles/h limit would not have been appropriate with the current measures.

1 Introduction

In recent years, local authorities have been able to install a wider range of speed reducing measures on main roads as a result of changes to legislation, together with special authorisation procedures. This has led to the implementation of a variety of village traffic calming schemes, many of which have been studied by TRL for the Department for Transport, Local Government and the Regions (DTLR) (Wheeler and Taylor, 1995, 1999, 2000; Wheeler *et al.*, 1993, 1994, 1996, 1997, 1998; Taylor and Wheeler, 2000). A number of schemes, however, have been criticised for their appearance being out of keeping with the rural environment.

In 1997, the Countryside Agency and DTLR, set up the Countryside Traffic Measures Group (CTMG) to support the planning and implementation by local authorities of innovative rural traffic management schemes. Under this initiative, local authorities were invited to propose schemes, forming part of their traffic and transport strategies, which are designed to integrate sensitively into the local environment. The DTLR's Charging and Local Transport Division commissioned TRL to monitor the effectiveness of a selection of schemes being progressed within the CTMG initiative. The schemes are located in Suffolk, Norfolk and Surrey (Kennedy and Wheeler, 2001; Wheeler *et al.*, 2001). (Schemes in Cumbria, Devon and Hampshire were originally included but were not pursued.)

The aim of the study was to investigate the extent to which schemes can be effective in meeting their traffic, transport and safety objectives whilst being designed with sensitivity to the countryside environment in which they are set. The results will be used to provide the basis for the development of technical advice suitable for widespread application.

The monitoring of a village traffic calming scheme at Charlwood in Surrey, is the subject of this report. The features of the area-wide CTMG initiative in Surrey are briefly summarised in Section 2, whilst Section 3 describes the Charlwood scheme. Before and After surveys were undertaken of vehicle speeds and flows (Section 4), vehicle and traffic noise (Section 5) and air quality (Section 6). A public opinion survey of residents' views is described in Section 7, whilst Section 8 gives the accident history. Overall results are summarised in Section 9.

2 The CTMG initiative in Surrey

2.1 The context of the Charlwood scheme

Charlwood lies within an area designated by Surrey County Council for the implementation of traffic management measures to improve environmental quality and safety for residents and those who wish to visit the area. Known as the Dorking Rural Box (DRB), shown in Figure 1, the area lies to the south east of the town and was suffering from rat-running commuter traffic to and from London and traffic generated by London Gatwick Airport. The DRB (later extended into West Sussex) is bounded by the A24, A25, A217 and A264, and forms part of Surrey County Council's Strategic Traffic Area Reduction (STAR) initiative; it was also proposed by the County Council as a demonstration project for the CTMG initiative.

The aim of the DRB was to reduce commuter and other through traffic within what was regarded as an inappropriate area and to encourage it to use the major roads surrounding the area instead. Another aim was to encourage those who wish to access the area to do so by other modes such as walking, cycling and horse riding. It was anticipated that additional facilities be provided for pedestrians, cyclists and horse riders to create a safer and more attractive environment for them. This would be achieved by reducing speeds, encouraging use of the Primary Route Network by through traffic and inhibiting future traffic growth in the area.

The main elements of the DRB were the introduction of:

- An area-wide 40 miles/h speed limit.
- Perimeter gateways into the DRB to discourage through traffic.
- Road narrowing to increase space for pedestrians, cyclists and horse riders.
- 30 miles/h speed limits on village approaches via gateway features.
- 20 miles/h speed limits in village centres supported by traffic calming measures.

By 1998, the 40 and 30 miles/h speed limits and gateways had been introduced and public consultation about the traffic calming proposals completed. Residents had requested traffic calming because of the adverse traffic conditions in the area, but they did not want this to be at the expense of the rural qualities of the areas to be treated. Charlwood was the first village to be traffic calmed, and measures were implemented in November 1999.

2.2 The village and its characteristics

Charlwood lies just to the north west of London Gatwick Airport and is one of several villages within the DRB (Figure 1). The layout of the village is shown in Figure 2. Prior to scheme installation, the main road through the village (The Street/Horley Road) carried over 6,000 vehicles per day, with 4,500 on Norwood Hill Road and 2,000 on Russ Hill/Rectory Lane. The speed limit was 30 miles/h within the built-up area and 40 miles/h outside as indicated in Section 2.1. Several distributor roads converge on the village:

- Horley Road (a continuation of The Street and linking with the A23/A217).
- Lowfield Heath Road (linking with business areas near the airport and Crawley).
- Ifield Road (linking with the Crawley area).
- Russ Hill/Rectory Lane/Norwood Hill Road linking with other parts of the DRB.

Off-airport long-term car parks can be accessed along Horley Road and Lowfield Heath Road.

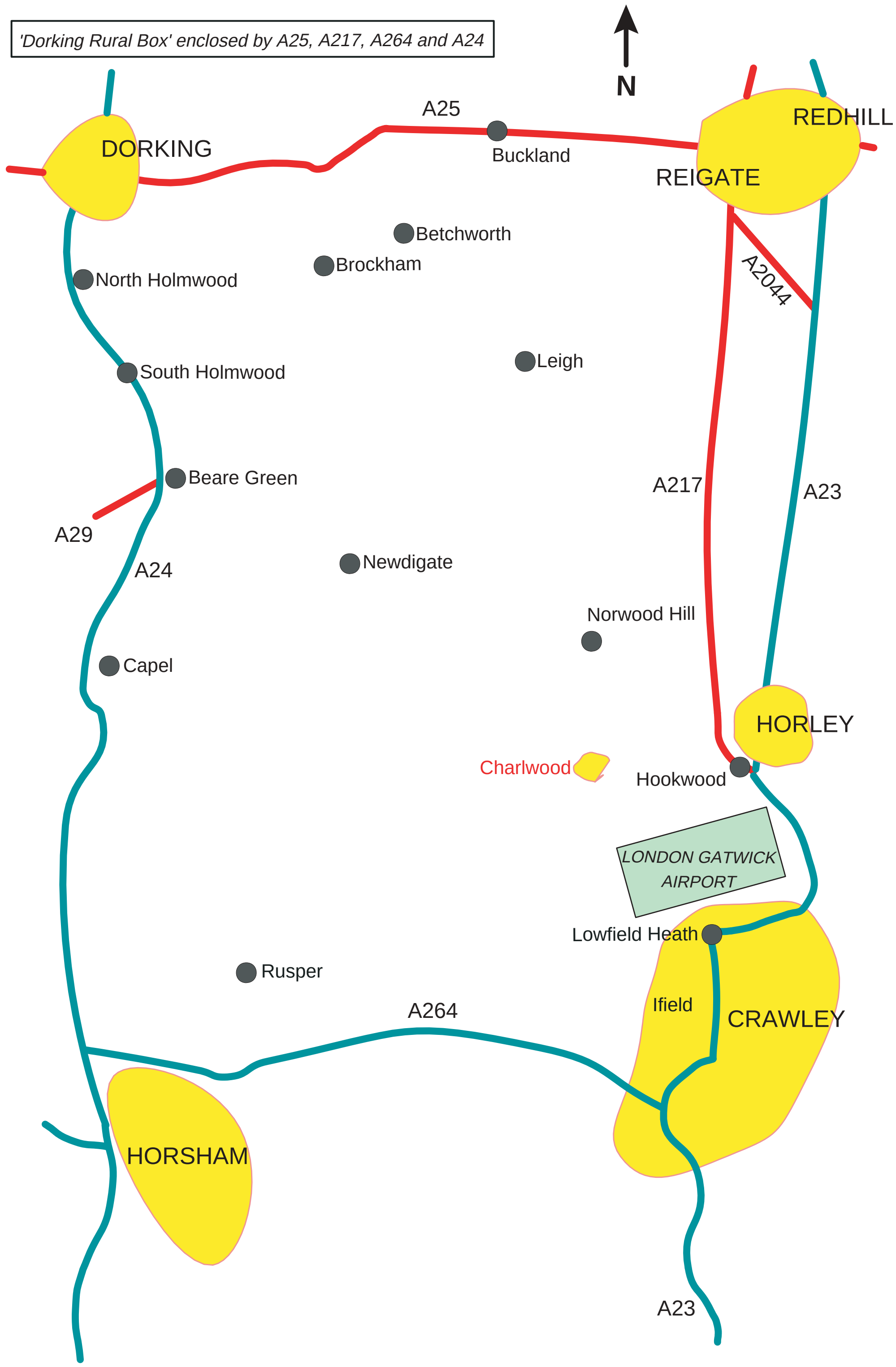


Figure 1 Location plan for Charlwood showing 'Dorking Rural Box' (Not all roads shown)

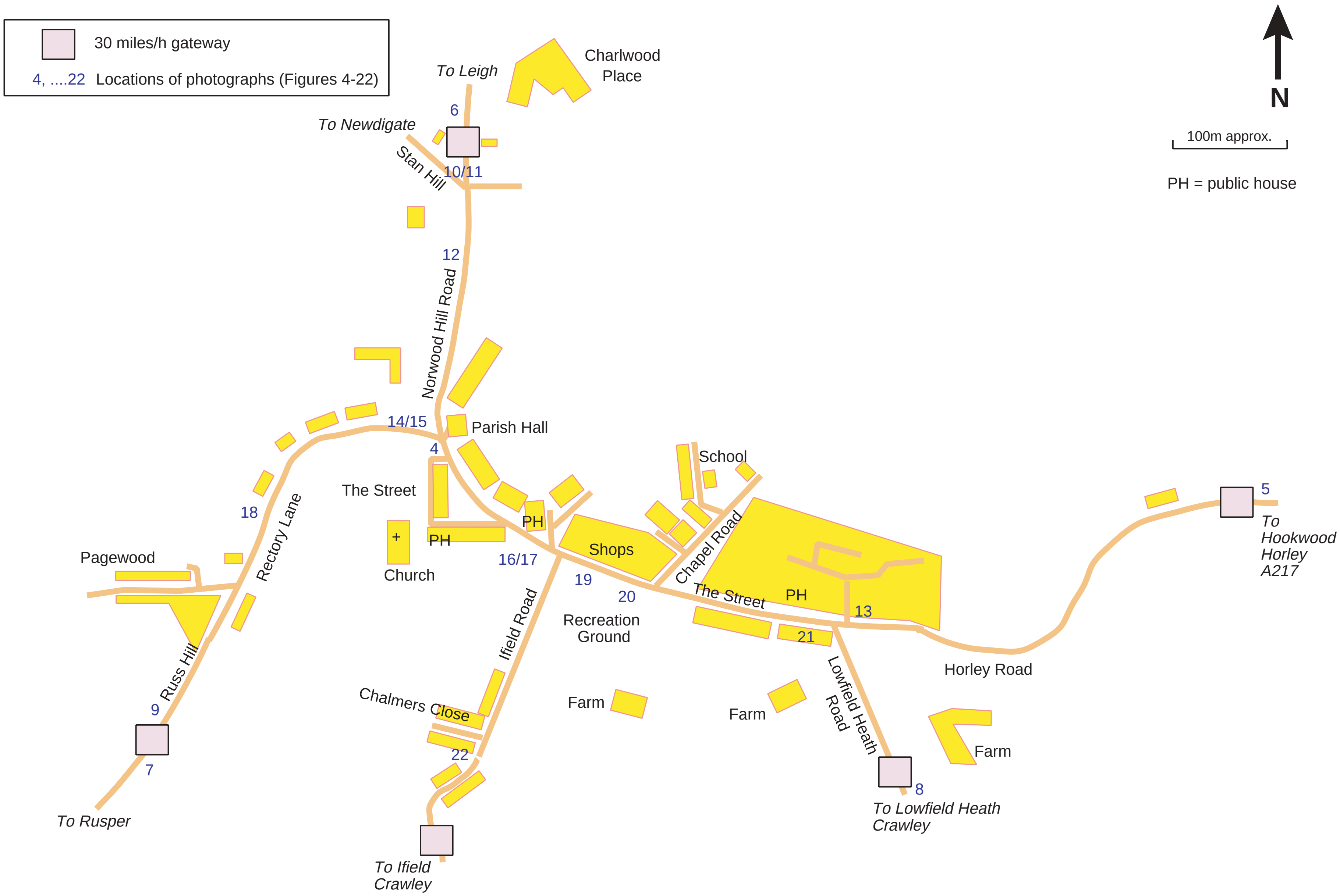


Figure 2 Village layout (simplified)

Footways are provided throughout except along Rectory Lane/Russ Hill, Ifield Road and Lowfield Heath Road further away from the village centre. The gateways where speed/flow monitoring was carried out lie on fairly straight to gently curved alignments, and the carriageway in the village centre is straight except at the western end. Before scheme installation, the carriageway width was generally 6m (5m on Russ Hill). There are a few shops and a pub near the junction with Ifield Road with a parking bay for several vehicles, and a number of small retail outlets, pubs and other businesses elsewhere. Residential frontages are mostly set back behind hedges and there are a number of junctions with residential roads and driveways. There is a recreation ground bordering The Street and Ifield Road. The Parish Hall is adjacent to the Norwood Hill/Rectory Lane/The Street junction.

3 The traffic calming measures

3.1 The scheme as monitored

An outline plan of the scheme, which was designed by Surrey County Council, is shown in Figure 3. The initial proposals included 30 miles/h gateways and rumble strips on the outer approaches and a 20 miles/h speed limit through the centre of the village, where narrowings and speed tables would be installed. Following public consultation, the speed tables were rejected in favour of an alternative proposal featuring granite setts (or similar) and widened footways throughout the 20 miles/h limit. This limit would extend between the junctions The Street/Lowfield Heath Road and The Street/Norwood Hill Road/Rectory Lane, and would be entered via carriageway narrowing at the former and changed priority at the latter. Subsequently, grey imprinted surfacing with a stone sett pattern was substituted for the granite setts as it would be easier to install with less disruption from road closures. However, only part of the funding for this scheme could be secured for the 1999-2000 financial year and this resulted in reducing the length of imprinted surfacing to between the Rectory Lane/Norwood Hill Road and the Ifield Road junctions only. This would be extended to Lowfield Heath Road at a later date. The existing 30 miles/h speed limit was retained and the 20 miles/h limit was not implemented.

The imprinted surfacing is pictured in Figure 4. The footways were widened and resurfaced along this section with new granite kerbing, narrowing the carriageway by 0.5m to 5.5m.

All of the other proposed measures were installed with slight modifications. After monitoring of the scheme in its reduced form went ahead as planned, to stay within the timescale of the CTMG project.

The scheme as implemented in November 1999 comprised:

- Grey imprinted surfacing in village centre:
  - footway widening;
  - carriageway narrowing with parking bay.
- Gateway features on five main approaches (the 30 miles/h speed limit was extended on Norwood Hill Road and Horley Road):
  - imitation gate structure with village sign (one or both sides of road);
  - 30 miles/h sign;
  - 30 miles/h roundel;
  - rumble strips at and just inside gateway (Horley Road);
  - rumble strips just inside gateway (Norwood Hill Road).
- Fencing to give channelling effect (three approaches).
- Carriageway narrowing (Horley Road).
- Change in priority at junction in village centre:
  - footway widening;
  - reflective posts.
- Informal pedestrian crossing:
  - cream coloured surfacing;
  - dropped kerbs;
  - build-outs;
  - reflective posts.
- Other minor measures:
  - Additional 30 miles/h roundel (Horley Road);
  - New kerbing.

The village nameplates were mounted on white gate-like structures on each side of the carriageway on Horley and Norwood Hill Roads (Figures 5 and 6), and on one side elsewhere (Figures 7 and 8). Rumble strips were installed immediately beyond the 30 miles/h carriageway roundel at the Horley Road gateway, comprising three bands of beige imprinted material with a similar pattern to that in the village centre. A further set was placed about 50m inside the gateway but was soon removed (prior to After monitoring) because excess noise was generated (they were close to properties and were more severe than existing devices). Hatched edge markings and white fencing were installed about 100m inside the Russ Hill gateway (Figure 9).

Further rumble strips of imprinted material were installed nearer the village on Horley Road and more extensively on Norwood Hill Road, where frontages were absent. The upstand of these strips was 15mm (in the centre of each strip) north of the junction of Norwood Hill Road with Stan Hill and 7mm to the south. Fencing was installed on Norwood Hill Road on both sides of the carriageway (with additional short lengths on Horley Road); its aim was to impart a less open aspect to drivers in order to help reduce speeds. The rumble strips and the fencing are pictured in Figures 10-13. Horley Road was also reduced in width to 5.5m (Figure 13) by widening the verge on the opposite side to the footway (which was refurbished), and was also intended to help reduce speeds.

Measures at the Norwood Hill Road/Rectory Lane/The Street junction are pictured in Figures 14 and 15. Priority was changed from the Norwood Hill Road - The Street axis (used by the main traffic flow) to the Rectory Lane - The Street axis. The kerb on the corner of Norwood Hill

Road and The Street was realigned forming a right-angled left turn for traffic entering the village on Norwood Hill Road. These measures were introduced to reduce speeds on The Street beyond the junction, and make it safer for those using the Parish Hall car park, the entrance of which is almost on the junction. Timber reflector posts were installed opposite the Parish Hall.

The informal pedestrian crossing (near the shops in the village centre shown in Figure 16 before scheme installation) was defined by overlaid cream coloured imprinted surfacing between dropped kerbs built out on one side, with timber reflector posts (Figure 17).

Additional kerbing was installed in Rectory Lane, to widen an existing narrow stretch of footway, in turn reducing the carriageway width in order to reduce speeds (Figure 18).

3.2 Additional measures installed post-monitoring

During September-November 2000 further works to complete the scheme (modified from the original proposals) were carried out. The measures installed comprise:

- Grey imprinted surfacing at the junctions of The Street with Ifield Road (Figure 19), Chapel Road (Figure 20) and Lowfield Heath Road (Figure 21), to highlight these junctions and reduce speeds at these points, together with a length on Ifield Road on the final straight approaching The Street.
- Two additional informal pedestrian crossings, one outside the shops (Figure 19) and the other near the junction with Chapel Road (Figure 20).
- Widened footway with new verge and carriageway narrowing alongside the imprinted surfacing at the Chapel Road junction (Figure 20).
- Buff surfacing at the junction of Ifield Road and Chalmers Close (Figure 22).
- Modifications to the rumble strips on Norwood Hill Road.

The stretches of imprinted surfacing are 40-50m long, the stretch at the Ifield Road junction being an extension of the existing imprinted surfacing. The informal pedestrian crossings adjoin these stretches just east of Ifield Road and west of Chapel Road. An existing parking bay opposite Ifield Road has also been surfaced with imprinted material. The imprinted surfacing on Ifield Road is close to the pedestrian entrance into the recreation ground. The maximum upstand of the rumble strips on Norwood Hill Road has been reduced from 15mm to 7mm north of the junction with Stan Hill and increased from 7mm to 15mm to the south of this junction, a reversal of the situation hitherto.

The cost of the scheme over the two years was £277,000.

4 Traffic flows and speeds

Monitoring of the scheme's effectiveness at reducing speed was carried out through Before and After measurements.

4.1 Data collection

Traffic flows and speeds were recorded before and after scheme installation at seven locations (S1 to S7 in Figure 23):

- Inside the gateways:
  - on Norwood Hill Road, Russ Hill and Horley Road (sites S1, S2 and S6).
- Within the village:
  - between the junctions of The Street with Norwood Hill Road/Rectory Lane and with Ifield Road (S3);
  - between the junctions of The Street with Ifield Road and with Lowfield Heath Road - also site of vehicle composition count (S4);
  - on Horley Road just east of Lowfield Heath Road (S5);
  - Hookwood-Leigh road - flow only (S7); possible diversion route.

The data were collected using automatic traffic classifiers (ATCs) connected to tube detectors over a one-week period during November/December 1998 (Before) and during the same period in 1999 (After), about one month after scheme implementation. In December 2000, further data (After 2) were collected at the sites where speeds were most likely to be affected (S4 and S5) following the installation of the additional measures described in Section 3.2. Mean traffic flows, mean speeds and 85th percentile speeds over the seven days were calculated.

4.2 Results

4.2.1 Traffic flows

Before two-way flows averaged 6,300 vehicles per day (24 hours) on The Street/Horley Road, about 4,500 on Norwood Hill Road and 2,000 on Russ Hill/Rectory Lane (Figure 24). After flows were 6-8% lower except on Russ Hill/Rectory Lane where it was 7% higher. On The Street (site S4), heavy goods vehicles made up 7% of the traffic before scheme installation and 6% after. On the Hookwood-Leigh road (site S7) no transfer of traffic from the scheme was detected.

