TRANSPORT RESEARCH LABORATORY

Leeds guided busway study

Prepared for Buses and Taxi Division, Department of the Environment, Transport and the Regions

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Executive Summary

The Transport Research Laboratory was commissioned by the Department of Transport (now the Department of Environment Transport and the Regions) to monitor and assess the impact of the first major bus guideway scheme in the UK. The scheme along Scott Hall Road in Leeds, includes a 450 m outbound guideway (Phase 1) located on the nearside of the carriageway and a 750m inbound guideway (Phases 2 and 3) located in the central reserve of a dual carriageway. All junctions that intersect the guideway are roundabouts, on the approach to which buses are given priority via a remote control signal technique. Other elements of the scheme included the signalisation of a busy junction, introduction of a contra-flow bus lane to improve the access of buses into the city centre, and re-routing buses along more direct paths.

Extensive surveys were undertaken to assess the effects of the scheme on bus service performance, public transport patronage and the consequences to other traffic. Analysis of the journey time data revealed that the inbound guideway improved bus journey times by an average of 70 seconds during the morning peak, but this increased to 2 minutes during the height of the peak. Isolating buses from the worst of the congestion reduced the variability of bus journey times by 75 per cent. The signalling technique used to give buses priority onto the roundabout improved average bus journey times by between 5-10 seconds although this could be as much as 30 second when the roundabout was most congested. Beyond the guideway, both buses and general traffic suffered increased delays on the approach to the busy Sheepscar Intersection, eroding much of the benefit accrued within the guideway. Bus journey times improved by about 40 seconds with the re-routing of buses into the city centre via a contra flow bus lane on North Street.

There is some evidence to suggest that southbound peak hour traffic flows on Scott Hall Road have decreased by up to 11 per cent. This is in contrast to changes on a parallel Corridor where flows have increased by between up to 26 per cent. It is suspected that this diversion of traffic away from Scott Hall Road is not due to the guideway delaying traffic, but rather to avoid the long delays that now build up on the Scott Hall Road approach to the Sheepscar Intersection. These changes suggest that although Scott Hall Road is still the busiest route into the City, its relative popularity when compared to Meanwood Road and Harrogate Road has decreased.

The success of the outbound guideway was mixed; while bus journey times improved by up to 2½ minutes within the guideway (compared to general traffic alongside it), they were delayed by increased traffic queues which extended past the end of the guideway. It has been estimated that this additional delay can be as high as 110 seconds during the height of the peak. The signalling technique used to give buses priority onto the roundabout was thought to be partly responsible for the increase in general traffic queues, but an increase in downstream traffic flows could not be ruled out.

The findings of two questionnaire surveys, which aimed to discover what car drivers and bus passenger thought of the scheme, are also detailed in this report.

1 Introduction

1.1 The study

TRL was commissioned in 1993 by the Department of Transport (now the Department for the Environment, Transport and the Regions) to carry out surveys and research on the Leeds Guided Busway - the first major scheme of its type in the UK. To assess the effects of the scheme on bus performance and the consequence for other traffic a comprehensive set of 'before' and 'after' surveys was undertaken. These surveys monitored, bus journey time, general traffic journey time, traffic flow and vehicle occupancy along Scott Hall Road and two parallel corridors, namely Meanwood Road and Harrogate Road/ Chapeltown Road.

A questionnaire survey was also undertaken by TRL in 1998 to assess the views of car drivers and bus passengers to the guideway and bus services along Scott Hall Road.

This reports begins by describing each phase of the scheme, detailing the infrastructure changes along in the study area between 1992 and 1998. A description of the journey time surveys is followed by a summary and discussion of the key results from these surveys (a more detailed account of the journey time analysis is given in Appendix A). A section describing the bus passenger and car driver surveys, is followed by the conclusions which draws together all the principle findings from the various surveys.

1.2 Background to the scheme

1.2.1 Leeds City Council transport strategy

In common with many major cities, Leeds suffers daily from congestion during the peak periods. In 1994 over 330,000 vehicles entered Leeds each day, amounting to approximately 430,000 person trips (assuming 1.3 persons per vehicle)[Leeds City Council, 1991a]. The City Council predicted that by 2010 general traffic levels will have grown by over 30 per cent during the peak times and by up to 60 per cent during the off-peak, though well before this time many parts of Leeds urban road system would become over saturated [Leeds City Council, 1995].

To ease traffic congestion in and around Leeds, the City Council proposed a Transport Strategy [Leeds City Council, 1991b]. The Strategy emphasised the importance of the public transport network and proposed ways by which it could be improved.

In recognition of the importance of buses to the transport network, the Strategy recommended improvements to the quality and reliability of the bus network. To achieve this, the Strategy supported the introduction of more bus priority measures such as bus lanes and signalling changes to help buses through junctions. One proposal, thought to be the best way of improving and promoting bus services was to build bus guideways along congested sections of the Primary Road Network. These guideways would isolate buses from the worst effects of congestion enabling them 'to compete with the car in terms of journey time and reliability'. Proposals for bus guideway schemes came under the *SUPER BUSWAY* Strategy.

1.2.2 The SUPER BUSWAY *strategy*

The *SUPER BUSWAY* concept

The *SUPER BUSWAY* strategy was developed by the City Council in collaboration with West Yorkshire Passenger Transport Executive and the City's main bus operators, notably Yorkshire Rider Limited (now Leeds City Link).

The advantage of bus guideways is that unlike conventional bus lanes, buses are physically separated from traffic on the main carriageway. This effectively prevents unauthorized use by other road traffic, reducing misuse and illegal parking which is commonplace with conventional bus lanes.

Locating the guideways along congested sections of road i.e. at the approach to major junctions, would allow buses to by-pass traffic queues and so eliminate the worst delays. This should produce faster and more consistent bus journey times along the whole route, so making bus and cars journey times comparable. In association with the introduction of strategically located Park & Ride sites the *SUPER BUSWAY* strategy was designed to attract car users onto the buses.

Guided bus demonstration projects

In its 1991 Transport Policies and Programme (TTP) the City Council proposed to establish two Guided Bus Demonstration projects along York Road and Scott Hall Road, two radial corridors approaching Leeds from the east and north respectively.

1.2.3 Design and operation principles for bus guideways

Construction of the guideway

The guideway is constructed by laying two edge beams or kerbing horizontally, at a precise distance apart (2600 mm). The kerbing is constructed from pre-cast concrete except at breaks in the guideway (e.g. to accommodate a pedestrian crossing) where steel guide rails are used. The buses travel on two concrete running strips which are approximately 0.5 m wide with a 1.6 m gap between them, which is filled with a free draining granular material.

The guideway costs about £700 per metre to construct but this can more than double if services such as street lighting, traffic signals, or statutory undertaker services need to be relocated. The main design constraint on the materials used came from the effects of the wheel loading on the concrete track. The sideways force imparted onto the kerbs by the guidewheels was not a major design constraint on the type of materials used for the kerbing.

The basic dimensions adopted for the guideways were derived from a review of the standards used in Essen (Germany) and Adelaide (Australia) [Yorkshire Rider, 1989]. The dimensions adopted are shown below with cross sectional diagrams to illustrate the various layouts used on Scott Hall Road.

- Width of guideway (between the guiderails) 2.60 m
- Height of guiderail above carriageway 0.18 m
- Width of single guideway without pedestrian refuge (Figure 1) 4.60 m
- With of single guideway with pedestrian refuge (Figure 2) 7.20 m

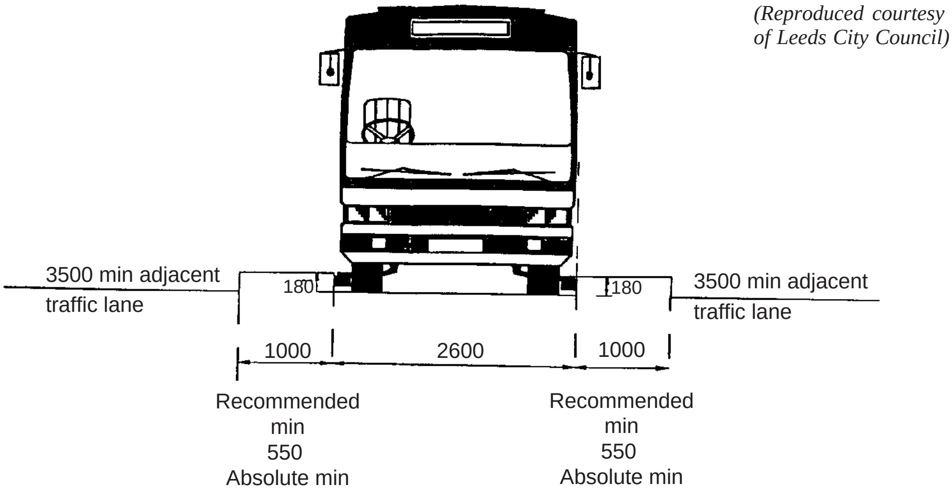

Figure 1 Single guideway without pedestrian refuge

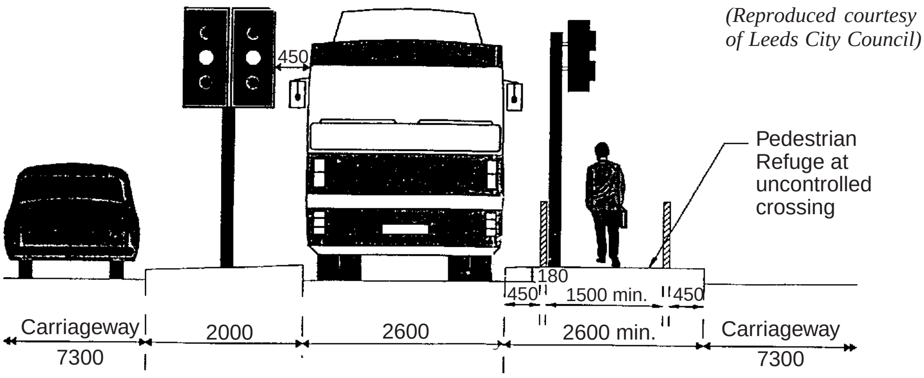

Figure 2 Single guideway with pedestrian refuge

The bus guideways on Scott Hall Road were located on either the nearside of the carriageway like a conventional with-flow bus lane, or, where space allowed, within the central reserve.

Operation of the guideway and junction control

As the bus approaches the guideway, the driver steers the bus into a funnel section. At some point within this section the guidewheels make contact with the guiderails which smoothly adjusts the path of the bus into the guideway. Once in the guideway, the steering is controlled automatically by the guidewheels bearing against the kerbing. The driver simply controls the acceleration and braking. At the end of the guideway the edge kerbing flares out allowing the driver to regain steering control and guide the bus smoothly onto the main carriageway.

To give buses priority at the two roundabouts that intersect the proposed guideway on Scott Hall Road, a technique of limited remote signal control was used. This technique involved installing signals on each approach to the roundabout that accommodates a guideway. These remote signals are installed approximately 30 m back from the roundabout give-way line creating a bus advance area between the signal/ pedestrian crossing and the roundabout. Buses are detected via a transponder located in the guideway, upstream of the junction. This triggers a red signal at the pedestrian crossing which holds general traffic away from the roundabout for a short period of time. During this time buses are free to bypass the signals and rejoin the main carriageway ahead of the general traffic. From this position buses have an unhindered path to the roundabout give-way line from where they can negotiate the roundabout in the conventional manner.

The buses

To use the guideway, buses must be adapted by attaching small guidewheels to the steering arms just forward of the front wheels. Adapting the buses is relatively cheap, costing about £3000 per bus [Pope AS, 1992].

The bus stops

Where bus stops are located within the guideway sections the kerb is raised so that the boarding platform and bus floor are at virtually the same level. The horizontal distance between the boarding platform and bus floor is a matter of millimeters. Along sections of the route where there is no guideway, bus stops may be modified to incorporate a raised boarding platform. This allows buses fitted with guidewheels to use the raised kerbing alongside the bus stop as a docking bay, allowing close alignment of the bus to the kerb edge. This minimises the step between kerb and bus and, with the newer low-floor buses which kneel, eliminates it altogether.

Bus stops located along a central section of guideway require good pedestrian crossing points to give passengers easy and safe access to the bus stop. Therefore all proposals for centrally located bus stops included installation of pelican crossings on each side of the carriageway.

Pedestrian facilities

The introduction of bus guideways along the nearside or central reserve of a dual two-way carriageway, created several safety implication for the safe movement of pedestrians.

To ensure the safety of pedestrians the four major crossing points within the guideway sections were signalised with pelican crossings. It was also important that once across the guideway there was a pedestrian refuge allowing crossing the road to take place in three discrete movements. To deter people from crossing between formal crossing points a pedestrian ‘unfriendly’ surface was used between the main carriageway and the guideway. Although this would deter some people from crossing it was thought that when faced with a 400 m detour to the nearest crossing point deterrents such as fencing and unfriendly pedestrian surfaces are unlikely to deter able body pedestrian. As a consequence a minimum 1 m verge on each side of the guideway allowed these pedestrians a safe enough location to wait within the central reserve.

The need to provide some crossing facilities at points along the route where pelican crossing were not justified (due to the low number of people wanting to cross) meant that at certain points the guideway was broken to allow low numbers of pedestrians to cross more easily at intermediate locations.

Park & Ride

It was expected that 60 per cent of car drivers who make the change onto Superbus routes will catch the guided buses near their home. However to increase the modal shift from car to bus, two Park & Ride sites are proposed, to appeal to car drivers who do not live near a Superbus route. The P&R sites will cater for between 150 and 200 cars.

2 The Scott Hall Road bus priority scheme

The bus priority scheme along Scott Hall Road was introduced in phases over several years. As well as sections of guideway, the scheme included junction improvements and modifications, conventional bus lanes, changes to bus routes and a Park and Ride site.

2.1 Description and operation of the bus guideways

2.1.1 Location of the scheme

Scott Hall Road (A61) is a major route from the north into Leeds city centre (Figure 3). The road starts near the Outer Ring Road (A6120) and continues southwards towards Sheepscar and the city centre. The dual two lane carriageway is on the Primary Route Network and carries traffic from Harrogate and North Leeds to the city centre, M1 and M62.

There are six major junctions between the Outer Ring Road and the Sheepscar Intersection; four are roundabouts of various shapes and sizes, at Stonegate Road, King Lane, Stainbeck Lane and Potternewton Lane while the other two are located at the intersections with Street Lane and Stainbeck Road.

The frontages on the northern section of Scott Hall Road are mostly residential, set behind grass verges. South of Potternewton Lane the A61 passes through an area of open space, and past low density public housing and commercial property. The road is dual carriageway along its entire length with a grassed central reserve which varies in width along the route. The average width of the central reserve on Scott Hall Road is:

- 4.1 m between Stonegate Road and Potternewton Lane.
- 5.7 m between Potternewton Lane and Buslingthorpe Lane.

There is a arterial corridor either side of Scott Hall Road. To the west, Meanwood Road runs in a north westerly direction, while the Harrogate Road/ Chapeltown Road corridor runs almost parallel to Scott Hall Road on the eastern side. In contrast to Scott Hall Road, Meanwood Road and Chapeltown Road both single carriageway roads. These three major routes from the north converge at the Sheepscar Intersection just north of the city centre.

The Sheepscar Intersection is a complicated junction distributing traffic on seven main roads (Figure B1). Meanwood Road, Sheepscar Street North, Chapeltown Road and Barrack Road all feed in from the north, while Claypit Lane, North Street and Sheepscar Street South feed traffic in from the south. The large number of roads intersecting at this point combined with high traffic demand necessitates a complicated junction layout with many signalised junctions.

Claypit Lane links the Sheepscar Intersection with the Inner Ring Road (A58M), while North Street is the main route taken by buses to access the city centre via Vicar Lane. Sheepscar Street South and Regent Street (A61) link the Sheepscar Intersection with York Road (A64).

2.1.2 The northbound guideway (Phase 1)

Phase 1 of the scheme introduced a 450 m northbound nearside guideway on the approach to the Potternewton Lane roundabout. A diagram of Phase 1 showing the location of the bus stops and two pedestrian crossings is shown in Figure 4, while Plate 1 is a photograph of Phase 1 looking southwards towards the city centre from the Potternewton Lane roundabout.

The guideway is terminated at the entrance to the roundabout. To improve the access for buses onto the roundabout, traffic on the main carriageway is held back at the pelican crossing each time a bus is detected in the guideway. This technique of limited remote signal control is discussed in Section 1.2.3. When a bus is detected in the guideway, the signals at the pelican crossing turn red for

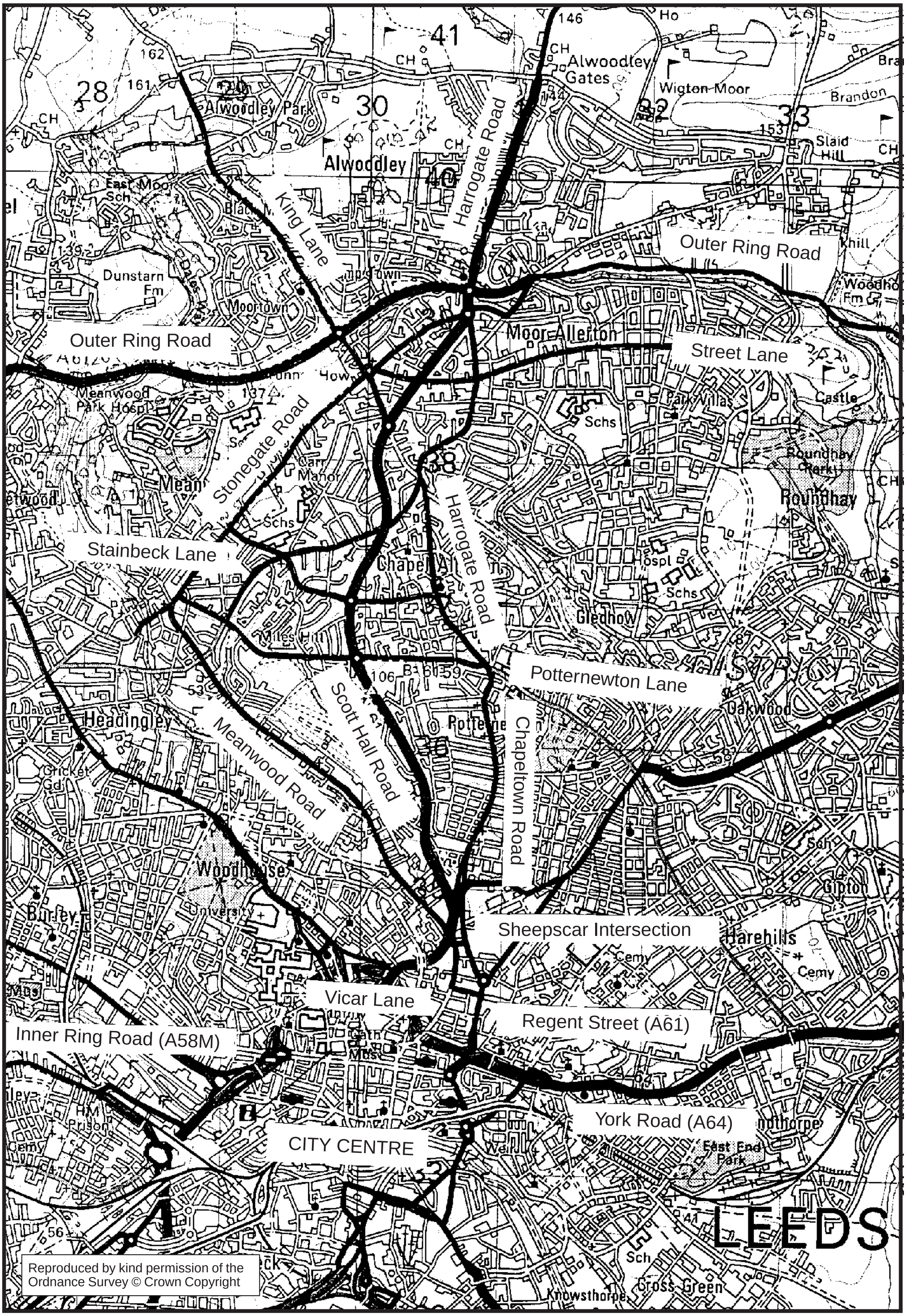

Figure 3 Location of Scott Hall Road in relation to Leeds city centre

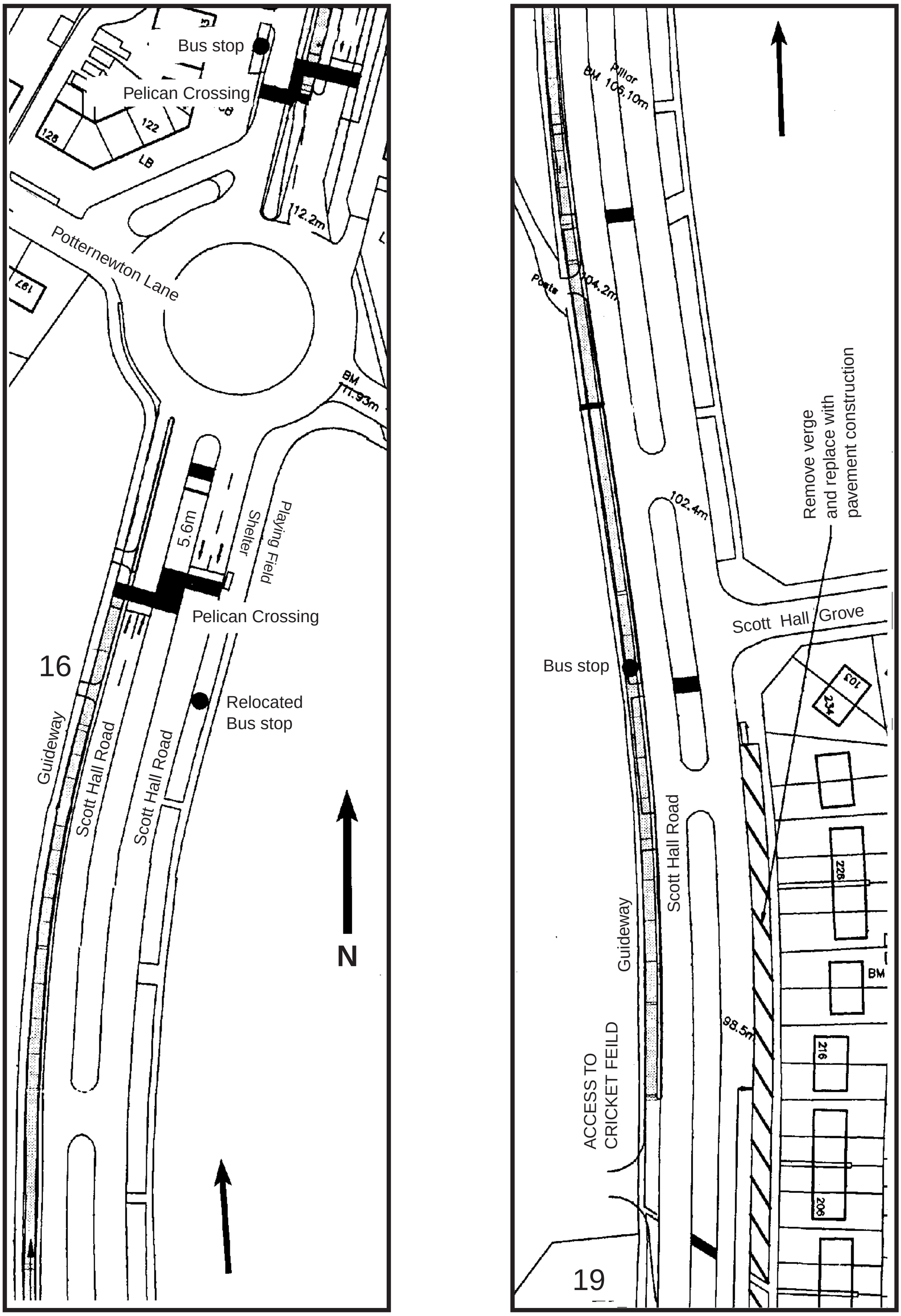

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Figure 4 Layout of northbound guideway (Phase 1)

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Plate 1 Photograph of the northbound guideway (Phase 1)

vehicles on the main carriageway. This allows the reservoir between the pelican crossing and roundabout (a distance of 38 m) to empty, so that by the time the bus arrives at the end of the guideway there are, in theory, no vehicles on the carriageway directly to the right of the bus. The bus must however still give way to circulating traffic that has entered from the other roundabout arms. This is illustrated by Plate 2 which shows a photograph of a bus as it approaches the end of the guideway. The foreground shows the end of the northbound guideway as it approaches the roundabout while in the background the end of the Phase 2 guideway can be seen as it approaches the roundabout in the central reserve.

Phase 1 was officially opened on the 25th September 1995 by which time all Yorkshire Rider/Leeds City Link buses that operated along Scott Hall Road were fitted with guidewheels and displayed the new Superbus livery. A special timetable leaflet was also issued by the PTE, showing a slightly better service than before.

2.1.3 The southbound central guideway (Phase 2)

The only feasible position to locate a guideway north of the Potternewton Lane roundabout is in the central reserve because of the frontage development and the multitude of private accesses along this part of Scott Hall Road. Phase 2 therefore introduced a 370 m central southbound guideway between the Stainbeck Lane and Potternewton Lane roundabouts. This phase of the scheme was completed during November 1996, the same time as the southbound contra-flow bus lane along North Street (Section 2.1.7). The layout of phase 2 which includes the guideway and the Potternewton Lane roundabout is shown in Figure 5.

Exiting the Stainbeck Lane roundabout, buses enter phase 2 of the guideway from the outside traffic lane. Approximately 30 m into Phase 2 there is a centrally located bus stop (believed to be the first of its kind in the UK). To allow bus passengers safe access to the bus stop, pelican crossings are provided on each side of the carriageway (Figure 5).

Beyond the bus stop, buses continue along the guideway, passing through another signalised pedestrian crossing (just south of Miles Hill View, see Plate 3), until they reach the Potternewton Lane roundabout (Plate 4). The signals at the pedestrian crossing are activated by buses detected in the guideway, giving them unhindered access to the roundabout give way line (Section 1.2.3).

Figure 5: Layout of the central southbound guideway and the Potternewton Lane roundabout (Phase 2)

2.1.4 The southbound central guideway (Phase 3)

By April 1997 Phase 3 had been completed which extended the central guideway of Phase 2 northwards from the Stainbeck Lane roundabout to Wensley Drive.

The layout of the Phase 3, the detailed modifications made to Stainbeck Lane roundabout (which links Phases 2 and 3), the location of the pedestrian crossings, and centrally located bus stop are all shown in Figure 6. A photograph showing the guideway as it approaches Stainbeck Lane is given in Plate 5. To improve bus access to the roundabout the same signalling technique was used as that on the approach to the Potternewton Lane roundabout (Section 1.2.3).

Buses travelleing south along Scott Hall Road access the guideway at Wensley Drive from the outside lane (Plate 6). Buses can then travel unhindered along the guideway until

(Reproduced courtesy of Leeds City Council)

Plate 2 Traffic held at the pelican crossing as bus approaches the roundabout

they reach the Stainbeck Lane roundabout. The distance between Wensley Drive and the Stainbeck Lane roundabout, approximately the length of Phase 3, is 380 m.

The guideway allows southbound buses to bypass queues of traffic that have built up on the approach to the Stainbeck Lane roundabout. Buses exit the guideway into the outside lane between the roundabout give-way line and the pelican crossing. From the outside lane buses move onto and across the roundabout, exiting in the outside lane from where they can rejoin the guideway.

2.1.5 Modification to the Stainbeck Road junction

Some buses were re-routed along Stainbeck Road to take advantage of the guideways on Scott Hall Road. New traffic signals were installed to assist bus turning movements between Stainbeck Road and Scott Hall Road.

Signalisation also allowed the movement of north and southbound vehicles turning right from Scott Hall Road into Stainbeck Road to be controlled, by giving these movements a separate phase within the signal plan - this in effect reduces the amount of green time available to north and southbound Scott Hall Road traffic. To accommodate the installation of the right turn feeder lanes the junction was widened.

