VOLUME 6 ROAD GEOMETRY
SECTION 2 JUNCTIONS

PART 1

TD 22/05

LAYOUT OF GRADE SEPARATED JUNCTIONS

SUMMARY

This Standard sets out the layout requirements for merge and diverge at grade separated junctions, and for weaving sections, at various levels of traffic flow. It is essential that comprehensive attention is paid to design if safe and efficient junctions are to be achieved. The effective performance of junctions is crucial to the efficient operation of the route. This Standard has been revised to take into account changes made in the revised TD 27/05 "Cross-Sections and Headrooms". A full revision of TD 22 is expected to be published later in 2005.

INSTRUCTIONS FOR USE

1. Remove Contents pages from Volume 6 and insert new Contents page for Volume 6 dated February 2005.

2. Remove TD 22/92 from Volume 6, Section 2 which is superseded by this Standard and archive as appropriate.

3. Insert TD 22/05 into Volume 6, Section 2.

4. Please archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd.

Volume 6 home page

THE HIGHWAYS AGENCY

SCOTTISH EXECUTIVE

WELSH ASSEMBLY GOVERNMENT
LLYWODRAETH CYNULLIAD CYMRU

THE DEPARTMENT FOR REGIONAL DEVELOPMENT
NORTHERN IRELAND

Layout of Grade Separated Junctions

Summary: This Standard sets out the layout requirements for merge and diverge at grade separated junctions, and for weaving sections, at various levels of traffic flow. It is essential that comprehensive attention is paid to design if safe and efficient junctions are to be achieved. The effective performance of junctions is crucial to the efficient operation of the route. This Standard has been revised to take into account changes made in the revised TD 27/05 "Cross-Sections and Headrooms". A full revision of TD 22 is expected to be published later in 2005.

Volume 6 home page

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

Volume 6 home page

VOLUME 6 ROAD GEOMETRY
SECTION 2 JUNCTIONS

PART 1

TD 22/05

LAYOUT OF GRADE SEPARATED JUNCTIONS

Contents

Chapter

1. Introduction
2. Design Procedure
3. Flow Standards
4. Geometric Standards
5. References
6. Enquiries

1. INTRODUCTION

General

1.1 This Standard benefits from the experience gained since the publication of **TD 22/86** which it now replaces. It had also become apparent that some extension of **TD 22/86** was necessary in view of higher predicted traffic flows.

1.2 The changes from **TD 22/86** can be summarised as follows:

i. the range of options for merges and diverges has been reduced to a selected option for each combination of flows;

ii. the flow range has been extended to include 5 lane carriageways where weaving requirements necessitate them;

iii. merges are specified as being operationally “channelled” to increase efficiency and safety; Diverges are treated as free flowing exits to clear the mainline;

iv. the use of auxiliary lanes is introduced where junctions are likely to be close to capacity for significant periods;

v. the design of weaving sections has been clarified and standards for 120/100A kph All-Purpose Roads introduced; and

vi. the section on Design Procedure in **TD 22/86** has been extended in this Standard to include procedures which cover the development of a junction and network strategy to arrive at a suitable level of junction provision. Procedures to ensure lane balance through a junction are also covered.

1.2A This interim revision (February 2005) has been made to take into account changes made in the revised **TD 27 (DMRB 6.1)**. The changes from TD 22/92 are:

(a) New paragraph 2.23A.

(b) Table 3/1 amended.

(c) Table 4/1 deleted.

(d) Figures 4/1, 4/2, 4/3 and 4/4 deleted.

(e) Changes to paragraphs 3.3, 4.1 and 4.14.

(f) Additional reference 4(h) in Chapter 5.

1.3 There may be occasions, particularly where projected traffic flows are at the lower end of the ranges, when even the minimum standards of provision put forward by this Standard prove difficult to achieve. Overseeing Departments will each be responsible for considering applications for relaxations and departures related to the Design Standards as set out here.

1.4 Such applications must be accompanied by the full technical, environmental and economic justifications in all cases, together with proposed ameliorative actions. They should include the location, any other relaxations or departures in the vicinity and the expected peak traffic loading in the design year, modified by any physical constraints.

1.5 For the purpose of these applications, relaxations shall be taken as a reduction in Standard from desirable minimum to absolute minimum. Departures shall be defined as being below absolute minimum. Relaxations and Departures shall be related to the design speed for the junction element, for example, the connector road, and shall be quoted in steps down in design speed as set out in **TA 43 (DMRB 6.1)** (Sections A3 and B1 refer: and Table B3 in **TD 9 (DMRB 6.1)**). For merges and diverges, design speed steps shall be taken as succeeding lines in Tables 4/4 and 4/5. For weaving lengths, design speed steps shall be taken as moving from para 4.22 to para 4.23.

Scope

1.6 This Standard sets out the layout and size requirements for new and improved grade separated junctions and interchanges on both rural and urban trunk roads and motorways where local and regional routes join them.

Implementation

1.7 This Standard should be used forthwith for all schemes for the construction and improvement of trunk roads including motorways currently being prepared provided that, in the opinion of the Overseeing Department, this would not result in significant additional expense or delay progress. Design organisations should confirm its application to particular schemes with the Overseeing Department.

Definitions

1.8 The terminology follows where possible the definitions contained in **BS 6100: Subsection 2.4.1:1990**.

1.9 The following additional terms have been defined for use in this Standard (See also Figure 1/1).

1.10 **Auxiliary Lane:** Additional lane at the side of the mainline carriageway to provide increased merge or diverge opportunity or additional space for weaving etc. - these used sometimes to be known as **parallel lanes**.

1.11 **Connector Road:** A collective term for interchange links, link roads, slip roads and loops.

1.12 **Downstream:** That part of the carriageway(s) where the traffic is flowing away from the section in question.

1.13 **Interchange:** Grade separated junction that provides free flow from one mainline to another.

1.14 **Interchange Link (formerly Link Roads):** Connector roads, one or two way, carrying free flowing traffic within an interchange between one level and/or direction and another.

1.15 **Link Road (formerly Collector-Distributor Road):** In the context of junctions, a one way connector road adjacent to, but separated from, the mainline carriageway travelling in the same direction, which is used to connect the mainline carriageway to the local highway network where successive direct connections cannot be provided to an adequate standard because the junction spacing is too close.

1.16 **Loops:** A connector road, one or two way, which passes through an angle of approximately 270 degrees.

1.17 **Mainline:** The carriageway carrying the main flow of traffic; generally traffic passing straight through the junction or interchange.

1.18 **Nose:** Paved section of carriageway before the merge or taper or after the diverge taper that separates the mainline from the connector road; delineated by road markings.

1.19 **Parallel Merge/Diverge:** Where an auxiliary lane is provided alongside the mainline carriageway to ease the merge or diverge manoeuvre.

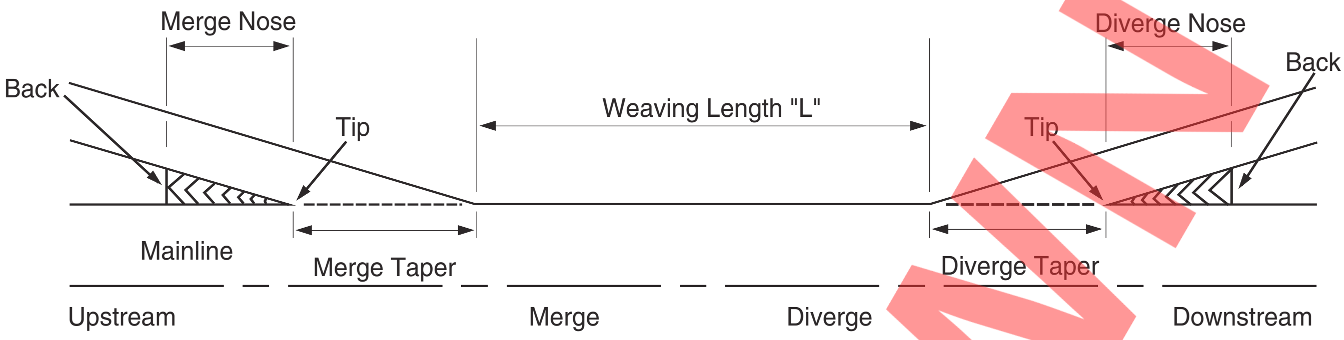
1.20 **Roads: Urban and Rural:** as defined in **TD 20** (DMRB 5.1), namely that an **Urban Road** is a road which is in a built up area which has either a single carriageway with a speed limit of 40mph or less or has a dual carriageway or is a motorway with a speed limit of 60mph or less. All other roads are **Rural Roads**.

1.21 **Slip Road:** A one way connector road within a junction between a mainline carriageway and the local highway network, or vice versa, which meets the local highway network at grade. Traffic using a slip road usually has to give way to traffic already on the mainline or on the local highway network.

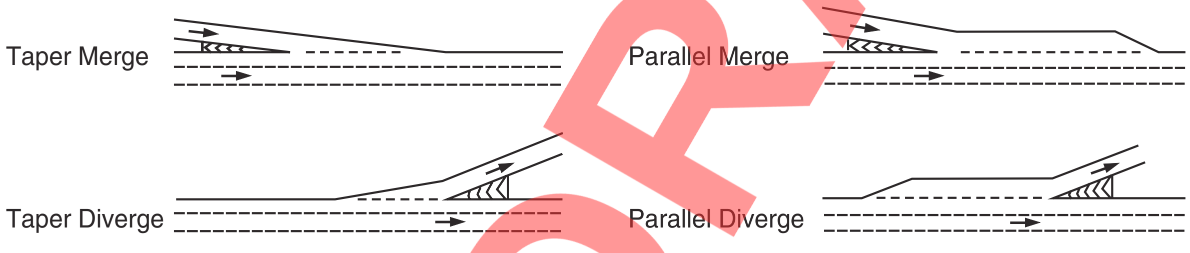
1.22 **Taper Merge/Diverge:** Where the merge or diverge joins or leaves the mainline carriageway through an area forming a funnel to or from the mainline carriageway.

