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# **Main Roads Supplement to the Austroads Guide to Traffic Management**

## **Part 3: Transport Study and Analysis Methods**

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October 2023

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## Document Control

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## Amendments

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0	October 2023	Document Approved	All

## PURPOSE

The purpose of this document is to detail Main Roads' approach to traffic studies and analysis so that they are designed and applied consistently and appropriately throughout Western Australia.

This Supplement has been developed to be read in conjunction with the Austroads Guide to Traffic Management (AGTM) Part 3: Transport Study and Analysis Methods (2020), a copy of which can be obtained via the [Austroads](#) website.

In Western Australia, Main Roads' policies, guidelines and standards take precedence over Austroads Guides and Standards Australia Standards. National Guides and Standards take precedence over International Guides and Standards, unless specifically stated otherwise.

This Supplement has the same structure as the equivalent Austroads Guide and only additional requirements, clarifications, or practices different from Austroads appear. Where appropriate, this Supplement may also contain additional sections and figures not covered by Austroads, but the numbering sequence found in the Austroads Guide remains. Figures and tables in this Supplement replace those with the same figure or table number in the equivalent Austroads Guide.

Where a reference has been made to a particular Main Roads WA document or drawing within this supplement, the reference provided can be used in the search facility on the Main Roads WA website to locate the current version.

## 1 INTRODUCTION

Main Roads has no supplementary comments for this section.

## 2 TRANSPORT STUDIES AND ANALYSIS OVERVIEW

Main Roads has no supplementary comments for this section.

## 3 TRAFFIC STUDIES AND SURVEYS

### 3.1 Traffic Studies and Data Needs

#### 3.1.1 Traffic Signals Approval Policy – Main Roads WA

Where studies include the requirement for new or modified traffic signals, reference must be made to Main Roads WA "[Traffic Signals Approval Policy – Network Operations Directorate](#)". The policy outlines the factors that Main Roads takes into account when considering approval for modifications to existing traffic signals and the provision of new traffic signals.

### 3.2 Planning and Designing Traffic Studies

#### 3.2.2 Preliminary Planning

##### ***Survey methods***

For manual traffic surveys at an intersection it is usual to undertake a video survey to identify the peak hour(s) and also provide visual operational performance for any subsequent analysis.

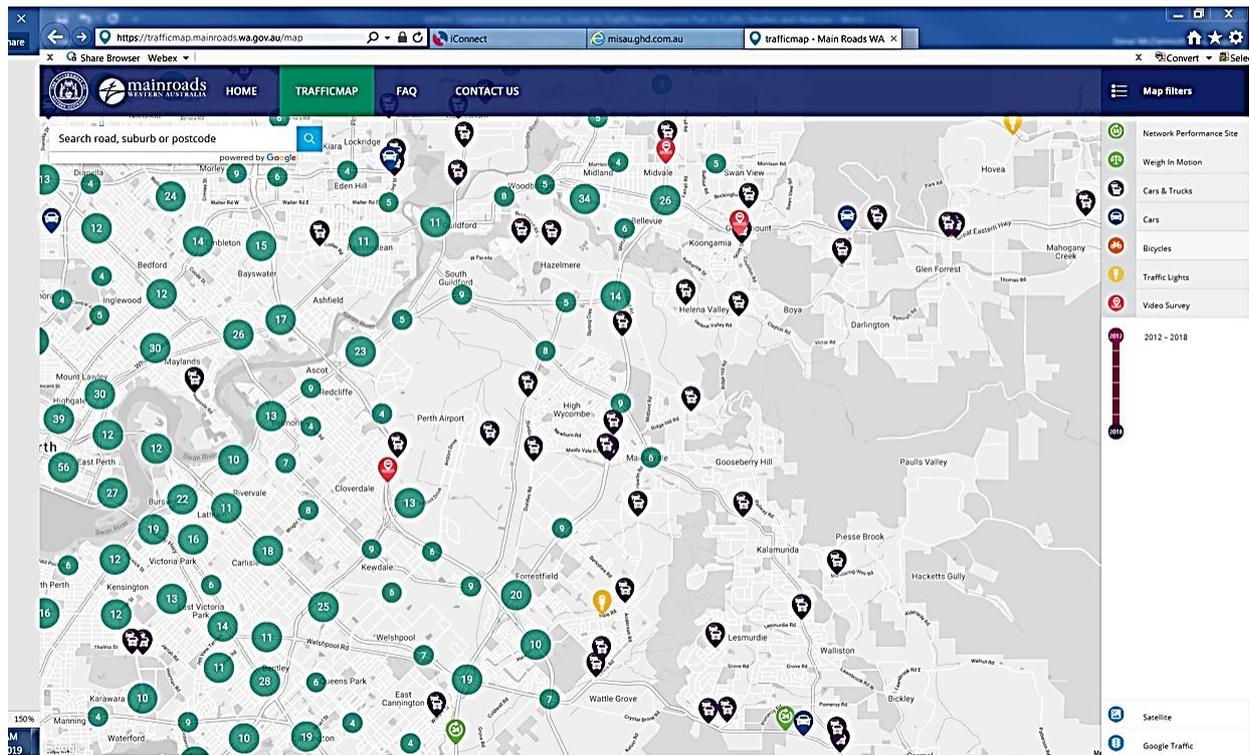
## 3.5 Traffic Surveys

### 3.5.1 Traffic Volume Surveys (Appendix A)

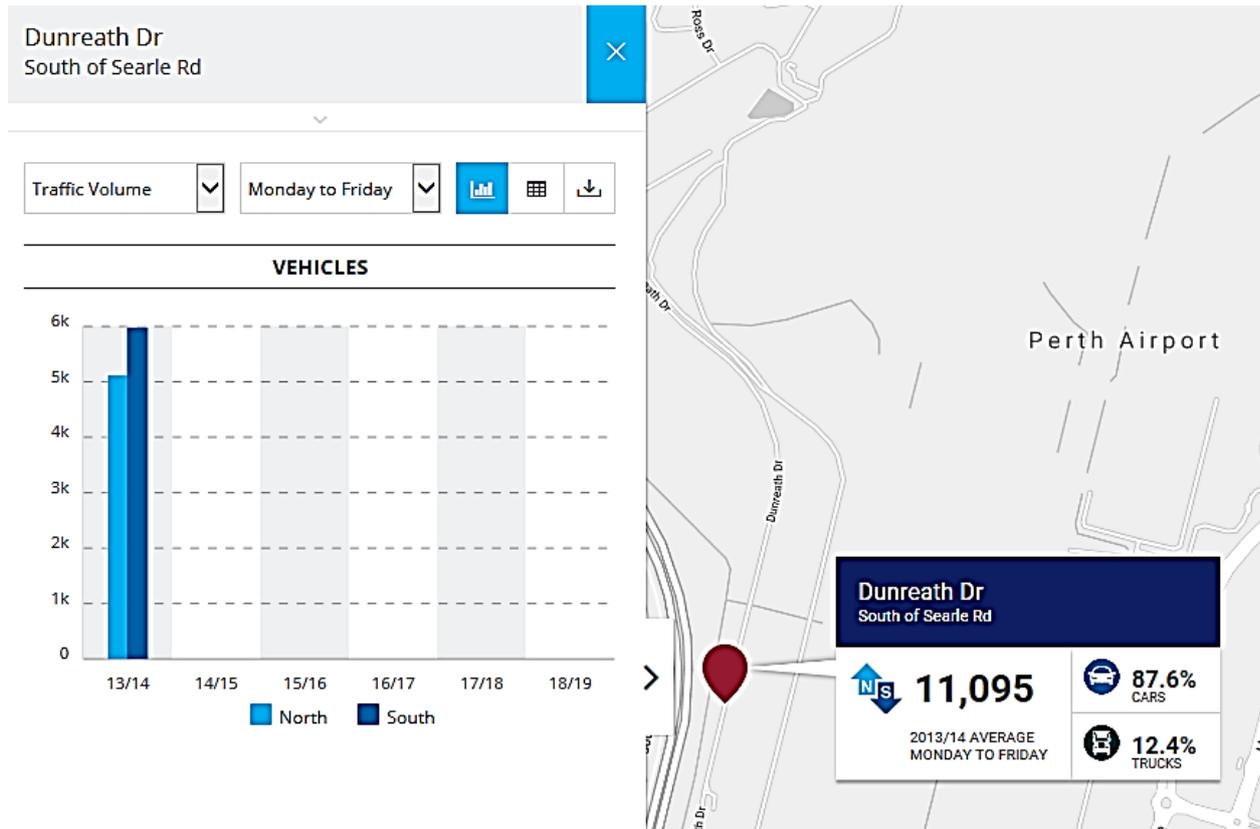
SCATS data and video survey results is available via Main Roads WA [Trafficmap](#). Standard SCATS data (a weekly snapshot of vehicles in an hourly format) and results from Main Roads' video surveys (over the past 6 years) can be accessed.

Examples of typical data are shown as follows:

#### Control page



### Daily traffic volumes



### Hourly traffic volumes

**Dunreath Dr South of Searle Rd**

Hourly | Monday to Friday

**VEHICLES 2013/14**

	NORTH	SOUTH	TOTAL
00:00	34	84	118
01:00	19	62	81
02:00	27	28	55
03:00	118	51	169
04:00	257	162	419
05:00	322	232	554
06:00	310	261	571
07:00	367	291	658
08:00	315	271	586

### 85<sup>th</sup> percentile speed

Dunreath Dr  
South of Searle Rd
>

v

Speed (85th)
v

Monday to Friday
v

|
|
|
|
|

|
|
|

|

85TH PERCENTILE SPEED (KM/H) 2013/14

	NORTH	SOUTH	BOTH
00:00	74	73	73
01:00	72	76	76
02:00	77	76	77
03:00	75	78	76
04:00	73	72	73
05:00	73	72	73
06:00	73	72	73
07:00	72	71	72
08:00	71	70	71

### SCATS data

**Traffic Signal Vehicle Counts**

Traffic Signal	LM000613
Road	1020006
Road Name	Hale Rd
SLK	3.62
Latitude	-31.988981
Longitude	116.011141
Intersection	Hale Rd & Strelitzia Av

TCS 613

FORRESTFIELD

376-D10

WEL

SS=38

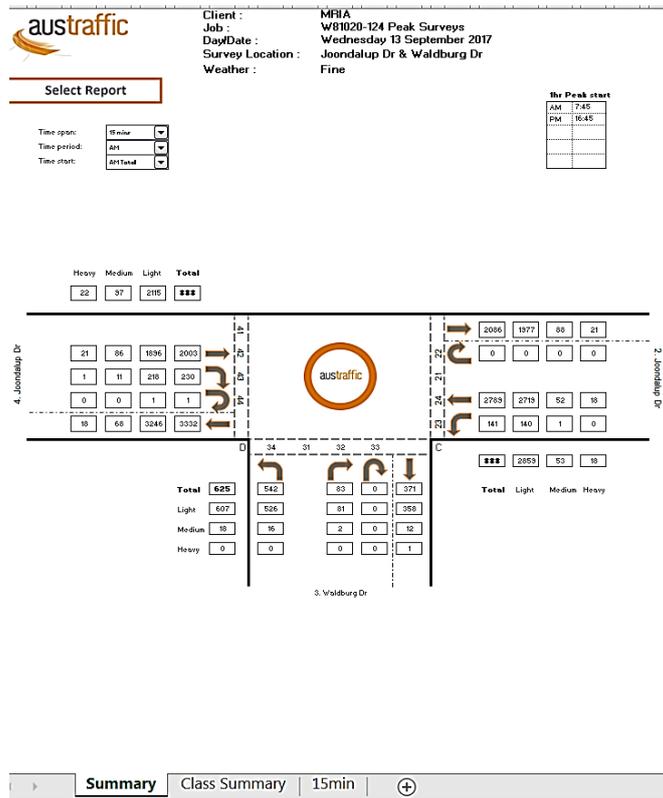
3 PHASES

A

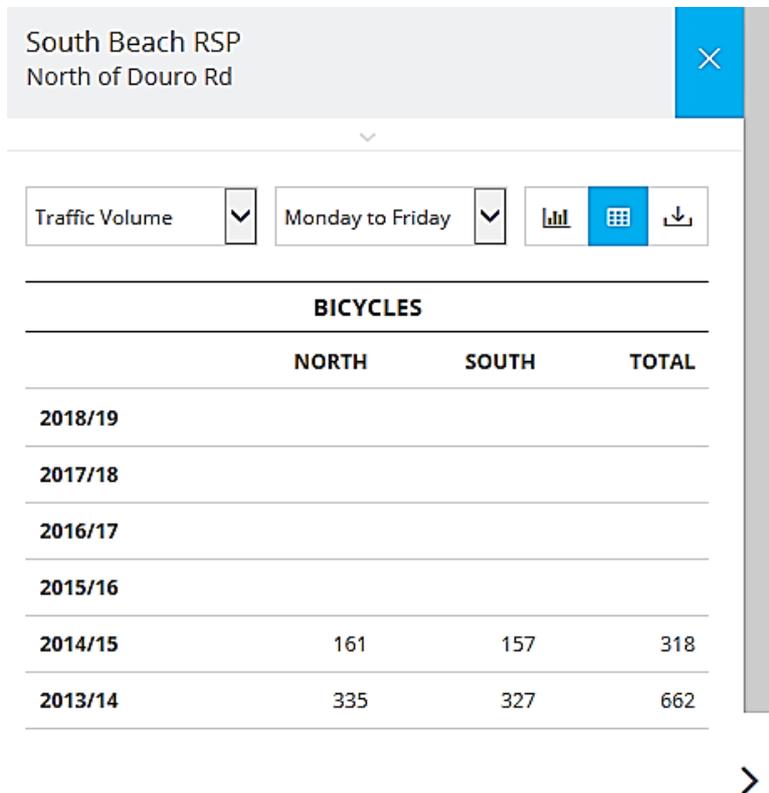
B

C

### Video surveys



### Bicycles



### 3.5.2 Speed Surveys (Appendix B)

Speed data is available via the Main Roads WA website using [Trafficmap](#).