Buses are afforded priority through the junction with the used of detectors upstream of the junction on Stainbeck Road. When a bus is detected, the signal green phase is either advanced or extended to allow the bus enough time to pass through the junction.

2.1.6 Off road parking bays

Off road resident parking bays were introduced along the southbound carriageway of Scott Hall Road between Scott Hall Gardens and Sholebroke Mount. These bays allowed residents to park off the main carriageway, ensuring both lanes could be used by city bound traffic

2.1.7 North Street improvements

The layout of North Street was changed substantially between 1993 and 1997. In 1993 North Street was effectively one way with two general traffic lanes and a with flow bus lane in the northbound direction. By 1997 the northbound bus lane was removed and a 250 m southbound contra flow bus lane was introduced next to two northbound general traffic lanes. Figure 7 shows the layout of North Street in 1997.

2.1.8 Bus stops

All bus stops along Scott Hall Road adjacent to the guideway sections were equipped with ‘docking stops’ which involves constructing a raised kerb (185 mm high) along the length of each bus stop. Using the guidewheels on the raised kerbing ensured buses could align themselves closely to the stop bus thus making an almost level boarding platform.

2.2 Bus service routes and changes

2.2.1 Inbound bus routes

In 1993 the main bus route from the Sheepscar Intersection into the city centre was Sheepscar Street South - Regent Street - New York Street - Vicar Lane - New Market Street (Figure 8).

An alternative route which avoided Regent Street followed the path from the Sheepscar Intersection into Clay Pit Lane then Woodhouse Lane - Albion Street - Park

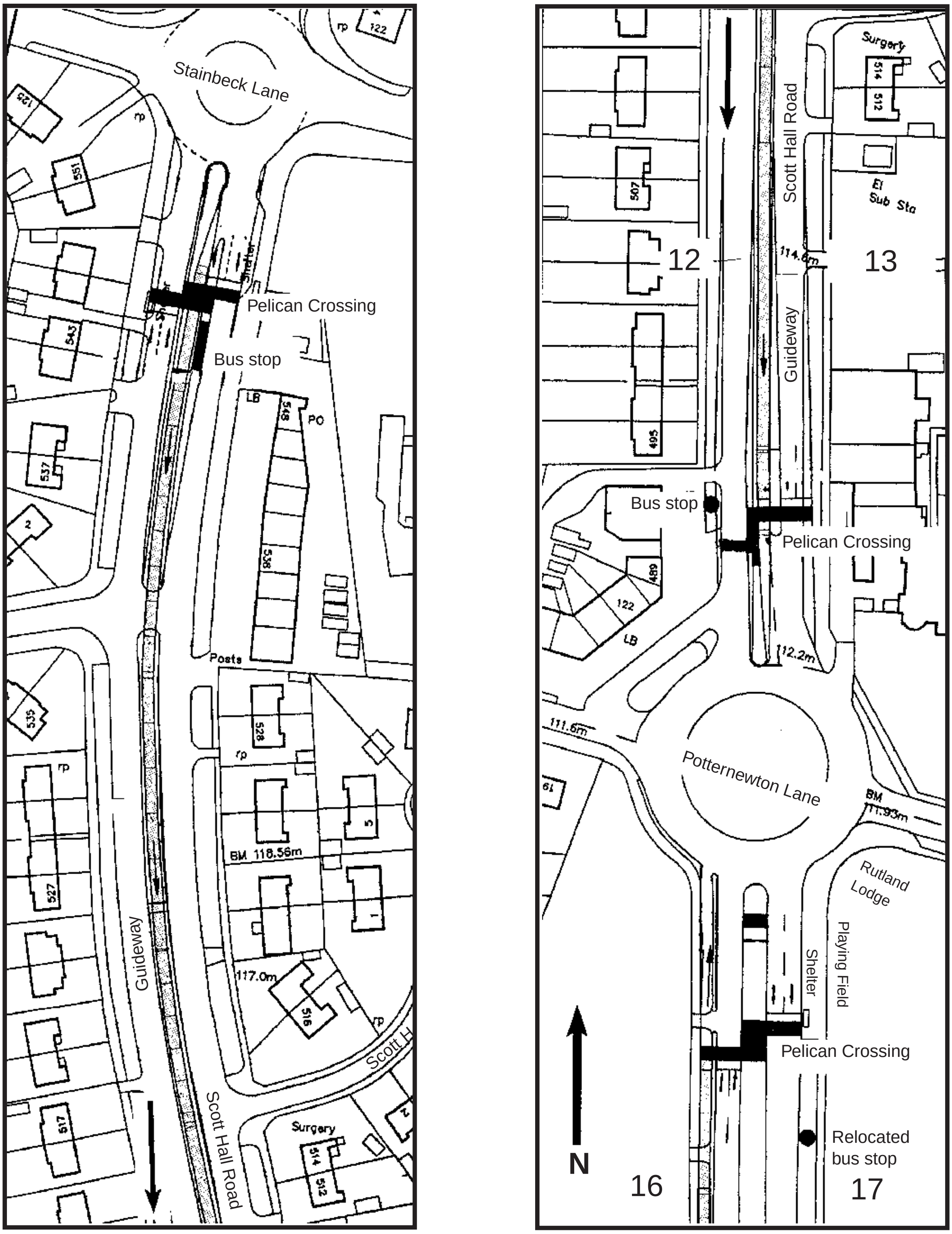

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Figure 5 Layout of central southbound guideway and the Potternewton Lane roundabout (Phase 2)

(Reproduced courtesy of Leeds City Council)

Plate 3 Photograph of bus using Phase 2 of the guideway

(Reproduced courtesy of Leeds City Council)

Plate 4 Photograph of bus approaching the Potternewton Lane roundabout

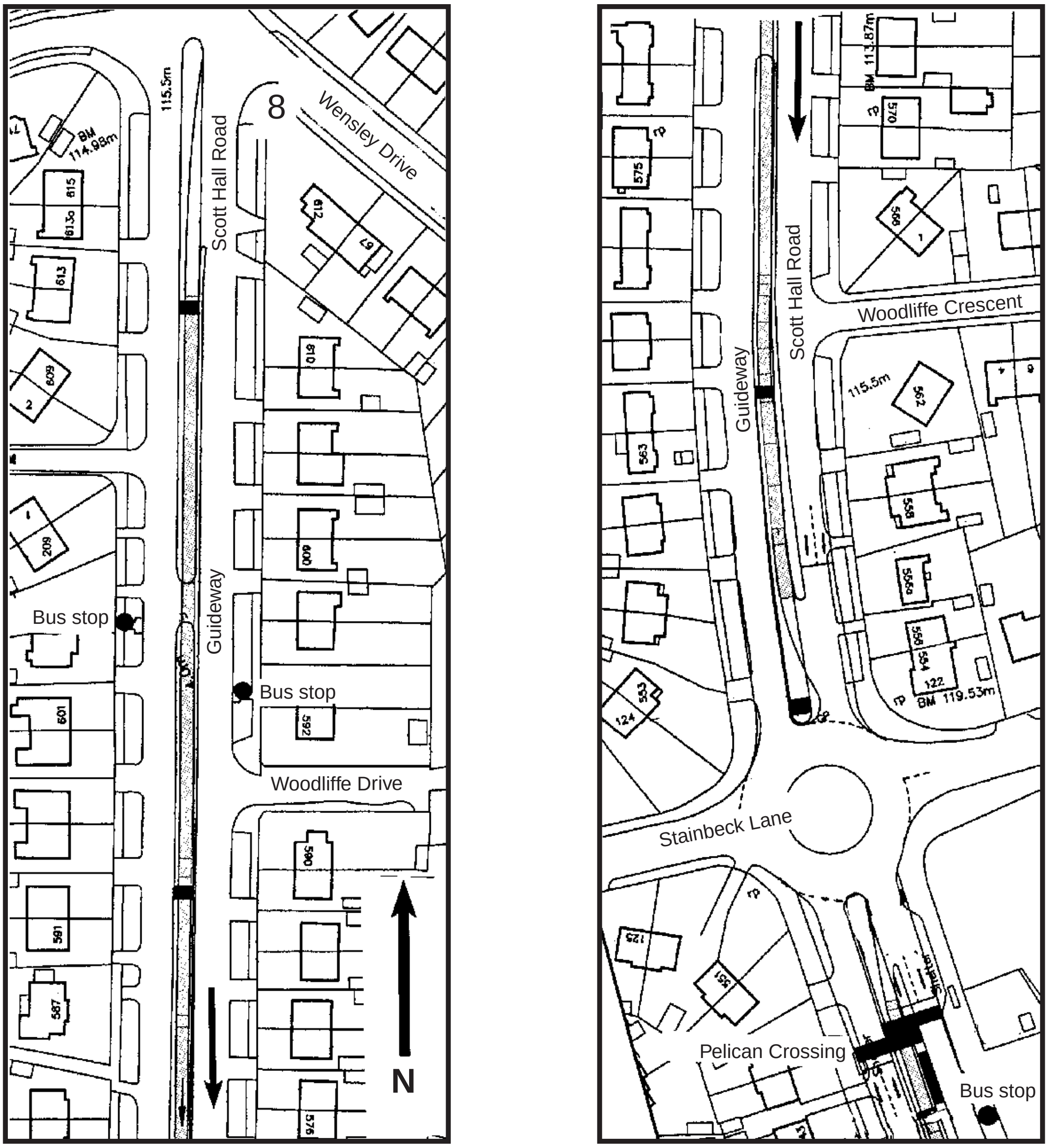

Figure 6 Layout of the southbound central guideway and Stainbeck Lane roundabout (Phase 3)

(Reproduced courtesy of Leeds City Council)

Plate 5 Photograph of bus entering the central guideway

(Reproduced courtesy of Leeds City Council)

Plate 6 Photograph of Phase 3 as it extends towards the Stainbeck Lane roundabout

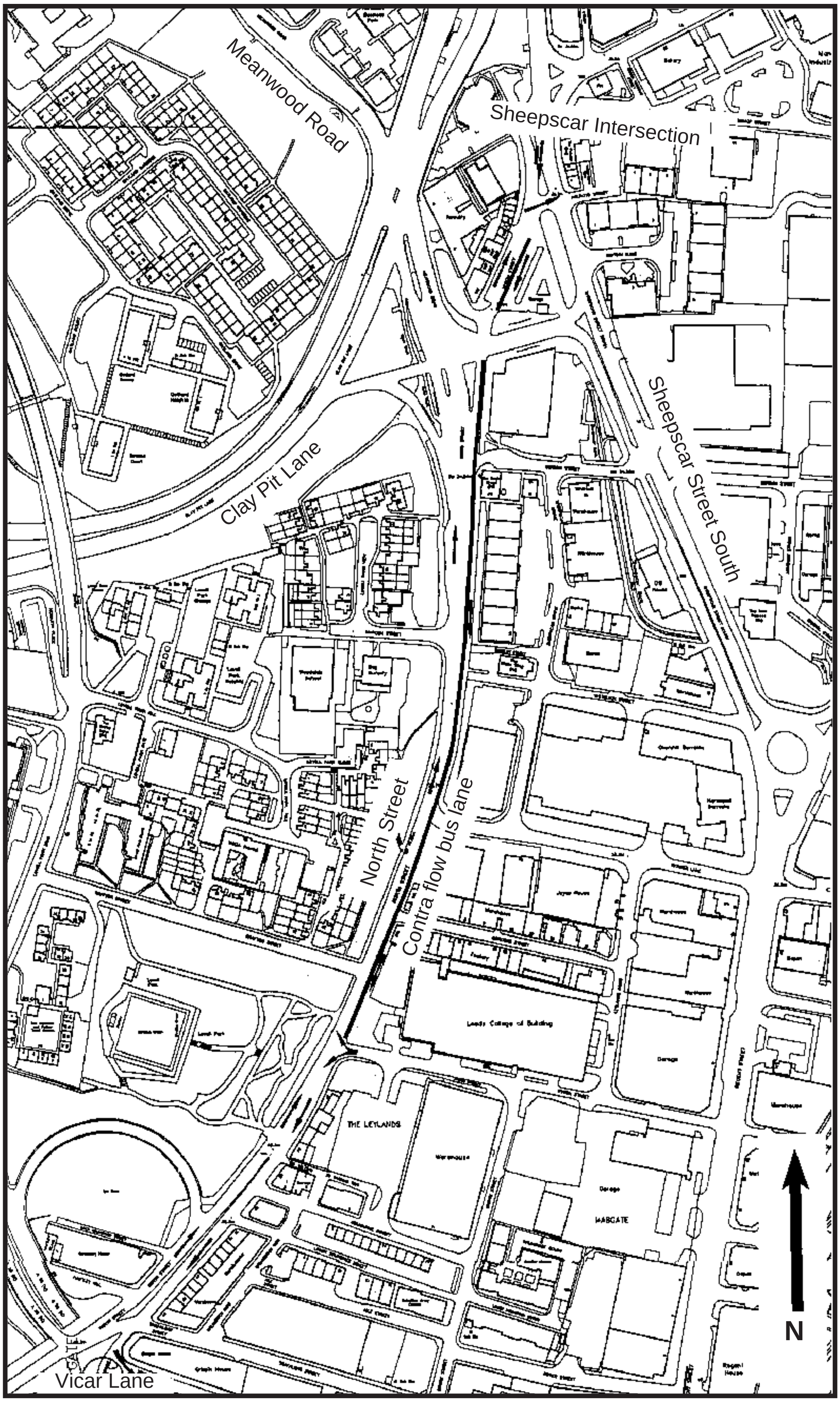

Figure 7 The layout of North Street in 1997

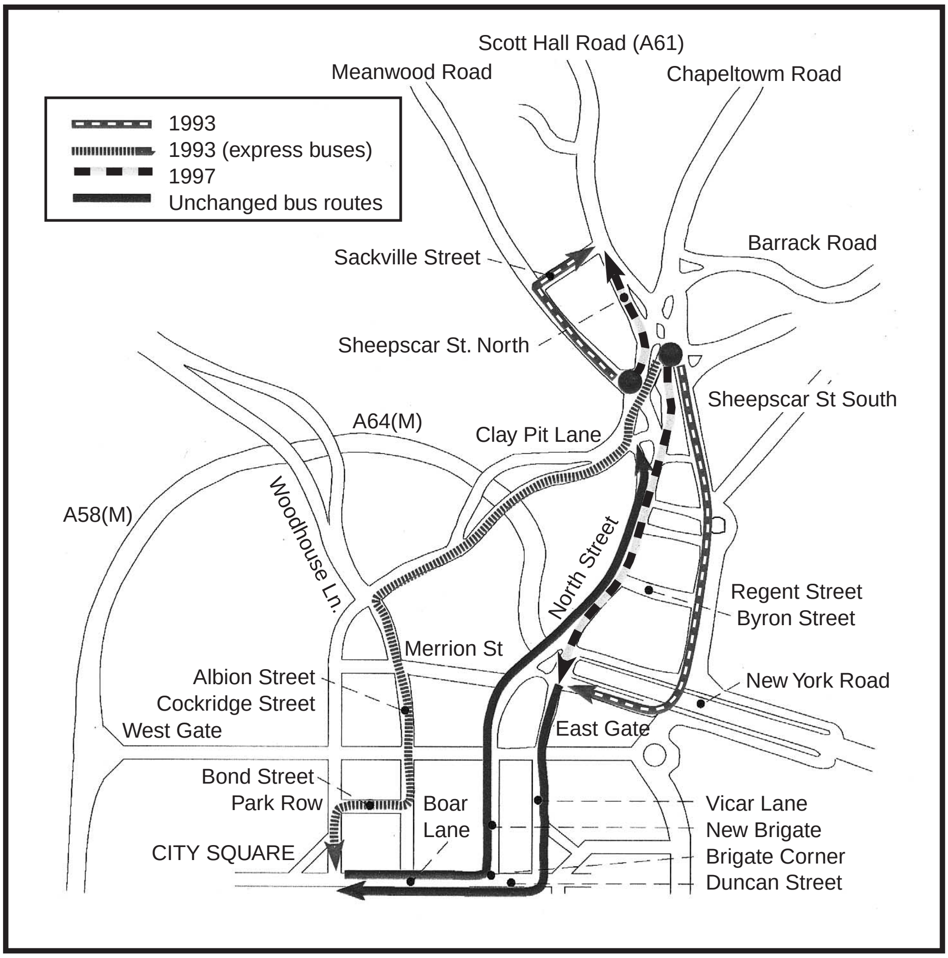

Figure 8 Map showing the changes to bus routes between 1993 and 1997

Row - Boar Lane - Briggate Corner. This more direct route into the City centre was used by two express routes (X34 and X35).

By 1997 bus routes from the Sheepscar Intersection into the city centre had changed considerably from the 1993 situation. To alleviate the severe delays incurred by buses along Regent Street the majority of southbound buses were re-directed into the new contra-flow bus lane along North Street. This reduced the distance travelled between Roundhay Road and the top section of Vicar lane by about 300 m (1000 m to 1300 m). To facilitate the movement of buses into North Street the signals on the Sheepscar Intersection were modified to give buses priority. These changes provided a more direct route into the city centre i.e. Sheepscar Intersection - North Street - Vicar Lane - New Market Street. To service bus stops on Regent Street (which were popular with commuters during the peak periods) several bus routes bypassed the North Street contra-flow bus lane choosing instead the route Sheepscar Intersection to Sheepscar Street South - Regent Street - Byron Street - North Street - Vicar Lane - New Market Street.

2.2.2 Outbound bus routes

In 1993 all outbound buses used the northbound bus lane along North Street to exit the city centre. Depending on the area served, northbound buses followed the route: City Square - Boar Lane - Briggate - New Briggate - North Street, then Meanwood Road (for Meanwood Road buses), Chapeltown Road (for Chapeltown Road buses), or Meanwood Road - Sackville Street - Sheepscar Street North - Scott Hall Road (for Scott Hall Road buses).

By 1997 the northbound bus lane along North Street had been removed and replaced with a single general traffic lane. This change to the layout of North Street had no impact on bus routes exiting the city centre, as instead of using the dedicated bus lane they now use the general traffic lane. The only change to bus routes occurred on Scott Hall Road buses where the diversion along Meanwood Road - Sackville Street was removed allowing buses to travel directly from Sheepscar into Sheepscar Street North and onto Scott Hall Road.

2.2.3 The bus operators

In 1993 the main bus company operating services along Scott Hall Road, Chapeltown Road and Meanwood Road was Yorkshire Rider Ltd. Other bus companies such as Taylor’s Coaches (21C and 19B) and Harrogate and District (36, 36A, 36C) ran a smaller number of express and off peak services.

By 1997 Yorkshire Rider Ltd. was a subsidiary of the First Group Company and now operates under the name First Leeds. Many of the smaller operators are still present, but still running express and off-peak services. For example Black Prince operates buses on routes X35, 52A and 53A during the evening and on Sundays but during the day the service is operated by Leeds City Link. Harrogate and District still operate the routes 36, 36A and 36C between Leeds, Harrogate and Ripon.

The timetables for bus services using Scott Hall Road, Meanwood Road and Chapeltown Road indicated that the number of buses using each of the corridors had increased substantially. Table 1 shows a breakdown of the number of buses defined by day (Weekdays, Saturdays, Sunday), time period and direction for the years 1993 and 1997.

Along Scott Hall Road during the weekdays there has been an increase of approximatley 3 buses per hour between 0730 hrs and 1830 hrs, which has resulted in an additional 35 bus journeys each day for each direction. On Saturday there are approximately 13 more bus journeys while on Sunday the level of service has remained static.

The pattern of bus services along Chapeltown Road differs slightly from that on Scott Hall Road and Meanwood Road. Weekdays show an increase in the level of service, but again most of the increase is between 0930-1630 hrs. A peculiarity of bus services on this corridor is that the level of service in the southbound direction has increased by over 8 per cent while the increase in the northbound direction is only 3.5 per cent. Saturdays show a decline in the level of service of about 5 per cent in each direction, while the decline during Sunday is more marginal.

The number of early morning and late night buses has remained at 1993 levels for all three corridors. Buses start at about 0530 hrs and continuing until about 2345 hrs.

2.3 Current and future developments

2.3.1 Phase 4 and Park & Ride Sites

A ‘Park & Ride’ (P&R) site near Allerton High School and Phase 4 of the guideway was completed during July 1998. The P&R site caters for approximatley 150 vehicles, while Phase 4 of the guideway is located between Lingfield approach and the Meanwood/ Moortown Ring Road (Figure B1). As these two components of the scheme were not introduced until after the last surveys they are not included this reports evaluation of the guideway.

Futher proposals for the corridor include:

- a northbound bus lane between Stonegate Road and the Meanwood/ Moortown Ring Road;
- part signalisation of the Meanwood/ Moortown Ring Road roundabout to give buses priority across the Ring Road; and
- a second Park & Ride site on the Harrogate Road corridor just north of the Moortown Ring Road.

2.3.2 Bus gate on Vicar Lane

During November 1997 a bus gate was introduced at the junction of Vicar Lane with North Street. This prevents vehicles other than buses, taxis and cyclist from entering Vicar Lane, being diverted instead into New York Street.

3 Survey methods

3.1 Journey time, traffic flow car occupancy surveys

3.1.1 Measurement of bus and car journey times

The technique used to determine vehicle journey times along the routes was to position observers at strategic positions along Scott Hall Road, Meanwood Road, Harrogate Road/ Chapeltown Road, the Sheepscar Intersection and North Street. Figure B1 shows the location of each timing point; each timing point was manned by two enumerators who recorded all bus registration number plates and a sample of general traffic number plates (all those ending in 1, 2 or 3). Observers recorded this information on hand-held computers, as the vehicles passed a defined point, at each location. The computers were programmed to time stamp each license plate as it was entered thus allowing the time at which each vehicle passed a defined point (along the route) to be recorded.

The ‘before’ survey took place during November in 1993 and the ‘after’ took place during June 1997. To ensure that traffic patterns were broadly similar both surveys were undertaken during school term times and in the absence of any major roadwork’s that would affect traffic flows along the corridors being surveyed. The ‘after’ survey took place approximately 2 months after the completion of Phase 3, allowing sufficient time for traffic patterns to adjust to the new traffic regime and stabilise. The ‘after’ survey was completed well before any work started on the King Lane P&R site and bus lanes along King Lane.

Observations were made over a total of 22 ½ hours in each survey, at the times shown in Table 2.

For each time period, data from the observation points was merged into a single file. Data within this file was defined by a unique code defining the location at which the data was recorded and whether it would be used as an origin or destination point. These files were then analysed by a number plate comparison program - NOPCOP [Lucas, 1986] which calculated average journey times between defined origin-destination points.

3.1.2 Measurement of traffic flow and car occupancy

During each survey period (‘before’ and ‘after’) traffic counts and car occupancies were recorded at sites along the Harrogate Road (A1), Meanwood Road (A2) and Scott Hall Road (A3) corridors. A diagram showing the location of the sites A1, A2 and A3 can be found in Appendix B, Figure B1.

3.2 Bus occupancy data

At the start of the study it was agreed that patronage data would be supplied by the main bus company. This negated the need to undertake bus occupancy counts before and after the scheme’s introduction. It was also thought that a continuous record of patronage levels between 1993 and 1997 would provided a more reliable measure of change than two snap-shot surveys before and after the schemes introduction.

Table 1 Number of buses defined by route, direction and time

	Number of buses																	
	Scott Hall Road						*Meanwood Road*						*Chapeltown Road*					
	Northbound			*Southbound*			*Northbound*			*Southbound*			*Northbound*			*Southbound*		
Time (hrs)	*1993*	*1997*	*Change*	*1993*	*1997*	*Change*	*1993*	*1997*	*Change*	*1993*	*1997*	*Change*	*1993*	*1997*	*Change*	*1993*	*1997*	*Change*
Monday to Friday																		
0500-0730	9	9	0	11	12	+1	9	7	-2	11	11	0	15	17	+2	18	17	-1
0730-0930	14	17	+3	21	26	+7	14	15	+1	14	17	+3	32	32	0	32	36	+4
0930-1630	45	70	+25	45	70	+25	41	56	+15	37	57	+20	106	118	+12	106	126	+20
1630-1830	19	28	+9	15	16	+1	16	17	+1	14	15	+1	39	37	-2	30	35	+5
1830-2359	23	23	0	23	23	0	13	14	+1	12	13	+1	33	29	-4	38	35	+3
Total	110	145	+37	115	147	+34	93	109	+16	88	113	+25	225	233	+8	224	249	+31
Saturday																		
0500-1100	22	26	+4	25	26	+1	24	26	+2	27	31	+4	65	57	-8	65	58	-7
1100-1400	19	24	+5	18	24	+6	18	25	+7	18	24	+6	45	50	+5	45	54	-11
1400-2359	52	55	+3	48	55	+7	40	52	+12	38	50	+12	98	89	-9	105	95	-10
Total	93	105	+12	91	105	+14	82	103	+21	83	105	+22	208	196	-12	215	207	-8
Sunday																		
0700-2359	61	63	+2	62	62	0	34	32	-2	34	32	-2	98	95	-3	100	95	-5

Table 2 Data collection times

Day	*am peak*	*inter peak*	*pm peak*
Wednesday Thursday Friday	0730 to 0930 hrs	1000 to 1130 hrs	1630 to 1830 hrs
Saturday (2 days)		1100 to 1400 hrs	

Unfortunately, while moving to a new bus depot the bus company lost much of the patronage data before 1994 and so was unable to provide the information needed.

3.3 Bus passenger and car driver surveys

A survey of bus passengers using Superbus routes and car drivers using Scott Hall Road was undertaken in February 1998 to assess what individuals thought of the scheme. The bus passenger survey explored reasons for using Superbus and any changes to travel behaviour, while the car driver survey explored reasons why the Superbus routes were not used. A full description of the surveys implementation, structure and results are given in Section 6.

3.4 Conditions during the surveys

Analysis of the journey time data revealed that certain periods during the surveys showed abnormally high values. Many of the discrepancies could be explained by referring to on-site observations, which detailed the location and time of any traffic accidents and other disruptive influences (such as extreme weather conditions) within the survey area. There were however times when these anomalies could not be explained by any of the on-site observations.

The most difficult example occurred during the weekday morning surveys in 1993 for vehicles travelling southbound towards Leeds city centre. Comparison of journey times revealed that on Wednesday average journey times were over 3 times higher than those recorded on Thursday and Friday. Initially, it was thought that the increased congestion on Wednesday was caused by the extreme weather conditions and subsequent cancellation of trains between Harrogate and Leeds. However, the situation is complicated by journey times recorded in the after survey which again showed Wednesday morning journey times to be higher than those on Thursday and Friday (although on this occasion the discrepancies between days was much smaller). On this occasion the on-site observations gave no explanation for the increased congestion during Wednesday.

Discussions with the City Council gave us no reason to suspect that Wednesdays are any different from other weekdays. On balance it was concluded that the 1993 results were adversely affected by the weather condition but those in 1997 could probably be explained by normal variations between weekdays.

Another example occurred during the 1997 surveys where bus journey times during the Thursday evening period in the southbound direction along Sheepscar Street South and North Street were approximately 1.8 times higher than those on Wednesday and Friday. No explanation could be found for this odd result.

To avoid the errors that are associated with comparing data that does not represent ‘normal conditions’ it was conceived that a more realistic result would be achieved if survey periods that showed anomalous journey time data was excluded from the overall comparison. To ensure continuity between bus and general traffic data and in recognition that bus journey times are inextricably linked to those of general traffic, each period of general traffic data that was removed was accompanied by the removal of the corresponding period in the bus data.

The process of removing selected sections of data is a rather subjective exercise and to avoid any criticism of bias, the results presented in this report give both the raw unedited data and our best estimate of the situation.

4 Survey results

4.1 Summary of traffic flow data

The surveys provided two sources of traffic flow data: the car occupancy and registration number plate data. The occupancy data was collected at three locations on Harrogate Road (A1), Meanwood Road (A2), and Scott Hall Road (A3) while the number plate data was collected at each timing point (1-30), Figure B1. Although this amounts to comprehensive traffic flow measurements for all parts of the study area it only represents a snap shot of traffic conditions.

