NRA
An tÚdarás um Bóithre Náisiúnta
National Roads Authority

Project Appraisal Guidelines

Unit 16.2 Expansion Factors for Short Period Traffic Counts

August 2012

Project Appraisal Guidelines

Unit 16.2
Expansion Factors for Short Period Traffic Counts

Version	Date	Comments
1.0	August 2012	New Guidance

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For further queries please contact:

Strategic Planning Unit
National Roads Authority
St Martin's House
Waterloo Road
Dublin 4

Tel: (01) 660-2511
Email: info@nra.ie
Web: www.nra.ie

Glossary

AADT	Annual Average Daily Traffic
WADT	Weekly Average Daily Traffic
AM Peak	The hour in which traffic flow peaks in the morning period
Inter Peak Period	The period between the AM Peak and the PM Peak periods
PM Peak Period	The hour in which traffic flow peaks in the evening period

Definitions

Annual Average Daily Traffic (AADT)
The total volume passing a point or segment of a road for one year, divided by the number of days in the year.

Weekday Average Daily Traffic (WADT)
The total volume passing a point or segment of a road for one full week (Monday to Sunday), divided by the number of days in the week (7).

Average Weekday Traffic
The total volume passing a point or segment of a road for one full working week (Monday to Friday), divided by the number of days in the working week (5).

Generic Expansion Factor Method
A method of extrapolating short period traffic counts to longer periods, or to other count periods using a series of standard indices.

Traffic Flow Profile
The shape of a line plot of hourly traffic flow across a 24-hour period, with hourly traffic flow expressed as a proportion of the total daily flow.

1. Overview

1.1. The planning and appraisal of any proposed works on the national road network requires an understanding of the traffic demand that will be supported by such improvements. This ensures that the proposed works can accommodate the anticipated demand, and allows the quantification of benefits as part of the scheme appraisal.

1.2. *PAG Unit 16.1: Estimating AADT on National Roads* sets out a methodology for calculating AADT using short period traffic counts for input to scheme design and appraisal. That Unit describes a series of options for additional data collection in order to convert localised short period counts or traffic model outputs into AADT.

1.3. It is accepted, nevertheless, that at an early stage in scheme planning the collection of data to support estimation of AADT may not be warranted. Instead, a means of developing outline indications of AADT, or of understanding the variability in traffic flow throughout the year is required. This allows the preparation of preliminary analysis, which can be supported by more detailed data collection at a later stage in scheme planning.

1.4. This PAG Unit has been prepared to support the conversion of Short Period Traffic Counts to AADT, or to facilitate the estimation of short period traffic flows at any point in a year using only a sample dataset of traffic information. The guidance achieves this by developing an annual traffic flow profile that considers time of day, day of week and month of year, thereby generating a series of indices to allow short period counts from one period to be extrapolated to any period of the year, or to AADT. This is referred to as the **Generic Expansion Factor Method.**

1.5. This guidance acknowledges the potential for statistical error in the Generic Expansion Factor Method. Confidence limits are set out where appropriate to ensure that the variability in observations can be considered.

1.6. The Generic Expansion Factor Method can be used for short period counts where nearby data is not available, and where the collection of localised period counts is not justified. This would normally be the case where data is required for high level studies only, and where outputs will not be used as the basis for Project Appraisal or any form of local capital investment. For all other applications, please refer to *PAG Unit 16.1: Estimating AADT on National Roads*. The guidance presented in RT201 is superseded by PAG Units 16.1 and 16.2.

1.7. For the purpose of this PAG Unit, short period traffic counts are defined as counts of duration less than 7 days. The flowchart in Figure 16.2.1 should be used to inform the most appropriate means of developing AADT estimates from short period traffic counts in different circumstances.

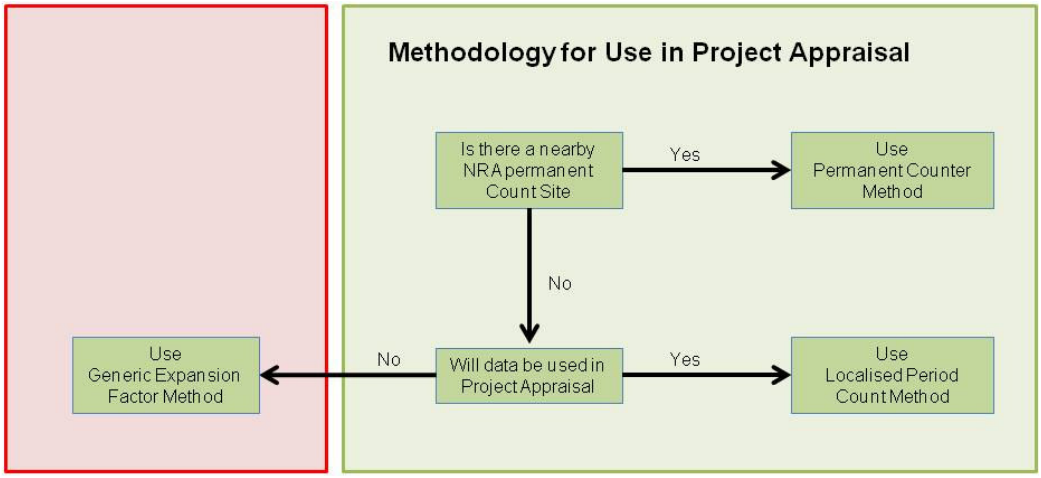


Figure 16.2.1: Approaches for Estimating AADT from Short Period Counts

2. Factors Effecting Traffic Flow Profiles

2.1. The conversion of short period traffic counts to alternative short periods or to AADT is dependant on the shape of the traffic flow profile across a defined period. Flatter traffic flow profiles indicate a more uniform distribution of traffic flow across a particular period, whilst roads with a more pronounced increase in traffic flow during particular hours, days or months will lead to increased variability in the traffic flow profile.

2.2. This is indicated below in Figure 16.2.2. The blue profile shows a distinct peak in traffic flow during the AM and PM Peak periods, with very low flows overnight and a notable reduction in flow during the middle of the day. The profile shown in red shows a lower peak effect, with higher proportional flows during the middle of the day and overnight. This demonstrates the impact of the daily flow profile on the validity of expansion factors used to generate daily traffic flow estimates from short period counts during the day.