After 2 flows at sites S4/5 were up slightly on the earlier After flows but were still 4% below Before flows.

4.2.2 Speeds

Mean speeds (Figure 25)

At the gateways, inbound speeds fell from 35 to 30 miles/h on Norwood Hill Road (S1), 36 to 33 miles/h on Russ Hill (S2) and from 35 to 31.5 miles/h on Horley Road (S6). Outbound speeds fell by 1-3 miles/h.

In the village, two-way mean speeds fell from 28 to 23 miles/h on the imprinted surfacing (S3). On the untreated section, there was a decrease from 32 to 30 miles/h at S5 but no change (from 32 miles/h) at S4. Part of the reduction at S3 was probably due to the change in priorities at the junction with Rectory Lane/Norwood Hill Road.

The additional measures yielded a further reduction to 29 miles/h at S5, eastbound drivers (having encountered the measures) contributing most to this change. At S4, the previously unchanged mean speed was now reduced by 4 miles/h to 28 miles/h.

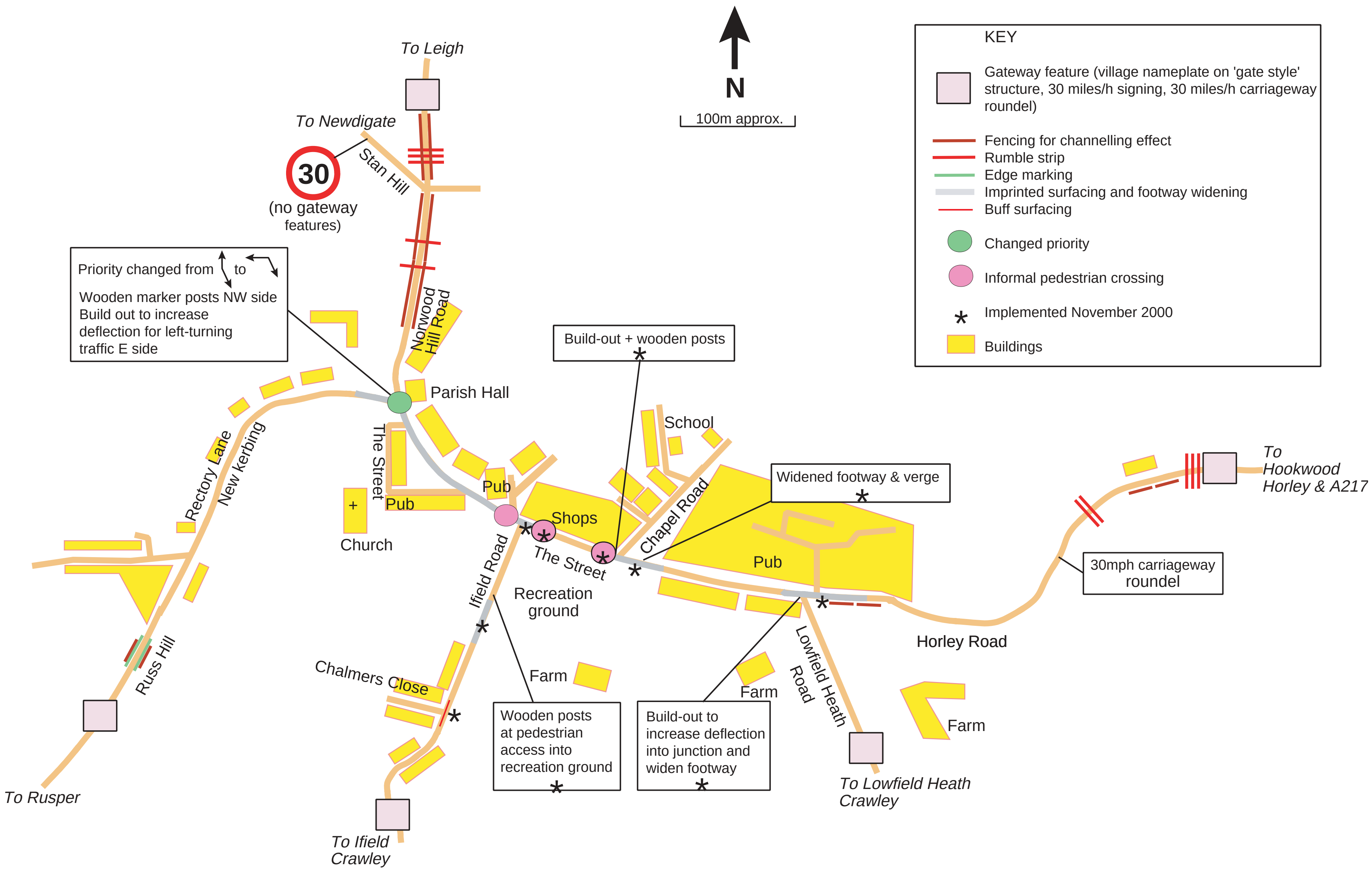


Figure 3 Outline plan of scheme
(Noise / air quality monitoring and public opinion survery carried out before implementation of measures asterisked)

Figure 4 The Street – imprinted surfacing looking east


Figure 5 Horley Road, with rumble strips of the imprinted material used within the village


Figure 6 Norwood Hill Road


Figure 7 Russ Hill


Figure 8 Lowood Heath Road


Figure 9 Russ Hill – fencing and hatched edge markings inside the gateway

Figures 5–8 Gateway features

Figure 10 Northwood Hill Road – rumble strips and fencing looking north towards gateway round bend

Figure 11 Northwood Hill Road – rumble strip detail

Figure 12 Norwood Hill Road – looking north from position south of that for Figure 10. The 30 miles/h village speed limit was extended to the position of the gateway round the bend in the distance

Figure 13 Horley Road, looking east – widened footway with granite kerbs replacing concrete; fencing on right. The camera position is at what would have been the eastern end of the 20 miles/h speed limit, but extension of the imprinted surfacing to this point (just east of the Lowfield Heath Road junction) commenced in September 2000

Figure 14 The junction of Norwood Hill Road (left), Rectory Lane (foreground) and The Street (right) – change of priority. The imprinted surfacing and the widened footway are also seen. Village hall on left

Figure 15 As Figure 14 but from Norwood Hill Road, looking towards village centre. The After photograph shows the kerb build-out (left), footway widening and timber reflector posts

Figure 16 The Street – shops, looking east (before scheme installation). The informal pedestrian crossing was installed in the foreground

Figure 17 The Street – informal pedestrian crossing, looking west

Figure 18 Rectory Lane – before and after installation of new kerbs (looking towards village centre)

Figure 19 Imprinted surfacing shown in Figure 17 extended across junction of The Street with Ifield Road, with additional informal pedestrian crossing in foreground (looking west). Shops on the right

Figure 20 Similar treatment to above at the junction of The Street and Chapel Road (looking east). Footway widening and verge (by repositioning kerb) on left

Figure 21 Imprinted surfacing, looking east, at the junction of The Street / Horley Road and Lowfield Heath Road (on right). Widened footway and renewed kerbing on right

Figure 22 Surface treatment on Ifield Road at junctin with Chalmers Close, looking north towards shops on The Street in distance. A stretch of imprinted surfacing was laid between here and The Street

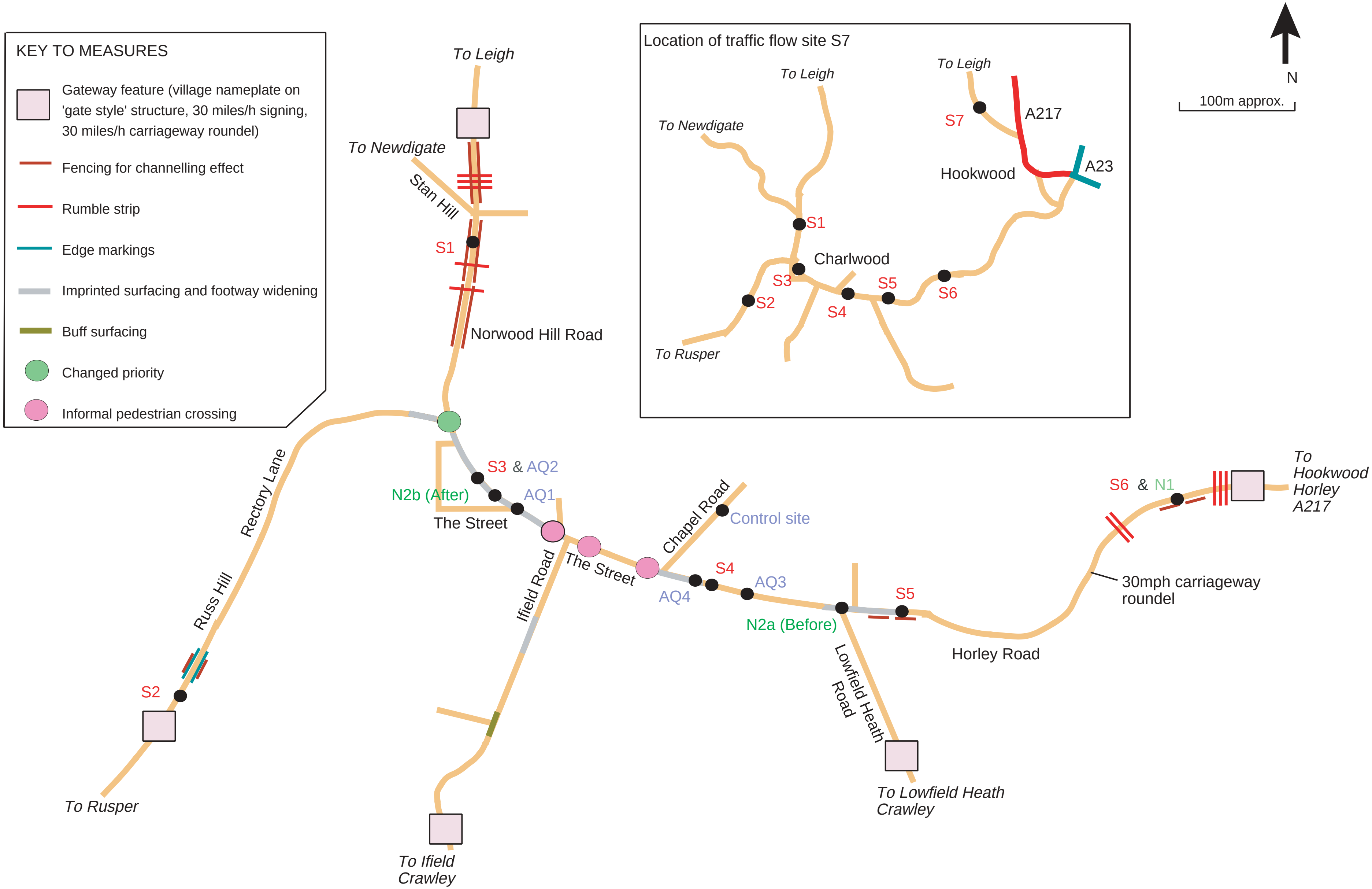


Figure 23 Monitoring positions (S1 = speed/flow, N1 = noise, AQ1 = air quality)

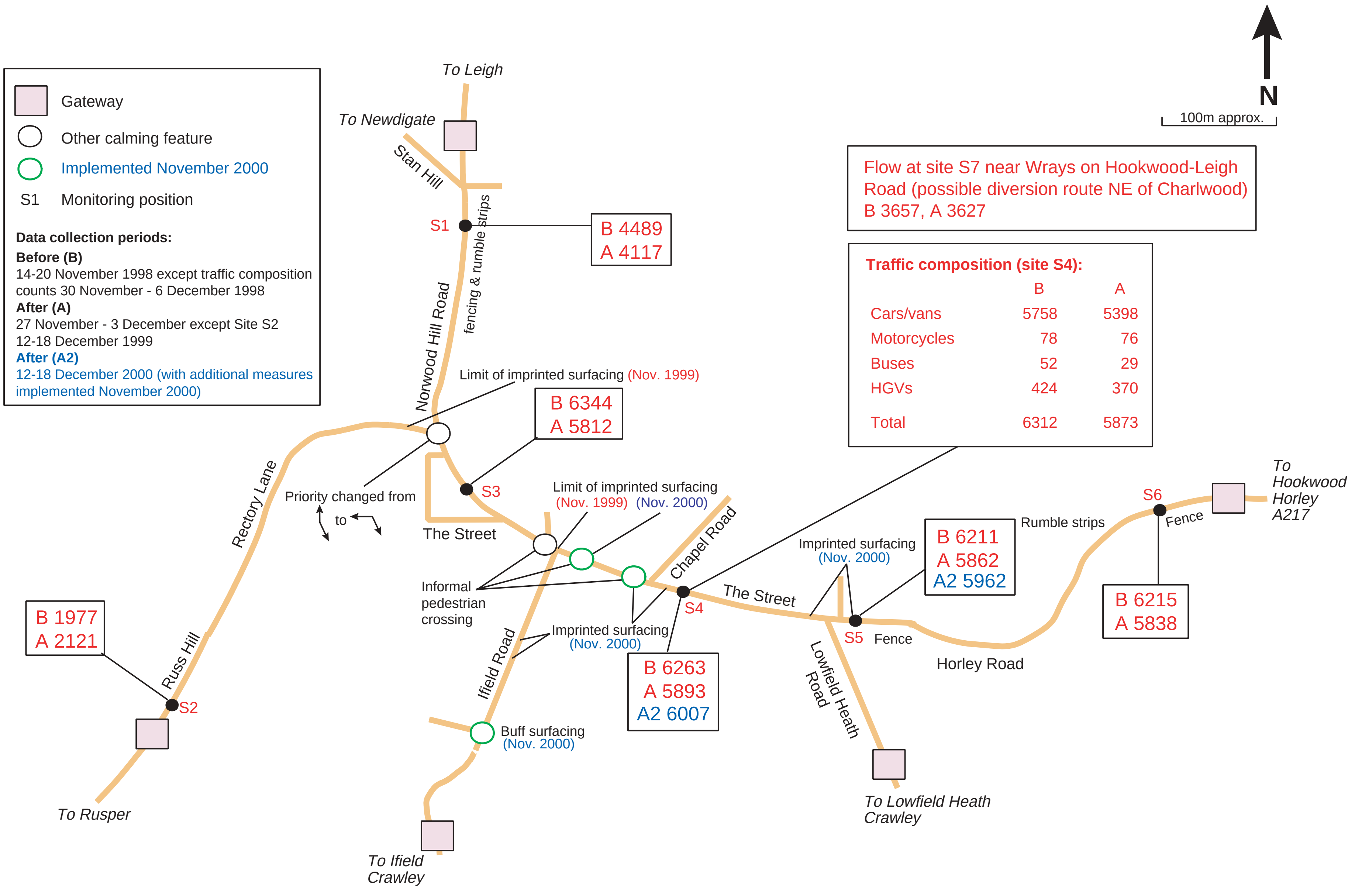


Figure 24 Before and After 24 hour traffic flows: two-way, 7-day mean

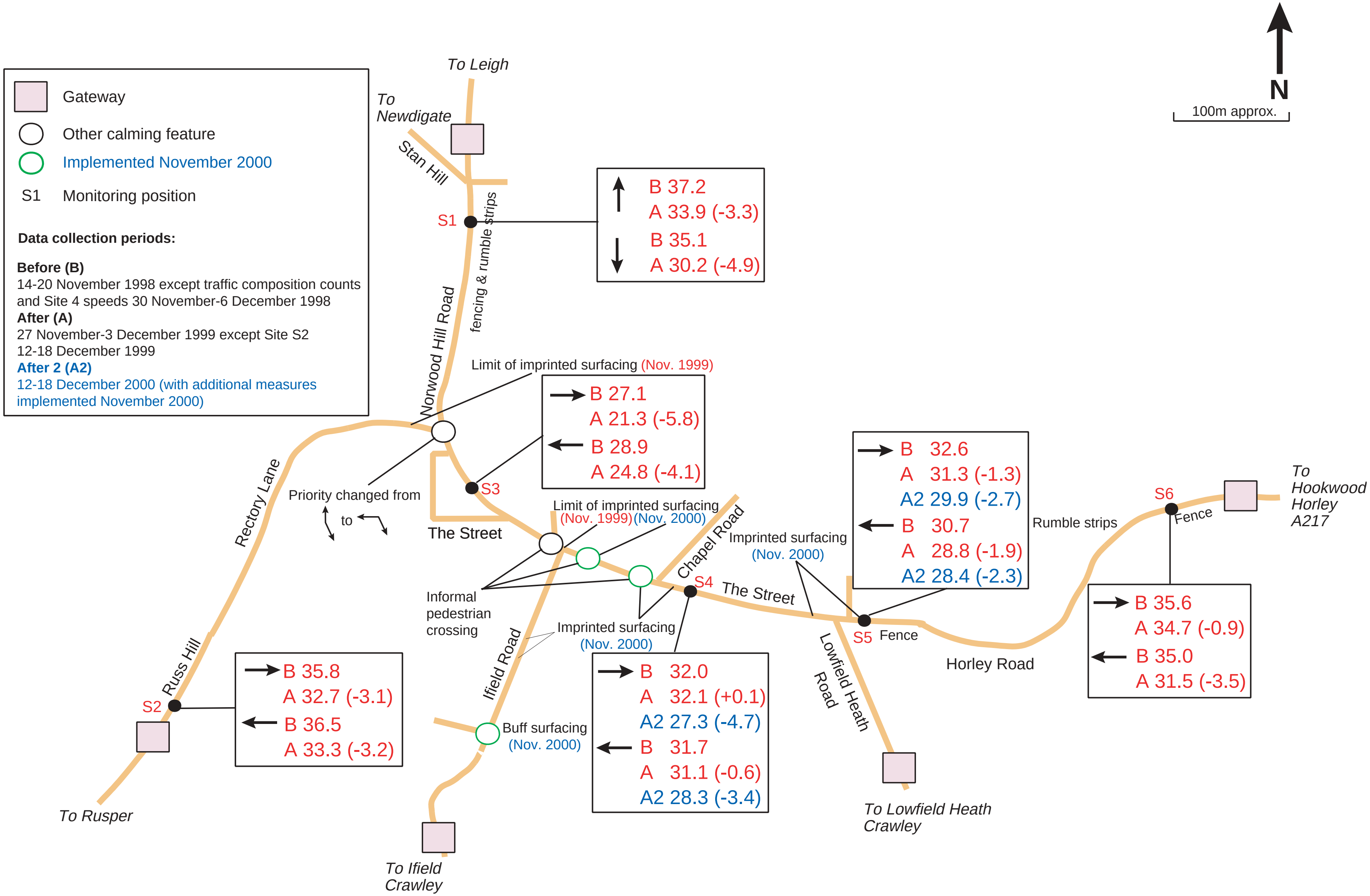


Figure 25 Before and After 7-day mean speeds (miles/h)

85th percentile speeds (Figure 26)

At the gateways, inbound speeds fell from 42 to 36 miles/h on Norwood Hill Road (S1), 42 to 39 miles/h on Russ Hill (S2) and from 40 to 38 miles/h on Horley Road (S6). Outbound speeds were down by 3-4 miles/h at S1 and S2, but were little changed at S6.

In the village, two-way 85th percentile speeds fell from 34 to 29 miles/h on the imprinted surfacing (S3); on the untreated section, speeds were down from 38.5 to 36.5 miles/h at S5, but there was little change from 39 miles/h at S4.

Following the installation of the additional measures, there was a further slight reduction to 35 miles/h at S5 (mostly attributed to eastbound drivers). At S4 the previously little changed 85th percentile speed was now down by 5 miles/h to 34 miles/h.

5 Noise measurements

5.1 Background

Measurements of vehicle noise and overall traffic noise were taken at selected sites at Charlwood before and after scheme installation. It is well established that the level of noise from roads is directly proportional to the volume and speed of the traffic and the proportion of heavy vehicles (Department of Transport and Welsh Office, 1988). It was anticipated that there would be a reduction in mean vehicle speeds resulting from the traffic calming surface treatments which would normally be expected to cause decreases in overall traffic noise levels. However, studies have shown that the presence of some designs of traffic calming surface treatments can cause slight increases in the level of noise or changes to the character of the noise (Sumner and Shippey, 1977; Webster and Layfield, 1993).