The [road information mapping system](#) is available via the Main Roads WA website and provides information on Main Roads Structures, Main Roads Network, Control of Access, Road Hierarchy, Special Use roads and Speed limits.

## 4 TRAFFIC ANALYSIS – CAPACITY AND LEVEL OF SERVICE (LOS)

### 4.5 Pedestrian Level of Service

#### 4.5.2 Pedestrians and Cyclists

The Department of Transport is developing a suite of guidelines to assist practitioners to plan and design for bike riding in Western Australia. The Department of Transport [Active Transport page](#) should be referenced to access current guidance for the development of cycling infrastructure/facilities

## 5 UNINTERRUPTED FLOW FACILITIES

Main Roads WA [Road Hierarchy for Western Australia](#) describes the type of road for each classification and provides indicative expected traffic volumes.

### 5.4 Freeways

#### 5.4.2 Ramps and Ramp Junctions

While the methodology documented in AGTM Part 3 may be used to estimate the LOS of ramp junctions, Main Roads advocates the use of the methodology contained in the Highways Agency (UK) publication “Design Manual for Roads and Bridges – CD 122, Geometric Design of Grade Separated Junctions – Rev 1”.

It should be noted that this methodology assumes a lane capacity of 1,800 vph. Currently accepted practice within WA is that **for unmanaged freeways** the maximum sustainable lane capacity is approximately 1,800 **pcu**/h/lane. Under typical peak hour freeway conditions, this equates to approximately 1,700 vph/lane. Capacities per lane tend to reduce as the number of lanes increase. Refer to ‘DoT Victoria’s Managed Motorway Design Guide Volume 2: Design Practice - Parts 2 and 3’ for detailed guidance on mainline lane capacities.

Similarly, currently accepted practice within WA is that **for managed freeways** the maximum sustainable lane capacity is approximately 2,100 pcu/h/lane. Under typical peak hour freeway conditions, this equates to approximately 1,900 – 2,000 vph/lane. Capacities per lane tend to reduce as the number of lanes increase. Refer to ‘DoT Victoria’s Managed Motorway Design Guide Volume 2: Design Practice - Parts 2 and 3’ for detailed guidance on mainline lane capacities.

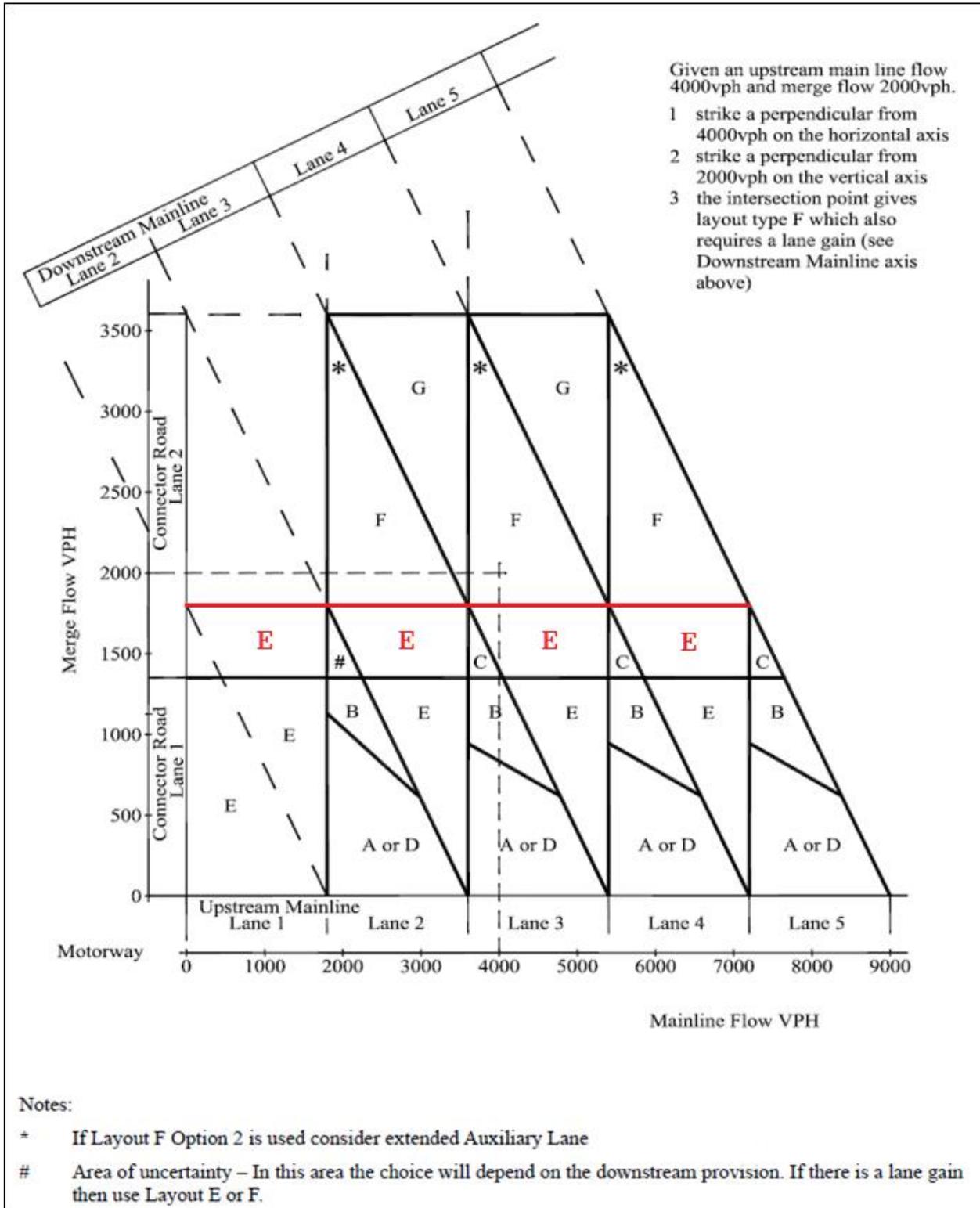
**For both managed and unmanaged freeways, the methodology may be used by converting traffic volumes in “vph” to volumes in “pcu/h”.**

### **5.4.2.1 Freeway Merges**

Figure 5.13 shows the nomograph to be used for freeway merges. Figure 5.14 shows the various merge layouts referred to in Figure 5.13 as Types A to G.

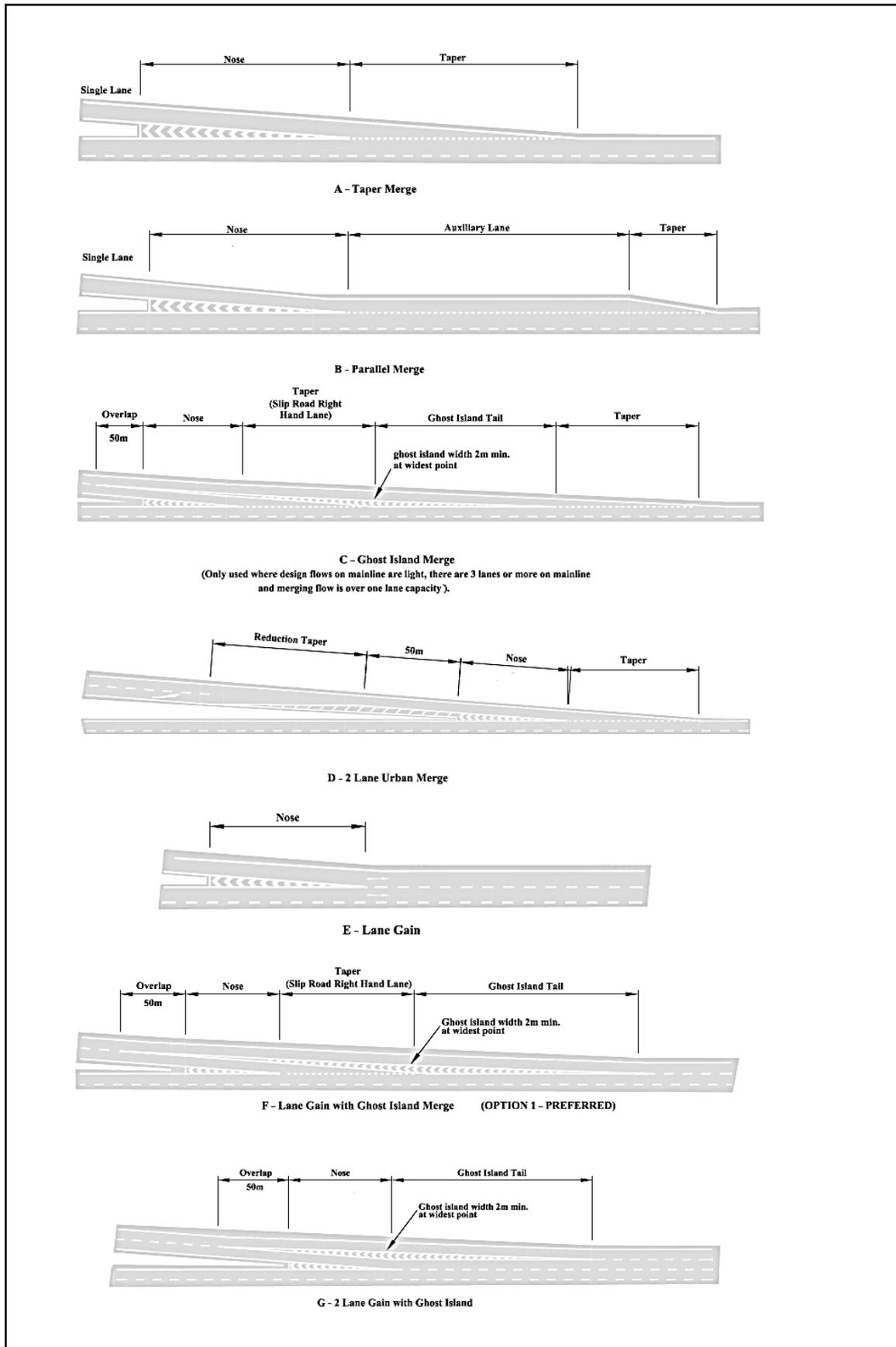
It should be noted that the horizontal line at a merge flow of 1,350 vph defines the limit of a single lane on-ramp. For merge flows greater than 1,350 vph the methodology recommends the use of a two-lane on-ramp (Type C, F and G). However, it has been noted in Perth that the use of an added lane on-ramp (eg. Powis Street southbound onto Mitchell Freeway) can frequently cater for volumes up to 1,800 vph without flow breakdown.

It is suggested therefore that the region "E" should be expanded as shown by the red line. This is dependent on there being limited turbulence on the ramp itself, especially at the merge from two lanes to one lane.