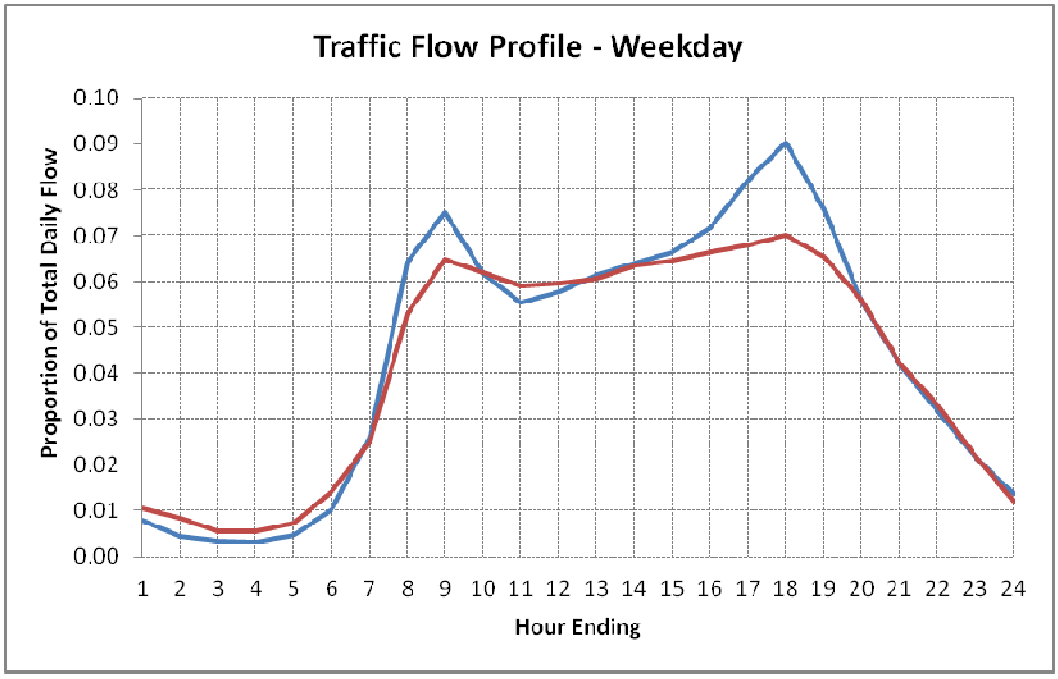


Figure 16.2.2: Daily Traffic Flow Profiles

2.3. In recognition of this, it is therefore necessary that this variability is considered in the development of indices to be applied to short period traffic counts. In this regard, the findings of *PAG Unit 16.1: Estimating AADT on National Roads* are referenced, which highlighted that the following factors influence the generation of indices for expansion of short period traffic counts:

- Geographical Location;
- Day of Week; and
- Month of Year.

2.4. For the Generic Expansion Factor Method, the effects of these criteria will also be incorporated into the preparation of indices.

3. Overview of the Generic Expansion Factor Method

3.1. The conversion of short period traffic counts to alternative periods, and to facilitate an outline estimation of AADT is based on the following datasets:

- **Hour of Day:** A series of traffic flow profiles that are representative of weekdays for different geographical regions;
- **Day of Week**: Indices that allow the conversion of a single 24-hour traffic flow to an average day for that week (WADT); and
- **Month of Year**: Indices that allow the conversion of WADT into an estimate of AADT.

3.2. Although the use of these datasets has been presented to convert short period traffic counts upwards to AADT, they can equally be used to convert between different

short periods thorough calculation of AADT, followed by inverted use of indices to estimate traffic flow for any short period.

4. Factoring by Hour of Day

4.1. 24-hour traffic flow profiles have been developed based on a series of geographical regions. In order to define regions, it was necessary to develop an indicator of the shape of the flow profile over a typical day.

4.2. The shape of a daily flow profile can either be described as 'peaky' or 'flat'. Peaky flow profiles exhibit high traffic volumes during AM and PM Peak periods, with relatively lower flow throughout the remainder of the day (shown as blue in Figure 16.2.2. This pattern is most evident on busy commuting corridors, with a limited number of non-employment related uses to generate ongoing demand throughout the day.

4.3. Flat profiles exist for a number of reasons. Congested roads can exhibit relatively flat profiles. The existence of a capacity constraint during peak periods can lead to spreading of peak demand into the peak shoulders, effectively restraining the peak flow whilst increasing the off-peak flows. In the most severe cases, the existence of bottlenecks or opposing movements downstream can lead to a significant reduction in traffic flow during the peak periods. This can skew the results of any expansion of peak hour flows quite considerably, and supports the conclusion that the use of short period traffic flows during congested periods should not be used as the basis for any estimation of WADT or AADT.

4.4. Nevertheless, flat profiles may also suggest that there is a broader range of trip purposes along a corridor, with commuting demand during the peak periods overlaid with retail, leisure or other business demands during the off peak periods. As such, flatter flow profiles can easily exist where there are no significant capacity limitations.

4.5. Finally, the use of flow profiles is not appropriate on routes where variable price tolling is employed (such as the Dublin Port Tunnel). In such cases, the variable pricing of tolls influences demand and traffic volumes can deviate significantly from the traffic flow profiles presented here.

4.6. In order to represent the 'Peakiness' of a traffic flow profile over a particular day, the concept of a 'p-factor' has been derived. The p-factor simply describes the scale of the reduction in flow between the AM Peak and the quietest period of the afternoon (the Inter-Peak), and from the Inter-Peak back up to the PM Peak. It is defined as follows:

$$p = a + b - 2c$$

where:

p = the peak factor (known as p-factor)
a = the maximum hourly proportion of traffic between 0:00 and 12:00 on a weekday
b = the maximum hourly proportion of traffic between 12:00 and 24:00 on a weekday
c = the minimum hourly proportion of traffic between 08:00 and 18:00 on a weekday

4.7. Consider the example below in Figure 16.2.3. The values for a, b, and c are shown on the graph. The p-factor yields a value of 0.057. Note that the maximum p-factor is 1.0, in which case all traffic flow would occur during 2 individual peak hours of the day, separated by a cessation of all traffic during the afternoon. The minimum possible theoretical value is zero.