1.23 **Upstream:** That part of the carriageway(s) where traffic is flowing towards the section in question.

1.24 **Weaving Section:** That section of carriageway where there is movement of traffic in the same general direction by which vehicles within two or more traffic streams intersect at a small angle so that the vehicles in one stream cross other streams gradually.



(a) Merge, Weaving Length, and Diverge



(b) Taper Merge/Diverge and Parallel Merge/Diverge

Figure 1/1: Defintion of Main Terms

2. DESIGN PROCEDURE

General Principles

2.1 Junction and Interchange design is an iterative process which is a key part of the overall design process for schemes. The flowchart (Figure 2/1) outlines that part of the process which touches on junction and interchange design.

2.2 The design of junctions is affected by decisions taken on the degree of access to be provided on the scheme. It is important to consider **from the outset** how much access should be allowed. It may not be possible to cater for the full predicted demand. Because other roads are crossed, it does not mean that a junction should be provided, or that if one is provided, it should be omnidirectional.

2.3 There could well be occasions when the design should not provide for certain movements to inhibit local commuting for the benefit of longer distance traffic and for environmental reasons to the benefit of local residents. The process of choosing between options as covered more fully in **TA 30 (DMRB 5.1)**.

2.4 The better scheme will use standard features and have comfortable weaving sections. Drivers should not be surprised by rare features when they use it.

The Design Process

2.5 Following through the flow-chart, the first stages would be to determine a network strategy, fix a design year, and decide whether urban or rural standards apply (see para 1.20). The next stage would then be to decide on an initial network and junction strategy - which connections should be made? Should the junction be omnidirectional? etc.

2.6 Having made those starting assumptions, it is then possible to derive low and high growth design year traffic flows from the traffic models (The **Traffic Appraisal Manual** (TAM) refers in England, Wales and Northern Ireland, and in Scotland, the **Scottish Traffic and Environmental Appraisal Manual** (STEAM) refers). An examination of these, applied to the network strategy adopted, will enable a decision to be taken (or confirmed) that the route should be Motorway or All-Purpose. Reference to **TD 20 (DMRB 5.1)** will give a starting point on the level of carriageway provision for the links on the network assumed.

2.7 The next stage, and the first step that could lead to iteration, is to look at the likely lane provision on the mainline and the connector roads. If the basic scheme cannot be tailored to cope with demands, including those likely to arise when maintenance work needs to be undertaken, then network and junction strategy will need to be reviewed and alternatives investigated - for example - reducing the number of junction accesses or using link roads. Link roads can reduce the frequency of direct access points along the mainline in order to ease weaving problems thus promoting free flow to preserve the high capacity of the mainline. They can also be used where it is unsafe or not possible to make direct connections.

2.8 The following stage may also lead to iteration. This is to determine the merge and diverge facilities and to check that weaving sections at or above the desirable minimum length can be provided. If these cannot be achieved, then the junction strategy should be reviewed.

2.9 The next stage is to check that desirable geometric standards can be achieved with the junction spacings, lane gains and lane drops proposed, and that an effective and economic signing system can be provided. Again the strategy may have to be adjusted.

2.10 Finally, the continuity of the lane provision and lane balance should be assessed to see that it meets the objectives of the strategy and is likely to cope with the expected demand.

2.11 If the junction and interchange designs pass these stages, the scheme can then be taken to the next stage in its preparation which is likely to be an assessment using **COBA** in England, Wales and Northern Ireland and **NESA** in Scotland. **COBA/NESA** analyses may not be sufficiently fine to evaluate the performance of individual junction elements. The best means of ensuring that a junction is effective is to carry out the operational check outlined above and on Figure 2/1.