Source: *Design Manual for Roads and Bridges – Volume 6, Road Geometry – Section 2, Junctions – Part 1: TD 22/06 - Layout of Grade Separated Junctions*, February 2006

**Figure 5.13: Nomograph to determine Freeway Merge Layout**



Source: *Design Manual for Roads and Bridges – Volume 6, Road Geometry – Section 2, Junctions – Part 1: TD 22/06 - Layout of Grade Separated Junctions*, February 2006

**Figure 5.14: Freeway Merge Lane Layouts for use with Figure 5.13**

### **5.4.2.2 Freeway Diverges**

Figure 5.15 shows the nomograph to be used for freeway diverges. Figure 5.16 shows the various diverge layouts referred to in Figure 5.15 as Types A to G.

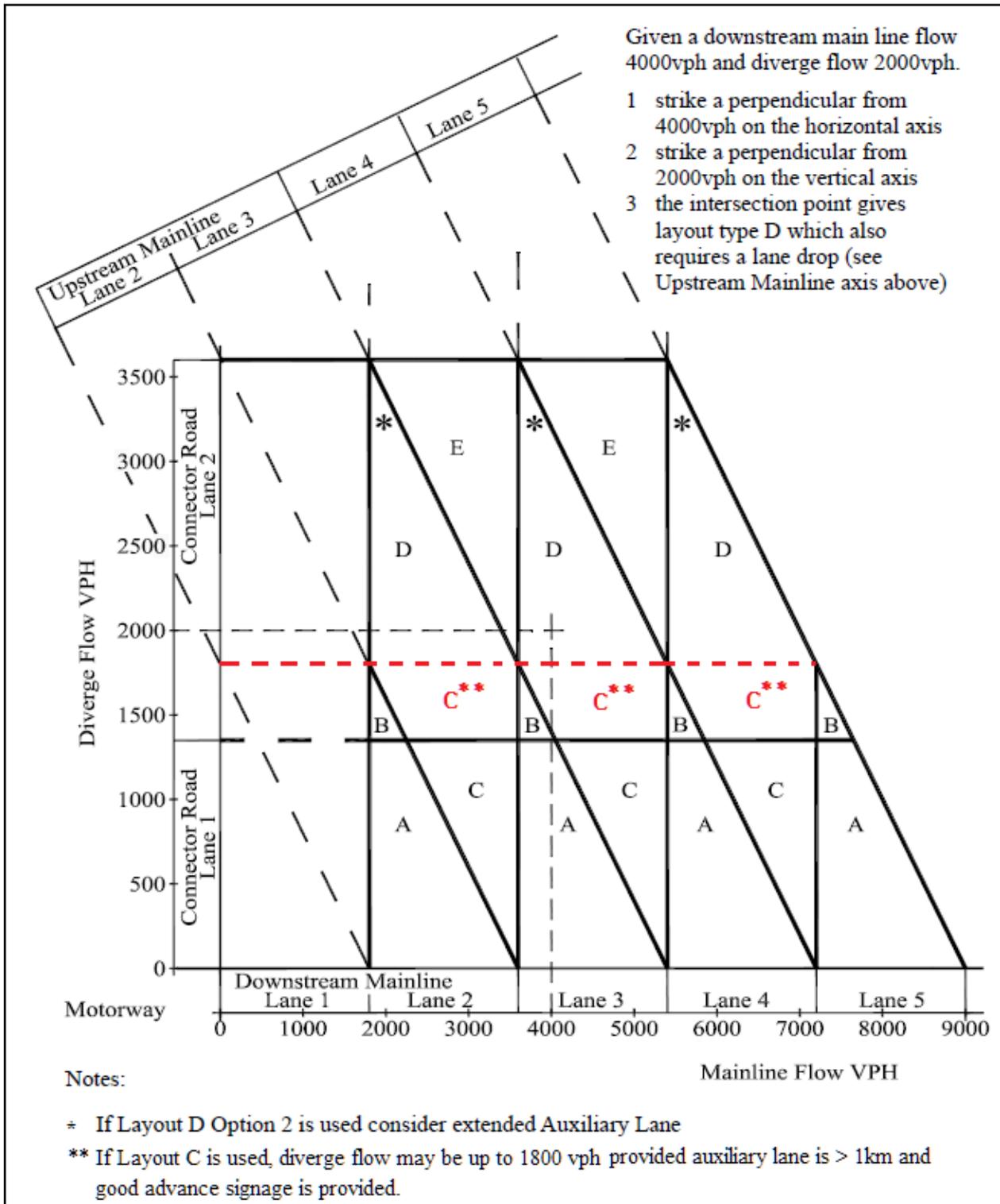
It should also be noted that the horizontal line at a diverge flow of 1,350 vph defines the limit of a single lane off-ramp. For diverge flows greater than 1,350 vph the methodology recommends the use of a two-lane off-ramp (Type B, D and E). However, it has been noted in Perth that the use of an exclusive off-ramp (eg. Reid Highway southbound off Mitchell Freeway) can frequently cater for volumes up to 1,700 vph without flow breakdown.

It is suggested therefore that the region "C" should be expanded as shown by the dashed red line. It is important that the auxiliary lane is sufficiently long (> 1km) and that good advance signage is provided. Moreover, there should be sufficient storage to prevent queues from backing up onto the freeway mainline.

For Layouts Type B and D, Option 1 is preferred unless implementation of Option 1 is not practical or may lead to queuing problems due to unequal volumes in each lane at the downstream junction with the cross-road.

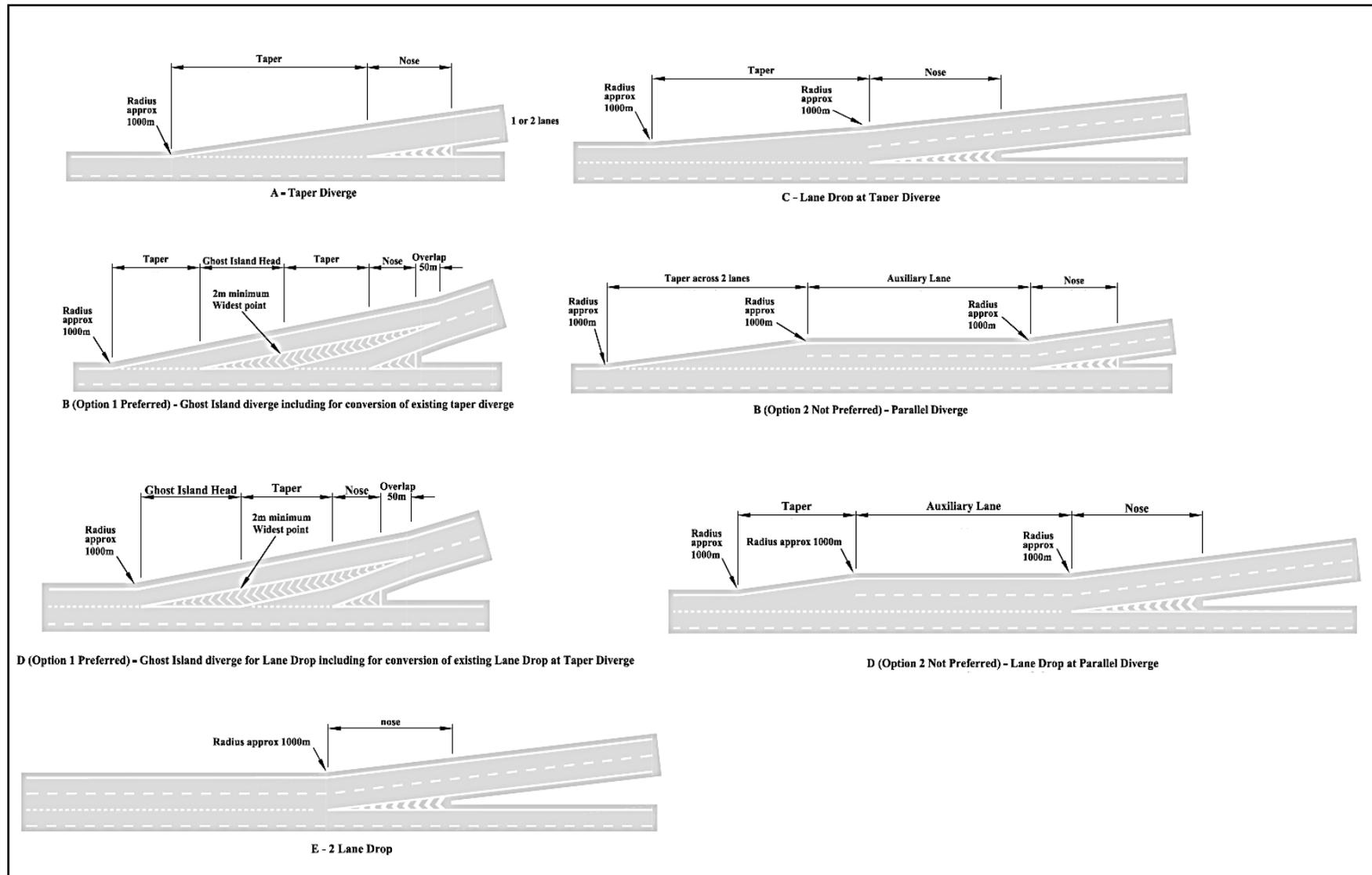
### **5.4.2.3 Worked Example**

A worked example using the Highways Agency nomograph methodology is provided in Appendices N and O. It should be noted that in this example use is made of the "All-purpose road" merging and diverging diagrams for those ramps joining the C-D roads. These roads are assumed to have a lower per lane capacity.



Source: *Design Manual for Roads and Bridges – Volume 6, Road Geometry – Section 2, Junctions – Part 1: TD 22/06 - Layout of Grade Separated Junctions*, February 2006

**Figure 5.15: Nomograph to determine Freeway Diverge Layout**



Source: *Design Manual for Roads and Bridges – Volume 6, Road Geometry – Section 2, Junctions – Part 1 : TD 22/06 - Layout of Grade Separated Junctions*, February 2006

**Figure 5.16: Freeway Diverge Lane Layouts for use with Figure 5.15**

## 6 INTERRUPTED FLOW FACILITIES

Managed Motorways are identified as Smart Freeways in Western Australia.

Main Roads WA has established a policy framework to guide overall planning, project development, delivery, and ongoing management of Smart Freeways in Western Australia. In doing so, Main Roads has developed a "[Supplement to Victoria's Managed Motorway Design Guide, Volume 2: Design Practice, Parts 2 and 3](#)".

## 7 INTERSECTIONS

### 7.4 Signalised Intersections

#### 7.4.4 Signal Calculations

The following Main Roads WA documents are applicable for the calculation and planning of traffic signal timings:

- Signal Data Information for Modelling – Appendix A of Main Roads WA "[Operational Modelling Guidelines](#)", accessible from the technical library on the Main Roads WA website.
- Main Roads WA "[Traffic Signals Approval Policy – Network Operations Directorate](#)", refer to clause 3.1.1 above.
- Main Roads WA "[Guidelines for the Analysis of Roundabout Metering Signals](#)". These guidelines have been developed for use by traffic engineering and road safety practitioners to assess whether an existing roundabout is suitable for the installation of traffic signals on any particular leg (or legs) of a roundabout in order to increase overall capacity. Equally, they should be used by the approving authority to determine the robustness of the analysis methodology and hence the appropriateness of the proposed treatment.

## 8 MODELLING GUIDELINES

Main Roads WA "[Operational Modelling Guidelines](#)" have been developed for Linsig, SIDRA, Vissim and AIMSUN analysis by Network Operations directorate, with contributions from the Transport Portfolio, other directorates and external industry experts. The objective of the guidelines is to ensure consistency in traffic modelling practice and to promote the production of accurate modelling outputs that will result in high-quality project design and assessment that transitions into operations.

Main Roads has developed a methodology to extract peak hour volumes for freeway sections (including ramp volumes) from ROM24 and apply suitable adjustment factors based on actual traffic volume counts. This may be found in the document [Guidelines for Analysing Freeway Sections: Obtaining Peak Hour Volumes from ROM 24 and Adjustment Process](#).

Main Roads WA "Traffic Modelling Instruction Form" is available to define LinSig, SIDRA, micro or mesoscopic modelling requirements for each project. Current submission protocols require the applicant (in nearly all cases, the client) to submit the completed form to Main Roads (through their Network Operations section). Consultants cannot submit the form on behalf of an applicant. The applicant should engage Main Roads as soon as possible (preferably prior to going to market for quotations) so that they have a clear understanding of the modelling scope Main Roads will require for their project to proceed.