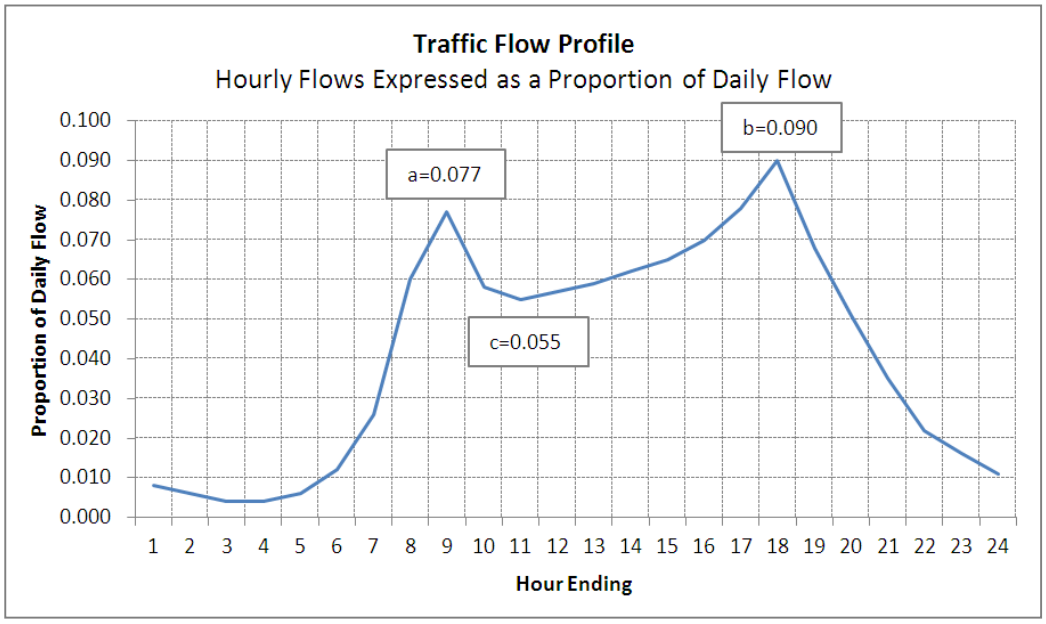


Figure 16.2.3: Calculation of p-factor

4.8. In order to understand the impact of geographical location on the p-factor, and hence the traffic flow profile, p-factors for NRA Permanent Counters have been calculated. Figure 16.2.4 presents a frequency plot of values over the range of p-factors from 0 to 0.15.

4.9. The analysis of p-factors demonstrates that the range of data is bounded by an upper 85 percentile value of 0.081, with a lower 85 percentile value of 0.043. The analysis also shows a cluster of values around the mean of 0.062.

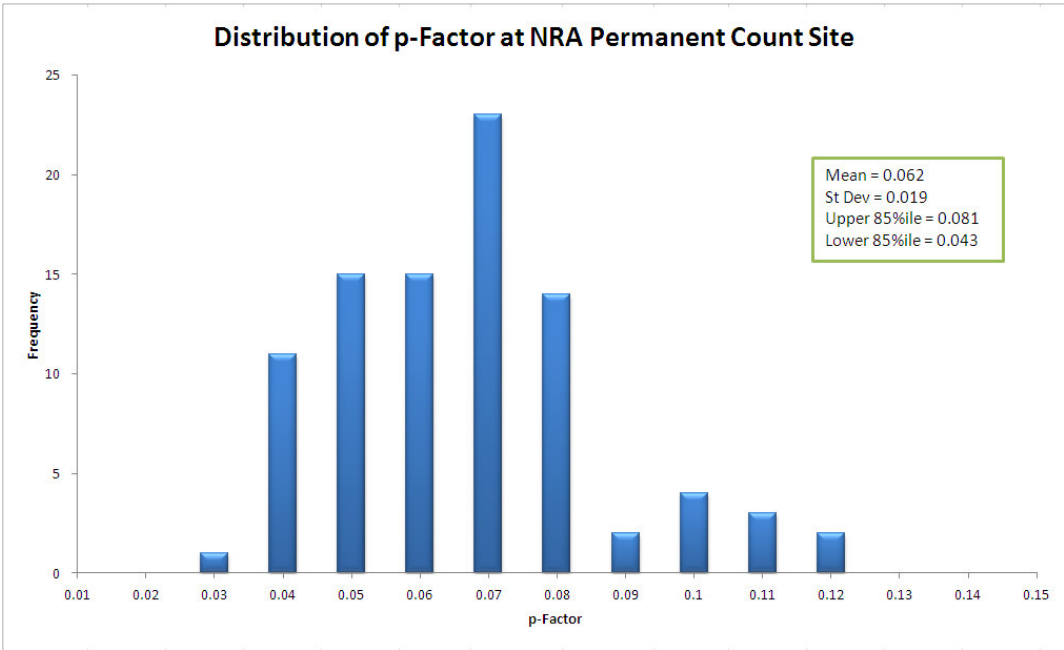


Figure 16.2.4: Distribution of p-factor at NRA Permanent Count Sites

4.10. As a further exercise, the range of p-factors has been plotted thematically to understand the influence of geography. This is presented in Figure 16.2.5 and shows high p-factor values as red/yellow, with lower values in blue. Mid range values are shown as green.