The noise from individual vehicles was monitored using the Statistical Pass-By (SPB) method at two positions: alongside the imprinted surfacing in the centre of the village (eastbound vehicles), and alongside the imprinted rumble strips on the eastern approach to the village (westbound vehicles). The SPB method is explained in Appendix A. Overall traffic noise exposure was monitored outside a residential property close to the rumble strips. These surveys were carried out before and after scheme installation. Each survey was conducted over a 48-hour period during the working week. Measurements of traffic noise exposure were also taken at a position chosen when plans to lay imprinted surfacing over the full length of The Street were still current. Because the scheme plans were changed following the Before survey resulting in the surfacing not being laid in this position, no Before and After comparison of traffic noise was possible here.

The assessment of traffic noise was complicated by the noise from aircraft movements at Gatwick airport, its runway being approximately 1.5km south-east of Charlwood. A methodology was developed as part of the study to identify and remove aircraft noise events from the noise record.

5.2 Vehicle and traffic noise surveys

The locations of the noise surveys are indicated in Figure 23 and shown more precisely in Figure 27. Table 1 shows the types of measurements (described below) carried out at the various sites before and after scheme installation. The Before and After surveys were conducted during November 1998 and November 1999 respectively.

Table 1 Data collected before and after scheme installation

	Data collected at each survey (B = Before, A = After)			
	Site N1 Gateway	*Site N2a*	*Site N2b*	*Remote site*
Vehicle noise	B & A	B	A	–
'DAT' recordings (see 5.2.1 below)	A	–	A	–
Traffic noise	A	–	–	B & A

It should be noted that the After SPB measurements alongside the imprinted surfacing were not taken at the same location as the Before measurements. This resulted from the shortening of the originally proposed length of imprinted surfacing which now terminated short of the Before SPB measurement site (shown as site N2a in Figure 27). For the After survey it was therefore necessary to select a different measurement position with equivalent site conditions. The position chosen was to the west of the village centre and is marked as site N2b in Figure 27. Ideally a site closer to site N2a would have been chosen, but no other suitable location could be found that was relatively free of reflecting (façade) surfaces close to either side of the road.

5.2.1 Vehicle noise surveys

As already mentioned, the Statistical Pass-by (SPB) method was used to measure vehicle noise before and after scheme installation. At each site the measurement microphone was located 1.2m above the road surface and 5m from the centre of the nearside lane. The microphone was connected to a noise analyser configured to record the maximum A-weighted sound level L_{Amax} during individual vehicle pass-bys. ('A-weighting' gives the noise measurement instrument a frequency response approximately equivalent to that of the human ear. For many noise assessment purposes the dB(A) scale has been found to correlate well with the subjective perception of noise.)

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. Each selected vehicle was subsequently classified as either 'light' (i.e. all cars and vans with an unladen weight less than 1.5 tonnes) or 'heavy' (goods vehicles with an unladen weight more than 1.5 tonnes). Vehicle speed was measured concurrently using a radar gun. This was positioned to be as unobtrusive as possible, to reduce the likelihood of altering driver behaviour. As each vehicle passed the microphone position, its speed was recorded and vehicle classification noted. Care was taken to ensure that measurements were not taken when aircraft noise could be heard.

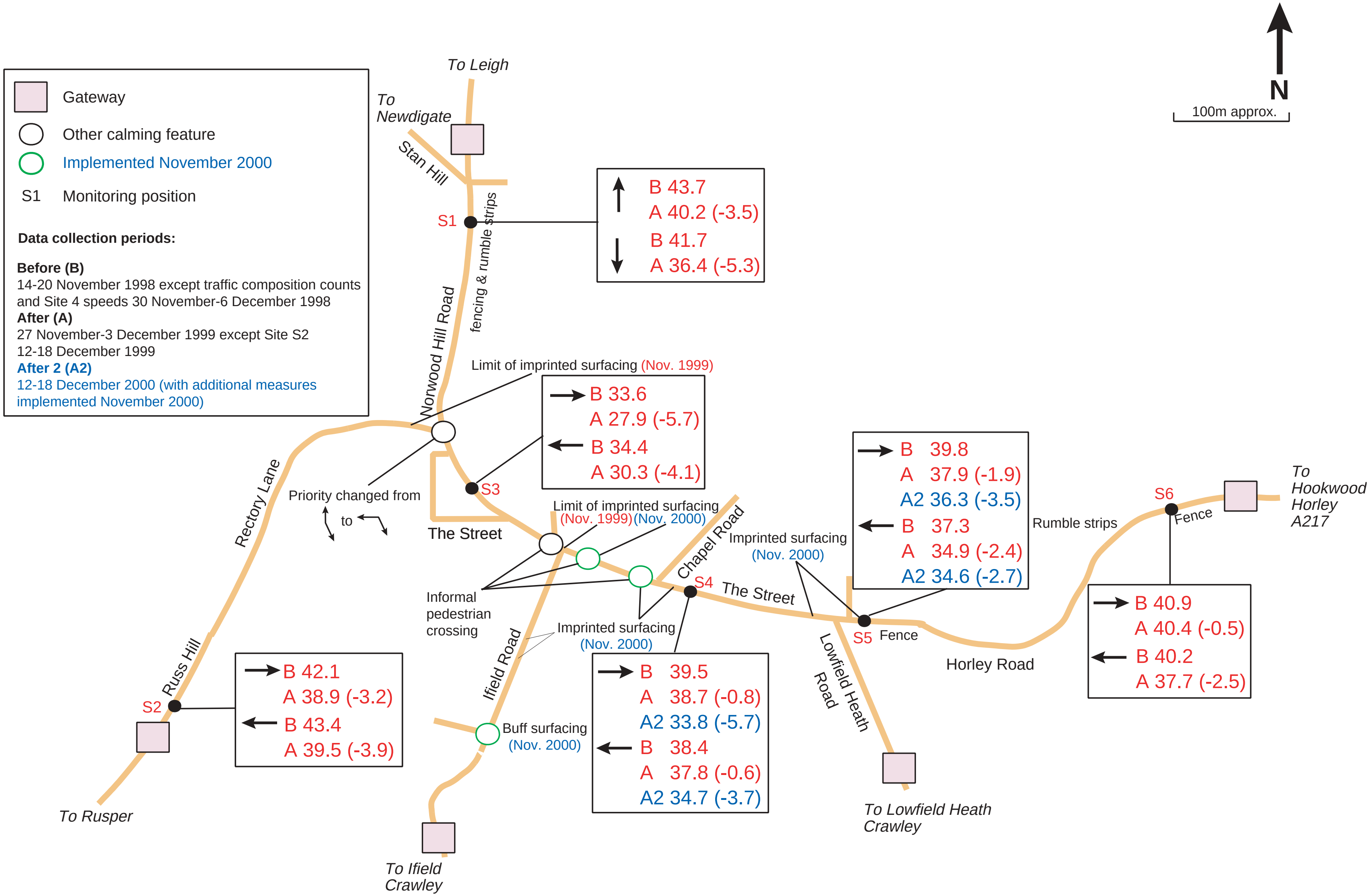


Figure 26 Before and After 7-day 85th percentile speeds (miles/h)

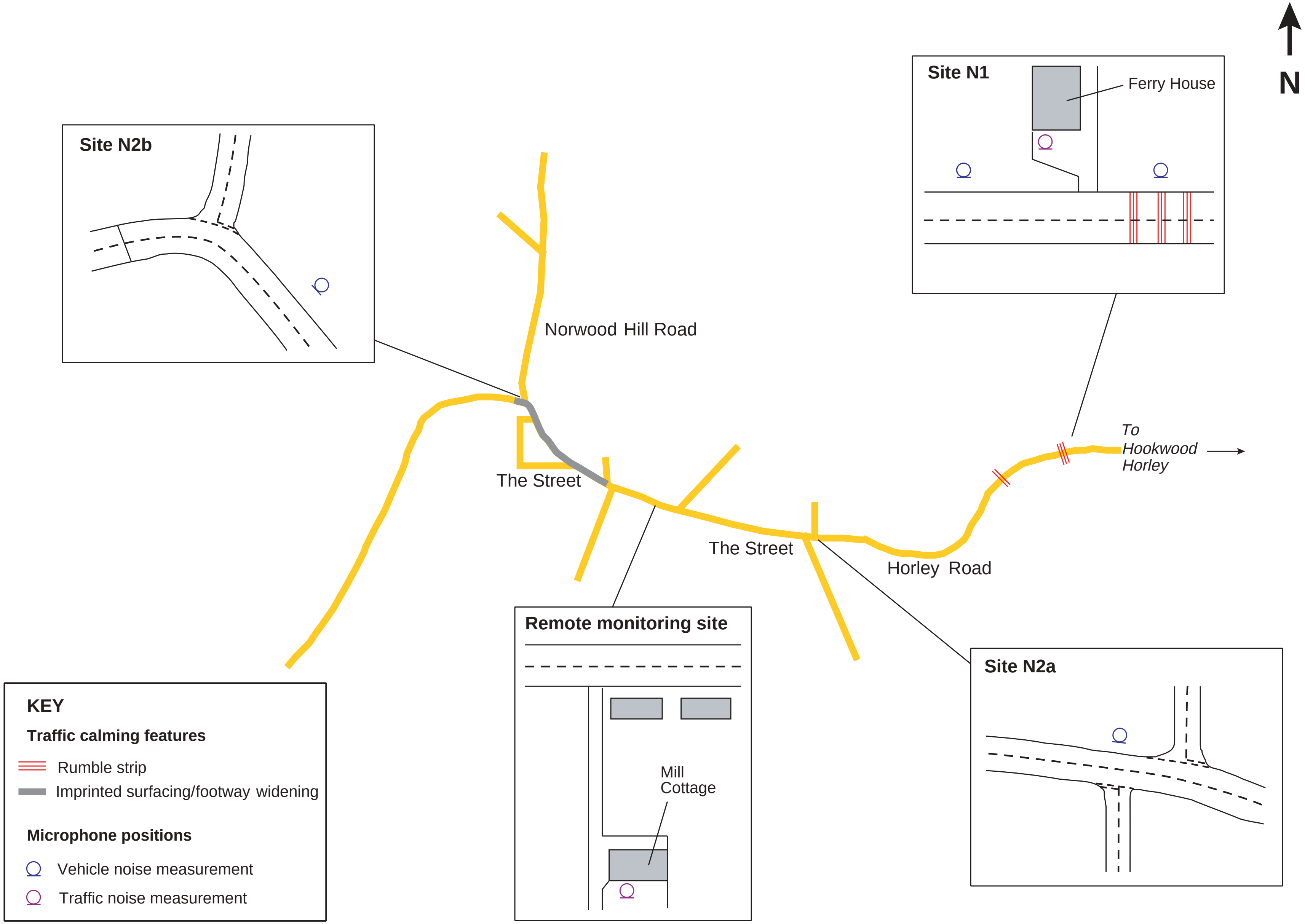


Figure 27 Detail of noise measurement positions

'DAT' recordings

During the After survey, tape recordings of noise from selected heavy vehicles were taken directly alongside the rumble strips at site N1, and alongside a level section of road a short distance before the feature. As for the SPB measurements, the microphones were positioned 5m from the centre of the nearside lane. It was intended that the analysis of the recordings would show any change in the level or character of the noise from individual heavy vehicles as they passed over the features compared to that alongside the level surface. The recordings were taken using high quality digital audio tape (DAT) recorders. It was not possible to carry out these comparative measurements alongside the imprinted surfacing at site N2b because the nearest section of level road was in an unsuitable position.

5.2 2 Traffic noise surveys

Traffic noise measurements were conducted outside a two-storey residential property close to the rumble strips as shown in Figure 27. Noise measurements were taken using an environmental sound level meter. The microphone was positioned 1m from the façade at a height of approximately 4m to minimise any screening effects of low walls or other obstructions. The façade of the property was 16m from the edge of the road. The rumble strips were approximately 20m east of the entrance to the property. It was noted that there was no occurrence of high wind speeds during the surveys, which might have affected the results of the noise measurements.

Influence of aircraft noise

Because of the proximity of Gatwick airport to the village, the local noise climate was considerably affected by arriving and departing aircraft. At peak times it was noted that there could be around 20 aircraft movements in one hour. For each movement the level of aircraft noise heard at the village was highly variable depending on the type of aircraft, direction of landing or take-off, and meteorological conditions.

Survey method to correct for the influence of aircraft noise

To assess traffic noise at the monitoring position a method was devised to take account of the influence of aircraft noise events. This required that aircraft noise events during the 48-hour measurement periods could be easily identified and removed from the noise record. In order to do this the noise logging instrumentation was configured to measure the noise in successive one-minute periods using the L_{Aeq} scale (A-weighted equivalent continuous noise level). The noise energy within the *un*affected minute periods could then be summed to calculate the equivalent average noise exposure in each hour ($L_{Aeq,1h}$) without the contribution of aircraft noise. For example, if the noise data for seven of the one-minute periods were corrupted by aircraft noise, these periods would be removed from the noise record and the L_{Aeq} values calculated over a period of 53 minutes to represent that particular hour. The L_{Aeq} scale is ideally suited to the summation and averaging of the noise energy in different periods to give an equivalent overall noise exposure over the total period.

To identify periods affected by aircraft noise a second noise logger was established at a location in the village away from the road and other significant noise sources. The position of this instrument (the remote logger), shown in Figure 27, was at the rear of a two-storey property approximately 80m south of the main road (The Street). The microphone was at a height of 4m at a distance of 1m from the façade. This position was well screened from the main road by the house itself and its surrounding buildings. The clock setting of the remote logger was matched precisely with that of the logger at the roadside site alongside the rumble strips ensuring that the two noise records were synchronised. After the remote logger was installed, an observer spent one hour recording the exact times when aircraft noise events occurred during a peak period of aircraft traffic. Comparing these times with the noise record it was possible to identify characteristic noise peaks during minute periods when aircraft movements occurred. In the absence of any other significant noise sources in this location, the peaks caused by aircraft noise were highly distinct. The criteria used to identify aircraft noise peaks throughout the complete 48-hour noise record are described in Section 5.3.2.

In the UK, road traffic noise is ordinarily assessed using the $L_{A10,18h}$ noise index . The index is currently used in the UK for assessing the impact of traffic noise from new and altered road schemes (Department of Transport and Welsh Office, 1988). It is also used for the determination of entitlement to statutory sound insulation of dwellings as described in the Noise Insulation (Amended) Regulations (House of Commons, 1988). It has been used by TRL in previous studies to assess the noise impact of traffic calming schemes. $L_{A10,18h}$ is derived from noise levels measured in an 18-hour period from 06:00 to 24:00. For each of the one-hour periods, the A-weighted noise level exceeded for 10 per cent of the time is calculated to give the noise index $L_{A10,1h}$. An arithmetic average of the 18 individual $L_{A10,1h}$ values is then calculated to give the $L_{A10,18h}$. Similarly the night-time noise levels (00:00 to 06:00 hours) can also be calculated by averaging the six one-hour $L_{A10,1h}$ values to give the $L_{A10, 6h}$.

However, because of the way L_{A10} is calculated it is not possible to divide the noise record into minute periods and accurately calculate an $L_{A10,1h}$ value. For this reason it was considered that the ability to edit the noise record and re-calculate an hourly noise exposure value using the L_{Aeq} scale made it the most appropriate measure for this particular survey.

Road traffic noise assessed using the L_{Aeq} scale and nuisance

Although the $L_{A10,18h}$ noise index is normally used in the UK for the assessment of road traffic noise, the L_{Aeq} scale is used in all other EU countries for this purpose. The L_{Aeq} scale is also widely used in the UK to measure many other sources of noise such as aircraft, railway and industrial noise.

Various studies have been conducted to compare the correlation between L_{A10} and L_{Aeq} and nuisance caused by traffic noise. This research shows that both measures generally correlate well with traffic noise. For example, work carried out at the Building Research Establishment by Langdon (1976) showed that both L_{Aeq} and L_{A10} were highly correlated with median dissatisfaction scores (r = 0.84 in both cases). However, for congested conditions neither scale performed particularly well. A more recent study carried out by TRL in 1984 provided further confirmation that L_{A10} and L_{Aeq} perform equally well in correlating measured traffic noise with people's responses (Watts, 1984).

5.3 Results

5.3.1 Vehicle noise

An analysis of the vehicle noise measured using the SPB method was undertaken, and the correlation between the logarithm of vehicle speed and noise were calculated for data obtained before and after scheme installation. Where appropriate, the regression relationships were used to calculate the maximum noise level for a typical vehicle travelling at the average speed for the site. Figures 28 and 29 show the data obtained from individual vehicle measurements for light and heavy vehicle categories. Summary analysis statistics for the measurement data are given in Appendix B. The results of the vehicle noise monitoring surveys are discussed below.

Light vehicles

The analysis showed that the correlation between light vehicle noise and the logarithm of vehicle speed was statistically significant at the 5% level for the data from both SPB sites.

Figure 28 shows the regression line of best fit through each data set for the Before and After surveys. A statistical analysis showed that the Before and After noise/speed relations were significantly different at the 5% level for both sites.

Table 2 gives the maximum light vehicle noise levels for a typical vehicle travelling at the average speed for the site. These values were calculated from the corresponding regression statistics given in Appendix B, Table B1 for both the Before and After surveys. The mean light vehicle speed was determined from a separate speed survey taken close to the time of the noise survey.

By using this independent data, the calculated mean speed is based on a larger, randomly selected, sample of vehicles and is therefore more representative of typical vehicle speed at each site. It should be noted that the speed survey for the After survey was conducted at a section of road to the east of site N2b (see Figure 27). As site N2b was just beyond a bend in the road at the junction between The Street, Rectory Lane and Norwood Hill Road, it was decided that a more representative measurement of the mean speed of vehicles travelling on the imprinted surfacing would be obtained further along the road.

The results show that at site N1, alongside the rumble strips, the mean speed of the sample of light vehicles measured by radar was reduced by 3.1 miles/h with a reduction in noise of 0.7 dB(A). Alongside the imprinted surfacing at site N2b the mean speed was reduced by 6.9 miles/h with a slight increase in noise level of 0.3 dB(A). The corresponding changes in noise level estimated simply from the before noise/speed relationships for each site are given in brackets in the final column of Table 2. In both cases the noise levels would have been expected to be lower had the reductions in mean speed occurred without the installation of the measures, especially at site N2b.

Heavy vehicles

Figure 29 shows the noise levels measured for heavy vehicles plotted against speed. The survey data samples for all of the sites were relatively small compared with the light vehicle data. To increase the sample size the heavy vehicle pass-by events on the far-side carriageway were also included.

In order to correct the noise levels to account for the greater propagation distance, the noise levels were adjusted using the inverse square law assuming point source propagation. This method was verified using data from a previous study where the noise from a total sample of 46 heavy vehicles on both sides of the road had been measured at a similar site (Wheeler *et al.*, 1998). In this case the actual difference in mean noise levels of heavy vehicles travelling on either side of the road was within 0.3 dB(A) of the distance correction predicted using the inverse square law.