Department of Transport have produced [Transport Modelling Guidelines](#). This document is a reference tool for both transport modellers and planners for the development and use of transport models that accompany Transport Assessments for such developments within Activity Centres.

## APPENDIX A TRAFFIC VOLUME SURVEYS

### A.4 Measurement and Estimation of AADT

#### A.4.1 Daily and Seasonal Variations and Traffic Volume

Seasonal adjustments – Certain areas of WA are impacted by seasonal traffic and a review of Main Roads WA traffic data may be required to determine whether to update surveyed traffic data. It is recommended that any adjustments are discussed with Main Roads WA as necessary.

### A.5 Vehicle Classification

#### A.5.2 Vehicle Classification Systems

In order to establish heavy vehicle routes and assessment material reference can be made to the following Main Roads WA documents.

Main Roads WA [RAV Mapping Tool](#) is available and provides an up to date map of the approved roads published in the Network Road Tables. The tool includes the locations of Road Train Assembly areas, Truck Bays, Parking Bays and Roadhouses and identifies Main Roads Regional boundaries, Local Government area boundaries. Networks available include:

- Tandem Drive Networks 1-10
- Tandem Drive Concessional (Level 1-3) Networks 1-10
- Tri Drive Networks 1-5
- Tri Drive Concessional (Level 1-3) Networks 1-5
- Oversize Road Train Networks

Main Roads WA "[Standard Restricted Access Vehicle Route Assessment Guidelines](#)" is available. These guidelines have been prepared by Main Roads Western Australia to assist Local Government, Main Roads' staff and transport operators or consultants in assessing the suitability of routes proposed for the operation of "standard" Restricted Access Vehicles (RAVs) on roads within the State of Western Australia. For the purpose of these guidelines, "standard" RAVs are those vehicle combinations specified as Category 1 to 10 vehicle combinations under the Prime Mover, Trailers Combinations Order 2017 and Truck, Trailer Combinations Order 2017.

Main Roads WA "[Guide to Design of Oversize and Over-Mass Vehicle Corridors](#)" is available. The document defines the design standards needed to satisfy efficient movement of High Wide Loads (HWL). HWL are defined as over-dimensional loads up to 8m high, 8m wide and 24m long with maximum 270t net mass. The design standards for other over-dimensional vehicles can be obtained from Main Roads Heavy Vehicle Operations Branch. Before applying the relevant design criteria, a detailed route assessment must be carried out to identify any possible risks or dangers for the movement of high wide loads. An effective route assessment should promote the following principles: Achieving HWL clearance envelope requirements; maintaining integrity of bridges and other structures; Ensure safe and efficient transport; and appropriate traffic management. A route assessment shall be carried out with appropriate traffic management measures to identify any modification work required. Delays to the other road users during undertaking these investigations shall be kept to minimum. It is recommended that before finalising the HWL route, replicated vehicles (full size unladen vehicles) should be driven along the selected routes, with their overhang and pivot point paths manually plotted. This will enable identification of roadside furniture, vegetation and other obstacles that may be affected by the movement of such vehicles. It is envisaged that as HWL movements become more frequent, the impact of HWL movements on

other road users will become more problematic. The impacts of HWL on the operation of a road should be assessed, based on the available traffic data.

## **A.6 Data Analysis and Presentation**

Crash data (5 years) is available via the Main Roads WA website. This includes, roads, intersections and those pre-qualified for Blackspot funding. Crash factor matrix, behaviour matrix, collision diagram, comparison with network average, counter measures and BCR report. Detailed crash reports are also available for local government areas. Reports are available for a crash history summary, detailed crash history and ROSMA KSI crash extract. by accessing Main Roads WA website and creating an account.

## **APPENDIX B SPEED SURVEYS**

Main Roads has no supplementary comments for this section.

## **APPENDIX C TRAVEL TIME, QUEUING AND DELAY SURVEYS**

Main Roads has no supplementary comments for this section.

## **APPENDIX D ORIGIN-DESTINATION SURVEYS**

Main Roads has no supplementary comments for this section.

## **APPENDIX E PEDESTRIAN AND BICYCLE SURVEYS**

Main Roads' Asset and Geospatial Information Branch launched Trafficmap, cycle counts across the road network are now available.

## **APPENDIX F NOISE, FUEL AND EMISSION SURVEYS**

Main Roads has no supplementary comments for this section.

## **APPENDIX G VEHICLE MASS AND DIMENSIONS SURVEYS**

Main Roads has no supplementary comments for this section.

## **APPENDIX H PARKING SURVEYS**

Main Roads has no supplementary comments for this section.

## **APPENDIX I TRAFFIC GENERATION SURVEYS**

Main Roads has no supplementary comments for this section.

## **APPENDIX J ERROR IN SEASONAL ADJUSTMENT FACTOR**

Main Roads has no supplementary comments for this section.

## **APPENDIX K EMERGING AND ALTERNATIVE TRAFFIC DATACOLLECTION TECHNOLOGIES**

Main Roads has no supplementary comments for this section.

## **APPENDIX L USE CASES OF NEW AND MULTIPLE DATA SOURCES**

Main Roads has no supplementary comments for this section.

## **APPENDIX M EXAMPLE PACKAGES FOR MODELLING**

Main Roads has no supplementary comments for this section.

## **COMMENTARY 1 – 4**

Main Roads has no supplementary comments for this section.

## APPENDIX N WORKED EXAMPLE USING HIGHWAY'S AGENCY METHODOLOGY FOR RAMP ANALYSIS

The question has been raised whether, as an interim (2021) solution, Redcliffe Bridge could be configured as indicated in Figure N1 below with 3 lanes southbound and 5 lanes northbound (3 main line lanes plus 2 C-D road lanes) as well as 2 southbound C-D lanes on a separate (new) structure. This structure would also cater for pedestrians. The forecast 2021 peak hour traffic volumes are also shown.

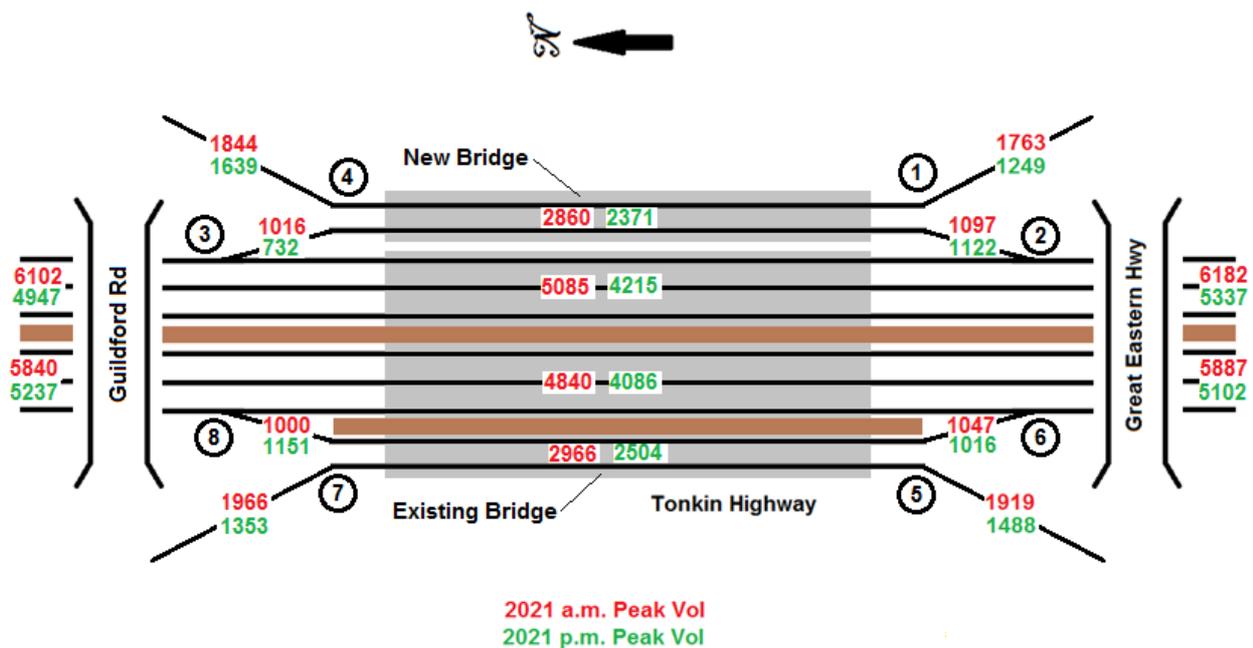


Figure N1: Proposed Year 2021 Tonkin Hwy Layout

### Diverge # 1 – C-D Road Southbound to GEH off-ramp

The UK Highways Agency (HWA) publication (TD22/06) provides a diagram for all purpose roads diverging (off-ramps). This is shown in Appendix O. This nomograph provides a methodology to determine the appropriate ramp configuration based on the downstream mainline and ramp traffic volumes.

For the C-D Road to GEH southbound exit ramp, using the worst peak hour scenario traffic volumes (a.m. peak hour), the required ramp configuration is a "Type D" configuration with one lane downstream and two lanes upstream. The ramp itself requires two lanes. This is shown in Figure N2 over the page.

It is clear that the proposed layout as indicated in Figure N1 will not be sufficient to cater for Year 2021 a.m. peak hour volumes: the ramp should be a two-lane off-ramp.



**Figure N2: Geometric requirements for Southbound C-D Road to GEH off-ramp based on HWA requirements (Type D diverge)**

### **Merge # 2 – C-D Road Southbound to Tonkin Hwy on-ramp**

The UK Highways Agency (HWA) publication (TD22/06) provides a diagram for freeway roads merging (on-ramps). This is shown in Appendix O. For the C-D Road to Tonkin Hwy southbound on-ramp, using the worst peak hour scenario traffic volumes (a.m. peak hour), the required ramp configuration is a “Type E” configuration with four lanes downstream and three lanes upstream. The ramp itself requires one lane. This is shown in Figure N3.



**Figure N3: Geometric requirements for Southbound C-D Road to Tonkin Hwy on-ramp based on HWA requirements (Type E merge)**

This analysis indicates that the proposed layout in Figure N1 will not be sufficient to cater for Year 2021 a.m. peak hour volumes and it would be necessary to increase the number of mainline lanes downstream from three to four. However, it should be noted that these nomographs are based on a per lane capacity of 1,800 vph, which is appropriate for an unmanaged freeway-standard road. If this section of road were to be “managed” through ramp-metering, the expected mainline throughput would be approximately 6,000 vph. Moreover the upstream volume prior to the C-D road off-ramp (diverge # 3) would also be restricted to 6,000 vph. Under these circumstances, three lanes downstream may just be sufficient. However, it would be appropriate to adopt a parallel (Type B) merge as indicated in Figure N4.

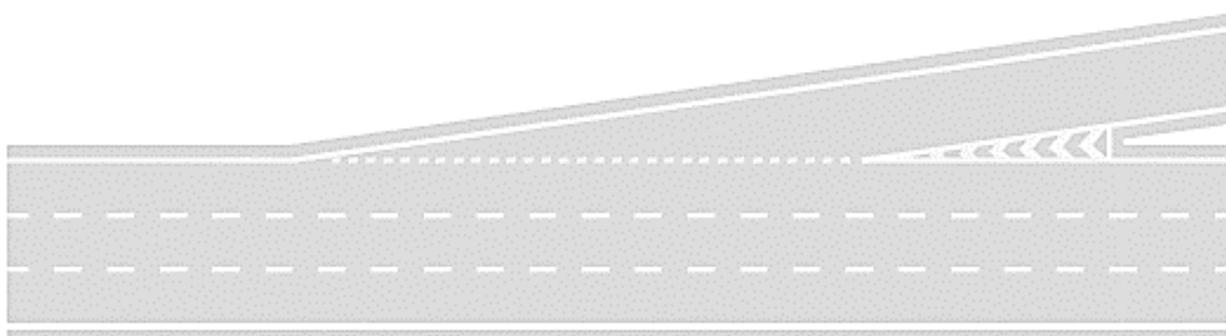


**Figure N4: Geometric requirements for Southbound C-D Road to Tonkin Hwy on-ramp based on Managed Motorways requirements (Type B merge)**

### **Diverge # 3 – Tonkin Hwy Southbound to C-D Road off-ramp**

The UK Highways Agency (HWA) publication (TD22/06) provides a diagram for freeway roads diverging (off-ramps). This is shown in Appendix O. For the Tonkin Hwy to C-D Road southbound off-ramp, using the worst peak hour scenario traffic volumes (a.m. peak hour), the required ramp configuration is a “Type C” configuration with four lanes upstream and three lanes downstream. The ramp itself requires one lane.