Analysis of the data , revealed some inconsistencies within and between the two data sets, which is believed to result from difficulties at recording number plate data at some locations. As an example the percentage of vehicles recorded at site 26 between 1630-1830 hrs differed greatly both between surveys and when compared with other sites in the same survey. There are two reasons for this: vehicle speeds as they pass site 26 are high, making it difficult for enumerators to record the full sample as vehicles platoon past. Therefore the percentage of vehicles recorded at 26 was always much less than those recorded at site 16, where vehicle speeds were generally slower. To compound this effect the 1993 survey took place in November when light levels between 1630-1830 hrs are poor compared with the same time period in June when the after survey took place.

Occupancy counts were less affected by traffic conditions as it is easier to record car occupancies than number plates, despite the larger sample sizes (enumerators collecting occupancy data recorded a 50 per cent sample of all vehicles, while only number plates ending in 1, 2 or 3, effectively 30 per cent, were recorded at the timing points). However this data was very localised and gave no information about traffic flows on other parts of the network.

A combination of both occupancy counts (for reliability) and number plate data (for extent) has therefore been used cautiously to examine the impact of the guideway on traffic flows within the study area. The data represents a snapshot of the traffic flows during each survey in 1993 and 1997, therefore some care must be taken when trying the assess the long term changes over the intervening 4 ½ years. This information is given in Table 3 where data from selected timing points and the occupancy counts are arranged to give traffic flow measures along Scott Hall Road, Meanwood Road, Harrogate Road and Chapeltown Road.

The shaded cells in Table 3 are thought to be the most reliable measures of flow and from these some general trends are identified for each corridor. These are discussed in the following three section.

4.1.1 Scott Hall Road

In the southbound direction traffic flows have remained at 1993 levels and perhaps even declined slightly during all survey periods. Data at A3 suggests there has been a decrease in the number of vehicles using the northern section of Scott Hall Road, while data from 23 shows a small increase in traffic approaching the Sheepscar Intersection from Scott Hall Road. Data from 13 and 17 shows too many inconsistencies in the relative number of vehicles recorded between the sites to make any confident conclusions. Analysis of the turning movements of vehicles at the Potternewton Lane roundabout (Section A1.2.3) show that these differences are not due to a large diversion of traffic from Scott Hall Road but rather a smaller percentage of vehicles recorded during the 1997 surveys.

In the northbound direction no reliable traffic flow data could be obtained for the southern section of Scott Hall Road. Data from A3 suggests that during the morning and evening peak traffic flows have remained at approximately 1993 levels, but increased by between 5-7 per cent during other time periods.

4.1.2 Harrogate Road and Chapeltown Road

Traffic flows increased in both directions along Harrogate Road and Chapeltown Road. The size of the increase depended very much on the time of day. During the peak periods in the direction when demand is greatest (i.e. southbound in the morning peak and northbound in the evening peak) flows increased on Harrogate Road by about 8 per cent and on Chapeltown Road by between 17-26 per cent.

4.1.3 Meanwood Road

At times when demand is greatest traffic flows generally decreased or remained at 1993 levels. At other times flows increased in both directions, with the size of the increase depending very much on the time of day. During the off peak periods, flows increased by almost 20 per cent.

4.2 Journey time results

A summary of the journey time changes are given in the following tables (Tables 4 - 7), which should be viewed in conjunction with the timing point map shown in Figure B1. Rows that are shaded indicate sections of the route that now contain bus priority measures, while changes in journey times that are not significanct at the 5 per cent level are enclosed in brackets ( ).

Anomalous journey time data (Section 3.4) has been removed to allow a more accurate estimate of the average journey time changes caused by the guideways. A symbol

Table 3 Average traffic flows during the surveys

		Traffic flow (veh\hr)											
		Weekday									*Saturday*		
		0730-0930 hrs			*1000-1130 hrs*			*1630-1830 hrs*			*1100-1400 hrs*		
Direction and road	*Location*	*1993*	*1997*	*% change*	*1993*	*1997*	*% change*	*1993*	*1997*	*% change*	*1993*	*1997*	*% change*
Southbound													
Scott Hall Rd	A3	1482	1458	-2%	744	699	-6%	704	693	-2%	890	831	-7%
	8	1403	1298	-8%	736	689	-7%	665	615	-8%	787	732	-7%
	13	1403	1602	12%	776	796	3%	703	743	5%	967	831	-16%
	17	1680	1488	-13%	811	684	-19%	757	682	-11%	940	757	-24%
	23	1883	1893	1%	1193	1262	5%	1030	1123	8%	1126	1129	0%
Harrogate Rd	A1	904	995	9%	521	579	10%	466	561	17%	615	702	12%
	6	937	1003	7%	553	540	-2%	430	575	25%	641	713	10%
Chapeltown Rd	21	722	970	26%	433	489	11%	373	475	21%	442	583	24%
	22	993	1243	20%	522	600	13%	503	552	9%	680	670	-1%
Meanwood Rd	A2	1294	1101	-18%	470	544	14%	415	458	9%	563	654	14%
	9	1268	1180	-7%	509	516	1%	407	460	12%	587	639	8%
Northbound													
Scott Hall Rd	A3	606	605	0%	591	620	5%	1459	1472	1%	814	877	7%
	16	635	648	2%	722	680	-6%	1745	1597	-9%	968	846	-14%
	12	523	655	20%	620	684	9%	1338	1522	12%	878	931	6%
Harrogate Rd	A1	351	461	24%	412	442	7%	949	1016	7%	594	656	9%
	7	358	422	15%	396	411	4%	808	1042	22%	573	647	11%
Chapeltown Rd	25	780	862	9%	840	873	4%	1422	1715	17%	839	1009	17%
	20	280	292	4%	300	313	4%	697	843	17%	406	437	7%
Meanwood Rd	A2	380	412	8%	430	528	19%	1196	1183	-1%	742	740	0%
	10	325	398	18%	349	507	31%	962	1162	17%	657	746	12%

Table 4 Weekday journey times (0730 to 0930 hrs)

o-d (distance)	*Journey time (seconds)* Bus 1993	1997	Change	General traffic 1993	1997	Change
Scott Hall Road (southbound)						
1-5 (1300m)	350	219	(-131)	195	164	-31
5-8 (910m)	119*[132]	122	(+3)	56*[66]	65	+9
8-13 (790m)	168*[176]	97	-71	126*[169]	77	-49
13-17 (200m)	62*[68]	35	-27	42*[48]	36	-6
17-23 (1725m)	n/a	n/a	-	141*[212]	208	+67
17-27 (1975m)	282*[325]	411	+129	n/a	n/a	-
27-30 [1]	227	189	-38	n/a	n/a	-
Total (1-23)	n/a	n/a	-	560[690]	550	-10[-140]
Total (1-30)	1208[1278]	1073	-135[-205]	n/a	n/a	-
Scott Hall Road (northbound)						
29-28 (700m)	213	n/a	-	n/a	n/a	-
28-19 (1810m)	277	n/a	-	n/a	n/a	-
29-26 (810m)	n/a	139	-	119	120	(+1)
26-19 (1430m)	n/a	132	-	n/a	n/a	-
26-16 (1900m)	n/a	n/a	-	117	113	-4
19-16 (500m)	45	39	-6	n/a	n/a	-
16-12 (200m)	51	35	-16	23	23	0
12-3 (1650m)	n/a	175	-11	120	143	+23
12-4 (1650m)	186	n/a		117	147	+30
4-2 (1300m)	181	n/a	+84	163	200	+37
3-2 (1625m)	n/a	265	-	n/a	n/a	-
Total (29-2)	953 (via 28)	785 (via 26)	-168	539	603	+64
Meanwood Road (southbound)						
9-27 (2500m)	493	441	(-52)	n/a	n/a	-
9-23 (2750m)	n/a	n/a	-	347	299	-48
Meanwood Road (northbound)						
29-28 (700m)	213	137	-76	177	132	-45
28-10 (2480m)	267	233	-34	181	171	-10
Total(29-10)	480	370	-110	358	303	-55
Harrogate Road/ Chapeltown Road (southbound)						
6-27 (3150m)	590*[611]	567	(-23)[-44]	n/a	n/a	-
6-21 (1360m)	n/a	n/a	-	173*[204]	177	+4
21-22 (1490m)	n/a	n/a	-	183*[243]	174	-9
Total(6-22)	n/a	n/a	-	356[447]	351	-5[-96]
Chapeltown Road/ Harrogate Road (northbound)						
29-25(840m)	158	150	(-8)	118	125	+7
25-7 (2960m)	479	419	-60	n/a	n/a	-
25-20 (1600m)	n/a	n/a	-	139	151	+12
20-7 (1360m)	n/a	n/a	-	137	131	-6
Total (29-7)	637	569	-68	394	407	+13

[1] 1993 (1300 m), 1997 (1000m).

Table 5 Weekday journey times (1000 to 1130 hrs)

	Journey time (seconds)					
	Buses			General traffic		
o-d (distance)	*1993*	*1997*	*Change*	*1993*	*1997*	*Change*
Scott Hall Road (southbound)						
1-5 (1300m)	206	175	(-31)	125	124	(-1)
5-8 (910m)	100	119	(+19)	53	64	+11
8-13 (790m)	92	97	(+5)	47	55	+8
13-17 (200m)	45	39	(-6)	20	20	0
17-23 (1725m)	n/a	n/a	-	108	112	+4
17-27 (1975m)	246	218	-28	n/a	n/a	-
27-30 [1]	225	177	-48	n/a	n/a	-
Total (1-23)	n/a	n/a	-	353	375	+22
Total (1-27)	914	825	-89	n/a	n/a	-
Scott Hall Road (northbound)						
29-28 (700m)	99	n/a	-	n/a	n/a	-
28-19 (1810m)	234	n/a	-	n/a	n/a	-
29-26 (810m)	n/a	110	-	76	105	+29
26-19 (1430m)	n/a	135	-	n/a	n/a	-
26-16 (1900m)	n/a	n/a	-	115	112	-3
19-16 (500m)	43	44	(+1)	n/a	n/a	-
16-12 (200m)	40	34	-6	21	23	+2
12-3 (1650m)	n/a	175	-25	119	126	+7
12-4 (1650m)	200	n/a	-	119	128	+9
4-2 (1300m)	184	n/a	+21	112	119	+7
3-2 (1625m)	n/a	205	-	n/a	n/a	-
Total (29-2)	800 (via 28)	703 (via 26)	-97	443	487	+44
Meanwood Road (southbound)						
9-27 (2500m)	380	319	-61	n/a	n/a	-
9-23 (2750m)	n/a	n/a	-	217	216	-1
Meanwood Road (northbound)						
29-28 (700m)	99	100	(+1)	76	104	+28
28-10 (2480m)	253	224	(-29)	175	164	-11
Total(29-10)	352	324	(-28)	251	268	+17
Harrogate Road/ Chapeltown Road (southbound)						
6-27 (3150m)	493	480	(-13)	n/a	n/a	-
6-21 (1360m)	n/a	n/a	-	146	168	+22
21-22 (1490m)	n/a	n/a	-	107	118	+11
Total(6-22)	n/a	n/a	-	253	286	+33
Chapeltown Road/ Harrogate Road (northbound)						
29-25(840m)	123	119	(-4)	85	115	+30
25-7 (2960m)	411	403	(-8)	n/a	n/a	-
25-20 (1600m)	n/a	n/a	-	129	153	+24
20-7 (1360m)	n/a	n/a	-	136	126	-10
Total (29-7)	534	522	-12	350	394	+44

[1] 1993 (1300 m), 1997 (1000m).

Table 6 Weekday journey times (1630 to 1830 hrs)

o-d (distance)	Journey time (seconds) Bus 1993	Bus 1997	Bus Change	General traffic 1993	General traffic 1997	General traffic Change
Scott Hall Road (southbound)						
1-5 (1300m)	165	170	(+5)	148	145	(-3)
5-8 (910m)	93	129	+36	55	86	+31
8-13 (790m)	68	72	(+4)	48	61	+13
13-17 (200m)	32	25	-7	22	21	-1
17-23 (1725m)	n/a	n/a	-	112	107	-5
17-27 (1975m)	228	220	(-8)	n/a	n/a	-
27-30 [1]	236	182‡[231]	-54[-5]	n/a	n/a	-
Total (1-23)	n/a	n/a	-	385	420	+35
Total (1-27)	822	798[849]	-24[+27]	n/a	n/a	-
Scott Hall Road (northbound)						
29-28 (700m)	112	n/a	-	n/a	n/a	-
28-19 (1810m)	237	n/a	-	n/a	n/a	-
29-26 (810m)	n/a	117†[149]	-	112	117†[139]	+5
26-19 (1430m)	n/a	178†[187]	-	n/a	n/a	-
26-16 (1900m)	n/a	n/a	-	159	192†[224]	+33
19-16 (500m)	65	49	-16	n/a	n/a	-
16-12 (200m)	47	42	(-5)	32	36	+4
12-3 (1650m)	n/a	193	(-14)	134	148	+14
12-4 (1650m)	207	n/a	-	133	152	+19
4-2 (1300m)	247	n/a	+9	229	325	+96
3-2 (1625m)	n/a	256	-	-	-	-
Total (29-2)	915 (via 28)	835[876] (via 26)	-80[-39]	665	822[876]	+157[+211]
Meanwood Road (southbound)						
9-27 (2500m)	361	350	(-11)	n/a	n/a	-
9-23 (2750m)	n/a	n/a	-	215	211	-4
Meanwood Road (northbound)						
29-28 (700m)	112	117†[149]	(+5)	97	107†[114]	+10
28-10 (2480m)	299	363	(+64)	246	306	+60
Total(29-10)	411	480[512]	+69[+101]	343	413[420]	+70[+77]
Harrogate Road/ Chapeltown Road (southbound)						
6-27 (3150m)	420	438	(+18)	n/a	n/a	-
6-21 (1360m)	n/a	n/a	-	158	162	(+4)
21-22 (1490m)	n/a	n/a	-	113	114	(+1)
Total(6-22)	n/a	n/a	-	271	276	(+5)
Chapeltown Road/ Harrogate Road (northbound)						
29-25(840m)	139	148†[164]	(+9)	107	120†[143]	+13
25-7 (2960m)	488	511	+23	n/a	n/a	-
25-20 (1600m)	n/a	n/a	-	173	233	+40
20-7 (1360m)	n/a	n/a	-	154	147	-7
Total (29-7)	627	659[675]	+32[-48]	434	500[523]	+66[-89]

[1] 1993 (1300 m), 1997 (1000m).

Table 7 Saturday journey times (1100 to 1400 hrs)

	Journey time (seconds)					
	Bus			General traffic		
o-d (distance)	*1993*	*1997*	*change*	*1993*	*1997*	*change*
Scott Hall Road (southbound)						
1-5 (1300m)	247	223	(-24)	132	135	(+3)
5-8 (910m)	89	111	+22	53	60	+7
8-13 (790m)	97	96	(-1)	47	57	+10
13-17 (200m)	46	35	-11	21	19	-2
17-23 (1725m)	n/a	n/a	-	108	107	(-1)
17-27 (1975m)	253	229	-24	n/a	n/a	-
27-30	198	170	-28	n/a	n/a	-
Total (1-23)	n/a	n/a	-	361	378	+17
Total (1-27)	930	864	-66	n/a	n/a	-
Scott Hall Road (northbound)						
29-28 (700m)	96	n/a	-	n/a	n/a	-
28-19 (1810m)	239	n/a	-	n/a	n/a	-
29-26 (810m)	n/a	111	-	85	103	+18
26-19 (1430m)	n/a	142	-	n/a	n/a	-
26-16 (1900m)	n/a	n/a	-	107	108	+1
19-16 (500m)	49	45	(-4)	n/a	n/a	-
16-12 (200m)	41	41	(0)	21	25	+4
12-3 (1650m)	n/a	189	(+21)	116	132	+16
12-4 (1650m)	168	n/a	-	115	139	+24
4-2 (1300m)	197	n/a	+23	184	156	-28
3-2 (1625m)	n/a	220	-	n/a	n/a	-
Total (29-2)	790 (via 28)	748 (via 26)	-42	512	531	+19
Meanwood Road (southbound)						
9-27 (2500m)	349	316	-33	n/a	n/a	n/a
9-23 (2750m)	n/a	n/a	-	207	206	(-1)
Meanwood Road (northbound)						
29-28 (700m)	96	105	(+9)	77	110	+33
28-10 (2480m)	255	220	-35	165	161	-4
Total(29-10)	351	325	-24	242	271	+29
Harrogate Road/ Chapeltown Road (southbound)						
6-27 (3150m)	496	502	(+6)	n/a	n/a	-
6-21 (1360m)	n/a	n/a	-	160	168	(+8)
21-22 (1490m)	n/a	n/a	-	110	112	+2
Total(6-22)	n/a	n/a	-	270	280	(+10)
Chapeltown Road/ Harrogate Road (northbound)						
29-25(840m)	109	124	+15	90	118	+28
25-7 (2960m)	434	432	(-2)	n/a	n/a	-
25-20 (1600m)	n/a	n/a	-	131	147	+16
20-7 (1360m)	n/a	n/a	-	139	124	-15
Total (29-7)	543	556	+13	360	389	+29

next to an edited journey time identifies the day that was removed using the following key:

* excludes Wednesday data

† excludes Friday data

‡ excludes Thursday data

To allow the reader to assess the extent of removing this anomalous data the raw data values are shown in [square brackets] next to the edited values.

Section 5 discuses the key results presented in Tables 4-7.

5 Discussion and summary of key results

5.1 Traffic conditions in the Study Area (1993-1997)

Peak traffic flows on Scott Hall Road and Meanwood Road have remained at roughly 1993 levels, although there is some evidence to suggest that flows have actually decreased by up to 7 per cent. In contrast, peak traffic flows on Harrogate Road increased by 8 per cent, with Chapeltown Road showing a much larger increase of between 17-26 per cent. During the weekday mid-morning periods and on Saturday, flows have increased by approximately 10 per cent on each of the three corridors.

When these changes are compared on a national background of increasing traffic flows the relative difference between the corridors is even more striking. National statistics [Department of the Environment Transport and the Regions, 1998] show increases in traffic levels in built-up areas of 4 per cent on major roads and 8.3 per cent increase on minor roads (1993-1996). Therefore during peak times traffic growth on Harrogate Road increased by about the national average, but on Chapeltown Road by between 9 and 16 per cent more than average.The reduction of 7 per cent on Meanwood Road and Scott Hall Road contrasted with national trends. Traffic flows during the weekday mid-morning and on Saturdays have increased by just over the national average.

Although Scott Hall Road is still the busiest route into the City, its relative popularity when compared to Meanwood Road and Harrogate Road has decreased. Averaged over all survey periods, in 1993 Scott Hall Road carried 27 per cent more traffic than Meanwood Road and 33 per cent more than Harrogate Road. By 1997 this had changed to 23 per cent and 24 per cent respectively, indicating an increase in the popularity of Harrogate Road as a route into the City.

One explanation for the reduced popularity of Scott Hall Road is that during the construction of the guideway some drivers may have diverted onto Harrogate Road and Chapeltown Road to avoid the increased delays. Although the 1997 surveys took place over two months after the completion of Phase 3 there is some concern that traffic patterns may not have returned to normal.

Another possibility is that end to end journey times are quicker along the Harrogate Road/ Chapeltown Road corridor, making it a more attractive route into the City. To explore this further Figure 9 shows the corresponding average journey times and speeds during the morning (southbound) and evening (northbound) along Chapeltown Road, Harrogate Road and Scott Hall Road. To give some idea of journey times during the height of the peak (0815-0845 hrs), average peak journey time and speed for each section of the route are also illustrated on Figure 9.

Journey times in both the morning and evening peaks are quicker along Harrogate Road/ Chapeltown Road than Scott Hall Road; morning peak vehicles are on average 70 seconds quicker while those in the evening are 20 seconds quicker. During the most congested times the difference during the morning peak is even more apparent, but less so in the evening.

End to end journey times are not strictly comparable as the distance along Scott Hall Road (5-23) is longer at 3600 m, than that along Chapeltown Road/ Harrogate Road (6-22) of 2900 m. The distance between the timing points may therefore explain the difference in journey times. A comparison of average speeds revealed that in the morning peak, southbound traffic is faster on Scott Hall Road (5-13) than along Harrogate Road (6-21). But beyond Potternewton Lane the reverse is true with vehicle speeds greater along Chapeltown Road (21-22) than Scott Hall Road (17-23). Averaged over the total distance travelled Harrogate Road/ Chapeltown Road speeds are approximately the same as those along Scott Hall Road, about 21 mph.

To avoid the long and highly variable delays on the Scott Hall Road approach to Sheepscar, drivers may therefore be placing greater importance on the Chapeltown Road approach when choosing their route into the City. Analysis of the turning movements at the Potternewton Lane roundabout suggest that few vehicles are diverting from Scott Hall Road onto Chapeltown Road at this point, so it seems drivers are rejecting Scott Hall Road altogether and approaching Chapeltown Road from Harrogate Road instead.

In the evening peak speeds are quicker along all sections of Scott Hall Road. Even with the delay at the Potternewton Lane roundabout the average speeds between 26-4 (Scott Hall Road) is 22 mph compared with 18 mph along the Chapeltown Road/ Harrogate Road corridor. This suggests that Scott Hall Road may be a more attractive route out of the city during the evening peak.

5.2 Impact on journey times along Scott Hall Road

Analysis of the journey times is complicated by the variability of the data between days of the same survey and between surveys. This is especially true on the approach to the Sheepscar Intersection were morning peak journey times fluctuate greatly from one day to the next. Most of the variation identified during the surveys could be explained by the abnormal travelling conditions such as bad weather, traffic accidents, etc. However there were occasion when long delays had no other cause than the shear volume of traffic trying to access the Sheepscar Intersection.

To assess the performance of the guideway it is useful to compare the journey times of buses along Scott Hall Road when congestion is at its worst (e.g. southbound in the morning peak and northbound in the evening peak). It is during these times that the benefits to buses from the guideway will be greatest.

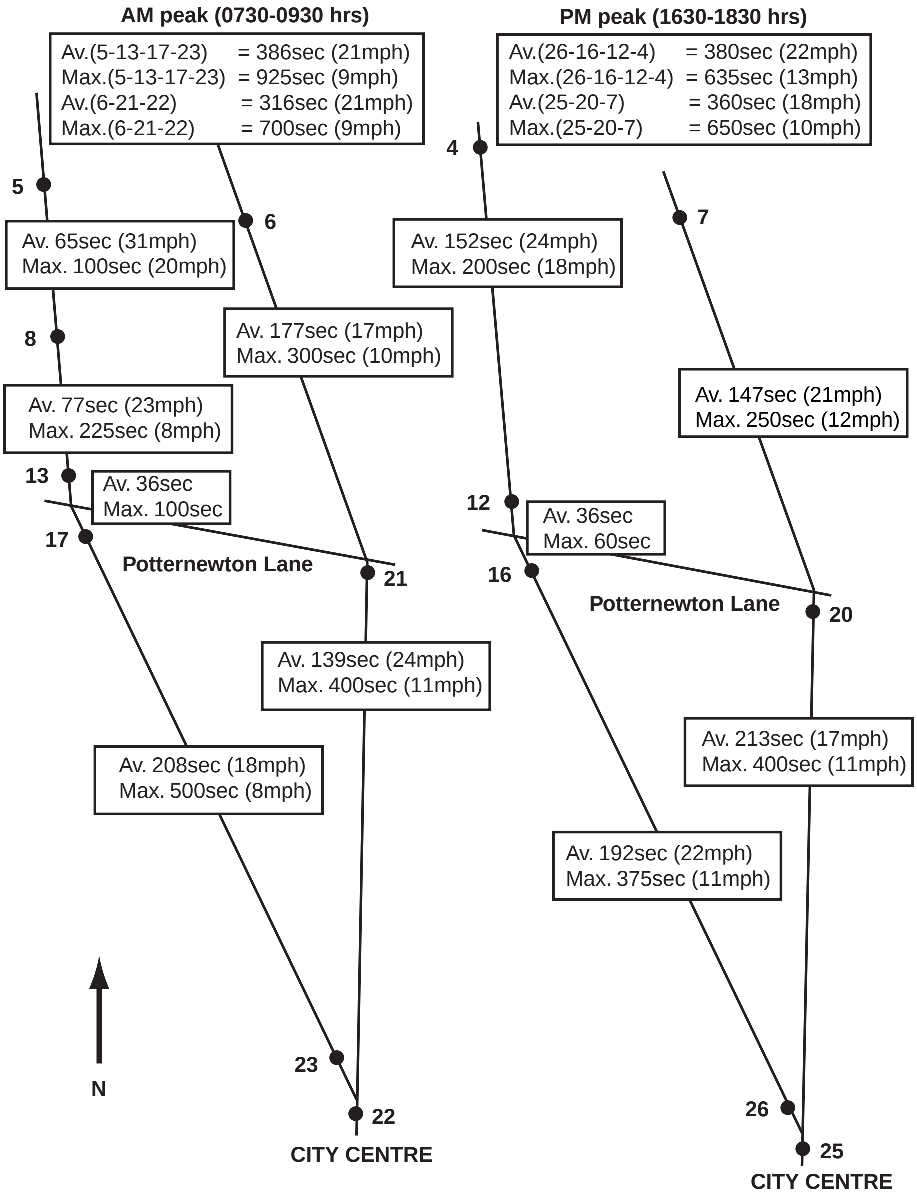

Figure 9 Summary of peak journey times along Scott Hall Road, Harrogate Road and Chapeltown Road

5.2.1 Scott Hall Road (southbound in the morning peak)

A summary of southbound bus and general traffic journey times along Scott Hall Road during the morning peak (0730 to 0930 hrs) is given in Table 8. The shaded cells indicate links that include sections of guideway.

Journey times on the link directly upstream of the guideway have remained unchanged, with buses taking 2 minutes and cars about 1 minute (31 mph) to travel between 5-8. The impact on journey times caused by the signalisation of the Stainbeck Road junction has therefore been neutral, assuming no reduction in flow along the link. This consolidation of journey times has been achieved alongside perceived benefits to both buses and general traffic using the signalised junction to access Scott Hall Road and Stainbeck Road.

Along the section of Scott Hall Road which now incorporates Phases 2 and 3 of the guideway and the modifications to the layout of the Stainbeck Lane roundabout (8-13), journey times improved significantly for both buses and general traffic. On average buses are saving about 70 seconds, reducing their journey time to about 100 seconds. The journey time profiles shown in Figures A4 to A6 clearly show that the guideway has isolated buses from the worst effects of congestion. Not

Table 8 Summary of southbound journey times in the morning peak (0730-0930 hrs)

	Journey time in second (speed in mph)					
	General traffic			*Buses*		
o-d	*1993*	*1997*	*Difference*	*1993*	*1997*	*Difference*
5-8	56 (36)	65 (31)	+9	119	132	+3
8-13	126 (14)	77 (23)	-49	168	97	-71
13-17	42 (11)	36 (12)	-6	62	35	-27
17-23/27	141 (27)	208 (19)	+67	282	411	+129
27-30	n/a	n/a	-	227	189	-38

only are the average bus journeys times much lower than before; they are also much less variable leading to greater punctuality. Overall buses are still slower than cars, because of the bus stops, but at the peak one or two buses are actually quicker. On an average day, buses operating during the height of the peak can save over 2 minutes when compared with the equivalent car journey time of 225 seconds (8 mph). The 1997 surveys suggest that journey times alongside the guideway on a normal day do not increase much above 225 seconds. However on odd days when there is chronic congestion e.g. similar to the Wednesday morning period in 1993 when journey time between 8-13 reached a maximum of 800 seconds, then benefit to buses will be much greater.

General traffic journey times now average 80 seconds (23 mph), a saving of almost 50 seconds when compared with the 1993 situation. As traffic flows between 8-13 were similar in both surveys the most likely reason for this improvement can be attributed to the removal of buses from the main carriageway; this eliminates a situation were buses servicing bus stops block a traffic lane.