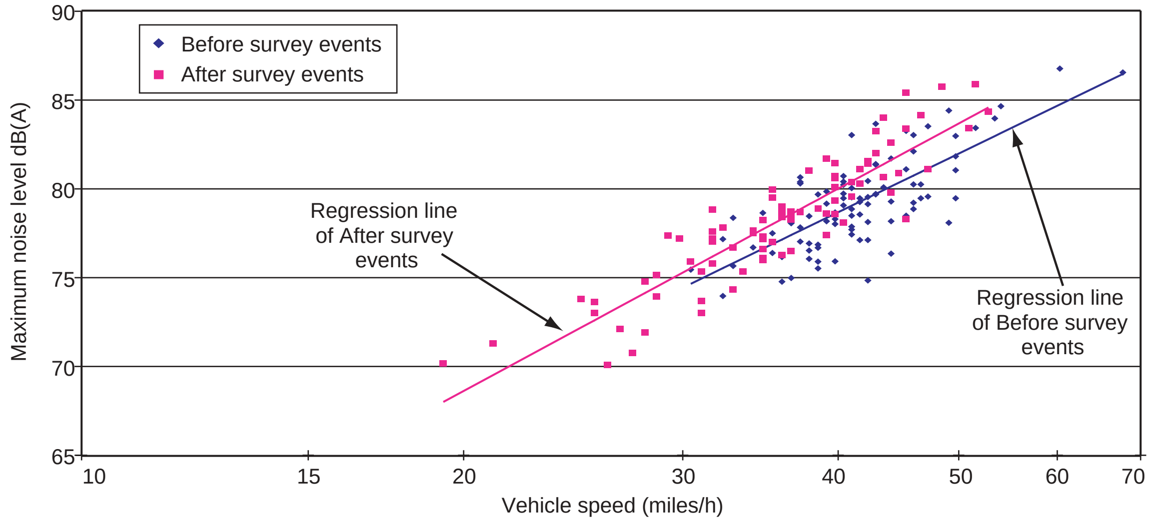
Table 2 Before and After light vehicle noise

		Before survey		*After survey*		*Difference*[1]	
Site	*Measurement condition*	*Mean speed*[2] *(miles/h)*	*Maximum vehicle noise level at mean speed (dB(A))*	*Mean speed*[2] *(miles/h)*	*Maximum vehicle noise level at mean speed (dB(A))*	*Mean speed (miles/h)*	*Maximum vehicle noise level at mean speed (dB(A))*
N1	Eastern gateway (rumble strips)	32.5	75.6	29.4	74.9	-3.1	-0.7 (-1.5)[3]
N2a	None	31.2	78.9	–	–	–	–
N2b	Imprinted surfacing	–	–	24.3	79.2	-6.9	0.3 (-3.6)[3]

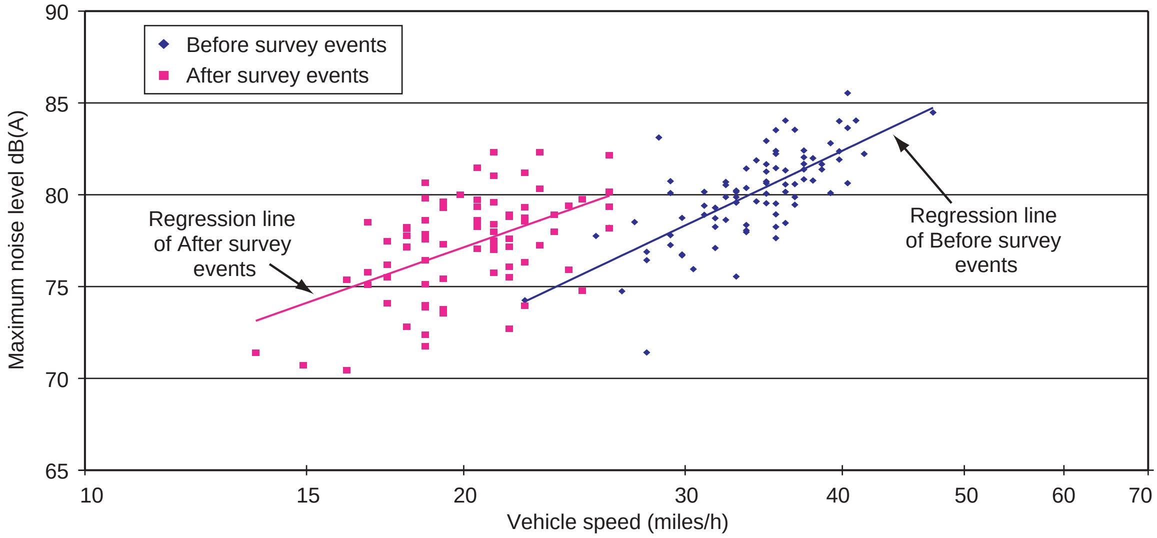
[1] *Negative numbers indicate a reduction in speed and noise level.*

[2] *Measured as described in this section.*

[3] *The figure in brackets is the estimated reduction in noise level at the mean speed measured in the After survey, calculated from the relationship between speed and noise determined in the Before survey.*

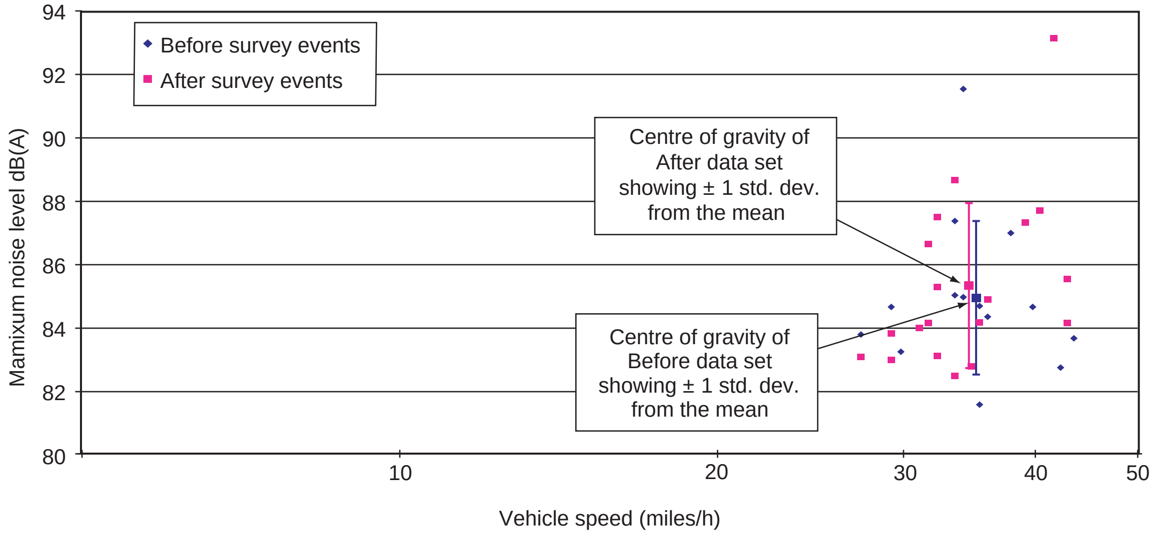


Site N1 - Rumble strips

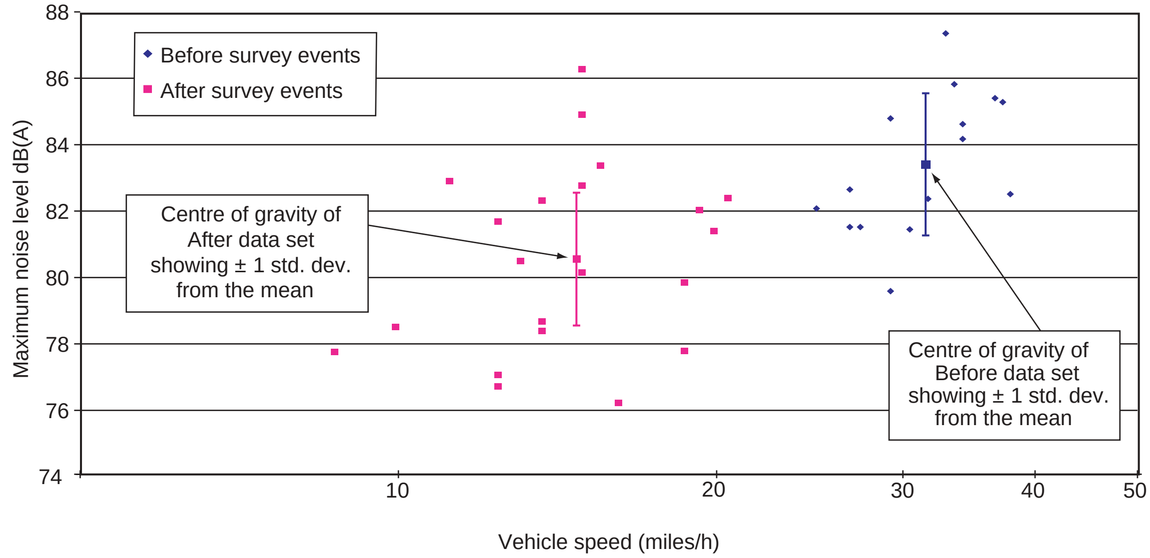


Site N2 - Imprinted surface

Figure 28 Light vehicle noise levels before and after scheme installation



Site N1 - Rumble strips



Site N2 - Imprinted surface

Figure 29 Heavy vehicle noise levels before and after scheme installation

An analysis of the data from each site showed that the relationships between noise level and heavy vehicle speed were not statistically significant. Therefore, instead of regression lines, the plots show the 'centre of gravity' for Before and After data sets; i.e. the mean noise level at the mean logarithmic speed value for each sample. The standard deviation of each sample is also shown.

The mean heavy vehicle noise levels are given in Table 3. The mean speeds given in the table are those calculated from the sample of vehicles selected for the noise survey. Because of the small numbers of heavy vehicles relative to light vehicles, it was not possible within the resources available to obtain a large, independent sample of heavy vehicle speeds. Mean heavy vehicle speeds were therefore taken from the vehicles sampled during the noise survey rather than being calculated from a separate larger survey as for the light vehicles. The reduction in heavy vehicle mean speed measured by radar at site N1 (rumble strips) during the noise survey was just 0.5 miles/h. The mean noise level was increased slightly by 0.3 dB(A). At site N2b (imprinted surfacing) the mean speed during the After survey was reduced by 16.8 with a decrease in noise level of 2.8 dB(A). However, it should be remembered that the After measurements were taken at a different location alongside the imprinted surfacing. The speed reduction is probably partly due to the location change (i.e. near to a bend in the road) and does not therefore truly reflect the effect of the imprinted surfacing on heavy vehicle speeds. For light vehicles it was possible to correct for this by using mean speeds measured on a section of imprinted surfacing similar to the site layout used in the Before survey and calculating a noise level for this mean speed from the regression statistics. For heavy vehicles the speed data was not available, and in any case the correlation between noise and speed was not significant, meaning it was not possible to estimate the noise level at other speeds.

To determine whether the mean heavy vehicle noise levels obtained for the before and after data samples were statistically significantly different, an unrelated t-test was used. The results showed that the slight increase in mean noise levels was not statistically significant at site N1 alongside the rumble strips. At site N2 the decrease in noise level was statistically significant.

Noise from individual heavy vehicles alongside the rumble strips

Figure 30 shows example time histories of A-weighted noise recorded during pass-bys of heavy vehicles at site N1 (DAT recordings, Section 5.2.1). These particular events were selected from various vehicle pass-bys recorded to illustrate the difference in the level and character of the pass-by noise that can occur alongside the rumble strips compared with that alongside a level surface.

For this survey it was not possible to record the position of the vehicle at any point during the pass-by. The start of each time history does not therefore represent a fixed reference position of a vehicle during its approach to the test surface. The time histories have simply been presented with the maximum noise level approximately in the middle of the time record.

The first example shows the pass-by noise of a 2-axle unladen flatbed truck passing on the far side of the road. The survey team noted the occurrence of body rattle noise as the vehicle passed over the rumble strips. (Heavy vehicle body noise is caused by impacts between parts of the vehicle body or between components of steel suspension systems. This can occur when heavy vehicles travel over a raised profile that causes vertical forces to be transmitted through the vehicle body via the suspension.)

Comparing the noise time history recorded on the rumble strips to that on the level surface it can be seen that on the rumble strips the maximum noise level generated by the vehicle was increased by about 6 dB(A). The record also shows impulsive peaks consistent with body noise. In contrast the noise time history generated on the level surface shows a relatively gradual rise and decay of the noise level as the vehicle passed the microphone.

The second pair of time histories shows the pass-by of a 2-axle box van on the far side of the road. In this case the maximum noise level is approximately the same on both the rumble strip and the level surface. However, the profile of the pass-by on the rumble strip shows a number of peaks throughout the general rise and decay of the pass-by noise.

5.3.2 Traffic noise

Identification of aircraft noise events

To establish a means of identifying aircraft noise events, measurements of aircraft noise were taken at the remote

Table 3 Before and After heavy vehicle noise

Site	Measurement condition	*Before survey* Mean speed[2] (miles/h)	*Before survey* Maximum vehicle noise level at mean speed (dB(A))	*After survey* Mean speed[2] (miles/h)	*After survey* Maximum vehicle noise level at mean speed (dB(A))	*Difference*[1] Mean speed (miles/h)	*Difference*[1] Maximum vehicle noise level at mean speed (dB(A))
N1	Eastern gateway (rumble strips)	35.1	85.0	34.6	85.3	-0.5	0.3
N2a	None	31.5	83.4	–	–	–	–
N2b	Imprinted surfacing	–	–	14.7	80.6	-16.8	-2.8

[1] Negative numbers indicate a reduction in speed and noise level.

[2] Measured as described in earlier in this section.

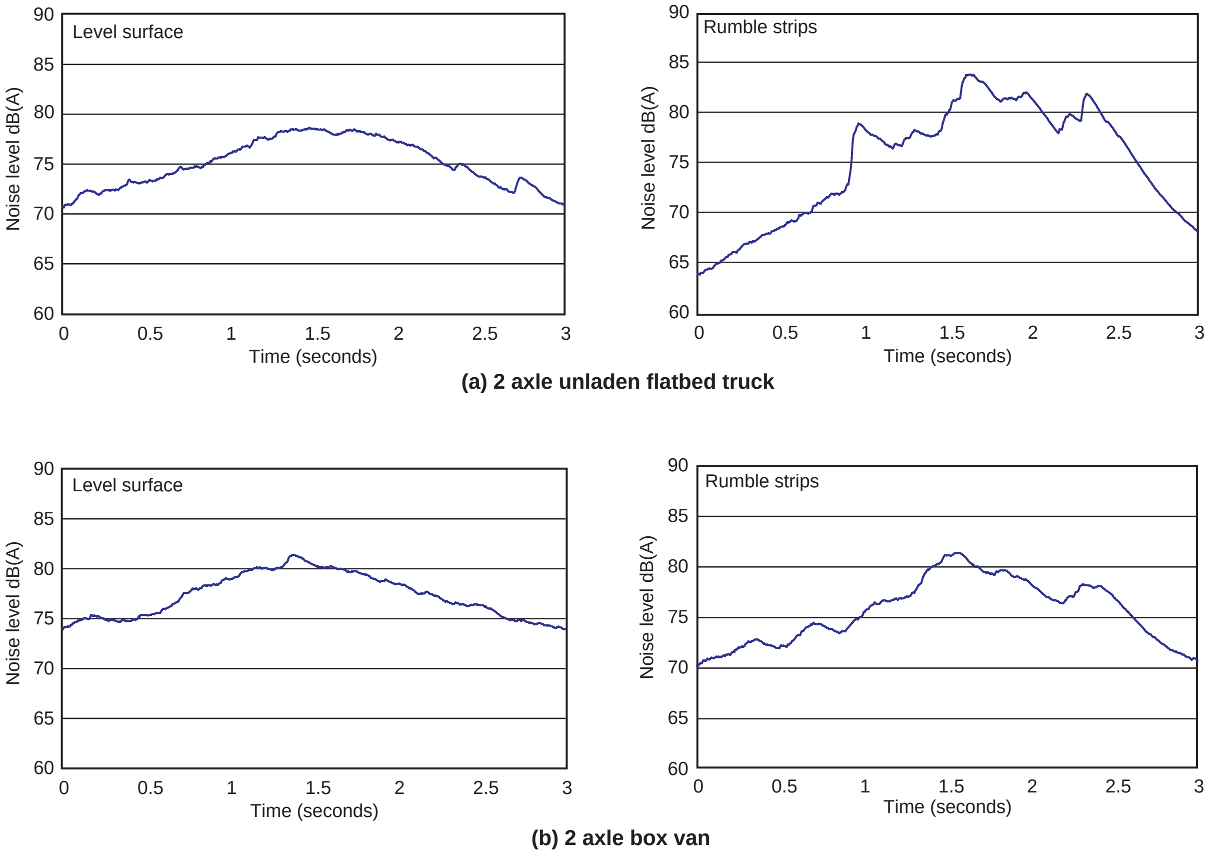


Figure 30 Comparison of noise from individual heavy vehicles alongside level surface and rumble strips

monitoring position over a period of an hour and the exact times that aircraft noise could be heard were noted. Figure 31 shows the noise record from this hour at the remote logging position and the roadside location alongside the rumble strips (site N1). The figure also shows the minute periods when aircraft noise occurred which clearly coincide with peaks in the noise records. To identify aircraft noise events throughout the 48-hour noise record it was necessary to establish test criteria to determine which peaks in the remote logger noise record represented aircraft noise events. To achieve this the characteristics of the aircraft noise peaks were carefully examined. Two selection criteria were developed as follows:

Criterion 1 = any minute period result >*55* dB(A), and *5* dB(A) > either adjacent minute period result,

or

Criterion 2 = any minute period result >*50* dB(A), and *10* dB(A) > either adjacent minute period result.

The first criterion is primarily aimed at daytime conditions such as that shown in the noise record in Figure 31. It can be seen that criterion 1 would have correctly identified 17 of the 18 aircraft events that occurred during this hour. The last event noted at 14:28 would not have been detected. However, although the observer noted that an aircraft movement could be heard it was clearly a relatively quiet event as neither noise record shows any particular noise peak during that minute period.

A potential flaw in this method of detection might occur if a succession of aircraft noise events were to span 3 consecutive minute periods. Assuming an approximately consistent noise level over the 3 minutes, the criterion might not detect that the second minute contained aircraft noise in the absence of a 5 dB(A) increase relative to either of the adjacent minute periods. However, given the typical separation of aircraft events it was never observed that aircraft noise movements spanned 3 consecutive minutes, even at periods of peak aircraft traffic.

The criterion would have identified the peak that occurred at 14:02 as an aircraft event although no aircraft movement was noted during this period. It was therefore necessary to accept that the criterion could falsely identify aircraft noise. On the basis of the observed hour at the remote logging position, and the general noise climate noted during visits at other times of day, it is considered that this would seldom occur. The residents reported that there had been no noisy activity (e.g. lawn mowing) near to the noise logger during the survey periods.

The second criterion was intended to detect aircraft noise at night that might otherwise be missed by criterion 1. It was noted that a number of peaks occurring at night, which were believed to be aircraft noise, were quieter than typical daytime aircraft noise events. Some of these peaks were below 55 dB(A). Because of night-time noise restrictions at Gatwick, a greater proportion of quieter aircraft are likely to operate at night (DTLR, 1999).