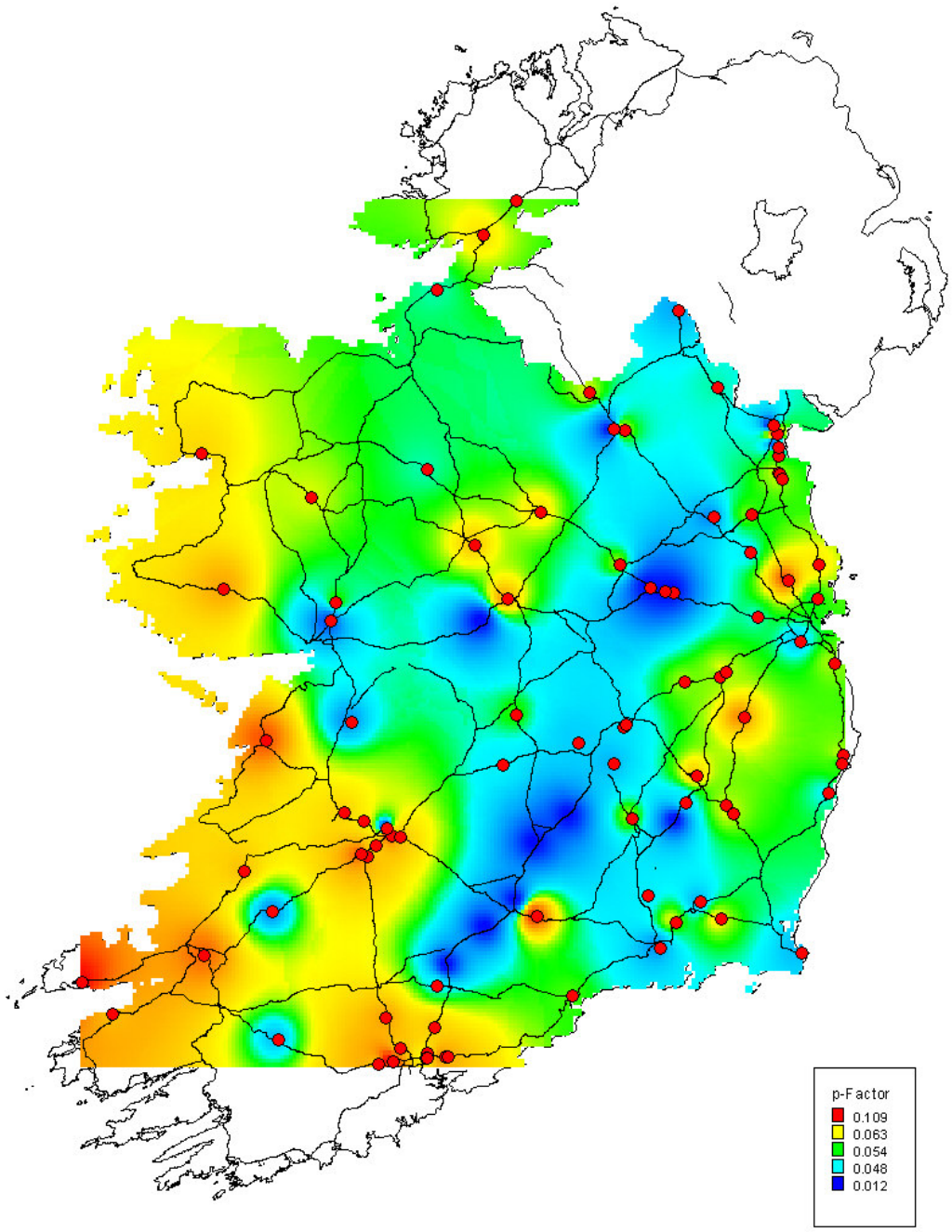


Figure 16.2.5: Thematic Mapping of p-factors at NRA Permanent Count Sites

4.11. The mapping shows a definite influence of geography on the p-factor, and hence on the shape of the traffic flow profile. There is a pattern of high p-factor values in the west and southwest, and to a lesser extent through the Greater Dublin Area. The lowest values are evident through the midlands.

4.12. On closer examination of individual results, it becomes clear that the Major Inter-Urban Routes exhibit relatively low p-factor values across the network. This suggests that the pattern of activity on the MIU's is substantively different to other roads, and warrants a separate classification.

4.13. As a result of the above findings, it is appropriate to develop a range of traffic flow profiles which reflect the different patterns across the Country, effectively reducing the standard deviation in p-factors within each area and facilitating a more accurate estimation of the 24-hour traffic flow from a short period count. The following geographies have been identified:

- The Major Inter-Urbans (excluding the Greater Dublin Area), which exhibit the lowest p-factors;
- The Southwest and West, comprising Counties Cork, Kerry, Limerick, Clare, Galway and Mayo;
- The Greater Dublin Area; and
- All other areas.

4.14. The relevant Traffic Flow Profiles for these areas are outlined in Annex A of this PAG Unit. A series of examples outlining the conversion of short period traffic counts to 24-hour weekday totals are outlined overleaf.

4.15. Confidence Intervals for expansion factors for each hour to the 24-hour total are also presented in Annex A based on a 95% Confidence Interval. The table shows those values which yield intervals greater than $\pm$20% in grey, suggesting that use of single-hour data from these periods will not yield a reliable result. For the estimation of 24-hour flow for traffic counts from these periods, they should be combined with flows from other periods to improve the accuracy of the estimation. In the case of counts from multiple periods, the 95% Confidence Interval may be assumed as the lowest value of the various hours for which data is available.

Example: Conversion of Short Period Traffic Count to a 24-hour total.

Consider a traffic count covering the period from 08:00 to 09:00 on the N5 at Bohola, County Mayo. The traffic count reports a traffic flow of 600 vehicles per hour (2-way).

Step 1: Identify the relevant geographical location. For this example, the relevant profiles are for the *Southwest and West*.

Step 2: Identify the proportion of daily traffic flow that relates to the short period count. From Annex A it can be seen that the proportion of the 24-hour flow occurring during the period 08:00 – 09:00 is **0.073**.

Step 3: Perform the calculation. The 24-hour estimate is therefore as follows

600/0.073 = 8219

The 24-hour estimate is therefore 8219 vehicles

Example: Conversion of Short Period Traffic Count to a 24-hour total.

Consider a traffic count covering the period from 08:00 to 09:00 and 14:00 – 16:00 on the N11 at Ferrycarraig, Co Wexford. The traffic count reports a traffic flow of 1400 vehicles (2-way) during the combined hours.

Step 1: Identify the relevant geographical location. For this example, the relevant profiles are for *All Other Areas*.

Step 2: Identify the proportion of daily traffic flow that relates to the short period count. From Annex A it can be seen that the proportion of the 24-hour flow occurring during the period 08:00 – 09:00 and 14:00 – 16:00 is **0.215**. (This is calculated as the sum of 0.07, 0.07 and 0.075 which cover the three individual time periods.

Step 3: Perform the calculation. The 24-hour estimate is therefore as follows

1400/0.215 = 6512

The 24-hour estimate is therefore 6512 vehicles

5. Factoring by Day of Week

5.1. Once a 24-hour estimate is derived, a further calculation can be undertaken to convert this to an average weekday (or to estimate 24-hour flows that might arise on other weekdays).

5.2. Figure 16.2.5 below shows a weekly flow profile based on data from the network of NRA Permanent Traffic Counters. The data shows a gradual increase in the 24-hour traffic flow from Monday through to a peak on Friday, with a reduction in total flows at weekends.

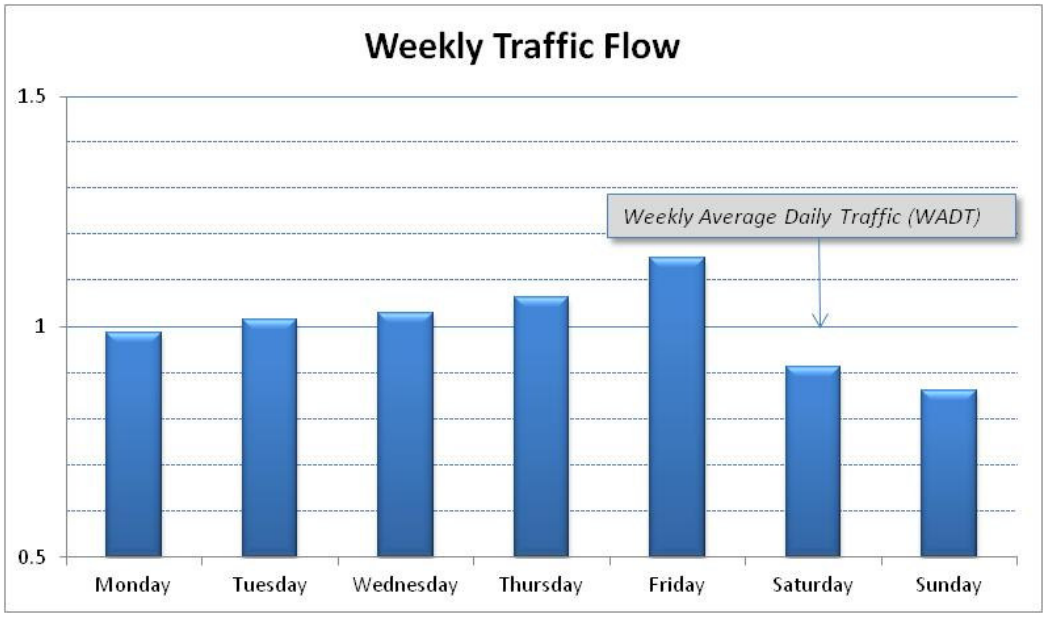


Figure 16.2.5: Weekly Flow Profile

5.3. Note that Weekly Average Daily Traffic (WADT) refers to the mean 24-hour traffic flow across a week. This is not to be confused with a Weekday Average, which represents a 24-hour average for the Monday to Friday period. Geography is not considered to be a significant factor in converting from a 24-hour estimate to WADT.