The introduction of the bus activated pelican crossing just before the Potternewton Lane roundabout has improved bus journey times across the roundabout (13-17). It has been estimated that buses are saving on average 5-10 seconds during the morning peak and up to 30 seconds when the roundabout is at its most congested. General traffic journey times were unaffected by the changes made to the roundabout, suggesting the new signal arrangements have not reduced access to the roundabout.

Turning movements at the roundabout, suggests that there has been no significant diversion of southbound Scott Hall Road traffic (13) via Potternewton Lane and Chapeltown Road, so as to avoid the delays on the Scott Hall Road approach to the Sheepscar Intersection. Nor has there been an increase in eastbound traffic on Potternewton Lane (11) continuing straight on or turning right into Scott Hall Road.

The southbound guideway ends at the Potternewton Lane roundabout, beyond which buses and general traffic share the dual carriageway towards the Sheepscar Intersection. Interpretation of the journey time data for the approach to this Interchange (17-23/27) was complicated by the variability of the measurements. However the overall trend is that both the magnitude and variability of journey times have deteriorated significantly for buses and general traffic. Buses are on average 2 minutes slower between 17-27 compared with 1993 measurements while general traffic between 17-23 is over 1 minute slower. The variability in bus journey times has increased by over 200 per cent in the morning peak, undoing much of the benefits accrued by buses from the guideway.

The average bus speed between 17-27 is very slow, currently averaging 11 mph over the 2 hour period (this value is calculated from the total journey time which includes travel time, bus stop time and delays at junctions). During the height of the peak buses average 550 seconds or 8 mph (Figures A12 and A13) but on congested days (Figure A11) this is reduced to walking speed (4 mph).

These extensive delays during the height of the peak, although only affecting a hand full of buses will inevitably detract from the bus guideway scheme and the route as a whole. If buses could be isolated from these delays significant improvements to both journey time and punctuality could be made. It has been estimated that if bus journey times are completely isolated from the peak journey times (as the guideway has done between 8-13) then buses could save on average between 2-3 minutes on a normal day and up to 11 minutes when congestion is severe.

The improvement to bus journey times between Sheepscar and the city centre (27-30) can be attributed to buses being transferred onto the more direct North Street route (saving approximately 300 m and several signalised junctions). In the morning peak buses are saving an average of 40 seconds due to these changes.

5.2.2 Scott Hall Road (northbound traffic in the evening peak)

A summary northbound bus and general traffic journey times along Scott Hall Road during the evening peak (1630-1830 hrs) is given in Table 9. The shaded cells indicate links that include the northbound guideway on the approach to the Potternewton Lane roundabout.

Table 9 Summary of northbound journey times in the evening peak (1630-1830 hrs)

	Journey time in seconds (speed in mph)					
	General traffic			*Buses*		
o-d	*1993*	*1997*	*Difference*	*1993*	*1997*	*Difference*
26-16	159(27)	192(22)	+33	n/a		-
28/26-19	n/a	n/a	-	237	176	-61
19-16	n/a	n/a	-	65	49	-16
16-12	32(14)	36(12)	+4	47	42	(-5)
12-3/4	134(28)	148(25)	+14	207	193	(-14)

Buses leaving the city centre via North Street and travelling across the Sheepscar intersection are taking approximately the same amount of time as in 1993, despite the removal of the northbound bus lane on North Street. Journey time between 29-28 (Meanwood Road) and 29-26 (Scott Hall Road) take approximately 2 minutes while those buses bound for Chapeltown Road, 29-25 take on average 30 seconds longer (due to the extra junction they must cross). This gives an average bus speed along North Street and across the Sheepscar Intersection of between 13-15 mph. which compares favorably with the equivalent inbound bus speed (27-30 via North Street) during the morning peak of 13 mph.

It is suspected that a 30 per cent reduction in traffic flows along North Street has off-set the effects of removing the bus lane. However the stability of bus journey times exiting the city centre was in contrast to those of general traffic which deteriorated slightly despite the decrease in traffic flows along North Street. Averaged over all three movements (29-28, 29-26 and 29-25) general traffic journey times increased by approximatley 12 seconds.

A comparison of journey times for buses travelling out of Leeds via Scott Hall Road is complicated by the removal of the Meanwood Road/Sackville Street loop. At face value buses between 26-19 in 1997 are about 1 minute quicker on average than the same buses between 28-19 in 1993. However it has been estimated that the removal of the Meanwood Road/ Sackville Street loop should save buses an average of 100 seconds, which in effect means buses are being delayed by an additional 40 seconds. This suggests that queues are building up on the approach to the Potternewton Lane roundabout, extending beyond the start of the guideway and delaying buses before they reach the guideway. It has been estimated that during a normal day, delays to buses on the approach to the guideway start when general traffic journey times between 26-16 exceeds about 200 seconds (22 mph). This increases to a maximum delay of almost 110 seconds during the height of the peak when general traffic journey times average 350 seconds (13 mph) between 26-16.

Once in the guideway, buses are able to bypass the traffic queues that have built up on the approach to the Potternewton Lane roundabout. Although buses are only saving an average of 15 seconds over the whole survey period, during the height of the peak buses are about 1 minute quicker when compared to 1993. However when compared with general traffic journey times alongside the guideway (which have deteriorated by about 30 seconds since 1993) its possible for buses to save up to 2½ minutes when congestion during a normal day is at its worst. Another important change attributed to the guideway is that the variability of bus journey times over the 2 hour evening period has been reduced by almost 50 per cent, the standard deviation decreasing from 21 to 12 seconds. This is in contrast to the variability of general traffic times between 26-16; in 1993 the journey times varied between 147-167 seconds but in 1997 this increased to 160-324 seconds.

A conservative estimate puts the increase to general traffic journey times along Scott Hall Road (26-16) at just over ½ minute. There are two possible explanations for this increase:

a An increase in traffic flows approaching the Potternewton Lane roundabout.

It is difficult to establish whether northbound traffic flows in the evening peak have increased as the surveys did not provide any accurate flow data for the approach to the Potternewton Lane roundabout. Data collected at 16 suggests that flows decreased by about 9 per cent (1750 to 1600 veh\hr), but reflects changes to the capacity of the junction (discussed in the next section) rather than the demand on the approach.

b A reduction in the capacity of the Scott Hall Road approach to the roundabout.

Although flow measurements at 16 indicate that the exit capacity onto the roundabout has been reduced, further evidence for this would manifest itself in increased journey times across the roundabout. Table A15 shows that although general traffic journey times have increased, the changes were small (+4 seconds). To examine this point more carefully the two underlying causes for reduced capacity on the Scott Hall Road approach are explored in sections i) and ii).

i A change in the proportions of turning or circulating traffic on the roundabout, thus reducing the opportunity of vehicles accessing the roundabout from Scott Hall Road.

Any increase in the popularity of an approach to a roundabout can disrupt the relative circulating flows, causing increased delays on other approaches. In the case of Potternewton Lane roundabout any increase in the number of vehicles entering onto the roundabout from the westbound Potternewton Lane arm (site 18) would reduce the opportunity for northbound Scott Hall Road traffic to access the roundabout. This would in affect reduce the exit capacity onto the roundabout and delay traffic on the Scott Hall Road approach.

Analysis of the turning movements of vehicles approaching the roundabout from Potternewton Lane (Section A2.2.3) revealed that although the amount of westbound traffic entering onto the roundabout increased by 23 per cent (259 to 320 veh/hr), the two movements conflicting with the Scott Hall Road approach (e.g. the straight on and right turn movements) showed a combined increase of 17 per cent (228 to 267 veh/hr) which amounts to only one extra vehicle every 1 ½ minutes. This relatively small increase is unlikely to reduce the exit capacity onto the roundabout from Scott Hall Road, so if capacity has indeed been reduced there must be some other cause.

ii Increased activation of the new traffic/pedestrian signals located just before the Potternewton Lane roundabout.

Each time a bus is detected in the guideway the pedestrian crossing is activated, severing the flow of vehicle to the roundabout. This allows vehicles between the signals and the roundabout to disperse, so that by the time the bus arrives at the roundabout they have an easier path onto the roundabout. The cost of giving buses priority is that each time the roundabout give way line empties, capacity to general traffic on the main carriageway is reduced. To estimate the extent of this reduction the proportion of time that the give way line is empty needs to be determined.

Approximately 15 buses use the northbound guideway each hour during the evening peak period, with each bus activating about 15 seconds of red time at the signals. This amounts to about 3 minutes 45 seconds of additional red time each hour compared to 1993, assuming the demand for the pedestrian crossings has remained constant and that bus activation is additional to any pedestrian activation. Obviously there will be times when pedestrian and bus activation of the signals coincide, therefore a conservative estimate would be that buses interrupt the flow of traffic every 5 minutes.

The distance between the pelican crossing and the roundabout is approximately 38 m and it can be assumed that during the evening peak this reservoir will be full. Allowing 7 m per car this amounts to about 10 cars in the reservoir when the signals turn red. For these 10 vehicles to disperse in 15 seconds would require a flow onto the roundabout of 2400 veh\hr. The average flow measured at 16 (1600 veh\hr) suggests that the area between signals and the roundabout will not clear completely and therefore capacity should not change. However the flow onto a roundabout will vary, depending on the amount of circulating traffic. At times when there are no conflicting traffic movements onto the roundabout from Scott Hall Road will reach a maximum of about 3600 veh/hr (this assumes a discharge rate for each lane of 1 vehicle every 2 seconds). This suggests there will be times when capacity is reduced, but without detailed modelling of the roundabout the extent of this reduction is difficult to determine accurately. An approximation may be made be to compare the average flows at 16 which gives a decrease of about 9 per cent.

Without accurate flow measurements it is difficult to determine exactly the reason for the increase in northbound general traffic journey times on the approach to the Potternewton Lane roundabout. The success of the signalling technique to provide priority for buses onto the roundabout relies on the capacity of the approach being reduced to zero for short periods of time; and there is some evidence to suggest that technique has been marginally successful. It is therefore possible the new signalling technique has been partially responsible for the increase to journey times between 26-16, but without reliable flow data its importance is difficult to determine.

Bus journey times across the Potternewton Lane roundabout were unchanged from the 1993 situation while general traffic took on average 4 seconds longer. This approach to the Potternewton Lane roundabout has not been as successful as the southbound approach where buses were saving up to 30 seconds when congestion on the roundabout was at its worst. Analysis of the video survey suggests that bus access from the nearside guideway onto the roundabout incurs more obstructions than those exiting from the central guideway. The main problem seems to be that when buses reach end of the nearside guideway they are prevented from exiting onto the roundabout by vehicles entering from the Scott Hall Road approach. Buses must therefore wait until there is a gap or (as was often recorded) force there way into the circulating flow. This problem does not occur in the southbound direction as the bus queues behind any vehicles still remaining at the roundabout give way line. The different approaches to the roundabout can be seen in Plate 2. To remedy this problem with the nearside guideway, a longer red phase is required at the signals to ensure the area between the signals and the roundabout clear completely by the time the bus reaches the roundabout. This would however only add to the delays of general traffic on the approach to the roundabout, so delaying buses even further before the guideway.

Along the section of Scott Hall Road directly beyond the roundabout (12-3/4) a similar journey time pattern emerges; buses taking approximately the same time as they did in 1993 while general traffic is about ¼ minute slower, reducing their average speed from 28 mph to 25 mph. Apart from the changes to the Stainbeck Lane roundabout, which shouldn't affect northbound traffic, the only change along this link has been the signalisation of the Stainbeck Road junction. Northbound Scott Hall Road traffic is now interrupted by the signal phase which allows southbound vehicles on Scott Hall Road to turn right into Stainbeck Road. This may explain why general traffic is now slightly slower than before.

A comparison of northbound journey times along King Lane is difficult to interpret as general traffic times have deteriorated considerably. General traffic is now over 1 ½ minute slower than in 1993 which has reduced average speeds along the link from 13 mph to 9 mph. This is despite vehicle flows remaining almost constant. Buses however avoided much of this extra delay by diverting via Street Lane, thus avoiding the King Lane approach to the Stonegate Road roundabout where it is suspected most of the delay originates. This means that bus journey times have remained approximately the same as those in 1993 and has created a situation where bus journey times are quicker than general traffic between the two timing points.

6 Bus passenger and car driver study

6.1 Bus passengers using SUPERBUS routes

6.1.1 The Survey

The bus passenger survey was made over five weekdays (0730–1830 hrs) and one Saturday (1100–1400 hrs) in the week 2-7 February 1998. This date was chosen as being long enough after the completion of the southbound sections of the guided busway between Stainbeck Road and Potternewton Lane (autumn 1997) for passengers to have become accustomed to the resulting service improvements, avoiding the pre- and post-Christmas periods, and preceding the next stage of construction work on the P&R site and guideway on King Lane (Section 2.3.1).

A total of 371 passenger interviews were completed, 341 between Monday and Friday, and 30 on Saturday. In addition, passenger counts were made on the Wednesday, Thursday and Saturday, to provide a basis for demand estimation and also to determine sampling rates achieved in the questionnaire survey. An estimated 1.5 per cent of weekday passengers (0730–1830 hrs) were interviewed, as were 2.7 per cent of Saturday passengers (1100–1400 hrs). These sampling rates determine weightings when it is necessary to combine weekday and Saturday results.

6.1.2 Passengers and bus journeys

Superbus passengers were asked, *inter alia*, how long they had been using the bus service, why they had started using it, how often they used it, whether their frequency of use had subsequently changed and, if so, by how much.

Their answers are summarised in Figure 10. The first of the pair of numbers in each bracket represents the number of respondents in each category, and the second represents the weekly number of return bus journeys *now* made using the service, or the change in frequency of use where appropriate.

Passengers are first divided into two categories: those that were using Scott Hall Road bus services before the introduction of Superbus (in July 1994), and those who started using it thereafter. The latter category were further subdivided into those who started using the service because of improvements, and those who had started for other reasons: mostly changes in journey requirements (e.g. because of relocation of workplaces, homes, schools etc) or in car availability (as drivers or passengers).

Further subdivisions are made according to whether people's use of the service changed following the introduction of Superbus or since they had started using it. Those whose frequency of use had changed were further subdivided according to the reason for change (service improvement or other reason).

Ideally, at each subdivision of a category, all the respondents in it should be allocated to one of the subcategories. In practice there are some minor discrepancies due to missing, unusable or illogical responses to questions. The same applies to numbers of journeys, which should follow a similar pattern, but not to frequency changes in the bottom rows of cells. The figure given for frequency changes are net changes, with increases of 16 journeys per week by some users being off-set by reductions of 14 per week by others, among those who were long-term users of the service and whose frequency of use had changed for reasons other than bus service improvements. Changes by more recent users included an increase of 6 journeys per week, partially off-set by reductions of 2 per week, all attributable to bus service improvements. As we can propose no convincing explanation of this, we have removed the apparently illogical responses suggesting that better services have caused some people to use buses less, assuming that they are erroneous.

These results suggest that among the weekday respondents , service improvements following the introduction of Superbus generated 90 journeys per week (74 by new users attracted by Superbus, 10 by long-term users , and 6 by recent users who had started using the service for reasons other than bus improvements, but subsequently increased their frequency of use because of improvements). This represents about 5.7 per cent of the total current demand by our weekday sample of passengers, and is equivalent to 10.4 per cent of the trips made new (since 1994) users of the service.

But this is only part of the picture. We have no direct measurement of numbers of journeys lost over this period as a result of people moving away from the area, changing jobs and schools, and acquiring new cars. As a first approximation we might assume that this should correspond to the number of new journeys (693) generated by similar causes. This would imply an overall increase in weekday patronage of 90, from 1495 to 1585, or 6.0 per cent.

A similar study of bus passengers by Streer Davies Gleave (1997) reported that for a 10 month period (May 1996 to March 1997), the growth of patronage on Superbus routes, relative to the rest of Leeds had been about 3 per cent[1].

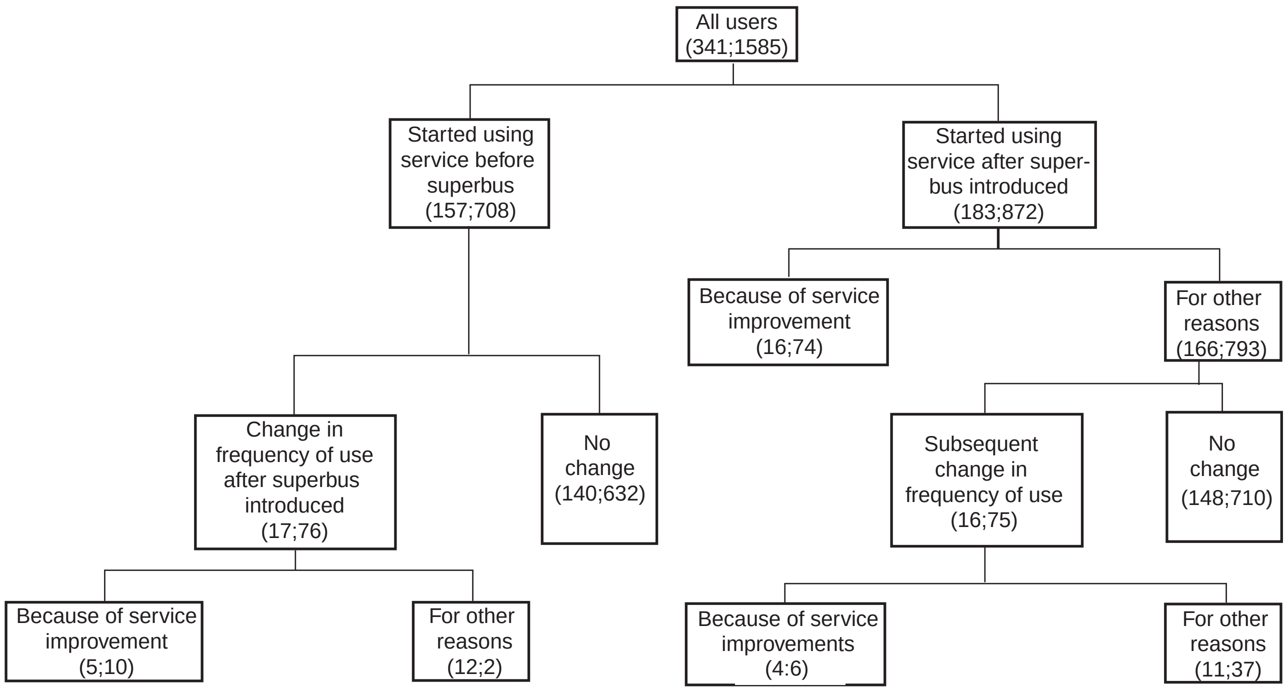

Figure 10 Summary of answers from bus passenger interviewed on weekdays

This estimate is clearly at odds with the estimates of increased patronage of the order of 50 per cent on the corridor published by FirstGroup (1998). These patronage gains reported by FirstGroup (1998) are illustrated in Figure 11. The graph compares patronage (in four week rolling periods) on Superbus routes with bus routes for the rest of Leeds over a 30 month period between July 1995 and December 1997. The trendlines show patronage increasing on Superbus routes by an average of 1.7 per cent per month while there is a general decline of -0.55 per cent per month for other routes in Leeds over the same period.[2] There are several possible explanations for the discrepancy between the survey and bus companies results:

- people have underreported numbers of new journeys, or increased frequency of use;
- people have given incorrect reasons for their new or increased use of buses;
- improved bus services may have been an implicit contributory factor in peoples' choice of modes for new journeys, or in countering tendencies for people to switch from bus to car.

While the first two of these cannot be entirely ruled out, it seems very implausible that the degree of bias in these responses would be sufficient to explain the anomaly. The third is more tenable, at least qualitatively. When deciding how to make a new, regular, journeys people may not be conditioned by habit, and willing to consider all options. A better bus service is more likely to be chosen than a less good one in preference to travel by car, say but the reason given for starting to travel by bus could well be to get to a new destination. Conversely, existing users of better bus services may be less dissatisfied with them than elsewhere, and less inclined to acquire cars or seek lifts. Thus the well known secular decline might be less than normal.

To explore these ideas further, we designate by X the number of weekly journeys lost by 'natural wastage' between the introduction of Superbus and the survey. Originally, the weekly number of journeys made by people *still using the service* would have been 708-12 = 696 (ie the number of trips made now, less those which have since been generated, for any reason). So we have:

Total original journeys			696+X
Less journeys lost by natural wastage	-X	=	696
Plus journeys gained by natural growth(793-6)	+787	=	1483
Plus journeys generated by service improvement	+ 90	=	1573

If we assume, in accordance with the estimates by FirstGroup (1996), that demand at the time of the survey exceeds the original level by 50 per cent, then 1573 must be 50 per cent greater than 696+X, which is therefore about 1050, and X is about 350. This implies that the balance

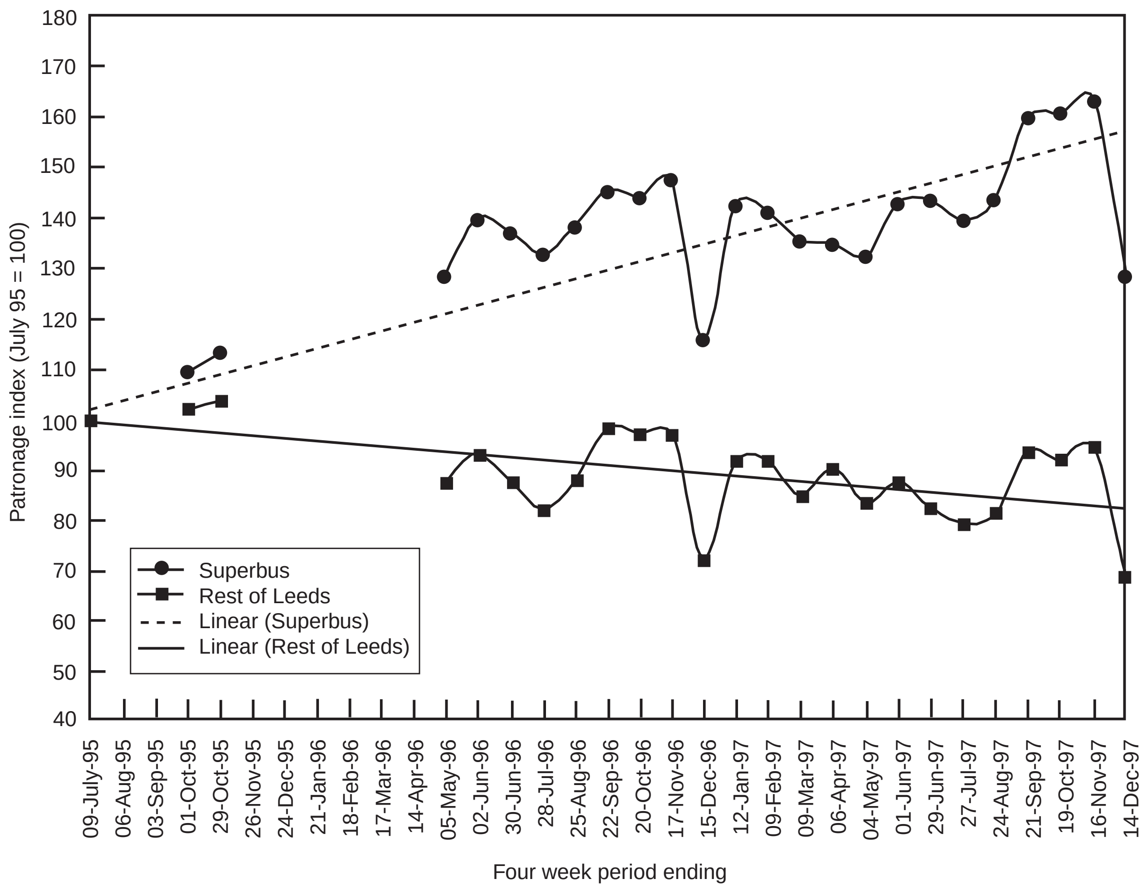

Figure 11 A comparison of patronage trends for Superbus routes and the rest of Leeds

between ‘natural’ decline and growth, which typically results in a net loss of a few per cent per annum or some 10 per cent in this case, has been converted into a substantial net gain, with growth exceeding loss by more than a factor of two. Thus it is arguable that the undeclared influence of the bus service improvements has resulted in far more new journeys than those which are specifically attributed to Superbus.

This hypothesis depends on too many unsubstantiated assumptions to be accepted without further evidence: unfortunately the available information on demand for Superbus services is insuffiently detailed for this purpose.

The Steer Davies Gleave study suggests that the root cause for the generation of new passengers is a result of lifestyle changes (eg. changes to residential, employment or educational location), rather than because of a change in the relative attractiveness of competing modes. Further clues to the attractiveness of Superbus are explored in the following sections.

6.1.3 Attitudes to SuperBus

6.1.3.1 Journey times

People were asked how journey times by Superbus compared with those by the previous bus services. Nearly half (183/371) replied that there was no difference, and rather more than half estimated that the difference was in the range 0±2½ minutes. A substantial minority (Figure 12) reported that Superbus was significantly quicker (2½ to 12½ minutes) than the previous service, and a small minority claimed greater time savings, or significantly increased journey times. Excepting the more extreme views, this pattern appears to be consistent with measured changes in journey times.

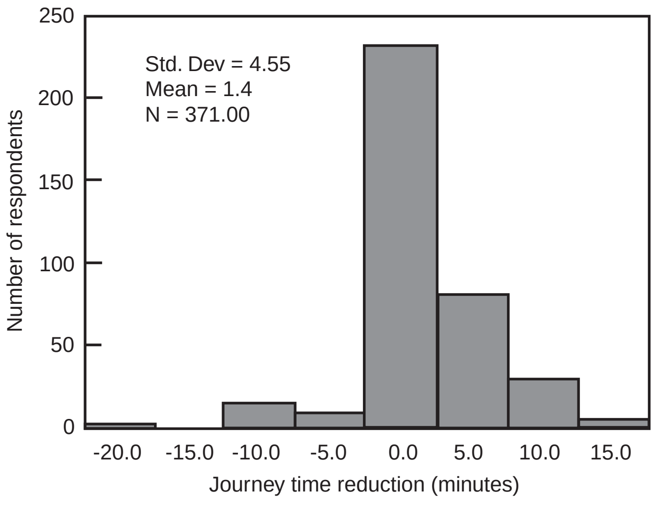

Figure 12 Superbus journey times compared with previous bus service

Concerns that the sample underestimated the perceived journey time savings because it included a number of passengers on Route 71 (a route that does not use central guideway) were not substantiated. Further analysis which separated the 71 passengers interviewed on Route 71 from main sample revealed that the perceived journey time saving was not significantly different from zero, independent of the route used.

6.1.3.2 Other aspects of Superbus service

Passengers were asked how Superbus services compared with the previous bus services in terms of a number of separate service characteristics, indicating in each case whether Superbus appeared better, worse or no different from its predecessor. Over 50 per cent of people (Figure 13) considered that there had been no change in waiting times, availability of seats, provision of information and value for money. However, 67 per cent considered that vehicle quality (cleanliness, comfort) had improved, 50 per cent thought that Superbuses were easier to board and alight (compared with 49 per cent who perceived no change), and 50 per cent thought that bus shelters had improved. Opinions on service frequency were quite evenly divided, with 44 per cent reporting improvement and 43 per cent no change. This possibly reflects the increases in off-peak frequencies which followed the introduction of Superbus, and the distribution of interviewees between peak and off-peak passengers.

In all cases only a small minority (ranging from 1 to 16 per cent) thought that Superbus services were not as good as previous services.

6.1.3.3 Aspects of Superbus service that require improvement

Interviewees were asked an open question on what aspects of the Superbus service they would like to see improved. Of the 371 people interviewed, 218 (59 per cent) responded, giving a total of 271 comments (some gave more than one answer). Almost 36 per cent of the comments related to the need for more buses and overcrowding while 11.4 per cent thought buses should adhere more closely to the timetable. The other most frequently made comments were; need for more and improved bus shelters (7.7 per cent), better timetable information (7.7 per cent), poor drivers attitude (5.9 per cent) and need for cheaper fares (5.5 per cent).

