JMP CONSULTANTS LTD

TRICS REPORT 89/4

TRAFFIC GENERATION FROM INDUSTRIAL ESTATES

1984

PART 1

REPORT ON SURVEYS AND ANALYSES

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PART ONE :

THE SURVEYS

SECTION ONE INTRODUCTION

General

1.1 As part of a wider study being undertaken jointly by the Government based Development Agencies within the United Kingdom to update their planning criteria for the development of Industrial and Commercial Estates, Jamieson Mackay and Partners were commissioned to undertake a Study of the levels of traffic generation from such Estates. The background to the Study is set out in the document entitled 'Site Planning and Development, Industrial Estate Traffic Generation' prepared by the Consultants in March 1983. The surveys were planned to investigate traffic generation from Estates throughout Great Britain, representative of those of the Agencies concerned, namely, the Scottish Development Agency, Highland and Islands Development Board, English Industrial Estates, Welsh Development Agency, Development Board for Rural Wales and the Industrial Development Board of Northern Ireland. *

1.2 Following the adoption of the Project by the Development Agencies the Consultants were also asked to undertake the field survey work in addition to the analyses and reporting work for the Scottish, Welsh and English Regions. In Northern Ireland the survey work was undertaken directly by the Industrial Development Board.

Contents of the Report

1.3 This Report is divided into two Parts. Part I (Sections 2-4) describes the surveys and Part II (Sections 5-7) describes the detailed analyses that were undertaken.

1.4 Following this Introduction, Section Two of the Report describes the aims of the surveys, the design considerations taken into account, and how a sample of survey sites in Great Britain and Northern Ireland was selected. Sections Three and Four deal with each of the surveys undertaken. The fieldwork associated with each survey is described covering aspects of sampling, interview techniques, scope of survey, type of data collected, and initial processing.

1.5 Within Part II of the Report, Section Five includes a detailed statistical analysis of trips generated by industrial location. Section Six examines data relating to peak hour traffic conditions, Section Seven describes parking analyses undertaken, and Section Eight considers the difficult problem of data variability.

* Throughout this Report these organisations are referred to collectively as the Development Agencies.

1.6 Within the Appendices to this Report is contained copies of all the Survey Forms used, in addition to Instructions to Interviewers and Enumerators and Notes for Police and Highway Authorities.

Acknowledgements

1.7 This Study has been undertaken in part as a joint exercise between the Consultants and the Development Agencies. In particular, the survey work in Northern Ireland was undertaken directly by the Industrial Development Board and the collation of data relating to the employment and activities at each firm was undertaken by all the Agencies.

1.8 The Consultants gratefully acknowledge the work that was undertaken by the Development Agencies and for the helpful comments and advice given to them throughout the course of the study.

SECTION TWO SURVEY OBJECTIVES

General

2.1 The principal objective of the Study is to investigate the traffic generation from industrial and commercial Estates throughout the United Kingdom. To achieve this objective it was necessary to survey a wide cross-section of Estates ranging in size from small single access sites with low occupancy levels to the large multi-access Estates with over 300 separate industrial and commercial units, including some large employers.

2.2 The Traffic and Land-Use Surveys were carried out to quantify the various traffic patterns which gave rise to the present observed traffic flows. The Study was designed so that the resulting data could provide basic information for assistance in the planning and development of future industrial and commercial sites, particularly with regard to the design of Estate roads and associated junctions.

2.3 Existing data sources covering traffic generation tend to be in excess of 10 years old and relate principally to England. There has been little research carried out in this subject within Scotland, Wales and Northern Ireland. Many of these studies have been of a research nature where the researchers have been attempting to explain all variations in traffic flow whereas this project has been designed to provide practical guidelines to estate planners.

2.4 To obtain a wide spectrum of different types of sites in differing areas a sample of some 60 sites was chosen throughout the country.

2.5 Two differing survey methodologies were considered. The first involved undertaking traffic counts at each site entrance so that the total traffic flow could be assessed. The second method involved undertaking a simple interview with each driver on leaving the site so that trip purpose and also details of the firm visited could be obtained. It was decided, in consultation with the Development Agencies, that this latter procedure would provide significantly increased amounts of data which could be justified against the additional cost. In particular, it would be possible to obtain trip rates by the firm's industry type and employment rather than factors which could only be used at an aggregated site level.

2.6 The one proviso that was made to the survey procedures was that due to the extra costs involved in mounting roadside interview survey (which also normally required the presence of a Police Officer) sites with only one or, at

the most, two entrances would be chosen in preference to sites with multi-accesses.

Details of Surveys

2.7 The most important element of the Study was the Roadside Interview Survey. This used a simple, direct interview technique to provide data relating to the traffic generation from each individual Estate.

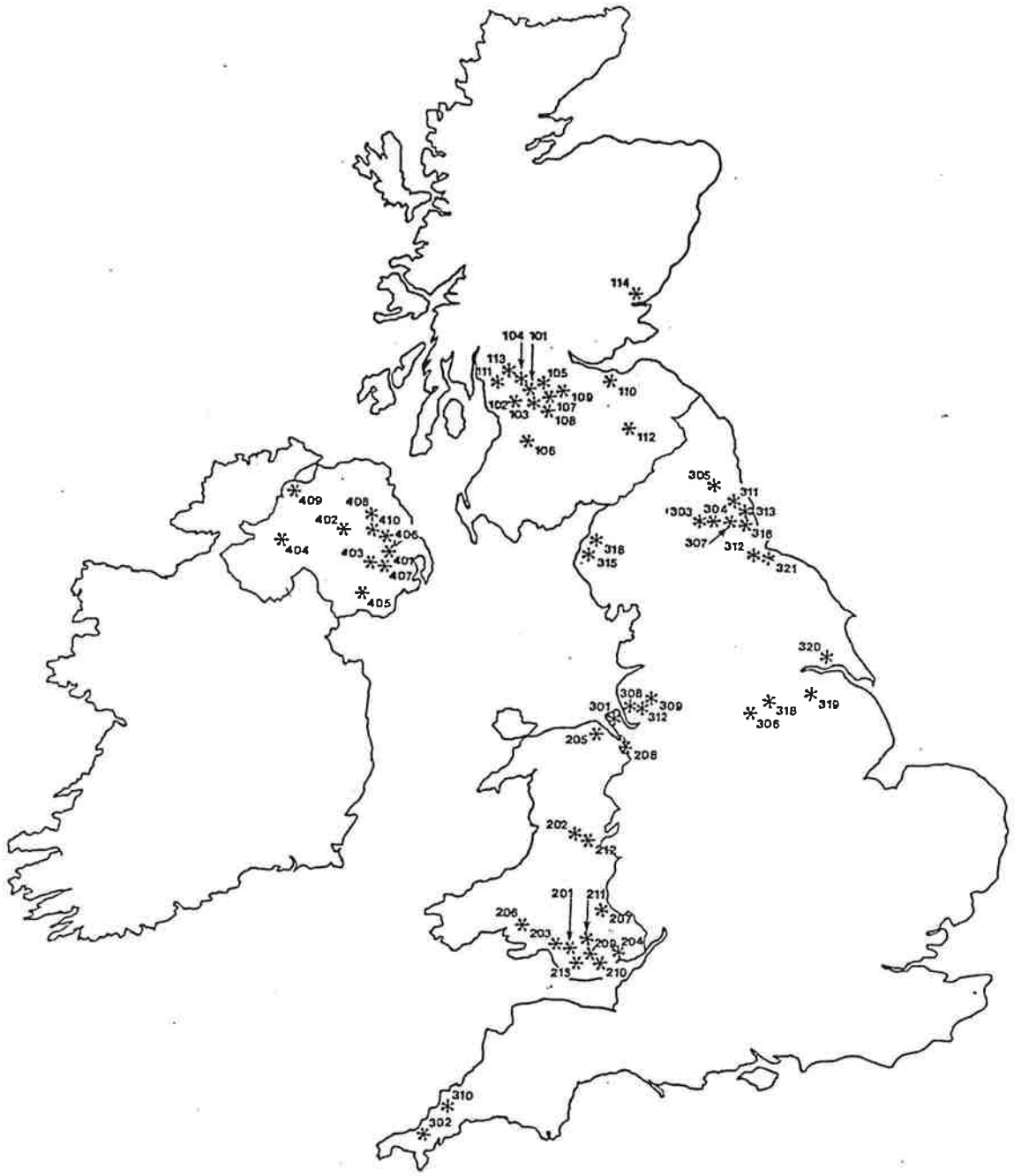
2.8 Volumetric counts on the Estate exit access roads provided a set of traffic flows for the survey period. For the purposes of the study all surveys were undertaken on a weekday and no surveys were carried out on Fridays or Public Holidays.

2.9 Within each Estate, parking surveys were undertaken at selected times throughout the day to determine the location and the extent of parked traffic.

2.10 The sampling procedure was designed to ensure that a representative sample of Estates was surveyed nationally. Study budget and timing restrictions realistically determined the number of survey locations and at the very early stages of project planning, it was decided to limit the survey to about sixty Estates. In discussion with Agency representatives at which the general study objectives and site selection criteria were explained, short lists of potential sites relating to each Agency were identified.

2.11 Initial selection relied on Agency knowledge of sites within their jurisdiction. It was dependent on such aspects as site suitability (the number, size and type of unit on any Estate, etc), survey practicality (number of accesses, highway geometric layout, etc) and geographical spread of survey sites throughout the country. Each Estate site was visited prior to making a final selection. In a few instances, after examining the exact servicing arrangements for each unit on an Estate, only a part of the Estate was selected in order to reduce the number of access points for survey purposes.

2.12 Highway and Police Authorities were consulted and unacceptable sites were rejected from the short list. The final sample was made up of 58 sites (Figure 2.1). Of this total, 21 Estates were in England, 14 in Scotland, 13 in Wales and 10 in Northern Ireland.



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SCOTTISH DEVELOPMENT AGENCY

101	ANNICK STREET (GLASCOW)
102	BEITH
103	BLANTYRE
104	CLYDEBANK
105	COATBRIDGE
106	CUMNOCK
107	ETNA
108	LARKHALL
109	NEWHOUSE
110	PEFFERMILL (EDINBURGH)
111	PORT GLASGOW
112	TWEEDBANK
113	VALE OF LEVEN
114	WESTER GOURDIE (DUNDEE)

WELSH DEVELOPMENT AGENCY
*DEVELOPMENT BOARD FOR RURAL WALES

201	BRIDGEND
202 *	DYFFRYN (NEWTOWN)
203	KENFIG (PYLE)
204	MAESGLAS (NEWPORT)
205	MANOR FLINT
206	PONTBENRI (LLANELLI)
207	RASSAU (BRADFORT)
208	SHOTTON
209	TREFOREST
210	TYNDALL STREET (CARDIFF)
211	UPPER BOAT (TREFOREST)
212 *	VASTRE (NEWTOWN)
213	WATERTON (BRIDGEND)

ENGLISH INDUSTRIAL ESTATES

301	ARGYLL STREET (BIRKENHEAD)
302	CARDEW ROAD (REDRUTH)
303	CONSETT LEADGATE
304	CONSETT NO 1
305	CRAMLINGTON (NEWCASTLE)
306	HELLABY (ROTHERHAM)
307	HODGETON LE SPRING
308	KNOWSLEY (LIVERPOOL)
309	LAMBERHEAD (WIGAN)
310	NEWQUAY
311	NORTH TYNE (WALLSEND)
312	PARR (ST.HELENS)
313	REKENDYKE (SOUTH SHIELDS)
314	RIVERSIDE PARK (MIDDLESBOROUGH)
315	SALTERBECK (WORKINGTON)
316	SEDGELETCH
317	SHAW LANE (DONCASTER)
318	SOLWAY MARYPORT
319	SOUTHPARK (SCUNTHORPE)
320	SUTTONFIELDS (HULL)
321	TEESIDE (MIDDLEBOROUGH)

INDUSTRIAL DEVELOPMENT BOARD OF NORTHERN IRELAND

401	ADELAIDE (BELFAST)
402	AUGHRIM ROAD (MAGHERAFELT)
403	BLARIS (LISBURN)
404	GORTRUSH (OMAGH)
405	GREENBANK (NEWRY)
406	HYDEPARK (BELFAST)
407	KNOCKMORE (LISBURN)
408	PENNYBRIDGE (BALLYMENA)
409	PENNYBURN (LONDONDERRY)

LOCATION OF SURVEY SITES

Figure 2.1

SECTION THREE ROADSIDE INTERVIEW SURVEY

Summary of Survey

3.1 The aim of this survey was to collect detailed information relating to the trip characteristics of the total number of vehicles leaving each Estate during the course of the day of the survey.

3.2 Interviewing took place on selected survey days (Table 3.1) between September and mid-November, 1983, using locally engaged staff under the supervision of the Consultants supervising staff. The survey work in Northern Ireland was directly operated and managed by the Development Agency but followed in all other respects the procedures set by the Consultants for all other locations. All survey team members were extensively briefed before starting their task.

3.3 At all survey sites interviews were carried out on one weekday for the 12 hour period extending from 0700-1900 hours inclusive. Where possible a 100% sample rate was sought and achieved, although in the very busy peak periods at some locations the sample rate dropped to alleviate traffic congestion. A classified count of both inbound and outbound traffic was taken during the same survey period as the Roadside Interviews.

3.4 Appendices A, B, and C give further details of the procedure adopted throughout the course of the survey.

3.5 Roadside interviews took place in the outbound direction only. The outbound was preferred to the inbound direction due to the safety aspects of warning drivers of the approaching interview. Also, it was considered that travellers would give a better description of the place that they had just visited while, in most cases, being under no great pressure of time to reply. Many of the smaller Estates had only one entry/exit point whilst larger Estates such as Treforest in South Wales generally had two or more entry/exit points. In each case all exits were covered by survey staff throughout the day during which the particular Estate was being surveyed.

3.6 Particular care was taken at all interview stations to ensure the safety of both survey staff and road users.

3.7 Before the survey commenced the Local Police Authorities and the Highway Authorities were consulted and given details of the survey and its location. Each Police Authority required the survey sites to be controlled by Police Offices (no such requirement was made for the sites surveyed in Northern Ireland).

3.8 Staff were employed to cover the 12 hour survey period. A team of (in most cases) three or four staff per site were engaged on the simultaneous Roadside Interview and Classified Count surveys. In addition one trained supervisor was responsible for monitoring all site surveys, checking the sample rate and ensuring, in conjunction with the Police, that safety was observed.

3.9 On the larger Estates all interview stations were operated simultaneously and survey teams were allocated accordingly. The Supervisor was responsible for all surveys taking place on an Estate on the day of survey.

3.10 Because of the nature of the survey sites, it was not possible (or desirable) to carry out the interviews off the carriageway. The normal procedure adopted was to cone off the nearside lane to form the interview bay (as shown diagramatically in Appendix C). Upstream of the bay a line of cones signified the start of the interview site as laid out according to Department of Transport Regulations.

3.11 Sampling was carried out by half-hour period with an aim to interview every vehicle. At some of the busier sites the reduction in road capacity occasionally threatened to produce excessively long queues. When this was observed the interviewing halted and the traffic was allowed to run freely past the interview bay until the queue had cleared. Such occurrences were comparatively rare and were confined mainly to the evening peak period on the larger Estates. The Classified Count surveys continued throughout these short periods of interruption in the Roadside Interview surveys.

3.12 Table 3.2 sets out the locations of the Surveys together with the number of interviews conducted at each exit point.

3.13 The roadside interviews were recorded on Form A (Appendix A). The following information was collected:-

(i) Vehicle Type/Occupancy (by inspection)

(ii) Firm visited on Estate

(iii) Purpose of trip

(iv) Whether Firm had been visited previously that day.

3.14 For both the traffic count and the interview, vehicles were sub-divided into classes, namely:

(i) cars

(ii) light goods vehicles (ie vans up to 30 cwts unladen)

(iii) heavy goods vehicles (i.e. over 30 cwts unladen weight).

The division at 30 cwts unladen is equivalent to 3.5 tons gross weight and is recognisable by having twin tyres on the rear axle.

3.15 Wherever possible the origin of the trip on the Estate was recorded in sufficient detail for the identification of the Firm to be made easily during the subsequent analysis. If the interviewee could not remember the name of the Firm visited supplementary questioning was used to ascertain the precise trip origin.

Survey Problems

3.16 A few minor technical problems manifested themselves during the course of the survey programme. On one or two sites the survey period was curtailed by 15 minutes or so when it became too difficult to carry out interviews safely due to the failing light. In each of these cases the traffic counted was very low since the Estate had discharged most of its traffic by that time. Another instance where the interviews were interrupted occurred when heavy rain fell for ten minutes thus interfering with the safety of the survey operation.

3.17 Identification of the Firm visited was sometimes a problem, particularly with drivers of heavy goods vehicles who would often give the name of their own haulage company because it was difficult to hear the question. It was the interviewers' responsibility to ensure that the questions asked were correctly understood by the driver and the correct answers received.

3.18 The percentage of through traffic varied from Estate to Estate. In most cases it represented a very small percentage (normally zero on a one entrance site). All vehicles were interviewed irrespective of their overall intentions. Certain sites possessed a non-industrial attraction such as a technical college or shop. Trips were recorded from such sites during the course of the survey.

Employment Data

3.19 In addition to collecting survey data relating to vehicular activity into and out of each Estate, data was collected on the activity of each unit on the Estate. The data was collected by the Development Agencies who were, in most cases, able to extract the data from their existing files.

3.20 The data collected for each unit included:-

(i) Employment on the site (by male and female, if possible)

(ii) Gross Site Area

(iii) Gross External Area of Floor Space

(iv) Details of main business undertaken

(v) Activity at site as under:

1	=	manufacturing	5	=	servicing
2	=	warehousing	6	=	research
3	=	wholesale	7	=	admin/management
4	=	retail	8	=	other

Initial Analysis

3.21 For most of the survey period the teams were able to interview 100% of all drivers leaving the site but for certain periods this proved impossible. Such occurrences normally arose when bad light or heavy rain curtailed the survey or for limited periods during the peak traffic hour when there was so much traffic that a long queue developed. In these instances expansion factors were applied to each interview to expand them to be representative of the traffic flow actually occurring during that period.

3.22 The next stage involved linking the results of the roadside interviews with the information obtained of the firms on each Estate. This linking highlighted a number of problems that had to be overcome. Typical of these were:-

(i) Through trips - trips that were passing directly through the Estate without stopping. These trips were excluded from the survey and were deleted from the traffic counts on both the in-bound and out-bound counts for the same half hour time period.

(ii) Trips that came onto the Estate but for no particular purpose - these included lost drivers, learner drivers, general site inspections and road sweeping vehicles. These trips were excluded from the survey and were deleted from the traffic counts on both the in-bound and out-bound counts for the same half hour time period.

(iii) Trips that visited many firms on one Estate - such as GPO vehicles, milk floats. These trips were allocated randomly around the firms on the Estate. This was achieved by allocating the trip to the

location of the preceding interview.

(iv) Drivers that refused to answer questions. These trips were allocated randomly around the firms on the Estate. This was achieved by allocating the trip to the location of the preceding interview.

(v) Trips that were visiting "unknown" firms. In many cases these "unknown firms" were different trading names for companies known to be on the Estate and the trips were allocated accordingly.

(vi) Trips that were going into the Estate but to locations such as construction or demolition sites. This information is not required for this study and the trips were eliminated and the outbound count consequently amended. As such visits are likely to be of some variable duration ranging from 10 minutes to drop a load to 8 hours to work on site it is more difficult to adjust the in-bound flow and in some cases this proved too difficult to undertake.

3.23 The type of industry undertaken at each location was given a code to represent the Standard Industrial Classification of the premises. The codes used are set out in Appendix D.

3.24 The survey identified trips by 4 purposes (work, business, collection/deliver load and other) and by various vehicle types (motorcycle, car, light goods and heavy goods). This gives a maximum combination of some 16 categories. This was too many for analysis and, therefore, was reduced to just 4 groups, namely:-

(i) cars on work purpose

(ii) cars on business purpose

(iii) cars on other purpose

(iv) all goods vehicles, all purposes

All trip information was recorded as 12 hour totals.

3.25 The data was coded and keyed into a micro-computer in the format of one record per firm. The data format was as follows:-

(i) firm number

(ii) male employees

(iii) female employees

(iv) total employees

(v) Gross Site Area (acres)

(vi) Gross External Area of floor space (sq. ft.) (subsequently converted to sq. m.)

(vii) Standard Industrial Classification (SIC)

(viii) firm activity

(ix) trips by car on work purpose

(x) trips by car on business purpose

(xi) trips by car on other purposes

(xii) trips by goods vehicles

(xiii) name of firm.

3.26 The name of the firm was retained on the record until all data accuracy checks were complete at which stage it was deleted in order to ensure total confidentiality for firms which participated in the project.

TABLE 3.1 SITE REFERENCE DETAILS

SITE NO		SITE NAME	SURVEY DATE	NUMBER OF STATIONS
SCOTTISH DEVELOPMENT AGENCY				
101		ANNICK ST.	06-10-83	1
102		BEITH	05-10-83	1
103		BLANTYRE	21-09-83	3
104		CLYDEBANK	22-09-83	2
105		COATBRIDGE	28-09-83	1
106		COMNOCK	08-09-83	2
107		ETNA	04-10-83	1
108		LARKHALL	29-09-83	1
109		NEWHOUSE	19-09-83	3
110		PEFFERMILL	15-09-83	1
111		PORT GLASGOW	20-09-83	3
112		TWEEDBANK	13-09-83	2
113		VALE OF LEVEN	27-09-83	1
114		WESTER GOURDIE	06-09-83	2
WELSH DEVELOPMENT AGENCY				
201		BRIDGEND	20-10-83	3
202	*	DYFFRYN NEWTOWN	12-10-83	2
203		KENFIG	24-10-83	1
204		MAESGLAS	12-10-83	1
205		MANOR FLINT	10-10-83	2
206		PONTHENRI	18-10-83	1
207		RASSAU	13-10-83	1
208		SHOTTON	12-10-83	1
209		TREFOREST	26-10-83	2
210		TYNDALL ST.	31-10-83	1
211		UPPER BOAT	27-10-83	2
212	*	VASTRE NEWTOWN	13-10-83	1
213		WATERTON	19-10-83	2
ENGLISH INDUSTRIAL ESTATES				
301		ARGYLL ST	22-09-83	1
302		CARDEW RD.	03-11-83	1
303		CONSETT LEADGATE	10-10-83	1
304		CONSETT NO 1	03-10-83	1
305		CRAMLINGTON	18-10-83	2
306		HELLABY	06-10-83	1
307		HOUGHTON LE SPRING	17-10-83	1
308		KNOWSLEY	26-09-83	2
309		LAMBERHEAD	20-09-83	2
310		NEWQUAY	02-11-83	1
311		NORTH TYNE	20-10-83	1
312		PARR ST.HELENS	03-10-83	2
313		REKENDYKE	18-10-83	1
314		RIVERSIDE PARK	12-10-83	1
315		SALTERBECK	06-10-83	2
316		SEDGELETCH	17-10-83	1
317		SHAW LANE	05-10-83	2
318		SOLWAY MARYPORT	05-10-83	2
319		SOUTHPARK	29-09-83	1
320		SUTTONFIELDS	28-09-83	1
321		TEESIDE	13-10-83	2
INDUSTRIAL DEVELOPMENT BOARD OF NORTHERN IRELAND				
401		ADELAIDE	11-10-83	1
402		AUGHRIM RD	22-09-83	1
403		BLARIS	20-09-83	2
404		GORTRUSH	06-10-83	1
405		GREENBANK	29-09-83	2
406		HYDEPARK	04-10-83	2
407		KNOCKMORE	22-09-83	1
408		PENNYBRIDGE	27-09-83	2
409		PENNYBURN	06-10-83	1
410		STEEPLE	08-09-83	1

Note: * Development Board for Rural Wales

TABLE 3.2 ROADSIDE INTERVIEW SAMPLE RATES

SITE NO		SITE NAME	VEHICLES OUT	NUMBER INTERVIEW	SAMPLE RATE
SCOTTISH DEVELOPMENT AGENCY					
101		ANNICK ST.	536	536	100
102		BEITH	251	251	100
103		BLANTYRE	1086	1086	100
104		CLYDEBANK	575	575	100
105		COATBRIDGE	217	217	100
106		CUMNOCK	580	580	100
107		ETNA	220	220	100
108		LARKHALL	336	336	100
109		NEWHOUSE	1926	1683	87
110		PEFFERMILL	259	259	100
111		PORT GLASGOW	826	826	100
112		TWEEDBANK	200	200	100
113		VALE OF LEVEN	864	864	100
114		WESTER GOURDIE	460	460	100
WELSH DEVELOPMENT AGENCY					
201		BRIDGEND	6770	5175	76
202	*	DYFFRYN NEWTOWN	422	422	100
203		KENFIG	1157	952	82
204		MAESGLAS	210	210	100
205		MANOR FLINT	449	449	100
206		PONTHENRI	43	43	100
207		RASSAU	673	673	100
208		SHOTTON	1325	1220	92
209		TREFOREST	5565	4245	76
210		TYNDALL ST.	378	378	100
211		UPPER BOAT	750	750	100
212	*	VASTRE NEWTOWN	553	528	95
213		WATERTON	2877	2736	95
ENGLISH INDUSTRIAL ESTATES					
301		ARGYLL ST	450	450	100
302		CARDEW RD.	168	168	100
303		CONSETT LEADGATE	252	252	100
304		CONSETT NO 1	586	586	100
305		CRAMLINGTON	538	375	70
306		HELLABY	134	134	100
307		HOUGHTON LE SPRING	547	527	96
308		KNOWSLEY	621	621	100
309		LAMBERHEAD	519	498	96
310		NEWQUAY	312	312	100
311		NORTH TYNE	928	889	96
312		PARR ST.HELENS	839	839	100
313		REKENDYKE	178	178	100
314		RIVERSIDE PARK	607	607	100
315		SALTERBECK	613	613	100
316		SEDGELETCH	116	116	100
317		SHAW LANE	1058	1023	97
318		SOLWAY MARYPORT	604	604	100
319		SOUTHPARK	198	198	100
320		SUTTONFIELDS	229	229	100
321		TEESIDE	1691	1656	98
INDUSTRIAL DEVELOPMENT BOARD OF NORTHERN IRELAND					
401		ADELAIDE	776	776	100
402		AUGHRIM RD	134	134	100
403		BLARIS	958	958	100
404		GORTRUSH	237	237	100
405		GREENBANK	1213	1213	100
406		HYDEPARK	2385	2385	100
407		KNOCKMORE	503	503	100
408		PENNYBRIDGE	2918	2918	100
409		PENNYBURN	1263	1263	100
410		STEEPLE	599	599	100
		TOTAL	51682	47735	92

Note: * Development Board for Rural Wales

SECTION FOUR CLASSIFIED COUNT AND PARKING SURVEYS

Manual Classified Counts

4.1 At every interview station, manual Classified Counts were undertaken and the information recorded on Form B (Appendix A). This data was accumulated and recorded on Form C (Appendix A) each day by the Supervisor on duty.