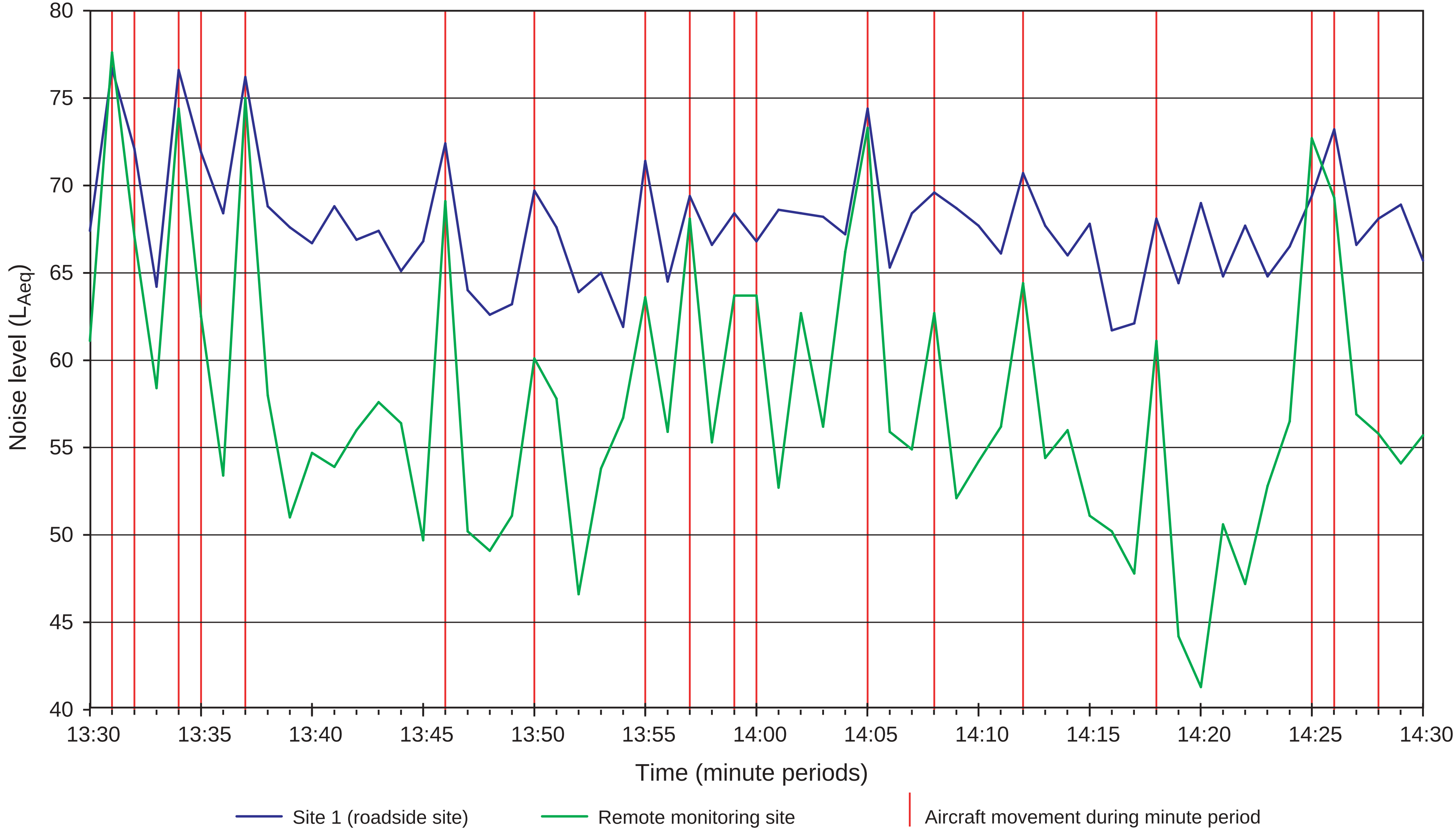


Figure 31 Identified aircraft noise events during sample hour recorded at remote monitoring position

However, had the criterion 1 threshold been set below 55 dB(A), a number of non-aircraft noise events recorded at the remote logger position during the day might have met the criterion conditions. In order to capture quieter aircraft events at night, criterion 2 was added. This test criterion set a reduced threshold of 50 dB(A) but the stricter requirement for a >10 dB(A) increase relative to the noise levels recorded in adjacent minutes. As background noise levels were so low at night-time at the remote logging position, any aircraft noise peaks easily met this condition. However, it is unlikely that any non-aircraft noise event would meet criterion 2.

Analysis to correct for aircraft noise influence

The results from the noise records were entered into a computer spreadsheet for analysis. If the result from any minute period met either test criterion 1 or 2 then that period was identified and excluded from the noise record. According to the above argument, it was considered highly likely that any such periods contained aircraft noise. Overall noise values for each hour were then calculated on the basis of the remaining minute periods. For each hour of the surveys Appendix C summarises the number of periods rejected from the noise record according to each test criterion. The range of remaining minute periods used to represent the hourly L_{Aeq} value varies from 27 to 60.

Assuming that the average rate of traffic flow across the remaining periods is equivalent to the average rate of flow over the whole hour, the calculated $L_{Aeq,1h}$ value can be considered valid. The times most affected by aircraft movements tended to be during the day (see Appendix C), when traffic flows were relatively high. During these hours it is considered that traffic flow was reasonably consistent and that the minute periods used to calculate the $L_{Aeq,1h}$ values were representative of the average across the hour.

Road traffic noise exposure

Figure 32a compares the variation in hourly $L_{Aeq,1h}$ levels (including aircraft events) at site N1 alongside the position of the rumble strips over a 24 hour period during the Before and After surveys. Noise was monitored for 48 hours during each survey so the mean of the two values for each hour is shown. Figure 32b shows the corrected noise record (i.e. aircraft noise events removed). The overall daytime and night-time noise levels recorded before and after scheme installation are shown in Table 4. The daytime level has been calculated over the same 18 hour period used to determine $L_{A10,18h}$ (i.e. 06:00 – 00:00). The night-time level is calculated over the remaining period (00:00 – 06:00). The table also gives the change in noise levels that occurred between the Before and After surveys.

Table 4 Before and After road traffic noise levels at site N1 (rumble strips)

Noise index	*Before noise level (dB(A))*	*After noise level (dB(A))*	*Difference (After – Before)*
$L_{Aeq,18h}$	65.6	64.6	-1.0
$L_{Aeq,6h}$	54.6	52.2	-2.4

The hourly noise level data in Figure 32b show that the $L_{Aeq,1h}$ *traffic* noise levels at site N1 were generally lower throughout the daytime period after the installation of the rumble strips. Reductions were typically of the order of 1-2 dB(A). During the night-time, the difference between the Before and After survey results were more variable. In this case reductions were between 0 and 7 dB(A). The Before and After $L_{Aeq,18h}$ and $L_{Aeq,6h}$ noise exposure values given in Table 4 show that the overall daytime traffic noise level ($L_{Aeq,18h}$) reduced by 1 dB(A) following the installation of the rumble strips. Night-time noise levels were reduced by 2.4 dB(A) ($L_{Aeq,6h}$).

The effect of changes in road traffic flow and composition

Before and After traffic flow data were used to predict to what extent changes in traffic noise levels following the installation of the rumble strips at site N1 were due solely to changes in traffic flow and composition. For this purpose a traffic noise prediction model was used which takes into account vehicle noise levels as well as traffic flow and the percentage of heavy vehicles.

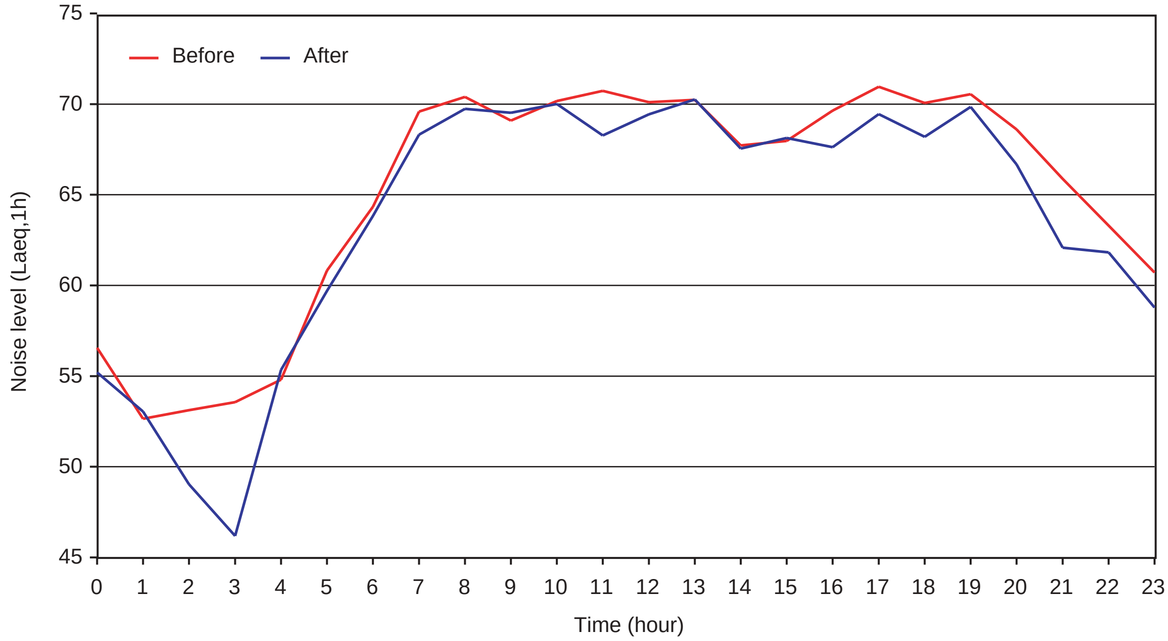
Full details of the prediction method are described in Appendix D together with the input variables necessary for the prediction. The results of this analysis predicted that, had the traffic flow and composition during the After survey been the same as those in the Before survey, the measured After $L_{Aeq,18h}$ level would have been 0.5 dB(A) greater. In other words, 0.5 dB(A) of the observed 1.0 dB(A) reduction could be attributed to changes in traffic flow and composition alone.

5.4 Summary and discussion

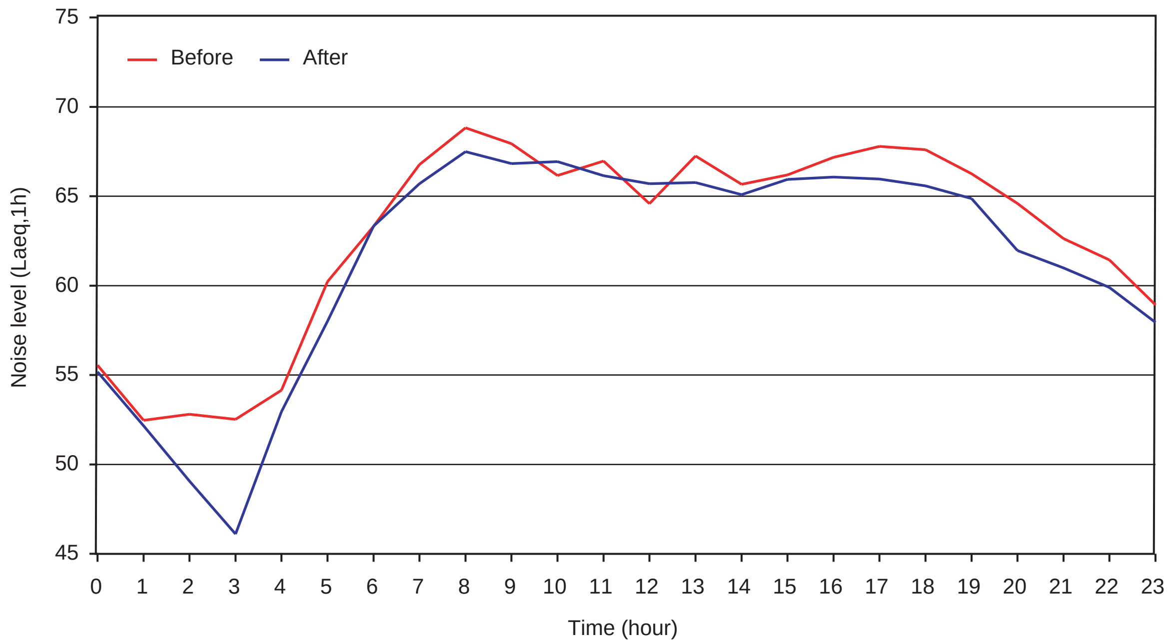
The noise from light vehicles was reduced at site N1 following installation of the rumble strips by just 0.7 dB(A) on average which cannot be considered to be a perceptible change. The reduction in mean light vehicle speed measured by radar was 3.1 miles/h. Alongside the imprinted surfacing at site N2b, light vehicle noise levels were increased by just 0.3 dB(A); again not a perceptible change. The mean speed of the light vehicles at this site reduced by 6.9 miles/h.

The decreases were less than would have been estimated from the reductions in mean speed, especially at site N2b (imprinted surfacing). These estimations were based on the noise/speed relationships obtained for the Before survey. The reduction in power train noise (i.e. engine, engine ancillaries, transmission and exhaust) expected from a reduction in vehicle speed at site N2b was possibly offset by the increase in tyre/road noise generated by the imprinted pattern. The survey team noted that the noise from vehicles passing over the imprinted surfacing had a particular character generated by the interaction of the tyres and the imprint pattern. A frequency analysis of the pass-by noise from selected vehicles showed that this noise was not strongly tonal. Distinct tonal components to the pass-by noise would tend to make the noise more noticeable and therefore potentially annoying.

The small change in mean heavy vehicle noise at site N1 following the installation of the rumble strips was not



(a) Complete noise record (including aircraft noise)



(b) Corrected noise record (i.e. aircraft noise events removed)

Figure 32 Hourly noise levels before and after the installation of the rumble strips at site N1 statistically significant. The reduction in mean (radar) speed was just 0.5 miles/h. At site N2b alongside the imprinted surfacing, mean heavy vehicle (radar) speeds during the After survey were reduced by 16.8 miles/h and the mean noise level was reduced by 2.8 dB(A). However, this speed reduction cannot be attributed entirely to the effect of the imprinted surfacing as the After survey had to take place in a different location, near to a bend in the road.

The time histories shown in Figure 30 demonstrate how heavy vehicle body noise can affect the maximum A-weighted noise level for different vehicle pass-bys. The time histories show distinct noise peaks. In some cases it is clear that the maximum noise level is not increased by the occurrence of body noise. However, the impulsive nature of the peaks that occur during the pass-by would be expected to make the event more noticeable and therefore potentially disturbing to nearby residents. Simply measuring the maximum A-weighted noise level may not, therefore, fully reflect the degree of disturbance experienced by some residents in response to body noise caused by some heavy vehicles.

For certain vehicles, the results show that pass-by noise levels can clearly increase substantially as a result of body noise generation. High level peaks of impulsive body noise would clearly be disturbing. The disturbance experienced by residents in response to these body noise events is likely to depend on the time of day, their activity, and the associated background noise levels. For example, distinctive body noise from a vehicle passing at midnight, when many residents are trying to sleep, is likely to be more disturbing than the same noise event occurring at midday.

Once the influence of aircraft had been corrected for, daytime traffic noise exposure ($L_{Aeq,18h}$) was found to be reduced by just 1 dB(A) at site N1 following the installation of the rumble strips. The plots of hourly noise levels (Figure 32b) show that a small noise reduction of 1–2 dB(A) was generally consistent throughout the daytime period. However, when the effects of changes in traffic flow and composition were taken into account, the estimated reduction in $L_{Aeq,18h}$ noise exposure was only 0.5 dB(A). Night-time noise levels at site N1 were reduced by 2.4 dB(A) ($L_{Aeq,6h}$).

Overall, the reductions in traffic noise exposure at this site were fairly small, but demonstrate that traffic noise exposure did not increase as a result of the rumble strips.

6 Air quality measurements

6.1 Introduction

For the U.K. as a whole, road traffic makes a large contribution to air pollution. This is illustrated in Table 5, which shows the percentage contribution from road traffic, along with commercial sources and domestic heating to the emissions of five of the pollutants of concern in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland during 1998 (DTLR, 2000).

At Charlwood, which is in a rural area where there are no significant industrial sources, local traffic will be the largest contributor to emissions. It is likely that the traffic emissions may show seasonal effects due to the village being close to Gatwick airport and Gatwick Zoo. It is also important to note that the proximity of the airport leads to the possibility that aircraft emissions may affect local air quality.

Table 5 Percentage emissions of pollutants by end user (AEA Technology plc, 1997)

End user	*NO_x*[1]	*CO*[1]	*SO_2*[1]	*PM_{10}*[1]	*Benzene**
Industry	21	17	34	19	16
Road Transport	47	73	6	26	66
Other Transport	6	<1	5	2	5
Domestic	13	7	28	23	9
Other	13	3	27	30	4

[1] NO_x nitrogen oxides; CO carbon monoxide; SO_2 sulphur dioxide; PM_{10} particulate matter (≤10µm)

** End user categories defined differently in raw data*

The exhaust emissions from a stream of traffic is dependent principally on the volume of traffic, the types of vehicle present and their individual emission rates. Following scheme installation the changes in driving pattern may result in a change in exhaust emissions rates and this will in turn impact on the air quality of the local area and it is this effect that the following section of the report considers.

6.2 The surveys

6.2.1 Site considerations

To assess the impact of the scheme on local air quality in Charlwood, the monitoring sites were located along The Street at the kerbside close to the emissions source. This enabled any changes in air quality resulting specifically from changes in emissions from traffic to be detected. Four sites AQ1-AQ4 (indicated in Figure 23 and shown more precisely in Figure 33) were chosen, two on each side of the road.

A control site located away from The Street was also required to enable a distinction to be made between changes in air quality due to the scheme (i.e. driver behaviour) and changes due to other effects such as a greater proportion of cleaner vehicles in the fleet and meteorological conditions. The control site chosen was on *Chapel Road*.

6.2.2 Measurement methods

The choice of sampling apparatus and pollutants to be measured was based on the contribution that traffic makes to emissions and also the availability of a relatively cheap but effective method. Of most interest in terms of the Air Quality Strategy (DTLR, 2000) is the pollutant nitrogen dioxide (NO_2). There is evidence in some areas, although not necessarily Charlwood, that NO_2 concentrations regularly exceed the health related air quality standards adopted in the Air Quality (England) Regulations 2000, and may continue to do so in the future. NO_2 is formed both in the exhaust and from chemical reactions of nitric oxide, which is also produced by vehicles. Benzene was also included in the surveys as vehicle exhausts are one of the main sources and it is an important pollutant in terms of local air quality.

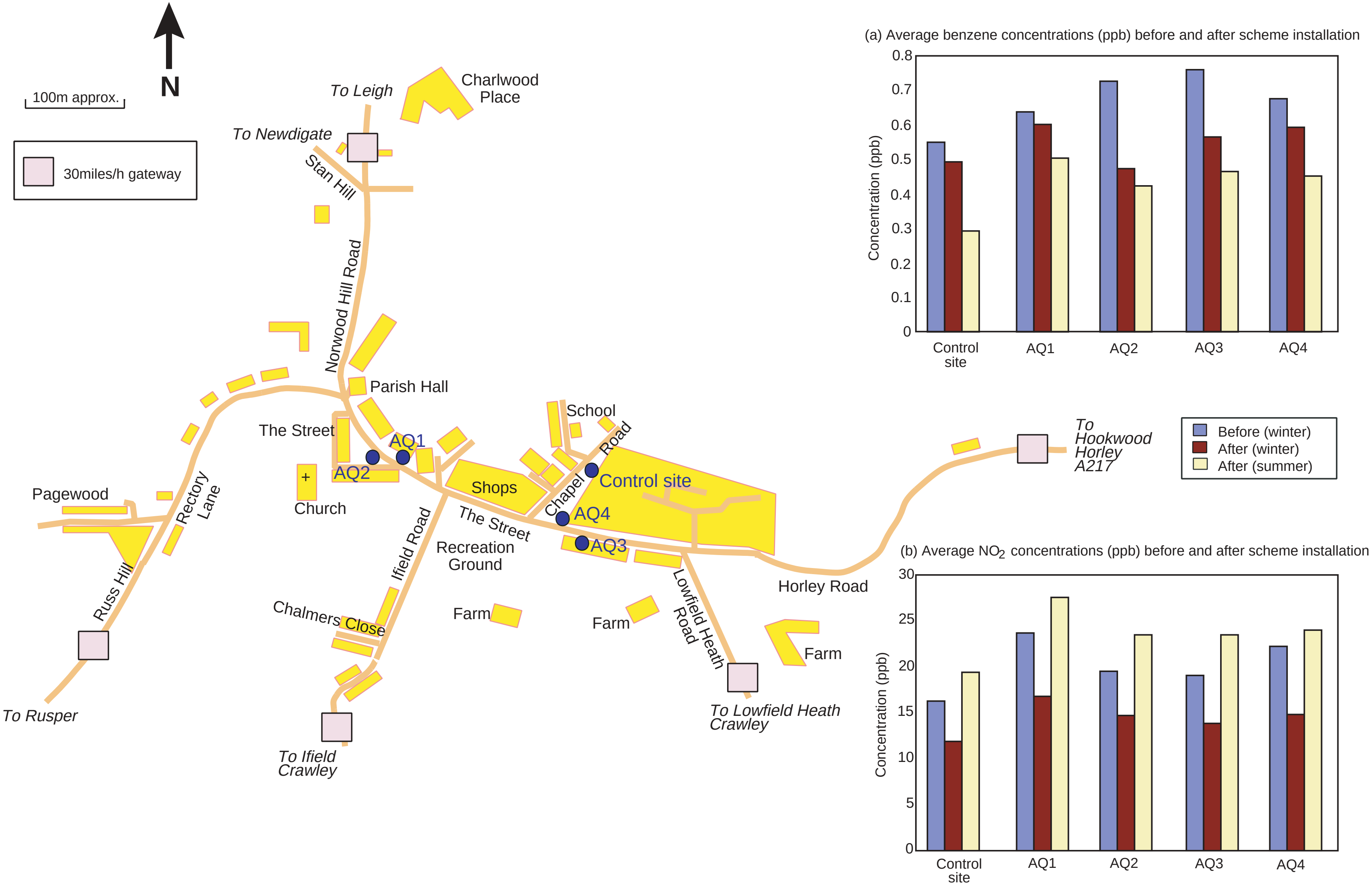


Figure 33 Air quality monitoring positions and results

Sampling of NO_2 and benzene was carried out using diffusion tubes. The tubes were mounted on lamp posts approximately 2.5m above ground such that they were in the region where people are exposed to air pollution but were also relatively inconspicuous and less likely to be stolen. Positions where the samplers would be sheltered (e.g. by bushes or trees) were avoided.