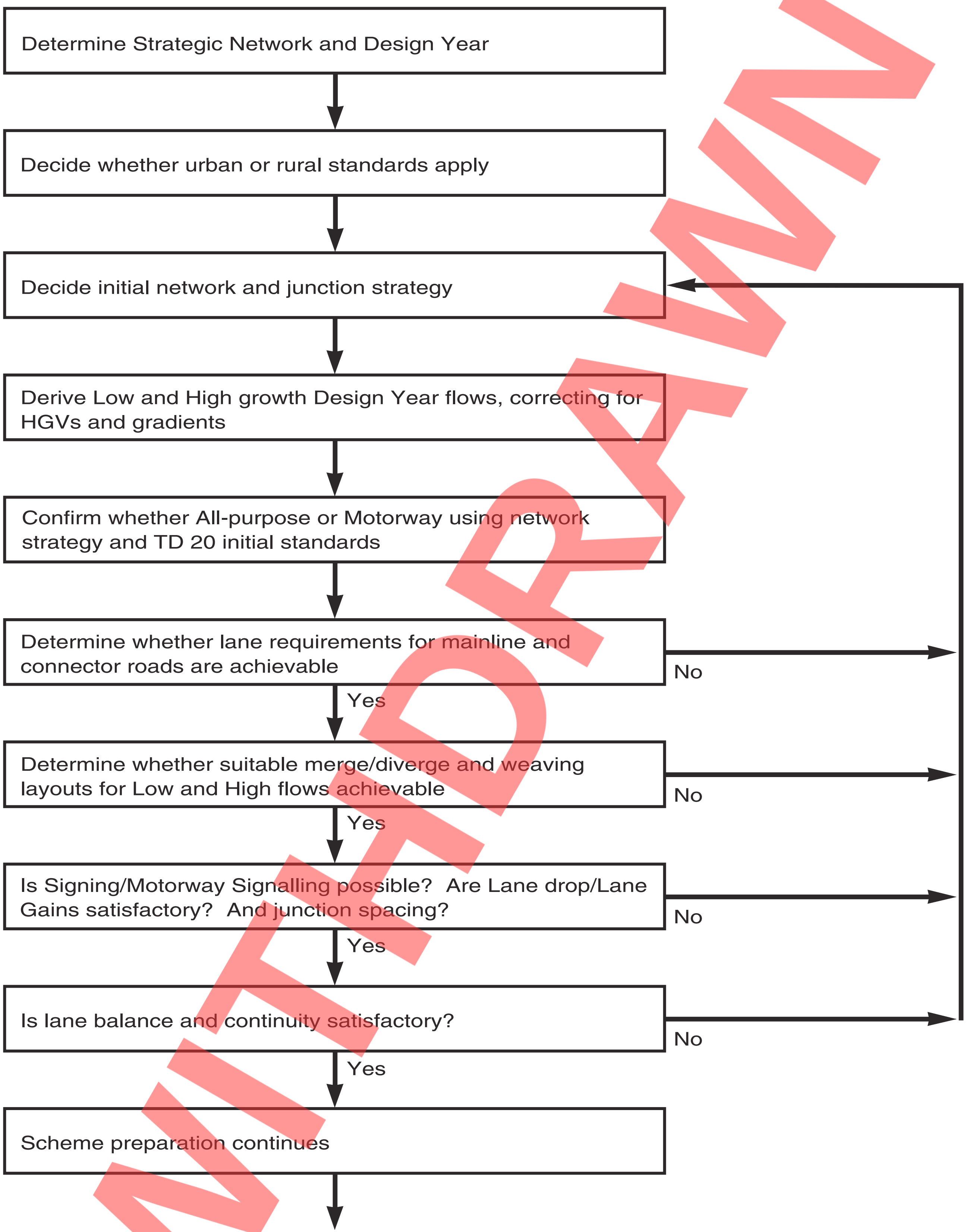


Figure 2/1: Flowchart Showing the Junction/Interchange Design Process

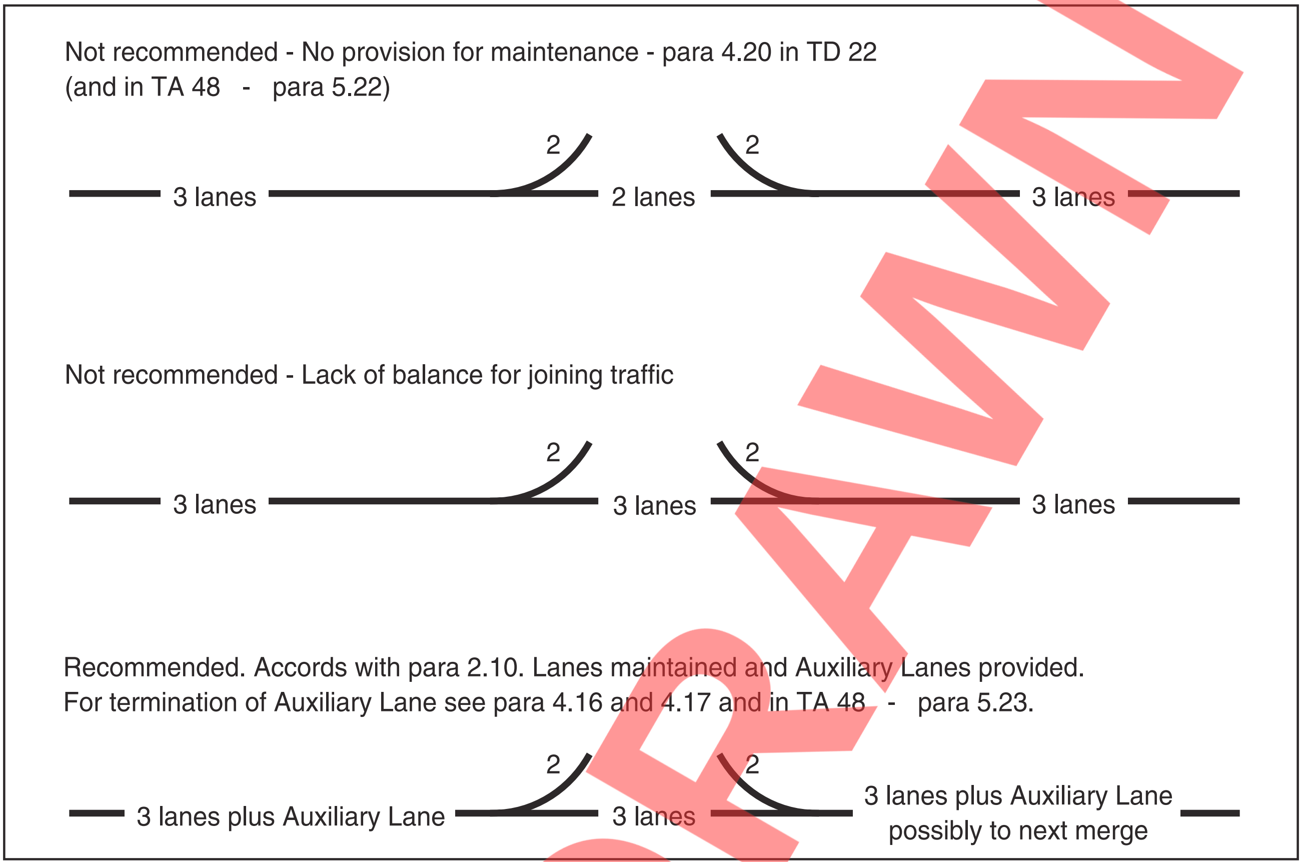


Figure 2/2 : Definition of Lane Balance - Example
Desirable Arrangement of Lanes Where Flow on Slip Roads Justifies Two Lanes

Junction and Interchange Design General Principles

2.12 A satisfactory junction or interchange design is unlikely to be achieved if the number of lanes, taking into account the mainline and the connector roads, does not balance through the junction or interchange (see Figure 2/2). Ideally, whether traffic is joining or leaving the mainline all that approaches a part of the junction either from the mainline or a connector road should be able to leave that part in equivalent comfort. This means that the number of lanes provided upstream of a section of the junction and the number to be provided downstream, either on the mainline or on a connector road, should not differ by more than one. It should be made clear to drivers by the consistent use of signs and road markings what the lane configurations ahead are where lane drops and lane gains occur, as outlined in **TA 58 (DMRB 8.2)**.

2.13 Where large traffic flows, close to capacity, are joining the mainline in an interchange or junction, turbulence can occur, with short headways and sudden braking. It may be necessary to consider a length of auxiliary lane to provide increased local capacity. This is covered more fully in para 4.16.

2.14 It may also be that the predicted turning flows are not realised in the proportions expected in the design year and the consequences of being wrong should be examined. Some form of sensitivity testing of flows should be undertaken as in the examples in Appendix 3 of **TA 23 (DMRB 6.2)**.

Merges - General Principles

2.15 It is important on safety grounds and to limit interference to mainline traffic that joining traffic is channelled into the merging area and arrives there in an orderly fashion to perform a safe and comfortable merge.

2.16 If joining flows are greater than one lane capacity then an additional lane should normally be added to the mainline as a lane gain. The individual merging area for each joining lane within a merge should be separated from the previous one and there should be space between them for mainline traffic to adjust.

2.17 Where design flows are close to capacity on both the connector road and on the mainline it is important to ensure that there is adequate provision for those merging. The use of auxiliary lanes should be considered, giving continuous merging opportunities, if the probability of merging opportunities is thought to be low for long periods of the day.

2.18 There may be occasions when the merge flow is greater than the mainline flow. The junction should be set out so that traffic entering from the left gives way to the mainline flow, except where additional lanes are provided on the downstream side.

Diverges - General Principles

2.19 Traffic should be able to leave the mainline and diverge area as easily and quickly as possible. Any queueing to rejoin the local network should be prevented as far as is possible from extending back to impede mainline traffic.

2.20 Where diverging flows exceed a single lane capacity and flows on the mainline flow are high, then those diverging should be given increased awareness of the diverge and prolonged opportunity to leave the mainline carriageway early by the provision of auxiliary lanes. Where there is a likelihood of queueing extending back onto the mainline carriageway, even with attention to the connection to the local road network, then auxiliary lanes should be considered so that queues occur off the mainline. Ideally, the capacity of the connections to the local highway network should be improved and this option should be examined first.

Designing Merges

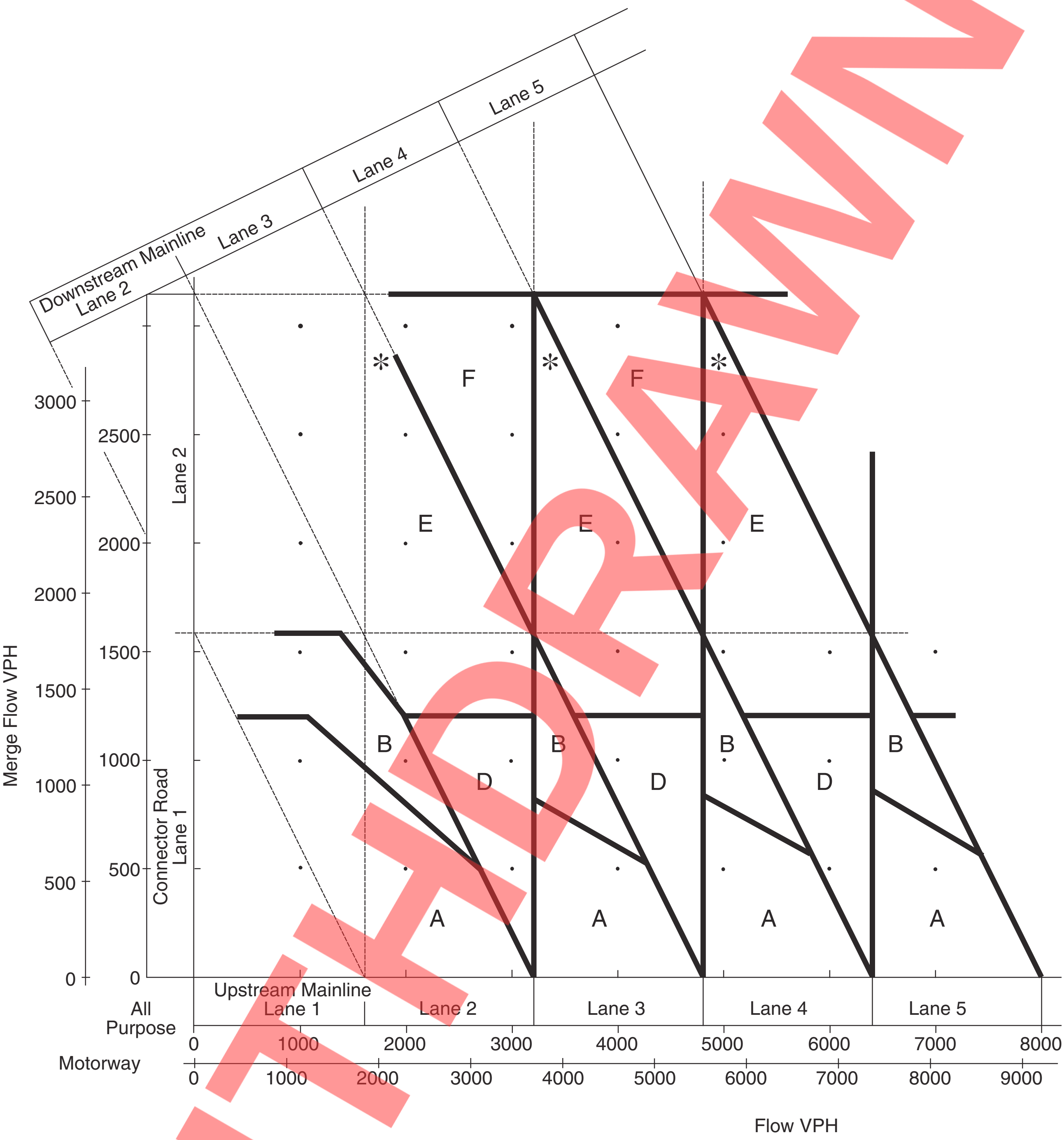
2.21 Hourly flows, as predicted from para 3.1 for the merge and the mainline upstream shall be inserted in Figure 2/3 to select a merge layout as shown in Figure 2/4. Where design flows lie close to, or on, a boundary between the flow regions, the probability of the particular flow actually occurring should be carefully reviewed so that unnecessary over provision of merge facilities is not made. That would neither be economic nor efficient as uncontrolled merging traffic could interfere with the free flow of the mainline.

2.22 Where, for reasons of route continuity, the mainline capacity provided is in excess of the design flows and a merging design flow of over one lane capacity is expected, then layout C of Figure 2/4 may be substituted for layout E, but normally, with such a large flow expected to merge, a lane would be added to the mainline.

Designing Diverges

2.23 The procedure shall be as in 2.21 previously but with diverge and downstream flows inserted in Figure 2/5 used to select a diverge layout from Figure 2/6.

2.23A The provision of a Layout B Parallel Diverge on a 4 lane mainline would create a 6 lane carriageway, contrary to the requirements of **TD 27 (DMRB 6.1)**. Any proposal for such a layout must be referred to the Overseeing Organisation.