4.2 At each site traffic was recorded separately for each direction between 0700-1900 hours by half-hour time period. The Vehicle Classification utilised is shown in Appendix B. Goods Vehicles of below 30 cwts were classified as Light Goods Vehicles and those of above were classified as Heavy Goods Vehicles. Two staff members undertook the Classified Counts to ensure that adequate rest periods were taken.

Parking Survey

4.3 The principal aim of this secondary survey was to establish an assessment of the demand for parking within the Estate during two periods of the day. This survey aimed to provide supplementary information and no detailed parking duration surveys were undertaken.

4.4 In order to assess the peak parking demand twice daily records of all parked vehicles were made for each Estate on the same day as the Roadside Interview Surveys were carried out. Usually the first parking survey took place during mid-morning followed by a second parking survey during mid-afternoon.

4.5 In the large Estates, such as Treforest and Bridgend in South Wales, greater difficulties were experienced in surveying parking due to the size of the site. In these sites the parking survey had to be undertaken on a different day to the main survey.

PART TWO :

THE ANALYSES

SECTION FIVE DATA ANALYSES

Introduction

5.1 In analysing Trip Generation data for the purposes of Estate Planning and Site Development, two main practical considerations should be taken into account.

(i) Firstly, in order to design the Estate access roads and junctions, the Development Agency should have details of the likely traffic flows. This is principally a function of the traffic demand within the peak periods of the working day. The main peak is recorded in either the morning or evening due to the preponderance of journey to work trips, although a lesser peak is recorded during lunch-time. Goods vehicle trip movements peak at different times from private vehicle trip movements.

(ii) Secondly, the environmental impact of the traffic is of importance both in siting Estates and their acceptability to the public. The principal environmental impacts relevant in Estate planning are Noise, Vibration and Visual Intrusion. These are related to the traffic demand of all vehicle types throughout the working day. In particular, heavy flows of commercial vehicle traffic tend to register high noise and vibration levels.

5.2 A less practical but important problem to be resolved is that of forecasting future traffic demand. These analyses present guidelines for estimating likely trip generation from a particular size of Estate and Industrial and Commercial Unit. It is clearly related both to the geographical location of the site and the type of industry attracted to the area. All estimates prepared from the survey analyses relate to existing traffic flow levels and no allowances have been made for future traffic flow increases.

5.3 A glossary of terms used frequently in the field of Highway and Transportation Planning is presented in Appendix E.

General Descriptions

5.4 As outlined in the preceding Sections the surveys were undertaken at 58 separate Estates throughout Great Britain and Northern Ireland. The sites comprised a wide mixture of types from small city centre locations to very large Estates encompassing both commercial and industrial units. In total 972 firms in the 58 Estates were surveyed. (Actually more firms existed but had to be deleted during

the processing stages due to lack of data on one or more important items). Table 5.1 identifies the basic parameters of the data base. The 972 firms in the data base employed some 36,000 staff and had a combined floor area of some 1.46 million sq metres.

5.5 The sites varied in size and in intensity of use. Table 5.2 illustrates the distribution of sites by employment and Table 5.3 by Gross External Area of floor space. It will be noted that out of 58 sites 34 of them had total employment of less than 500 and 32 had a total Gross External Area of floor space of less than 20,000 sq m.

5.6 Each site has been described in terms of its locality, namely:-

(i) within urban area (ie adjacent to extensive residential areas)

(ii) adjacent to urban area (ie close to residential in at least one direction)

(iii) rural area (ie no residential close by).

It was expected that such a grouping would show differing trip rates with the more rural sites exhibiting a higher car driver trip rate. The number of sites within each Region by locality is given in Table 5.4. While the majority of sites fall within the middle group about a quarter of the sites fall within the urban and rural categories respectively.

5.7 As a background to considering trip rates for individual firms, Table 5.5 sets out the number of firms by number of employees, and Table 5.6 describes the same data in terms of Gross External Area of Floor space of each unit. Figures 5.1 and 5.2 provide a graphical representation of the same data. In both cases the data is very skewed towards the low end and cannot be considered to be normally distributed about the mean. This has implications, which will be discussed later, on the reliability of regression equations. It will be noted that nearly half of the recorded firms had less than 10 employees and had a Gross External Area of Floor space of under 500 sq m.

5.8 Each firm was described by two parameters to identify type of industrial activity. The first was the SIC (Standard Industrial Classification) of the industry to which the firm belonged and the second was the type of activity being undertaken at that site. These descriptions are tabulated in Table 5.7 and 5.8. The full definition of SIC categories is given in Appendix D.

5.9 Analysis later in this report identified that Public Utilities had significantly higher goods vehicle activities than other firms which were within their own SIC grouping. These premises were spread through 3 different SIC grouping and it was considered that there was merit in grouping them together with the Utilities SIC group. The activities included:

Electricity Board (correctly within Utilities Group).

Post Office (should be in Transport).

British Telecom (should be in Transport).

Northern Ireland Housing Executive - Maintenance (should be within Public Administration).

5.10 The greatest concentration of firms was in light engineering being represented by SIC groups 7, 8, 9, 12 and 19. It was difficult to be specific about SIC classification due to the level of information available about each firm; this resulted in some overlapping between individual classifications. Most firms undertook manufacturing at their premises with a minority of firms being involved in wholesale or servicing.

5.11 The number of trips generated by each Estate was sub-divided into four groups, namely:-

(i) Cars - Work (commuting)
(ii) Cars - Business (not normal place of employment)
(iii) Cars - Other (including retail purposes)
(iv) All Goods Vehicles

In total 38,000 trips were observed as being generated from all the sites during the 12 hour survey period (0700 - 1900 hours). Of these 54% were car work trips, 12% car business trips, 9% car other trips, and 25% goods vehicle trips. The distribution of total trips from each site is given in Table 5.9. It will be noted that only nine Estates had traffic generation in excess of 1,000 vehicles a day.

Floor Space

5.12 In planning any Estate one of the basic planning assumptions that has to be made is the floor space per employee. Quite clearly this would vary considerably on a firm by firm basis. Table 5.10 gives the frequency distribution of this ratio based on a site definition; it will be noted that most Estates exhibit combined Gross External Area of Floor space per employee ratios of between 20 and 50 sq m. Table 5.11 produces the same value but defined in terms of SIC. (These have been

grouped into a smaller number than the original 27 codes). It will be noted that Textiles and Instrument and Electrical Engineers have very low ratios, whereas Distributive trades have a ratio some two and a half times larger.

5.13 The variation within each group is also very large. Two things accounted for this, one being the skewness of the data and the other the inclusion of a few 'rogue' points in many of the data entries. These rogue points related to a small number of firms with very large floor space to employee ratios.

5.14 An alternative way of examining floor space per employee is in terms of the activity being undertaken at each unit (ie manufacture, warehousing, administration). The values of these ratios are given in Table 5.12. It should be noted that wholesale and warehousing have high floor area ratios and this accounts for the high ratio for distributive trades in the previous group.

5.15 Table 5.13 sets out the relationship for each firm between SIC and Activity. For most SIC groups, the main activity is manufacturing but for Distributive Trades the main activity is warehousing and wholesale. This Table, together with the information from the previous two Tables, suggest a more appropriate grouping of the data which is more likely to lead to consistent and valid analysis. The revised grouping relate to:

(a) The Manufacture, Processing and Servicing of:

(1)	Food, Drink, Tobacco	(SIC 1, 3)
(2)	Chemicals and Pharmaceuticals	(SIC 4, 5)
(3)	Metals, Manufacturing & Vehicles	(SIC 6, 7, 11)
(4)	Other Manufacturing	(SIC 12, 19)
(5)	Instruments & Electrical	(SIC 8, 9)
(6)	Textiles and Clothing	(SIC 13, 14, 15)
(7)	Bricks and Glass	(SIC 16)
(8)	Timber and Furniture	(SIC 17)
(9)	Paper and Printing	(SIC 18)
(10)	Construction	(SIC 20)

(b) (11) All activities associated with Transport (SIC 22).

(c) (12) All Warehousing and Wholesale from all SIC's plus Distributive Trades (SIC 23).

(d) (13) Professional and Administration (SIC 24, 25, 26 & 27), Management & Research from all SIC's plus Public Utilities (SIC 21).

(e) A further grouping of (4) Other Manufacturing with (7) Bricks and Glass, (8) Timber and Furniture, (9) Paper

and Printing and (10) Construction was found to be appropriate due to the small number of observations within each individual group.

5.16 Table 5.14 illustrates the basic parameters of floor space per employee and trips per employee for each of the four regions. With the exception of commercial vehicle trip generation from the Irish sites there would not seem to be any major difference between the regions. This difference with the Irish sites is reduced, but not totally explained, once the Public Utilities sites are excluded as most of these locations have high goods vehicle activities and are only to be found on Irish sites. Table 5.15 shows the same comparison but by the three locality descriptors (urban, suburban and rural). This highlights two points, a lowering of floor space per employee towards the urban sites and a lowering of work trip rates for the urban area. The lower floor space in urban sites either could be a real lowering of standards or could reflect a concentration of the denser industries (such as textiles and electrical engineering) within that area. To examine this Table 5.16 illustrates the distribution of type of firm by locality and it can be seen that there is not a concentration of the more dense firms in suburban and rural areas so the reduction of floor space per employee rates within urban areas is a real effect and consists of a difference of about 30% from the mean suburban condition.

Car Work Trip Generation Rates

5.17 Investigations were undertaken in order to seek out the best regression equation upon which car work trips could be estimated. It was expected that employment or floor space would give the best fit and these were tested in both a linear and power function mode, that is,

$$\text{Trips} = a + b\,(\text{Employment}) \qquad \text{(Linear function)}$$

$$\text{Trips} = a\,(\text{Employment})^{b} \qquad \text{(Power function)}$$

where a and b are co-efficients and Emp is a function of employment (or floor space).

Many of these relationships involve mathematical equations and, for simplicity of presentation, the following abbreviations have been used throughout this Report.

(TE) - Total Employment.

(ME) - Male Employment.

(MEE) - Male Equivalent Employment (which incorporates a female to male equivalence for estimating traffic generation.

(FE) - Female Employment.

(GEA) - Gross External Area of Floor Space, (measured in units of 100 square metres).

5.18 The results from linear regression using data from all firms on all Estates, were:

$$\text{CAR WORK TRIPS} = 3.07 + 0.46\ (\text{TE}) \qquad (R^2 = 0.80)$$

$$\text{CAR WORK TRIPS} = 5.19 + 0.67\ (\text{ME}) \qquad (R^2 = 0.66)$$

$$\text{CAR WORK TRIPS} = 2.47 + 0.54\ (\text{ME}) + 0.38\ (\text{FE}) \qquad (R^2 = 0.82)$$

$$\text{CAR WORK TRIPS} = 11.72 + 0.61\ (\text{GEA}) \qquad (R^2 = 0.43)$$

(Note: Floor space is measured in units of 100 sq meters throughout analyses).

5.19 It can be seen from the analysis that employment was a better predictor of trips than floor space and the inclusion of female employment marginally increased the accuracy of the prediction. (This being judged by the value of R^2 - the regression coefficient, where a value closer to unity is a better representation of the events).

The power form of the regression model gave the equation:

$$\text{CAR WORK TRIPS} = 1.21\ (\text{TE})^{0.78} \qquad (R^2 = 0.73)$$

The equation relating to a power function of both male and female employment separately was not reliable due to the large number of either missing or zero entries. On the basis of the above data the linear regression seemed to provide the better fit to the data.

5.20 There was some evidence that a power function could have some relevance to the larger Estates and individual firms. When the data was tested at an Estate level the comparison of the two model forms was:-

$$\text{CAR WORK TRIPS} = 31.10 + 0.48\ (\text{TE}) \qquad (R^2 = 0.91)$$

$$\text{CAR WORK TRIPS} = 1.025\ (\text{TE})^{0.90} \qquad (R^2 = 0.87)$$

(With a number of Estates not having data on the male/female split there was insufficient data upon which to undertake an analysis of these parameters). These results indicated that, on the larger Estates, there could be a slightly lower trip rate arising from the greater opportunity employees have for car sharing.

5.21 Initial results indicated that urban sites had a lower trip rate than other sites. Regression equations were calculated for the two subsets.

For Urban sites:

$$\text{CAR WORK TRIPS} = 0.71 + 0.66\ (\text{ME}) + 0.31\ (\text{FE}) \qquad (R^2 = 0.92)$$

$$\text{CAR WORK TRIPS} = 3.90 + 0.35\ (\text{TE}) \qquad (R^2 = 0.79)$$

For Other sites:

$$\text{CAR WORK TRIPS} = 2.62 + 0.52\ (\text{ME}) + 0.43\ (\text{FE}) \qquad (R^2 = 0.80)$$

$$\text{CAR WORK TRIPS} = 3.99 + 0.45\ (\text{TE}) \qquad (R^2 = 0.86)$$

These results showed a slight improvement from the previous sets.

5.22 Table 5.17 sets out the results of the regression analyses by the separate 13 groups of activities by two forms of equations based on a male/female division of the work force and a total work force (regression equation were not run for the Public Utilities Group as there was insufficient data). The male/female split provided a better estimate on 11 out of the 13 cases and it can therefore be seen that the daily number of commuting trips is best projected by means of estimations based on the number of male and female employees totalled separately. A scatter plot of trips against total employment is given in Figure 5.3. Estimations for separate firms could be obtained from the equations in Table 5.17 but care must be taken with these equations as many of them do not exhibit a sufficiently high R2 value to be used with any confidence.

5.23 To estimate traffic at an Estate level it is suggested that global values are used. Table 5.18 sets out the mean observed trip rate by each Type of Industrial Activity. There is a wide spread about the mean of 0.53 trips per employee. This is largely accounted for by the changing ratio of male to female employees for each of the separate activity types. From the regression coefficients given above the Male Employment variable has a much higher coefficient than the corresponding Female Employment. Taking all sites together the Female coefficient is 70% of the Male. Therefore, if it is assumed that each female worker is equivalent to 0.7 of a male worker (only in terms of traffic generation!) then the revised trip rate against this "male equivalent" level of employment is found to be remarkably stable at 0.64 trips per "male equivalent" employee for most Types of Industrial Activity. Exceptions are the electrical and textile industries with a lower rate (by 10% and 30% respectively) and the transport and distributive trades with a higher rate (by some 10% and 30% respectively).

5.24 Traffic generation from urban sites (Table 5.15) was found to be 20% lower.

Goods Vehicle Trip Generation Rates

5.25 After commuting car trips the next most predominent group of trips are those of goods vehicles. These comprised some 25% of all daily trip generations in the survey.

5.26 Regressions were carried out on the full data set with the following results:

GOODS	= 4.83 + 0.12 (ME) + 0.05 (FE)	(R^2 = 0.25)
GOODS	= 7.09 + 0.07 (TE)	(R^2 = 0.20)
GOODS	= 7.80 + 0.12 (GEA)	(R^2 = 0.12)
GOODS	= 7.15 + 0.07 (TE) + 0.001 (GEA)	(R^2 = 0.20)

(Note: Floor space is measured in units of 100 sq m throughout the analyses).

These relationships are so poor that they cannot reasonably be used in any predictive way. A scatter plot of goods trips against total employment is given in Figure 5.4.

5.27 Table 5.19 sets out average goods vehicle trip rates for each of the industry type. The very wide range of values should be noted with transport and distributive trades having high rates and textiles and electrical groups having low rates. A detailed set of regression equations are presented in Table 5.20 for each of the separate Types of Industrial Activity. The R2 values are higher for the individual groups than for the total but this is as much a function of the lower number of observations within each group as it is to do with a better set of prediction variables.

5.28 The surveyed results giving such a low degree of predictability of goods vehicle trips is not unexpected and is consistent with the findings of other studies. It is suggested, therefore, that values similar to those given in Table 5.19 should be used, but they can only give a broad indication of traffic levels.

5.29 Table 5.14 showed a high goods vehicle trip rate for the Irish sites. An examination of the data entries showed that these high rates were attributable to three Northern Ireland firms, (a dairy, an Electricity Board depot and a British Telecom depot) all on suburban sites and all having very large movements of commercial vehicles. The exclusion of certain sites now grouped as 'Public Utilities' (see

paragraph 5.9) reduced the difference but still left an unexplainable higher value for the Northern Ireland sites.

Car Business and Other Trip Generation Rates

5.30 Car business and other trips made up some 12% and 9% respectively of the total surveyed traffic generation and, therefore, are of less significance than the other trip type groups. A series of regression analyses on the full data sets were undertaken and the results were:

For Car Business Trips:

TRIPS	= 3.27 + 0.04 (TE)	(R^2 = 0.28)
TRIPS	= 3.75 + 0.07 (GEA)	(R^2 = 0.16)
TRIPS	= 3.28 + 0.04 (TE) − 0.01 (GEA)	(R^2 = 0.28)

For Car Other Trips:

TRIPS	= 3.12 + 0.14 (TE)	(R^2 = 0.02)
TRIPS	= 3.19 + 0.03 (GEA)	(R^2 = 0.02)
TRIPS	= 3.08 + 0.01 (TE) + 0.01 (GEA)	(R^2 = 0.02)

(Note: Floor space is measured in units of 100 sq m throughout analyses).

5.31 The above results gave no accurate predictor. Regressions were also run against car work trips and goods vehicle trips (these being the independent variables this time).

The results were:

BUSINESS = 2.77 + 0.10 (CARS WORK)	(R^2 = 0.38)
BUSINESS = 2.41 + 0.25 (GOODS)	(R^2 = 0.27)
OTHER = 2.85 + 0.04 (CARS WORK)	(R^2 = 0.03)
OTHER = 1.51 + 0.21 (GOODS)	(R^2 = 0.11)

5.32 These equations are only slightly more accurate than the preceding ones. It is suggested that a simple factor should be added to the number of car work trips to make allowances for the addition of business and other trips. Average factors of 23% for business trip and 17% for other trips would be appropriate. (These being the ratios of business and other trips to car work trips - see paragraph 5.11). Scatter plot diagrams of business and other trips against car work trips is given in Figures 5.5 and 5.6.

Effect of Firm Size

5.33 An analysis has been undertaken of activity within different sized units. This is illustrated in Table 5.21 and in Figure 5.7. Over the range of units between 150 sq m and 1,000 sq m (accounting for 50% of the units surveyed) there is very little variation on any of the major parameters. Smaller firms - up to 150 sq m (some 16% of firms surveyed) - seem to have a slightly higher trip rate for car work trips. For larger firms - over 1,000 sq m (some 33% of the firms surveyed) - the trip rates for both car work and goods vehicle decline.

TABLE 5.1 BASIC PARAMETERS

	Scotland	Wales	England	Northern Ireland	Total
Number of Estates	14	13	21	10	58
Number of Firms	177	256	328	211	972
Total Employment	7553	13298	9483	6282	36616
Total Gross External Area of Floorspace (1000 sq m)	323	493	378	269	1463

TABLE 5.2 ESTATES BY EMPLOYMENT

Number of Employees	Number of Estates
0 - 250	18
250 - 500	16
500 - 750	9
750 - 1000	4
1000 - 1250	5
1250 - 1500	2
1500 - 1750	1
1750 - 2000	0
2000 - 2250	0
2250 - 2500	1
2500 - 2750	0
2750 - 3000	0
3000 - 3250	1
3250 - 3500	0
3500 - 3750	0
3750 - 4000	0
4000 - 4250	0
4250 - 4500	0
4500 - 4750	0
4750 - 5000	1
TOTAL	58

TABLE 5.3 ESTATES BY GEA OF FLOORSPACE

Gross External Area of Floorspace (1000 sq m)	Number of Estates
0 - 10	19
10 - 20	13
20 - 30	8
30 - 40	8
40 - 50	3
50 - 60	3
60 - 70	1
70 - 80	1
80 - 90	0
90 -100	0
100 -110	1
110 -120	0
120 -130	0
130 -140	0
140 -150	1
TOTAL	58

TABLE 5.4 ESTATES BY LOCALITY

	Scotland	Wales	England	Northern Ireland	Total
1) Urban	4	1	4	4	13
2) Adjacent to Urban	8	7	9	4	28
3) Rural	2	5	8	2	17
TOTAL	14	13	21	10	58

TABLE 5.5 FIRMS BY NUMBER OF EMPLOYEES

Number of Employees	Number of Firms	Cumulative %
0 - 10	420	44.26
10 - 20	208	66.17
20 - 30	90	75.66
30 - 40	49	80.82
40 - 50	40	85.04
50 - 60	27	87.88
60 - 70	17	89.67
70 - 80	15	91.25
80 - 90	6	91.89
90 -100	10	92.94
100 +	90	100.00
TOTAL	972	100.00

TABLE 5.6 FIRMS BY GEA OF FLOORSPACE

Gross External Area of Floorspace (sq.m)	Number of Firms	Cumulative %
0 - 100	127	13.86
100 - 200	96	24.34
200 - 300	144	40.07
300 - 400	40	44.43
400 - 500	79	53.06
500 - 600	53	58.84
600 - 700	25	61.57
700 - 800	26	64.41
800 - 900	20	66.59
900 -1000	58	72.93
1000 -1100	14	74.45
1100 -1200	14	75.98
1200 -1300	12	77.29
1300 -1400	20	79.48
1400 -1500	25	82.21
1500 -1600	7	82.97
1600 -1700	7	83.73
1700 -1800	8	84.61
1800 -1900	17	86.46
1900 -2000	8	87.34
2000 +	172	100.00
TOTAL	972	100.00

TABLE 5.7 FIRMS BY STANDARD INDUSTRIAL CLASSIFICATION (SIC)

SIC Reference	Descriptor	Number of Firms
1	Agriculture	3
2	Mining	0
3	Food, Drink,Tobacco	62
4	Coal and Petroleum	1
5	Chemicals	35
6	Metal Manufacture	21
7	Mechanical Engineering	189
8	Instrument Engineering	30
9	Elèctrical Engineering	84
10	Shipbuilding	0
11	Vehicles	30
12	Other Metal goods	30
13	Textiles	19
14	Leather and Fur	8
15	Clothing	30
16	Bricks and Glass	24
17	Timber and Furniture	45
18	Paper and Printing	50
19	Other Manufacturing	74
20	Construction	40
21	Gas, Electricity, Water(see note)	7
22	Transport	38
23	Distributive Trades	81
24	Insurance, Banking, Business	4
25	Professional services	10
26	Miscellaneous	42
27	Local Government	13
	Unknown	2
	TOTAL	972

Note:Contrary to normal SIC grouping this included a number of other public utilities which had similar characteristics including Electricity Boards,British Telecom and Northern Ireland Housing Executive.

TABLE 5.8 FIRMS BY ACTIVITY

	Activity	Number of Firms
1	Manufacturing	656
2	Warehousing	41
3	Wholesale	81
4	Retail	15
5	Servicing (inc repairs)	84
6	Research	7
7	Admin and Management	18
8	Others	70
	TOTAL	972

TABLE 5.9 NUMBER OF TRIPS PER ESTATE

Number of Trips (0700-1900 hours inclusive)	Number of Estates
0 - 250	19
250 - 500	15
500 - 750	9
750 -1000	6
1000 -1250	2
1250 -1500	2
1500 -1750	0
1750 -2000	2
2000 +	3
TOTAL	58

TABLE 5.10 GEA OF FLOORSPACE PER EMPLOYEE BY ESTATE

GEA of Floorspace/Employee (sq.m.)	Number of Estates
0 - 10	0
10 - 20	3
20 - 30	10
30 - 40	16
40 - 50	10
50 - 60	7
60 - 70	2
70 - 80	4
80 - 90	4
90 -100	0
100 -110	2
TOTAL	58

TABLE 5.11 GEA OF FLOORSPACE PER EMPLOYEE BY SIC

SIC grouping	GEA of Floorspace/Employee (sq.m. per Employee)	Number of Firms
1) Food & Drink	43.33	65
2) Chemical & Pharmaceutical	43.54	36
3) Metals & Manufacturing	55.31	240
4) Other Manufacturing	47.73	106
5) Instruments/Electrical	27.47	114
6) Textiles & Clothing	26.33	57
7) Bricks & Glass	59.43	24
8) Timber & Furniture	29.86	45
9) Paper & Printing	50.98	50
10) Construction	31.28	40
11) Transport	53.57	38
12) Distributive Trades	64.36	81
13) Professional & Admin	34.76	69
14) Public Utilities	*	7
Note: Further grouping Other Manufacturing (Groups 4,7,8,9,10)	(43.38)	(263)
TOTAL	39.45	972

TABLE 5.12 FLOOR SPACE PER EMPLOYEE BY ACTIVITY

	Activity	GEA of Floorspace/Employee (sq.m./Employee)
1	Manufacturing	39.29
2	Warehouse	78.68
3	Wholesale	71.43
4	Retail	50.35
5	Service	29.63
6	Research	*
7	Administrative	28.89
8	Other	32.70
	TOTAL	39.49

TABLE 5.13 FIRMS BY SIC GROUPING AND ACTIVITY

SIC Grouping	Activity (see note) 1	2	3	4	5	6	7	8	TOTAL
1) Food and Drink	48	4	8	1	1	0	1	2	65
2) Chemicals	33	0	3	0	0	0	0	0	36
3) Manufacturing	213	1	1	0	17	2	1	5	240
4) Other Manufacturing	100	2	1	1	2	0	0	0	106
5) Ind/Elec	95	1	0	0	13	1	2	2	114
6) Textiles	51	2	1	0	1	0	1	1	57
7) Bricks	21	2	0	0	1	0	0	0	24
8) Timber	43	0	0	0	1	0	0	1	45
9) Paper	39	0	2	0	1	0	0	8	50
10) Construction	4	0	0	0	19	0	2	15	40
11) Transport	2	19	1	1	4	0	3	8	38
12) Distribution	0	7	63	6	3	0	0	2	81
13) Proffessional	7	2	1	6	19	4	7	23	69
14) Public Utilities	0	1	0	0	2	0	1	3	7
TOTAL	656	41	81	15	84	7	18	70	972

Note: 1 : Manufacturing
2 : Warehousing
3 : Wholesale
4 : Retail
5 : Services
6 : Research
7 : Administration
8 : Other

TABLE 5.14 DATA BY REGION

	Scotland	Wales	England	Northern Ireland
Number of Estates	14	13	21	10
GEA of Floorspace/ Employee(sq.m)	42	37	40	43
Car Work trips/Employee	.55	.54	.56	.57
Goods trips/Employee	.19(.19)	.19(.18)	.23(.21)	.51(.49)
% Male	NA	54	63	NA

Note: Figures in brackets show values excluding Public Utilities

TABLE 5.15 DATA BY LOCATION TYPE

	(Urban)	(Suburban)	(Rural)
Number of Estates	13	28	17
Number of firms	205	524	243
GEA of Floorspace/ Employee(sq.m)	29	38	52
Car Work trips/Employee	.47	.54	.56
Goods trips/Employee	.29(.28)	.26(.25)	.21(.19)

Note: Figures in brackets show values excluding Public Utilities.