The benzene diffusion tubes were analysed with a mass spectrometer using gas chromatography and the NO_2 diffusion tubes were analysed using a UV spectrophotometer. The analytical error on each procedure is ±5% and ±10% respectively.

Other pollutants associated with road traffic, such as PM_{10} and CO, are also important in terms of local air quality but were not included in the surveys. This was due to the high cost of the instrumentation required to achieve adequate coverage of the area.

6.2.3 Monitoring periods

Diffusion tubes are usually deployed for between one and four weeks depending on the ambient concentrations found at a site. For this survey the tubes were exposed for consecutive periods of two weeks. This was to allow as much detail on temporal variation as possible without the risk of levels being undetectable. Each monitoring period was continued for at least three months in order to be confident that the data were representative. The monitoring periods were as follows:

- Before survey:
  - 8 December 1998 - 15 March 1999 (winter).
- After surveys:
  - 6 December 1999 - 28 March 2000 (winter);
  - 6 May 2000 - 7 August 2000 (summer).

After monitoring took place before the installation of additional measures in November 2000.

6.3 Results

6.3.1 Statistical analysis of air quality data

The report compares concentrations at each of the monitoring sites and also between sampling periods. To determine the significance of the differences observed, t-tests were employed. The tests assumed that concentrations at each of the sites were independent of each other. In each test the null hypothesis, that there is no difference between two means, was rejected at the probability of less than 0.05, i.e. the difference can be said to be significant at the 5% level.

6.3.2 Benzene concentrations

Mean benzene concentrations (parts per billion) in the Before and the two After surveys are shown in Figure 33a, with the raw data in Appendix E, Table E1. The values obtained were well below the Air Quality Standard of 5 ppb (which is for a running annual mean of hourly values).

Comparison between sampling sites

Mean benzene concentrations at each of the individual kerbside sites were compared with the mean benzene concentration at the control site (Appendix E, Table E2). It was found that during each of the Before and the two After surveys, measured kerbside concentrations were generally higher than those at the control site, but the differences were not statistically significant except in the After (summer) survey. There was no significant difference between concentrations at any of the kerbside sites in any one monitoring period.

The mean combined kerbside concentrations were higher (0.70, 0.55 and 0.46 ppb in the Before, After (winter) and After (summer) surveys respectively) than at the control site (0.54, 0.49 and 0.29 ppb).

Comparison between sampling periods

Table E3 in Appendix E shows that the After (summer) concentrations of benzene at all the kerbside sites were lower than the After (winter) concentrations, but the differences were not statistically significant. The control site, however, saw a statistically significant decrease in concentration between the two seasons. For this reason, it was not thought appropriate to combine data from the two After surveys and Before and After comparisons were therefore between the two winter surveys. Table 6 shows the differences in concentrations between these surveys and their statistical significance (one-tailed t-test, 5% confidence level).

Table 6 Mean benzene concentrations (ppb) in winter before and after scheme installation

Site	*Before (winter)*	*After (winter)*	*Change (%)*	*Change statistically significant?*
Control	0.54	0.50	-9	No
AQ1	0.68	0.59	-14	No
AQ2	0.76	0.56	-26	No
AQ3	0.72	0.47	-35	Yes
AQ4	0.64	0.60	-7	No
Combined kerbside sites	0.70	0.55	-20	No

At the control site, there was a 9% decrease in benzene concentration between the winter Before and After surveys, but this change was not statistically significant. All kerbside sites also saw a decrease in benzene concentration between these two surveys, although only the decrease at site AQ3 was statistically significant. The mean combined kerbside concentration also decreased but the change was not statistically significant. There was no statistically significant difference between the reduction in concentration at the control site and the reductions at the kerbside sites.

6.3.3 Nitrogen dioxide concentrations

Mean NO_2 concentrations in the Before and the two After surveys are shown in Figure 33b with the raw data in Appendix E, Table E4. All measured concentrations were below the Air Quality Standard of 40 $\mu g/m^3$ (21 ppb annual mean).

Comparison between sampling sites

Mean NO_2 concentrations at each of the individual kerbside sites were compared with the mean NO_2 concentration at the control site (Appendix E, Table E5) for each survey period. It was found that all kerbside concentrations were higher than that at the control site, but only at sites AQ1 and AQ4 was this difference statistically significant (in all three monitoring periods).

Measured NO_2 concentrations were higher at the combined kerbside sites (21.06, 14.91 and 24.63 µg/m^3 in the Before, After (winter) and After (summer) surveys respectively) than at the control site (16.17, 11.70 and 19.14 µg/m^3).

Comparison between sampling periods

Table E6 in Appendix E shows that the After (summer) concentrations of NO_2 at all sites were statistically significantly greater than the After (winter) concentrations. For this reason, it was not thought appropriate to combine data from the winter and summer After surveys and comparisons were again between the winter Before and After surveys. Table 7 shows the differences in concentrations between these surveys and their statistical significance.

Table 7 Nitrogen dioxide concentrations (µg/m^3) in winter before and after scheme installation

Site	*Before (winter)*	*After (winter)*	*Change (%)*	*Change statistically significant?*
Control site	16.17	11.70	-28	Yes
AQ1	22.38	14.74	-34	Yes
AQ2	19.04	13.78	-28	Yes
AQ3	19.31	14.61	-24	Yes
AQ4	23.51	16.51	-30	Yes
Combined kerbside sites	21.06	14.91	-29	Yes

At the control site, there was a 28% decrease in NO_2 concentrations between the winter Before and After surveys, and concentrations also decreased at all the kerbside sites. All of these changes (including the change at the combined kerbside sites) were statistically significant. However, there was no statistically significant difference between the reduction in concentration at the control site and the reductions at the kerbside sites. Thus there is no evidence to suggest that the changes were due to scheme installation.

6.4 Summary and discussion

The measured concentrations of benzene and NO_2 were well below the Air Quality Standards of 5 ppb for benzene and 40 µg/m^3 for NO_2. Benzene concentrations were also below the provisional objective of 1 ppb for the year 2005.

After (summer) concentrations of NO_2 were greater than during the winter Before and After sampling periods, whereas those of benzene were lower. The difference between the mean concentrations in the winter and summer After surveys at the control site was statistically significant and therefore concentrations were compared between the winter Before and After surveys.

Measured concentrations of benzene at the control site decreased by 9% between the winter Before and After surveys, whereas at the kerbside sites they decreased by between 7% and 35%, with a mean decrease of 20%. Only at one site was the change statistically significant. There was no statistically significant difference between the reduction in mean concentration at the control site and those at the kerbside sites.

Measured concentrations of NO_2 showed a statistically significant 28% decrease at the control site between the winter Before and After surveys and a similar change in kerbside concentrations (decrease by between 24% and 34%, with a mean decrease of 29%). There was again no statistically significant difference between the reduction in concentration at the control site and the reductions at the kerbside sites.

There is no evidence to suggest that the changes in concentrations of benzene and NO_2 were due to scheme installation. The fact that the two pollutants did not follow the same winter/summer variation suggests that the excess NO_2 may not be attributed to the local traffic, but may have been transported from outside the survey area. Aircraft emissions from Gatwick Airport may be one of many sources of NO_2 in the local area. Also summer conditions such as bright sunlight and higher temperatures allow for greater conversion of NO_x to NO_2, leading to higher summer concentrations.

7 Public opinion survey

7.1 Interviews

A total of 150 people resident in Charlwood before 1999 were interviewed in their homes during May 2000, before the installation of the additional measures. The aim was to establish people's perceptions of the measures and their effectiveness, or otherwise, in reducing any traffic problems in the village. Views on the appearance of the scheme were also sought. The questionnaire is reproduced in Appendix F with the survey results (summarised below) incorporated.

A stratified sample from every road within the parish boundary was assembled using the number of households in each road as a basis, to ensure that the sample across the village be representative of its population. Of the respondents:

- 60% were female;
- 59% were aged 45 or over;
- 44% lived on the main road (The Street, Norwood Hill Road and Horley Road);
- 37% had children (aged 16 or under) in the household;
- 83% were car/van drivers and 12% had no transport;
- 51% were not working (33% were retired).

Male and female respondents and respondents under and over 45 years of age had broadly similar views.

7.2 Results

Problems before the changes (Q.3)

Because respondents often mentioned more than one problem, the percentages shown in Appendix F total more than 100%. Of all respondents:

- 51% mentioned excessive speed;
- 42% (aggregate) made comments related to heavy traffic, a further 9% mentioning airport traffic, traffic avoiding Crawley and rat-running to Dorking;
- 16% (aggregate) mentioned difficulty crossing the road (nearly half of these respondents referring to children);
- 10% (aggregate) mentioned problems with lorries (their numbers and speed, and that they were dangerous).

Other problems mentioned were associated with reversing in/out of driveways and emerging on to the main road (6% each); danger to young children and accidents (5% each), and parking problems (5%).

Effectiveness of changes in making the village safer (Q.4)

Over 60% of respondents thought that the imprinted surfacing and the narrower carriageway in conjunction with wider footways in the village centre were very or fairly effective in making the village safer. At least 50% thought the same about the informal pedestrian crossing and the changed priorities at the Norwood Hill Road/ Rectory Lane/The Street junction. Opinion was divided about the 30 miles/h carriageway roundels at the gateways and the rumble strips. The fencing and the gateway signing was considered to be the least effective.

Mean scores for the responses were also calculated. Based on a score of 3 for ‘very effective’, 2 for ‘fairly effective’ and 1 for ‘not effective’, the feature considered the most effective at improving safety was the narrower carriageway/wider footways (2.0) and the least effective (by some margin) was the fencing (1.2).

Satisfaction with the village’s appearance (Q.5)

Two-thirds of the respondents were very or fairly satisfied with the effect of the scheme on the appearance of the village. The mean score (based on 4 for ‘very satisfied’ down to 1 for ‘not satisfied’) was 2.7 (closest to ‘fairly satisfied’).

Effect of individual changes on the village’s appearance (Q.6, Q.6a)

Over 60% of respondents thought that the imprinted surfacing improved the appearance of the village. Opinion was divided on the gateway signing and the fencing, particularly the latter. Around two-thirds of respondents thought that the 30 miles/h carriageway roundels and rumble strips on the village approaches made no difference to its appearance. The mean scores (based on 3 for ‘improves appearance’, 2 for ‘makes no difference’ and 1 for ‘spoils appearance’) ranged from 2.5 for the imprinted surfacing to 1.8 for the rumble strips. The scores for the 30 miles/h roundels and the fencing were at or close to 2.0.

Below are a number of common reasons given by respondents as to why they thought certain measures spoilt the appearance of the village. (In Appendix F, the percentages total more than 100% because respondents often gave more than one reason.) The majority of these measures were criticised over their suitability in a rural situation. Examples of comments were:

- ‘unsuitable for / out of keeping with the village’;
- ‘looks better without’ / ‘unattractive’;
- ‘looks urban/modern’;
- ‘less rural’ / ‘spoils country road’ / ‘prefer countryside look’.

These comments applied mainly to the gateway signing (some suggested green imitation gates would be better), 30 miles/h roundels, the rumble strips and the new kerbing.

Other concerns not related to the appearance included:

- *Gateway signing, roundels, fencing:* pointless, unnecessary.
- *Rumble strips*: ineffective; damage to cars; vibrations - though a few implied they were more comfortable to cross at speed.
- *Imprinted surfacing:* noisy; artificial; not real cobblestones; unsafe e.g. for walking on.
- *New kerbs* on Rectory Lane: unsafe; too high e.g. if vehicles come close (nowhere to take avoiding action).
- *Fencing:* difficult to maintain/cut hedges; unsafe e.g. for horse riders, if vehicles come close (nowhere to take avoiding action).

Agreement with statements about the changes (Q.7)

There was general agreement that the changes were necessary (mean score 3.9, based on 5 for ‘agree a lot’ to 1 for ‘disagree a lot’) and that they make it safer to walk along the footways (3.8) but speeds were not thought to have reduced enough (1.9). The changes were considered to have increased noise (3.5) and were not thought to have improved safety for cyclists (2.3). Traffic fumes were not thought to have been affected (2.4).

Opinion was divided as to whether the changes:

- Had made it safer/easier to cross the road.
- Had made it safer for motorists.
- Had reduced speeds.
- Had improved the appearance of the village.
- Had improved the environment in the village.
- Should be introduced in other villages.

Suggestions for improvements to the scheme (Q.8)

There were many suggestions, the majority made by just a few respondents each. Many suggestions were related to reducing speeds (made by an aggregate of 52% of respondents) e.g. calling for speed cameras, humps, chicanes, lower speed limits, rumble strips right through the village and more enforcement; 13% wanted the imprinted surfacing to be extended through the village. An aggregate of 16% of respondents called for better pedestrian crossing facilities, particularly converting the informal crossing near the shops into a ‘proper’ crossing. 13% of respondents wanted features removed, i.e. the fencing, rumble strips and (gateway) signing. Other suggestions included mini-roundabouts (particularly at the Norwood Hill Road/Rectory Lane/The Street junction), measures to discourage through traffic and more narrowing in the village centre.

Satisfaction with the scheme (Q.9)

Just over half of the respondents were fairly or very satisfied with the scheme, and about one-third were dissatisfied. However, male respondents were slightly less satisfied with the scheme overall than females, and the same was true for respondents over 45 years old compared with the younger respondents.

Consultation (Q.10-Q.12)

Nearly all respondents had heard about the scheme prior to installation, through leaflets, an exhibition/public meeting, and from friends/relatives or by mailshot.

Over 70% thought that people had been given enough opportunity to air their views on the proposals and nearly two-thirds were satisfied with the information given about these. Those who were dissatisfied said there was insufficient detail and that the plans were unclear. Others mentioned a lack of options, insufficient consultation and awareness of the proposals beforehand, no model of the village showing the plan and ‘minds already made up’.

8 Accidents

Reported injury accidents on all the main roads within the village inside the gateways, summarised from STATS19 details, are shown in Table 8 for 4.8 years before and 1.7 years after scheme installation. (The After period is rather too short for valid conclusions on the effect of the scheme to be drawn.)

Table 8 Accident summary

Before (1 January 1994 - 31 October 1998) - 37 accidents (7.7 per year)

Severity	*Weather/light Conditions*	*Location*	*Vulnerable road users*
1 fatal 6 serious 30 slight	9 dark 28 daylight 22 wet 15 dry	20 Horley Road 8 The Street 5 Ifield Road 2 Lowfield Heath Road 1 Rectory Lane 1 Norwood Hill Road	3 cyclist 2 pedestrian

Vehicle manoeuvres

13 single vehicle (9 Horley Road of which 8 on bends and 1 hit kerb; 2 Ifield Road - both overtaking; 1 Lowfield Heath Road avoiding animal; 1 The Street - cyclist hit kerb);
10 head-on collisions on bends (9 on Horley Road; 1 involving cyclist on Ifield Road);
4 collisions with parked cars (3 The Street, 1 Horley Road);
2 pedestrian (The Street, within 200m of Ifield Road)
2 emerging on to main road (The Street/Ifield Road and Stan Hill/Norwood Hill junctions);
2 nose-to-tail (Horley Road, Ifield Road);
1 head-on overtaking (Lowfield Heath Road);
1 head-on passing parked vehicle (Rectory Lane);
1 right turner off main road + oncoming vehicle (The Street/Ifield Road);
1 reversed into another vehicle (Ifield Road).

After (1 November 1998 - 30 June 2000) - 7 accidents (4.2 per year)

Severity	*Weather/light conditions*	*Location*	*Vulnerable road users*
1 serious 6 slight	4 dark 3 daylight	2 Horley Road 2 The Street 2 Lowfield Heath Road 1 Rectory Lane	None

Vehicle manoeuvres

3 single vehicle (Horley Road - bend, The Street - right turn and Lowfield Heath Road - avoiding animal);
2 head-on collisions, both on bend (Rectory Lane, Lowfield Heath Road);
1 nose-to-tail (Horley Road);
1 collision with parked car (The Street).

9 Summary

9.1 The scheme

The main features of the scheme as implemented in November 1999 were as follows:

- Gateway features on five main approaches.
- Rumble strips inside two gateways.
- Fencing to give channelling effect (main approaches to village centre).
- Carriageway narrowing (main approaches).
- Grey imprinted surfacing in village centre:
  - footway widening;
  - carriageway narrowing.
- Change in priority at junction in village centre.
- Informal pedestrian crossing.
- Other minor measures (30 miles/h roundels, new kerbing).

By November 2000, additional measures to complete the scheme had been installed, the main elements being imprinted surfacing to highlight the two hitherto untreated junctions on the main road through the village, and two additional informal pedestrian crossings. The 30 miles/h speed limit was retained.

9.2 Monitoring

Monitoring comprised automatic speed/flow measurements over seven days before and after scheme installation at three of the gateways and within the village. Flows were also measured on a route that could be used to avoid the scheme. Before and After noise and air quality monitoring, together with a public opinion survey on the scheme as implemented in November 1999, were conducted. Further speed/flow monitoring within the village was carried out following the completion of the additional measures in November 2000.

9.3 Results

9.3.1 Traffic speeds and flows

Following scheme implementation in November 1999, the inbound mean speed at the *gateways* dropped by between 3 and 5 miles/h to between 30 and 33 miles/h, and outbound speeds dropped by between 1 and 3 miles/h. The mean speed in the centre of the village on the *imprinted surfacing* dropped by 5 miles/h to 23 miles/h, but it is not clear whether the decrease was due to the scheme as a whole, or more specifically to the imprinted surfacing and/ or to the *change in priority at the junction*. The mean speed in the centre of the village away from the imprinted surfacing was little changed at about 32 miles/h. With the additional measures implemented in November 2000, however, this speed was reduced to about 28 miles/h.

There was a 7% decrease in traffic through the centre of the village (from about 6,000 vehicles per day), but no change on a possible diversion route. Possibly the area-wide 40 miles/h speed limit and perimeter gateways associated with the Dorking Rural Box might have influenced traffic flow through the village. At the junction where the priority had changed, however, traffic on the former minor arm *increased* by 7%, possibly because it had become easier to turn right from this arm. Following the implementation of the additional measures, village centre traffic increased slightly but was still 4% below the Before levels.

9.3.2 Noise measurements

Before and After noise measurements were taken at two sites - alongside the imprinted surfacing and the rumble strips associated with the Horley Road gateway. The main findings were as follows:

1 Despite the reduction in mean speed, noise from light vehicles changed by less than 1 dB(A) at each of the vehicle noise monitoring sites. Changes in noise level of this magnitude are considered to be imperceptible.

2 Alongside the rumble strips, neither the noise from heavy vehicles nor their speeds changed to any degree. Alongside the imprinted surfacing, the mean heavy vehicle noise was reduced by 2.8 dB(A), coinciding with a large reduction in mean speed. However, this speed reduction must be partly attributed to the change in monitoring position for the After survey resulting from the reduction in the length of surface treatment originally proposed.

3 Time histories of selected heavy vehicles passing over the rumble strips sometimes showed distinct, multiple noise peaks caused by body rattle noise. For some vehicles this caused substantial increases in the maximum pass-by noise level. In other cases the occurrence of commercial body noise did not affect the maximum noise level. However, the impulsive nature of the noise would be expected to make the pass-by noise more noticeable and therefore potentially disturbing to nearby residents. Simply measuring the maximum A-weighted noise level may not, therefore, fully reflect the degree of disturbance experienced by some residents in response to body noise caused by some heavy vehicles.

4 The degree of disturbance experienced by residents in response to these body noise events is likely to be dependent on the time of day, their activity, and the associated background noise levels.

5 Alongside the imprinted surfacing, the reduction in power train noise that might have been expected from a reduction in speed was possibly offset by the increase in tyre/road noise caused by the imprint pattern. The survey team noted that the noise from vehicles passing over the imprinted surfacing had a noticeable character generated by the interaction of the tyres and the imprint pattern.