6.1.4 Factors influencing choice of service

Appreciation of better quality in various aspects of public transport services do not necessarily affect people’s choice of mode of travel, or of service. In order to shed some light on which aspects of Superbus services had most influence on transport decisions, the 110 interviewees who said that they could make the same journeys using other services than Superbus were asked why they had chosen to use Superbus. Their answers are summarised in Table 10.

In many cases, people are influenced by features which depend on the service pattern: they prefer routes which minimise walking distances, are more direct or more frequent, but many will board the first bus to arrive. Bus journey time is also important: this can be affected by routing as well as by bus priority measures.

6.1.5 Changes in transport mode

6.1.5.1 Recorded modal shift

Modal shift is, by definition, confined to those interviewees who have switched to bus travel from other modes. Those who were using the service before the introduction of Superbus have not changed mode (although it is possible that some of them might otherwise have switched from bus to car).

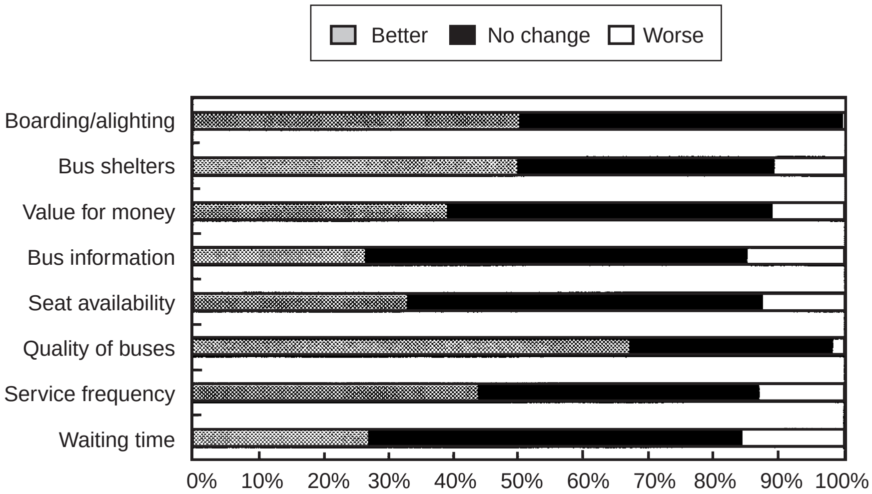

Figure 13 Passengers' assessment of Superbus compared with previous bus service

Table 10 Reasons for choice of Superbus rather than alternative service

Reason	*Number of respondents*
Stops nearer home/destination	32
First bus to arrive	24
Quicker	21
Better service (frequency, reliability)	12
Prefer Superbus	12
More direct	7
Newer/cleaner buses	2
Cheaper	2

The majority (166 out of 183 weekday interviewees, Figure 10)of people who had started using buses after the introduction of Superbus had done so for reasons other than bus service improvements (eg change of trip ends or car availability). Only 25 of these made the same journey before they started using Superbus, and of those 21 had travelled by car as drivers or passengers, but had changed modes because this option was no longer available. Of the remainder, one had switched from walking and one from cycling to Superbus; two had switched from other buses and should not therefore have been included in this category.

There were 16 weekday interviewees (Figure 10) who had started using buses because of the Superbus improvements. Six of these had not made the journey before, and so their trips appear to be generated travel (rather than modal change), eight previously travelled by car (drivers or passengers), and one cycled. There is little direct evidence therefore of modal shift from car to bus, although, as we have previously argued, people making new trips may have been more likely to choose bus rather than car as a result of the improved service.

6.1.5.2 Choice of bus by people who could use cars

An alternative way of assessing the effect of bus services on car use is to explore whether bus passengers have a choice between car and bus use, and if so why they choose to travel by bus. Among our sample of 371 passengers, there were 115 who could have made the journey by car. This represents 31 per cent of the total. We have not yet been able to find similar statistics for other bus services in similar areas, in order to establish whether Superbus is attracting abnormally high proportions of people from cars. Bailey and Layzell (1982) found that 26.5 per cent of Oxford bus passengers in 1976 could have used cars, but comparison is complicated by differences between the areas and the long interval between the surveys.

The reasons for bus use by those in our survey who had cars available are given in Table 11.

Table 11 Reasons for using buses when car travel was possible

Reason	*Number of respondents*
Buses more environmentally friendly	2
Buses cheaper	22
Buses faster	3
Buses more convenient	29
Traffic congestion	11
Town centre parking	45
Bus company publicity	1
No response	2

Difficulties in driving into the city centre, and finding somewhere to park, seem to persuade many people to use buses. These reasons are possibly reflected in the responses relating to convenience. Similarly, parking costs may be a factor in the perception that buses are cheaper.

6.2 Car drivers using Scott Hall Road

6.2.1 The surveys

Questionnaires were handed to car drivers while they queued at traffic signals on the approach to the city centre at the southern end of Sheepscar Street North, during the morning peak period on Tuesday 24 February 1998. This operation was accomplished with no major difficulties, and some 1500 questionnaires were distributed between 0730 and 1100 hrs. By mid March nearly 700 of these questionnaires had been completed and returned, and were coded for analysis.

6.2.2 Car journeys

6.2.2.1 Journey purpose

Answers to the question on journey purpose, are shown in Table 12.

Table 12 Journey purposes

Reason for journey	*Number of respondents*
To work	646
To education	26
Employer's business	92
Shopping	239
Personal business	45
Visiting friends etc	131
Leisure	198
Escort	28

The total number of reasons given is considerably in excess of the number of respondents (693), since many people gave multiple answers, reflecting multi-purpose journeys. Nevertheless, for 93 per cent of respondents, travelling to work was one, if not the only journey purpose.

6.2.2.2 Journey frequency

As expected in view of their journey purposes, most of those questioned were regular travellers: journey frequencies for all respondents are shown in Table 13. Over three quarters made the journey at least five times per week on weekdays. Nearly half also made the journey at least once a week at weekends.

Table 13 Frequency of travel (return journeys)

Trip frequency: Monday-Friday	*Trip frequency: Saturdays*		
	<1/week	*$\geq$1/week*	*All*
<5/week	96	59	155 (22%)
$\geq$5/week	252	286	538 (78%)
All	348 (50%)	345 (50%)	693

6.2.2.3 Trip ends

Most respondents (661) gave sufficient details of their trip ends to enable postcode zones to be identified. For the purposes of this report we have grouped origin and destination zones as follows (Figures 14 and 15):

Origins

- North Leeds: LS7 2, LS7 3, LS7 4, LS8 1, LS8 2, LS17 5, LS17 6, LS17 7, LS17 8.
- Harrogate area: all HG codes, LS17 9 (Harewood and district).
- Other: all other origins.

Destinations

- Central Leeds: LS1, LS2, LS3.
- Areas adjacent to central Leeds: LS4, LS6, LS7, LS8, LS9, LS10, LS11, LS12.
- Other: all other destinations.

These groups of origins and destinations were defined so as to be relevant to travellers using Scott Hall Road.

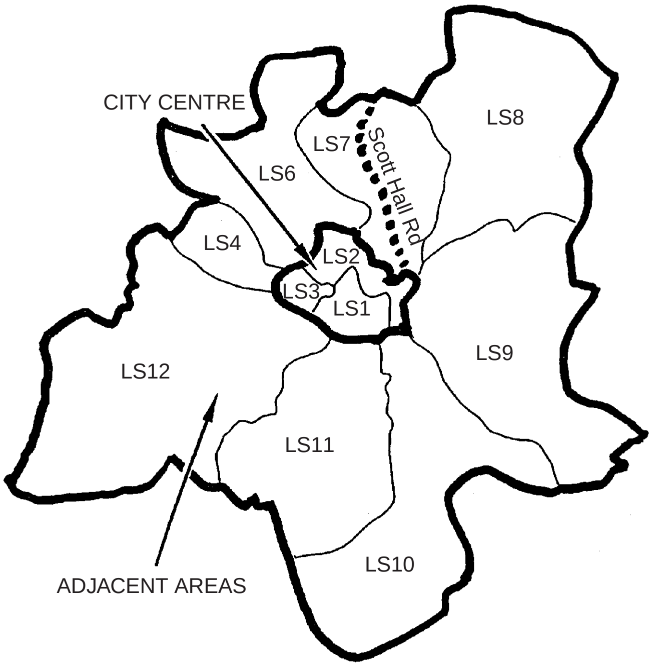

Figure 14 Car journey origins

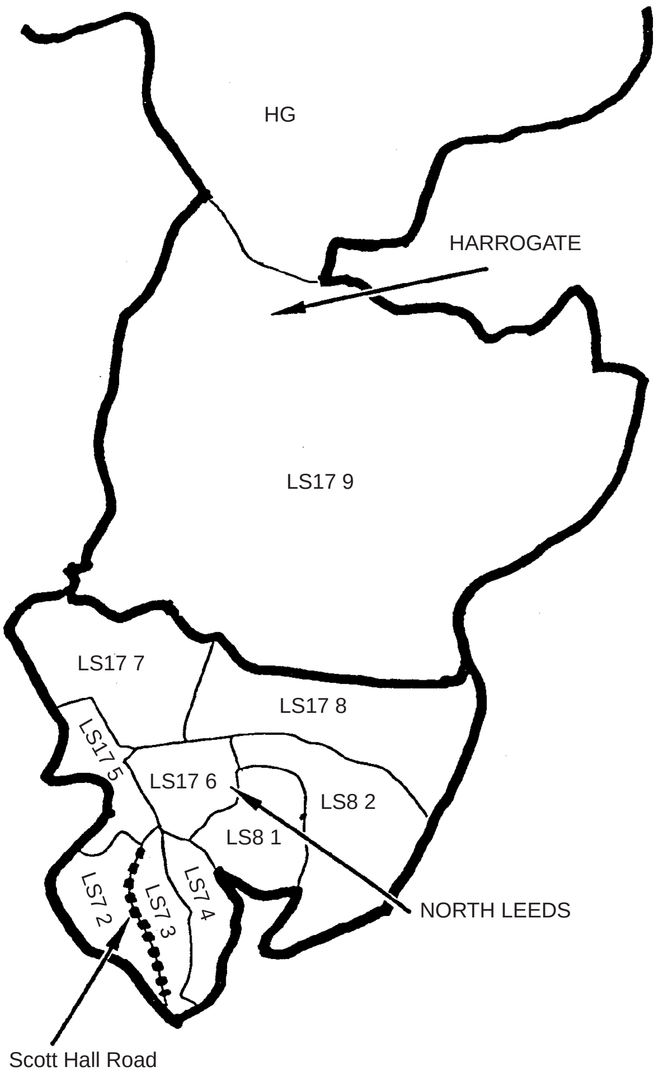

Figure 15 Car journey destinations

Generally buses routed via Scott Hall Road served the area we have defined as North Leeds. Buses also run between Harrogate and Leeds, mostly using Chapeltown Road, a little to the east. The city centre is judged to be accessible by buses from Harrogate and those using Scott Hall Road . Bus journeys to adjacent parts of Leeds, or other destinations would generally require interchange in Leeds.

Numbers of respondents making journeys between these groups of origins and destinations are shown in Table 14 (in rows labelled 'all').

Table 14 Journey origins and destinations

Destination	*Driver category*	*Origin* North Leeds	*Harrogate*	*Other*
Central Leeds	All	101	86	57
	Bus available	74	27	27
	Bus user	35	6	10
Adjacent areas	All	103	65	69
	Bus available	49	12	21
	Bus user	16	1	6
Other	All	102	32	46
	Bus available	40	1	4
	Bus user	18	0	2

6.2.3 Use of buses

6.2.3.1 Dependence on trip ends

Respondents were asked whether there were bus services available to them to make the journeys for which they were actually using cars, and, if so, whether they ever used such buses. Their answers are also shown in Table 14.

Travellers from North Leeds proved most likely to consider that buses were available, and most likely to make use of them, at least occasionally. This finding is consistent with North Leeds being served by a comprehensive network of relatively high frequency urban bus services, whereas the Harrogate services are less frequent and not accessible to all residents of the area. The other origins are too mixed in character to permit meaningful generalisation.

People destined for central Leeds were more likely to consider that buses were available, and use them. This reflects service patterns, with most buses converging on the city centre, necessitating interchange for many people with non-central destinations. The introduction of the Superbus network may indeed have increased the need for interchange: several pre-1995 through bus routes, between north Leeds and places to the south and west of the city centre, were split, with the new Superbus services operated on the northern sections only.

6.2.4 Dependence on service type

People who said that bus services were available were asked which they could use. Their replies are summarised in Table 15.

Table 15 Type of bus service available

Bus type available	*Bus use* Sometimes	*Never*	*Total*
Superbus	27 (37%)	46	73
Superbus and other buses	29 (58%)	21	50
Other buses only	35 (33%)	70	105
Service number unknown	6 (18%)	27	33
Totals	97 (37%)	164	261

A total of 261 respondents indicated that there were bus services available which they could use, and 97 actually did so. (NOTE: these totals are slightly greater than those derived from Table 2, since they include a few people whose origins or destinations could not be identified). There is no significant difference in the propensity to use buses between those who could use Superbuses, and those who only have other types available. However, those who could use both Superbuses and other types of services have a higher propensity so to do, perhaps because where both types operate, combined frequencies are higher. It is not surprising that least use is made of buses by those who think buses are available, but do not know their route numbers.

6.2.4.1 Other factors

Table 16 gives some indication of how other factors affect propensity to use buses.

The categories of driver shown in this table are not mutually exclusive: over three quarters of those with company cars also benefit from free parking, and over three quarters also receive some other form of assistance

Table 16 Other factors influencing bus use

	Free parking	*Company car*	*No company car, but assistance with motoring costs*	*No free parking, no company car, no assistance*	*All drivers*
All drivers	*576*	*240*	*80*	*92*	*693*
Drivers with no available bus	369 (64%)	181 (75%)	48 (60%)	46 (50%)	432 (62%)
Drivers who could but DO NOT use buses	136 (24%)	45 (19%)	19 (24%)	26 (28%)	164 (24%)
Drivers who sometimes use buses	71 (12%)	14 (6%)	13 (16%)	20 (22%)	97 (14%)
ALL drivers with buses available	207 (36%)	59 (25%)	32 (40%)	46 (50%)	261 (38%)
Drivers who sometimes use buses	71 (12%)	14 (6%)	13 (16%)	20 (22%)	97 (14%)

Percentages apply to 'all drivers' in second row with costs, but further subdivision would render categories too small for useful statistical analysis.

There are significant differences in the proportions of those who sometimes use buses, between people with company cars, people with free parking, and people who enjoy no benefits at all. There are also significant differences in the proportions indicating that bus services are available for their journeys. For company car drivers this could be the result of perception of public transport being affected by constant car availability, or possibly because those with company cars are more affluent than average, and live in more upmarket areas which may be less well served by buses. The connection with free parking is less clear, and may be due in part to the correlation between free parking and company car use.

6.2.4.2 Frequency of bus use

Drivers who sometimes use buses were asked how often, and their responses are compared, in aggregate form, with the frequencies of their car journeys in Table 17.

Table 17 Frequencies of car and bus journeys (return journeys per week)

	Car trips		*Bus trips*	
	Total	*Per person*	*Total*	*Per person*
All drivers	4340	6.3	-	-
Bus-using drivers	610	6.3	103	1.1

There appears to be no difference in car trip rates between those who sometimes use buses, and those who never do so. In all, the bus trips account for only about 2.3 per cent of all journeys into Leeds by our survey respondents.

6.2.5 Reasons for use of buses and cars

6.2.5.1 Reasons for bus use

The 97 people who sometimes use buses gave the reasons summarised in Table 18.

Table 18 Reasons for bus use

Reason	*Number of responses*
Car unavailable	30
Parking difficult	22
Drinking not driving	21
Parking expensive	18
Traffic congestion	15
Buses more convenient	7
Weather	7
Environmental concerns	7
Buses quicker	3
Other	7

6.2.5.2 Reasons for not using buses

People who could use buses, but did not do so, gave a variety of reasons, summarised in Table 19.

The total number of responses exceeds the number of respondents, many of whom gave several reasons. The commonest reason, given by half the respondents, for non-use of buses was that bus journey times took too long; nearly as many responses indicated that people needed their cars for work purposes. Other reasons, given by smaller numbers of respondents concerned bus service quality (reliability, frequency, comfort, evening services). Other factors such as fare levels, passenger information and safety were cited by only a small minority.

Table 19 Reasons for not using available buses (164 respondents)

Reason	*Number of responses*
Need car for work/business	75
Bus journey too long	82
Bus fares too high	27
Bus services unreliable	53
Buses infrequent	45
Poor evening services	28
Overcrowding/discomfort	35
Safety	9
Carrying goods/shopping	24
Carrying children[1]	5
Inadequate information	20
Other	42

[1]It is not clear whether the children in question were babes in arms, pushchair passengers or simply children being given lifts to schools etc.

6.2.5.3 Reasons for excessively long bus journey times

Those who complained that bus journeys took too long were asked why; their answers are summarised in Table 20.

Table 20 Reasons why bus journeys take too long (82 respondents)

Reason	*Number of responses*
Too far to walk to stop (from trip origin)	17
Too far to walk from stop (to destination)	22
Need to change buses	35
Bus too slow	26
Buses unreliable	15
Other	6

The total number of responses again exceeds the number of respondents because of multiple responses. There is no overwhelming reason for slow bus journeys, but the lack of direct services, necessitating interchange is the most commonly cited. Aspects of bus services which might be improved by bus priority systems are roughly balanced by convenience factors, relating to excessive walking distances between origins or destinations and bus stops.

6.2.5.4 Comparison of bus and car journey times

People who gave the excessive duration of bus journeys as a reason for non-use were asked how long they thought bus journeys would take. Their answers are plotted in Figure 16 against their average car journey times. Both measures are somewhat subjective. People who do not use buses may well have an exaggerated perception of bus journey times, and average car journey times are unlikely to be calculated with any precision. Nevertheless, the comparison is valid insofar as people's mode choice will

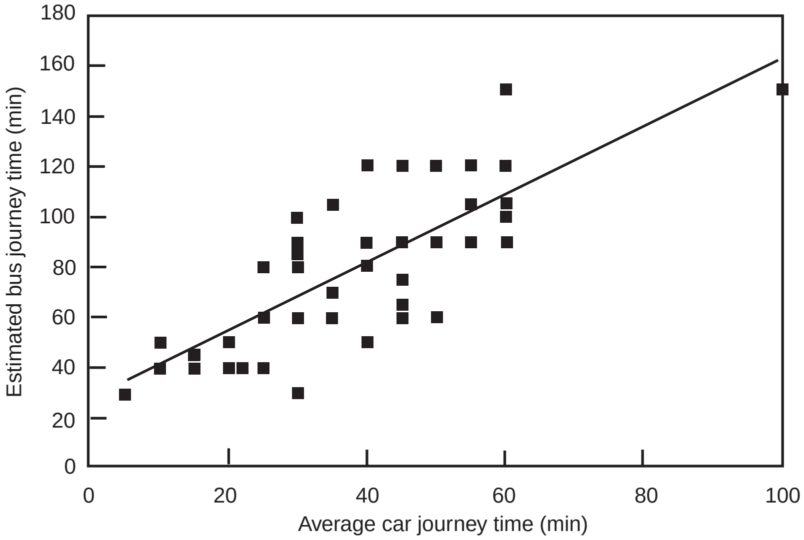

Figure 16 Comparison of bus and car journey times

depend on their perceptions of the options rather than objective measures.

In the great majority of cases the estimated bus journey time exceeds the car journey time by a considerable amount, averaging 40 minutes. It is clear that bus journey time improvements (two to three minutes) resulting from the priority measures so far introduced in the Scott Hall Road corridor are unlikely to effect any significant transfer from these car users to public transport.

6.2.6 Improvements required to encourage bus use

Non-users of buses were asked what improvements, if any, to bus services might encourage them to use them instead of travelling into Leeds by car. Table 21 shows the responses given by people who could use buses but do not, those who could not use buses, all non-users, and non-users travelling into central Leeds from North Leeds and Harrogate.

Except for a hard core of people (about one third overall) who could not be persuaded by any means to us buses, no clear pattern of priorities emerges from these results. Those who say that buses are available would be more likely to be influenced by faster journeys, higher frequencies, better reliability and lower fares; this is reasonably consistent with there reasons for not using buses (Table 19). Those who say no buses are available seem more concerned with distances to and from stops, and more direct services.

People travelling from North Leeds to the city centre seem most concerned with service frequencies, reliability and fares, while those from Harrogate would require better accessibility between trip ends and bus stops, and possibly through convenient park and ride arrangements.

6.2.7 Park and Ride

6.2.7.1 Reactions to proposed service

All respondents were invited to indicate whether the proposed park and ride site near Allerton High School would be conveniently located for their journeys into Leeds, and whether they intended to use the park and ride service. The responses are given in Table 22.

Just over a third of all drivers regard the Allerton High School park and ride site as being conveniently located, but most of these are undecided about whether they will use it, and only a tiny minority indicate any intention so to do.

Table 21 Bus service improvements needed to attract non-uses to buses

	Bus services available?			*Travellers from:*	
	Yes	*No*	*All non -users*	*N Leeds to city centre*	*Harro -gate to city centre*
Sample size	164	432	596	66	80
Lower fares	30%	16%	20%	32%	25%
Stops closer to home/destination	27%	26%	27%	23%	34%
More reliable	30%	18%	21%	39%	13%
Better information	17%	14%	15%	23%	11%
Faster journey	35%	19%	23%	26%	26%
Convenient P&R	15%	20%	18%	24%	34%
Higher frequency	32%	20%	23%	42%	25%
More direct service	25%	26%	26%	12%	16%
Other	9%	8%	8%	8%	15%
Nothing	23%	37%	33%	27%	20%

Percentages relate to sample sizes in the fourth row

Table 22 Attitudes to park and ride

	P&R site convenient	*Will use P&R service?* Yes	*Undecided*	*Sample size*
All respondents	239	18	169	693
Travellers from North Leeds to city centre	44	2	32	101
Travellers from Harrogate to city centre	22	0	23	86

It is curious that drivers from Harrogate seem less enthusiastic about park and ride than those from North Leeds. This seems to suggest that longer-distance commuters will accept smaller relative diversions from their ‘natural’ routes than more local travellers. The proposed park and ride site nearer the Harrogate road may prove more attractive to Harrogate commuters. However, in view of the proportion of commuters who claim to need their cars for work, and the numbers who enjoy free parking or various forms of motoring subsidy, it seems that park and ride services, however well planned and operated, will attract only a minority .

6.2.7.2 Relative importance of park and ride service features

Respondents were also asked to rank various attributes of a park and ride bus service in order of importance. The results are shown in Table 23.

Table 23 Ranking of park and ride attributes

	Rank						
Attribute	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Frequency	158	145	129	56	38	27	4
Fare level	67	70	89	90	70	70	86
Site quality	37	45	44	64	79	116	145
Journey time	73	86	73	82	79	71	70
Hours operated	45	60	73	74	102	91	84
Service quality	68	108	109	92	75	60	23
Site security	146	61	53	61	68	65	88
Total	594	575	570	519	511	500	500

Not all respondents who attempted to answer this question ranked each attribute, but 500 people managed to put all seven attributes in order. Service frequency and site security (involving lighting, closed circuit television and manned help points) were most commonly selected as first in order of importance. Various overall rankings may be obtained by assigning different weightings to first, second, third etc choices (subject to the condition that weights are less for lower rankings), and there is no objective way of selecting the best system of weighting. Two limiting cases are to assign equal weights to all choices, and to ignore all but first choices. Both of these lead to the selection of service frequency and site security as first and second priorities. Intermediate weighting methods reveal journey time and service quality (running on time) and fare levels to be third or fourth in order of priority. It was surprising to find that the hours operated (ie the times of the first and last buses) seemed to be of relatively minor importance (possibly people assumed that services would run at times they wanted). Site quality (shelters, seating, service information, telephones) were also considered relatively unimportant, suggesting that people will tolerate less than ideal waiting conditions if high frequency services result in short waiting times.

7 Conclusions

7.1 Journey time surveys

The guideways along Scott Hall Road have sucessfully isolated buses from the worst of the congestion. This has resulted in bus journey times during the height of the peak being quicker than the equivalent car journey, despite buses having to service bus stops.

The main conclusions from the journey time surveys are as follows:

- Phases 2 and 3 of the guideway have improved bus journey times in the morning peak by an average of 70 seconds. Overall buses are still slower than cars, because of the bus stops, but during the peak one or two buses are actually quicker. On an average day, buses operating during the height of the peak can save over 2 minutes when compared with the equivalent car journey time of 225 seconds (8 mph). The guideway has isolated buses from the worst of the congestion, reducing the variability of bus journey times by 75 per cent.
- General traffic alongside the guideway has also improved with journey time savings of almost 50 seconds when compared with the 1993 situation. The most likely explanation for this improvement is that the removal of buses from the main carriageway has eliminates the situation were buses servicing bus stops block a traffic lane.
- There is some evidence to suggest that peak hour traffic flows on Scott Hall Road and Meanwood Road have decreased by up to 11 per cent. In contrast traffic flows on Harrogate Road increased by 2 per cent and on Chapeltown Road by between 13-23 per cent. These changes have meant that although Scott Hall Road is still the busiest route into the City, its relative popularity when compared to Meanwood Road and Harrogate Road has decreased.
- It is suspected that this diversion of traffic away from Scott Hall Road, especially in the morning peak is not due to the guideway, which does not delay traffic, but rather to avoid the long delays that now build up on the Scott Hall Road approach to the Sheepscar Intersection.
- The introduction of the bus activated pelican crossing just before the Potternewton Lane roundabout has improved average bus journey times across the roundabout by between 5-10 seconds, and up to 30 seconds when the roundabout is at its most congested. General traffic journey times were unaffected by the changes made to the roundabout, suggesting the new signal arrangements have not reduced access to the roundabout.
- The Sheepscar Intersection is the main source of delay on the route and the delays vary greatly from day to day. From the survey results, the best estimate is that between Potternewton Lane and the Sheepscar Intersection the magnitude and variability of southbound journey times during the morning peak have deteriorated significantly for buses and general traffic. Buses are on average 2 minutes slower between timing points 17 and 27 compared with 1993 measurements while general traffic between 17-23 is over 1 minute slower. The variability in bus journey times has

increased by over 200 per cent in the morning peak, undoing much of the benefits accrued by buses from the guideway. The average bus speed between 17-27 is very slow, currently averaging 11 mph over the 2 hour period. During the height of the peak buses average 550 seconds or 8 mph but on congested days this is reduced to walking speed (4 mph). Isolating buses from these delayed could in theory save buses between 2-3 minutes on a normal day and up to 11 minutes when congestion is severe.