* Consider extended Auxiliary Lane

Figure 2/3: Merging Diagram

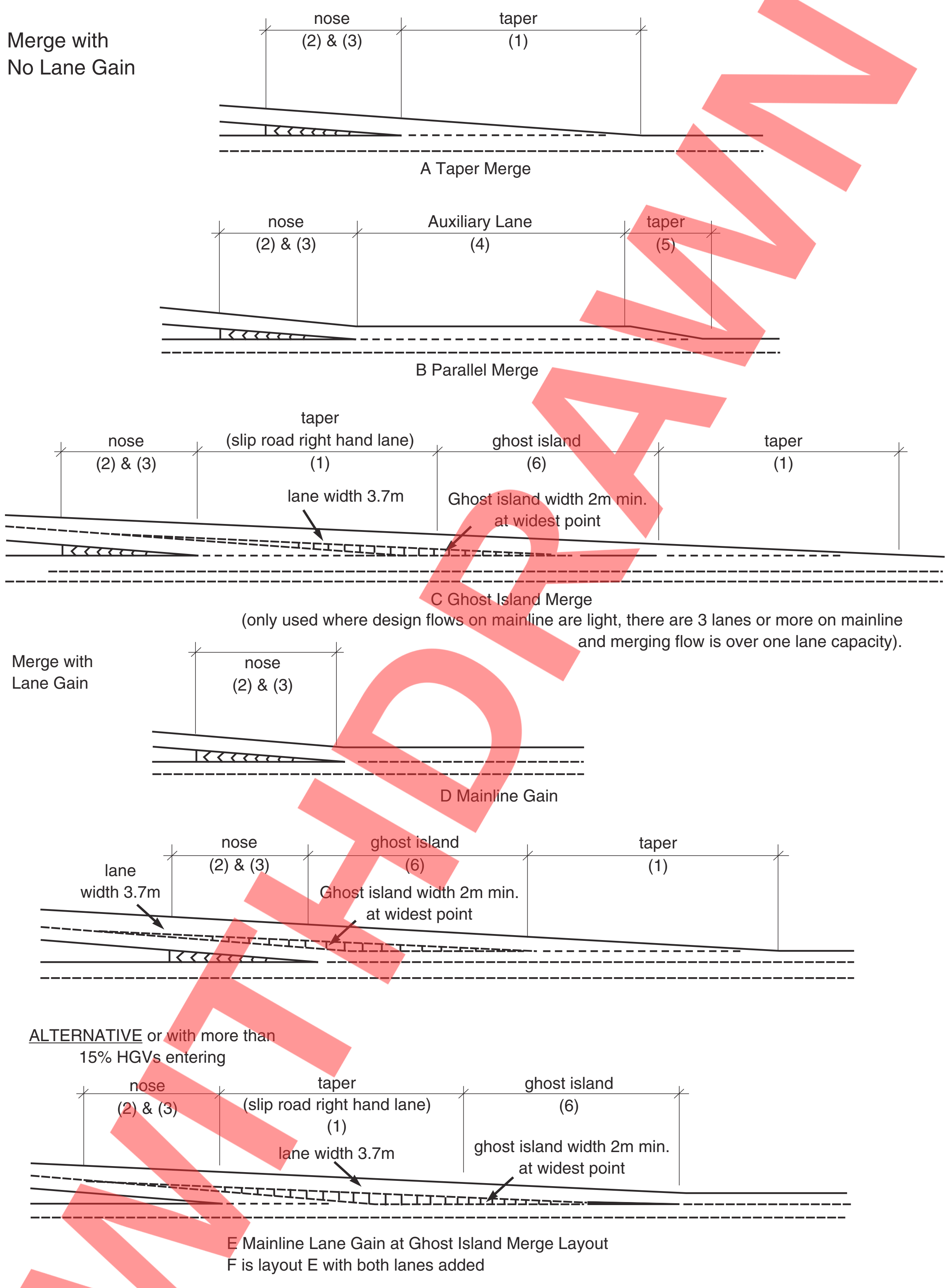


Figure 2/4: Merge Lane Layouts for Use with Figure 2/3
N.B. Figures in brackets refer to columns in Table 4/4