This analysis indicates that the proposed layout in Figure N1 will not be sufficient to cater for Year 2021 a.m. peak hour volumes and it would be necessary to increase the number of mainline lanes upstream from three to four. However, as mentioned previously, these nomographs are based on a per lane capacity of 1,800 vph, which is appropriate for an unmanaged freeway-standard road. If this section of road were to be “managed” through ramp-metering, the expected mainline throughput would be approximately 6,000 vph. Under these circumstances, three lanes upstream may just be sufficient. A Type A diverge as indicated in Figure N5 would be appropriate.

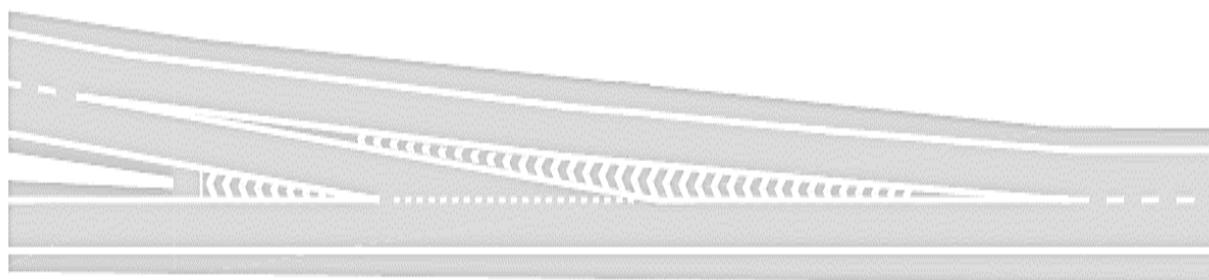


**Figure N5: Geometric requirements for Tonkin Hwy Southbound to C-D Road off-ramp based on Managed Motorways requirements (Type A diverge)**

### **Merge # 4 – Guildford Road to C-D Road Southbound on-ramp**

The UK Highways Agency (HWA) publication (TD22/06) provides a diagram for all purpose roads merging (on-ramps). This is shown in Appendix O. For the Guildford Road to C-D Road southbound on-ramp, using the worst peak hour scenario traffic volumes (a.m. peak hour), the required ramp configuration is a “Type F” configuration with two lanes downstream and one lane upstream. The ramp itself requires two lanes. This is shown in Figure N6.

It is clear that the proposed layout as indicated in Figure N1 will not be sufficient to cater for Year 2021 a.m. peak hour volumes: the ramp should be a two-lane on-ramp.

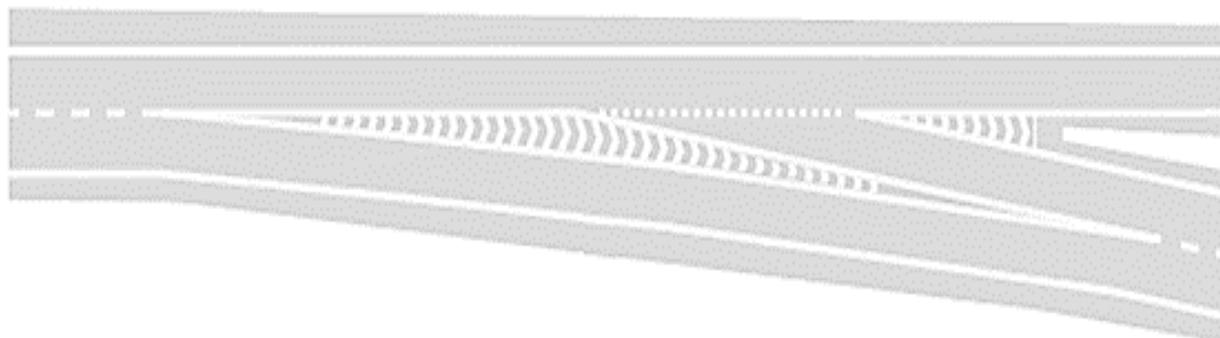


**Figure N6: Geometric requirements for Tonkin Hwy Southbound to C-D Road off-ramp based on Managed Motorways requirements (Type A diverge)**

### **Merge # 5 – GEH to Northbound C-D Road on-ramp**

The UK Highways Agency (HWA) publication (TD22/06) provides a diagram for all purpose roads merging (on-ramps). This is shown in Appendix O. For the GEH to C-D Road northbound on-ramp, using the worst peak hour scenario traffic volumes (a.m. peak hour), the required ramp configuration is a “Type F” configuration with two lanes downstream and one lane upstream. The ramp itself requires two lanes. This is shown in Figure N7.

It is clear that the proposed layout as indicated in Figure N1 will not be sufficient to cater for Year 2021 a.m. peak hour volumes: the ramp should be a two-lane on-ramp.

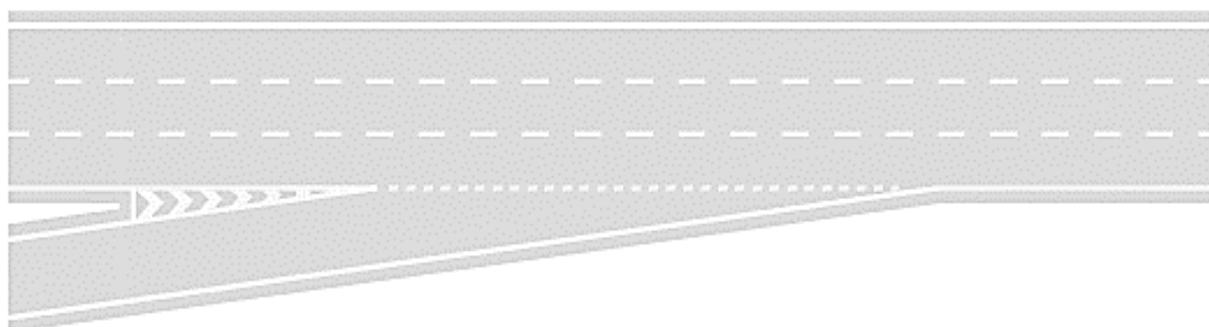


**Figure N7: Geometric requirements for Northbound GEH to C-D Road on-ramp based on HWA requirements (Type F merge)**

### **Diverge # 6 – Tonkin Hwy Northbound to C-D Road off-ramp**

The UK Highways Agency (HWA) publication (TD22/06) provides a diagram for freeway roads diverging (off-ramps). This is shown in Appendix O. For the Tonkin Hwy to C-D Road northbound off-ramp, using the worst peak hour scenario traffic volumes (a.m. peak hour), the required ramp configuration is a “Type C” configuration with four lanes upstream and three lanes downstream. The ramp itself requires one lane.

This analysis indicates that the proposed layout in Figure N1 will not be sufficient to cater for Year 2021 a.m. peak hour volumes and it would be necessary to increase the number of mainline lanes upstream from three to four. However, as mentioned previously, these nomographs are based on a per lane capacity of 1,800 vph, which is appropriate for an unmanaged freeway-standard road. If this section of road were to be “managed” through ramp-metering, the expected mainline throughput would be approximately 6,000 vph. Under these circumstances, three lanes upstream would be sufficient (5887 vph). A Type A diverge as indicated in Figure N8 would be appropriate.



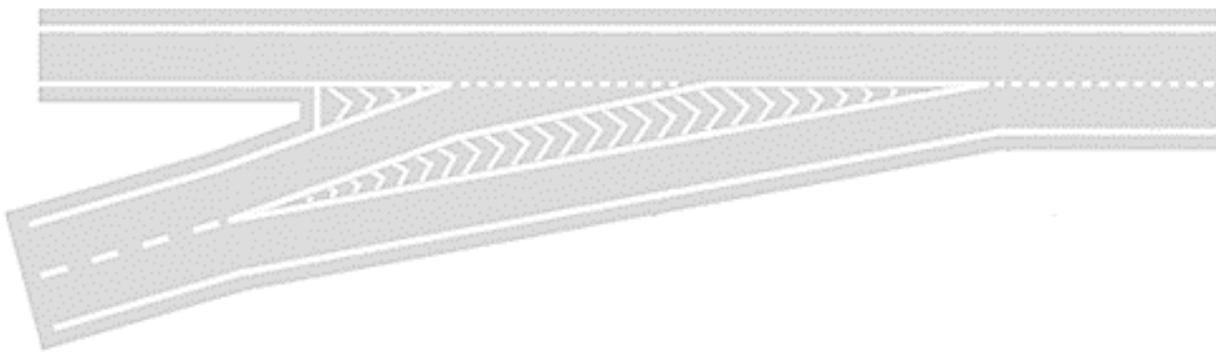
**Figure N8: Geometric requirements for Tonkin Hwy Northbound to C-D Road off-ramp based on Managed Motorways requirements (Type A diverge)**

**Diverge # 7 – C-D Road Northbound to Guildford Road offramp**

The UK Highways Agency (HWA) publication (TD22/06) provides a diagram for all purpose roads diverging (off-ramps). This is shown in Appendix O. This nomograph provides a methodology to determine the appropriate ramp configuration based on the downstream mainline and ramp traffic volumes.

For the C-D Road to Guildford Road northbound exit ramp, using the worst peak hour scenario traffic volumes (a.m. peak hour), the required ramp configuration is a “Type D” configuration with one lane downstream and two lanes upstream. The ramp itself requires two lanes. This is shown in Figure N9.

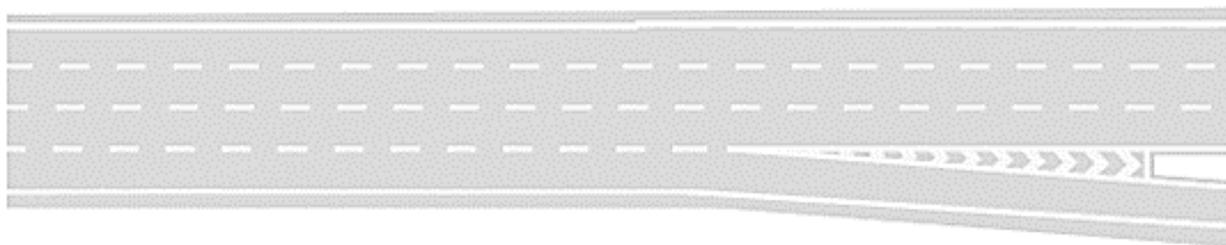
It is clear that the proposed layout as indicated in Figure 1 will not be sufficient to cater for Year 2021 a.m. peak hour volumes: the ramp should be a two-lane off-ramp.



**Figure N9: Geometric requirements for Northbound C-D Road to Guildford Road off-ramp based on HWA requirements (Type D diverge)**

**Merge # 8 – C-D Road Northbound to Tonkin Hwy on-ramp**

The UK Highways Agency (HWA) publication (TD22/06) provides a diagram for freeway roads merging (on-ramps). This is shown in Appendix O. For the C-D Road to Tonkin Hwy northbound on-ramp, using both the a.m. and p.m. peak hour traffic volumes, the required ramp configuration is a “Type E” configuration with four lanes downstream and three lanes upstream. The ramp itself requires one lane. This is shown in Figure N10.



**Figure N10: Geometric requirements for Northbound C-D Road to Tonkin Hwy on-ramp based on HWA requirements (Type E merge)**

This analysis indicates that the proposed layout in Figure N1 will not be sufficient to cater for Year 2021 a.m. peak hour volumes and it would be necessary to increase the number of mainline lanes downstream from three to four. However, it has been previously noted that these nomographs are based on a per lane capacity of 1,800 vph, which is appropriate for an unmanaged freeway-standard road. If this section of road were to be “managed” through ramp-metering, the expected mainline throughput would be approximately 6,000 vph. Under these circumstances, three lanes downstream would be sufficient (a.m. 5840 vph, p.m. 5237 vph). However, it would be appropriate to adopt a parallel (Type B) merge as indicated in Figure N11.