TABLE 5.16 NUMBER OF FIRMS BY SIC AND LOCATION

SIC Grouping	Location 1 (Urban)	Location 2 (Suburban)	Location 3 (Rural)
1) Food Drink Tobacco (1&3)	21 (10.2)	31 (5.9)	13 (5.3)
2) Chemicals (4&5)	4 (1.9)	23 (4.4)	9 (3.7)
3) Metal Man and Veh (6,7&11)	43 (21.0)	118 (22.6)	79 (32.5)
4) Other Manufacture (12&19)	27 (13.2)	46 (8.8)	33 (13.6)
5) Instr and Elec Eng (8&9)	19 (9.3)	64 (12.2)	31 (12.7)
6) Tex and Clothing (13,14&15)	16 (7.8)	31 (5.9)	10 (4.1)
7) Brick and Glass (16)	9 (4.4)	9 (1.7)	6 (2.5)
8) Timber and Furniture (17)	12 (5.9)	18 (3.4)	15 (6.2)
9) Paper and Printing (18)	12 (5.9)	27 (5.1)	11 (4.5)
10) Construction (20)	8 (3.9)	29 (5.5)	3 (1.2)
11) Transport (22)	10 (4.9)	20 (3.8)	12 (4.9)
12) Distriburive Trades (23)	10 (4.9)	61 (11.7)	10 (4.1)
13) Prof and Admin (24,25,26&27)	14 (6.8)	47 (9.6)	11 (4.8)
Note: Further grouping Other Manufacturing (Groups 4,7,8,9,10)	[68 (33.2)]	[129 (24.6)]	[68 (28.0)]
TOTAL	205 (100)	524 (100)	243 (100)

Note: Percentages given in brackets

TABLE 5.17 REGRESSIONS FOR CAR WORK TRIPS BY TYPE OF INDUSTRIAL ACTIVITY

Type of Industrial Activity	By Male/Female		By Total Employment	
	male · female	R^2	emp	R^2
1) Food,Drink & Tobacco	-2.63 + 1.12 + 0.55	0.94	1.89 + 0.51	0.87
2) Chemicals & Pharmaceuticals	-0.53 + 1.33 - 0.03	0.94	1.55 + 0.51	0.75
3) Metals,Mechanical & Vehicle Engineering	4.70 + 0.41 + 0.74	0.81	4.15 + 0.45	0.80
4) Other manufacturing	1.80 + 0.57 + 0.35	0.86	2.61 + 0.46	0.79
5) Instrument & Electrical Engineering	-5.67 + 0.81 + 0.38	0.90	2.27 + 0.45	0.92
6) Textiles & Clothing	0.17 + 0.49 + 0.29	0.88	6.07 + 0.30	0.75
7) Bricks & Glass	1.91 + 1.01 + 0.15	0.95	1.09 + 0.48	0.91
8) Timber & Furniture	0.81 + 0.46 + 0.81	0.96	-0.16 + 0.59	0.94
9) Paper & Printing	1.90 + 0.53 + 0.28	0.98	0.66 + 0.47	0.97
10) Construction	3.20 - 0.10 + 6.21	0.59	3.53 + 0.48	0.60
11) Transport	0.06 + 0.78 - 1.16	0.77	0.34 + 0.72	0.70
12) Distributive trades	0.77 + 0.81 + 0.79	0.80	1.20 + 0.72	0.75
13) Professional & Admin	-1.57 + 0.87 + 0.15	0.75	3.44 + 0.54	0.66
Note: Further grouping Other Manufacturing (Groups 4,7,8,9,10)			1.95 + 0.49	0.88

TABLE 5.18 CAR WORK TRIP RATE BY TYPE OF INDUSTRIAL ACTIVITY

Type of Industrial Activity	Trip Rate Cars/Employee	% Male	Trip Rate Cars/Male Equivalent Employee
1) Food,Drink & Tobacco	0.57	61	0.64
2) Chemicals & Pharmaceuticals	0.54	48	0.66
3) Metal,Mechanical & Vehicle Engineering	0.57	82	0.60
4) Other Manufacturing	0.57	62	0.64
5) Instrument & Electrical	0.48	51	0.56
6) Textile & Clothing	0.35	26	0.45
7) Bricks & Glass	0.56	56	0.64
8) Timber & Furniture	0.59	68	0.65
9) Paper & Printing	0.49	70	0.54
10) Construction	0.61	92	0.63
11) Transport	0.73	97	0.74
12) Distributive trades	0.81	70	0.89
13) Professional & Admin	0.61	75	0.66
Note: Further grouping Other Manufacturing (Groups 4,7,8,9,10)	(0.56)	(69)	(0.62)
TOTAL	0.53	61	

TABLE 5.19 GOODS VEHICLE TRIP RATE BY TYPE OF INDUSTRIAL ACTIVITY

Type of Industrial Activity	Trip Rate/ Employee	Trip Rate/100sq.m GEA of Floorspace
1) Food,Drink & Tobacco	0.50	1.50
2) Chemicals & Pharmaceuticals	0.14	0.35
3) Metals,Mechanical & Vehicle Engineering	0.23	0.47
4) Other Manufacturing	0.25	0.57
5) Instrument & Electrical	0.11	0.38
6) Textile & Clothing	0.11	0.43
7) Bricks & Glass	0.33	0.69
8) Timber & Furniture	0.27	0.92
9) Paper & Printing	0.21	0.42
10) Construction	0.51	1.80
11) Transport	0.66	1.23
12) Distributive trades	0.91	1.52
13) Professional & Admin	0.27	0.78
Note: Further grouping Other Manufacturing (Groups 4,7,8,9,10)	(0.30)	(0.69)

TABLE 5.20 REGRESSIONS FOR GOODS VEHICLE TRIPS

Type of Industrial Activity	Employment		GEA of Floorspace(100 sq.m)		Both	
	emp	R^2	floor	R^2	emp floor	R^2
1) Food,Drink & Tobacco	4.78 + 0.35	0.78	5.89 + 0.80	0.59	4.22 + 0.28 + 0.19	0.79
2) Chemicals & Pharmaceuticals	2.10 + 0.10	0.74	2.40 + 0.16	0.72	2.13 + 0.08 + 0.19	0.74
3) Metals,Mechanical & Vehicle Engineering	5.52 + 0.06	0.31	6.55 + 0.54	0.20	5.21 + 0.09 - 0.04	0.32
4) Other manufacturing	2.79 + 0.14	0.45	3.80 + 0.17	0.27	2.76 + 0.21 - 0.15	0.49
5) Instrument & Electrical Engineering	4.72 + 0.04	0.52	4.70 + 0.15	0.52	4.69 + 0.02 + 0.01	0.53
6) Textiles & Clothing	4.67 + 0.06	0.51	5.05 + 0.21	0.48	3.81 + 0.04 + 0.11	0.57
7) Bricks & Glass	0.64 + 0.28	0.80	0.55 + 0.52	0.59	1.21 + 0.42 - 0.32	0.83
8) Timber & Furniture	1.37 + 0.22	0.82	1.23 + 0.65	0.53	1.27 + 0.21 + 0.03	0.81
9) Paper & Printing	3.17 + 0.12	0.79	2.66 + 0.24	0.81	2.69 + 0.04 + 0.16	0.83
10) Construction	2.35 + 0.41	0.64	6.45 + 0.79	0.51	2.60 + 0.32 + 0.26	0.67
11) Transport	5.10 + 0.45	0.61	10.47 + 4.20	0.12	4.86 + 0.44 + 0.30	0.61
12) Distributive trades	4.78 + 0.55	0.31	6.11 + 0.65	0.25	4.54 + 0.45 + 0.18	0.32
13) Professional & Admin	8.04 + 0.05	0.09	6.87 + 0.24	0.21	6.98 - 0.01 + 0.27	0.21
Note: Further grouping Other Manufacturing (Groups 4,7,8,9,10)	3.38 + 0.17	0.50	4.13 + 0.27	0.34	3.46 + 0.18 - .04	0.51

TABLE 5.21 ACTIVITY BY SIZE OF UNIT

Unit size sq m	Sq m/ Employee	Work Trip/ Employee	Goods Trip/ Employee
under 150	19	0.71	0.52
150 - 250	25	0.61	0.52
250 - 350	28	0.68	0.48
350 - 500	29	0.67	0.60
500 - 1000	34	0.64	0.45
1000 - 2000	41	0.58	0.30
2000 +	42	0.49	0.17

TOTAL EMPLOYMENT		NUMBER OF FIRMS	0 100 200
.00 <	5.00	206	|==========
5.00 <	10.00	214	|==========
10.00 <	15.00	124	|==========
15.00 <	20.00	84	|==========
20.00 <	25.00	40	|=====
25.00 <	30.00	50	|======
30.00 <	35.00	19	|==
35.00 <	40.00	30	|====
40.00 <	45.00	22	|==
45.00 <	50.00	18	|==
50.00 <	55.00	15	|==
55.00 <	60.00	12	|=
60.00 <	65.00	5	|
65.00 <	70.00	12	|=
70.00 <	75.00	7	|
75.00 <	80.00	8	|=
80.00 <	85.00	5	|
85.00 <	90.00	1	|
90.00 <	95.00	5	|
95.00 <	100.00	5	|

Note: 90 firms with 100 or more employees

HISTOGRAM

TOTAL EMPLOYMENT : NUMBER OF FIRMS

Figure 5.1

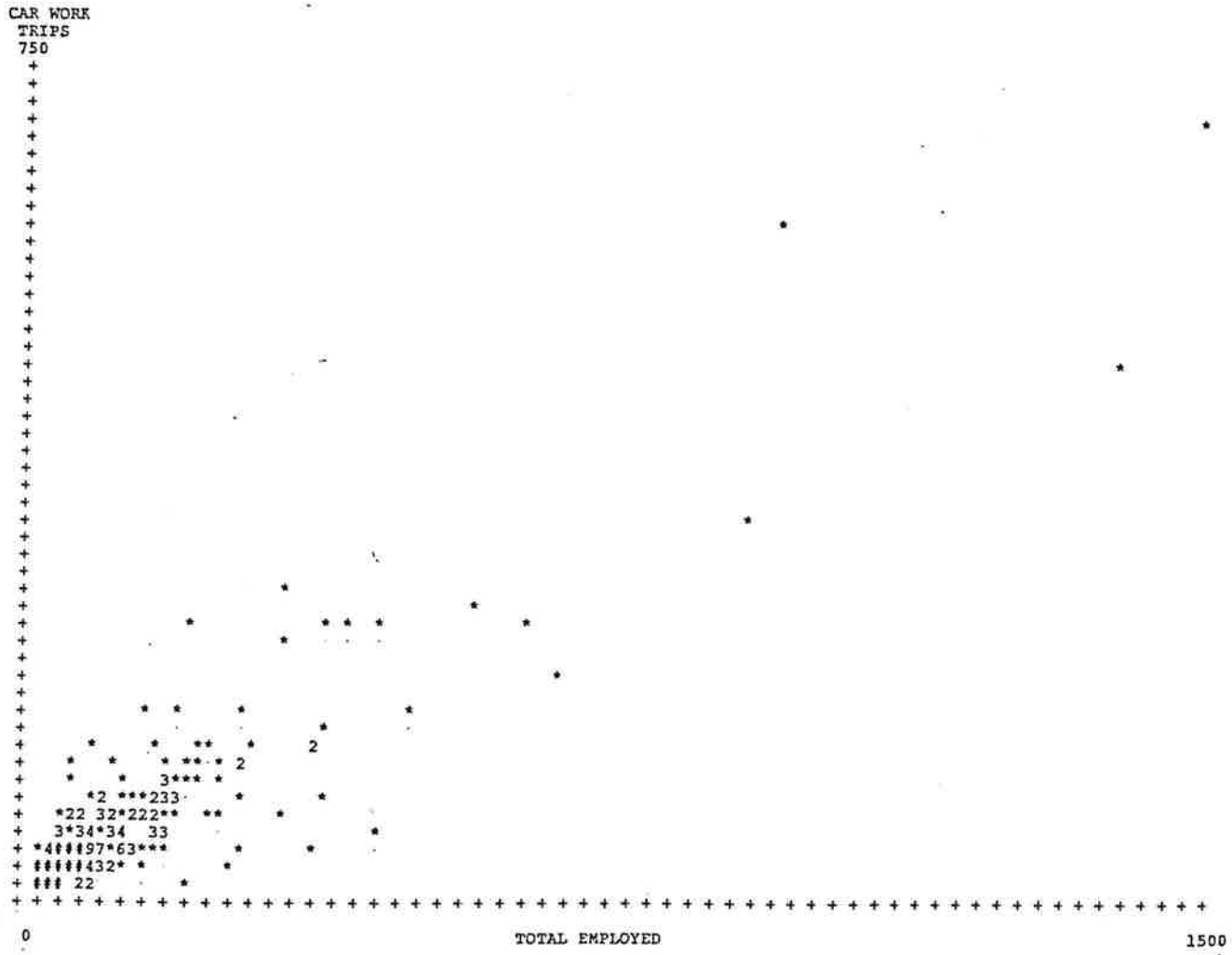
GEA of FLOOR SPACE(sq.m)		NUMBER OF FIRMS	0 100
.00 <	100.00	127	|==========
100.00 <	200.00	96	|==========
200.00 <	300.00	144	|==========
300.00 <	400.00	40	|========
400.00 <	500.00	79	|==========
500.00 <	600.00	53	|==========
600.00 <	700.00	25	|=====
700.00 <	800.00	26	|=====
800.00 <	900.00	20	|====
900.00 <	1000.00	58	|==========
1000.00 <	1100.00	14	|==
1100.00 <	1200.00	14	|==
1200.00 <	1300.00	12	|==
1300.00 <	1400.00	20	|====
1400.00 <	1500.00	25	|=====
1500.00 <	1600.00	7	|=
1600.00 <	1700.00	7	|=
1700.00 <	1800.00	8	|=
1800.00 <	1900.00	17	|===
1900.00 <	2000.00	8	|=
2000.00 <	2100.00	6	|=
2100.00 <	2200.00	2	|
2200.00 <	2300.00	6	|=
2300.00 <	2400.00	16	|===
2400.00 <	2500.00	15	|===
2500.00 <	2600.00	2	|
2600.00 <	2700.00	3	|
2700.00 <	2800.00	6	|=
2800.00 <	2900.00	3	|
2900.00 <	3000.00	6	|=