5.4. A series of Weekly Flow Indices have been generated using this data to enable the conversion from a specific day to a Weekly Average day. These are outlined in Annex B of this PAG Unit. An example of a conversion from a single day to an estimate of the Weekly Average Daily Traffic is outlined below.

Example: Conversion of 24-hour flow to a Weekly Average Day.

Consider a 24-hour traffic volume collected on a Tuesday. The traffic count reports a traffic flow of 12,500 vehicles over the 24-hours.

Step 1: Identify the relevant day, which in this case is a Tuesday.

Step 2: Extract the correct factor to convert to Weekday Average Day. For a Tuesday, Annex B shows that the relevant factor is 0.98

Step 3: Perform the calculation. The WADT is therefore as follows

12,500*0.98 = 12,250

The WADT estimate is therefore 12,250 vehicles

6. Factoring by Month of Year

6.1. The final calculation is to convert WADT to AADT. This final stage recognises the significant variation that can occur in traffic flows across the year. Such variations arise as a result of:

- The seasonal effects of tourism;
- Reductions in school trips during holiday periods;
- The effect of annual leave on the volume of commuting trips during the summer months; and
- Changes in the level of retail activity.

6.2. This effect is also referred to as seasonality, which describes the variability in traffic flow at different times of the year. To demonstrate the scale of the seasonality effect, Figure 16.2.6 shows WADT for each month expressed as a proportion of AADT. The data shows that daily traffic flows peak during the summer period, with the lowest flows during the months of December and January.

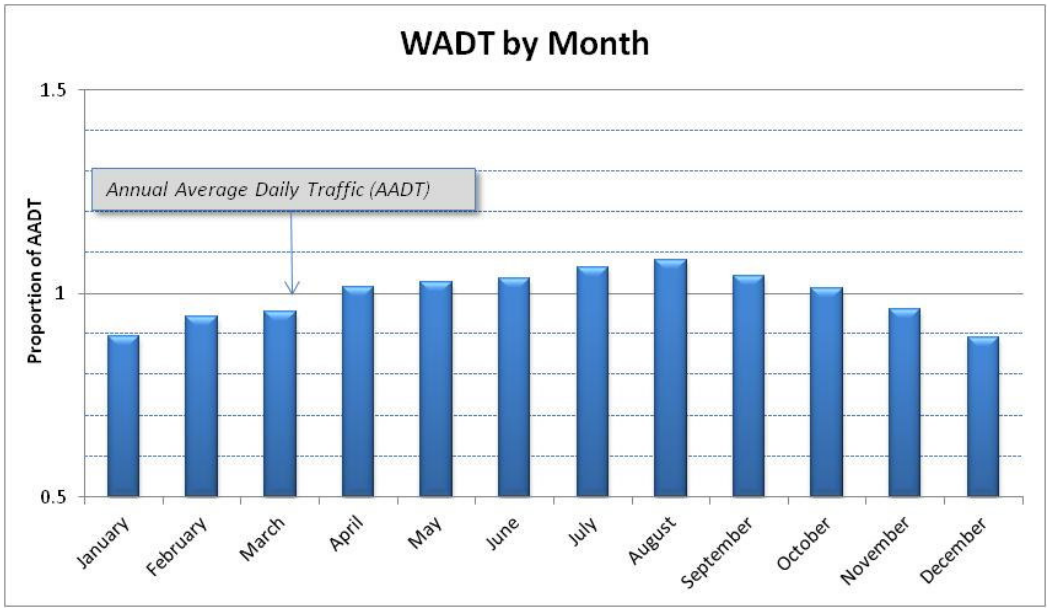


Figure 16.2.6: Monthly Flow Profile

6.3. It is noted that the relatively low level of traffic flow during December and January is influenced by the Christmas period where traffic flows reduce significantly over a period of 2 weeks. This therefore reduces WADT for that period. Likewise, the high levels of traffic in August are driven by the increased levels of tourism and leisure movements which tend to take place outside peak periods.

6.4. For the purpose of this PAG Unit, the monthly indices for December and January have been adjusted to remove the influence of the Christmas Period. In this regard, these relationships do not hold for short period traffic counts undertaken during periods of abnormal traffic flow (i.e. Christmas, Easter or Bank Holiday weekends). Furthermore, care should be taken when using short period traffic counts for July and August to extrapolate to AADT due to the influence of tourist traffic on the 24-hour traffic flow profile. Where possible, some conversion to 24-hour data using NRA Permanent Counters or Temporary Count Sites should be considered.

6.5. Monthly Flow Indices to account for the influence of seasonality are outlined in Annex C of this PAG Unit. An example of a conversion from a single day to an estimate of the Weekly Average Daily Traffic is outlined below.

Example: Conversion of Weekly Average Day to Annual Average Day.

Consider a Weekly Average Daily Traffic Flow of 10,000 vehicles on a site in Co. Roscommon during March. This is to be converted to an estimate of AADT.

Step 1: Identify the relevant month, which in this case is March.

Step 2: Extract the correct factor to convert to Annual Average Day. For the Month of March, Annex C shows that the relevant factor is 1.05.

Step 3: Perform the calculation. The AADT is therefore as follows

10,000*1.05 = 10,500.