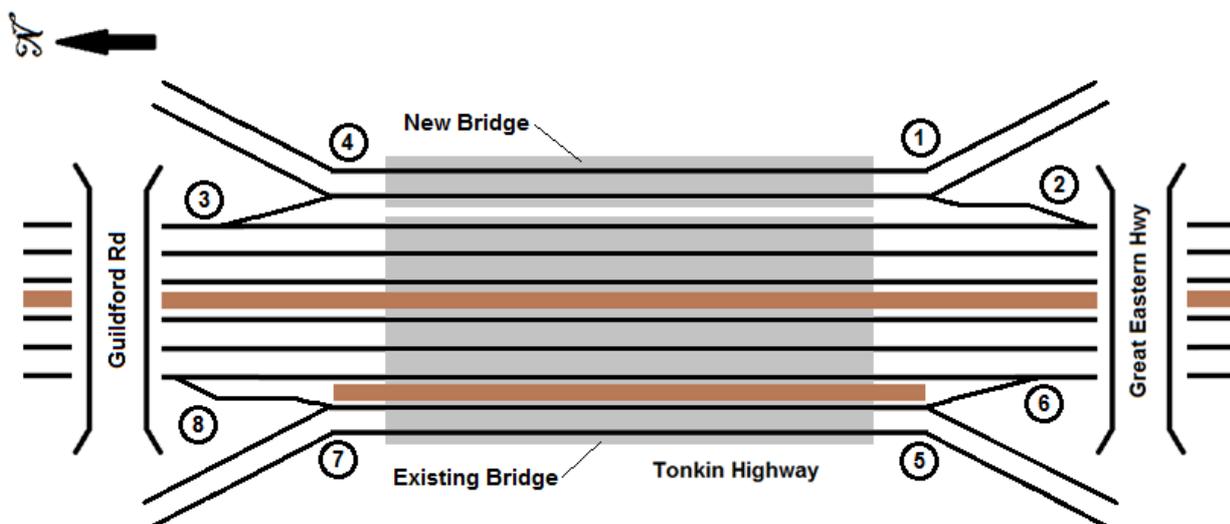
**Figure N11: Geometric requirements for Northbound C-D Road to Tonkin Hwy on-ramp based on Managed Motorways requirements (Type B merge)**

### **Summary**

In summary, the proposed “interim” (Year 2021) layout for the Redcliffe Bridge and ramps to and from the C-D roads, as indicated in Figure N1 will need to be modified as follows in order to operate efficiently:

- Both on-ramps to the C-D roads from GEH and Guildford Road will need to be upgraded to two-lane on-ramps.
- Both off-ramps from the C-D roads to GEH and Guildford Road will need to be upgraded to two-lane off-ramps.
- Both on-ramps from the C-D roads to Tonkin Highway will need to have an extended parallel section.
- For the mainline section to operate efficiently, this section of freeway will need to be operated on a “managed freeway” basis, i.e. with ramp metering to ensure a capacity of 2,000 vph per lane is achieved.

The proposed revised layout is given in Figure N12.



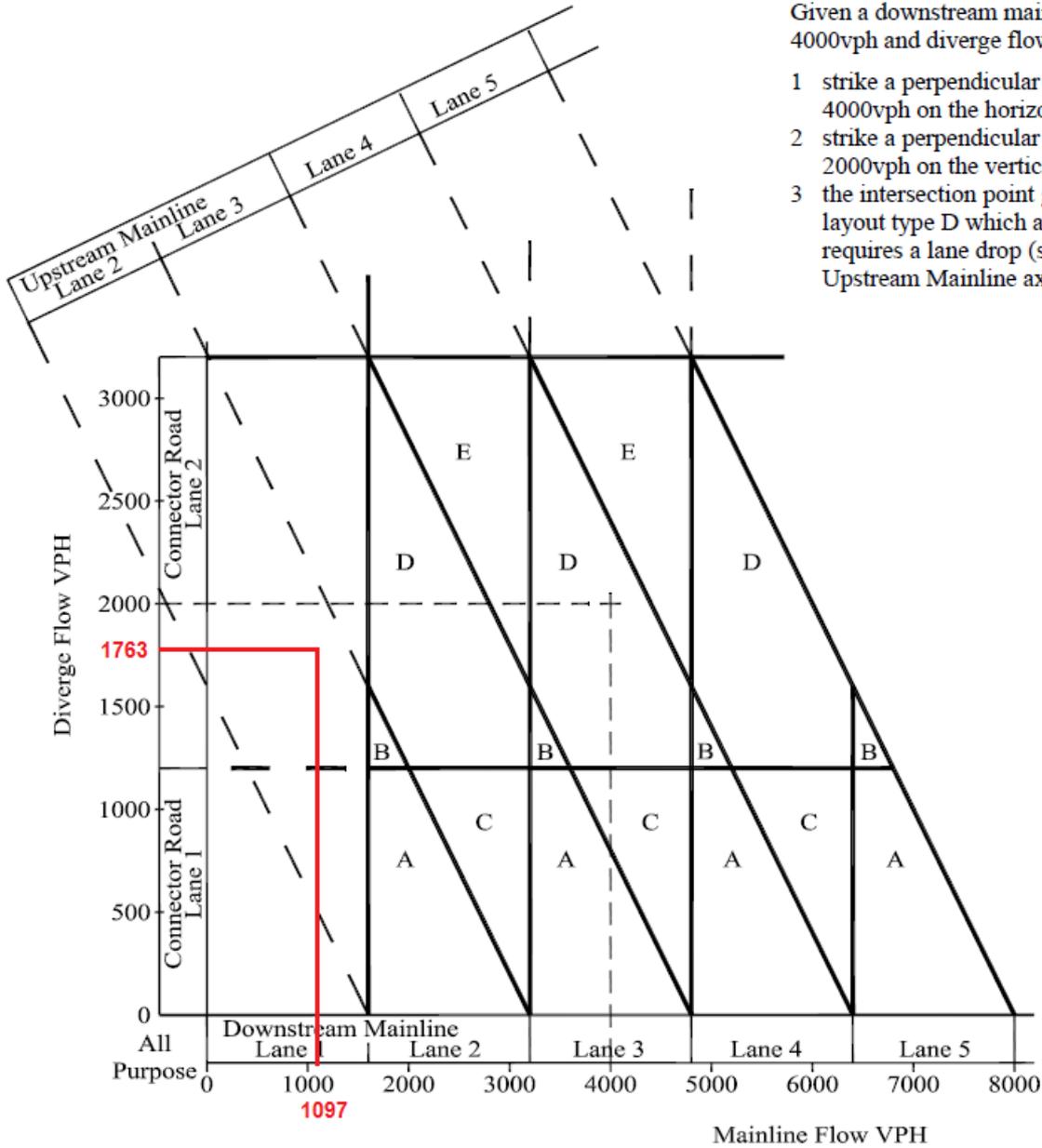
**Figure N12: Proposed, Revised Year 2021 Tonkin Hwy Layout**

# APPENDIX O WORKED EXAMPLE – HIGHWAYS AGENCY NOMOGRAPHS

## Diverge # 1 – C-D Road Southbound to GEH off-ramp

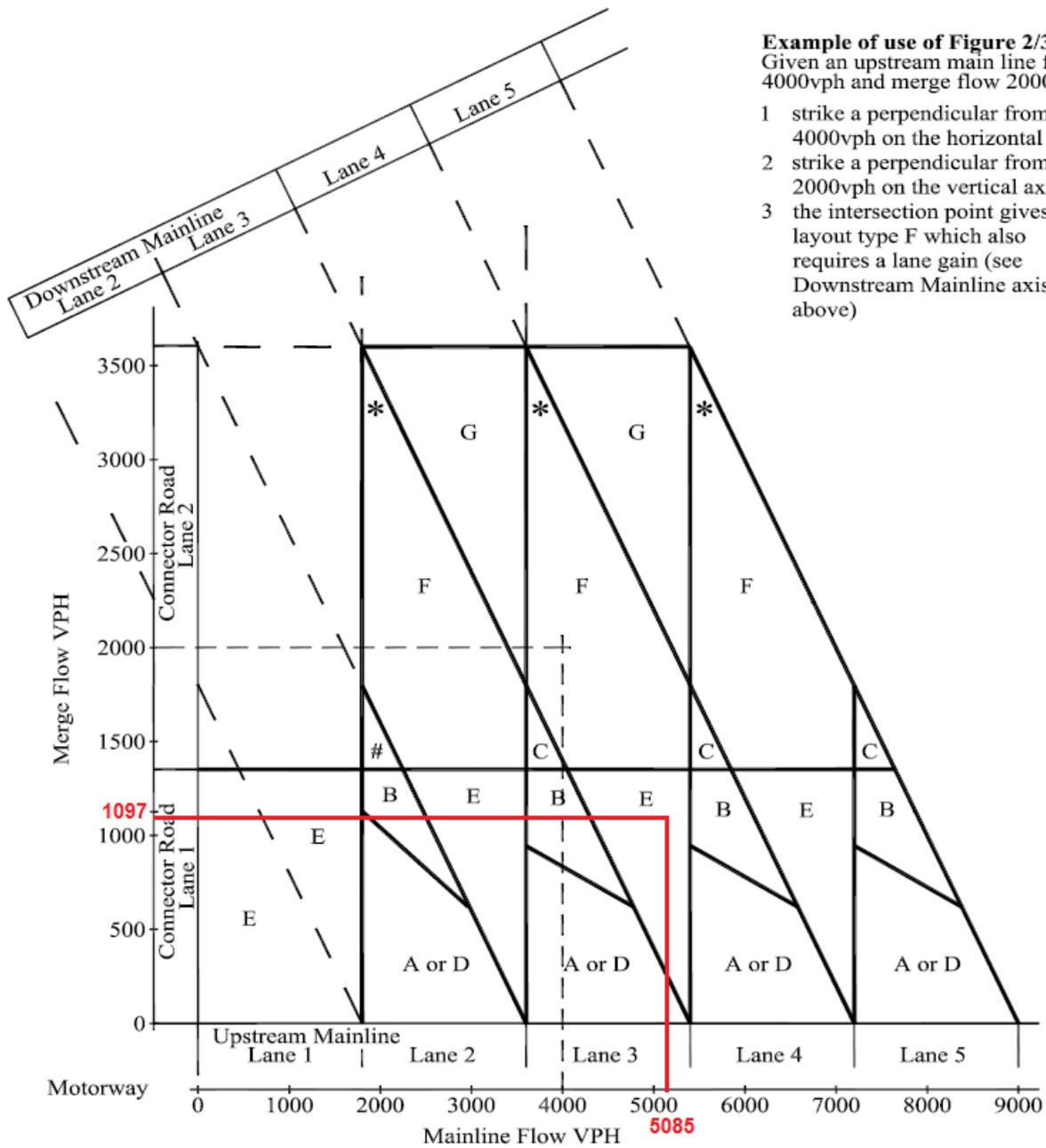
**Example of use of Figure 2/5AP**  
 Given a downstream main line flow 4000vph and diverge flow 2000vph.