Note: 107 firms with a floor space of 3000 sq.m. or greater

HISTOGRAM

FLOORSPACE : NUMBER OF FIRMS

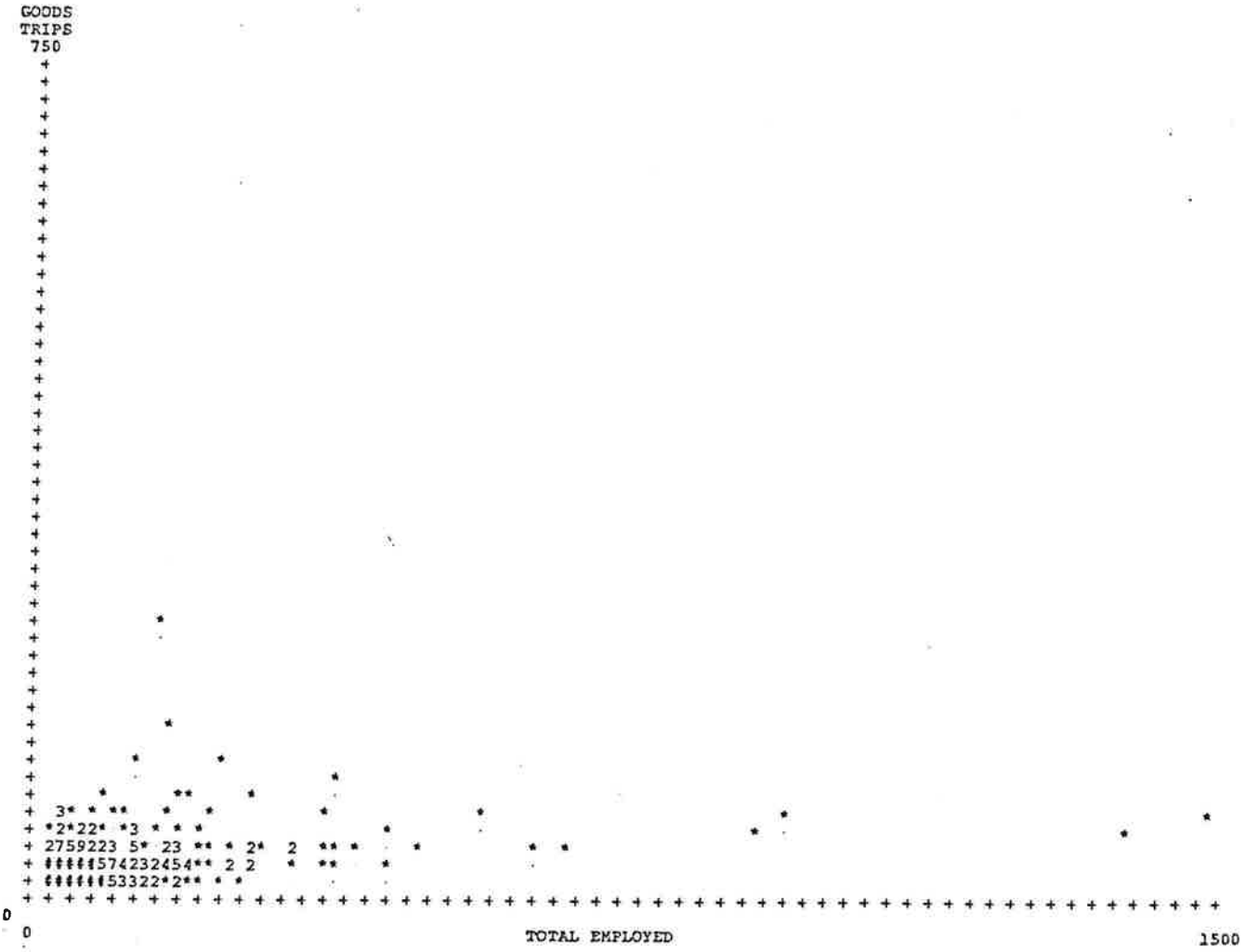
Figure 5.2



SCATTER PLOTS

CAR WORK TRIPS : EMPLOYMENT

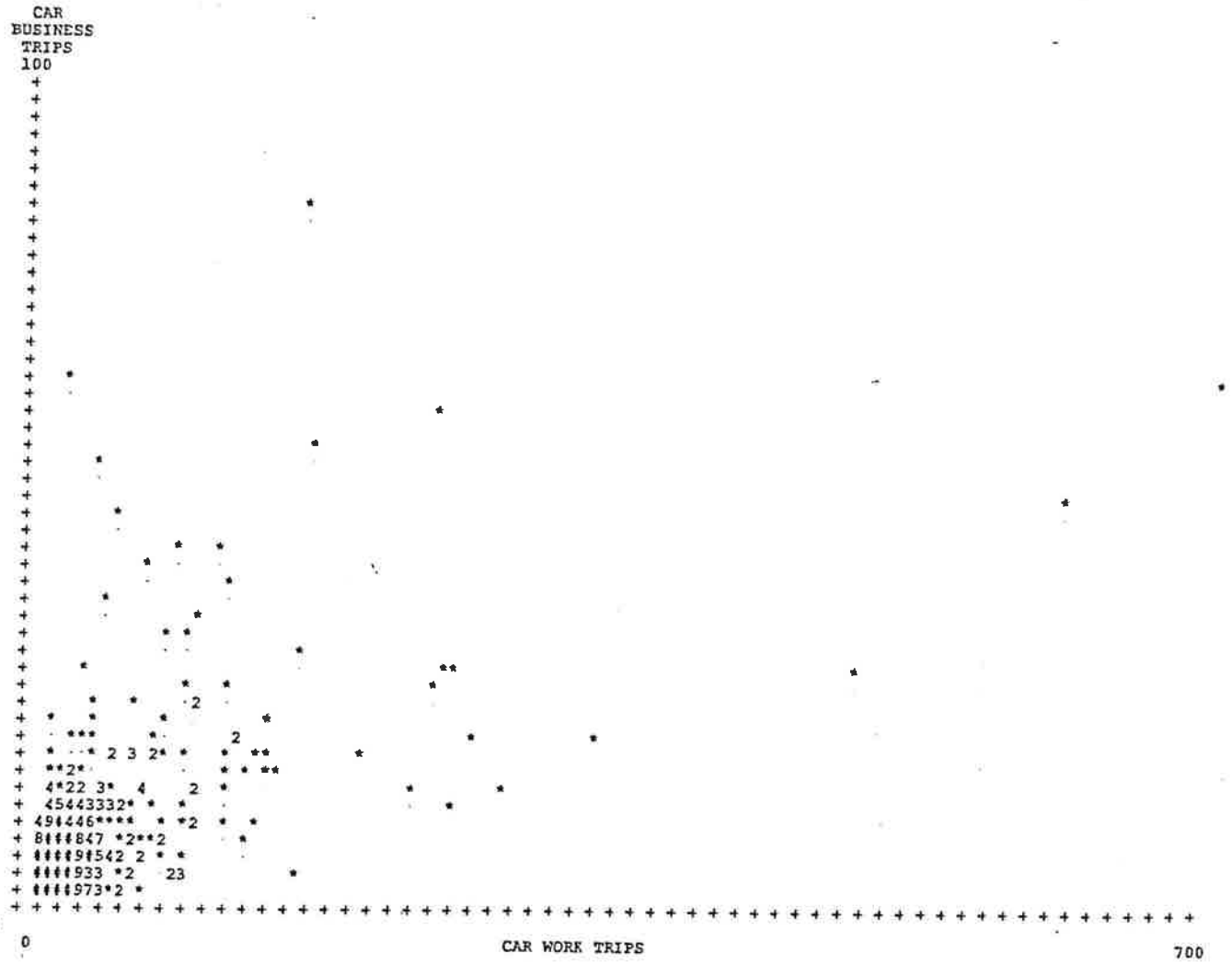
Figure 5.3



SCATTER PLOTS

GOODS TRIP : EMPLOYMENT

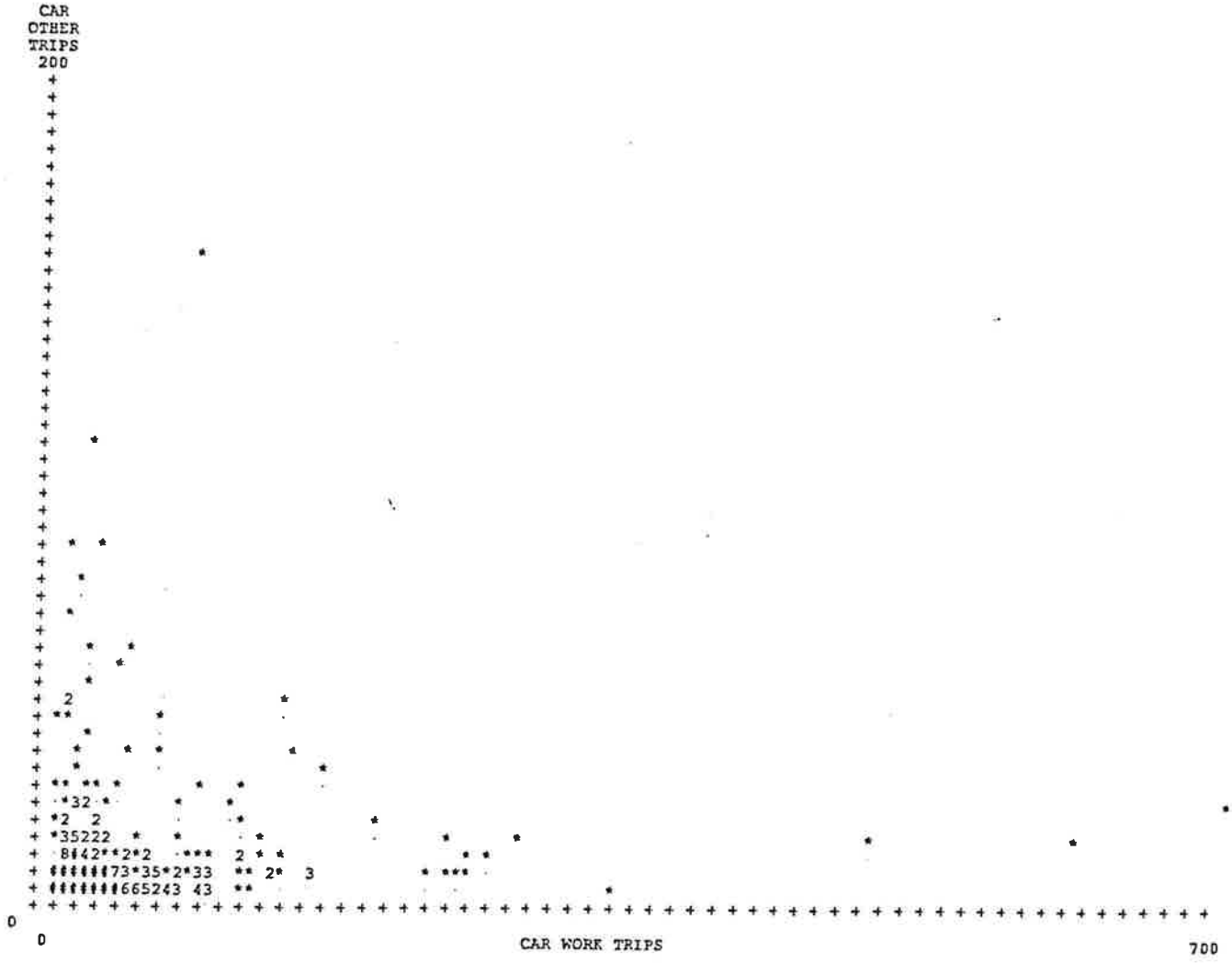
Figure 5.4



SCATTER PLOTS

CARS BUSINESS : CARS WORK

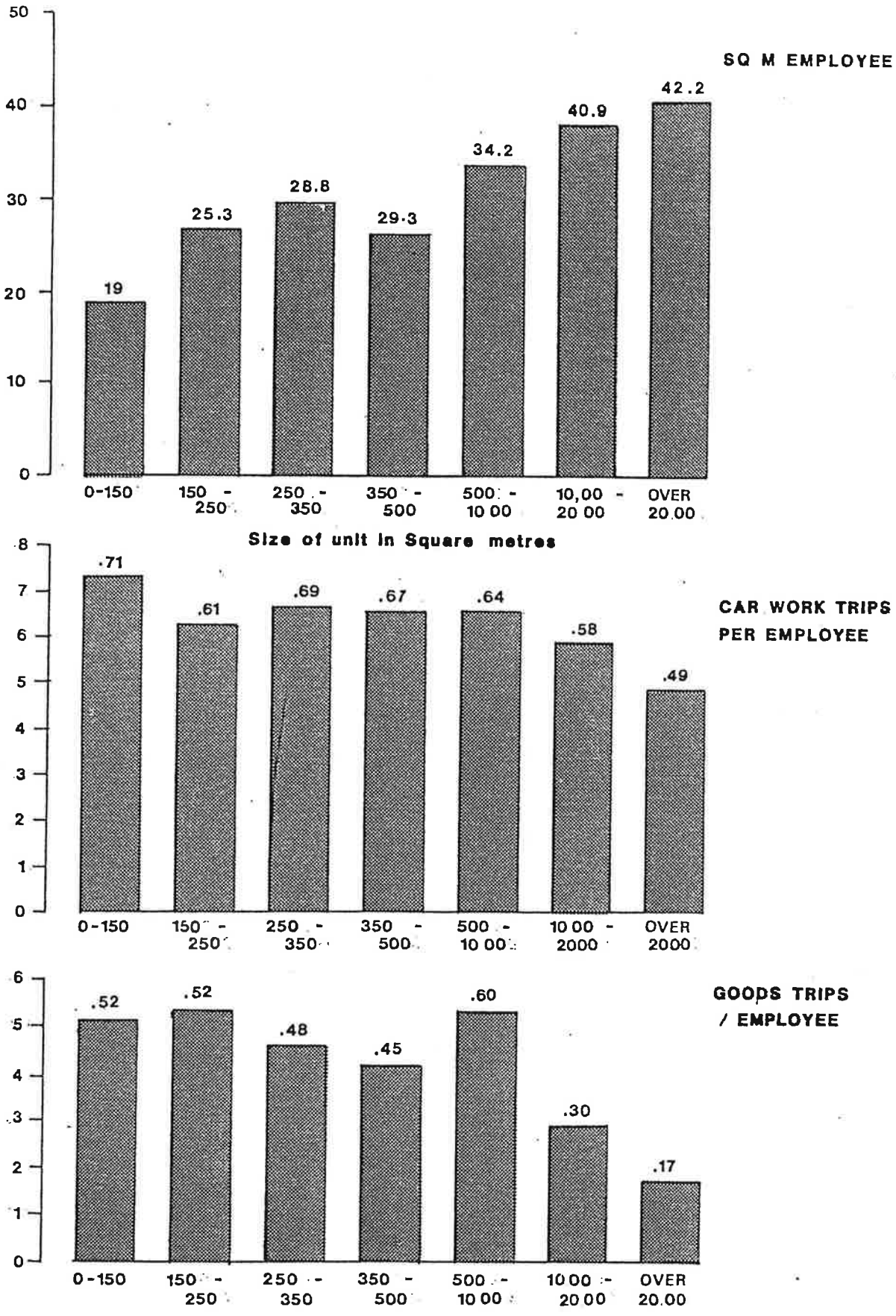
Figure 5.5



SCATTER PLOTS

CARS OTHER : CARS WORK

Figure 5.6



EFFECT OF SIZE OF UNIT

Figure 5.7

SECTION SIX HOURLY TRAFFIC FLOWS

6.1 An important part of the traffic prediction for design purposes is the estimation of the peak hour flow and the average off-peak hour flows. The preceding Section has laid out an analysis procedure for the estimation of daily levels of traffic. This Section considers the sub-division of that data into different periods of the day.

6.2 During the data collection process the interview data was subdivided by half hour time period but was then amalgamated to all day totals. However, a separate traffic count was undertaken of both inbound and outbound traffic flows. These counts often included trips which were not destined for one of the firms surveyed so, while being representative of the traffic patterns, the flow levels by survey station were not directly comparable with the data held on the trip analysis file. Data was collected for both inbound and outbound movements but only the outbound movements included the full breakdown by purpose (the inbound records categorised cars and goods vehicles only). The results of traffic flow by type and time of day are illustrated in Figures 6.1-6.5 for outbound trips and Figures 6.6-6.8 for inbound traffic flows.

Outbound Trips

6.3 Figure 6.1 shows a clear peak hour occurring between 1630-1730 hours. The flows in these two half hours were about 10% of the daily traffic, so the peak hourly flow was about 20% of the daily flow. Of these trips 82% were car (work trips), 4% were cars (business trips), 5% were cars (other trips) and 9% were goods vehicles. It will be noted that goods vehicles contribute only a small portion of the peak hour flows. This is fortunate as it can therefore be noted that a poor estimate of daily goods vehicles flow levels will have only a marginal effect on total peak hour traffic flow. A typical off-peak period (say, 0900-1200 hours and 1330-1530 hours) would have an hourly flow of some 7% of the daily total.

6.4 Considering the hourly flow profiles by purpose nearly a third of all work trips occurred in the evening peak hour with an off-peak rate of about 4%. Goods vehicle traffic had no really strong peak flow with an hourly generation rate over the period 0800-1600 hours of around 5%. The pattern of business trips and other trips was not so distinct.

6.5 The peak hour factors (expressed as a percentage of the daily traffic flow in the corresponding direction) for each Estate are set out in Table 6.1.

Assuming the Peak Hour to be 1630-1730 hours, the following traffic relationships have been derived:

(i) Peak Hour Traffic is:

20.4% of Total Daily Traffic

(ii) and is made up of:

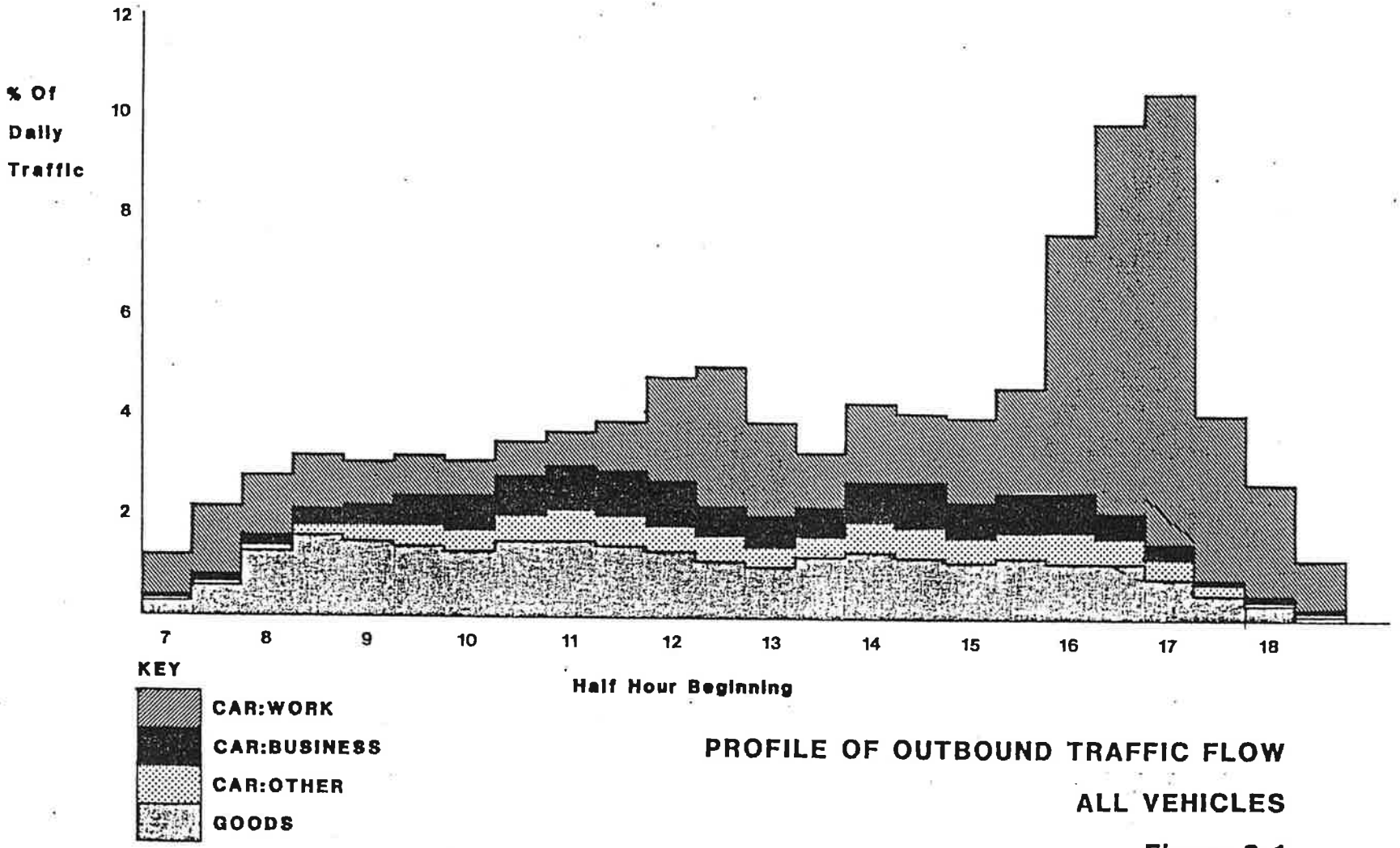
31.7% of Daily Car Work Trips
6.3% of Daily Car Business Trips
9.5% of Daily Car Other Trips
7.4% of Daily Goods Trips

(iii) Peak Hour Composition of Traffic is:

82.3% Car Work Trips
3.7% Car Business Trips
4.6% Car Other Trips
9.4% Goods Vehicles

TABLE 6.1 PEAK HOUR TRAFFIC GENERATION RATES

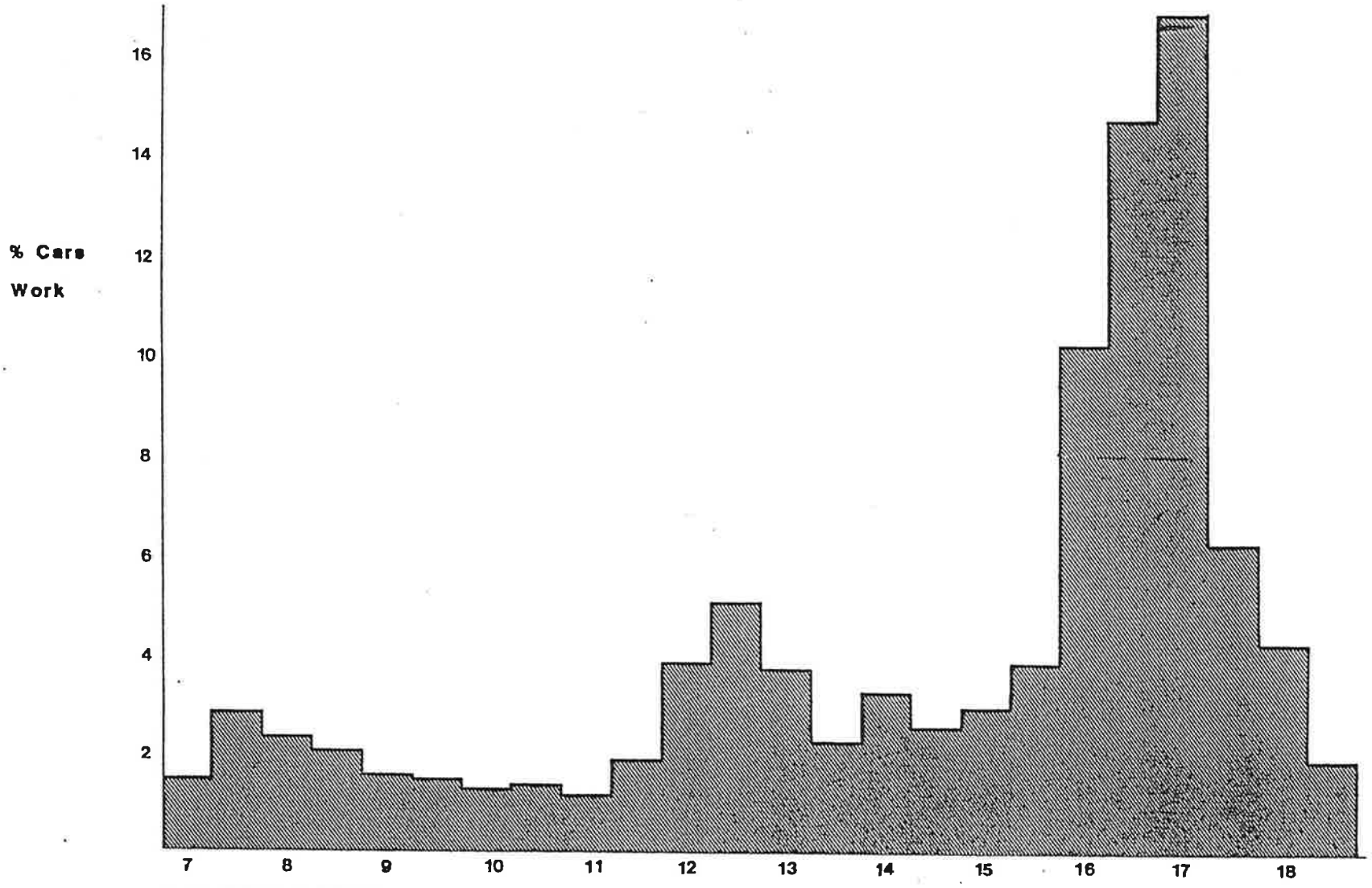
Estate reference	Site	Outbound Evening Peak Hour	%	Inbound Morning Peak Hour	%
101	ANNICK ST	16.30-17.30	13.2	7.30-8.30	17.8
102	BEITH	16.00-17.00	22.1	7.30-8.30	27.1
103	BLANTYRE	16.00-17.00	31.4	7.30-8.30	31.6
104	CLYDEBANK	16.00-17.00	18.0	7.30-8.30	15.6
105	COATBRIDGE	16.00-17.00	27.4	7.30-8.30	23.8
106	CUMNOCK	16.00-17.00	17.5	7.00-8.00	22.4
107	ETNA	16.30-17.30	16.3	7.30-8.30	16.3
108	LARKHALL	16.00-17.00	18.2	8.00-9.00	16.6
109	NEWHOUSE	16.30-17.30	43.6	7.00-8.00	29.7
110	PEFFERMILL	16.30-17.30	10.8	8.00-9.00	20.9
111	PORT GLASGOW	16.30-17.30	29.5	7.30-8.30	34.9
112	TWEEDBANK	16.30-17.30	20.6	7.30-8.30	23.8
113	VALE OF LEVEN	15.30-16.30	23.6	7.00-8.00	31.8
114	WESTER GOURDIE	16.30-17.30	14.0	7.30-8.30	19.3
201	BRIDGEND	16.00-17.00	21.8	7.00-8.00	22.1
202	DYFFRYN NEWTOWN	16.30-17.30	31.7	7.30-8.30	34.0
203	KENFIG	16.30-17.30	30.8	7.30-8.30	25.1
204	MAESGLAS	16.30-17.30	14.5	8.00-9.00	16.4
205	MANOR FLINT	16.30-17.30	19.0	7.30-8.30	22.1
206	PONTHENRI	16.00-17.00	23.1	7.30-8.30	29.2
207	RASSAU	16.30-17.30	22.4	7.30-8.30	25.9
208	SHOTTON	16.30-17.30	24.0	7.30-8.30	29.1
209	TREFOREST	16.00-17.00	20.7	7.30-8.30	12.6
210	TYNDALL ST	16.00-17.00	16.0	8.00-9.00	16.2
211	UPPER BOAT	16.30-17.30	16.0	8.30-9.30	18.7
212	VASTRE	17.00-18.00	22.9	7.30-8.30	24.1
213	WATERTON	15.30-16.30	20.5	7.00-8.00	25.7
301	ARGYLL ST	16.30-17.30	15.7	7.30-8.30	19.8
302	CARDEW RD	17.00-18.00	24.0	7.30-8.30	28.8
303	CONSETT	16.30-17.30	29.5	7.30-8.30	33.1
304	CONSETT No1	16.30-17.30	20.2	7.30-8.30	16.7
305	CRAMLINGTON	16.30-17.30	42.2	8.00-9.00	40.4
306	HELLABY	16.30-17.30	31.2	8.30-9.30	23.8
307	HOUGHTON	16.00-17.00	22.7	7.30-8.30	25.5
308	KNOWSLEY	16.00-17.00	21.9	7.30-8.30	35.9
309	LAMBERHEAD	16.30-17.30	31.7	7.30-8.30	30.8
310	NEWQUAY	16.30-17.30	14.9	7.30-8.30	17.6
311	NORTH TYNE	16.30-17.30	17.7	7.30-8.30	17.9
312	PARR	16.30-17.30	43.1	7.30-8.30	41.8
313	REKENDYKE	17.30-18.30	10.2	8.00-9.00	20.2
314	RIVERSIDE PARK	17.00-18.00	21.2	8.00-9.00	23.2
315	SALTERBECK	16.00-17.00	21.7	7.00-8.00	19.8
316	SEDGELETCH	17.00-18.00	28.6	8.00-9.00	15.7
317	SHAW LANE	16.30-17.30	21.5	7.30-8.30	18.0
318	SOLWAY	16.00-17.00	15.8	8.00-9.00	15.5
319	SOUTHPARK	15.30-16.30	16.9	8.00-9.00	29.0
320	SUTTONFIELDS	16.30-17.30	19.2	7.30-8.30	16.3
321	TEESIDE	16.30-17.30	20.9	7.30-8.30	20.0
401	ADELAIDE	16.00-17.00	14.6	8.00-9.00	15.2
402	AUGHRIM RD	17.00-18.00	23.9	7.30-8.30	29.6
403	BLARIS	16.30-17.30	21.8	8.00-9.00	20.1
404	GORTRUSH	17.00-18.00	21.3	7.30-8.30	16.7
405	GREENBANK	16.30-17.30	23.2	8.00-9.00	28.9
406	HYDEPARK	16.30-17.30	22.0	8.00-9.00	19.1
407	KNOCKMORE	16.30-17.30	17.0	8.00-9.00	17.2
408	PENNYBRIDGE	16.30-17.30	13.5	8.00-9.00	13.7
409	PENNYBURN	16.30-17.30	11.8	8.00-9.00	11.1
410	STEEPLE	16.30-17.30	15.3	7.30-8.30	16.8