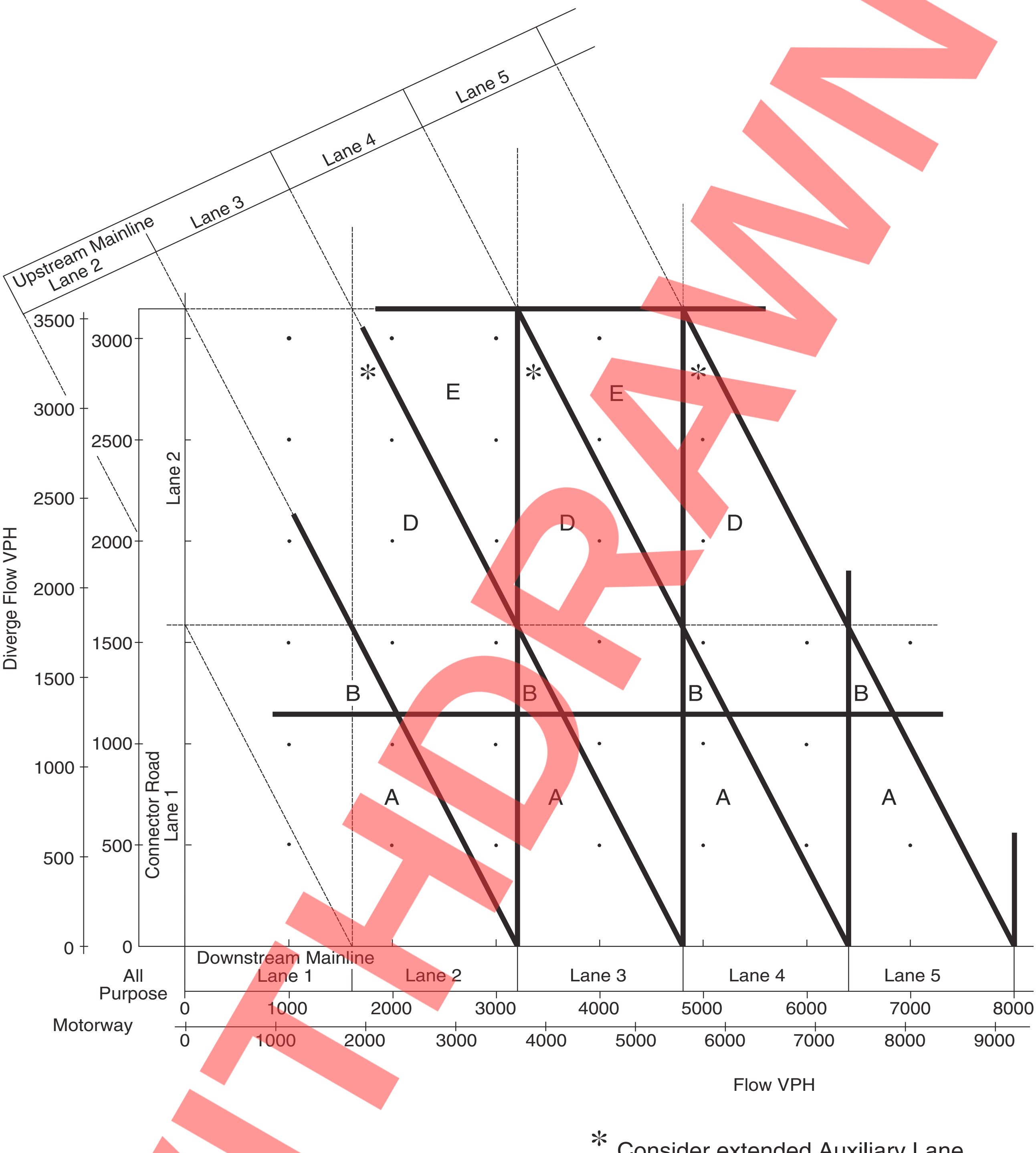


Figure 2/5: Diverging Diagram

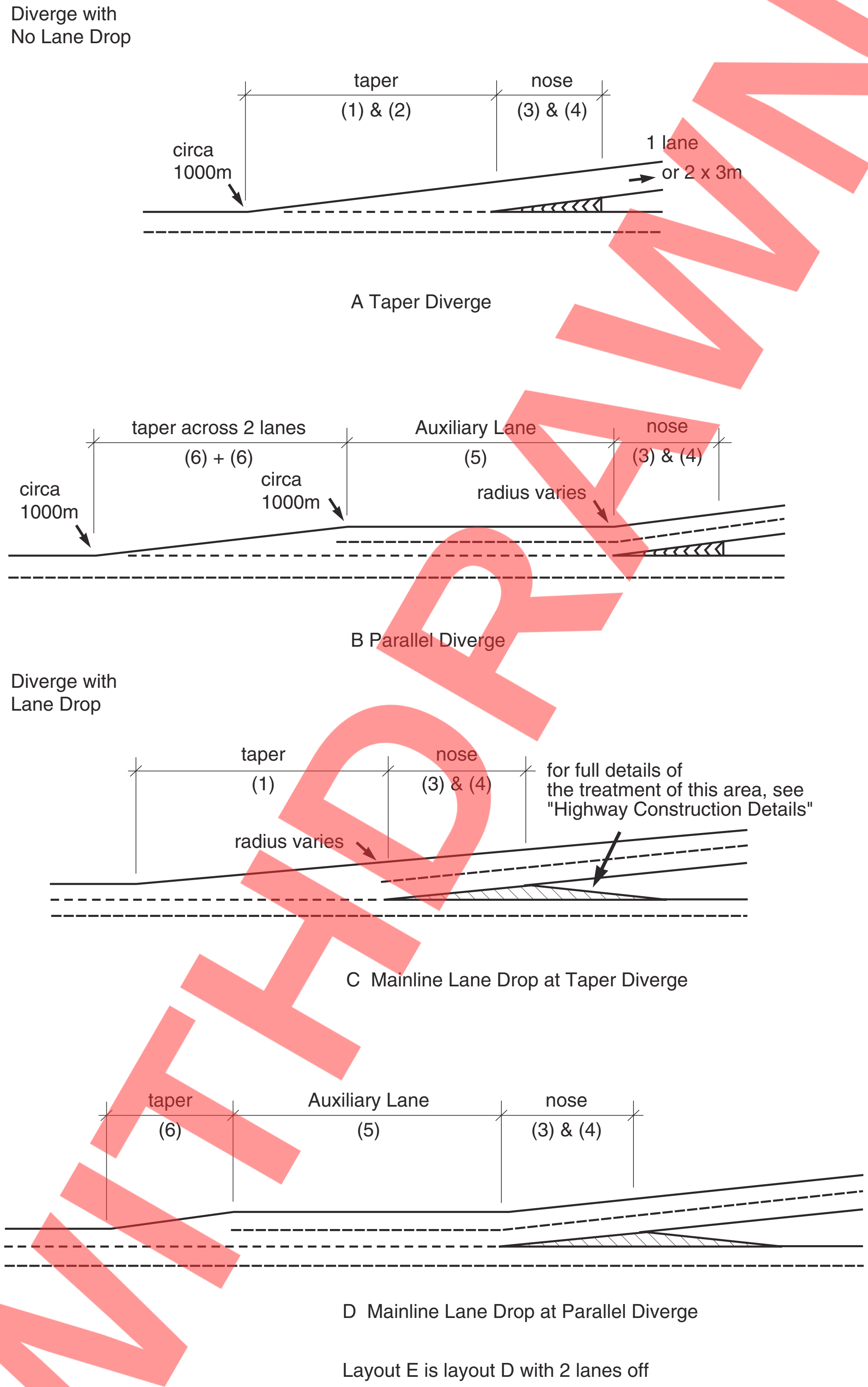


Figure 2/6: Diverging Lane Layouts for Use with Figure 2/5
N.B. Figure in brackets refer to columns in Table 4/5

Volume 6 home page

Designing Weaving Sections

2.24 The principle of calculating weaving sections is that the length is fixed in paras 4.21 to 4.23 and the width is calculated from the formula in 2.26. This determines the number of lanes and invariably indicates the addition of one or two auxiliary lanes. The formula shows that the minor weaving flow has an impact on the traffic demand of 3 times its numerical value. This can be reduced if the weaving length available is longer than the desirable minimum and a factor to do this is included in the formula. **An actual weaving length less than the desirable minimum shall not be entered into the formula**.

2.25 In the case of wide carriageways, there should be no relaxation below the desirable minimum weaving length. A vehicle on a 5 lane carriageway requires at least 1,000m to cross the full carriageway in comfort to leave at a diverge and the driver will need advance warning. The formula in 2.26 should still be used, but non-weaving traffic may be excluded from the calculation if it travels in a reserved lane. Alternatively, link roads could be considered.

2.26 For weaving sections on all types of road, design flows shall be calculated as in paragraph 3.1. To calculate the number of traffic lanes required for weaving the following equation shall be used (and see Figure 2/7):

$$N = \frac{1}{D}\left(Q_{nw} + Q_{w1} + Q_{w2}\left(2\frac{L_{\min}}{L_{act}} + 1\right)\right)$$

Where			
	N	=	Number of traffic lanes
	Qnw	=	Total non-weaving flow in vph
	Qw1	=	Major weaving flow in vph
	Qw2	=	Minor weaving flow in vph
	D	=	Maximum mainline flow from para 3.2 in vph per lane
	Lmin	=	Desirable Minimum weaving length for the road class as in paras 4.21 to 4.23
	Lact	=	Actual weaving length available in metres

(where Lact is greater than Lmin)

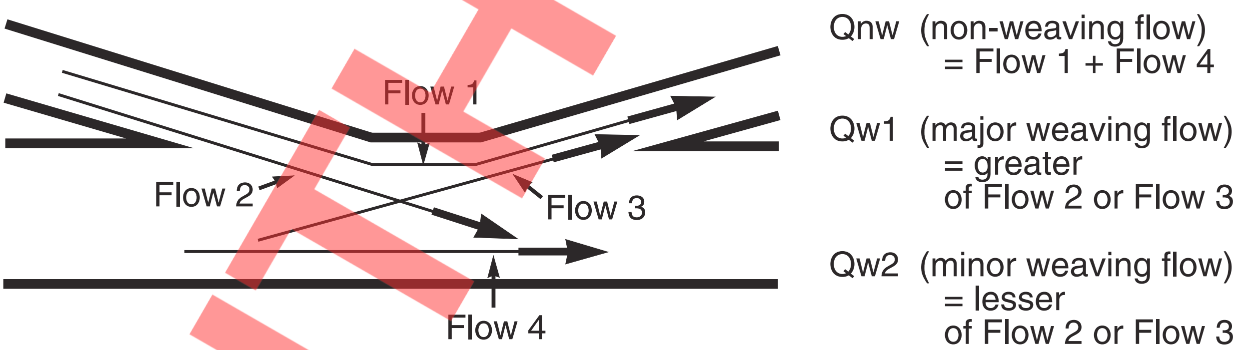


Figure 2/7: Terms used in Weaving

3. FLOW STANDARDS

Hourly Design Flow

3.1 Hourly Design Flows shall be calculated in accordance with the **Traffic Appraisal Manual** or the **Scottish Traffic and Environmental Appraisal Manual**. For roads of the Main Urban road type (as defined in the **TAM/STEAM**), junction and weaving area design shall be based on the 30th highest hourly flow. For Inter-Urban and Recreational road types, the 50th and 200th highest hourly flows respectively shall be used. The highest value of the total design flow, corrected as in paras 3.4 and 3.5 for HGVs and gradient, projected to the 15th year after opening, shall be taken as the basis of design for merges, diverges, and weaving sections.

Mainline Traffic Capacity

3.2 For the purpose of designing junctions and interchanges, the maximum lane capacity for All-Purpose Roads should be taken as 1,600 vehicles per hour and for Motorways as 1,800 vph. These values have been used in Figures 2/3 and 2/5 in this Standard. If higher values have been used in the design of the mainline carriageways, then the equivalent number of lanes should be used, instead of design flows, for that part of Figures 2/3 and 2/5 that relate to the mainline.

Design Flow Ranges and Connector Road Cross-Sections

3.3 Connector road cross-sections corresponding to design traffic flow ranges are given in Table 3/1. Further details of the cross-sections are given in Chapter 4.

Table 3/1a Cross-sections for Connector Roads To/From Mainline All Purpose Roads

Connector Road Flow +	Merge (Rural)	Merge (Urban)	Diverge (Rural)	Diverge (Urban)	Interchange Link/Loop (Rural)	Interchange Link/Loop (Urban)
0-800	MG1C Single lane* with hardshoulder	MG1D Single lane* with hardshoulder	DG1C Single lane* with hardshoulder	DG1D Single lane* with hardshoulder	IL1C Single lane* with hardshoulder	IL1D Single lane* with hardshoulder
801-1200	MG1C Single lane* with hardshoulder	MG1D Single lane* with hardshoulder	DG2E Two lanes with hardstrip	DG2F Two lanes with hardstrip	IL1C Single lane* with hardshoulder	IL1D Single lane* with hardshoulder
1201-2400	MG2E Two lanes with hardstrip	MG2F Two lanes with hardstrip	DG2E Two lanes with hardstrip	DG2F Two lanes with hardstrip	IL2C Two lanes with hardstrip	IL2D Two lanes with hardstrip
2401-3200	MG2E Two lanes with hardstrip	MG2F Two lanes with hardstrip	DG2E Two lanes with hardstrip	DG2F Two lanes with hardstrip	IL2C Two lanes with hardstrip	IL2D Two lanes with hardstrip

Table 3/1b Cross-sections for Connector Roads To/From Mainline Motorways

Connector Road Flow +	Merge (Rural)	Merge (Urban)	Diverge (Rural)	Diverge (Urban)	Interchange Link/Loop (Rural)	Interchange Link/Loop (Urban)
0-900	MG1A Single lane* with hardshoulder	MG1B Single lane* with hardshoulder	DG1A Single lane* with hardshoulder	DG1B Single lane* with hardshoulder	IL1A Single lane* with hardshoulder	IL1B Single lane* with hardshoulder
901-1350	MG1A Single lane* with hardshoulder	MG1B Single lane* with hardshoulder	DG2A Two lanes with hardstrip	DG2B Two lanes with hardstrip	IL1A Single lane* with hardshoulder	IL1B Single lane* with hardshoulder
1351-2700	MG2C Two lanes with hardshoulder	MG2D Two lanes with urban hardshoulder	DG2A Two lanes with hardstrip	DG2B Two lanes with hardstrip	IL2A Two lanes with hardshoulder	IL2B Two lanes with urban hardshoulder
2701-3600	MG2C Two lanes with hardshoulder	MG2D Two lanes with urban hardshoulder	DG2C Two lanes with hardshoulder	DG2D Two lanes with urban hardshoulder	IL2A Two lanes with hardshoulder	IL2B Two lanes with urban hardshoulder

Notes For tables 3/1a and 3/1b

* See Para 4.3 for restrictions on use of single lane interchange links
\+ Peak corrected design flow (vehicles per hour)
Refer to **TD 27 (DMRB 6.1)** for actual dimensions of cross-section components

Flow Corrections for Uphill Gradients and for HGVs

3.4 Corrections for uphill gradients and for the presence of HGVs as set out in Table 3/2 shall be made to the predicted hourly flows before corresponding values are read off from Table 3/1 and from Figures 2/3, 2/5, and 4/12.