- 1 strike a perpendicular from 4000vph on the horizontal axis
- 2 strike a perpendicular from 2000vph on the vertical axis
- 3 the intersection point gives layout type D which also requires a lane drop (see Upstream Mainline axis above)



**Based on All Purpose Road Diverging Diagram**

**Merge # 2 – C-D Road Southbound to Tonkin Hwy on-ramp**

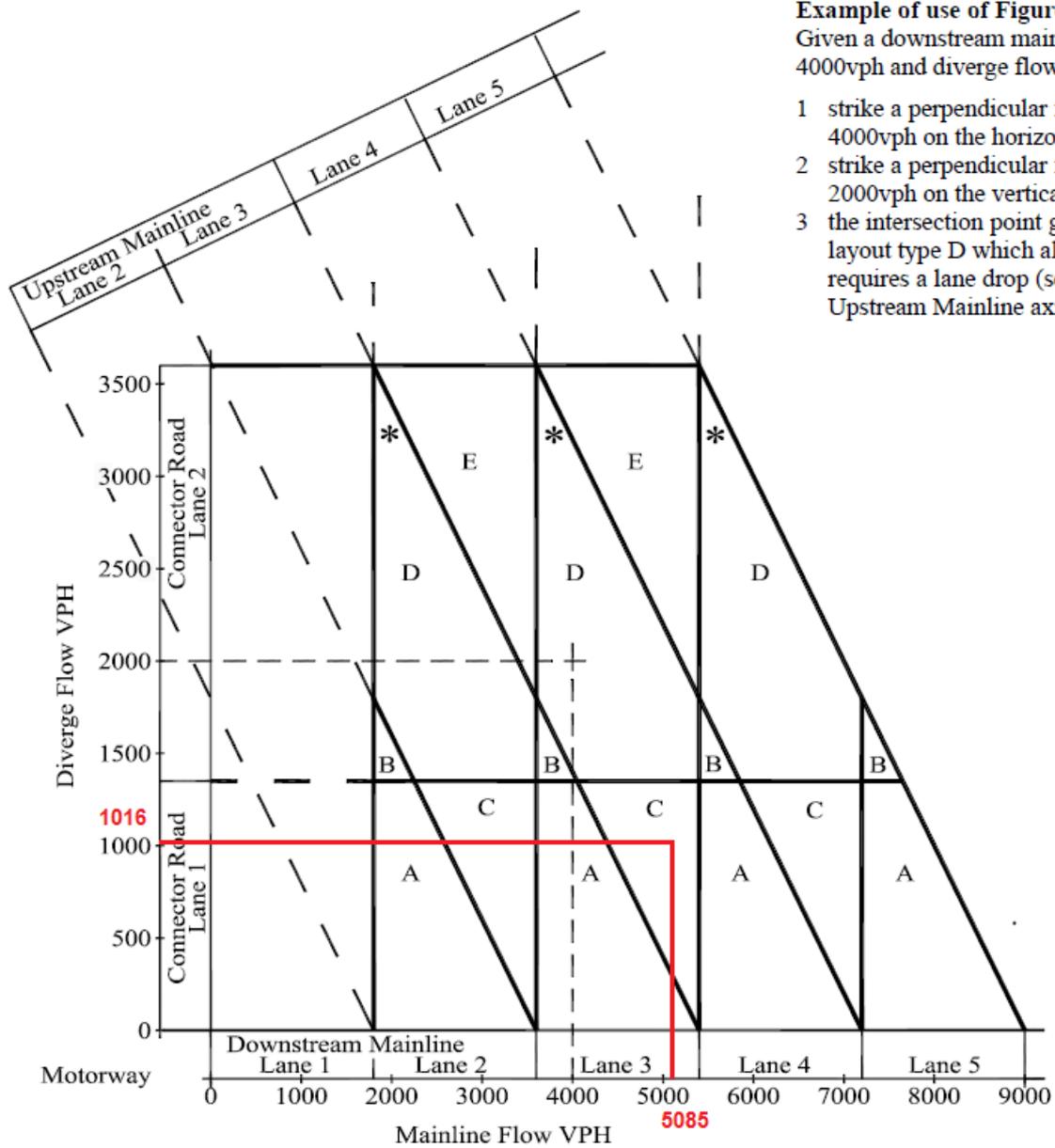


**Example of use of Figure 2/3MW**  
 Given an upstream main line flow 4000vph and merge flow 2000vph.

- 1 strike a perpendicular from 4000vph on the horizontal axis
- 2 strike a perpendicular from 2000vph on the vertical axis
- 3 the intersection point gives layout type F which also requires a lane gain (see Downstream Mainline axis above)

**Based on Freeway Merging Diagram**

**Diverge # 3 – Tonkin Hwy Southbound to C-D Road off-ramp**

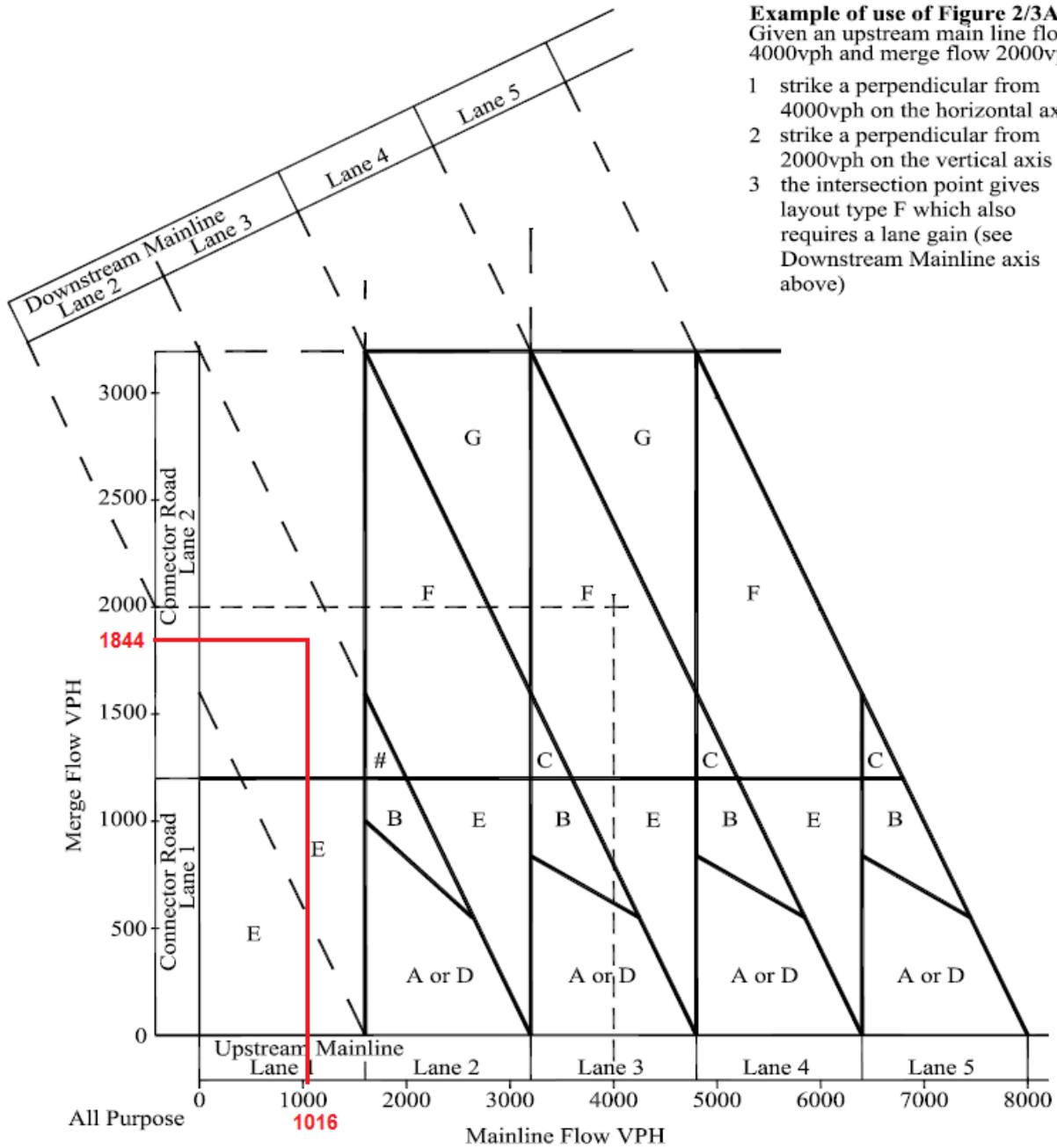


**Example of use of Figure 2/5MW**  
 Given a downstream main line flow 4000vph and diverge flow 2000vph.

- 1 strike a perpendicular from 4000vph on the horizontal axis
- 2 strike a perpendicular from 2000vph on the vertical axis
- 3 the intersection point gives layout type D which also requires a lane drop (see Upstream Mainline axis above)

**Based on Freeway Diverging Diagram**

**Merge # 4 – Guildford Road to C-D Road Southbound on-ramp**

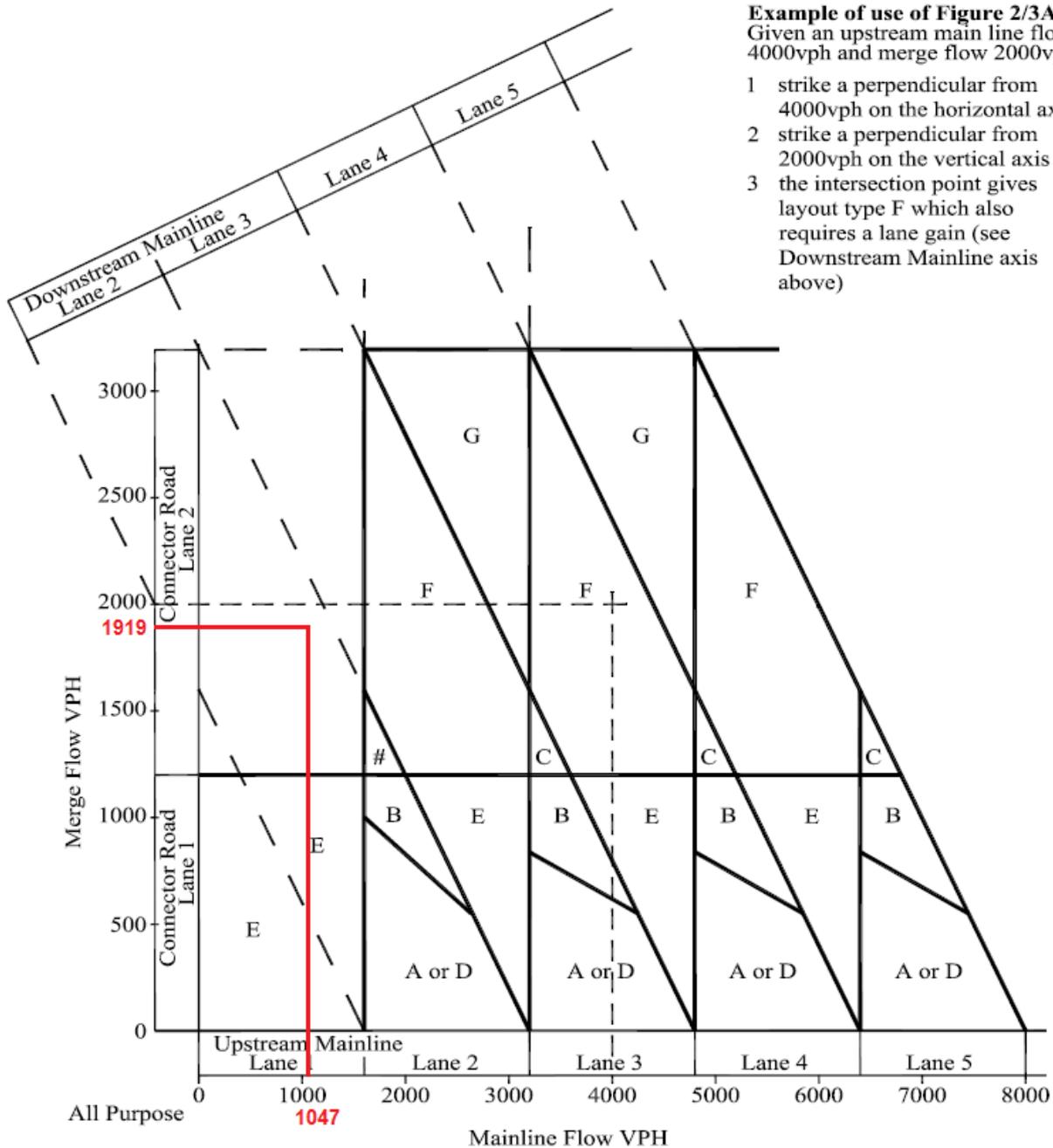


**Based on All Purpose Road Merging Diagram**

**Merge # 5 – GEH to C-D Road Northbound on-ramp**

**Example of use of Figure 2/3AP**  
 Given an upstream main line flow 4000vph and merge flow 2000vph.

- 1 strike a perpendicular from 4000vph on the horizontal axis
- 2 strike a perpendicular from 2000vph on the vertical axis
- 3 the intersection point gives layout type F which also requires a lane gain (see Downstream Mainline axis above)