PROFILE OF OUTBOUND TRAFFIC FLOW

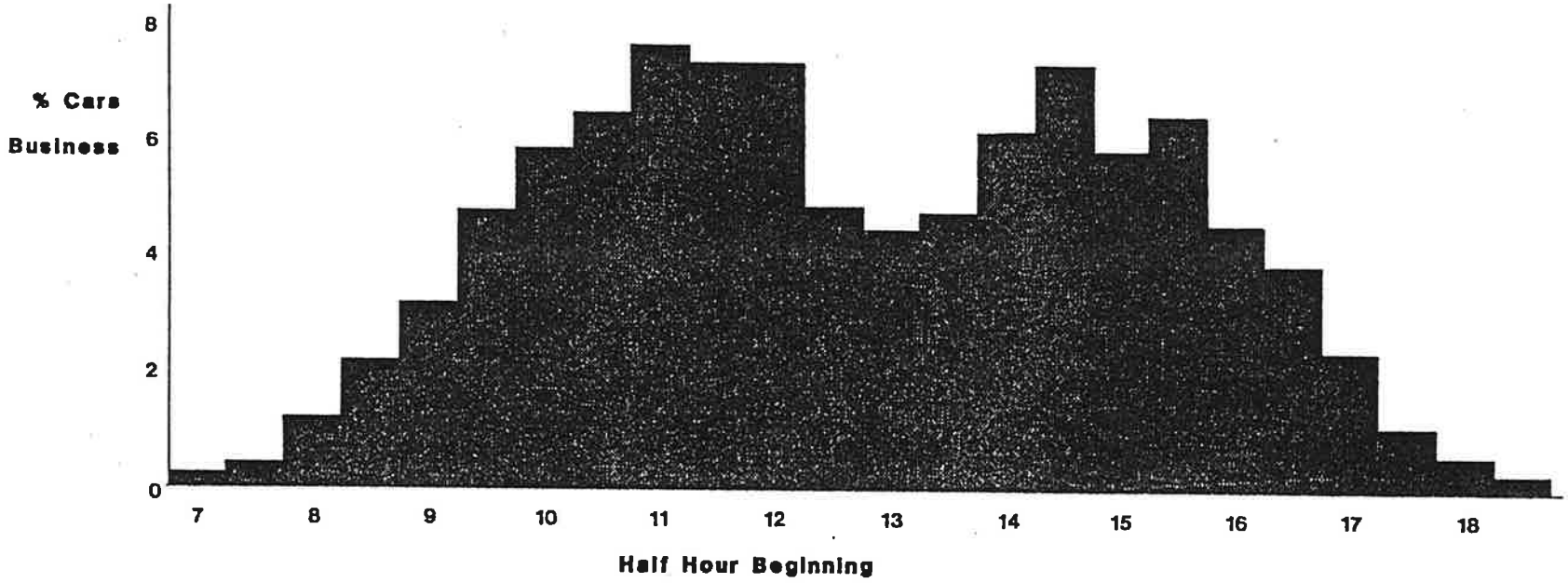
ALL VEHICLES

Figure 6.1



PROFILE OF OUTBOUND TRAFFIC FLOW

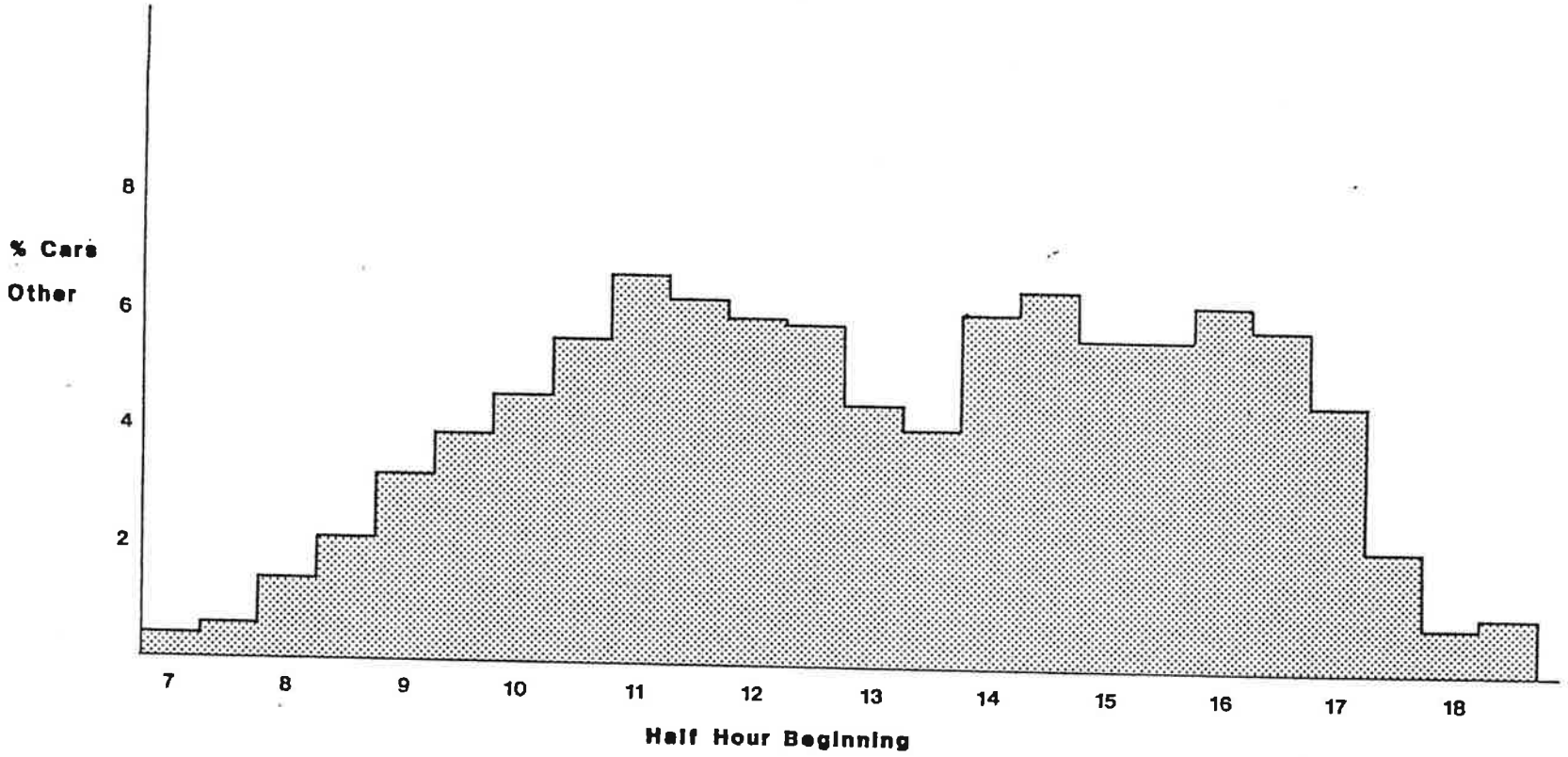
CARS : WORK **Figure 6.2**



PROFILE OF OUTBOUND TRAFFIC FLOW

CARS : BUSINESS

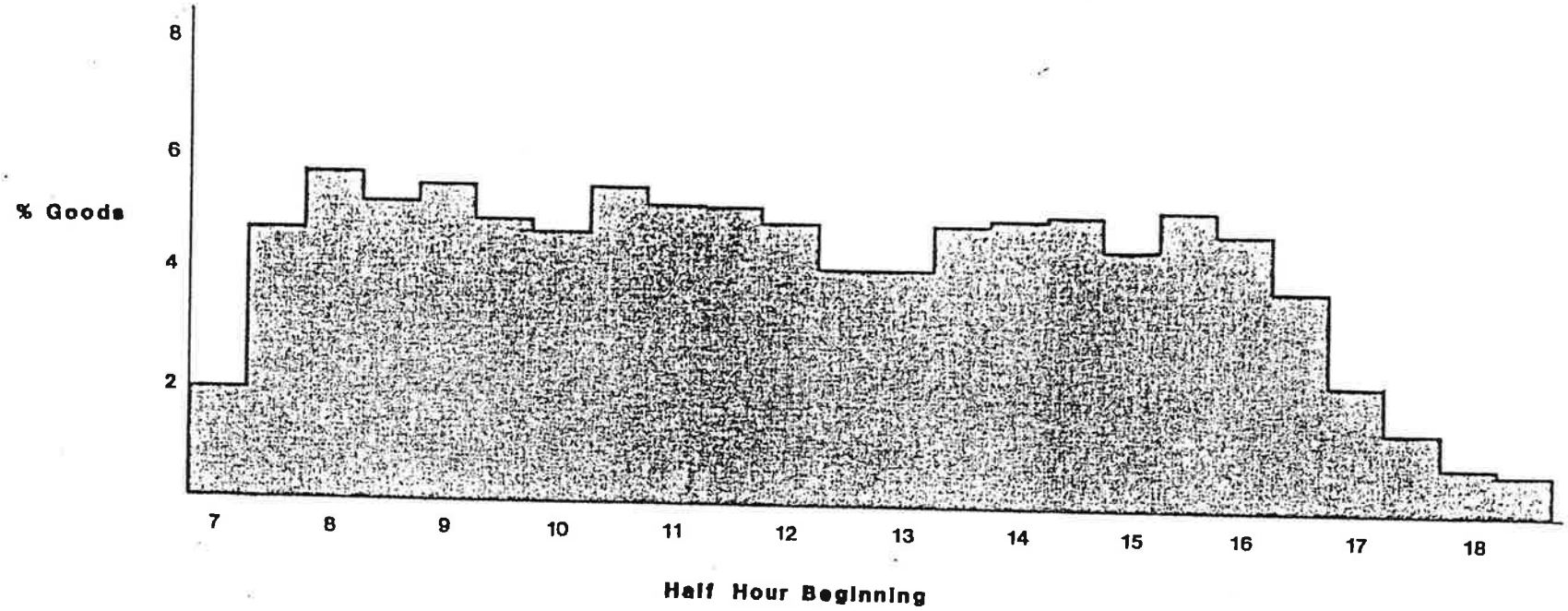
Figure 6.3



PROFILE OF OUTBOUND TRAFFIC FLOWS

CARS : OTHER

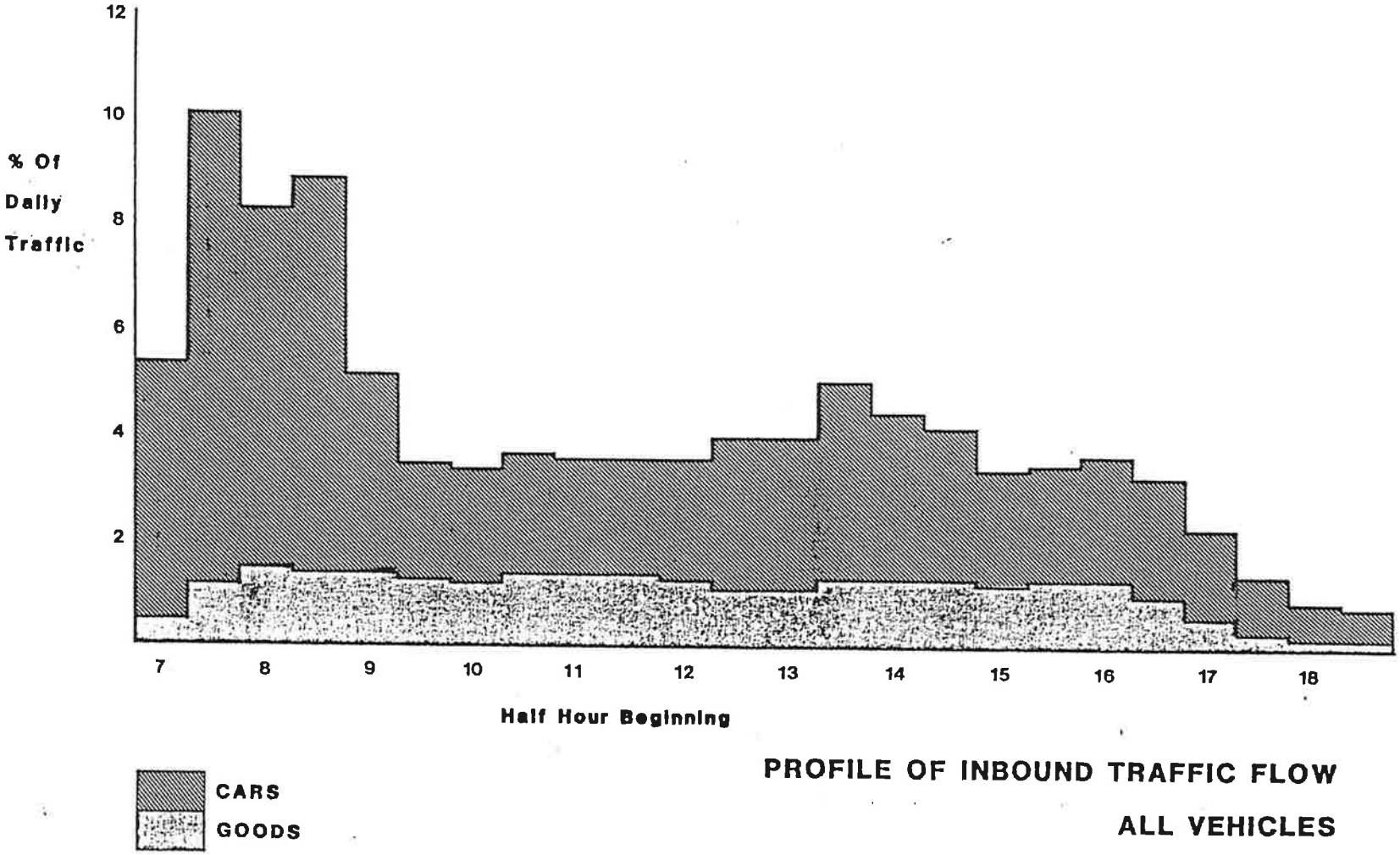
Figure 6.4



PROFILE OF OUTBOUND TRAFFIC FLOW

GOODS : VEHICLES

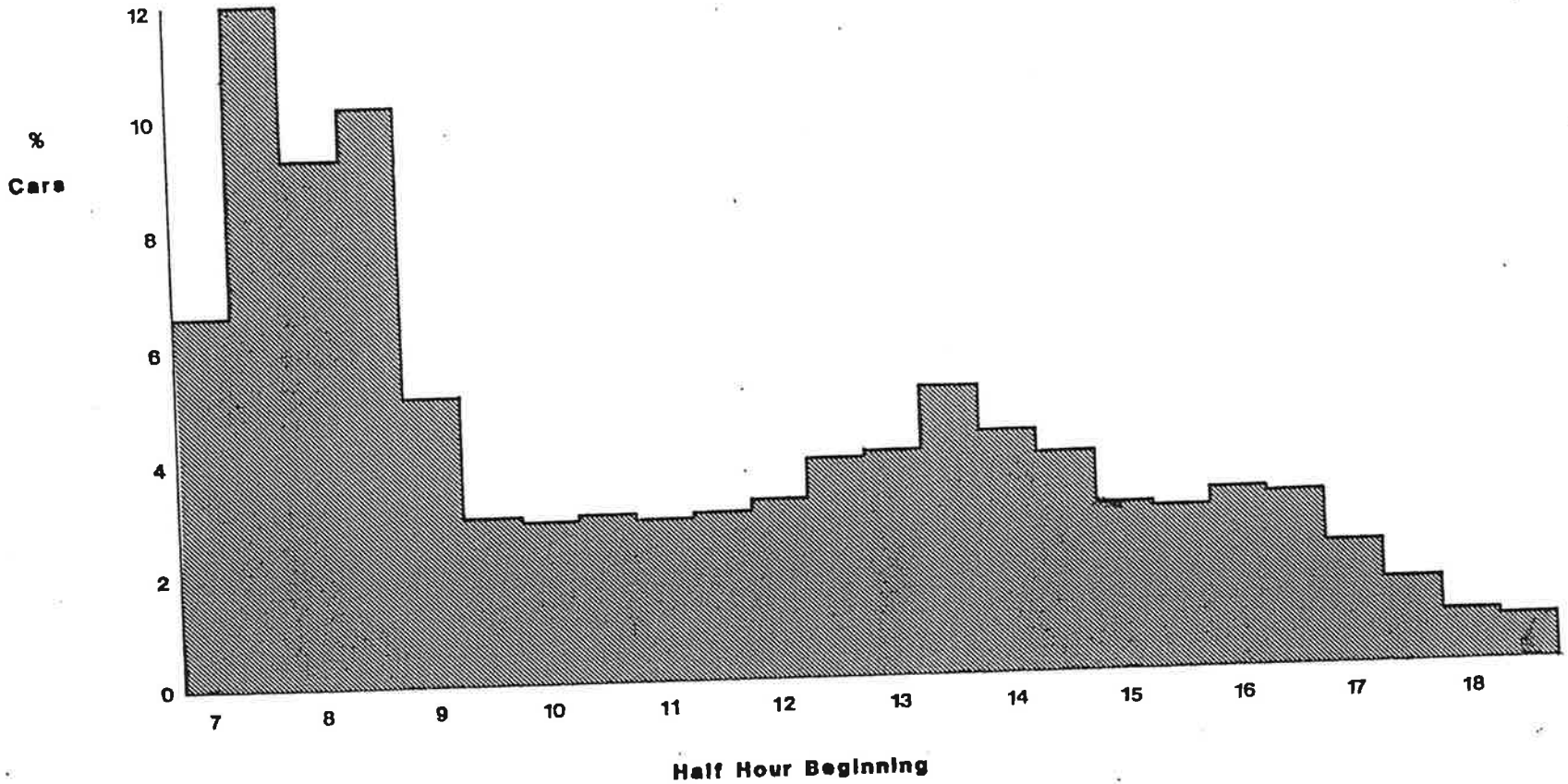
Figure 6.5



PROFILE OF INBOUND TRAFFIC FLOW

ALL VEHICLES

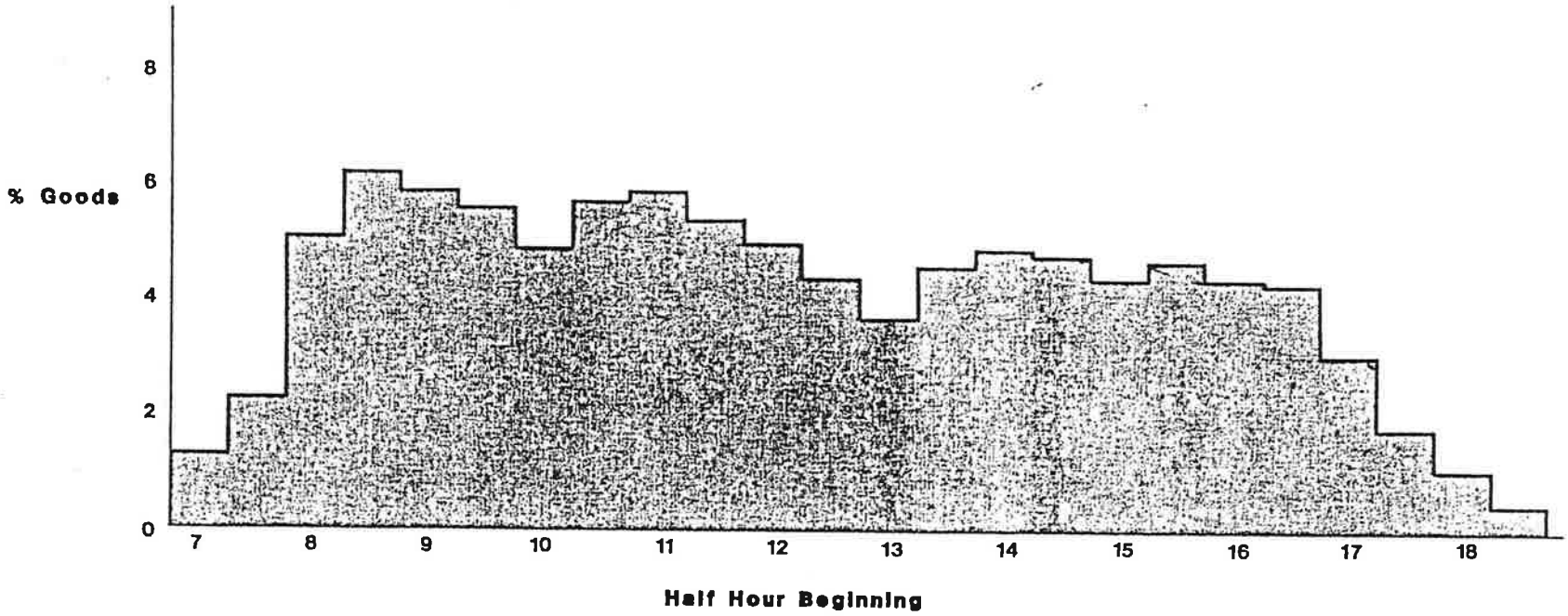
Figure 6.6



PROFILE OF INBOUND TRAFFIC FLOWS

CARS

Figure 6.7



PROFILE OF INBOUND TRAFFIC FLOW

GOODS

Figure 6.8

SECTION SEVEN PARKING

7.1 One of the basic design criteria in the layout of an industrial site is the extent of car parking required. In general, parking divides into three types, namely:

(i) Operational, that is, parking essential to the business. This sub-divides into two groups, commercial vehicles, and cars.

(ii) Visitor.

(iii) Commuter.

7.2 In an attempt to estimate parking requirements a survey of the number of vehicles parked on each Estate was made, separately for a mid-morning and mid-afternoon period. On many Estates the analysis of the collected data proved to be very difficult. Certain firms had to be excluded from the data base since, in many of these cases, the parking was outside the curtilage of the development and hence it proved impossible to ensure that the parking data remained consistent with the employment data. It was also found that much of the parking was on streets or in shared parking areas not immediately adjacent to the premises. Therefore, it was impossible to allocate parking specifically to individual firms and hence only global Estate values could be obtained.

7.3 An alternative method of examining parking requirements was to take the difference between the inflow and the outflow of vehicles to any Estate at various times of the day. The residual number gave an estimate of the number of vehicles remaining on the Estate at that time, that is, the number parked. This method was used to provide an estimate of maximum parking levels. It was compared to the on-site survey and, where possible, reconciliation between the two separate estimates was undertaken in order to provide the best estimate. The estimate thus calculated is the maximum number of cars parked at any time on each Estate. In designing parking supply, the number of spaces provided should be higher than this value to balance between high and low usage firms.

7.4 No attempt was made to estimate operational space for commercial vehicles as this varied so much between individual premises and no sub-division between the types of parking was possible.

7.5 Two ways of considering parking use were examined, namely:

(i) Cars parked per employee.
(ii) Cars parked per daily trip generated.

Cars Parked Per Employee

7.6 From the surveyed data the average number of cars parked per employee was found to be 0.27 (ie 27 cars parked per 100 employees). This figure was calculated at an Estate level and hence conceals a large variation for individual firms around this mean. The distribution at the Estate level is given in Table 7.1. It should be noted that there is a very considerable variation with 15% of sites having a value in excess of 44 cars parked per 100 employees.

Cars Parked Per Daily Trip

7.7 It has been noted earlier in this Report that there were wide variations in estimating daily trip generation from employment levels so an attempt was made to take account of this variation by relating parking to the daily trip generation. It was found, on average, that the mean cars parked was 38% of the daily trip generation. The distribution at an Estate level, is given in Table 7.2. As with Table 7.1 it should be noted that there is a considerable variation with 15% of sites having a value in excess of 47%.

7.8 A comparison of Tables 7.1 and 7.2 indicates that the use of the daily trip value as a prediction gives less variation but as this can only be used once the detailed calculation of trip generation rates is completed it is probably as simple to make use of the cars parked per employee value.

TABLE 7.1 CARS PARKED PER EMPLOYEE

Cars Parked per 100 Employees	Number of Estates
0 - 5	0
5 - 10	4
10 - 15	1
15 - 20	4
20 - 25	13
25 - 30	11
30 - 35	5
35 - 40	6
40 - 45	5
45 - 50	5
50 - 55	1
55 - 60	1
TOTAL	56

Note: Two Estates not included due to insufficient data being available

TABLE 7.2 CARS PARKED PER DAILY TRIP GENERATION

Cars Parked per Daily Trip Generation (%)	Number of Estates
0 - 5	0
5 - 10	0
10 - 15	0
15 - 20	2
20 - 25	6
25 - 30	10
30 - 35	9
35 - 40	11
40 - 45	5
45 - 50	8
50 - 55	3
55 - 60	1
60 - 65	1
TOTAL	56

Note: Two Estates not included due to insufficient data being available

SECTION EIGHT VARIABILITY

8.1 Other than during the introductory Section this Report has so far only considered the mean ratios and trip rates which have been derived from the data. However, it must be noted that there are very wide spreads in the data (this is indicated by the low R2 values obtained from most of the analyses). The problem with using mean values throughout a prediction exercise is that it is likely that the end result will be exceeded on something like 50% of occasions. This is not an adequate base on which to design any infrastructure. A more appropriate design level is likely to be one that is exceeded on only one in ten or one in twenty occasions (that is, designed for the 90th or 95th percentile).

8.2 The degree of variability within the data is accounted for by two factors. The first is the grouping together of different types of industry and activities into one data file and the other is the inherent variability of the data itself. Figures 8.1-8.4 illustrate the variability in floor space per employee, car work trips per employee, goods vehicle trips per employee and peak hour to daily traffic flow ratios.

8.3 It is possible to see from the graphs the values that will not be exceeded by 1 in 10 or 1 in 20 cases on each set of relationships. However, it would be inappropriate to use such values directly since the final estimation is derived from an accumulation of several sets of variable data and there is no reason to expect that all the extreme values are additive; it is just as likely that the differences could be compensating.

8.4 There are two or three basic stages in the traffic projection. To arrive at an estimate of daily traffic the stages are:

(i) Estimate employment from Floor Space.

(ii) Estimate daily trip generation from employment.

To arrive at an estimate of peak hourly traffic, the stages are:

(i) Estimate employment from Floor Space.

(ii) Estimate daily trip generation from employment.

(iii) Estimate peak hourly generation from daily trip generation.

(These stages may be a simple factor or may involve a number of separate steps incorporating male/female split

or trip generation by industry). If it is assumed that the variation of each parameter is independent of all other parameters then for a two stage estimation a 95th percentile value can be estimated from two separate distributions taking their individual 80th percentile (approximately) (value exceeded by 20% x value exceeded by 20% = value exceeded by 4%, ie 96th percentile). For a three stage estimation a 95th percentile value can be estimated from three separate distributions taking their 60th percentiles (approximately) (value exceeded by 40% x value exceeded by 40% x value exceeded by 40% = value exceeded by 6.4%, ie 93.6th percentile). These relationships are illustrated in Figures 8.5 and 8.6.

8.5 The preceding sections of this Report have concentrated on producing estimates of mean values so rather than reproduce all the relationships separately for 60th or 80th percentile values global relationships of the ratio of the 50th to 60th percentile and 50th to 80th percentile have been used.

8.6 Table 8.1 sets out for the four major relationships the ratios of:

$$\frac{\text{60th percentile}}{\text{50th percentile}} \text{ and } \frac{\text{80th percentile}}{\text{50th percentile}}$$

It should be noted that the goods vehicle trips have a very much wider spread and, for these trips, the 80% percentile is over 3 times the mean value. If, of course, more is known about the type of industrial activity and the variability is considered on an industry by industry basis, the ratios reduce considerably as set out in Table 8.2. This illustrates a high degree of uniformity between the individual data sets. It can be seen, therefore, that if nothing is known about the type of industry the 80th percentile is some 3.26 time more than the mean, but if the type of industry is known the 80th percentile is just 1.70 times the mean value.

8.7 A similar analysis to Table 8.2 is given in Table 8.3 which sets out the variability of floor space per employee by the different types of industrial activity. Unlike the analysis of goods vehicles this shows very little difference between the global relationship and that of the separate grouping (in fact there is a wider variation in the separate groups than there is in the total data set).

TABLE 8.1 DATA VARIABILITY (ratios)

Relationship	60th percentile/ 50th percentile	80th percentile/ 50th percentile
Floor space/employee	1.18	1.41
Cars work trips/employee	1.17	1.70
Goods trips/employee	1.48	3.26
Peak hour/daily trips	1.10	1.38

TABLE 8.2 GOODS VEHICLE TRIP RATE VARIABILITY BY TYPE OF INDUSTRIAL ACTIVITY (ratios)

Type of Industrial Activity	60th percentile/ 50th percentile	80th percentile/ 50th percentile
1) Food,drink & tobacco	1.14	2.14
3) Metal,mechanical & Vehicle Eng	1.15	1.70
4) Other Manufacturing	1.15	1.52
5) Instruments/Elect	1.15	1.67
6) Textile & Clothing	1.17	1.60
12) Distributive trades	1.20	1.64
13) Professional & Admin	1.20	1.70
Note: Further grouping Other Manufacturing (Groups 4,7,8,9,10)	(1.31)	(2.55)

Note:Insufficient data for other groups

TABLE 8.3 FLOOR SPACE PER EMPLOYEE VARIABILITY BY TYPE OF INDUSTRIAL ACTIVITY (ratios)

Type of Industrial Activity	60th percentile/ 50th percentile	80th percentile/ 50th percentile
1) Food,drink & tobacco	1.16	2.14
2) Chemicals & Pharmaceutical	1.14	1.56
3) Metal,mechanical & Vehicle Engineering	1.18	1.71
4) Other Manufacturing	1.15	1.52
5) Instruments/Electrical Engineering	1.16	1.67
6) Textile & Clothing	1.18	1.62
7) Bricks & Glass	1.08	1.35
8) Timber & Furniture	1.18	1.90
9) Paper & Printing	1.25	1.65
10) Construction	1.23	2.39
11) Transport	1.21	1.64
12) Distributive trades	1.17	1.98
13) Professional & Admin	1.20	1.71
Note: Further grouping Other Manufacturing (Groups 4,7,8,9,10)	(1.15)	(1.55)

GEA of FLOOR SPACE PER EMPLOYEE (sq.m.)		NUMBER OF FIRMS	0 50 100
.00 <	5.00	9	|=== | |
5.00 <	10.00	44	|============ | |
10.00 <	15.00	50	|============== |
15.00 <	20.00	86	|============================== |
20.00 <	25.00	81	|============================ |
25.00 <	30.00	65	|==================== |
30.00 <	35.00	82	|============================ |
35.00 <	40.00	65	|==================== |
40.00 <	45.00	47	|============== |
45.00 <	50.00	68	|====================== |
50.00 <	55.00	48	|================ |
55.00 <	60.00	32	|========== | |
60.00 <	65.00	26	|======== | |
65.00 <	70.00	45	|============== |
70.00 <	75.00	21	|======= | |
75.00 <	80.00	25	|======== | |
80.00 <	85.00	13	|==== | |
85.00 <	90.00	20	|====== | |
90.00 <	95.00	15	|===== | |
95.00 <	100.00	12	|==== | |
100.00 <	105.00	8	|== | |
105.00 <	110.00	9	|=== | |
110.00 <	115.00	10	|=== | |
115.00 <	120.00	12	|==== | |
120.00 <	125.00	6	|== | |
125.00 <	130.00	2	| | |
130.00 <	135.00	6	|== | |
135.00 <	140.00	5	|= | |
140.00 <	145.00	3	|= | |
145.00 <	150.00	3	|= | |
150.00 <	155.00	6	|== | |
155.00 <	160.00	2	| | |
160.00 <	165.00	6	|== | |

Note: 40 firms have 165 sq.m or greater of floor space per employee

HISTOGRAM

FLOOR SPACE PER EMPLOYEE : NUMBER OF FIRMS

Figure 8.1

CAR WORK TRIPS PER EMPLOYEE		NUMBER OF FIRMS	0 50 100
.00 <	.10	84	|==========
.10 <	.20	23	|=====
.20 <	.30	65	|===============
.30 <	.40	75	|==================
.40 <	.50	83	|====================
.50 <	.60	120	|==============================
.60 <	.70	102	|========================
.70 <	.80	71	|=================
.80 <	.90	67	|================
.90 <	1.00	28	|======
1.00 <	1.10	67	|================
1.10 <	1.20	26	|======
1.20 <	1.30	37	|========
1.30 <	1.40	18	|====
1.40 <	1.50	12	|==
1.50 <	1.60	16	|===
1.60 <	1.70	16	|===
1.70 <	1.80	6	|=
1.80 <	1.90	6	|=
1.90 <	2.00	1	|