3.5 To establish the mainline gradient, a 1 kilometre section shall be used, 0.5km either side of the merge or diverge nose tip, and the average gradient determined. The merge connector road gradient shall be based on the average of the 0.5km section before the nose tip.

Table 3/2 Percentage Correction Factors for Gradients and for the presence of Heavy Goods Vehicles

%HGVs	Mainline Gradient		Merge Connector Gradient		
	<2%	>2%	<2%	2%-4%	>4%
5	-	+10	-	+15	+30
10	-	+15	-	+20	+35
15	-	+20	+5	+25	+40
20	+5	+25	+10	+30	+45

4. GEOMETRIC STANDARDS

Cross Sections

4.1 For the purposes of designing junctions and interchanges, cross-sections for the mainline and all connector roads are given in **TD 27 (DMRB 6.1)**. Refer to Table 3/1 for design flow ranges corresponding to the various cross-sections.

(Table 4/1: Not used)
(Figure 4/1: Not used)
(Figure 4/2: Not used)
(Figure 4/3: Not used)
(Figure 4/4: Not used)

Maximum Lengths of Slip Roads and Interchange Links

4.2 A Slip Road longer than 0.75km is to be designed as an **Interchange Link.**

4.3 Single Lane **Interchange Links** shall only be provided where their length does not exceed 1km in length if they are level or downhill, and 0.5km if on an average upgrade of 3% or steeper. The length shall be taken to extend from the tip of the diverge nose to the tip of the subsequent merge nose.

Design Speed

4.4 Design speeds for the mainline are determined from **TD 9 (DMRB 6.1)**. The design speeds of **connector roads** shall be as given in Table 4/2. The design speed for **link roads** should normally be one design speed step below that of the mainline and as shown in Table 4/2, and to achieve this, should be subject to an appropriate speed limit, either mandatory or advisory. The design speed may also be the same as that for the mainline. Relaxations and Departures are available under **TD 9 (DMRB 6.1) but see paras 1.3 to 1.5**.

4.5 Any **transition curves** at locations where the design speed changes shall be designed to the higher design speed value.

Horizontal and Vertical Alignment

4.6 The geometric standards for horizontal and vertical alignment etc. for the mainline through a grade separation and for the connector roads shall be provided in accordance with Standard **TD 9 (DMRB 6.1)**. A further relaxation of the gradient on motorway connector roads from 4% in **TD 9 (DMRB 6.1)** to 6% is permissible.

4.7 Connector roads shall be widened on curves in accordance with paragraphs B 3.7 of **TD 9 (DMRB 6.1)** and 8.13 of **TA 20 (DMRB 6.1)**.

4.8 In the case of the **horizontal curvature and superelevation for loops**, there is evidence to suggest that the radii of loops (Figure 4/5) can safely be much less than that for curves turning through lesser angles, provided that adequate warning is given to drivers and clear sight lines are maintained. For **loops** the minimum radii may therefore be those given in Table 4/3. The standards for superelevation for loops are set out in paragraphs B3.2 and B3.4 of **TD 9 (DMRB 6.1)**. Superelevation greater than 7% and up to 10% may be provided as shown in Figure 5 of **TD 9 (DMRB 6.1)**, but the greatest superelevation should be used with caution where there is a risk of prolonged icy conditions. Where loops leave or join the mainline, crossfall by the nose shall be the minimum required for drainage design as laid down in paragraph B3.5 of **TD 9 (DMRB 6.1).** Widening on loops shall be as set out in para 8.13 of **TA 20 (DMRB 6.1)**.

Table 4/2 Connector Road Design Speed - kph

Mainline Design Speed	**Urban: (i) 100 or (ii) 85 kph**			**Rural: (i) 120 or (ii) 100A kph**		
Connector Road:	Interchange Link	Slip Road	Link Road	Interchange Link	Slip Road	Link Road
Design Speed	(i) and (ii) 70	(i) and (ii) 60	(i) 100 or 85 (ii) 85 or 70	(i) and (ii) 85	(i) and (ii) 70	(i) 120 or 100A (ii) 100A or 85

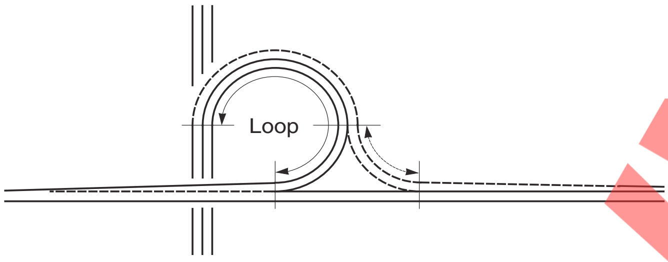


Figure 4/5: Definition of a Loop

Table 4/3 Minimum Loop Radii m
(see paragraph 4.8)

Motorway On/Off Mainline	All-Purpose	
	On to Mainline	Off Mainline
75	30	50

Sight Distance

4.9 At least Desirable Minimum Stopping Sight Distance should be provided in accordance with the design speed selected. The values are as laid down in section B2 of **TD 9 (DMRB 6.1)**.

4.10 For **merges**, the Stopping Sight Distance on the connector road shall be that related to the design speed selected for that road. This will apply along to the back of the merge nose. From then on, the Stopping Sight Distance shall be that for the design speed selected for the mainline. There shall be no obstruction to sight lines between the connector road and the mainline and vice versa for the length of the merge nose. There is a minimum approach angle at which drivers can merge on direct sight otherwise blind spots to the rear of the vehicle will be troublesome. Below this they will have to merge using mirrors and must therefore run parallel to the mainline carriageway. It follows that there is a minimum width of merge nose and this can be derived from the geometric parameters (para 4.15).

4.11 For **diverges**, the Stopping Sight Distance related to the mainline design speed shall be maintained into the diverge as far as the back of the diverge nose. The stopping sight distance can then be reduced to that for the design speed selected for the connector road. On the length where the two sight distances overlap, the requirements of the longer Stopping Sight Distance shall be met.

4.12 For **Loops**, there shall be no obstruction to sight lines across loops of minimum radius and loops where the radius is between this and the limiting radius shown in Part B Table 3 of **TD 9 (DMRB 6.1)**. This includes where the loops connect to the mainline carriageway as shown in Figure 4/5. The minimum radius is shown in Table 4/3.

4.13 For the connections to the local road system, guidance on sight distance standards at major/minor junctions is given in **TA 20 (DMRB 6.1)** and for roundabouts in **TD 16 (DMRB 6.2)**.

Hardstrip and Hard Shoulder

4.14 Where the hard shoulder has to taper into a slip or interchange link road hardstrip or vice versa, this shall be done in accordance with **TD 27 (DMRB 6.1)**. The slip or interchange link hardstrip shall terminate prior to an at grade junction in accordance with Figures 5 and 6 of **TA 42 (DMRB 6.2)**.

Merges and Diverges

4.15 The geometric parameters applicable to merges and diverges shall be those in Tables 4/4 and 4/5 respectively. Figures 2/4 and 2/6 illustrate their use in typical layouts. Lengths are measured along the left edge of the carriageway. Ghost island merges are not normally appropriate at the lower speeds and more restricted layouts of urban roads.

Table 4/4 Geometric Design Parameters for Merging Lanes
(See also Figure 2/4)

Road Class	**Length of entry taper m (1)**	**Taper for min angle at nose (2)**	**Nose length m (3)**	**Minimum auxiliary lane length m (4)**	**Length of aux lane taper m (5)**	**Ghost island length m (6)**
Rural Motorway	205	1:40	115	230	75	180
Rural Dual Carriageway Design Speed 120 kph 100A kph or less	 150 130	 1:30 1:25	 85 75	 190 160	 55 55	 150 150
Urban Road Speed Limit 60 mph 50 mph or less	 95 75	 1:15 1:12	 50 40	 125 100	 40 40	 n/a n/a

Table 4/5 Geometric Design Parameters for Diverging Lanes
(See also Figure 2/6)

Road Class	Length of exit taper m		Taper for min angle at nose (3)	Nose length m (4)	Minimum auxiliary lane length m (5)	Length of aux lane taper m (6)
	1 lane (1)	2 lane (2)				
Rural Motorway	170	185	1:15	80	200	75
Rural Dual Carriageway Design Speed 120 kph 100A kph or less	 150 130	 150 130	 1:15 1:15	 70 70	 170 150	 55 55
Urban Road Speed limit: 60 mph 50 mph or less	 95 75	 110 90	 1:15 1:12	 50 40	 125 100	 40 40

4.16 Where, in a **merge** on a rural motorway, it is anticipated that the connector road and mainline will frequently be carrying traffic flows approaching their design capacities, it is desirable to extend the minimum auxiliary lane length of 230m (Table 4/4) to 370m. As a guide, this should be considered when these flows reach 85% of capacity, as defined in para 3.2, for more than 1,000 hours per year. Figure 4/6 shows an example for the layout of a ghost island merge. Within larger interchanges, this distance may be increased to 500m. The auxiliary lane should be extended to an adjoining diverge if this is close and the early termination of the auxiliary lane is considered a safety hazard.

4.17 Where, in a **diverge** on a rural motorway, it is anticipated that the connector road and the mainline will frequently be carrying traffic flows approaching their design capacities, it is desirable to project a single auxiliary lane upstream for a further 400m prior to the diverge (an example is shown in Figure 4/6), connected by a taper of length as shown in Table 4/5 Column 6 to the two lane section as shown in layout B in Figure 2/6. The lane should also commence with such a taper. The same guide as in 4.16 may be taken to indicate when an extended auxiliary lane should be considered.