- The improvement to bus journey times between Sheepscar and the city centre can be attributed to buses being transferred onto the more direct North Street route. In the morning peak buses are saving about 40 seconds due to these changes.
- Buses leaving the city centre via North Street and travelling across the Sheepscar Intersection are taking approximately the same amount of time as in 1993, despite the removal of the northbound bus lane on North Street. It is suspected that a 30 per cent reduction in traffic flows along North Street has off-set the effects of removing the bus lane. The stability of bus journey times exiting the city centre was in contrast to those of general traffic which deteriorated slightly despite the decrease in traffic flows.
- A comparison of journey times for buses travelling out of Leeds via Scott Hall Road is complicated by the removal of the Meanwood Road/Sackville Street loop. However it has been estimated that the removal of the Meanwood Road/ Sackville Street loop should save buses an average of 100 seconds, which in effect means buses are being delayed by an additional 40 seconds in the evening peak. This suggests that queues are building up on the approach to the Potternewton Lane roundabout, extending beyond the start of the guideway and delaying buses before they reach the guideway.
- Once in the guideway, buses are able to bypass the traffic queues that have built up on the approach to the Potternewton Lane roundabout. Although buses are only saving an average of 15 seconds over the whole survey period, during the height of the peak buses are about 1 minute quicker when compared to 1993. However when compared with general traffic journey times alongside the guideway (which have deteriorated by about 30 seconds since 1993) its possible for buses to save up to 2½ minutes when congestion during a normal day is at its worst. The guideway has again isolated buses from the worst effect of congestion, reducing the variability of bus journey times by almost 50 per cent, the standard deviation decreasing from 21 to 12 seconds.
- A conservative estimate puts the increase to general traffic journey times along Scott Hall Road (26-16) at just over ½ minute. Without accurate flow measurements it is difficult to determine exactly the reason for the increase in northbound general traffic journey times on the approach to the Potternewton Lane roundabout. However there is some evidence to suggest the signalling technique to give buses priority onto the roundabout is contributing to the delay of general traffic between 26-16.
- Bus journey times (northbound) across the Potternewton Lane roundabout were unchanged from the 1993 situation while general traffic took on average 4 seconds longer. This approach to the Potternewton Lane roundabout has not been as successful as the southbound approach were buses were saving up to 30 seconds when congestion on the roundabout is at its worst. The main problem seems to be that when buses reach the end of the nearside guideway they are prevented from exiting onto the roundabout by vehicles entering from the Scott Hall Road approach. Buses must therefore wait until there is a gap or (as was often recorded) force their way into the circulating flow. A longer red phase at the pelican crossing might improve the situation but possibly at the expense of increased delays to general trafffic on the approach to the guideway, which in turn might delay buses approacing the guideway.
- Along the section of Scott Hall Road directly beyond the roundabout (12-3/4) a similar journey time pattern emerges; buses taking approximately the same time as they did in 1993 while general traffic is about ¼ minute slower. The signalisation of the Stainbeck Road junction means that northbound Scott Hall Road traffic is now interrupted by the signal phase which allows southbound vehicles on Scott Hall Road to turn right into Stainbeck Road. This explains why general traffic is now slightly slower than before, but the priority given to buses at this junction, isolated buses from these delays.

7.2 Bus passenger survey

The survey of bus passengers suggests that the overall increase in weekday patronage on Superbus routes, due to improved bus services, is 6 per cent[3] - this agrees broadly with a value reported by a similar study undertaken by Steer Davies Gleave in 1997. However, figures reported by First Group indicate that patronage along the route has increased by between 40-60 per cent since July 1995.

One explanation for the discrepancy is that the introduction of the Superbus services has made bus travel along the corridor a more attractive option to those people deciding how to make a new, regular journey. The interviewees may therefore have given the reason for starting to travel by bus as a need to get to a new destination rather than the attributes of the new bus service.

Bus company figures suggest that the ‘natural’ decline in patronage on Superbus routes is less than on other routes in Leeds (the change in patronage increases from 40-60 per cent to 60-85 per cent if compared with other routes in Leeds). This indicates that passengers using Superbus routes may in general be more satisfied with the service and therefore less inclined to stop using the bus for some other form of transport, such as driving in by cars or seeking a lifts.

Although not substantiated, it is arguable that the undeclared influence of the bus service improvements has resulted in far more new journeys than those which are specifically attributed to Superbus.

The survey revealed that the most noted bus service improvement was attributed to the new buses with 67 per cent of respondents stating that vehicle quality had improved. This is not surprising as the Superbus routes use a dedicated fleet of buses no older than three years. Over 50 per cent thought that the Superbuses were easier to board and alight (compared with 49 per cent that reported no change)while a similar number thought the bus shelters had improved. The majority of respondents did not perceive any improvements to journey time and service reliability. Over 50 per cent of those interviewed considered there had been no change to journey times (generally consistent with measured journey times), waiting times, availability of seats, provision of information and value for money. Opinions on service frequency were mixed.

The aspects that most influenced people's use of buses were that they preferred services which minimise walking distances, and are more direct or frequent. Bus journey time was also important, but many respondents replied that they will board the first bus to arrive rather than wait for a faster (more direct) bus.

There was little direct evidence of modal shift from car to bus, although, as we have previously argued, people making new trips may have been more likely to choose bus rather than car as a result of the Superbus services. Of those bus travellers that could use a car; difficulties driving into the city centre and finding somewhere to park seem to persuade many people to use buses.

7.3 Car driver survey

The results from the car driver survey illustrate some fairly obvious reasons why public transport is not the preferred option for many people who can choose to travel by car, and indicates which of these factors might be capable of manipulation by various means.

The overwhelming impression is that car travel tends to be much more convenient. The majority of motorists claimed there were no bus services by which they could make their journeys, and most of those who admitted that bus travel was a possibility were not bus users. There is no pre-eminent reason for this lack of convenience: distances to and from bus stops, lack of direct services, slow bus journeys and unreliable services are often cited. The last two of these could, in principle, be improved by means of much more extensive priority schemes (perhaps including busways), but the first two require network modifications whose costs may be disproportionate to any additional patronage they mighty generate.

Our sample appears to be biased towards people who drive company cars, or those who have free parking spaces at their destinations, or both. Such perquisites are clearly counterproductive in encouraging public transport use. Most of the sample in this survey were aware of the new guided busway (driving alongside it they could hardly be unaware of it) , but were not persuaded that any resulting improvements in journey time, service frequency or reliability were sufficient to make buses the preferred option.

8 References

Balcombe R J (1998). *Leeds guided busway: car driver survey*. Project Report PR/TT/084/98, Transport Research Laboratory, Crowthorne. (*Unpublished report available on direct personal application only*)

Balcombe RJ (1998). *Leeds guided busway: bus passenger survey*. Project Report PR/TT/194/98, Transport Research Laboratory, Crowthorne. (*Unpublished report available on direct personal application only*)

Bailey J M and A D Layzell (1982). *Travel behaviour and traffic restraint: a study of households in Oxford.* Supplementary Report SR734. Transport Research Laboratory, Crowthorne.

Department of the Environment, Transport and the Regions (1998). *Transport Statistics Great Britain*. Stationery Office.

First Group (1996). *The Superbus Effect: One Year On - The Growth Continues*. Second Report (December 1996). FirstBus Business Development and Leeds City Link, Leeds.

First Group (1998). *The Superbus Effect: Two Years On - New Passegers Keep Coming.* Third Report (April 1998). FirstBus Business Development and Leeds City Link, Leeds.

Leeds City Council (1991a). *Transport Leeds: A Summary of the City's Transport Strategy (1991)*. Leeds City Council and West Yorkshire PTA.

Leeds City Council (1991b). *Leeds Transport Strategy - Technical Report*. Leeds City Council, Leeds.

Leeds City Council (1995). *Leeds SUPER BUSWAY.* A Public Information Leaflet. Department of Highways and Transportation, Leeds City Council, Leeds.

Lucas C F (1986). *User guide to the NOPCOP range of numberplate comparison programmes*. Application Guide AG4. Transport Research Laboratory, Crowthorne.

Pope A S (1992). *The use of guided busways as a means of bus priority*: *The Leeds study*, (November 1992). Bus Priority Conference, Aston University, Birmingham.

York I O (1993). *Factors affecting bus stop times*. Project Report PR2. Transport Research Laboratory, Crowthorne.

Yorkshire Rider Limited (1989). *Bus Express Transit - Paving the Way for Rapid Transit in East Leeds*. Yorkshire Rider Limited.

Notes

[1] This figure was reported to have varied between +15 per cent and -1 per cent.

[2] The missing data between November 1995 and May 1996 occurred during the introduction of new ticketing analysis software.

[3] This figure assumes that the the number of new journeys on Superbus routes generated by lifestyle changes (eg. moving into in the area, new job or school) correspond directly to the number of journeys lost by similar causes.

Appendix A: Analysis of journey time changes

A1 Southbound traffic

A11 King Lane

A1.1.1 1-5 (Lingfield Approach to Scott Hall roundabout)

This link contains three major roundabouts which intersect King Lane at the Meanwood Ring Road, Stonegate Road and Scott Hall Road. Timing point 1 is located on King Lane just north of the junction with Lingfield Approach while point 5 is on the roundabout exit onto Scott Hall Road. There are 2 bus stops along this link, which is approximately 1300m in length. A summary of average journey times between 1-5 are shown in Table A1.

During the weekday morning peak (0730-0930 hrs) general traffic journey times improved by 31 seconds while the change to bus journey times (-131 seconds) was not statistically significant due to the small sample. It is difficult to explain why this should occur when traffic flows are at their highest. It may be that there is now less traffic entering the roundabouts from the right, giving King Lane traffic more opportunity to enter onto the roundabout. However, given the data available this is only conjecture.

There were no significant journey time changes during the remaining weekday and Saturday periods; buses were at worst 1½ minutes slower than general traffic during these times.

A1.2 Scott Hall Road

A1.2.1 5-8 (King Lane roundabout to Wensley Drive)

Once past the King Lane/ Scott Hall Road roundabout (timing point 5) vehicles travel along Scott Hall Road towards the new signalised junction at Stainbeck Road. Beyond this junction there is a bus stop just before timing point 8 at Wensley Drive. In total there are two bus stops along this link which is approximately 910 m in length. Average bus and general traffic journey times between 5-8 are shown in Table A2.

When traffic flows are heaviest (0730-0930 hrs) bus journey times remained almost unchanged from 1993 values, while general traffic journey times increased slightly. This pattern in journey time changes is evident in the mid-morning period (1000-1130 hrs). The similarity in journey times for the two morning periods suggest traffic has remained free flowing along this link, averaging about 34 mph.

In the weekday evening period (1630-1830 hrs) both bus and general traffic journey times deteriorated by ½ minute. The cause of this delay could be caused by the new signal arrangements at the Stainbeck Road junction. In 1993, northbound traffic turning right into Stainbeck Road had to give way and wait for a gap in the southbound traffic. Signalisation of the junction now gives northbound right turning traffic (including buses) a separate green phase which halts southbound traffic. The traffic signal plan for this junction is likely to allocate more green time for this phase in the evening, since northbound flows are higher as commuters return home, thus explaining the ½ minute delay.

Table A1 Average journey times between 1-5

		Average journey time between 1-5 (seconds)						
		Buses			*General traffic*			*Estimated change in flow Ω*
Day	*Time (hrs)*	*1993*	*1997*	*Change*	*1993*	*1997*	*Change*	
WKd	0730-0930	350	219	(-131)	195	164	-31	No change
	1000-1130	206	175	(-31)	125	124	(-1)	+14%
	1630-1830	165	170	(+5)	148	145	(-3)	+33%
Sat	1100-1400	247	223	(-24)	132	135	(+3)	-4%

( ) Indicates a change not significant at the 5 per cent level of confidence
Ω Estimated from data collected at timing point 1.

Table A2 Average journey times between 5-8

		Average journey time between 5-8 (seconds)						
		Buses			*General traffic*			*Estimated change in flow Ω*
Day	*Time (hrs)*	*1993*	*1997*	*Change*	*1993*	*1997*	*Change*	
Wkd	0730-0930	119*	122	(+3)	56*	65	+9	-7%
	1000-1130	100	119	(+19)	53	64	+11	-3%
	1630-1830	93	129	+36	55	86	+31	-11%
Sat	1100-1400	89	111	+22	53	60	+7	-14%

( ) Indicates a change not significant at the 5 per cent level of confidence
Ω Estimated from data collected at timing point 5
** Excludes Wednesday*

A1.2.2 8-13 (Wensley Drive to Potternewton Lane roundabout)

The link between 8 and 13 contains Phase 2 and 3 of the guideway and includes the modification made to the Stainbeck Lane roundabout. This link incorporates almost 620 m of dedicated guideway over a total length of 790 m so it is over this section that the highest benefits to buses are likely to be accrued. The number of bus stops along this link has been reduced from 3 to 2. A summary of average journey time between 8-13 are shown in Table A3.

The southbound guideway has had the desired impact on bus journey times, improving them on average by over 1 minute during the morning peak period (0730-0930 hrs). However, closer scrutiny of the journey time profiles for vehicles reveals a more complicated situation than that suggested by average journey times. Figures A1 to A3 show the journey times of cars and buses on the Wednesday, Thursday and Friday morning during the 1993 survey.

These journey time profiles show that the Wednesday (Figure A1) morning was not typical when compared with Thursday (Figure A2) and Friday (Figure A3); showing abnormally high delays between 0815 and 0915 hrs. It appears bad weather on this day had severe effects on traffic, creating anomalously high journey times for both buses and general traffic. It is therefore recommended that the journey time data for the Wednesday morning in 1993 be omitted from the weekday mean (Table A3). The process of selectively removing data is rather a subjective exercise, but in this case it is believed to offer the most realistic comparison of journey times along this section of the route. Figures A1, A2 and A3 also show, as expected, that before the guideway was introduced buses journey times were inextricable linked to the delays of general traffic.

For comparison, journey time profiles for general traffic and buses after introduction of the guideway are shown in Figures A4-A6. It is clear that the guideway has isolated buses from the worst effects of congestion. Not only are average bus journeys times much lower than before; they are also much less variable (the standard deviation has decreased from 80 to 20 seconds). Overall they are still slower than cars, because of the bus stops, but at the peak one or two buses are actually quicker than cars. These buses can save between 80 and 140 seconds (Wednesday and Thursday respectively).

The improvement in general traffic journey times may be due to the removal of buses and the bus stops from the main carriageway. This in effect increases the carriageways capacity, allowing general traffic to flow more smoothly than it did in 1993. The average speed between 8-13 in 1997 is about 22 mph over the 2 hour morning period.

In all other time periods bus journey times remain unchanged while general traffic times deteriorated by an average of 10 seconds. This increase, when traffic is free flowing, may be explained by the introduction of the pelican crossing just after the Stainbeck Lane and Potternewton Lane roundabouts. Thepelican crossing just after the Stainbeck Lane roundabout is activated by both pedestrains crossing the road and bus travellers gaining access to the bus stop while the pelican crossing just before Potternewton Lane is activated by both pedestrians and buses. This in theory, due to their increased use, will delay more cars.

One other result to take encouragement from is that there seems to be no journey time disadvantage in using the guideway. The time taken to enter, travel along it and exit the guideway is approximately the same as the time taken to travel along the original carriageway in free flow conditions.

A1.2.3 13-17 (across the Potternewton Lane roundabout)

Timing points 13 and 17 were positioned so that it would be possible to measure the impact of the new signal arrangements at the pedestrian crossing just before the Potternewton Lane roundabout. Unfortunately the bus stop just after the roundabout, but before timing point 17, in the 1993 survey was relocated to a position just beyond point 17 in the 1997 surveys. This meant that journey times measured in 1993 included the bus stop dwell times whereas in 1997 the measurements did not.

From timing point 13 buses travel through the pelican crossing, exiting into the bus advance area between the pelican crossing and roundabout give-way line. The situation is slightly different from the Stainbeck Lane roundabout in that there is no central guideway on the other side. Buses must therefore move from the guideway, across the outside lane, and into the nearside lane (if it is clear). Analysis of the video data suggests that the use of the pelican signals to clear the bus advance area is effective, making this manoeuvre easy to do. If buses are

Table A3 Average journey times between 8-13

		Average journey time between 8-13 (seconds)						
		Buses			*General traffic*			*Estimated change*
Day	*Time (hrs)*	*1993*	*1997*	*Change*	*1993*	*1997*	*Change*	*in flow*¤
Wkd	0730-0930	168*	97	-71	126*	77	-49	-2 %
	1000-1130	92	97	(+5)	47	55	+8	-6 %
	1630-1830	68	72	(+4)	48	61	+13	-2 %
Sat	1100-1400	97	96	(-1)	47	57	+10	-7 %

( ) Indicates a change not significant at the 5 per cent level of confidence
¤ ***E****stimated from the occupancy data at site A3*
** Excludes Wednesday*

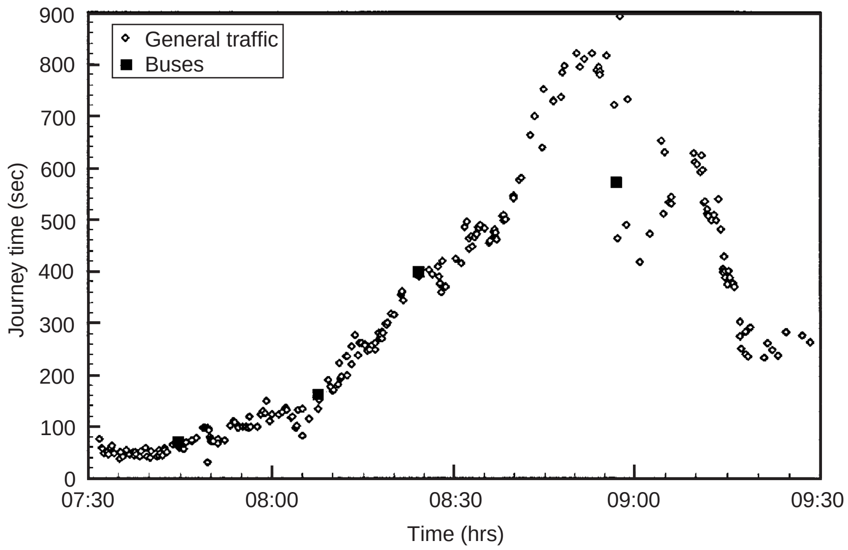

Figure A1 Journey times between 8–13 (0730–0930 hrs) Wednesday 24 November 1993

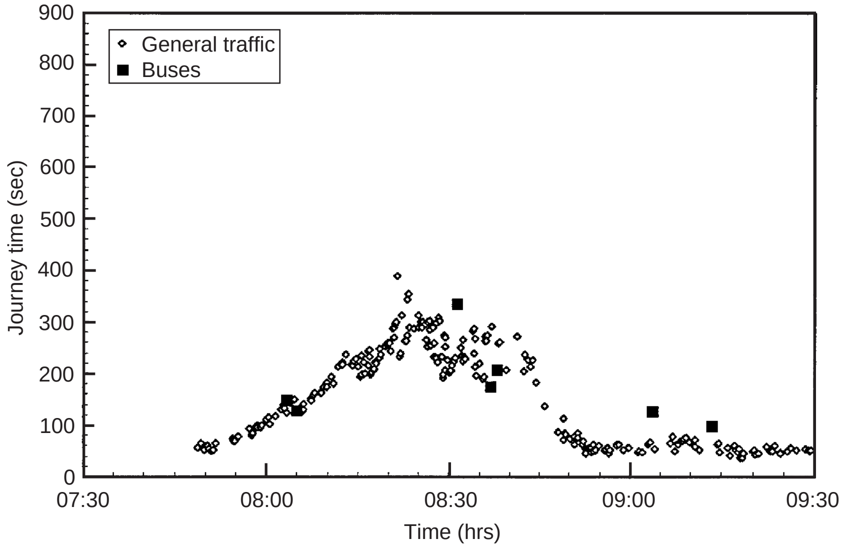

Figure A2 Journey times between 8–13 (0730–0930 hrs) Thursday 25 November 1993

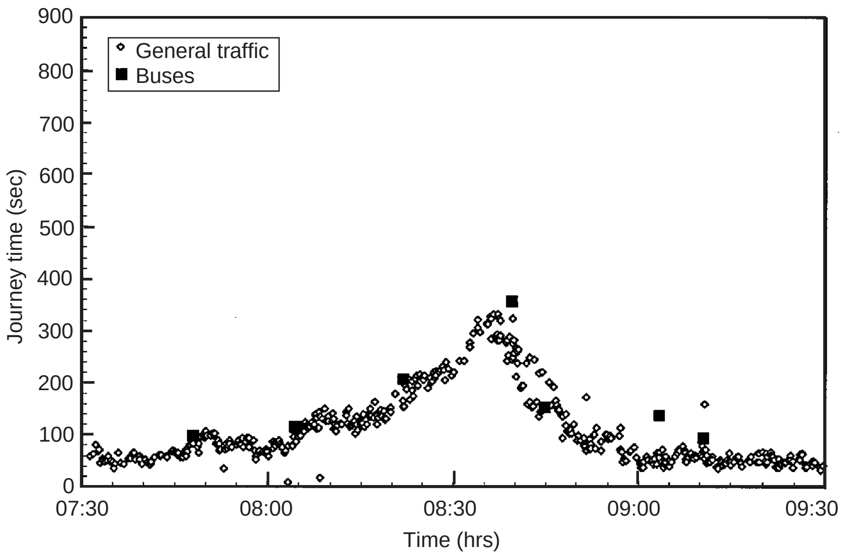

Figure A3 Journey times between 8–13 (0730–0930 hrs) Friday 26 November 1993

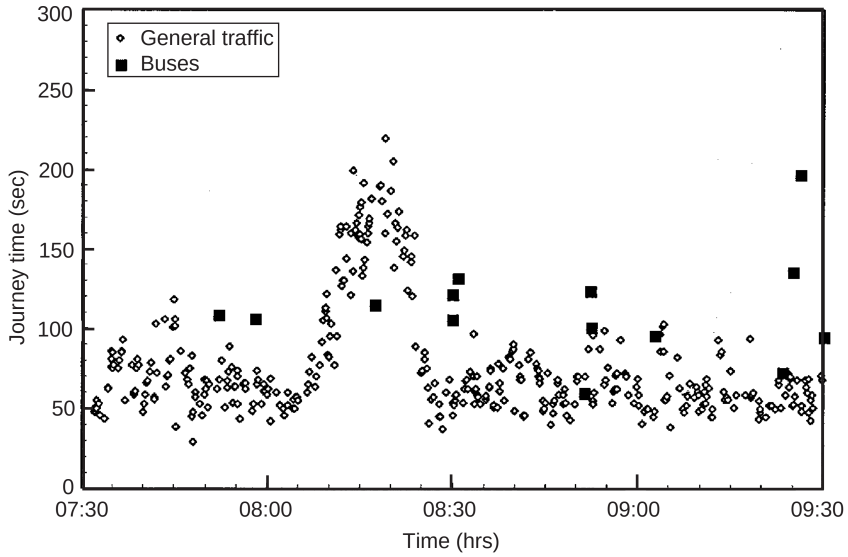

Figure A4 Journey times between 8–13 (0730–0930 hrs) Wednesday 18 June 1997

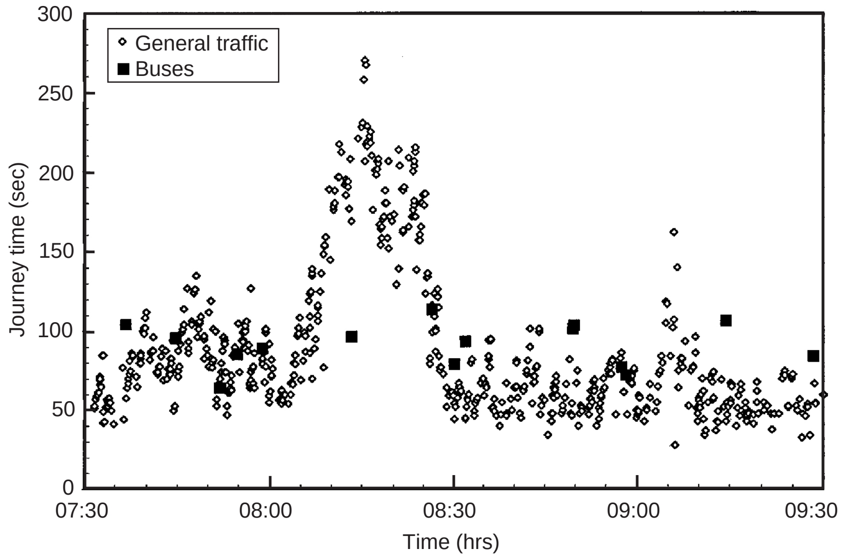

Figure A5 Journey times between 8–13 (0730–0930 hrs) Thursday 19 June 1997

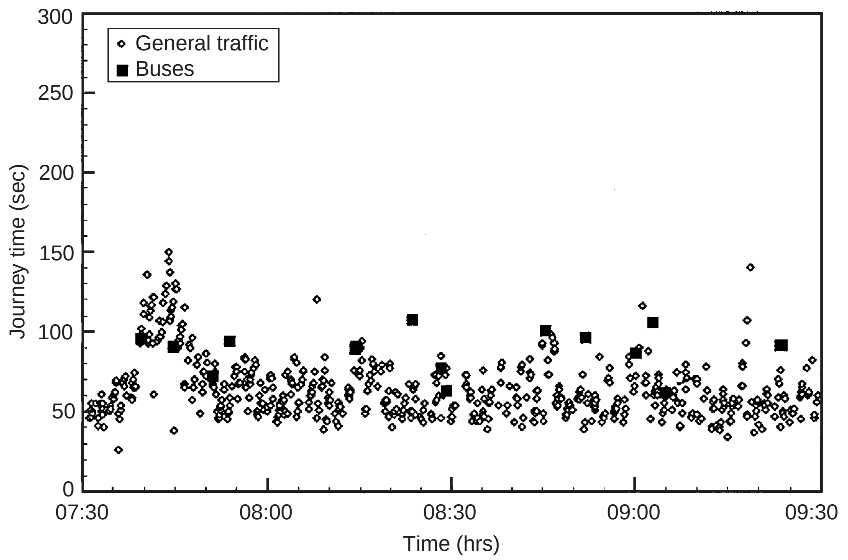

Figure A6 Journey times between 8–13 (0730–0930 hrs) Friday 20 June 1997 unable to get into the nearside lane (analysis of the video suggests this is a rare event) they have to approach the roundabout in the outside lane and negotiate a path across the roundabout. Timing point 17 was located approximately 55 m from the roundabout making the total distance between 13 and 17 approximately 200 m. Average bus and general traffic journey times between 13-17 are shown in Table A4.

During the morning period bus journey times across the Potternewton Lane roundabout improved by almost 50 per cent (62 to 35 seconds). However, it is suspected that some (but not all) of this improvement is due to the exclusion of bus stop dwell times[1] in the 1997 data rather than an improvement in journey time across the roundabout. All the other survey periods showed a small improvement, but for the reason given above it is impossible to determine if buses now are quicker across the roundabout.

The journey time profiles for buses and general traffic across the roundabout shows that in 1993 bus journey times follow the profile of general traffic across the roundabout. However in 1997 at times when the roundabout is most congested buses seem to have a slight journey time advantage over general traffic. This is most obvious during the Thursday morning period which is shown in Figure A7.

General traffic journey times were unaffected by the introduction of the guideway and new bus activated pelican signals. General traffic averaged about 20 seconds in free flow conditions, which were recorded in 6 of the 8 survey periods.

Analysis of the turning movements of vehicles approaching the Potternewton Lane roundabout revealed that the dynamics of the roundabout have remained very similar to 1993. The heaviest flows at 13 are those on Scott Hall Road during the morning peak. The dominant movement for this traffic is the 'straight on' movement towards the city centre, which accounted for about 97 per cent of the total flow for both surveys. The left and right turning movements into Potternewton Lane also remained stable with 2 per cent turning left and 1 per cent turning right.