Note: 49 firms with 2 or more car work trips per employee

HISTOGRAM

CAR WORK TRIPS PER EMPLOYEE : NUMBER OF FIRMS

Figure 8.2

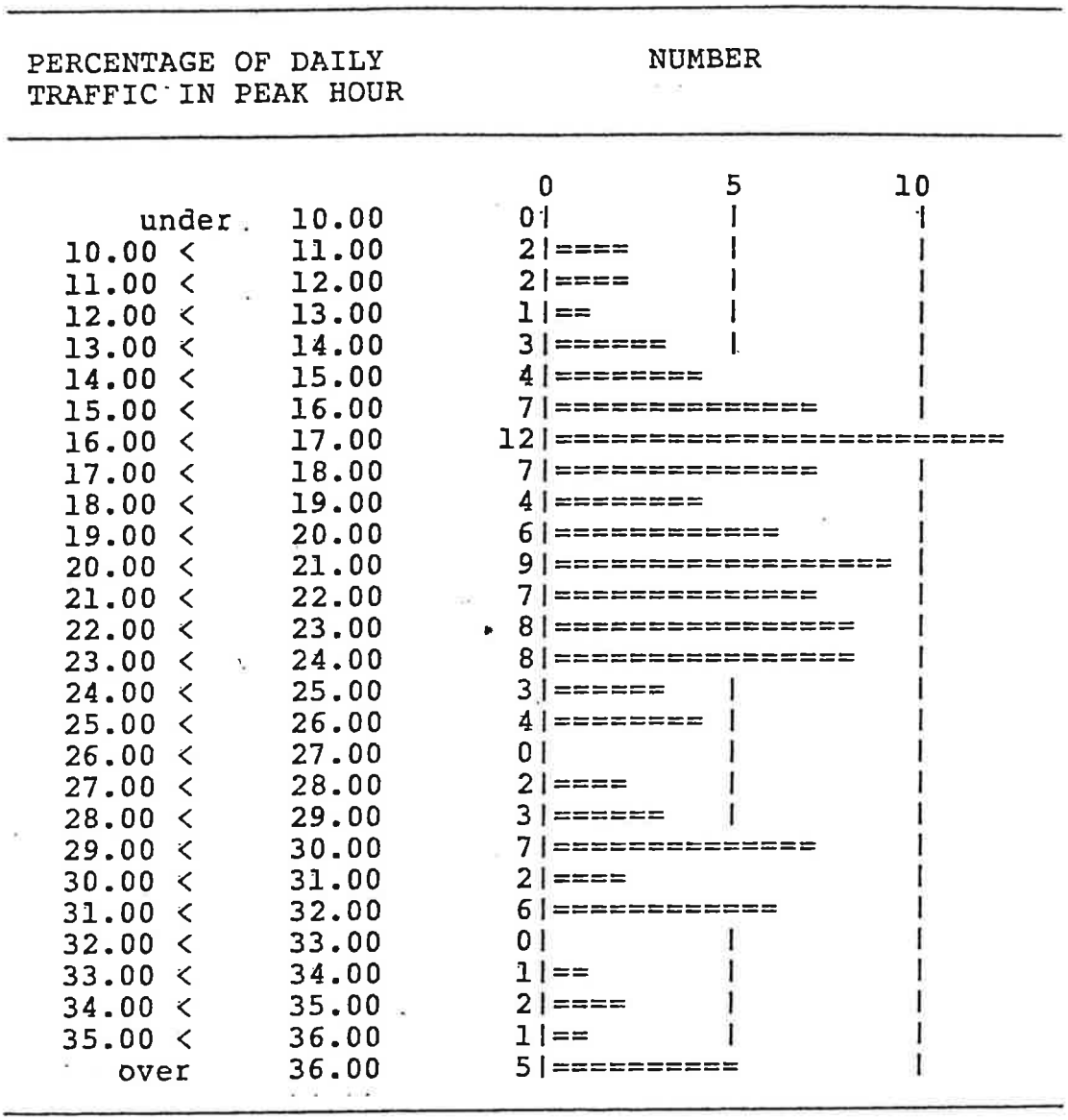
GOODS TRIPS PER EMPLOYEE		NUMBER OF FIRMS	0 50 100 150
.00 <	.05	163	==========
.05 <	.10	66	==========
.10 <	.15	77	==========
.15 <	.20	55	==========
.20 <	.25	50	==========
.25 <	.30	63	==========
.30 <	.35	52	==========
.35 <	.40	31	==========
.40 <	.45	37	==========
.45 <	.50	12	==========
.50 <	.55	41	==========
.55 <	.60	18	==========
.60 <	.65	24	==========
.65 <	.70	19	==========
.70 <	.75	18	==========
.75 <	.80	11	==========
.80 <	.85	11	==========
.85 <	.90	17	==========
.90 <	.95	6	==========
.95 <	1.00	4	==========
1.00 <	1.05	33	==========
1.05 <	1.10	6	==========
1.10 <	1.15	7	==========
1.15 <	1.20	6	==========
1.20 <	1.25	7	==========
1.25 <	1.30	15	==========
1.30 <	1.35	9	==========
1.35 <	1.40	3	==========
1.40 <	1.45	4	==========
1.45 <	1.50	1	==========

Note: 94 with 1.5 or more goods trips per employee

HISTOGRAM

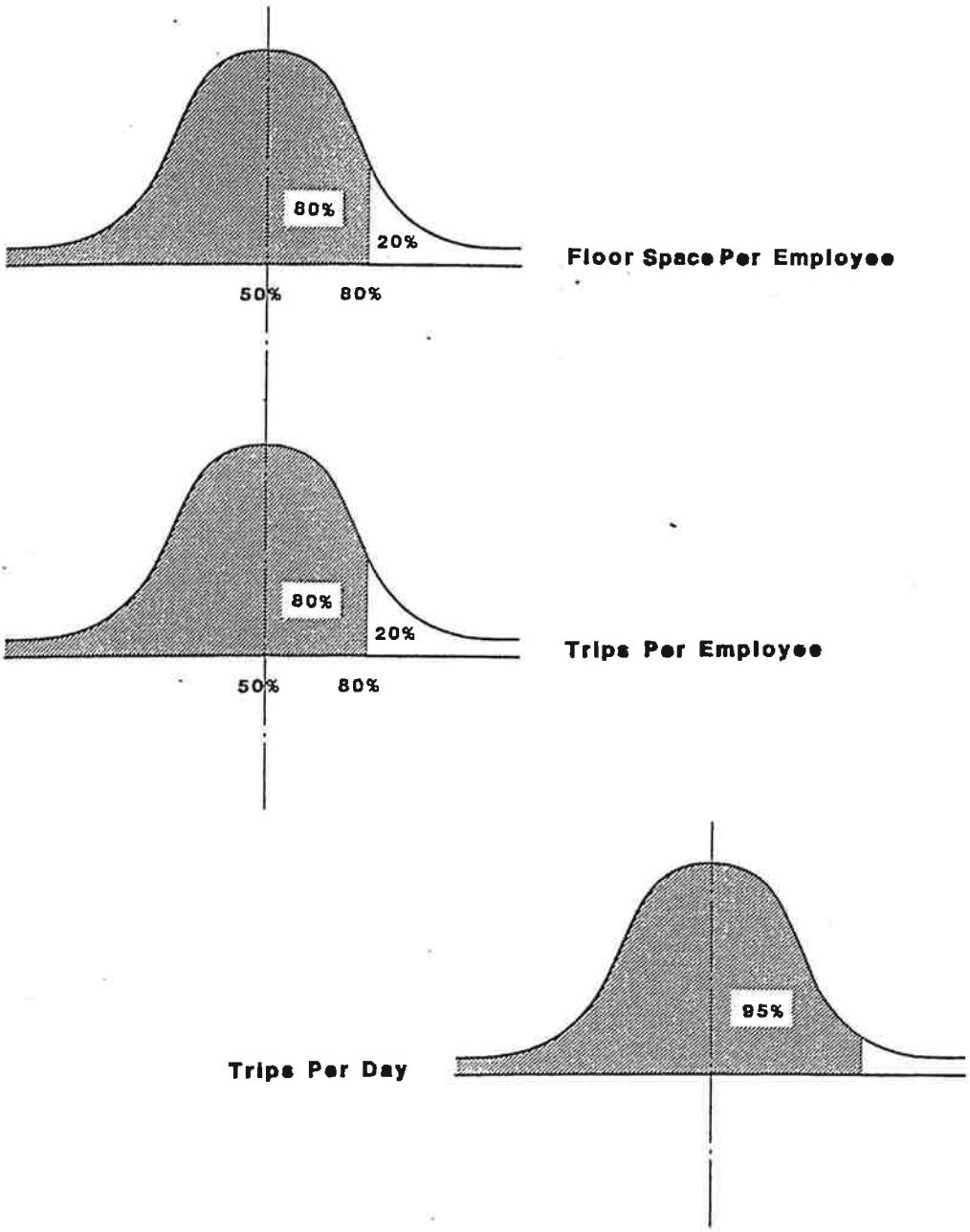
GOODS TRIPS PER EMPLOYEE : NUMBER OF FIRMS

Figure 8.3



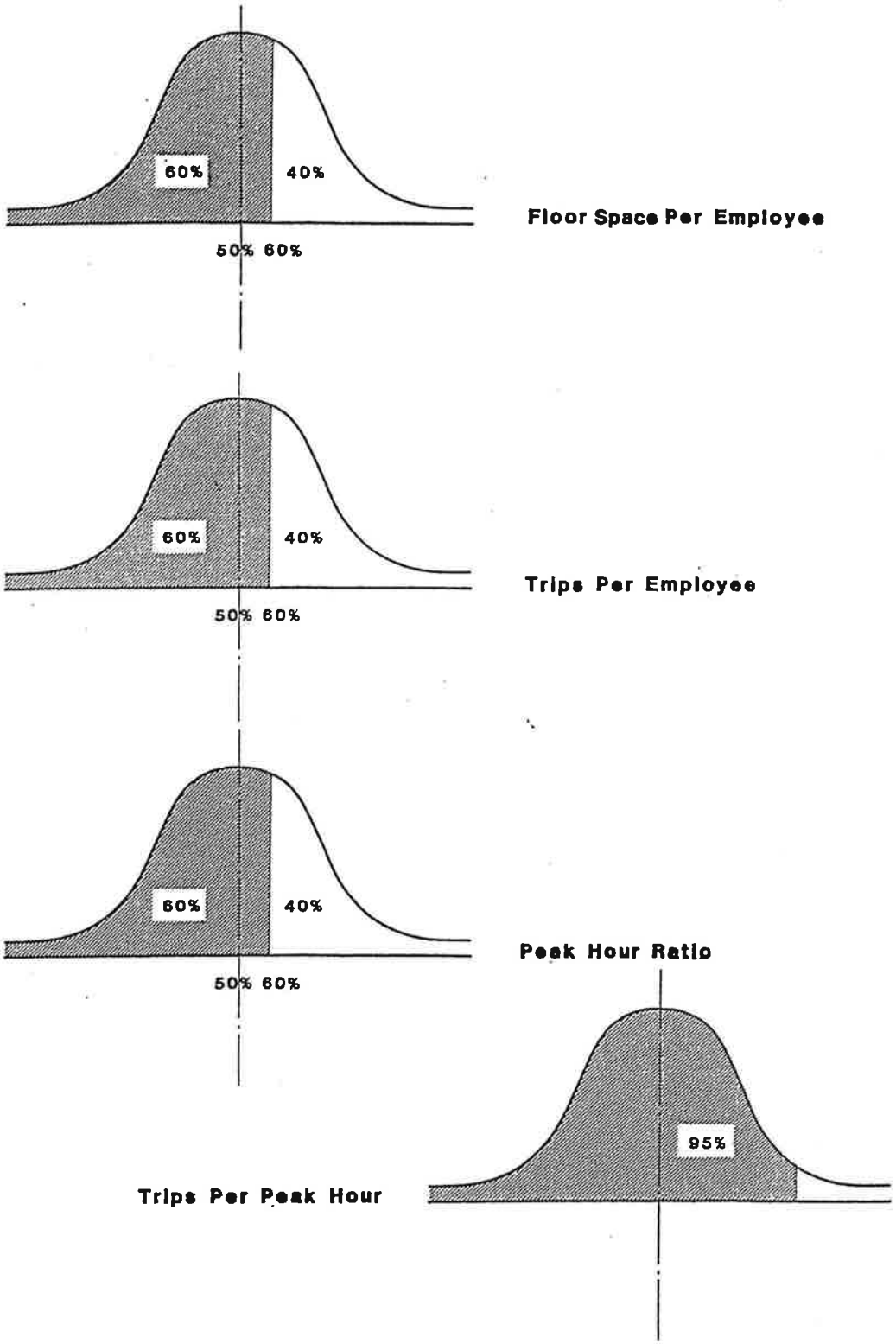
VARIABILITY OF PEAK HOUR : DAILY RATIO

Figure 8.4



TWO STAGE MODEL

Figure 8.5



THREE STAGE MODEL

Figure 8.6

PART 2

PROCEDURES FOR ESTIMATING TRAFFIC GENERATION

FOREWORD

The Scottish Development Agency, English Industrial Estates, Welsh Development Agency, Development Board for Rural Wales, Industrial Development Board of Northern Ireland and the Highland and Islands Development Board (referred to collectively in this Report as the Development Agencies) acting through a Joint Technical Committee initiated a study to up-date their planning criteria for the development of industrial and commercial estates. Jamieson Mackay and Partners were commissioned by the Joint Technical Committee to undertake a study of the levels of traffic generation from such estates.

This Report summarises the work undertaken by the Consultants and also sets out recommended procedures for estimating traffic generation from industrial and commercial estates. Where necessary, the reader may wish to refer to the Consultant's Report on Surveys and Analyses which details the procedures adopted in their investigations and contains supportive facts to those set out and applied in this Summary Report.

The Consultants are indebted to the officers of the Development Agencies who provided guidance and assistance in the many processes of the study procedures. In particular, they would like to record their appreciation to Mr C D MacCalman and Mr D H Mann (Scottish Development Agency), Mr M Stevenson (Department of Environment, Northern Ireland), Mr J W Hall (English Industrial Estates), Mr V Skyrme and Mr J H Pavitt (Welsh Development Agency) and Mr R Griffiths (Development Board for Rural Wales).

SUMMARY

The estimation of traffic generation from industrial and commercial sites is an important issue in the overall determination of the infrastructure requirements for such developments. There is limited background data available to enable such estimates to be made. The Joint Technical Committee of the Development Agencies is to be congratulated for commissioning this study which not only adds considerably to the data base available on the subject but also provides a methodology for applying such data to the practical problem of determining the likely levels of traffic generation from an industrial or commercial estate development.

The survey base consisted of 972 edited and verified records, one for each firm on the 58 estates surveyed throughout the United Kingdom. Each record contains data relating to the firm and its activities, together with the number of trips by type generated from the premises during the particular survey day. The surveys, conducted for one typical weekday per estate, were carried out in the period September to mid-November, 1983.

General and traffic generation relationships have been developed using simple and regression analysis techniques. Employment to floor space and male/female relationships have been produced, together with car work trip, goods vehicle trip, business and other trip relationships and taking account of other factors, as appropriate, such as two-way total traffic, the peak hour and car parking. The variability of the data is explained in some detail and techniques developed to take account of such inherent effects.

This Report contains two worked examples for the estimation of traffic generation. These illustrate and apply the various factors developed from the study analyses. The examples use common assumptions but more detailed information regarding possible development is input to the second example. The differences in results between the two examples are explained and an overall summary illustrates the better level of accuracy obtainable if more is known about the activities likely to occupy an industrial or commercial site.

(Continued...,)

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

GENERAL

1.1 In developing a new industrial or commercial site or in the extension of an existing site one of the pertinent issues could be the level of infrastructure required or the amount of current infrastructure taken up by the demands of the new development. In this context infrastructure should be considered to be the basic services, such as drainage, water, electricity, gas, and transport. The importance of correct infrastructure planning is further emphasised once it is realised that, in most cases, the provision of these services must be a 'front end cost' incurred before the site begins to generate any revenue and the developer has a clear idea of what activities and/or companies are likely to move into the area.

1.2 The cost implications of being wrong, either by over-provision or under-provision will be high, but the information on which judgements can be made to estimate the correct level of provision will be poor. In terms of making a correct judgement of provision for an industrial estate, the situation is made more complex due to outside pressure from Local Planning Authorities and Public Utilities who would normally wish to see infrastructure provided to the highest level of engineering design, often with little regard to the economic and financial considerations of the developer. This interaction between developer and Public Authority can lead to the construction of highways and services with capacity well in excess of demand. This in turn is uneconomic and eventually leads to extra costs being passed on to tenants.

1.3 This current Study is considering just the transport side of infrastructure development. Its aim is to provide more information to the developer on the likely level of transport infrastructure and to illustrate the implications which would arise from varying the basic planning parameters.

DESIGN CRITERIA

1.4 The Department of Transport and the various Highway Authorities have laid down a series of criteria on which to judge and design highway construction. Different elements of design are

related to different criteria. In general, highway provision is related to daily traffic flows; junction provision to peak hour flows; carriageway thickness to passage of heavy commercial vehicles; and environmental effects to the daily flow of vehicles, particularly commercial vehicles. Useful references relating to design elements and their specific criteria are set out in Table 1.

1.5 In addition to the specific requirements of the Highway Authorities any public inquiry that may arise from the proposed development may wish to examine a range of issues upon which the developer will be expected to provide answers.

1.6 In terms of predicting traffic, it is necessary to distil from the preceding list of variables a series of values from which the various criteria can be assessed. Conventionally, this has taken the form of predicting daily traffic flow for different types of traffic, summing them to give daily totals and then applying a factor to the daily total to give a peak hourly flow. This is the form that has been adopted within this procedure.

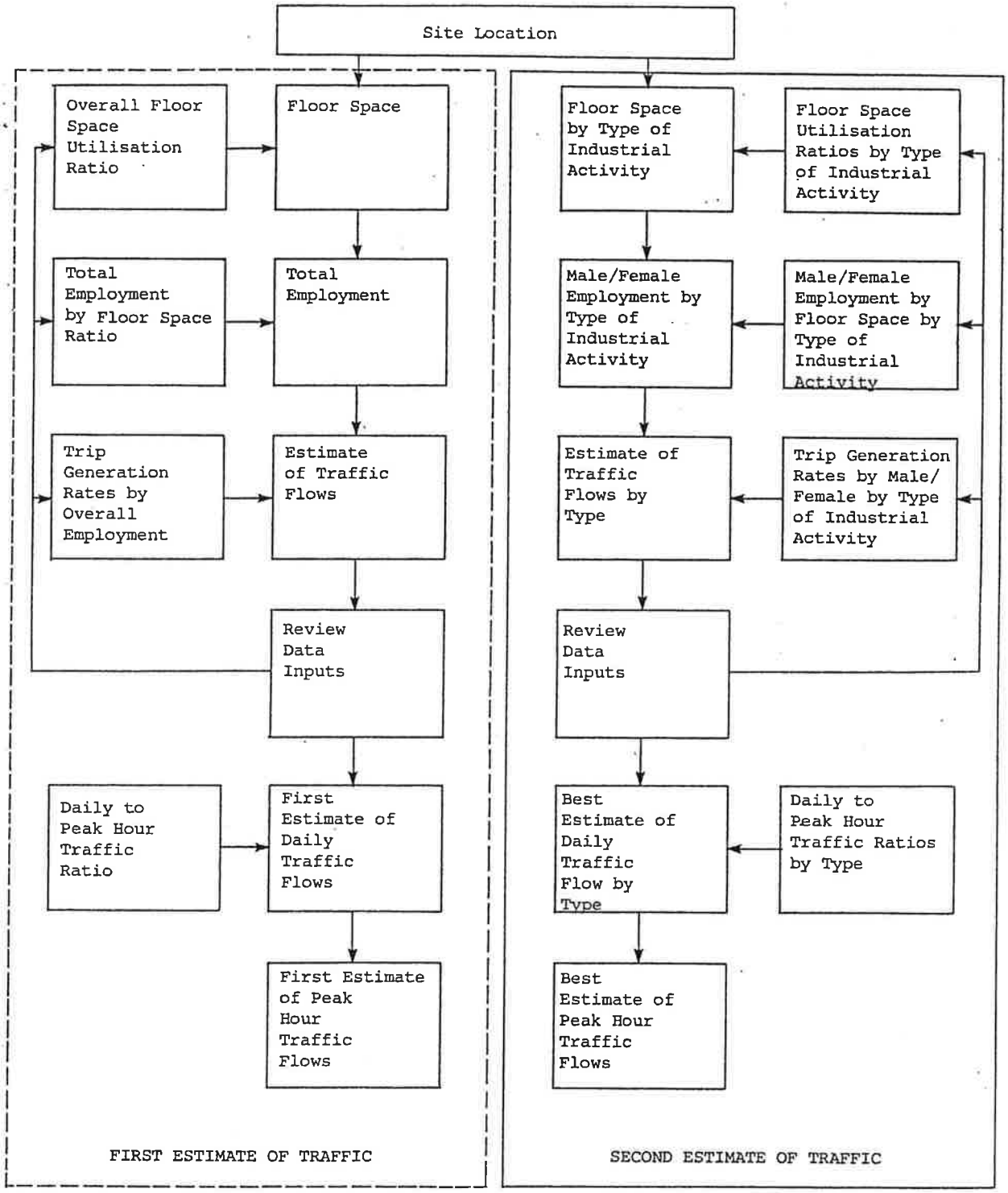
1.7 Experience of site operations led to the decision to collect traffic data for just the 12 hour period (0700-1900) as traffic flows outside that period normally are negligible and, hence, the survey results from the 12 hours of observation can be assumed to be equally applicable to either 16 hour or 18 hour definitions, these latter sometimes being required for certain design criteria. Traffic flows are defined into four separate groups:

(i) Cars - Work (commuting)
(ii) Cars - Business (not normal place of employment)
(iii) Cars - Other (including retail purposes)
(iv) All Goods Vehicles.

If each group can be predicted separately then factors can be applied to give daily peak hour totals.

1.8 Before predicting traffic flows, one must consider which of the basic planning parameters the developer should know or be able to predict with any certainty. The likely stages of a typical study (Figure 1) are:

Stage 1: An area of land is considered for development. Its area is known. As a planning decision the developer can define a utilisation rate (that is, how much of the site area can be built on or, in other words, gross floor space as a percentage of gross site area). This ratio can vary considerably from, say, 20% for a spaciously designed industrial park to 40% for an intensively developed urban area site.



TYPICAL PROCEDURES FOR ESTIMATING TRAFFIC GENERATION

Figure 1

Stage 2: A total estimate of floor space is derived from Stage 1 and, hence, by assuming a ratio of floor space to employment, a first approximation of total site employment can be obtained. However, it is known that floor space rates vary considerably by firm and by type of employment. Until more information is known the estimate of employment may be very poor.

Stage 3: At this stage it is often necessary to arrive at a first estimation of traffic.

Stage 4: Further consideration of the potential for the site and discussions with potential occupiers may lead to a more definitive picture emerging of the type of development likely to take place. All such refinements can lead to alternative traffic estimations. For instance, a large textile company is likely to employ a higher number of female workers but generate a lower number of trips than a similar sized mechanical engineering company employing a mostly male workforce. One large firm may generate a different number of trips from a large number of small firms occupying the same floor space.

Stage 5: All planning stages are iterative and the process will pass up and down many times during the formulation stage.

1.9 In order to predict traffic, it is necessary to have a procedure which is responsive to the varying levels of information available at any time. It is, however, important to realise that such prediction can never be exact even if a considerable amount of information is known. For instance, two very similar firms employing the same number of staff may have very different traffic generation rates. The aim of the procedure, therefore, is to set out a range of relationships which assist in describing the traffic flows for varying levels of information.

1.10 A danger in attempting to estimate traffic flows from detailed information is the uncertainty of change with time of the basic planning parameters. For example, initial site planning is based on known or assumed detailed estimates of firm size, employment and industry type but it may be only a few years before one or more of these firms re-locate and are replaced by firms with considerably different activities and hence traffic generation levels.

1.11 This Report describes relationships which have been derived from the survey data for various parameters. There is, however, a danger in using average factors; the final result will be produced from a series of average values which, when

combined, may not in itself be an average. Also if one projects an average value then this value will be exceeded on 50% of occasions and hence is not an adequate projection on which to design the desired infrastructure. As well as knowing the average value it is also necessary to know the likely range of accuracy and particularly the sensitivity of the traffic flows to the assumptions within the relationships.

TABLE 1

Traffic Design Element	Significant Criteria	Useful References (see Note)
1. Highway and Junction Provision	Daily and Peak Traffic Flows	TD9/81 : Road Layout and Geometry: Highway Link Design (DTp). TD20/81 : Junctions and Accesses: The Layout of Major/Minor Junctions (DTp). TA23/82 : Junctions and Accesses: Determination of Size of Roundabouts and Major/Minor Junctions (DTp). TA28/82 : Layout of Roads in Rural Areas: A Guide to Revisions 1982 (DTp). TA32/82 : Roads in Urban Areas: Revisions subsequent to "A" Guide to Revisions 1979 (DTp). H1/73 : Criteria for traffic light signals at junctions (DTp). TA16/81 : General Principles of Control by Traffic Signals. H6/74 : Design Flows for Motorways and Rural All-Purpose Roads (DTp). H9/76 : Design Flows for Urban Roads (DTp).
2. Road Pavement	Traffic Flows especially Heavy Goods Vehicles. Equivalent Standard Axles.	Road Note 29 (TRRL) H6/78 : Road Pavement Design (DTp).
3. Turning Circles	Size of largest vehicles.	Designing for Deliveries: Freight Transport Association (1983).
4. Environmental Intrusion	Daily Traffic and percentage of goods vehicles.	Manual of Environmental Appraisal (1983) (DTp). Calculation of Road Traffic Noise (HMSO) (1975). H14/76 : Noise Barriers: Standards and Materials (DTp).
5. Parking (commuter, service and goods vehicle)	Normally related to space per employee or per sq.m. of development.	Varies by Authority and relevant standards should be checked.

Note: Department of Transport (DTp) references are quoted and apply in England and Wales. Scottish Development Department and Northern Ireland Office equivalent references should be used as appropriate.