4.18 **Taper merges and diverges**, (Layouts A in Figures 2/4 and 2/6), shall be replaced by **parallel merges and diverges**, (Layouts B), if the mainline:

i. has a horizontal radius less than the Desirable Minimum (Table 3 of **TD 9 (DMRB 6.1)**) for merges in the left hand curve direction and for diverges in the right;

ii. is on an upgrade of 3% or steeper for longer than 1.5km prior to the start of the taper;

iii. is on a downgrade of 3% or steeper for longer than 1.5km prior to the start of the taper, or,

iv. if the connector road entering a merge is on an upgrade of 3% or steeper for longer than 500m before the merge.

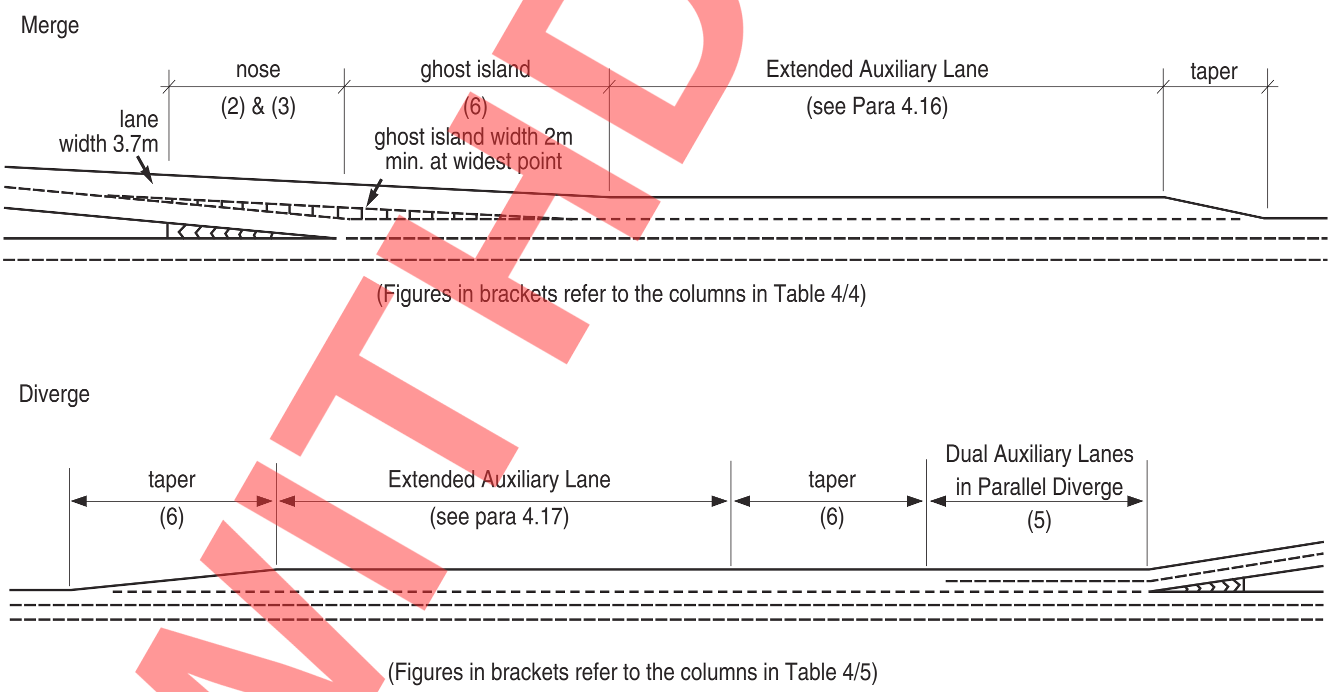


Figure 4/6: Extended Auxilary Lanes

Successive Merges or Diverges within Interchanges

4.19 Where there are closely spaced successive merges or diverges within a junction or interchange (Figure 4/7), the minimum spacing between the tips of noses shall be 3.75V m, where V is the design speed in Kph for the mainline, subject to the minimum requirements for effective signing and motorway signalling. If the merges or diverges are on a connector road, the design speed shall be that for the connector road.

Lane Drop/Lane Gain and Through Carriageway

4.20 Where a dual 3 lane operational carriageway is to be reduced to dual 2 lanes through a junction, provision must be made for maintenance activities, incidents and for future contra-flow systems during major maintenance. This means that the mainline carriageway shall be constructed through as 3 lane (with hard shoulder) with the left hand lane normally hatched out and not used for traffic during normal operation. This repeats advice in **TA 48 (DMRB 6.2.2)**, para 5.22. Regular use of the left hand lane can inhibit joining traffic, which, under these conditions, can be heavy, and this, in effect, destroys the concept of lane balance.

Weaving Lengths

4.21 Weaving lengths can be measured as in Figure 1/1 in standard layouts and in Figures 4/7-4/11 where the layout has special features.

4.22 On **Rural Motorways**, the Desirable Minimum weaving length shall be 2 kilometres. However, in extreme cases with traffic forecasts at the lower end of the range for the specific carriageway (Table 2 in **TD 20 (DMRB 5.1)**, an Absolute Minimum distance of 1 kilometre can be considered. Above about 3 kilometres apart, merges and diverges tend not to interact and can be considered as separate entities, since weaving ceases to occur. The maximum possible weaving length can thus be taken as 3 kilometres. This would appear to be the case up to and including weaving sections 5 lanes wide.

4.23 For **Rural All-Purpose Roads** with design speeds of 120 or where speed limits have been imposed to create a design speed of 100A kph, the Desirable Minimum weaving length shall be 1 kilometre with an Absolute Minimum of 450m for the extreme cases with traffic forecasts at the lower end of the range for the specific carriageway as mentioned in 4.22. Here, for example, on carriageways up to 3 lanes wide, the maximum distance over which successive merges and diverges are likely to interact and cause weaving is around 2 kilometres and this should be taken as the maximum weaving length.

4.24 For **Urban Roads** as defined in para 1.20, the design flows shall be inserted in Figure 4/12 to obtain a minimum weaving length (Lmin). This shall then be compared to the Design Speed related Absolute Minimum weaving length in Figure 4/12 and the greater of the two lengths taken as the minimum length of weaving section, subject to minimum signing requirements.

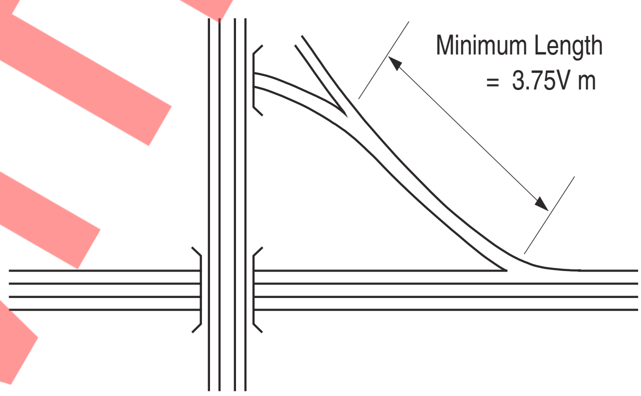


Figure 4/7: Example of Successive Merges/Diverges

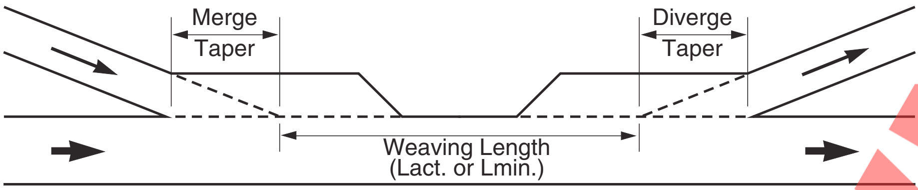


Figure 4/8: Parallel Merge/Diverge as for Taper Merge/Diverge by Notional Layout.

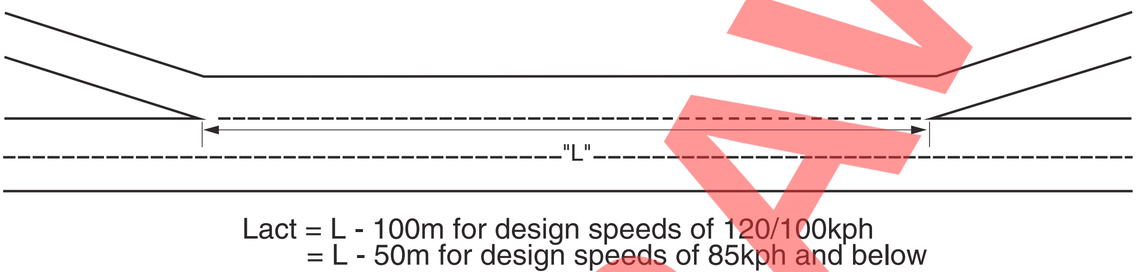


Figure 4/9: Recommended for Lane Gain/Lane Drop.

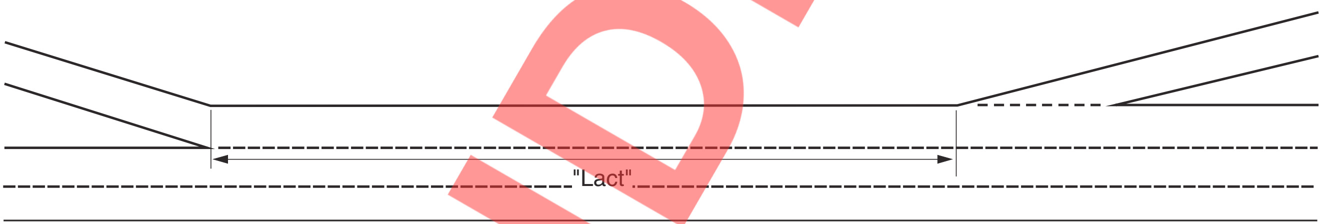


Figure 4/10: Recommended for Lane Gain only.