The AADT estimate is therefore 10,500 vehicles

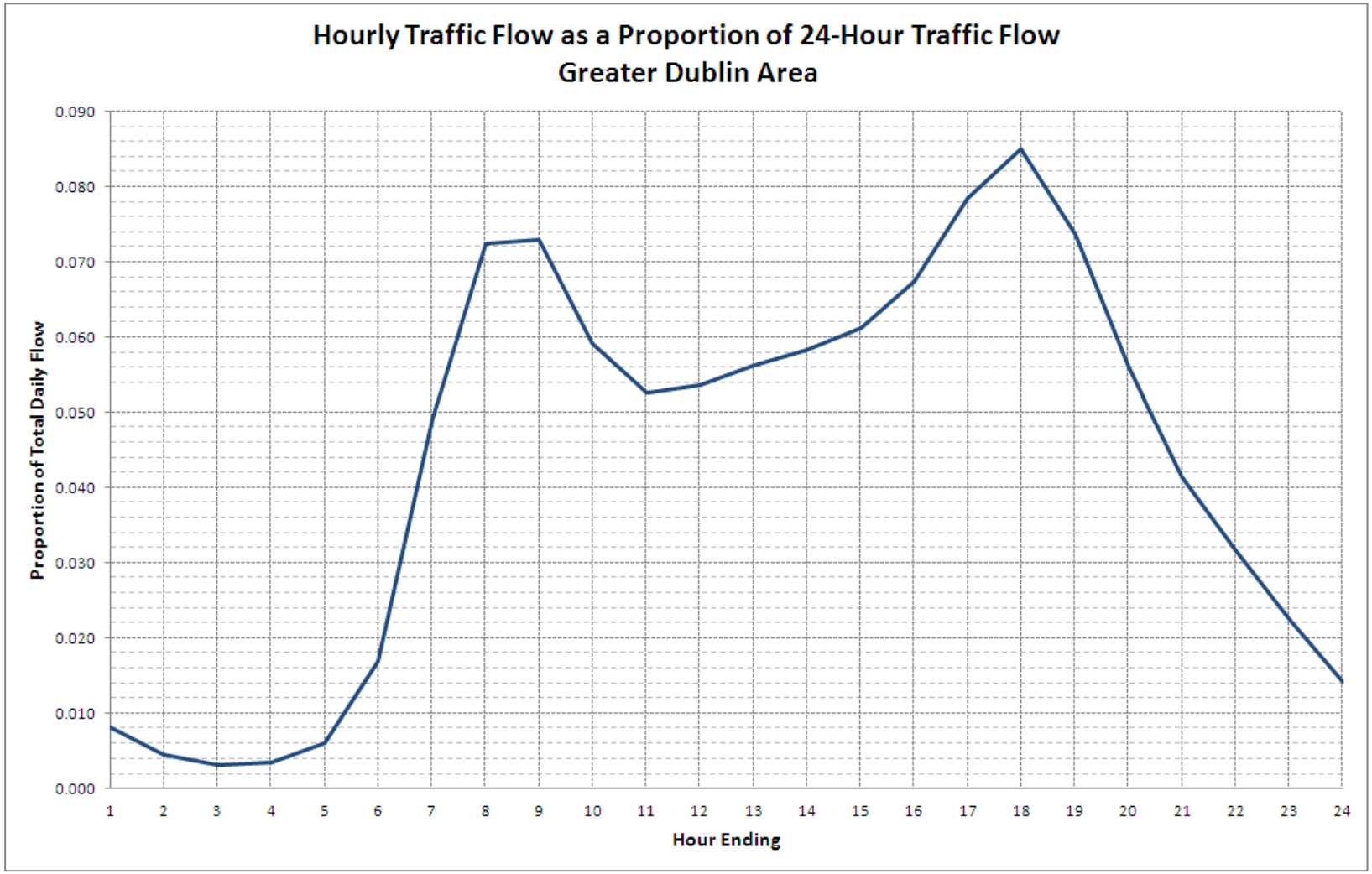
7. Dealing with Multiple Datasets

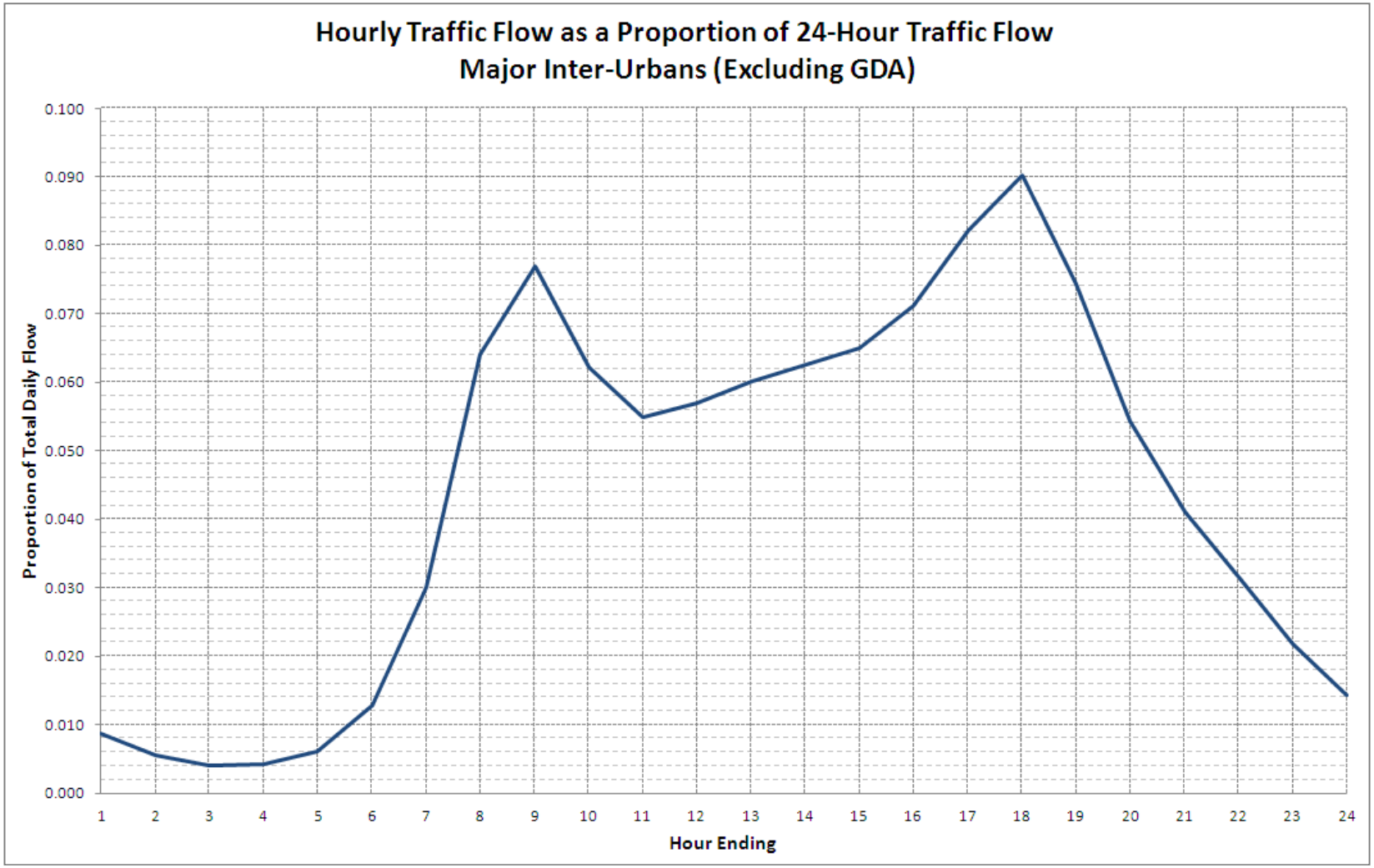
7.1. In some cases, a selection of data may be available to support the estimation of AADT. For example, a particular location may provide data for March and a separate dataset for May, and estimating AADT from these datasets individually will provide different results.