BACKGROUND

SURVEYS

Traffic and Parking

2.1 The principal objective of the Study was to investigate the traffic generations from Industrial and Commercial Estates throughout the United Kingdom. To achieve this objective it was necessary to survey a wide cross-section of Estates ranging in size from small single access sites with low occupancy levels to the large multi-access Estates with over 300 separate industrial and commercial units, including some large employers.

2.2 Site survey selection was constrained by study budget and timing considerations and the final sample comprised 58 sites (Figure 2) of which 21 Estates were in England; 14 in Scotland; 13 in Wales (including two in Rural Wales); and 10 in Northern Ireland. The surveys took place between September and mid-November, 1983.

2.3 The most important element of the Study was the Roadside Interview Survey. This used a simple, direct interview technique to provide data relating to the traffic generation from each Estate. Interviewing was carried out on one weekday at each site for the 12-hour period extending from 0700-1900 hours. A 100% sample rate was sought and achieved, except in very busy peak periods at some locations. A classified count, by half hour time intervals, of all outbound traffic, and separately for inbound traffic, was taken during the same survey period as the Roadside Interviews.

2.4 The Roadside Interviews recorded within each half hour time interval the following information for outbound traffic from each Estate:

(i) Vehicle Type/Occupancy (by inspection).

(ii) Firm visited on Estate.

(iii) Purpose of trip.

not to scale

SCOTTISH DEVELOPMENT AGENCY

101		ANNICK STREET (GLASCOW)
102		BEITH
103		BLANTYRE
104		CLYDEBANK
105		COATBRIDGE
106		COMNOCK
107		ETNA
108		LARKHALL
109		NEWBOUSE
110		PEFFERMILL (EDINBURGH)
111		PORT GLASGOW
112		TWEEDBANK
113		VALE OF LEVEN
114		WESTER GOURDIE (DUNDEE)

WELSH DEVELOPMENT AGENCY
*DEVELOPMENT BOARD FOR RURAL WALES

201		BRIDGEND
202	*	DYFFRYN (NEWTOWN)
203		KENFIG (PYLE)
204		MAESGLAS (NEWPORT)
205		MANOR FLINT
206		PONTHENRI (LLANELLI)
207		RASSAU (BRAUFORT)
208		SHOTTON
209		TREFOREST
210		TYNDALL STREET (CARDIFF)
211		UPPER BOAT (TREFOREST)
212	*	VASTRE (NEWTOWN)
213		WATERTON (BRIDGEND)

ENGLISH INDUSTRIAL ESTATES

301	ARGYLL STREET (BIRKENHEAD)
302	CARDEW ROAD (REDRUTH)
303	CONSETT LEADGATE
304	CONSETT NO 1
305	CRAMLINGTON (NEWCASTLE)
306	HELLABY (ROTHERHAM)
307	HOUGHTON LE SPRING
308	KNOWSLEY (LIVERPOOL)
309	LAMBERHEAD (WIGAN)
310	NEWQUAY
311	NORTH TYNE (WALLSEND)
312	PARR (ST.HELENS)
313	REKENDYKE (SOUTH SHIELDS)
314	RIVERSIDE PARK (MIDDLESBOROUGH)
315	SALTERBECK (WORKINGTON)
316	SEDGELETCH
317	SHAW LANE (DONCASTER)
318	SOLWAY MARYPORT
319	SOUTHPARK (SCUNTHORPE)
320	SUTTONFIELDS (HULL)
321	TEESIDE (MIDDLEBOROUGH)

INDUSTRIAL DEVELOPMENT BOARD OF NORTHERN IRELAND

401	ADELAIDE (BELFAST)
402	AUGHRIM ROAD (MAGHERAFELT)
403	BLARIS (LISBURN)
404	GORTRUSH (OMAGH)
405	GREENBANK (NEWRY)
406	HYDEPARK (BELFAST)
407	KNOCKMORE (LISBURN)
408	PENNYBRIDGE (BALLYMENA)
409	PENNYBURN (LONDONDERRY)
410	STEEPLE (ANTRIM)

LOCATION OF SURVEY SITES

Figure 2

(iv) Whether Firm had been visited previously that day.

2.5 For both traffic counts and the interviews, vehicles were sub-divided into the following classes:

(i) Cars.

(ii) Light Goods Vehicles (that is, vans up to 30 cwts unladen.

(iii) Heavy Goods Vehicles.

(The division at 30 cwts unladen is equivalent to 3.5 tons gross weight and is recognisable by having twin tyres on the rear axle).

2.6 The principal aim of the parking survey was to establish an assessment of the demand for parking within each Estate. This survey aimed to provide supplementary information and no detailed parking duration surveys were undertaken. In order to assess the peak parking demand twice daily records of all parked vehicles were made for each Estate. Usually the first count took place during mid-morning of the Roadside Interview Survey day followed by a second count during mid-afternoon.

Data relating to Firms Activity

2.7 Data were also collected on the activity of each unit on each Estate. These data were collected by the Development Agencies who were, in most cases, able to extract the data from their records.

2.8 The collected data for each unit comprised:

(i) Employment (by male and female, if available).

(ii) Gross Site Area.

(iii) Gross External Area of Floor Space.

(iv) Details of the main business undertaken.

(v) The activity of the site, categorised under manufacturing, warehousing, wholesale, retail, servicing, research, administration/management and other.

ANALYSES

2.9 For most of the survey period a 100% sample was achieved. Where this was not possible, expansion factors were applied. The next stage involved linking the results of the Roadside Interviews with the data obtained for each firm on each Estate. The edited and verified data were coded and keyed into a micro-computer in the format of one record per firm, (a total of 972 records). Each record contained:

(i) Firm number.

(ii) Male employees.

(iii) Female employees.

(iv) Total employees.

(v) Gross Site Area (acres).

(vi) Gross External Area of Floor Space (sq. ft. converted to sq. m.).

(vii) Standard Industrial Classification (SIC).

(viii) Firm's activity.

(ix) Total daily trips by car on work purpose.

(x) Total daily trips by car on business purpose.

(xi) Total daily trips by car on other purposes.

(xii) Total daily trips by goods vehicles.

(xiii) Name of Firm (subsequently deleted after completion of accuracy checks to retain total confidentiality for firms which participated in the project).

2.10 Table 2 sets out the basic parameters abstracted from the survey records.

TABLE 2

	Scot-land	Wales	Eng-land	N. Ire-land	Total
Estates by Locality:					
(i) Urban	4	1	4	4	13
(ii) Adjacent to Urban	8	7	9	4	28
(iii) Rural	2	5	8	2	17
TOTAL	14	13	21	10	58
Number of Firms	177	256	328	211	972
Total Employment	7,553	13,298	9,483	6,282	36,616
% Male Employment	N/A	54	63	N/A	N/A
Gross External Area of Floor Space (1,000 sq. m.)	323	493	378	269	1,463
Floor Area per Employee (sq. m./employee)	42	37	40	43	40
Car Work Trips/Employee	0.55	0.54	0.56	0.57	0.54

2.11 The greatest concentration of firms surveyed was in light engineering. More than two-thirds of the firms undertook manufacturing at their premises with a minority being involved in wholesale, servicing or other ancillary activities. In total some 38,000 trips were observed as being generated from all the sites during the 12-hour survey period. Of these 54% were car work trips, 12% car business trips, 9% car other trips, and 25% goods vehicle trips. Only nine Estates generated traffic in excess of 1,000 vehicles a day.

2.12 Investigations were undertaken in order to seek out the best regression equations for the various types of trip movement, using employment or floorspace as parameters. Linear regression provided the best fit to the data although the results obtained were affected to some degree by the skewness of the data and some "rogue", but valid, data entries. Reasonable relationships were developed for car work trip generation rates only. Car Business, Car Other and Goods Vehicle trip generation rates proved to be of limited accuracy and simplifying assumptions were necessary.

TRAFFIC GENERATION RELATIONSHIPS

GENERAL

3.1 The following section outlines the basic relationships developed from the survey data. (A fuller set of tabulations are enclosed within the supporting documents. Reference is made as appropriate).

3.2 Many of these relationships involve mathematical equations and, for simplicity of presentation, the following abbreviations have been used throughout this Report (and in the detailed Report on Surveys and Analyses).

(TE) - Total Employment.

(ME) - Male Employment.

(MEE) - Male Equivalent Employment (which incorporates a female to male equivalence for estimating traffic generation).

(FE) - Female Employment.

(GEA) - Gross External Area of Floor Space, (measured in units of 100 square metres).

EMPLOYMENT BY FLOOR SPACE

3.3 Having established total floor space for each Estate, it is required to project a first estimate of employment levels. The average floor space per employee within the surveyed sites was 40 sq. m./employee, but this average encompasses a very wide spread. Part of this spread of data points reflects the types of industrial and commercial activity that existed in the Survey. Table 3 illustrates average values by Type of Industrial Activity.

TABLE 3

Type of Industrial Activity		Floor Space per Employee (sq.m./employee)
(i)	The manufacture, processing and servicing of Food, Drink and Tobacco.	33
(ii)	The manufacture, processing and servicing of Chemicals and Pharmaceuticals.	44
(iii)	The manufacture, processing and servicing of Metals, Manufacturing and Vehicles.	48
(iv)	The manufacture, processing and servicing of "Other" manufacturing (which includes Paper and Printing, Bricks and Glass, Timber and Furniture and Construction).	43
(v)	The manufacture, processing and servicing of Instruments and Electrical.	27
(vi)	The manufacture, processing and servicing of Textiles and Clothing.	25
(vii)	All activities associated with Transport	34
(viii)	All Warehousing, Wholesale and Retail and Distributive Trades.	59
(ix)	All Professional and Administration, including Management and Research.	28

Source: Report on Surveys and Analyses (paragraphs 5.12 - 5.16).

3.4 As well as a large variation by type of industrial activity, there is also an observed large variation between the location of the sites: average floor space per employee varied between 27 sq. m. in urban areas, 40 in suburban areas and 52 in rural areas. An examination of the data illustrated that these variations by locality were independent of industry type. It can be assumed that the values given above represent typical suburban sites, but for urban areas the floor space rates should be decreased by 30% and for rural sites they should be increased by 30%.

EMPLOYMENT BY MALE/FEMALE

3.5 One of the major determinants of commuting trips by car to an Estate is found to be the number of female workers, as there is

a much lower car usage amongst such workers. Hence, it is important to have an indication of the percentage males to females. This percentage varies considerably by type of industrial activity. (Table 4).

TABLE 4

Type of Industrial Activity		% Male Employment
(i)	The manufacture, processing and servicing of Food, Drink and Tobacco.	61
(ii)	The manufacture, processing and servicing of Chemicals and Pharmaceuticals.	48
(iii)	The manufacture, processing and servicing of Metals, Manufacturing and Vehicles.	82
(iv)	The manufacture, processing and servicing of "Other" manufacturing (which includes Paper and Printing, Bricks and Glass, Timber and Furniture and Construction).	69
(v)	The manufacture, processing and servicing of Instruments and Electrical.	51
(vi)	The manufacture, processing and servicing of Textiles and Clothing.	26
(vii)	All activities associated with Transport	97
(viii)	All Warehousing, Wholesale and Retail and Distributive Trades.	70
(ix)	All Professional and Administration, including Management and Research.	75

Source: Report on Surveys and Analyses, (paragraph 5.23).

CAR WORK TRIPS

3.6 Detailed regression analyses indicated that the best prediction of car trips to work is the employment level of each site. This can be improved marginally if the percentage of males and females can be included - particularly important where there may be one or two very large female employing firms.

3.7 If no information on type of industrial activity is known and, hence, no indication of male/female split is available, then the best prediction can be obtained from:

CAR WORK TRIPS = 0.47 (TE) (Urban Sites)

CAR WORK TRIPS = 0.55 (TE) (Other Sites)

If the type of industrial activity or an estimation of male/female split is known, then an equivalent estimation of employment should be calculated on the basis of "one female equivalent to 0.7 male". (This factor to be used for traffic generation purposes only!) and the following equations should be used:

CAR WORK TRIPS = 0.50 (MEE) (Urban Sites)

CAR WORK TRIPS = 0.64 (MEE) (Other Sites)

3.8 For Transport and Distributive Trade groups, the trip rate should be increased by 15%. For Textiles and Clothing and for Instrument/Electrical the rate should be reduced by 15%. (Reference: Report on Surveys and Analyses, paragraph 5.23).

GOODS VEHICLE TRIPS

3.9 As with car work trips detailed regression analyses indicated that the best predictions of goods vehicle trips are based on the total employment of the site. However, these values are very poor due to the wide variation in the data. A global estimate of daily goods vehicle trips can be given on the basis of:

GOODS TRIPS = 0.25 (TE)

3.10 If information is known about the proposed type of industrial activity within the site the ratios set out in Table 5 can apply.

TABLE 5

Type of Industrial Activity		Goods Trip Rate per Employee
(i)	The manufacture, processing and servicing of Food, Drink and Tobacco.	0.50
(ii)	The manufacture, processing and servicing of Chemicals and Pharmaceuticals.	0.14
(iii)	The manufacture, processing and servicing of Metals, Manufacturing and Vehicles.	0.23
(iv)	The manufacture, processing and servicing of "Other" manufacturing (which includes Paper and Printing, Bricks and Glass, Timber and Furniture and Construction).	0.30
(v)	The manufacture, processing and servicing of Instruments and Electrical.	0.11
(vi)	The manufacture, processing and servicing of Textiles and Clothing.	0.11
(vii)	All activities associated with Transport	0.87
(viii)	All Warehousing, Wholesale and Retail and Distributive Trades.	0.91
(ix)	All Professional and Administration, including Management and Research.	0.26

Source: Report on Surveys and Analyses, (paragraphs 5.25 - 5.29).

BUSINESS AND OTHER TRIPS

3.11 The best estimate of daily business trips is given by:

BUSINESS TRIPS = 0.23 x CAR WORK TRIPS

and the best estimate of daily 'other' trips is given by:

OTHER TRIPS = 0.17 x CAR WORK TRIPS

(Reference: Report on Survey and Analyses, paragraph 5.32).

OTHER FACTORS

3.12 The Report on Surveys and Analyses identified a number of other factors which affect trip generation rates, for example, the size of the establishments and the details of the industry and activity being undertaken. If such details are known the planner can make use of some of the other factors determined from the analyses.

3.13 The data included in this Report relate to a range of typical industries and firms but they should not be used to estimate traffic from individual firms. Care must be taken if it is known that the development site is likely to contain a firm which might have specific requirements. In particular, the above estimates are unlikely to reflect adequately traffic generation from firms, such as:

retail outlets - superstores, DIY, etc.

cash and carry stores

major food distribution centres

dairies and bakeries

large depots for public utilities such as British Telecom, gas and electricity boards, post office.

PEAK AND OFF-PEAK HOUR TRAFFIC FLOWS

3.14 An important part of the traffic prediction for design purposes is the estimation of the peak hour flow and the average off-peak hour flows.

3.15 For most Estates, a prominent peak hour will occur in the late afternoon and factors appropriate to this peak hour have been developed from the surveyed data. These factors should be applied to the total daily generated traffic from the Estate as determined by the application of the appropriate traffic generation relationships.

3.16 Peak hour traffic outbound from an Estate could constitute some 20% of the equivalent Total Daily traffic. If trip type is known, this is equivalent to some 30% of Daily Car Work trips, plus 7% of Daily Goods trips, plus 7% of Daily Car Business trips, plus 10% of Daily Car Other trips.

3.17 A typical off-peak period (say 0900-1200 hours and 1330-1530 hours) can be assumed to have an hourly traffic flow of some 5-10% of the Total Daily traffic outbound from an Estate.

TWO-WAY TOTAL TRAFFIC FLOWS

3.18 To estimate Total Daily two-way traffic it can be assumed that

the inbound and outbound traffic totals are equal, after allowance has been made for any special circumstances, (for example, possible through traffic routeing of an Estate).

3.19 For the Peak Hour, traffic in the direction opposite to the dominant traffic flow is likely to constitute less than 5% of the equivalent Total Daily traffic flow for an Estate, after allowance has been made for any special circumstances (through routeing, etc.).

DATA VARIABILITY

3.20 All the factors and ratios set out above are average values and mention has been made of the wide spread within the data. The problem with using mean values throughout a prediction exercise is that it is likely that the end result will be exceeded on something like 50% of occasions. This is not an adequate base on which to design any infrastructure. A more appropriate design level is likely to be one that is exceeded on only one in ten or one in twenty occasions (that is, designed for the 90th or 95th percentile).

3.21 The degree of variability is accounted for by two factors. The first is the grouping together of different types of industry and activities into one data file and the other is the inherent variability of the data. (The Report on Surveys and Analyses illustrate the variability in floor space per employee, car work trips per employee, goods vehicle trip per employee and peak hour to daily traffic flow).

3.22 It is possible to see from the graphs contained in that Report the values that will not be exceeded by 1 in 10 or 1 in 20 cases in each set of relationships, but it would be inappropriate to use such values as it is an accumulation of several sets of variable data and there is no reason to expect that all the extreme values are additive; it is just as likely that the difference will be compensating. To arrive at an estimate of daily traffic the stages are:

(i) Estimate employment from floor space.

(ii) Estimate daily trip generation from employment.

To arrive at an estimate of peak hourly traffic the stages are:

(i) Estimate employment from floor space.

(ii) Estimate daily trip generation from employment.

(iii) Estimate peak hourly generation from daily trip generation.

(These stages may be a simple factoring or may involve a number of separate steps incorporating male/female split or trip generation by industry).

3.23 For a two stage estimation a 95th percentile value can be estimated from two separate distributions, taking their 80th percentile (approximately). For a three stage estimation a 95th percentile value can be estimated from three separate distributions taking their 60th percentiles (approximately). This is illustrated in Figures 3 and 4.

The 60th percentile and 80th percentile of each value can be estimated from the factors set out in Table 6 and should be applied to the mean values.

TABLE 6

	Ratio of Percentile to Mean	
	60th Percentile	80th Percentile
Floor space per employee (global)	1.15	1.40
Floor space per employee (by type of industrial activity)	1.10	1.30
Car trips per employee (global)	1.15	1.70
Car trips per employee (by type of industrial activity)	1.15	1.50
Goods trips per employee (global)	1.50	3.20
Goods trips per employee (by type of industrial activity)	1.15	1.70
Peak Hour to Daily Factor	1.10	1.40

Source: Report on Surveys and Analyses (Section Eight).

3.24 If an upper estimate (unlikely to be exceeded by more than 1 in 20 cases) of daily traffic levels is to be made the 80th percentile factor should be applied to the equation. If an upper estimate (unlikely to be exceeded by more than 1 in 20 cases) of a peak hour flow is to be made then the 60th percentile factors should be applied to each equation.

CAR PARKING

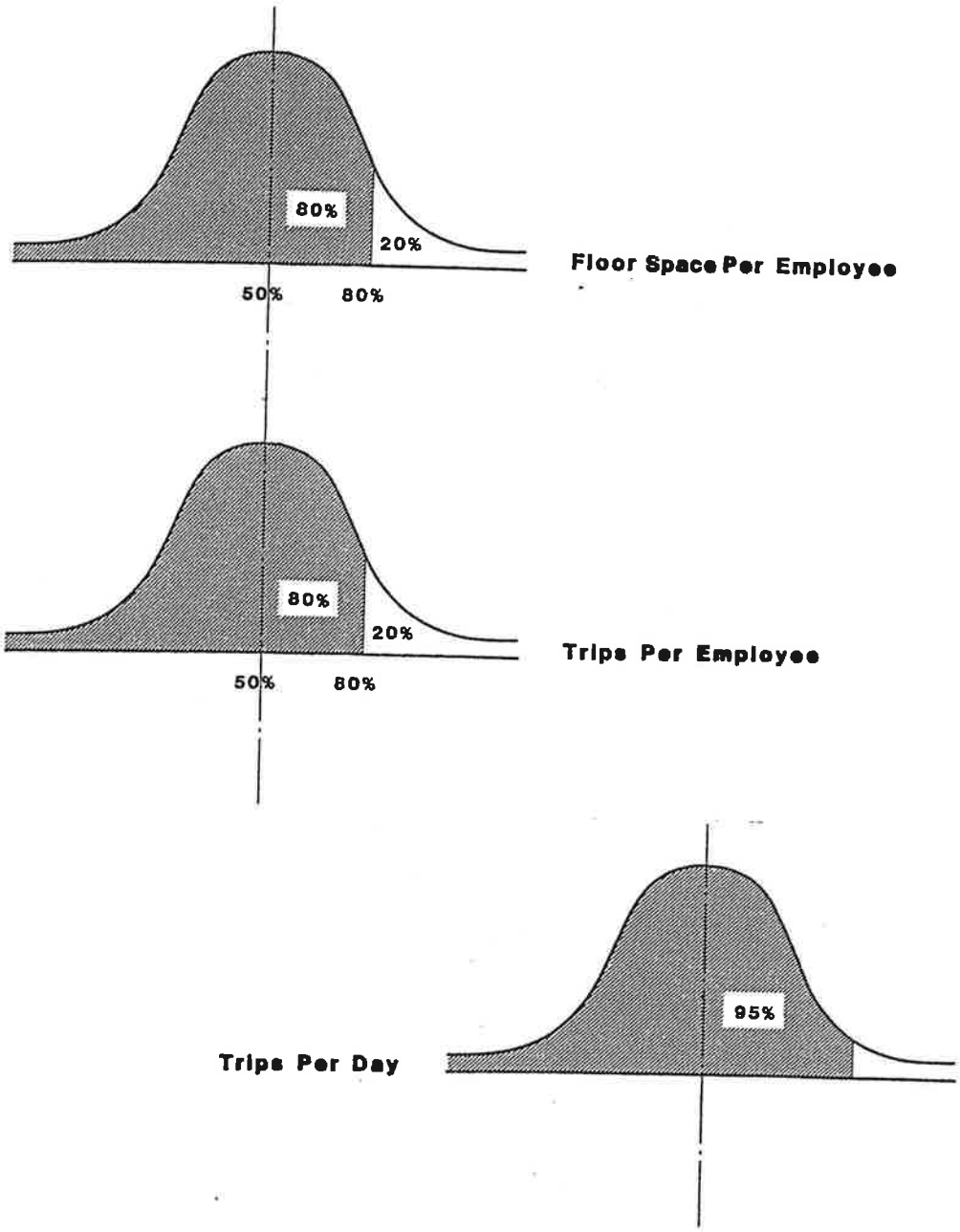
3.25 One of the basic design criteria in the layout of an Estate is the extent of car parking required. In general, parking divides into three types, namely, Operational (that is, essential to the business and comprises commercial vehicle and car parking), Visitor and Commuter. The surveys conducted as part of this Project were not designed to undertake a comprehensive examination of parking but were intended to

identify general parameters related to overall parking needs. Estimates of parking are best calculated from known data provided for individual industrial and commercial activities.

3.26 Therefore, guidelines based on cars parked per 100 employees and per daily trips generated are produced. No sub-division between types of car parking has been attempted nor have estimates been made of operational spaces for commercial vehicles.

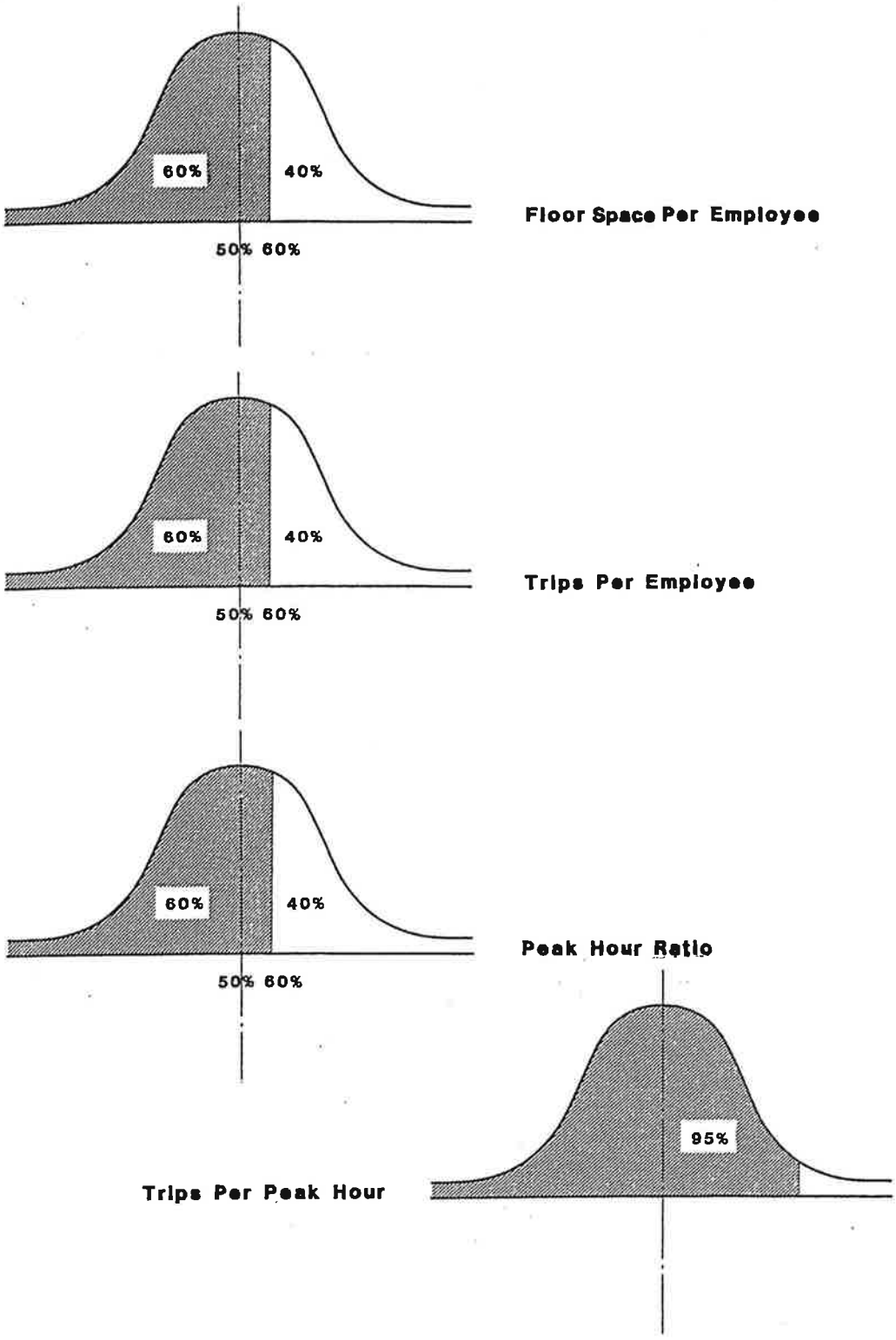
3.27 At an Estate level, an average estimate of the order of 27 cars parked per 100 employees was surveyed (equivalent to 44 at the 85th percentile value). Based on daily trip generation, the mean cars parked represented 38% (equivalent to 47% at the 85th percentile value).