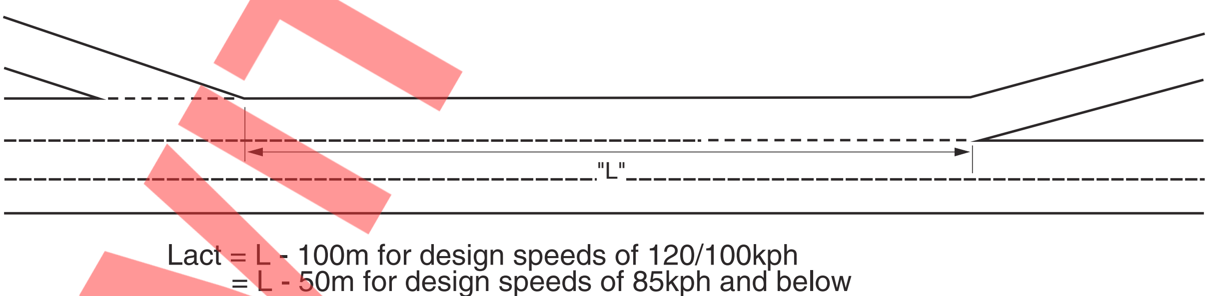
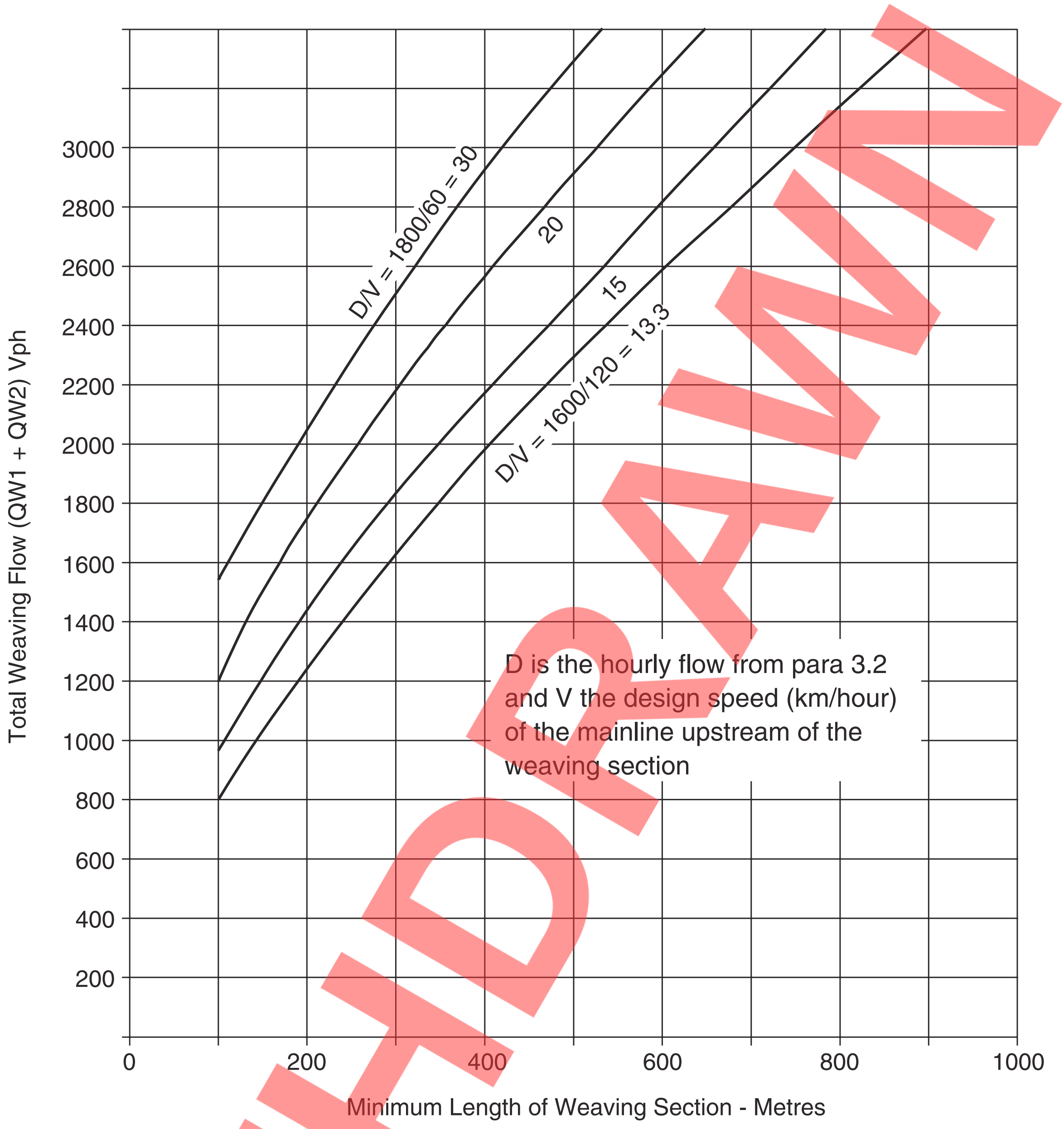
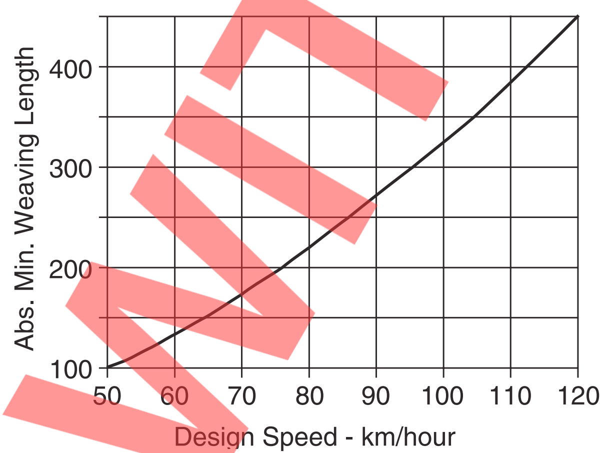


Figure 4/11: Recommended for Lane Drop only.

Figure 4/8 - 4/11: Definition of Terms Used in Weaving and Alternatives for Weaving Length





To determine the minimum length of weaving section (Lmin) for insertion within the formula of Paragraph 2.26

1. For known total weaving flow and chosen D/V value, read off the minimum length of weaving section from the graph above.
2. Check the absolute minimum weaving length allowable for chosen design speed from the graph on the left.
3. Select the greater of the two lengths.

Figure 4/12: Weaving Length Diagram for Urban Roads

5. REFERENCES

1. Introduction

(a) **BS6100 Subsection 2.4.1 1990** - The British Standard Glossary of Building and Civil Engineering Terms - Part 2 Civil Engineering; Section 2.4 Highway and Railway Engineering; Subsection 2.4.1 Highway Engineering: British Standards Institution 1990 (UDC 001.4:(624+69))

(b) **TD 20** - Traffic Flow and Carriageway Width Assessment: (DMRB 5.1)

2. Design Procedure

(a) **TA 30** - Choice Between Options for Trunk Road schemes: (DMRB 5.1)

(b) **Traffic Appraisal Manual** - (TAM) 1: DTp: 1982

(c) **Scottish Traffic and Environmental Appraisal Manual** - (STEAM): SDD: 1986

(d) **TD 20** as Chapter 1 (DMRB 5.1).

(e) **COBA - Cost Benefit Analysis - COBA 9 Manual**: DTp: 1981

(f) NESA - **Network Evaluation from Surveys and Assignments** - NESA: SDD: 1986

(g) **TA 58** - Traffic Signs and Road Markings for Lane Gains and Lane Drops on All Purpose Dual Carriageway and Motorway Trunk Roads (DMRB 8.2)

(h) **TA 23** - Determination of Size of Roundabouts and Major/Minor Junctions: (DMRB 6.2)

3. Flow Standards

(a) **Traffic Appraisal Manual** (TAM) as Chapter 2.

(b) **Scottish Traffic and Environmental Appraisal Manual** (STEAM) as Chapter 2.

4. Geometric Standards

(a) **"Highway Construction Details"** HMSO: 1991. (MCHW 3.1)

(b) **TD 9** - Highway Link Design: and Amendments (DMRB 6.1)

(c) **TA 20** - The Layout of Major/Minor Junctions: (DMRB 6.2)

(d) **TD 16** - The Geometric Design of Roundabouts: (DMRB 6.2)

(e) **TA 42** - The Geometric Design of Roundabouts: (DMRB 6.2)

(f) **TA 48** - Layout of Grade Separated Junctions: (DMRB 6.2.2)

(g) **TD 20** as Chapter 1 (DMRB 5.1)

(h) **TD 27** - Cross-Sections and Headrooms: (DMRB 6.1)

6. ENQUIRIES

All technical enquiries or comments on this Standard should be sent in writing as appropriate to:

Chief Highway Engineer The Highways Agency 123 Buckingham Palace Road London SW1W 9HA	G CLARKE Chief Highway Engineer

Chief Road Engineer Scottish Executive Victoria Quay Edinburgh EH6 6QQ	J HOWISON Chief Road Engineer

Chief Highway Engineer Transport Directorate Welsh Assembly Government Llywodraeth Cynulliad Cymru Crown Buildings Cardiff CF10 3NQ	M J A PARKER Chief Highway Engineer Transport Directorate

Director of Engineering The Department for Regional Development Roads Service Clarence Court 10-18 Adelaide Street Belfast BT2 8GB	G W ALLISTER Director of Engineering