6 The influence of aircraft was removed from the noise record in order to estimate changes in traffic noise alongside the rumble strips. When the effects of changes in traffic flow and composition were also taken into account, the estimated reduction in $L_{Aeq,18h}$ noise exposure due to the installation of the rumble strips was only 0.5 dB(A).

7 Night-time traffic noise (also corrected to remove the influence of aircraft noise) was reduced by 2.4 dB(A) ($L_{Aeq,6h}$).

8 Overall, the reductions in traffic noise exposure in Charlwood were not considerable, but the total noise exposure levels were shown not to have increased as a result of the rumble strips.

9.3.3 Air quality measurements

From the air quality measurements, there was no evidence to suggest that the scheme had affected local air quality. Concentrations measured before scheme installation were already well below the current air quality standards.

9.3.4 Public opinions

The public opinion survey was carried out on the scheme as implemented in November 1999. It showed that the *imprinted surfacing* was considered to increase safety and to improve the appearance of the village, but was thought to be noisy.

There was general agreement that the *footway widening in conjunction with carriageway narrowing* on the section with the imprinted surfacing was effective in improving safety for those on foot. However, the narrowing was the subject of some concern to one local farmer, who was worried about large agricultural vehicles being unable to pass each other, and may have been the reason why safety was not thought to have been improved for cyclists. Speeds were not considered to have been reduced enough.

The *change in priority at the junction* and the *informal pedestrian crossing* were considered to improve safety.

Opinions on the effectiveness of the *gateways*, *roundels and rumble strips* were mixed. The *fencing* was not thought to be effective. Most thought these features did not affect the appearance of the village, but those who disliked them commented that they were out of keeping in a rural village.

There was agreement that the changes were necessary and just over half of those interviewed were satisfied with the scheme overall, but many suggested further speed-reducing measures, for example, speed cameras, humps and chicanes, and more enforcement. More pedestrian crossing facilities, a mini-roundabout at the junction where priority had been changed and measures to discourage through traffic were also suggested.

9.3.5 Accidents

On the main roads within the gateways, there were 7.7 reported injury accidents per year over nearly 5 years before scheme installation and 4.2 per year after over 20 months (although this period is too short for a valid comparison). The majority of the Before accidents occurred on the eastern approach to the village, on a series of bends on Horley Road, either as head-on collisions or single vehicle accidents.

9.4 Discussion

Overall, the success of the scheme (as monitored) in meeting CTMG objectives was mixed. Most of the measures were not visually obtrusive, but the imprinted surfacing was noisy. There were reasonable speed reductions at the gateways and on the continuous imprinted surfacing near the village centre, but initially there was little change elsewhere in the village. The two additional patches of imprinted surfacing installed in November 2000 led to a useful speed reduction, with mean speeds there falling just below the 30 miles/h limit.

The slight reduction in traffic through the village may possibly be attributed to the implementation of peripheral gateways into the Dorking Rural Box and the introduction of an area-wide 40 miles/h speed limit within it.

It is possible that the scheme might reduce bend accidents on the eastern approach to the village as it is likely that these were speed related, with drivers losing control in the majority of cases. Resurfacing might have improved skidding resistance on this section but may encourage higher speeds.

The absence of vertical and horizontal deflections will have limited the speed reductions achieved. The relatively high speeds that still occur at the eastern end of the village suggest that a 20 miles/h limit would not have been appropriate with the current measures.

10 Acknowledgements

The work described in this report was carried out by TRL Limited under a contract placed by the Charging and Local Transport Division of the Department for Transport, Local Government and the Regions. The authors are grateful to Mr E H E Wyatt for his guidance and support.

The authors would also like to thank the staff of Surrey County Council for providing data, plans and background information.

11 References

AEA Technology Environment – National Environment Technology Centre (1997). *Air pollution annual report.* (www.aeat.co.uk/netcen/report96/)

Department for Transport, Local Government and the Regions (1999). *Night restrictions at Heathrow, Gatwick and Stansted (revised restrictions with effect from 31 October 1999)*. London: The Stationery Office.

Department for Transport, Local Government and the Regions (2000). *The sir quality strategy for England, Scotland, Wales and Northern Ireland - working together for clean air.* London: The Stationery Office.

Department of Transport and Welsh Office (1988). *Calculation of Road Traffic Noise (CRTN).* London: The Stationery Office.

Franklin R E, Harland D G and Nelson P M (1979). *Road surfaces and traffic noise.* Laboratory Report LR896. Crowthorne: TRL Limited.

Harland D G (1974). *Rolling noise and vehicle noise.* Laboratory Report LR652. Crowthorne: TRL Limited.

House of Commons (1988). *The noise insulation (amendment) regulations (1988).* Statutory Instrument No. 2000. London: The Stationery Office.

International Organisation for Standardisation (1996). *Acoustics - method for measuring the influence of road surfaces on traffic noise - Part 1: 'The Statistical Pass-By Method'.* ISO 11819-1.

Langdon F J (1976). *Noise nuisance caused by road traffic in residential areas: Part 1.* Journal of Sound and Vibration (1976) vol 47(2) 243-263.

Kennedy J V and Wheeler A H (2001). *Countryside Traffic Measures Group: Demonstration schemes.* TRL Report TRL502. Crowthorne: TRL Limited.

Noise Advisory Council (1978). *A guide to measurement and prediction of the equivalent continuous sound level L*eq. London: The Stationery Office.

Sumner R and Shippey J (1977). *The use of rumble areas to alert drivers.* Laboratory Report LR800. Crowthorne: Crowthorne.

Taylor M C and Wheeler A H (2000). *Changes in accident frequency following the introduction of traffic calming in villages.* Proceedings of the European Transport Conference Seminar J, Cambridge, 11-13 September 2000. Association for European Transport.

Watts G R (1984). *Vibration nuisance from road traffic – results of a 50 site survey.* Laboratory Report LR1119. Crowthorne: TRL Limited.

Webster D C and R E Layfield (1993). *An assessment of rumble strips and rumble areas.* Project Report PR33. Crowthorne: TRL Limited.

Wheeler A, Taylor M and Payne A (1993). *The effectiveness of village 'gateways' in Devon and Gloucestershire.* Project Report PR35. Crowthorne: TRL Limited.

Wheeler A, Taylor M, and Barker J (1994). *Speed reduction in 24 villages: details from the VISP study.* Project Report PR85. Crowthorne: TRL Limited.

Wheeler A and Taylor M (1995). *Reducing speeds in villages: the VISP study.* Traffic Engineering + Control, 36(4) 213-219.

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 TRL212. Crowthorne: TRL Limited.

Wheeler A H, Abbott P G, Godfrey N S, Phillips S M, and Stait R (1997). *Traffic calming on major roads: the A47 trunk road at Thorney, Cambridgeshire.* TRL Report TRL238. Crowthorne: TRL Limited.

Wheeler A, Harris G, Chinn L, Taylor M, and Abbott P (1998). *A traffic calming scheme at Costessey, Norfolk*. TRL Report TRL364. Crowthorne: TRL Limited.

Wheeler A and Taylor M (1999). *Traffic calming in villages on major roads: Final Report.* TRL Report TRL385. Crowthorne: TRL Limited.

Wheeler A H and Taylor M C (2000). *Changes in accident frequency following the introduction of traffic calming in villages.* TRL Report TRL452. Crowthorne: TRL Limited.

Wheeler A H, Kennedy J V, Davies G J and Green J M (2001). *Countryside Traffic Measures Group: Traffic calming schemes in Norfolk and Suffolk.* TRL Report 500. Crowthorne: TRL Limited.

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 Organisation for Standardisation, 1996).

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 Figure A1. The traffic population is categorised into ‘light’ vehicles (which includes all cars and vans with an unladen weight less than 1.5 tonnes) and ‘heavy’ vehicles (all other 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 relationship between the maximum sound level (L_{Amax}) and the speed of a passing vehicle has been shown to take the form (Harland, 1974):

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

where V is the speed of the vehicle in km/h, and a and b are constants.

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 1.0 dB(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.

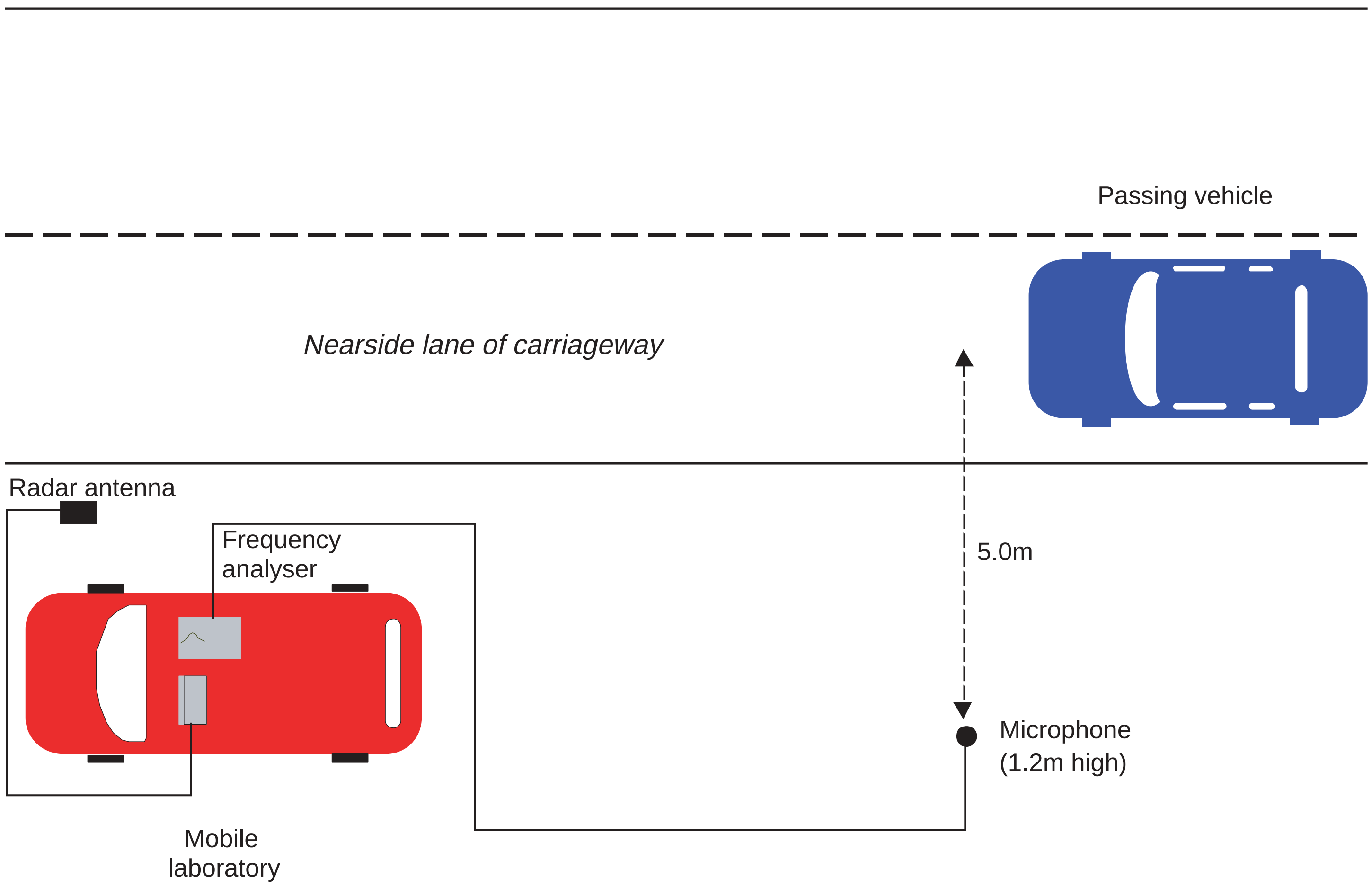


Figure A1 Site layout for Statistical Pass-By (SPB) measurements

Appendix B: Noise measurements – regression statistics

Table B1 Regression analysis of vehicle noise and speed for light vehicles

		*Regression analysis statistics**				
Site	*Survey*	*Constant (a)*	*Slope (b)*	*Standard error (se)*	*Corre -lation (r)*	*Standard deviation dB(A)*
1	Before	17.2	34.0	1.71	0.75	2.57
	After	11.6	37.8	1.56	0.90	3.57
2	Before	23.5	32.5	1.71	0.72	2.47
	After	40.6	24.3	2.33	0.51	2.70

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

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

where	a	=	the constant term
	b	=	the slope of the regression line, b
	se	=	the standard error of the slope
	r	=	the correlation coefficient
and	Standard Deviation	=	the residual standard deviation

All of the regressions were significant at the 5% level.

Appendix C: Noise measurements – minute periods in each hour of Before and After surveys affected by aircraft noise

	Before survey (17- 19 November 1998)				*After survey (30 Nov. – 2 December 1999)*			
	Number of minute periods that met test criterion				*Number of minute periods that met test criterion*			
Time	*Test 1*	*Test 2*	*Test 1, 2*	*Usable periods*	*Test 1*	*Test 2*	*Test 1, 2*	*Usable periods*
	17 Nov.				*30 Nov.*			
15:00	8	0	7	45	9	0	14	37
16:00	13	0	3	44	3	0	17	40
17:00	6	0	8	46	6	0	15	39
18:00	11	0	6	43	8	2	16	34
19:00	12	0	7	41	9	0	21	30
20:00	12	0	6	42	5	0	23	32
21:00	6	0	15	39	5	2	12	41
22:00	3	0	15	42	1	6	9	44
23:00	0	5	5	50	1	2	16	41
	18 Nov.				*1 Dec.*			
00:00	0	2	4	54	0	0	0	60
01:00	1	1	1	57	0	1	0	59
02:00	2	0	3	55	0	1	0	59
03:00	0	0	2	58	0	1	1	58
04:00	0	0	3	57	0	0	4	56
05:00	3	0	4	53	1	4	5	50
06:00	5	0	9	46	0	0	4	56
07:00	7	0	17	36	1	0	12	47
08:00	7	0	13	40	2	0	23	35
09:00	7	0	20	33	3	0	23	34
10:00	0	2	30	28	7	0	26	27
11:00	5	1	24	30	5	1	27	27
12:00	2	0	24	34	4	0	29	27
13:00	5	1	23	31	4	0	25	31
14:00	1	2	18	39	6	2	14	38
15:00	1	0	18	41	6	0	11	43
16:00	1	0	14	45	2	0	10	48
17:00	4	0	10	46	1	0	17	42
18:00	0	0	16	44	2	0	20	38
19:00	5	1	23	31	4	3	22	31
20:00	5	2	18	35	3	2	22	33
21:00	0	0	4	56	1	0	5	54
22:00	0	2	7	51	0	0	9	51
23:00	0	2	1	57	0	0	6	54
	19 Nov.				*2 Dec.*			
00:00	0	0	0	60	3	0	4	53
01:00	0	2	0	58	0	0	1	59
02:00	0	0	0	60	0	0	0	60
03:00	0	2	3	55	0	1	0	59
04:00	0	2	0	58	0	0	1	59
05:00	0	2	3	55	0	1	1	58
06:00	0	0	7	53	0	2	5	53
07:00	0	0	18	42	3	0	17	40
08:00	4	0	17	39	5	0	17	38
09:00	8	0	19	33	4	0	24	32
10:00	3	0	27	30	5	0	27	28
11:00	8	0	18	34	8	0	18	34
12:00	4	2	27	27	6	0	24	30
13:00	5	0	12	43	6	0	23	31
14:00	13	0	5	42	4	0	18	38

Appendix D: Noise measurements – traffic noise prediction model

D.1 General

A method for predicting traffic noise using the L_{Aeq} scale was developed by a Working Party for the Technical Sub-Committee of the Noise Advisory Council (Noise Advisory Council, 1978). The first section below, Section D.1.1, briefly outlines the method and describes the input parameters. The following section, Section D.1.2, then applies the method to predict the change in traffic noise at the survey site.

D.1.1 Basic equation for predicting traffic noise levels, $L_{Aeq,18h}$

The basic equation for predicting traffic noise level, $L_{Aeq,18h}$ is given by the following formula:

$$L_{Aeq,18h} = 10 Log_{10}\left[N \sum_{n=l}^{n=m} p_n .10^{L_{AX_n}/10} \right] + C \qquad \text{(D.1)}$$

where N = total traffic flow over the 18 hour period
m = the number of different vehicle categories
p_n = the percentage of vehicles in the traffic stream which are classified as vehicle category n

and $L_{AXn} = L_{Amax} - 10Log_{10}v$

where L_{Amax} is the maximum pass-by noise level from a vehicle travelling at a speed of v km/h.

L_{AXn} is a measure of the total energy associated with a single vehicle pass-by for a vehicle classified as vehicle category n.

The final term C is constant for a given location, site layout, and specified time period.

To calculate, using equation (D.1), the change in traffic noise level, $L_{Aeq,18h}$, after the traffic calming scheme was installed, requires the following input parameters for both the Before and After situations:

a the traffic flow over a specified time period;

b the number of vehicles in each vehicle category expressed as a percentage of the total flow (%);

c the mean road speed (km/h) for each vehicle category together with the maximum pass-by noise level, L_{Amax} dB(A), at the mean road speed.

D.1.2 Predicting the change in traffic noise level

Table D1 shows the input parameters to the prediction model which were used to predict the change in traffic noise levels attributable to the change in traffic flow and composition. The vehicle speed and noise level data used for the prediction were that obtained alongside the rumble strips.

The L_{AXn} value was calculated for each vehicle category by combining the noise contribution from each vehicle within the category, taking account of the proportion of those vehicles travelling on the road. For each survey the noise contribution from each vehicle category was combined to give the total predicted noise level from all the traffic.

For this analysis the vehicle speeds and maximum vehicle noise levels (L_{Amax}) from the After survey were used as input parameters for the predictions of traffic noise during both survey periods. The expected difference in overall traffic noise due to changes in traffic flow and composition *alone* could then be determined. The results of these predictions estimated that the changes in traffic flow and composition would have caused a reduction of 0.5 dB(A) in the $L_{Aeq,18h}$ level.