3.28 A comparison of these overall guidelines indicates that the use of the daily trip value as a prediction gives less variation, but as this can only be used once the detailed calculation of trip generation rates is completed, it is probably as simple to make use of the cars parked per 100 employees value.



TWO STAGE MODEL

Figure 3



THREE STAGE MODEL

Figure 4

WORKED EXAMPLES

GENERAL

4.1 The calculations for two worked examples are set out. Common assumptions for each are a suburban location and 50,000 square metres of Gross External Area of floor space. In Worked Example (1) this floor space has a general allocation to Industrial Units. However, in Worked Example (2) it is assumed that 50% of these units would be for Mechanical Engineering activities, 25% for Textiles and Clothing and 25% for Professional and Administrative.

4.2 The differences in results are explained in an overall comment and reflect better accuracy obtained if more is known about the activities likely to occupy an industrial or commercial site.

(1) FIRST ESTIMATES OF TRAFFIC GENERATIONS

Calculations	Reference
(A) <u>This assumes a preliminary investigation where little is known of the potential for the site.</u>	
Stage 1: Basic input planning parameters. (a) Suburban location. (b) 50,000 sq.m. (GEA of floor space) industrial units.	
Stage 2: First Estimate of Employment	
<u>Assume:</u> 40 sq. m. per employee (suburban) Number of Employees (TE) = 50,000 ÷ 40 = <u>1,250</u>	para 3.4
Stage 3: No information available on Type of Industrial Activity or Male/Female Split	
<u>Assume:</u> CAR WORK TRIPS = 0.55 (TE) Daily Car Work Trips = 0.55 x 1,250 = <u>690</u>	para 3.7
<u>Assume:</u> GOODS TRIPS = 0.25 (TE) Daily Goods Trips = 0.25 x 1,250 = <u>310</u>	para 3.9
<u>Assume:</u> CAR BUSINESS TRIPS = 0.23 (Car Work Trips) Daily Car Business Trip = 0.23 x 700 = <u>160</u>	para 3.11
<u>Assume:</u> CAR OTHER TRIPS = 0.17 (Car Work Trips) Daily Car Other Trips = 0.17 x 700 = <u>120</u>	para 3.11
TOTAL DAILY TRIPS = 690 + 310 + 160 + 120 = <u>1,280</u> (Outbound)	
TOTAL DAILY TRIPS = <u>1,280</u> (Inbound)	para 3.18
THEREFORE, TOTAL DAILY TWO-WAY TRIPS = <u>2,560</u>	
Stage 4: Daily to Peak Hour Conversions	
Car Work Trips = 30% Daily Car Work Trips = 0.30 x 690 = <u>210</u>	para 3.16
Goods Trips = 7% Daily Goods Trips = 0.07 x 310 = <u>20</u>	para 3.16

Calculations	Reference
Car Business Trips = 7% Daily Car Business Trips = 0.07 x 160 = 10	para 3.16
Car Other Trips = 10% Daily Car Other Trips = 0.10 x 120 = 10	para 3.16
TOTAL PEAK HOUR TRIPS = 210 + 20 + 10 + 10 = 250 (Outbound)	
TOTAL PEAK HOUR TRIPS = 0.05 x 1,290 = 60 (Inbound)	para 3.19
THEREFORE, TOTAL PEAK HOUR TWO-WAY TRIPS = 310	
This provides a first estimate of trip generation but no indication of the likely range of variation which could occur.	
Therefore, the calculations are repeated using 80th percentile values to arrive at a 95th percentile estimate of Daily trip generation and 60th percentile values to arrive at a 95th percentile estimate of Peak Hour trip generation.	para 3.20 to 3.24
(B) Calculation of Daily Trips using 80th percentile values to arrive at 95th percentile estimates	
Stage 1: (As before), Basic input planning parameters. (a) Suburban location. (b) 50,000 sq. m. (GEA of floor space) industrial units.	
Stage 2: Estimate of Employment.	
Assume: (80th percentile) sq.m. per employee = 1.40 Number of Employees (TE) = 1,250 x 1.40 = 1,750 (80th percentile)	Table 6 (A) Stage 2
Stage 3: No information available on Type of Industrial Activity or Male/Female Split	
Assume: CAR WORK TRIPS = 0.55 (TE)	para 3.7

WORKED EXAMPLE (1) (CONTINUED)

Calculations	Reference
Assume: Car Work Trips per employee = 1.70 (80th percentile) Daily Car Work Trips = 0.55 x 1,750 x 1.70 = 1,635 (95th percentile)	Table 6
Assume: GOODS TRIPS = 0.25 (TE)	para 3.9
Assume: Goods Trips per employee = 3.20 ((80th percentile) Daily Goods Trips = 0.25 x 1,750 x 3.20 = 1,400 (95th percentile)	Table 6
Assume: CAR BUSINESS TRIPS = 0.23 (CAR WORK TRIPS) Daily Car Business Trips = 0.23 x 1,635 = 375 (95th percentile)	para 3.11
Assume: CAR OTHER TRIPS = 0.17 (CAR WORK TRIPS) Daily Car Other Trips = 0.17 x 1,635 = 280 (95th percentile)	para 3.11
(95th percentile) TOTAL DAILY TRIPS (outbound) = 1,635 + 1,400 + 375 + 280 = 3,690	
(95th percentile) TOTAL DAILY TRIPS (inbound) = 3,690	para 3.18
THEREFORE, (95th percentile) TOTAL DAILY TWO-WAY TRIPS = 7,380	

(C) Calculation of Peak Hour Trips using 60th Percentile Values to arrive at 95th Percentile Estimates

Stage 1: (As before) basic input planning parameters.

(a) Suburban location.
(b) 50,000 sq. m. (GEA of floor space) industrial units.

Stage 2: Estimate of Employment	
Assume: sq. m. per employee = 1.15 (60th percentile) Number of employees (TE) = 1,250 x 1.15 = 1,440 (60th percentile)	Table 6 (A) Stage 2

WORKED EXAMPLE (1) (CONTINUED)

Calculations	Reference
Stage 3: No information available on Type of Industrial Activity or Male/Female Split.	
Assume CAR WORK TRIPS = 0.55 (TE)	para 3.7
Assume: Car Work Trips per employee = 1.15 (60th percentile) Daily Car Work Trips = 0.55 x 1,440 x 1.15 = 910 (84th percentile)	Table 6
Assume: GOODS TRIPS = 0.25 (TE)	para 3.9
Assume: Goods Trips per employee = 1.50 (60th percentile) Daily Goods Trips = 0.25 x 1,440 x 1.50 = 540 (84th percentile)	
Assume: CAR BUSINESS TRIPS = 0.23 (CAR WORK TRIPS) Daily Car Business Trips = 0.23 x 910 = 210 (84th percentile)	para 3.11
Assume: CAR OTHER TRIPS = 0.17 (CAR WORK TRIPS) Daily Car Other Trips = 0.17 x 910 = 155 (84th percentile)	para 3.11
(84th percentile) TOTAL DAILY TRIPS (outbound) = 910 + 540 + 210 + 155 = 1,815	
Stage 4: Daily to Peak Hour Conversions	
(84th percentile) Car Work Trips = 30% Daily Car Work Trips = 0.30 x 925 = 270	para 3.16
Goods Trips = 7% Daily Goods Trips = 0.07 x 540 = 40	para 3.16
Car Business Trips = 7% Daily Car Business Trips = 0.07 x 210 = 15	para 3.16
Car Other Trips = 10% Daily Car Other Trips = 0.10 x 155 = 15	para 3.16
(84th percentile) Total Peak Hour Trips (outbound) = 270 + 40 + 15 + 15 = 340	

WORKED EXAMPLE (1) (CONTINUED)

Calculations			Reference
Assume: (60th percentile) Peak Hour to Daily Factor = 1.10			Table 6
(95th percentile) TOTAL PEAK HOUR TRIPS (outbound) = 350 x 1.10 =		375	
(95th percentile) TOTAL PEAK HOUR TRIPS (inbound) = 0.05 x 3,690 =		185	para 3.19
THEREFORE, (95th percentile) TOTAL PEAK HOUR TWO-WAY TRIPS =		560	
(D) SUMMARY			
These procedures estimate the:			
(Mean) TOTAL DAILY TRIPS (Outbound)	=	1,280	(A) Stage 3
(Mean) TOTAL DAILY TRIPS (Inbound)	=	1,280	(A) Stage 3
(Mean) TOTAL DAILY TRIPS (Two-Way)	=	2,560	(A) Stage 3
(95th percentile) TOTAL DAILY TRIPS (Outbound)	=	3,690	(B) Stage 3
(95th percentile) TOTAL DAILY TRIPS (Inbound)	=	3,690	(B) Stage 3
(95th percentile) TOTAL DAILY TRIPS (Two-Way)	=	7,380	(B) Stage 3
(Mean) TOTAL PEAK HOUR TRIPS (Outbound)	=	250	(A) Stage 4
(Mean) TOTAL PEAK HOUR TRIPS (Inbound)	=	60	(A) Stage 4
(Mean) TOTAL PEAK HOUR TRIPS (Two-Way)	=	310	(A) Stage 4
(95th percentile) TOTAL PEAK HOUR TRIPS (Outbound)	=	375	(C) Stage 4
(95th percentile) TOTAL PEAK HOUR TRIPS (Inbound)	=	185	(C) Stage 4
(95th percentile) TOTAL PEAK HOUR TRIPS (Two-Way)	=	560	(C) Stage 4

(Note: The 95th percentile represents the level of estimate unlikely to be exceeded by more than 1 in 20 occasions).

(2) SECOND ESTIMATES OF TRAFFIC GENERATIONS

Calculation	Reference

(E) <u>This assumes the same site characteristics as in Worked Example (1) but with more information known</u>

Stage 1: Basic input planning parameters.

(a) Suburban location.
(b) 50,000 sq. m. (GEA of floor space) Industrial Units.
(c) 50% Mechanical engineering
25% Textiles and Clothing
25% Professional and Administration.

Stage 2: Estimates of Employment

<u>Assume:</u> Mechanical engineering = 48 sq.m./employee — Table 3
Textiles and Clothing = 25 sq.m./employee — Table 3
Professional and Admin.= 28 sq.m./employee — Table 3

Number of Employees (TE) in:
Mechanical engineering = 50,000 x 0.50 - 48 = 520
Textiles and clothing = 50,000 x 0.25 - 25 = 500
Professional/Admin. = 50,000 x 0.25 - 28 = 445

Number of Employees (TE) = 520 + 500 + 445
= <u>1,465</u>

<u>Assume:</u> Male/Female employment split.
Mechanical engineering = 82% male — Table 4
Textiles and clothing = 26% male — Table 4
Professional/Admin. = 75% male — Table 4

<u>Assume:</u> Male equivalent employment (MEE) ratio of 0.7 for Female employees — para 3.7

Male Equivalent Employment (MEE)
Mechanical engineering = 520 (0.82 + 0.18 x 0.7)
= <u>490</u>
Textiles and clothing = 500 (0.26 + 0.74 x 0.7)
= <u>390</u>
Professional/Admin. = 445 (0.75 + 0.25 x 0.7)
= <u>410</u>

TOTAL MALE EQUIVALENT EMPLOYMENT (MEE) = <u>1,290</u>

WORKED EXAMPLE (2) (CONTINUED)

Calculation			Reference
Stage 3: Estimation of Daily Trips			
Assume: CAR WORK TRIPS = 0.64 (MEE)			para 3.7
Daily Car Work Trips:			
Mechanical engineering = 0.64 x 490	=	315	
Textiles and clothing = 0.64 x 390 (x 0.85)	=	210	para 3.8
Professional/Admin. = 0.64 x 410	=	260	
Daily Car Work Trips = 315 + 210 + 260	=	785	
Assume:			
(Mechanical engineering) GOODS TRIPS = 0.23 (TE)			Table 5
= 0.23 x 520	=	120	
(Textiles and Clothing) GOODS TRIPS = 0.11 (TE)			Table 5
= 0.11 x 500	=	55	
(Professional/Admin.) GOODS TRIPS = 0.26 (TE)			Table 5
= 0.26 x 445	=	115	
Daily Goods Trips = 120 + 55 + 115	=	290	
Assume: CAR BUSINESS TRIPS = 0.23 (CAR WORK TRIPS)			para 3.11
Daily Car Business Trips = 0.23 x 785	=	180	
Assume: CAR OTHER TRIPS = 0.17 (CAR WORK TRIPS)			para 3.11
Daily Car Other Trips = 0.17 x 785	=	135	
TOTAL DAILY TRIPS = 785 + 290 + 180 + 135 (Outbound)	=	1,390	
TOTAL DAILY TRIPS (Inbound)	=	1,390	para 3.18
THEREFORE, TOTAL DAILY TWO-WAY TRIPS	=	2,780	

WORKED EXAMPLE (2) (CONTINUED)

Calculation	Reference
Stage 4: Daily to Peak Hour Conversions	
Car Work Trips = 30% Daily Car Work Trips = 0.30 x 785 = 235	para 3.16
Goods Trips = 7% Daily Goods Trips = 0.07 x 290 = 20	para 3.16
Car Business Trips = 7% Daily Car Business Trips = 0.07 x 180 = 10	para 3.16
Car Other Trips = 10% Daily Car Other Trips = 0.10 x 135 = 15	para 3.16
TOTAL PEAK HOUR TRIPS = 235 + 20 + 10 + 15 = 280 (Outbound)	
TOTAL PEAK HOUR TRIPS = 0.05 x 1,390 = 70 (Inbound)	para 3.19
THEREFORE, TOTAL PEAK HOUR TWO-WAY TRIPS = 350	
This provides a first estimate of trip generation but no indication of the likely range of variation which could occur.	
Therefore, the calculations are repeated using 80th percentile values to arrive at a 95th percentile estimate of daily trip generation and 60th percentile values to arrive at a 95th percentile estimate of Peak Hour trip generation.	para 3.20 - 3.24

(F) Calculation of Daily Trips using 80th percentile values to arrive at 95th percentile estimates

Stage 1: (As before) basic input planning parameters.

(a) Suburban location.
(b) 50,000 sq. m. (GEA of floor space) Industrial Units.
(c) 50% Mechanical engineering.
25% Textiles and clothing.
25% Professional and Administration.

WORKED EXAMPLE (2) (CONTINUED)

Calculation	Reference
Stage 2: Estimates of Employment	
Assume: (80th percentile) sq.m. per employee = 1.30	Table 6
(80th percentile) Number of employees (TE) in:	(E) Stage 2
Mechanical engineering = 520 x 1.30 = 675	
Textiles and clothing = 500 x 1.30 = 650	
Professional/Admin. = 445 x 1.30 = 580	
(80th percentile) number of employees (TE) = 1,905	
(80th percentile) male equivalent employment (MEE) in:	(E) Stage 2
Mechanical engineering = 490 x 1.30 = 635	
Textiles and clothing = 390 x 1.30 = 505	
Professional/Admin = 410 x 1.30 = 535	
(80th percentile) male equivalent employment (MEE) = 1,675	
Stage 3: Estimation of Daily Trips	
Assume: CAR WORK TRIPS = 0.64 (MEE)	para 3.7
Assume: (80th percentile) Car Work Trips per employee = 1.50	Table 6
(95th percentile) Daily Car Work Trips	
Mechanical engineering = 0.64 x 635 x 1.50 = 610	
Textiles and clothing = 0.64 x 505 (x 0.85) x 1.50 = 410	para 3.8
Professional/Admin. = 0.64 x 535 x 1.50 = 515	
(95th percentile) Daily Car Work Trips = 1,535	
Assume: GOODS TRIPS = 0.23 (TE) (Mechanical engineering)	Table 5
Assume: GOODS TRIPS = 0.11 (TE) (Textiles and clothing)	Table 5
Assume: GOODS TRIPS = 0.26 (TE) (Professional/Admin.)	Table 5

Calculation	Reference
Assume: (80th percentile) Goods Trips per employee = 1.70	Table 6
(95th percentile) Daily Goods Trips in:	
Mechanical engineering = 0.23 x 675 x 1.70 = 265	(F) Stage 2
Textiles and clothing = 0.11 x 650 x 1.70 = 120	(F) Stage 2
Professional/Admin. = 0.26 x 580 x 1.70 = 255	(F) Stage 2
(95th percentile) Daily Goods Trips = 640	
Assume: CAR BUSINESS TRIPS = 0.23 (CAR WORK TRIPS)	para 3.11
(95th percentile) Daily Car Business Trips = 0.23 x 1,535 = 355	
Assume: CAR OTHER TRIPS = 0.17 (CAR WORK TRIPS)	para 3.11
(95th percentile) Daily Car Other Trips = 0.17 x 1,535 = 260	
(95th percentile) TOTAL DAILY TRIPS = 1,535 + 640 + 355 + 260 = 2,790 (Outbound)	
(95th percentile) TOTAL DAILY TRIPS = 2,790 (Inbound)	
THEREFORE, (95th percentile) TOTAL DAILY TWO-WAY TRIPS = 5,580	

(G) Calculation of Peak Hour Trips using 60th percentile values to arrive at 95th percentile estimates

Stage 1: (As before) Basic input planning parameters.

(a) Suburban location.
(b) 50,000 sq.m. (GEA of floor space) Industrial Units.
(c) 50% Mechanical engineering
25% Textiles and clothing
25% Professional and administration.

Stage 2: Estimates of Employment

Assume: (60th percentile) sq.m. per employee = 1.10 | Table 6

WORKED EXAMPLE (2) (CONTINUED)

Calculation			Reference
(60th percentile) number of employees (TE) in:			(E) Stage 2
Mechanical engineering	= 520 x 1.10 =	570	
Textiles and clothing	= 500 x 1.10 =	550	
Professional and Admin	= 445 x 1.10 =	490	
(60th percentile) number of employees (TE) =		1,610	
(60th percentile) Male Equivalent Employment (MEE) in:			(E) Stage 2
Mechanical engineering	= 490 x 1.10 =	540	
Textiles and clothing	= 390 x 1.10 =	430	
Professional and Admin	= 410 x 1.10 =	450	
(60th percentile) male equivalent employment (MEE) =		1,420	
Stage 3: Estimation of Daily Trips			
Assume: CAR WORK TRIPS = 0.64 (MEE)			para 3.7
Assume: (60th percentile) Car Work Trips per employee = 1.15			Table 6
(84th percentile) Daily Car Work Trips in:			
Mechanical engineering = 0.64 x 540 x 1.15 =		395	(G) Stage 2
Textiles and clothing = 0.64 x 430 (x 0.85) x 1.15 =		270	para 3.8
Professional/administation = 0.64 x 450 x 1.15 =		330	
(84th percentile) Daily Car Work Trips =		995	
Assume:			
GOODS TRIPS = 0.23 (TE) (mechanical engineering)			Table 5
GOODS TRIPS = 0.11 (TE) (textiles and clothing)			Table 5
GOODS TRIPS = 0.26 (TE) (professional/administration)			Table 5
Assume: (60th percentile) Goods Trips per employee = 1.15			Table 6

WORKED EXAMPLE (2) (CONTINUED)

Calculation	Reference
(84th percentile) Daily Goods Trips:	
Mechanical engineering = 0.23 x 570 x 1.15 = 150	(G) Stage 2
Textiles and clothing = 0.11 x 550 x 1.15 = 70	
Professional/admin. = 0.26 x 490 x 1.15 = 145	
(84th percentile) Daily Goods Trips = 365	
Assume: CAR BUSINESS TRIPS = 0.23 (CAR WORK TRIPS)	para 3.11
(84th percentile) Daily Car Business Trips = 0.23 x 995 = 230	
Assume: CAR OTHER TRIPS = 0.17 (CAR WORK TRIPS)	para 3.11
(84th percentile) Daily Car Other Trips = 0.17 x 995 = 170	
(84th percentile) TOTAL DAILY TRIPS (outbound) = 995 + 365 + 230 + 170 = 1,760	
(84th percentile) TOTAL DAILY TRIPS (inbound) = 1,760	
THEREFORE, (84th percentile) TOTAL DAILY TWO-WAY TRIPS = 3,520	
Stage 4: Daily to Peak Hour Conversions	
(84th percentile) Car Work Trips = 30% Daily Car Work Trips = 0.30 x 995 = 300	para 3.16
Goods Trips = 7% Daily Goods Trips = 0.07 x 365 = 25	
Car Business Trips = 7% Daily Car Business Trips = 0.07 x 230 = 15	
Car Other Trips = 10% Daily Car Other Trips = 0.10 x 170 = 15	
(84th percentile) Total Peak Hour Trips (outbound) = 300 + 25 + 15 + 15 = 355	
Assume: (60th percentile) Peak Hour to Daily Factor = 1.10	Table 6

Calculation			Reference
(95th percentile) TOTAL PEAK HOUR TRIPS (outbound)	= 355 x 1.10 =	390	
(95th percentile) TOTAL PEAK HOUR TRIPS (inbound)	= 0.05 x 2,790 =	140	para 3.19
THEREFORE, (95th percentile) TOTAL PEAK HOUR TWO-WAY TRIPS	=	530	

(H) SUMMARY

These procedures estimate the:

(Mean) TOTAL DAILY TRIPS (Outbound)	=	1,390	(E) Stage 3
(Mean) TOTAL DAILY TRIPS (Inbound)	=	1,390	(E) Stage 3
(Mean) TOTAL DAILY TRIPS (Two-way)	=	2,780	(E) Stage 3
(95th percentile) TOTAL DAILY TRIPS (Outbound)	=	2,790	(F) Stage 3
(95th percentile) TOTAL DAILY TRIPS (Inbound)	=	2,790	(F) Stage 3
(95th percentile) TOTAL DAILY TRIPS (Two-way)	=	5,580	(F) Stage 3
(Mean) TOTAL PEAK HOUR TRIPS (Outbound)	=	280	(E) Stage 4
(Mean) TOTAL PEAK HOUR TRIPS (Inbound)	=	70	(E) Stage 4
(Mean) TOTAL PEAK HOUR TRIPS (Two-way)	=	350	(E) Stage 4
(95th percentile) TOTAL PEAK HOUR TRIPS (Outbound)	=	390	(G) Stage 4
(95th percentile) TOTAL PEAK HOUR TRIPS (Inbound)	=	140	(G) Stage 4
(95th percentile) TOTAL PEAK HOUR TRIPS (Two-way)	=	530	(G) Stage 4

(Note: The 95th percentile represents the level of estimate unlikely to be exceeded by more than 1 in 20 occasions).

WORKED EXAMPLES (1) AND (2)

(I) Overall Comment

Comparison of the results obtained from Worked Examples (1) and (2) reflect the variation in the level of basic input planning parameters. The differences between the mean and 95th percentile values are lessened with the inclusion of more detailed input data in the calculations. These are illustrated in the following Table.

	(1)	(2)
(Mean Values)		
Total Daily Trips (2-way)	2,560	2,780
Peak Hour Trips (2-way)	310	350
(95th percentile values)		
Total Daily Trips (2-way)	7,470	5,580
Peak Hour Trips (2-way)	560	530
Ratio of 95th percentile to Mean Values for:		
Total Daily Trips (2-way)	2.9	2.0
Peak Hour Trips (2-way)	1.8	1.5

(1) Site location and total area of Industrial Activity assumed.
(2) Site location and area of Industrial Activity by type assumed.

(J) First Estimates of Car Parking Requirements

(i) Estimate based on Number of Employees (see para 3.27).

Number of Employees = 1,465 (Example 2)

Mean Car Parking = 27 cars parked per 100 employees
= 400 cars parked (650 @ 85th percentile value)

(ii) Estimate based on Daily Trip Generations (see para 3.27).

Mean Total Daily Trips = 1,390 (inbound or outbound - Example (2))

Mean Car Parking = 38% of daily trip generations
= 530 cars parked (650 @ 85th percentile value)

Note: Detailed estimates are best calculated from known data provided for individual, industrial and commercial activities.

APPENDIX

APPENDIX

GLOSSARY OF TERMS USED IN TRAFFIC GENERATION STUDIES

TRIP:	A one-way movement between a point of origin and a point of destination.
TRIP PURPOSE:	Stratification of person/vehicle trips by journey purpose.
TRAFFIC:	All vehicle types on a given section of the road network: a standard classification of vehicle types is usually applied.
PEAK HOUR TRAFFIC:	In respect of any road the period of one hour's duration in the 24 hour day during which the greatest amount of traffic is carried: in practise it is usual to distinguish morning, mid-day, or evening peak hours.
PRIVATE VEHICLE:	Generally includes 3-wheeled vehicles, estate cars, light vans with side windows to the rear of the driver, taxis, mini-buses and car towing caravan or trailer.
LIGHT COMMERCIAL VEHICLE:	All goods vehicles up to 30 cwt unladen weight.
HEAVY COMMERCIAL VEHICLE:	All goods vehicles over 30 cwt unladen weight.
MODAL CHOICE:	The choice of mode of transport selected in travelling.
PCU:	The measurement of traffic flow in equivalent passenger car units.
ROAD CAPACITY:	The practical capacity in terms of vehicles per hour that can be accommodated on a section or road: a road has reached and exceeded capacity if queues are formed and congestion ensues.
JUNCTION CAPACITY:	The practical capacity of a road junction, a roundabout or a signalised junction: queues are generally formed in the peak period if the capacity is exceeded.

TRIP GENERATION: The prediction of future levels of person or vehicle travel, usually by traffic zone: in the case of Industrial and Commercial Estates the trip generation rate is a function of three main variables, namely

(i) Site Area

(ii) Gross Floor Space

(iii) Size of Employment

EXPANSION FACTORS: Growth factors used to estimate future trip ends by traffic zones using trip generation rates that have been derived from land-use data.

SIC: Standard Industrial Classification of type of industry/employment.