The eastbound approach on Potternewton Lane (11) is also important. An increase in the straight on or right turn movements would reduce the opportunity for vehicles on Scott Hall road to exit onto the roundabout, and so increase their journey time. Analysis revealed that there has been a decrease of 15 per cent (491 to 418 veh/hr) in the amount of eastbound traffic entering onto the roundabout. The main movement is the right turn into Scott Hall Road which has decreased from 60 to 51 per cent, while the gain of the straight on movement has

Table A4 Average journey times between 13-17

		Average journey time between 13-17 (seconds)					
		Buses			*General traffic*		
Day	*Time (hrs)*	*1993*	*1997*	*Change*	*1993*	*1997*	*Change*
Wkd	0730-0930	62*	35	-27	42*	36	-6
	1000-1130	45	39	-6	20	20	(0)
	1630-1830	32	25	-7	22	21	(-1)
Sat	1100-1400	46	35	-11	21	19	(-2)

( ) Indicates a change not significant at the 5 per cent level of confidence
** Excludes Wednesday*

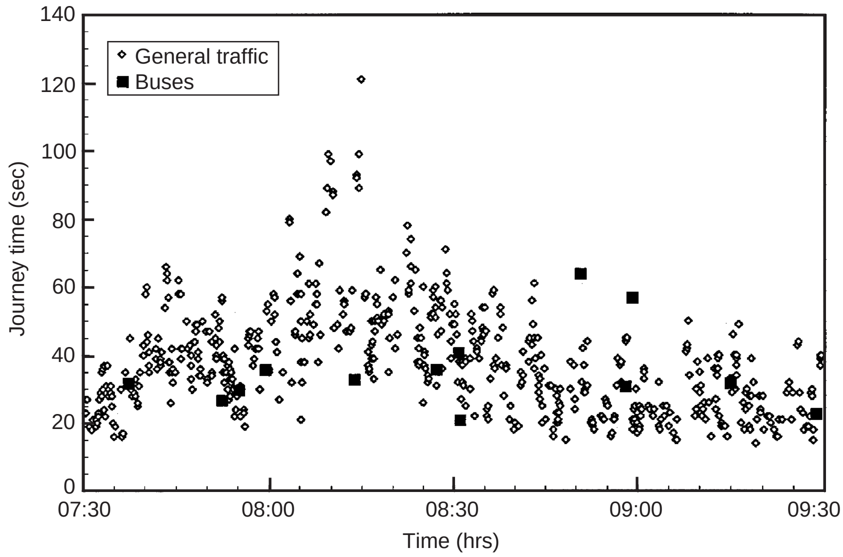

Figure A7 Journey times between 13–17 (0730–0930 hrs) Thursday 19 June 1997 increased from 36 to 42 per cent. The combined proportion however of straight on and right turning vehicles has remained the same, and therefore unlikely to contribute to any journey time changes between 13-17.

A1.2.4 17 to 23(general traffic)/ 27(buses) (Potternewton Ln to Sheepscar Interchange)

Beyond 17, different timing points were used for buses and general traffic. The general traffic timing point (23) is located on Sheepscar Street North just before the main junction signals onto the Sheepscar Intersection. This is the last timing point for southbound general traffic using Scott Hall Road. Buses meanwhile, travel across the Chapeltown\ Claypit Lane junction onto Sheepscar Street South where timing point 27 is located just before Roundhay Road. Buses are therefore measured over a longer distance (approximately 250 m) than general traffic. The distance between 17-23 is 1725 m while that between 17-27 for buses is 1975 m. There are 5 bus stops and 4 pelican crossings between timing points 17 and 23.

Few changes were made to the road layout along this section of Scott Hall Road/ Sheepscar Street North. The most noticeable was the construction of off-road residential parking bays between Scott Hall Grove and Sholebroke Mount. As a consequence both southbound lanes of the dual carriageway remained clear at all times during the 1997 surveys.

Again interpretation of journey time measurements during the morning peak period is complicated by the variability during the weekdays in 1993. Figures A8 to A10 show the journey time profiles for buses and general traffic during the weekdays survey in 1993.

During the Wednesday survey in 1993 (Figure A8) bus and general traffic levels are stable up until 0815 hrs, averaging about 28 mph. Beyond this time delays start to increase reaching a maximum of about 15 minutes, which equates to an average speed of 4 ½ mph, by 0845 hrs. These delays continue until the end of the survey period (0930 hrs). Comparing the Wednesday journey time profile with those of the subsequent Thursday (Figure A9) and Friday (Figure A10) shows that the stability observed during the first 45 minutes on Wednesday is maintained throughout the morning period on Thursday and Friday. The knock-on effects of these delays during Wednesday have already been observed in the journey times across the Potternewton Lane roundabout and beyond.

The situation is complicated further when the journey time profiles for the 1997 survey are plotted (Figures A11 to A13). Comparison between surveys shows that journey times during 1997 were much more variable than those in 1993 (excluding the Wednesday). Despite this, it was thought that the extent of the variability between days did not justify the exclusion of any 1997 data. The resulting journey time estimates for each survey period is given in Table A5.

In the weekday morning peak period bus journey times (17-27) increases by 129 seconds, while general traffic (17-23) increased by 67 seconds. Since no priority measures were introduced over this section, additional delays to general traffic must have some other, unknown cause. The average bus speed is very slow, currently averaging 11 mph over the 2 hour period. During the height of the peak buses average 550 seconds or 8 mph (Figures A12 and A13) but on congested days (Figure A11) this is reduced to walking speed (4 mph).

During the other periods bus journey times improved, while general traffic times remained unchanged. The improved service frequency, reducing the average dwell time at bus stops, may explain why bus journey times have improved but not those of general traffic.

A1.3 Sheepscar Street South & North Street

A1.3.1 27-30, buses (Roundhay Road to Merrion Place)

Due to the various routes possible for general traffic between timing point 27 and 30 only bus journey times were measured through the Sheepscar Intersection. The bus routes between 27 and 30 changed significantly between 1993 and 1997 (Section 2.2.1) which makes a comparison of journey times along a particular route impossible. However, if access to popular bus stops is unaffected by changing the route (as in this cases) then any improvement to the journey time is just as important to bus passengers.

In 1993 the main bus route into the city centre from the north was: from the Sheepscar Intersection, Sheepscar Street South - Regent Street - New York Street - North Street (past timing point 30) and into Vicar Lane (Figure 8, p. 21).

With the introduction of a southbound contra-flow bus lane along North Street buses now had a more direct route

Table A5 Average journey times between 17-23 (general traffic) / 27 (buses)

		Average journey time between 17-23/27 (secs)					
		Buses (17-27)			*General traffic (17-23)*		
Day	*Time (hrs)*	*1993*	*1997*	*Change*	*1993*	*1997*	*Change*
Wkd	0730-0930	282*	411	+129	141*	208	+67
	1000-1130	246	218	-28	108	112	+4
	1630-1830	228	220	(-8)	112	107	-5
Sat	1100-1400	253	229	-24	108	107	(-1)

( ) Indicates a change not significant at the 5 per cent level of confidence
** Excludes Wednesday*

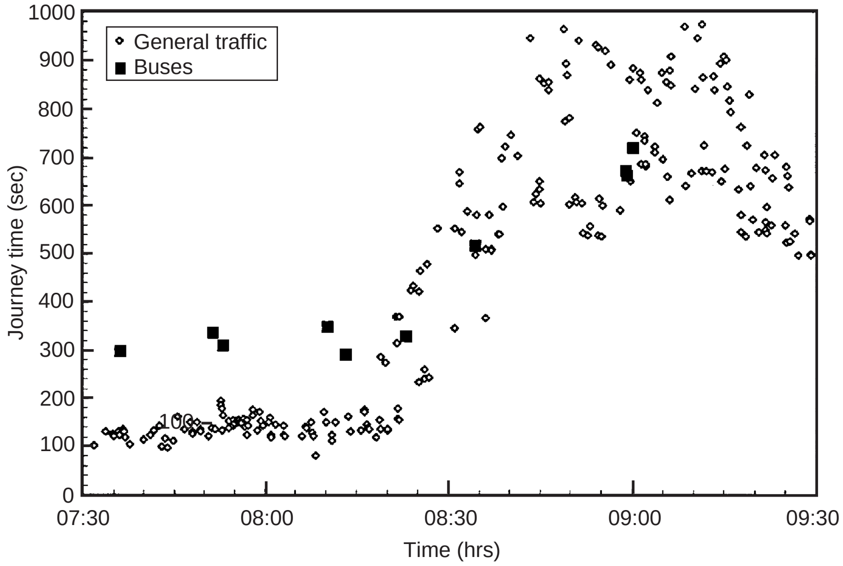

Figure A8 Journey times between 17–23/27 (0730–0930 hrs) Wednesday 24 November 1993

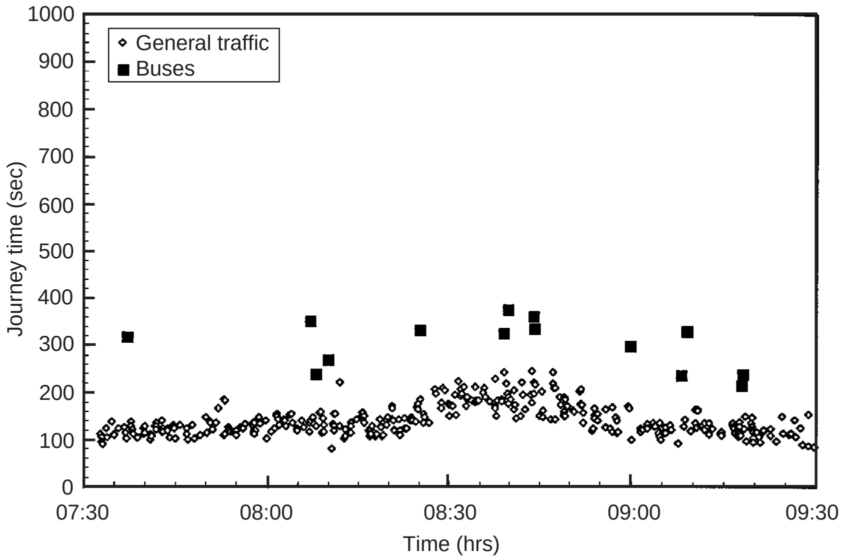

Figure A9 Journey times between 17–23/27 (0730–0930 hrs) Thursday 25 November 1993

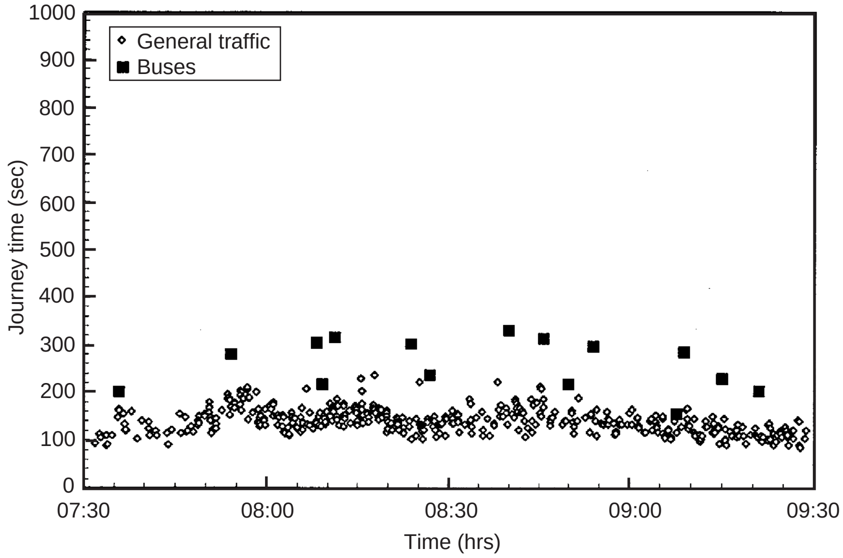

Figure A10 Journey times between 17–23/27 (0730–0930 hrs) Friday 26 November 1993

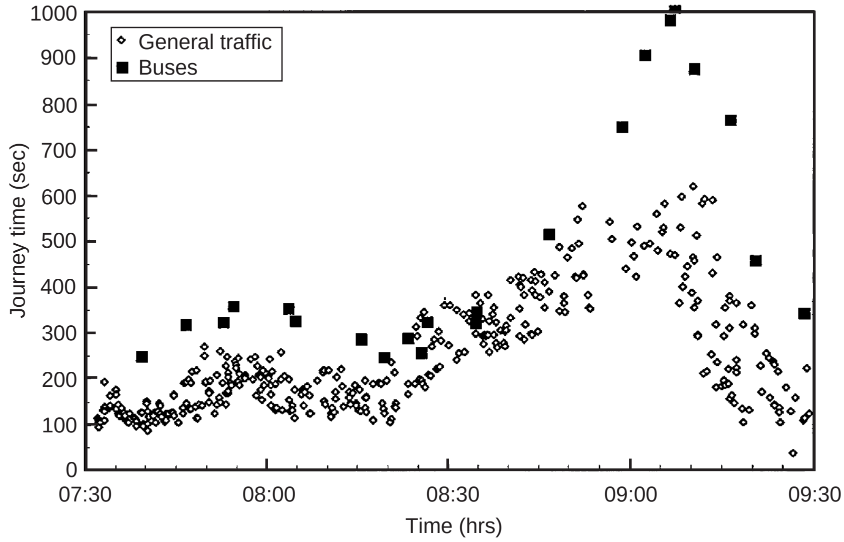

Figure A11 Journey times between 17–23/27 (0730–0930 hrs) Wednesday 18 June 1997

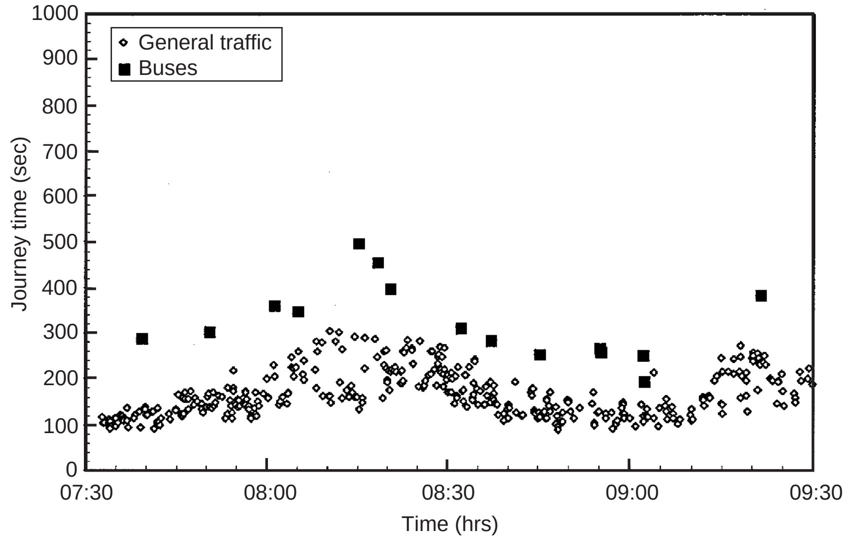

Figure A12 Journey times between 17–23/27 (0730–0930 hrs) Thursday 19 June 1997

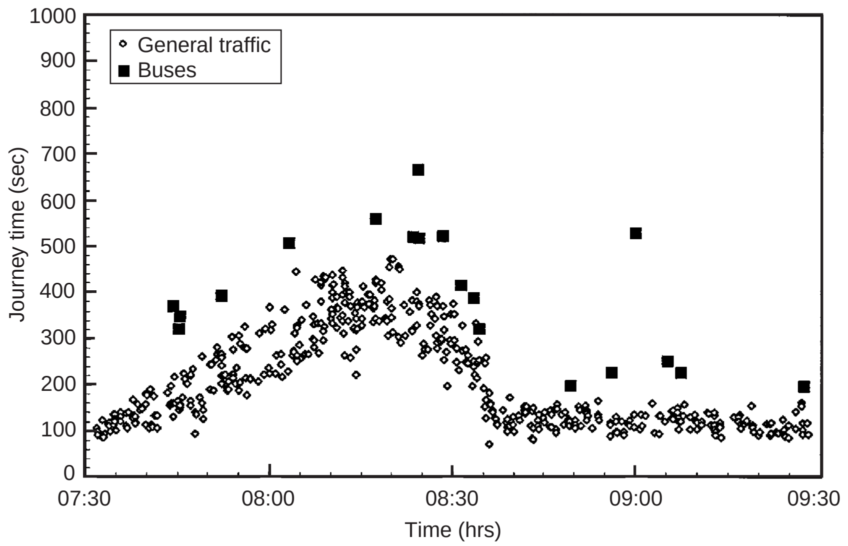

Figure A13 Journey times between 17–23/27 (0730–0930 hrs) Friday 20 June 1997 into the city centre. To assist buses into North Street new signals were installed on the south side of the Sheepscar Intersection. The main bus route into the City was now; Sheepscar, North Street (past timing point 30) and into Vicar Lane.

To service bus stops on Regent Street several bus routes used a slightly different route which bypassed the North Street contra-flow bus lane i.e. Sheepscar - Sheepscar Street South - Regent Street - Byron Street - North Street (past timing point 30) and into Vicar Lane. This alternative route was only used during the peak periods (to drop off and pick up commuters whose place of work was near Regent Street).

A summary of journey times between 27-30 is shown in Table A6.

Table A6 Average journey times between 27-30 (buses only)

		Average bus journey times between 27-30 (seconds)		
Day	*Time (hrs)*	*1993 (via Regent St)*	*1997 (via North St)*	*Change*
Wkd	0730-0930	227	189	-38
	1000-1130	225	177	-48
	1630-1830	236	182‡	-54
Sat	1100-1400	198	170	-28

‡ Excludes Thursday data due to an accident

The change to bus routes and the introduction of the contra-flow bus lane along North Street has brought about substantial journey time improvements for southbound bus entering the city centre from Sheepscar. Buses are saving between 28 and 54 seconds when compared with the corresponding time periods in 1993.

A1.4 Meanwood Road

A1.4.1 9-23/27 (Claremont Cresent to the Sheepscar Intersection)

The one way system at the southern end of Meanwood Road directs all traffic travelling towards the Sheepscar Intersection via Sackville Street and Sheepscar Street North. Journey times are therefore measured between 9-23 (for general traffic) and 9-27 (for buses).

There are three signalised junction between the timing point, Meanwood Road/ Sackville Street, Sackville Street/ Sheepscar Street North and Sheepscar Street North/ Sheepscar Street South. There are no bus priority measures along this section of the route. The distances between 9-23 and 9-27 is approximately 2500 m and 2750 m respectively.

Bus journey times improved in all survey periods although only the weekday mid-morning period and Saturday period showed any statistically significant change. Buses during the weekday off-peak were saving over 1 minute, while those on Saturday saved just over ½ minute. These improvements occurred despite an average 14 per cent increase in the flow of traffic entering Meanwood Road from the North.

General traffic journey times have generally remained unchanged from their 1993 values except during the weekday mornings where an improvement of over ½ minute was recorded. This improvement could be attributed to the 18 per cent reduction in traffic flow.

A1.5 Harrogate Road/Chapeltown Road

A1.5.1 6-22(general traffic)/27 (buses) (King Lane to the Sheepscar Intersection)

There were no major changes made to the layout or signalling along the Harrogate Road/ Chapeltown Road corridor between 1993 and 1997. The only bus priority along this corridor is a 350 m southbound bus lane on the approach to the Barrack Road junction. This bus lane was introduced before 1993 so should not influence any journey time changes along this link.

Timing point 6 is located on Harrogate Road just after the junction with Halcyon Hill. Different timing points were required for buses and general traffic at the Sheepscar Intersection, so general traffic journey times were measured between 6-22 and buses between 6-27. The distance between 6-22 is approximately 2850 m while that between 6-27 is slightly longer at 3150 m.

Table A8 shows a summary of the average journey times along Harrogate Road and Chapeltown Road. The journey times for general traffic were calculated by adding together journey times between 6-21 and 21-22.

Despite recording increases in traffic flow along both Harrogate Road and Chapeltown Road no significant journey time increases were measured for buses. General traffic journey times remained at approximately 1993 levels during the morning peak, and deteriorated in all other periods.

Table A7 Average journey times between 9- 23 (general traffic) / 27 (buses)

		Average journey time between 9-23/27 (sec)						
		Buses (9-27)			*General traffic (9-23)*			
Day	*Time (hrs)*	*1993*	*1997*	*Change*	*1993*	*1997*	*Change*	*Estimated change in flow¤*
Wkd	0730-0930	493	441	(-52)	347	299	-48	-18%
	1000-1130	380	319	-61	217	216	(-1)	+14%
	1630-1830	361	350	(-11)	215	211	(-4)	+9%
Sat	1100-1400	349	316	-33	207	206	(-1)	+14%

( ) Indicates a change not significant at the 5 per cent level of confidence
*¤ **E**stimated from data collected at A2*

Table A8 Average journey times between 6-22 (general traffic) / 27 (buses)

Day	Time (hrs)	Average journey time between 6- 27/22 (sec): Buses (6-27) 1993	1997	Change	General traffic (6-22) 1993	1997	Change	Estimated change in flow¤
Wkd	0730-0930	590*	567	(-23)	356*	351	-5	+9%
	1000-1130	493	480	(-13)	253	286	+33	+10%
	1630-1830	420	438	(+18)	271	276	+5	+17%
Sat	1100-1400	496	502	(+6)	270	280	+10	+12%

( ) Indicates a change not significant at the 5 per cent level of confidence
¤ Estimated from data collected at A1
** Excludes Wednesday*

A2 Northbound traffic

A2.1 North Street

A2.1.1 29-28 (St. Thomas Row to Meanwood Road)

Timing points 29 and 28 measure the journey times of all traffic travelling along North Street and onto Meanwood Road. Timing point 28 is located on North Street just beyond the junction with St. Thomas Row, while timing point 29 is just beyond the pedestrian crossing at the beginning of Meanwood Road. The distance between 29-28 is approximately 700m along which there is one bus stop and two signalised junctions.

Although there have been changes to this section of the route, the path buses take when leaving the city centre has remained the same. In 1993, North Street was one way accomodating two general traffic lanes and a with-flow bus lane in the northbound direction. By 1997 the outbound bus lane was removed leaving two general traffic lanes and a contra-flow bus lane for southbound buses. Table A9 summarises the average journey time changes between 29-28.

The only significant change to bus journey times occurred in the weekday morning peak period when bus journey times improved by over 1¼ minutes. This was accompanied by a 45 seconds improvement in general traffic journey times. This improvement is probably due to the 36 per cent reduction in traffic flows along North Street. Therefore the effects of removing the bus lane on bus journey times has been off-set by the reduction in the amount of general traffic along North Street.

All other time periods showed the trend of static bus journey times, increased general traffic journey times and reduced traffic flows. In 1993 general traffic was between 10 and 20 seconds faster than buses despite the outbound bus lane; this difference can probably be accounted for by the bus stop on North Street. By 1997 general traffic journey times had deteriorated by up to ½ minute resulting in comparable bus and general traffic journey times despite the bus stop, more road space for general traffic and reduced flows.

A2.1.2 29-26 (St. Thomas Row to Sheepscar Street North)

Timing points 29 to 26 measure the journey times of all vehicles travelling along North Street, across the Sheepscar Intersection and into Sheepscar Street North. The link is approximately 810 m long with two signalised junction. The changes made to the layout of North Street between 1993 and 1997 are described in Section 2.1.7.

There were no bus journey time measurements in 1993, since all buses destined for Scott Hall Road approached it via the Meanwood Road/Sackville Street loop, passing 28. In 1997 this loop was removed and buses travelled directly from North Street to Sheepscar Street North, passing 26. Table A10 summarises the average journey time changes between 29-26.

General traffic journey times during the morning peak remained at their 1993 level, despite the ¾ minute improvement in journey time for those vehicles continuing into Meanwood Road. The discrepancy has two possible explanations. Firstly the signals in 1997 give a higher proportion of green time to traffic using Meanwood Road than traffic exiting onto the Sheepscar Intersection. The second explanation is that general traffic now has to share

Table A9 Average journey times between 29-28

Day	Time (hrs)	Average journey time between 29-28 (seconds): Buses 1993	1997	Change	General traffic 1993	1997	Change	Estimated change in flow Ω
Wkd	0730-0930	213	137	-76	177	132	-45	-36 %
	1000-1130	99	100	(+1)	76	104	+28	-31 %
	1630-1830	112	117	(+5)	97	107	+10	-35 %
Sat	1100-1400	96	105	(+9)	77	110	+33	-27 %

( ) Indicates a change not significant at the 5 per cent level of confidence
Ω Estimated from data collected at timing point 29

Table A10 Average journey times between 29-26

Day	Time (hrs)	Average journey time between 29-26 (seconds): Buses 1993	Buses 1997	Buses Change	General traffic 1993	General traffic 1997	General traffic Change	Estimated change in flow Ω
Wkd	0730-0930	-	139	n/a	119	120	(+1)	-36%
	1000-1130	-	110	n/a	76	105	+29	-31%
	1630-1830	-	117†	n/a	112	117†	+5	-35%
Sat	1100-1400	-	111	n/a	85	103	+18	-27%

( ) Indicates a change not significant at the 5 per cent level of confidence
Ω Estimated from data collected at timing point 29

the carriageway with buses using Scott Hall Road.

General traffic journey times changes at other times showed a similar trend to those measured between 29-28 i.e. increased journey times despite a reduced traffic flows.

A2.1.3 29-25 (St. Thomas Row to Sheepscar Interchange)

This link is used by all traffic travelling from North Street through the Sheepscar Interchange and towards Chapeltown Road. It is approximately 840m in length and contains one bus stop and two signalised junctions. Table A11 summarises the journey time changes between 29-25.

The largest changes to general traffic journey times occurred during the weekday mid-morning and Saturday periods, with decreases of about ½ minute. Both these changes are consistent with changes between 29-28 and 29-26 at the same time of day (Table A12).

A2.2 Scott Hall Road

A2.2.1 28/26-16 (Sheepscar Intersection to the Potternewton Lane roundabout)

In 1993 Scott Hall Road buses exiting North Street would travel via Meanwood Road, past 28, into Sackville Street (via a signalised junction) and then into Sheepscar Street North via another signalised junction. By 1997 this loop had been removed and Scott Hall Road buses from North Street travel via 26. The next timing point for buses and general traffic is point 16, which is located about 60 m from the Potternewton Lane roundabout give-way line. An additional timing point 19 (recording buses only) was located just north of Scott Hall Avenue (the start of the northbound guideway). The distance between 19 and 16 is about 500 m.

Table A12 The difference in general traffic journey times between 29-28, 29-26 and 29-25

Day	Time (hrs)	Journey time difference (seconds): 29-28	29-26	29-25
Wkd	0730-0930	-45	+1	+7
	1000-1130	+28	+29	+30
	1630-1830	+17	+5	-13
Sat	1100-1400	+33	+18	+28

There are 5 bus stops between Sackville Street and the Potternewton Lane Roundabout, approximately 300 m apart, with one located in the guideway. The distance between 28-19 (via Meanwood Road/ Sackville Street) is approximately 1810 m compared with 1430 m between 26-19. Buses between 28-19 therefore travel an extra 400 m, as well as negotiating an additional signalised junction.

It is inappropriate to make direct comparisons of bus journey times along this section of the route, because of the change in the paths followed by buses between the before and after surveys. The overall time saving for buses is therefore believed to result from:

i a shorter distance to travel;

ii a reduction in the number of junctions to be negotiated;

iii the northbound section of guideway which allowed buses to bypass traffic queues approaching the Potternewton Lane roundabout.

Table A11 Average journey times between 29-25

Day	Time (hrs)	Average journey time between 29-25 (seconds): Buses 1993	Buses 1997	Buses Change	General traffic 1993	General traffic 1997	General traffic Change	Estimated change in flow Ω
Wkd	0730-0930	158	150	(-8)	118	125	+7	-36%
	1000-1130	123	119	(-4)	85	115	+30	-31%
	1630-1830	139	148†	(+9)	107	120†	+13	-35%
Sat	1100-1400	109	124	+15	90	118	+28	-27%

( ) Indicates a change not significant at the 5 per cent level of confidence
Ω Estimated from data collected at timing point 29
† Excludes Friday

In the following section we attempt to estimate the effects of i) and ii), by comparing bus and general traffic journey times over relevant links (Table A13). To do this, it is assumed that timing points 26 and 28 are approximately the same distance from the Sheepscar Intersection.

Comparing general traffic journey times (26-16) reveals that journey times between 1993 and 1997 are almost identical except in the evening peak were journey times have deteriorated by about ½ minute. It can therefore be assumed that in all other periods the differences in buses journey times between 1993 (28-19) and 1997 (26-19) is due solely to the difference in routes.

The removal of the Sackville Road loop therefore amounts to an average time saving of:

234-135 = 99 seconds (during the weekday mid-morning time period).

239-142 = 97 seconds (during the Saturday time period).

Giving an average time saving for buses of 98 seconds. The morning weekday period (0730-0930 hrs) has been excluded from the calculation, because the heavy southbound flows turning left into Sackville Street from Meanwood Road will dominate the signal staging at this junction, so disadvantaging northbound buses disporportionally. This explains why the buses take longer in the morning (277 seconds) than in the evening (237 seconds) peak, despite heavier northbound flows. It is therefore arguable that the effect of the change of route would be to reduce bus journey times in the weekday evening peak to:

237 (28-19, 1993) - 98 = 139 seconds.