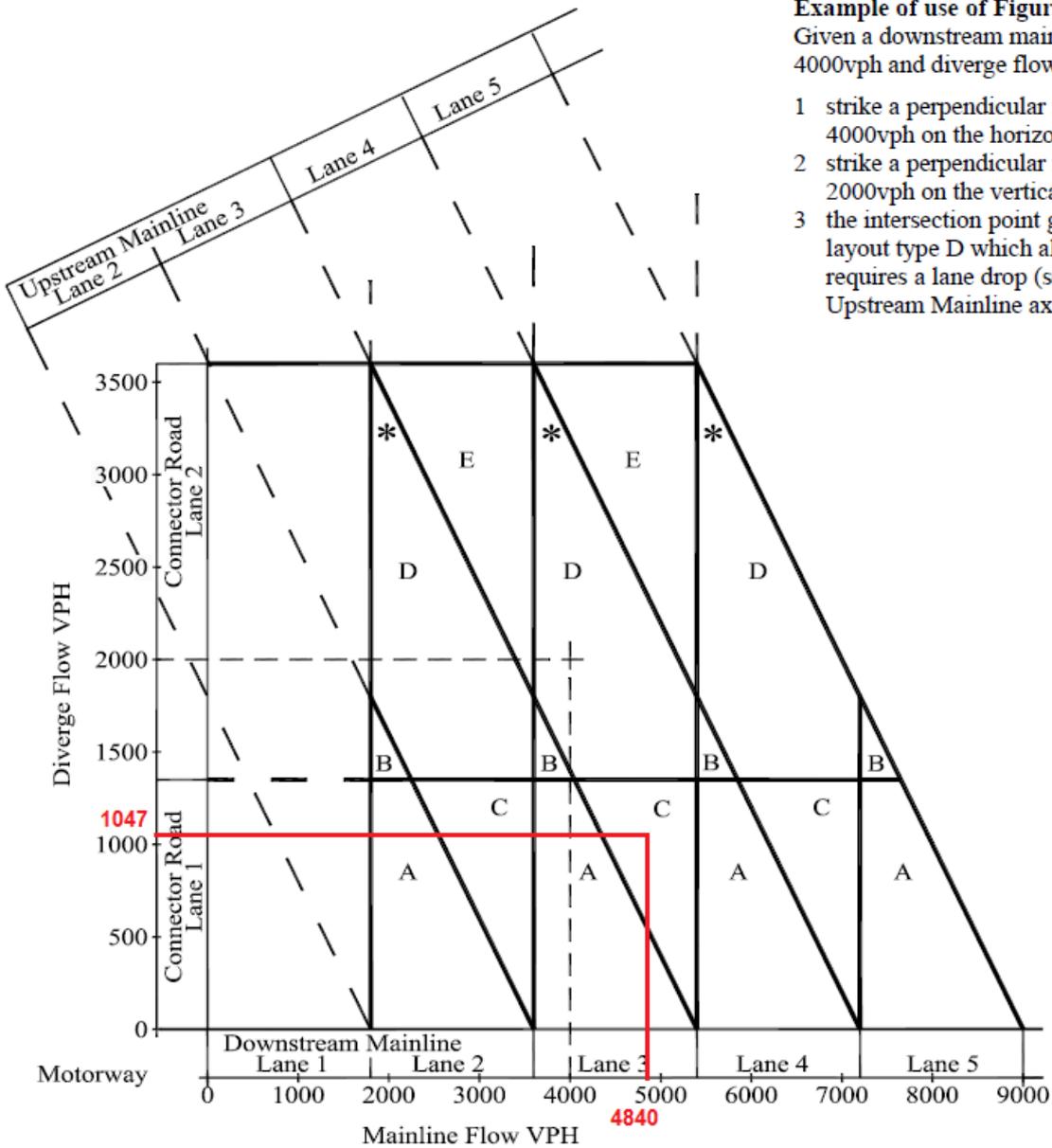


**Based on All Purpose Road Merging Diagram**

**Diverge # 6 – Tonkin Hwy Northbound to C-D Road off-ramp**

**Example of use of Figure 2/5MW**  
 Given a downstream main line flow 4000vph and diverge flow 2000vph.

- 1 strike a perpendicular from 4000vph on the horizontal axis
- 2 strike a perpendicular from 2000vph on the vertical axis
- 3 the intersection point gives layout type D which also requires a lane drop (see Upstream Mainline axis above)

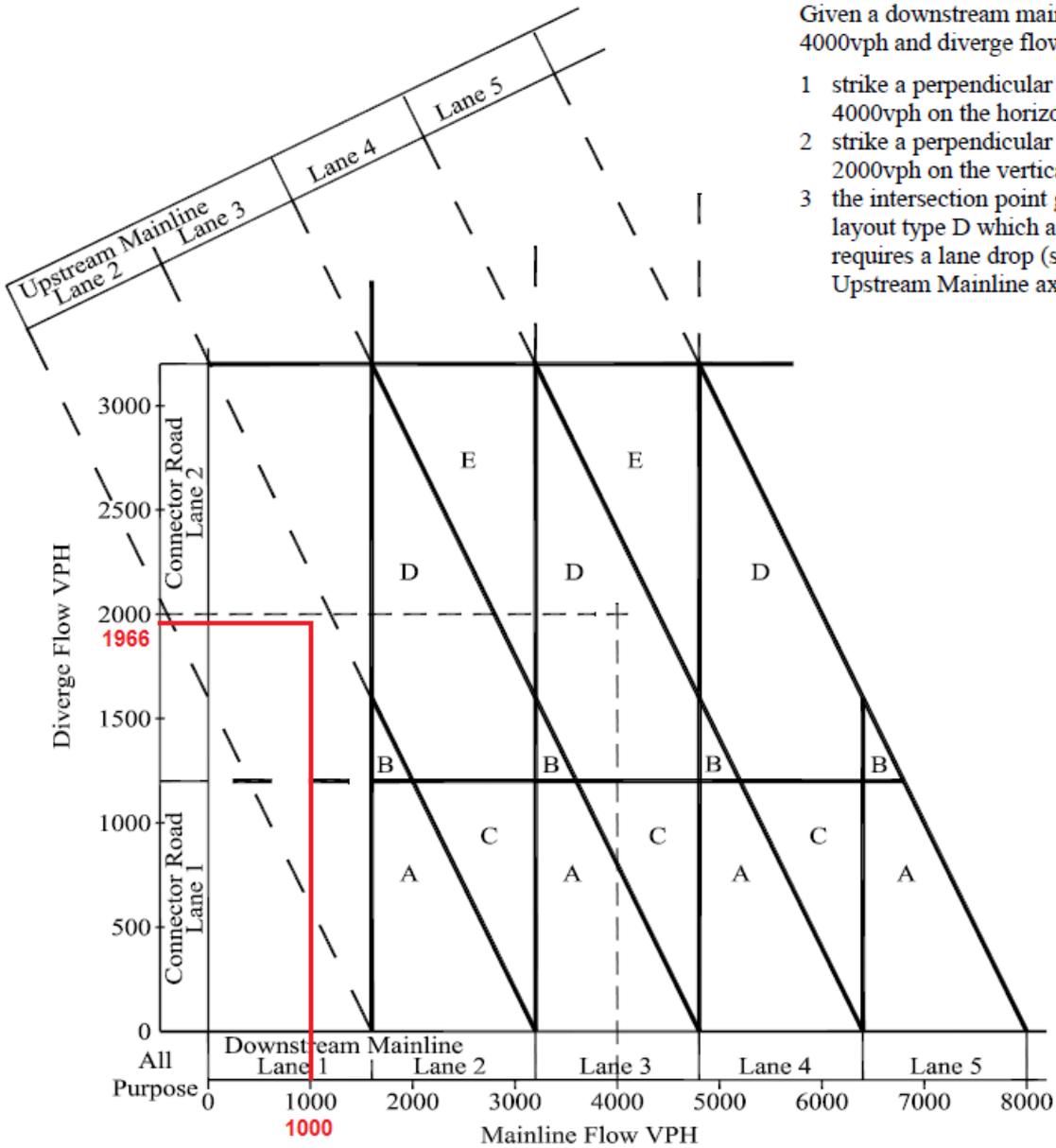


**Based on Freeway Diverging Diagram**

**Diverge # 7 – C-D Road Northbound to Guildford Road off-ramp**

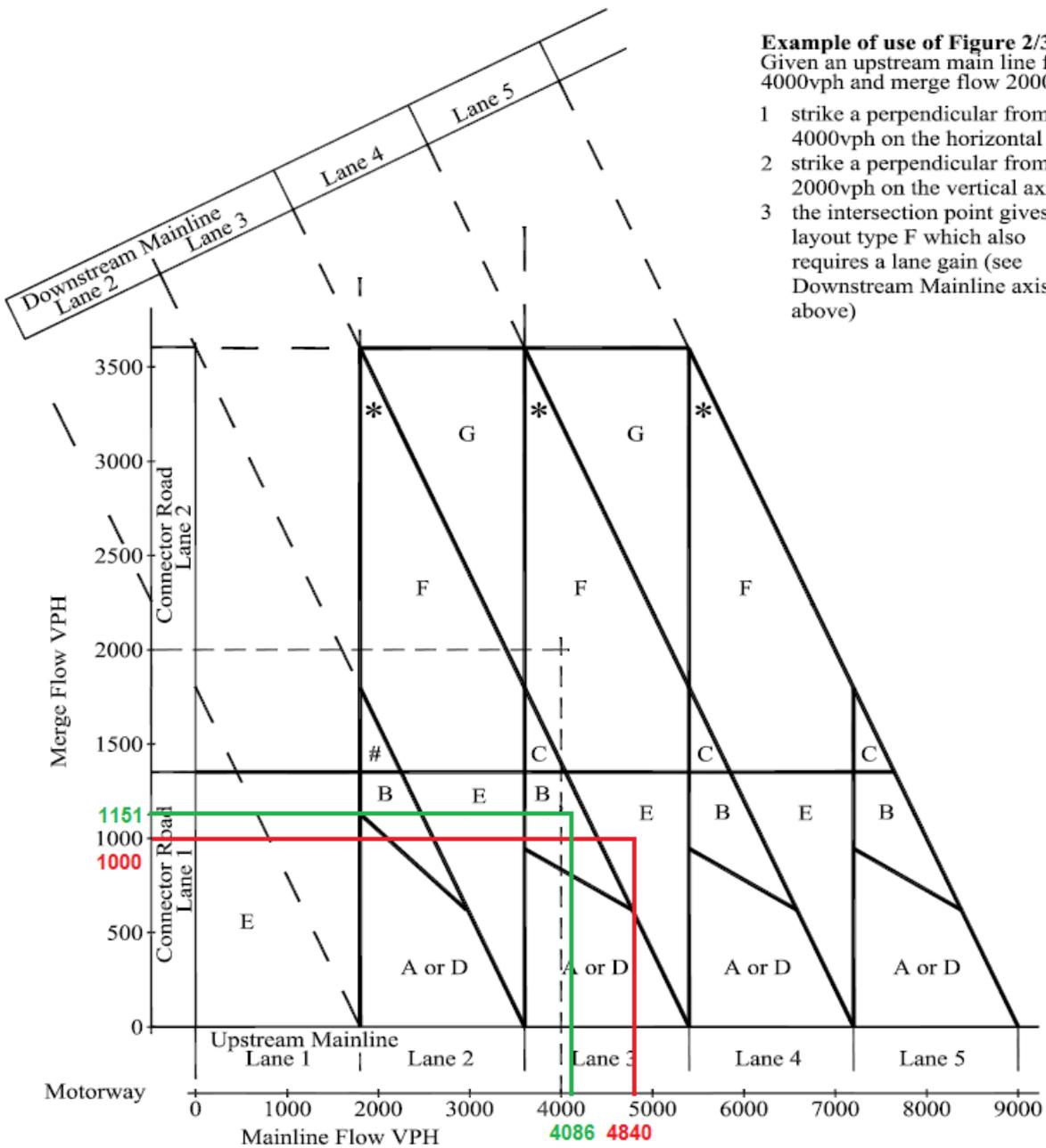
**Example of use of Figure 2/5AP**  
 Given a downstream main line flow 4000vph and diverge flow 2000vph.

- 1 strike a perpendicular from 4000vph on the horizontal axis
- 2 strike a perpendicular from 2000vph on the vertical axis
- 3 the intersection point gives layout type D which also requires a lane drop (see Upstream Mainline axis above)



**Based on All Purpose Road Diverging Diagram**

**Merge # 8 – C-D Road Southbound to Tonkin Hwy on-ramp**



**Example of use of Figure 2/3MW**  
 Given an upstream main line flow 4000vph and merge flow 2000vph.

- 1 strike a perpendicular from 4000vph on the horizontal axis
- 2 strike a perpendicular from 2000vph on the vertical axis
- 3 the intersection point gives layout type F which also requires a lane gain (see Downstream Mainline axis above)

**Based on Freeway Merging Diagram**