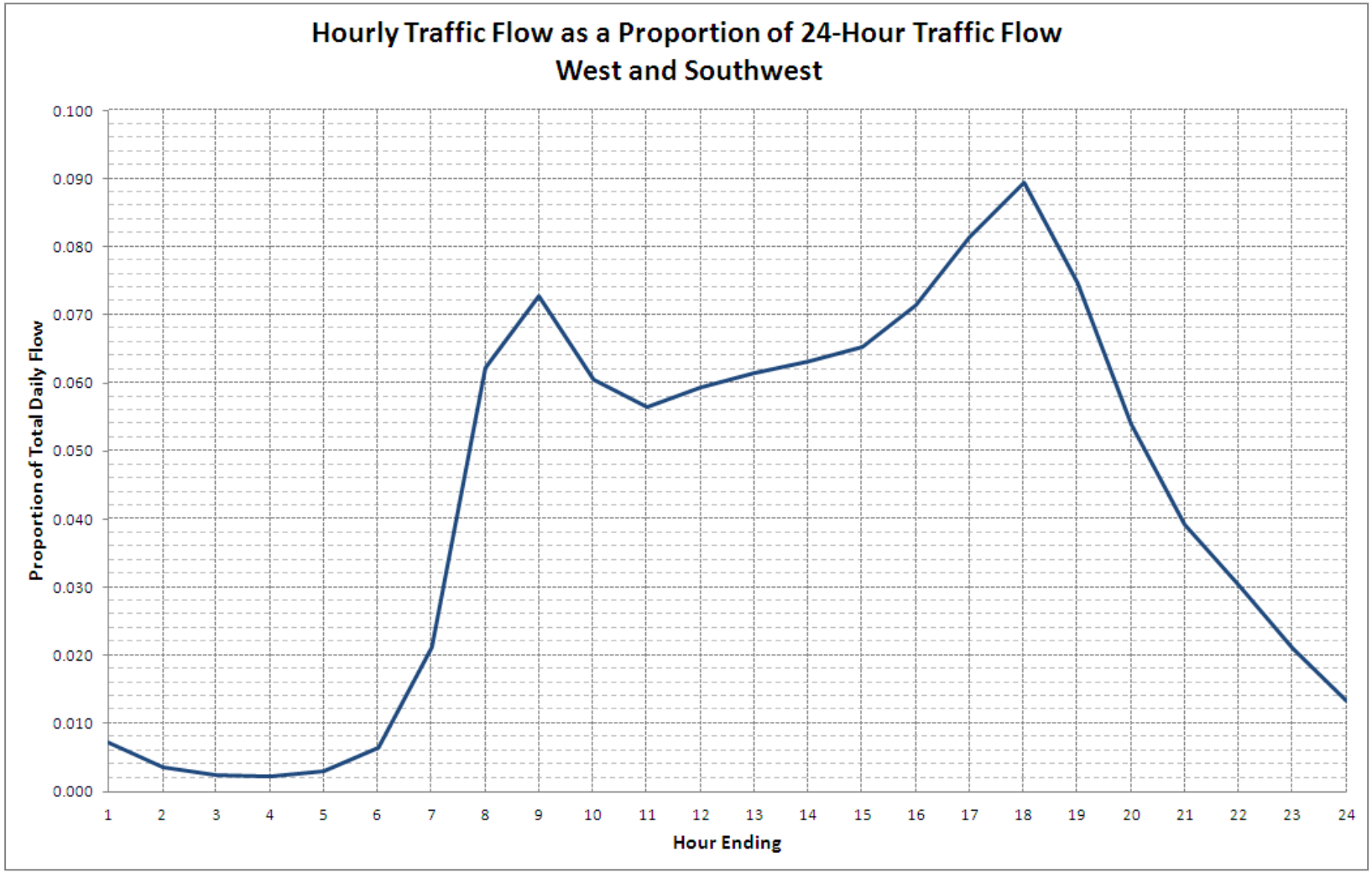
7.2. Whilst some variability in the results is expected, it is noted that the procedure outlined in this PAG Unit is intended to give no more than an indicative estimate of AADT based on short period counts. Where more detailed estimates are required, reference should be made to *PAG Unit 16.1: Estimating AADT on National Roads*.