Comparing this with the journey time between 26-19 in 1997 of 178 seconds it can be concluded that buses are being delayed by an additional 39 seconds (139 -178 = -39 seconds) during the evening peak period. This value is corroborated, by comparing bus journey times (26-19) in 1997 during the evening peak with those at other times. This gives a value for the average additional delay incurred by buses during the evening peak of:

Average (132,135,142) - 178 = - 42 seconds.

This suggests that the new signal arrangement at the Potternewton Lane roundabout is delaying general traffic at the busiest times, causing queues to build up to beyond the start of the guideway (19). This causes delays to buses as they queue in traffic on the approach to the guideway. Further analysis suggests that the average delay of 39 seconds, is the situation when congestion is at its worst along Scott Hall Road on a normal day, with maximum journey times between 26 - 16 not exceeding 400 seconds or 11 mph (as during the Wednesday and Thursday surveys in 1997, Figure A14). Also, because this value is an average over a 2 hour period, there will be times when buses suffer no delay on the approach to the guideway, but at others times the delay will be much greater than 39 seconds. It has been estimated (from Figure A14) that under ‘normal’ conditions, delays to buses from traffic queuing past the start of the guideway start when journey times between 26-16 exceed about 200 seconds or 22 mph (1710 hrs, Figure A14). At the height of the peak (1715-1745 hrs, Figure A14), when journey times average 350 seconds the delay to buses is approximately 110 seconds. This value is calculated by comparing the average journey time of buses before 1710 hrs (200 seconds) with those buses between 1715 and 1745 hrs (300 seconds).

Obviously if conditions deteriorate beyond the ‘normal’ then the delay to buses will increase in line with those suffered by cars. This occurred on Friday during the 1997 surveys, when an accident on Scott Hall Road created long traffic queues on Scott Hall Road, increasing general traffic journey times between 26-16 to over 800 seconds (Figure A15).

Figures A14 and A15 showing individual journey times between 26-16 (the two common timing points)[2] also illustrate how bus and general traffic journey times differ now the guideway has been introduced.

The most obvious difference is that Friday is more congested (due to the accident), with journey times almost double those on Thursday. Comparison of the two graphs show how the guideway isolates buses from traffic queues on the approach to Potternewton Lane (discussed further in Section A2.2.2), but also how the effectiveness of the guideway can be diluted when traffic congestion is severe.

- Between 1630 and 1700 hrs buses are approximately a minute slower than general traffic. This can be explained by the extra time spent at bus stops, but it should also be noted that the section of route between the Sheepscar Intersection and Scott Hall Avenue is a steep incline along which buses are likely to be slower than cars.

Table A13 Journey times between Sheepscar and Potternewton Lane

		Journey times (seconds)									
		Buses								*General traffic*	
		1993			*1997*					*1993*	*1997*
Day	*Time (hrs)*	*29-28*	*28-19*	*19-16*	*29-28*	*29-26*	*26-19*	*19-16*		*26-16*	*26-16*
Wkd	0730-0930	213	277	45	137	139	132	39		117	113
	1000-1130	99	234	43	100	110	135	44		115	112
	1630-1830	112	237	65	117	117†	178†	49		159	192†
Sat	1100-1400	96	239	49	105	111	142	45		107	108

† Excluding Friday data due to an accident on Scott Hall Road.

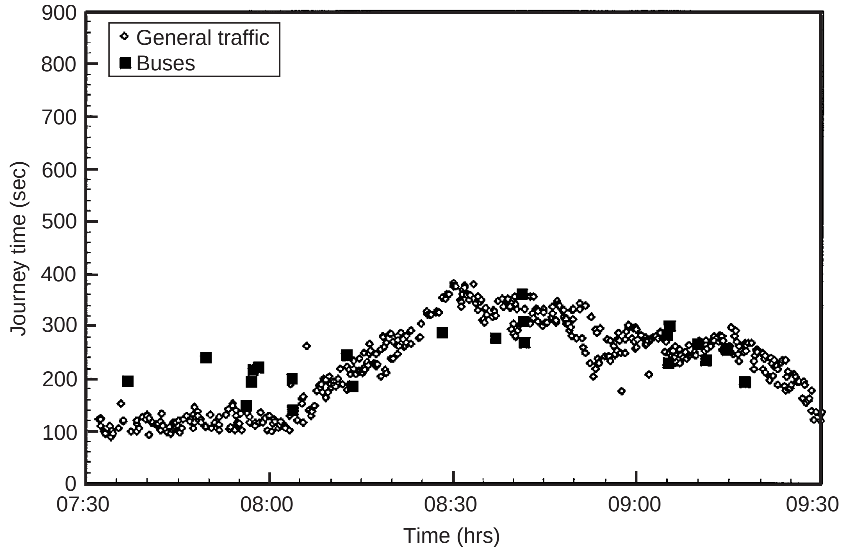

Figure A14 Journey times between 26–16 (1630–1830 hrs) Thursday 19 June 1997

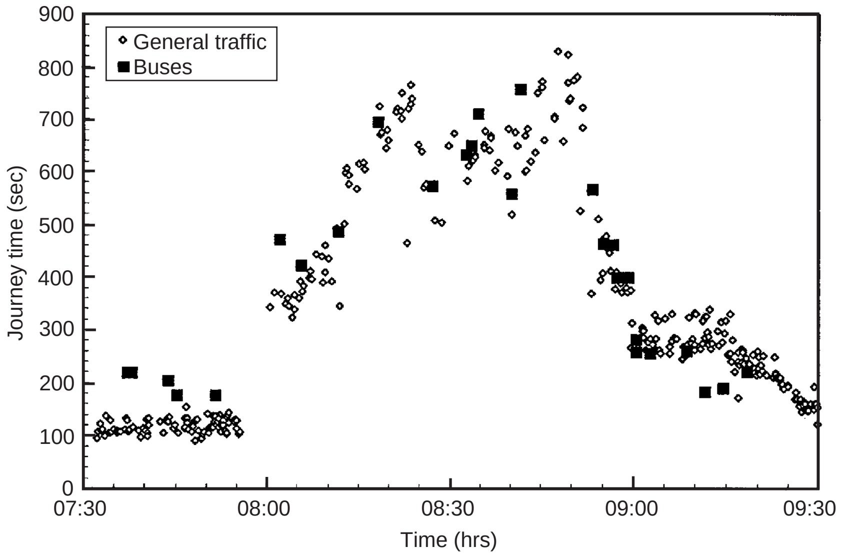

Figure A15 Journey times between 26–16 (1630–1830 hrs) Friday 20 June 1997

- At times when traffic congestion is ‘normal’ the benefits to buses from the guideway can be observed. The journey time profile on Thursday (Figure A14) shows that despite the incline and buses stopping to allow passengers to board and alight, there are times when buses are actually quicker than other traffic between 26-16. However, as discussed above buses are not completely isolated from peak traffic, showing an increase in journey times beyond 1715 hrs.
- At times when traffic congestion is severe, as on the Friday, the effect of queues extending beyond the start of the guideway is even more dramatic, masking all the benefit buses accrue in the guideway. This can be seen in Figure A15 between 1700 and 1800 hrs, when delays to traffic are high, the journey time advantage buses have over general traffic non-existent.

A2.2.2 19-16 (alongside the guideway)

Once in the guideway, buses are able to bypass traffic queues that have built up on the approach to the Potternewton Lane roundabout. Comparison of bus journey times between 19-16 (Table A14) show that bus journey times have improved by 16 seconds during the evening peak, with small benefits in all other periods except the weekday inter peak period.

To illustrate how bus journey times during the evening weekday peak have changed, Figure A16 shows the comparison of bus journey times between 19-16 for 1993 and 1997. This figure illustrates that bus journey times are now much less variable; individual bus journey time measurements show that the average standard deviation has been reduced from 21 to 12 seconds, thus allowing the bus company to schedule buses more accurately along this section of the route. Although buses are saving an average

Table A14 Average bus journey times between 19-16 (seconds)

Day	*Time*	*Average bus journey time between 19-16 (seconds)* 1993	1997	*Change*
Wkd	0730-0930	45	39	-9
	1000-1130	43	44	(+1)
	1630-1830	65	49	-16
Sat	1100-1400	49	45	-4

( )Indicates a change not significant at the 5 per cent level of confidence

of 15 seconds over the whole peak period, during the height of the peak (1730-1800 hrs) buses are about 1 minute quicker when compared to 1993. If it is assumed that traffic congestion along this section of the route has remained at 1993 levels then the savings given above reflect the advantage buses now have over general traffic. However Table A13 suggests (26-16 journey times) that congestion has increased since 1993 and so this underestimates the advantage buses now have over general traffic.

An interim report by the main bus operator (FirstBus Transit Developments and Leeds City Link, 1996) indicated that buses are consistently gaining between 2.5 and 3 minutes along this section of guideway throughout the evening peak period, compared to traffic remaining on the main carriageway.

To test this result with the data collected we need to estimate the journey time of general traffic between 19-16. Since all vehicles used the general carriageway in 1993, bus journey times between 19-16 are a good estimate for those of general traffic. This gives an average journey time estimate for general traffic in 1993 of 1 minute, with a maximum of 2 minutes at the height of the peak (Figure A16). Under these conditions (no increase of congestion on the approach to the Potternewton Lane roundabout) it would be impossible for buses using the guideway to be 2-3 minutes quicker than general traffic, since buses take an average of 50 seconds to travel along the guideway.

However there is some evidence to suggest that traffic congestion along this section of the route has deteriorated, increasing general traffic journey times by an average of 1 minute. If we assume all this delay is incurred between 19-16 then general traffic journey times during the evening peak should average 2 minutes, with a maximum of about 3 minutes. So during the height of the peak it is possible that buses could save up to 2 minutes when compared to traffic alongside the guideway. To save 3 minutes along a 500 m section of carriageway would suggest general traffic suffering delays averaging about 6 mph.

Analysing the data used for Figure A14 (journey times between 26-16) indicated that under these ‘normal’ traffic conditions general traffic averaged about 350 seconds or 13 mph during the height of the peak (1715-1745 hrs). Therefore it is quite possible that during this 30 minute period, the approach to the Potternewton Lane roundabout is sufficiently slow, to create conditions where buses are saving 2-3 minutes over general traffic.

A2.2.3 16-12 (across the Potternewton Lane roundabout)

From timing point 16, buses (in the guideway) and cars (on the main carriageway) travel towards the roundabout. Approximately 30 m from the roundabout there is the pedestrian crossing whose signals are activated by buses (in the guideway) and pedestrians. These signals give buses priority onto the roundabout in the same way as southbound buses on the approach to the Potternewton Lane and Stainbeck Lane roundabouts (Section 1.1.3).

Timing point 12 is located approximately 90 m from the roundabout exit, making the distance between 16-12 approximately 200 m. There is a bus stop about 45 m north of the roundabout. A summary of journey times for general traffic and buses between 16-12 is given in Table A15.

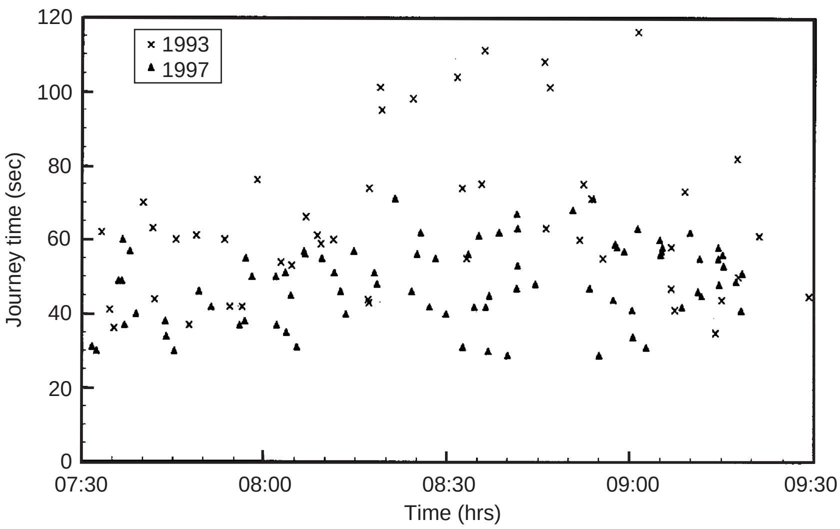

Figure A16 Bus journey times between 19–16 1630–1830 hrs)

Table A15 Average journey times between 16-12

Day	Time (hrs)	Average journey time between 16-12 (seconds)					
		Buses			General traffic		
		1993	1997	Change	1993	1997	Change
Wkd	0730-0930	51	35	-16	23	23	(0)
	1000-1130	40	34	-6	21	23	+2
	1630-1830	47	42	(-5)	32	36	+4
Sat	1100-1400	41	41	(0)	21	25	+4

( ) Indicates a change not significant at the 5 per cent level of confidence

Bus journey times have improved considerably in the morning peak period, saving approximately 16 seconds. On the other hand general traffic journey times have increased marginally, but by no more than 4 seconds in any particular period.

Analysis of the video survey suggests that bus access from the nearside guideway onto the roundabout incurs more obstructions than those exiting from the central guideway. The main problem seems to be that when buses reach the end of the nearside guideway they are prevented from exiting onto the roundabout by vehicles still entering from Scott Hall Road. Buses must therefore wait until there is a gap or (as was often recorded) force their way into the circulating flow. This problem does not occur in the southbound direction as the bus can queue behind any vehicles still remaining at the roundabout give way line, so consolidating there position in the approaching traffic queue.

Analysis of the turning movements of vehicles approaching the Potternewton Lane roundabout revealed that the dynamics of the roundabout have remained very similar to 1993.

The heaviest flows approaching the roundabout are those northbound evening flows along Scott Hall Road (16). The dominant movement for this traffic is the ‘straight on’ movement which accounts for 86 per cent in 1993 and 87 per cent in 1997 of the total flow. The left and right turning movements into Potternewton Lane also remained stable with approximately 7 per cent turning left and 6 per cent turning right.

The westbound approach from Potternewton Lane (18) is also important; an increase in the straight on or right turn movements would reduce the opportunity for vehicles on Scott Hall Road to exit onto the roundabout, so increasing their journey time. Analysis revealed that although there had been an increase of 23 per cent (259 to 320 veh/hr) in the amount of westbound traffic entering onto the roundabout, there were no significant changes to the portions of vehicles turning left, straight on and right. The dominate straight through movement decreased from 73 to 66 per cent, at the expense of slightly more left and right turning traffic into Scott Hall Road. The percentage of left and right turning vehicles is the same, but increased from 14 to 16 per cent for each movement.

This suggests that there has been no significant diversion of traffic via Chapeltown Road and Potternewton Lane to avoid the delays on the Scott Hall Road. Combining journey times to give measurements between 26-12 (Scott Hall Road) and 25-12 (Chapeltown Road/ Potternewton Lane) shows why this possible diversion route during the evening peak is not an attractive alternative on a normal day.

$$
\begin{aligned}
26\text{-}12 &= (26\text{-}16) + (16\text{-}12) \\
&= 192 + 36 \\
&= \textit{228 seconds}
\end{aligned}
$$

$$
\begin{aligned}
25\text{-}12 &= (25\text{-}20) + (20\text{-}18) + (18\text{-}12) \\
&= 213 + 75 + 31 \\
&= \textit{319 seconds.}
\end{aligned}
$$

A2.2.4 12-3/4 (Potternewton Lane to the King Lane roundabout)

Beyond timing point 12 buses and general traffic share the dual carriageway as far as the King Lane roundabout. Timing point 3 is located on the Scott Hall Road exit of this roundabout while point 4 is on the King Lane exit. The link is approximately 1650 m in length along which there are 4 bus stops (approximately 280 m apart) and 3 pedestrian crossings (one before the Stainbeck Lane roundabouts and one each side of the new Stainbeck Road junction.

Changes in bus journey times are not statistically significant, but other traffic is taking somewhat longer to travel over this section. The only change has been to the junction with Stainbeck Road, which is now signalised; this may account for the increase, especially in the weekday morning peak when southbound flows are heaviest.

A2.3 King Lane

A2.3.1 4/3-2 (Car Manor Road to Lingfield Approach)

Timing points 4 and 2 measure vehicle journey times along King Lane from the King Lane/ Scott Hall Road roundabout to the Allerton High School site. The distance between 4-2 is approximately 1300 m along which there are 3 bus stops. Average journey times for this section of the route are shown below in Table A17.

By 1997 northbound bus routes had been modified, omitting the southern part of King Lane and instead continuing along Scott Hall Road beyond the King Lane roundabout, thence via Street Lane to the junction of King Lane and Stonegate Road. This increases the distance traveled by buses by some 325 m, but the approach to Stonegate Road via Street Lane was judged to be less congested, which should have compensated for the additional distance. Therefore, Table A17 compares bus

Table A16 Average journey times between 12-3/4

		Average journey time between 12-3/4 (sec)						
		Buses			*General traffic*			*Estimated change in flow Ω*
Day	*Time (hrs)*	*1993*	*1997*	*Change*	*1993*	*1997*	*Change*	
Wkd	0730-0930	186	175	(-11)	120	143	+23	No change
	1000-1130	200	175	(+25)	119	126	+7	+5%
	1630-1830	207	193	(-14)	134	148	+14	+1%
Sat	1100-1400	168	189	(+21)	115	133	+18	+7%

( ) Indicates a change not significant at the 5 per cent level of confidence
Ω Estimated from data collected at A3

Table A17 Average journey times between 4/3-2

		Average journey time between 4-2 (seconds)						
		Buses (4/3-2)			*General traffic (4-2)*			*Estimated Change in flow Ω*
Day	*Time (hrs)*	*1993*	*1997*	*Change*	*1993*	*1997*	*Change*	
Wkd	0730-0930	181	265	(+84)	163	200	+37	+2%
	1000-1130	184	205	(+21)	112	119	+7	+8%
	1630-1830	247	256	(+9)	229	325	+96	+4%
Sat	1100-1400	197	220	(+23)	184	156	-28	-22%

( ) Indicates a change not significant at the 5 per cent level of confidence
Ω Estimated from data collected at timing point 4

journey times between 4-2 in 1993 with those between 3-2 in 1997). All bus journey times increased due to the increased distance travelled. However when congestion between 4-2 is severe (in the evening peak vehicles between 4-2 average only 9 mph), re-routing buses via Street Lane actually makes buses over 1 minute quicker than traffic between 4-2.

There were increases of comparable magnitude for other traffic (except on Saturday). This contrasts with the southbound journey times over the same section (Section A1.1.1) that remained the same, except during the morning peak where an improvement of 31 seconds was recorded. Both north and southbound journey times may have been affected by changes in traffic flow on the Ring Road, but without traffic flow data for the Ring Road this again is only conjecture.

A2.4 Meanwood Road

A2.4.1 28-10 (Corner Meanwood Road/Claypit Lane to Claremont Crescent)

There have been no changes to the layout or signal timings on Meanwood Road since 1993. The distance between 28-10 is approximately 2480 m along which there is one signalised junction at Sackville Street. Table A18 shows the average journey times for northbound vehicles along Meanwood Road.

Bus journey times improved by over ½ minute during the morning peak and on Saturdays. In the evening peak when flows are heaviest, buses are loosing over 1 minute compared with 1993. General traffic journey times showed roughly the same journey time trends as those of buses.

A2.5 Harrogate Road/Chapeltown Road

A2.5.1 25 -7 (Sheepscar Interchange to Halcyon Hill)

Timing point 25 to 7 measure the journey times of vehicles that use the Harrogate Road/ Chapeltown Road corridor. The distance between 25 to 7 is approximately 3000 m along which there are 2 signalised junctions. There is no bus priority between 25 and 7 and there have been no changes to the road layout or signal timings along this corridor.

A summary of the average journey times along the Harrogate Road/ Chapeltown Road corridor is shown below in Table A19.

Bus journey times improved by 1 minute in the morning peak, but this may result from the abnormally high journey times recorded on the Wednesday and Thursday in 1993. This results in northbound journey times in 1993 being almost the same as those in the evening peak when northbounf traffic flows are much higher. No explanation could be found for this odd result. In the evening peak buses journey times have deteriorated, due to the increased congestion along this section of the route.

General traffic journey times either remained at 1993 levels (morning peak) or increased, with the greatest loss occuring in the evening peak.

Table A18 Average journey times between 28-10

Day	Time(hrs)	*Average journey time between 28-10 (seconds)* Buses 1993	1997	Change	General traffic 1993	1997	Change	Estimated Change in flow¤
Wkd	0730-0930	267	233	-34	181	171	-10	+8%
	1000-1130	253	224	(-29)	175	164	-11	+19%
	1630-1830	299	363	+64	246	306	+60	-1%
Sat	1100-1400	255	220	-35	165	161	-4	No change

( ) Indicates a change not significant at the 5 per cent level of confidence
¤ ***E**stimated from data collected at A2*

Table A19 Average journey times between 25-7

Day	Time (hrs)	*Average journey time between 25-7 (secs)* Buses 1993	1997	Change	General traffic 1993	1997	Change	Estimated change in flow¤
Wkd	0730-0930	479	419	-60	276	282	-6	+24 %
	1000-1130	411	403	(-8)	265	279	+14	+7 %
	1630-1830	488	511	+23	327	380	+53	+7 %
Sat	1100-1400	434	432	(-2)	270	271	+1	+ 9 %

( ) Indicates a change not significant at the 5 per cent level of confidence
¤ ***E**stimated from data collected at A1*

Appendix A: Notes

[1] The time for a typical bus to slow down and stop, to wait while 3 passengers board and to accelerate to cruise speed is some 27 seconds more than it would take to cover the same distance without stopping [York, 1993]

[2] Unfortunately bus journey time data for the Wednesday was lost, so no journey time profile is shown for this day. However it should be noted that the journey time profile for general traffic on the Wednesday was almost the same as Thursday.

Appendix B: The study area

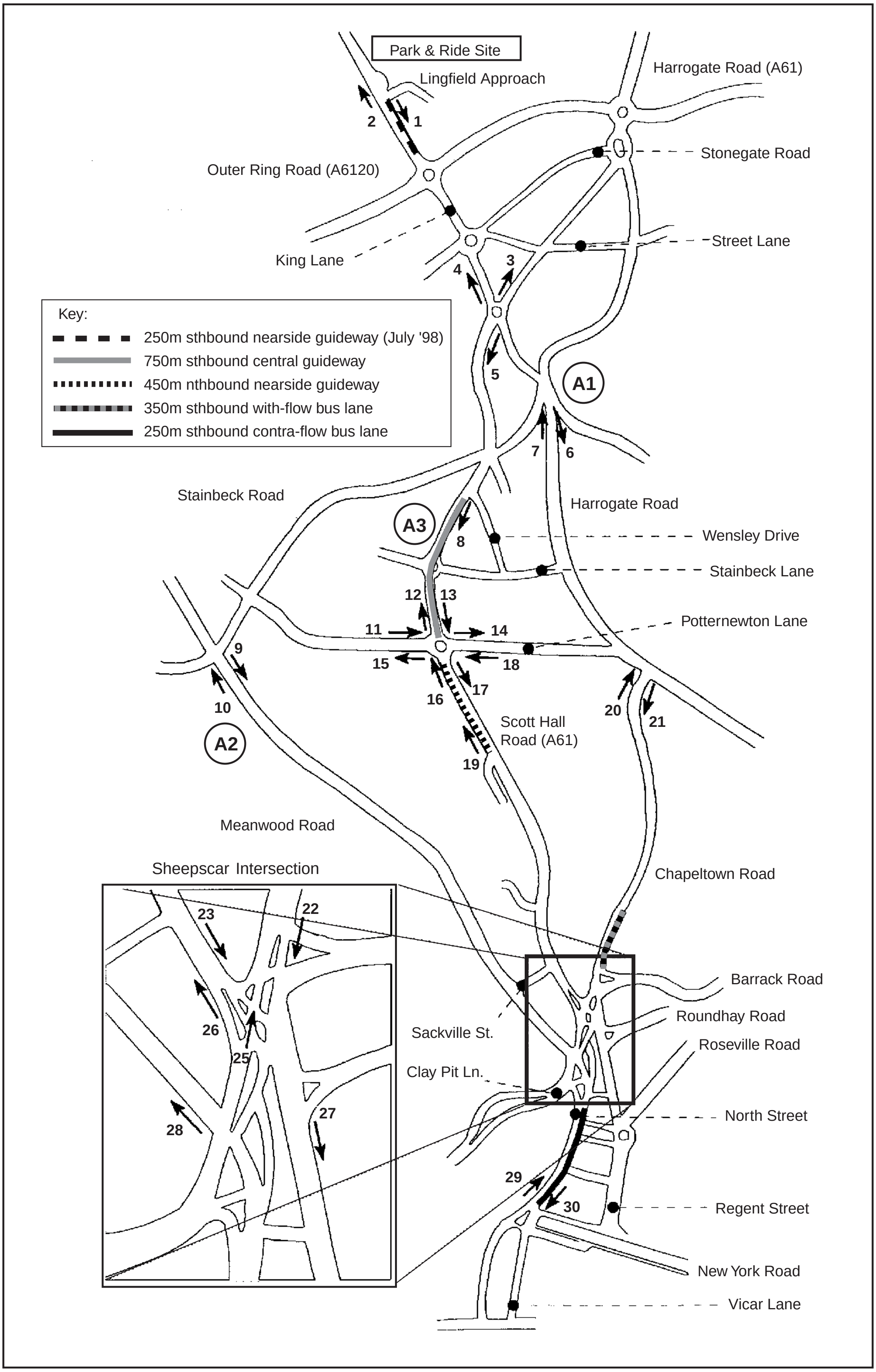

Figure B1 Location of survey timing and occupancy points

Abstract

The Leeds guided busway on Scott Hall Road consists of a 450 m outbound guideway on the nearside of the carriageway (Phase 1) and a 750 m inbound guideway located in the central reserve of a dual carriageway (Phase 2 and 3). All junctions that intersect the guideway are roundabouts, through which buses are given priority via a remote control signal technique. Other elements of the scheme included the signalisation of a busy junction, and the introduction of a contra-flow bus lane to improve bus access into the city centre.

The inbound guideway saved buses on average 70 seconds during the morning peak, but this increased to 2 minutes during the height of the peak. Also, by isolating buses from the worst of the congestion the guideway reduced the variability of bus journey times by 75 per cent. The signalling technique used to give buses priority onto the roundabout improved average bus journey times by between 5-10 seconds although this could be as much as 30 seconds when the roundabout was most congested. Beyond the guideway, both buses and general traffic suffered increased delays on the approach to a busy intersection, eroding much of the benefit accrued within the guideway. Bus journey times improved by about 40 seconds with the re-routing of buses into the city centre via the contra flow bus lane on North Street.

The success of the outbound guideway was mixed; while buses journey times improved by up to 2½ minutes within the guideway (compared to general traffic alongside it), they were delayed by increased traffic queues on the approach to the Potternewton Lane roundabout. It is thought that these extended queues delay buses on the approach to the start of the guideway. It has been estimated that this additional delay can be as high as 110 seconds during the height of the peak. The signalling technique used to give buses priority onto the roundabout was thought to be partly responsible for the increase in general traffic queues, but an increase in downstream traffic flows could not be ruled out.

A questionnaire survey was also undertaken to assess the views of car drivers and bus passengers to the guideway and bus services along Scott Hall Road.

Related publications

TRL194 *Bus priority approaching a roundabout: The Doncaster bus advance area* by A Astrop and R J Balcombe. 1996 (price £25, code E)

TRL140 *Performance of bus priority measures in Shepherd's Bush* by A Astrop and R J Balcombe. 1995 (price £25, code E)

PR2 *Factors affecting bus stop times* by I O York. 1993 (price £25, code E)

CR88 *Bus priority by selective detection* by N B Hounsell and M McDonald. 1988 (price £35, code I)

CT19.2 Bus priority measures update (1996-1998). *Current Topics in Transport: selected abstracts from TRL Library's database* (price £20)

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