Table D1 Input parameters to the prediction model used to predict the change in traffic noise levels resulting from changes in traffic flow and composition

		Light vehicles (n=1)			*Heavy vehicles (n=2)*		
Survey	*Traffic flow* N (veh/18h)*	*Flow p* (%)*	*Speed v (km/h)*	*L_{Amax} (dB(A))*	*Flow p* (%)*	*Speed v (km/h)*	*L_{Amax} (dB(A))*
Before	6,806	92.4	(47.3)**	(74.9)	7.6	(55.7)	(85.3)
After	6,159	92.8	47.3	74.9	7.2	55.7	85.3

* *The traffic flow and percentages were based on automatic classified traffic counts conducted close to the position of site N1.*

** *For the purposes of this analysis (i.e. to determine just the effect of changes in traffic flow and composition) it was assumed that vehicle speed and maximum vehicle noise level (L_{Amax}), were the same during both surveys.*

Appendix E: Air quality monitoring

Table E1 Benzene concentrations (ppb) for each two-week exposure

Control site			*Site AQ1*			*Site AQ2*			*Site AQ3*			*Site AQ4*		
B	AW	AS	B	AW	AS	B	AW	AS	B	AW	AS	B	AW	AS
0.53	0.63		0.68	0.84		0.65	0.81	0.51	1.02	0.41	0.52	0.80	0.72	
0.27	0.32	0.23	0.64	0.39	0.42	0.49	0.35	0.32	0.68	0.33	0.32	0.30	0.63	0.37
0.50	0.83	0.35	0.46	0.94	0.41	0.47	0.91	0.41	0.51	0.77	0.44	0.78	1.00	0.53
0.71	0.57	0.30	1.14	0.63	0.79	0.92	0.66	0.80	0.83	0.50	0.64	0.81	0.57	0.95
0.66	0.28	0.29	0.76	0.36	0.36	1.13	0.36	0.44	0.80	0.32	0.41	0.59	0.41	0.44
0.56	0.37	0.30	0.30	0.52	0.42	0.72	0.50	0.38	0.37	0.63	0.33	0.69	0.53	0.32
0.54		0.25	0.78	0.45	0.42	0.92	0.38	0.38	0.83	0.40	0.31	0.53	0.35	0.37
	0.44			0.55			0.51			0.40			0.57	

B = Before survey - winter (8 December 1998 - 15 March 1999)
AW = After survey - winter (6 December 1999 - 28 March 2000)
AS = After survey - summer (2 May 2000 - 7 August 2000)

Table E2 Comparison between benzene concentrations at kerbside sites and control site

	P – Value	*Difference statistically significant?*
Before survey - winter		
Control – AQ4	0.259	No
Control – AQ3	0.090	No
Control – AQ2	0.063	No
Control – AQ1	0.236	No
After survey - winter		
Control – AQ4	0.321	No
Control – AQ3	0.818	No
Control – AQ2	0.530	No
Control – AQ1	0.390	No
After survey - summer		
Control – AQ4	0.056	No
Control – AQ3	0.024	Yes
Control – AQ2	0.024	Yes
Control – AQ1	0.021	Yes

Table E3 A comparison between summer and winter average benzene concentrations (ppb)

	After (winter)	*After (summer)*	*P-Value*	*Difference statistically significant?*
Control	0.50	0.29	0.037	Yes
AQ1	0.59	0.45	0.232	No
AQ2	0.56	0.46	0.342	No
AQ3	0.47	0.42	0.544	No
AQ4	0.60	0.50	0.402	No

Table E4 NO_2 concentrations ($\mu g/m^3$) for each two-week exposure

Control site			*Site AQ1*			*Site AQ2*		
B	*AW*	*AS*	*B*	*AW*	*AS*	*B*	*AW*	*AS*
12.74	13.53	18.67	22.31	18.39	26.87	17.18	15.72	27.36
12.78	8.29	17.39	11.74	11.86	22.45	12.37	12.74	21.92
13.84	12.90	19.24	19.13	15.72	25.62	15.73	13.48	19.35
14.49	11.97	19.20	17.88	13.38	21.16	17.96	11.76	22.43
17.71	12.73	21.37	29.07	13.42	23.83	17.29	13.00	28.59
20.51	9.96	19.03	27.55	13.94	24.77	28.16	13.56	23.17
21.12	8.41	19.11	29.01	10.60	23.71	24.63	11.21	21.61
	15.86			20.62			18.75	

Site AQ3			*Site AQ4*		
B	*AW*	*AS*	*B*	*AW*	*AS*
16.82	16.61	29.62	22.67	20.91	
9.85	11.40	22.61	14.32	14.30	23.55
12.50	14.77	19.45	20.10	16.99	28.46
20.14	13.28	22.30	22.35	15.85	29.50
23.75	15.74	26.91	30.64	16.71	30.39
26.06	12.50	20.26	26.23	15.33	23.38
26.09	11.02	21.74	28.28	13.40	28.59
	21.56			18.64	

B = *Before survey - winter (8 December 1998 - 15 March 1999)*

AW = *After survey - winter (6 December 1999 - 28 March 2000)*

AS = *After survey - summer (2 May 2000 - 7 August 2000)*

Table E5 Comparison between NO_2 concentrations at kerbside sites and control site

	P – Value	*Difference statistically significant?*
Before survey - winter		
Control – AQ4	0.012	Yes
Control – AQ3	0.285	No
Control – AQ2	0.265	No
Control – AQ1	0.048	Yes
After survey - winter		
Control – AQ4	0.003	Yes
Control – AQ3	0.079	No
Control – AQ2	0.124	No
Control – AQ1	0.432	Yes
After survey - summer		
Control – AQ4	<0.001	Yes
Control – AQ3	0.015	Yes
Control – AQ2	0.007	Yes
Control – AQ1	<0.001	Yes

Table E6 A comparison between summer and winter average NO_2 concentrations ($\mu g/m^3$)

	After (winter)	*After (summer)*	*P-Value*	*Difference statistically significant?*
Control site	11.70	19.14	$1.14x10^{-5}$	yes
AQ1	14.74	24.06	$2.08x10^{-5}$	yes
AQ2	13.78	23.49	$1.81x10^{-5}$	yes
AQ3	14.61	23.67	$4.07x10^{-4}$	yes
AQ4	16.51	27.31	$8.19x10^{-6}$	yes

Appendix F: Questionnaire incorporating results

COUNTRYSIDE TRAFFIC MEASURES GROUP: QUESTIONNAIRE FOR RESIDENTS

Scheme: **Charlwood, Surrey**

Good morning/afternoon/evening. I am from TRL. W are carrying out a survey for the Department for Transport, Local Government and the Regions about people's opinions of the traffic calming scheme in this village.

Q.1 Were you living in the village before 1999? *(base: 150)*		ROUTE
Yes	100%	Q.2
No	-	Discontinue Interview

Q.2 Recently some changes were made on the main roads into and through the village to slow the traffic. Are you aware of this? *(base: 150)*		ROUTE
Yes	100%	Q.3
No	-	Discontinue Interview

Q.3 Thinking back before these changes were made, did the main roads through the village and their traffic cause any problems? *(base: 150)*
(*Probe fully and write in below)*

Traffic too fast/speeding traffic: 51%
Volume of traffic / heavier/heavy traffic: 19%
Heavy traffic especially at peak times: 13%
Congested/busy: 10%
Difficult to cross road: 9%
Lots of heavy lorries: 7%
Children couldn't cross the street: 7%
Difficult to reverse into/out of own drive: 6%
Serious accidents: 5%
Dangerous for young children: 5%
Airport traffic: 5%
Parking on road: 4%
Dangerous: 3%
Dangerous/speeding local lorries: 3%
Drivers unfamiliar with bends in village: 3%
Delays emerging onto main road: 3%
Very noisy: 3%
'Rat run' to Dorking: 2%
Difficult for elderly: 2%
No footpath: 2%
Hard to park in village: 1%
Flooding: 1%
Bad driving: 1%
Parking on road opposite recreation ground: 1%
Obstructed vision: 1%
Dangerous for pets: 1%
Obstructed vision for drivers from Chapel Road: 1%
Main road used to avoid traffic congestion in Crawley: 1%
Traffic speeding near park: 1%
Difficult to turn into main road: 1%
Other: 25%

ROUTE:
Q.4

Q.4 How effective do you consider the following changes that have been made in making the village safer? *(base: 150)*

Mean scores in brackets (based on: very effective = 3; fairly effective = 2; not effective = 1)

	Very effective	Fairly effect- -ive	Not effect- -ive	Don't know/ No opinion
New signing on village approaches (1.56)	3%	29%	67%	1%
30 miles/h roundels on the road on village approaches (1.57)	9%	35%	52%	4%
Rumble strips on Horley Road/Norwood Hill Road approaches (1.46)	12%	33%	54%	1%
New fencing on Horley Road and Norwood Hill Road (1.17)	3%	9%	79%	8%
Different surfacing (cobbled effect) in village centre (1.90)	27%	35%	36%	2%
Pedestrian facilities near shops (dropped kerbs/tactile paving/highlighted carriageway etc) (1.75)	16%	35%	38%	11%
Changed priorities at Norwood Hill Road/Rectory Lane junction (1.89)	33%	17%	43%	7%
Narrower carriageway and wider footways (2.04)	32%	31%	28%	9%

ROUTE
Q.5

Q.5. How do you feel about the appearance of the village since the changes? *(base: 150)*	CODE	ROUTE
Mean score (based on: very satisfied = 4; fairly satisfied =3; no opinion either way = 2; not satisfied = 1) = 2.72		
Very satisfied	25%	
Fairly satisfied	39%	
No opinion either way	19%	
Not satisfied	17%	
Don't know	1%	Q.6

Q.6 What effect do you think the following changes have on the appearance of the village? Do they improve it, spoil it or do they make no difference? *(base: 150)*

Mean scores in brackets (based on: improves appearance = 3; makes no difference = 2; spoils appearance = 1)

	Improves appearance	Makes no difference	Spoils appearance	Don't know
New signing on village approaches (2.05)	35%	35%	30%	-
30 miles/h roundels on the road on village approaches (2.01)	15%	71%	13%	1%
Rumble strips (1.84)	11%	61%	27%	2%
New fencing on Horley Road and Norwood Hill Road (2.00)	41%	18%	41%	1%
Different surfacing (cobbled effect) in village centre (2.46)	61%	21%	16%	1%
New kerbs on Rectory Lane (2.25)	40%	19%	20%	21%

ROUTE:
For each item ringed '3' in Q.6, ask Q.6A
If none, go to Q.7

Q.6a What is it about the.... that spoils the appearance of the village?
All those stating *new signing on village approaches* spoils appearance (*base: 45)*   Not suitable / not in keeping with village / less rural: 44%   Spoils country road / looks urban: 18%   Gate should be green / not white / white is an eyesore: 16%   Looks better without / unattractive: 13%   Prefer countryside look: 9%   Looks modern: 7%   Pointless: 7%   Looks like Dallas / American / Legoland: 4%   Waste of money: 4%   Paint already peeling / looking tatty: 4%   Surplus to requirements / unnecessary: 4%   Intrusive: 4%
All those stating *30 miles/h roundels on the road on village approaches* spoils appearance *(base: 20)*   Not suitable / not in keeping with village / less rural: 30%   Spoils country road / looks urban: 25%   Spoils appearance of road: 20%   Doesn't work / ineffective: 15%   Surplus to requirements / unnecessary: 15%   Pointless: 5%   Looks modern: 5%
All those stating *rumble strips* spoil appearance *(base: 40)*   Not suitable / not in keeping with village / less rural: 25%   Doesn't work / ineffective: 20%   Looks better without / unattractive: 18%   Spoils country road / looks urban: 18%   Spoils appearance of road: 15%   Easier / no problem if go over them fast: 10%   Gives appearance of road dug up / potholes: 8%   Damage to cars: 8%   Prefer countryside look: 5%   Jarred around in car / vibrations: 3%   Residents' homes shake: 3%   Wearing out where lorries go over them: 3%   Noisy / increased noise: 3%   Looks modern: 3%   Other: 3%
All those stating *new fencing on Horley Road and Norwood Hill Road* spoils appearance *(base: 61)*   Difficult to maintain / cut hedges: 31%   Pointless: 26%   Waste of money: 18%   Prefer natural hedge: 16%   Looks better without / unattractive: 15%   Spoils country road / looks urban: 13%   Not suitable / not in keeping with village / less rural: 11%   Prefer verge to road / more 'country' appearance: 7%   Horses dangerous / if fall off / as no verge: 7%   Will go rotten / will fall down / due to lack of funds: 5%   No room to escape if cars too close: 5%   Dangerous: 3%   No footpath for walking: 3%   Artificial: 2%   Doesn't work / ineffective: 2%   Other: 3%

Q.6A (continued)

All those stating *different surfacing (cobbled effect) in village centre* spoils appearance *(base: 24)*

Noisy / increased noise: 33%
Not real cobblestones: 21%
Artificial: 21%
Looks better without / unattractive: 17%
Spoils appearance of road: 13%
Dangerous: 13%
Doesn't work / ineffective: 13%
Easier / no problem if go over them fast: 13%
Hazard / people trip over: 8%
Cobbles slippery when wet / icy: 8%
Spoils country road / looks urban: 8%
Wearing out where lorries go over it: 4%
Jarred around in car / vibrations: 4%
Damage to cars: 4%
Surplus to requirements / unnecessary: 4%
Unsuitable for walking: 4%
Other: 3%

All those stating *new kerbs on Rectory Lane* spoil appearance *(base: 30)*

Prefer verge to road / more 'country' appearance: 33%
Spoils country road / looks urban: 30%
Too high / tall / deep: 20%
Not suitable / not in keeping with village / less rural: 17%
Dangerous: 13%
Dislike square kerbs / straight : 10%
No room to escape if cars too close: 10%
Increased flooding: 7%
Like a race track / cars go faster: 7%
Looks better without / unattractive: 3%
Other: 3%

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 *(base: 150)*

Mean scores in brackets (based on: agree a lot = 5; agree a little = 4; no opinion = 3; disagree a little = 2; disagree a lot: 1)

	Agree a lot	Agree a little	No opinion	Disagree a little	Disagree a lot	DK
The changes were necessary (3.86)	48%	25%	3%	11%	13%	1%
They have improved the appearance of the village (3.06)	13%	42%	6%	17%	22%	-
The changes make it safer/easier to cross the road (3.06)	21%	29%	5%	16%	25%	4%
They make it safer to walk along the footways (3.81)	39%	33%	6%	8%	12%	2%
They make it safer for motorists (2.65)	8%	23%	16%	25%	23%	5%
They make it safer for cyclists (2.32)	6%	16%	13%	23%	34%	8%
They have reduced speeds (2.83)	12%	39%	-	16%	32%	1%
They have reduced speeds enough (1.91)	7%	14%	1%	18%	58%	2%
They have increased noise (3.47)	31%	21%	17%	8%	15%	9%
They have increased traffic fumes (2.42)	7%	9%	26%	12%	30%	16%
They should be introduced in other villages (3.02)	14%	25%	21%	10%	21%	9%
The environment in the village has been improved (2.85)	9%	32%	12%	21%	22%	3%

ROUTE:
Q.8

Q.8 Would you suggest any improvements to the changes in the village? *(base: 150)*

(Write in)

Continue cobbles right through:	13%
Need speed cameras:	12%
Introduce speed humps:	11%
Continue rumble strips through village:	10%
More narrowing in village centre:	6%
Put motorists off coming through village:	5%
Anything to slow down traffic:	5%
Sight of a policeman / police presence / radar:	5%
Proper pedestrian crossing on highlighted area:	5%
Remove fencing from Norwood Hill Road:	4%
Remove rumble strips:	4%
Remove signs:	4%
Roundabout at Norwood Hill junction (with Rectory Lane):	3%
Need crossing by the park e.g. Chapel Road:	3%
Need directions for Norwood Hill Lane:	3%
20 miles/h speed limit:	3%
High pavements Horley Road dangerous:	3%
Different road surface colours red/green:	3%
30 miles/h speed limit on main road:	2%
Bigger humps:	2%
Zebra crossing near school:	2%
Chicanes at village entries:	2%
Change priorities on main road entering village:	2%
Introduce weight restriction:	2%
Mini-roundabout at bottom of village:	2%
Pedestrian crossing near shop:	2%
Need a safe place to cross:	2%
Pedestrian crossing near pub:	2%
Footpath on Ifield Road to village:	2%
Need yellow lines to restrict parking by pubs:	1%
Replace signs with something more rustic:	1%
Mini-roundabout by village hall:	1%
Link road off Dorking road to airport:	1%
Mini-roundabout top of village:	1%
Need parking for village shops:	1%
Roundabout at Lowfield Heath Road junction:	1%
Address problem of blind spot at Norwood Hill Lane:	1%
Need footpaths along Runs Hill Road:	1%
Other:	21%
None:	10%

ROUTE: Q.9

Q.9 How satisfied are you overall with the changes that have been made in the village so far *(base: 150) (Read out)* *Mean score (based on: very satisfied =5; fairly satisfied = 4; no opinion either way = 3; fairly dissatisfied = 2; very dissatisfied = 1) = 3.07*	CODE	ROUTE
Very satisfied	7%	
Fairly satisfied	45%	
No opinion either way	13%	
Fairly dissatisfied	19%	
Very dissatisfied	16%	
Don't know	-	Q.10

Q.10 Did you hear about the changes in Charlwood before they occurred? *(base: 150)*	CODE	ROUTE
Yes	96%	Q.10a
No	4%	Q.13
Can't remember	-	Q.13

Q.10a If yes, how? *(base: all who heard about changes beforehand – 144)*		
(Do not read out) Leaflets	34%	Q.11
Attended exhibition/public meeting	37%	Q.11
From friends/relatives	17%	Q.11
Local papers	10%	Q.11
Local radio	-	Q.11
Public notices in the street	12%	Q.11
Can't remember	5%	Q.13
Other *(write in below)*		Q.11
Notice in shops	8%	
Letter / mailshot	16%	
Door-to-door survey	2%	
Parish Council meeting	1%	
From parish councillor	2%	
Unspecified	3%	

Q.11 Was enough opportunity given overall for people to say what they thought about the traffic calming scheme? *(base: all who heard about changes from a specific source – 137)*	CODE	ROUTE
Yes	71%	.
No	21%	
Can't remember	8%	Q.12

Q.12 Were you satisfied with the information given about the proposed scheme? *(base: all who heard about changes from a specific source – 137)*	CODE	ROUTE
Yes	63%	Q.13
No opinion either way	4%	Q.13
No	28%	Q.12a
Don't know/can't recall	6%	Q.13

Q.12a If no, for what reason? (*Write in) (base: all dissatisfied with information about scheme – 38)*

Insufficient detail: 37%
Confusing / not clear: 26%
Only given two options: 11%
No one knew what was going on beforehand: 11%
Insufficient consultation: 11%
Should have model of village showing plan: 11%
People already made up minds: 11%
Could not reject both options: 5%
Kept changing: 5%
Parish council had own agenda: 3%
Other: 3%

ROUTE
Q.13

Q.13 CLASSIFICATION

	CODE		CODE
(A) Sex *(by observation)* Male Female	 40% 60%	**(D)** Do you have any children in the household? Yes No If yes, how old are they? *(Ring all that apply)* Under 5 5-10 11-16	 37% 63% 13% 19% 22%
(B) What age group do you come in? 18-29 30-44 45-59 60+	 7% 35% 21% 38%	**(E)** Do you do any of the following? *(Ring all that apply)* Drive a car or van Drive a lorry Ride a motorcycle Ride a pedal cycle None of these	 83% 2% 4% 29% 12%
(C) Live on or off the main road? *(by observation)* On main road Elsewhere	 44% 56%	**(F)** What is your working status? Employed full time Employed part-time Self-employed Unemployed Housewife Retired	 29% 15% 5% 5% 13% 33%

THANK AND CLOSE

Abstract

In November 1999, traffic calming measures were implemented in the Surrey village of Charlwood. They were installed as an element of the Dorking Rural Box (DRB) scheme, part of Surrey County Council's Strategic Traffic Area Reduction (STAR) initiative. The Dorking Rural Box scheme was submitted under the Countryside Traffic Measures Group (CTMG) initiative, a joint initiative of the Countryside Agency and the Department for Transport, Local Government and the Regions. The initiative aimed to support the planning and implementation by local authorities of innovative rural traffic schemes designed to integrate sensitively into the local environment. The DRB (bounded by the A24, A25, A217 and A264) suffered from London commuter traffic and traffic to and from nearby London Gatwick Airport. The aims of the DRB scheme were to reduce this traffic by implementing an area-wide 40 miles/h speed limit entered by gateways, with 20 miles/h limits in villages (to be traffic calmed) within the area, benefiting other road users such as walkers, cyclists and horse riders.

The report describes a traffic calming scheme in Charlwood, the first village within the DRB to be treated. It presents the results of monitoring undertaken to assess its effectiveness in terms of vehicle speeds, noise, air quality and public attitudes.

Related publications

TRL504 *Norfolk Quiet Lanes Scheme: 'Before' monitoring* by J V Kennedy and A H Wheeler. 2001 (price £35, code H)

TRL503 *Kent Quiet Lanes Scheme: 'Before' monitoring* by J V Kennedy and A H Wheeler. 2001 (price £35, code H)

TRL502 *Countryside Traffic Measures Group: Demonstration schemes* by J V Kennedy and A H Wheeler. 2001 (price £35, code H)

TRL500 *Countryside Traffic Measures Group: Traffic calming schemes in Norfolk and Suffolk* by A H Wheeler, J V Kennedy, G J Davies and J M Green. 2001 (price £50, code L)

TRL452 *Changes in accident frequency following the introduction of traffic calming in villages* by A H Wheeler and M C Taylor. 2000 (price £25, code E)

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

TRL364 *A traffic calming scheme at Costessey, Norfolk* by A H Wheeler , G Harris, L Chinn, M C Taylor and P Abbott. 1998 (price £35, code J)

TRL238 *Traffic calming on major roads: the A47 trunk road at Thorney, Cambridgeshire* by A H Wheeler, P G Abbott, N S Godfrey, S M Phillips and R Stait. 1997 (price £50, code L)

TRL212 *Traffic calming on major roads: the A49 trunk road at Craven Arms, Shropshire* by A H Wheeler, P G Abbott, N S Godfrey, D J Lawrence and S M Phillips. 1996 (price £50, code L)

Prices current at July 2001

For further details of these and all other TRL publications, telephone Publication Sales on 01344 770783 or 770784, or visit TRL on the Internet at www.trl.co.uk.