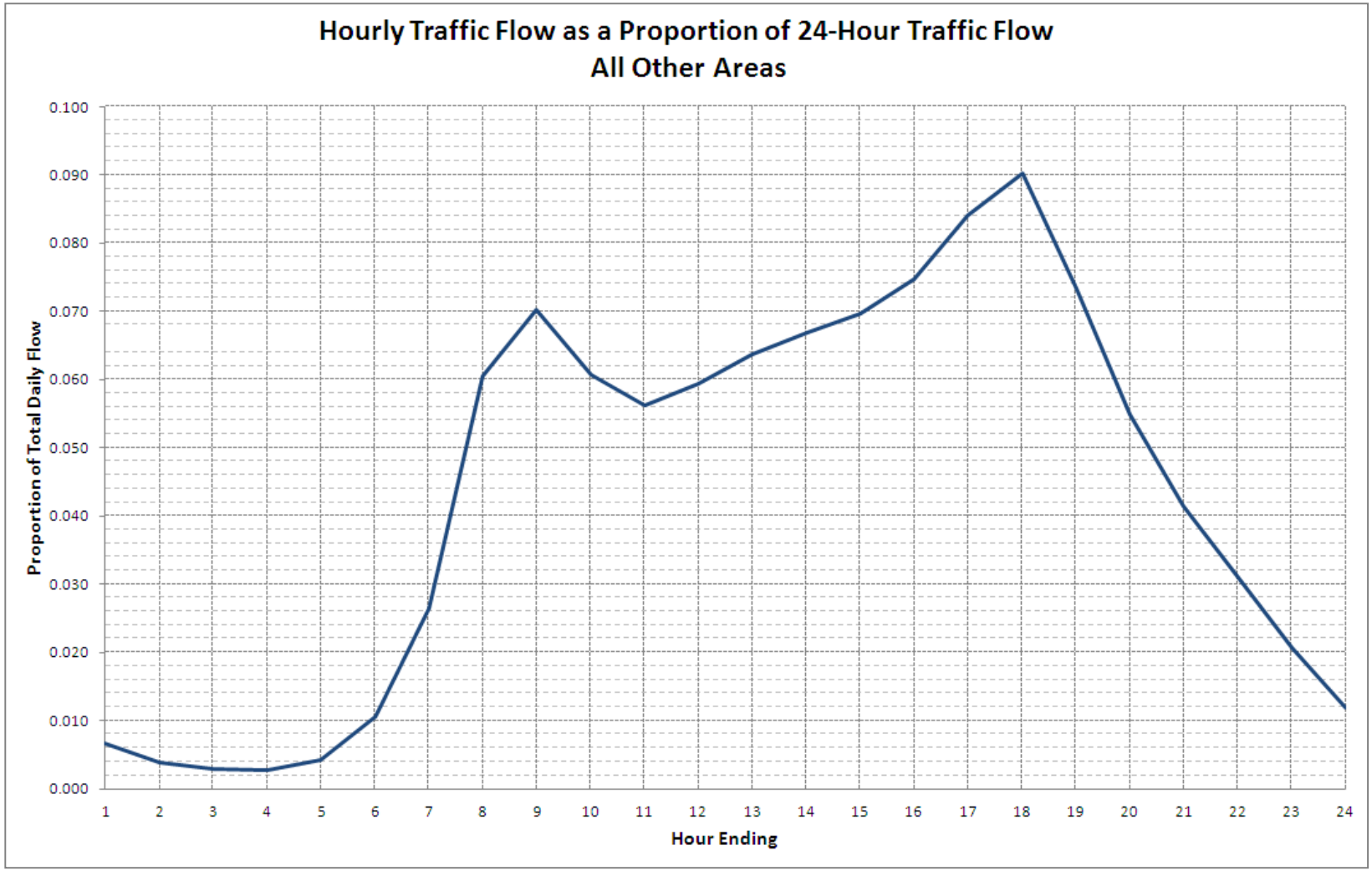
7.3. Where multiple results for a single site can be derived based on alternative data, the user should take a practical view as to the conclusions that can be inferred from them. Obviously the more data that is captured within the short period traffic count; the more robust will be the final calculation.

Annex A
Traffic Flow Profiles


Hourly Traffic Flow as a Proportion of 24-Hour Traffic Flow
Greater Dublin Area
Proportion of Total Daily Flow
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour Ending


Hourly Traffic Flow as a Proportion of 24-Hour Traffic Flow
Major Inter-Urbans (Excluding GDA)
Proportion of Total Daily Flow
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour Ending


Hourly Traffic Flow as a Proportion of 24-Hour Traffic Flow
West and Southwest
Proportion of Total Daily Flow
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour Ending


Hourly Traffic Flow as a Proportion of 24-Hour Traffic Flow
All Other Areas
Proportion of Total Daily Flow
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour Ending

Hourly Traffic Flow as a Proportion of 24-hour Traffic Flow

Hour Ending	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00
Greater Dublin Area	0.008	0.005	0.003	0.004	0.006	0.017	0.049	0.072	0.073	0.059	0.053	0.054
Major Inter-Urbans (Excl. GDA)	0.009	0.005	0.004	0.004	0.006	0.013	0.030	0.064	0.077	0.062	0.055	0.057
West and Southwest	0.007	0.004	0.002	0.002	0.003	0.006	0.021	0.062	0.073	0.060	0.056	0.059
All Other Areas	0.007	0.004	0.003	0.003	0.004	0.011	0.026	0.060	0.070	0.061	0.056	0.059

Hour Ending	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	24:00
Greater Dublin Area	0.056	0.058	0.061	0.068	0.079	0.085	0.074	0.056	0.041	0.032	0.023	0.014
Major Inter-Urbans (Excl. GDA)	0.060	0.063	0.065	0.071	0.082	0.090	0.074	0.054	0.041	0.031	0.022	0.014
West and Southwest	0.062	0.063	0.065	0.071	0.081	0.089	0.075	0.054	0.039	0.030	0.021	0.013
All Other Areas	0.064	0.067	0.070	0.075	0.084	0.090	0.073	0.055	0.041	0.031	0.021	0.012

95% Confidence Intervals for 24-hour Flow Estimations

Hour Ending	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00
Greater Dublin Area	±58%	±62%	±62%	±51%	±77%	±103%	±55%	±33%	±23%	±15%	±12%	±13%
Major Inter-Urbans (Excl. GDA)	±41%	±52%	±45%	±36%	±60%	±63%	±50%	±36%	±26%	±17%	±11%	±8%
%West and Southwest	±42%	±54%	±60%	±68%	±91%	±79%	±66%	±62%	±38%	±13%	±17%	±21%
All Other Areas	±64%	±67%	±72%	±73%	±100%	±83%	±67%	±54%	±24%	±15%	±12%	±11%

Hour Ending	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	24:00
Greater Dublin Area	±13%	±12%	±11%	±13%	±14%	±17%	±18%	±22%	±28%	±31%	±39%	±46%
Major Inter-Urbans (Excl. GDA)	±10%	±11%	±9%	±10%	±15%	±17%	±13%	±16%	±21%	±18%	±24%	±31%
West and Southwest	±17%	±13%	±14%	±13%	±13%	±17%	±11%	±16%	±24%	±25%	±28%	±35%
All Other Areas	±13%	±13%	±13%	±16%	±18%	±17%	±20%	±27%	±27%	±31%	±38%	±51%

Annex B
Weekly Flow Indices

Weekly Flow Indices – All Locations

Day	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Proportion of WADT	0.99	1.02	1.03	1.07	1.15	0.91	0.86
Index	1.01	0.98	0.97	0.93	0.87	1.10	1.16

Note:

Proportion of WADT measures the level of the 24-hour flow for any day against the weekly average day (i.e. traffic flow for a Tuesday is 1.02 times the Weekday Average Daily Traffic).

The **Index** is the factor that is applied to the 24-hour total to convert it to WADT.

Annex C
Monthly Flow Indices

Monthly Flow Indices – All Locations

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Proportion of AADT	0.94	0.94	0.96	1.02	1.03	1.04	1.06	1.08	1.04	1.01	0.96	0.96
Index	1.06	1.06	1.04	0.98	0.97	0.96	0.94	0.93	0.96	0.99	1.04	1.04

Note:

Proportion of AADT measures the level of the WADT for each month against AADT (i.e. WADT in March is 0.96 times AADT).

The **Index** is the factor that is applied to WADT to convert it to AADT.