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M4 Corridor around Newport

Traffic Forecasting Report

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Contents

		Page
1	The Project	1
2	Introduction	4
3	Model Overview	5
4	Modelling Future Year Travel	19
5	Reference Case Demand	31
6	Future Year Highway Networks	35
7	Public Transport Model	39
8	Variable Demand Model	43
9	Core Scenario Traffic Forecasts	51

1 The Project

1.1 Context

1.1.1 The Welsh Government has awarded a Professional Services Contract for the next stage of Scheme development and environmental surveys for the M4 Corridor around Newport Project ("the Scheme") up to publication of draft Orders and an Environmental Statement. The contract has been awarded to a Joint Venture of Costain, Vinci and Taylor Woodrow with consultants Arup and Atkins, supported by sub-consultant RPS. The team shall be developing proposals in anticipation of publishing draft Orders and an Environmental Statement in Spring 2016 and a Public Local Inquiry later that year. This process will then inform the next stage of Ministerial decision making.

1.1.2 Since 1989 there have been various studies to identify the problems and propose possible solutions. The M4 Corridor around Newport WelTAG Stage 1 (Strategy Level) Appraisal concluded that a new section of 3-lane motorway to the south of Newport following a protected (TR111) route, in addition to reclassification measures to the existing M4 to the north of Newport, would best achieve the goals and address the problems of the M4 Corridor around Newport and should be progressed for further appraisal. These options have subsequently formed the basis for the development of the draft Plan, which was published in September 2013 and was the subject of public consultation from September to December 2013.

1.1.3 Having taken into account the responses to this participation process, as well as the assessments of the draft Plan, the Welsh Government has decided to publish a Plan for the Scheme. Alongside this Plan, the Welsh Government has published updated strategy-level reports, including a Strategic Environmental Assessment Statement, to demonstrate how the participation process has informed its decision making. It also announced in July 2014 a revised preferred route, which protects a corridor for planning purposes. These documents can be accessed from the website http://m4newport.com.

1.2 Scheme objectives and reason for the scheme

1.2.1 The aims of the Welsh Government for the Scheme are to:

a) Make it easier and safer for people to access their homes, workplaces and services by walking, cycling, public transport or road.

b) Deliver a more efficient and sustainable transport network supporting and encouraging long-term prosperity in the region, across Wales, and enabling access to international markets.

c) To produce positive effects overall on people and the environment, making a positive contribution to the over-arching Welsh Government goals to reduce greenhouse gas emissions and to making Wales more resilient to the effects of climate change.

1.2.2 The Scheme aims to help to achieve or facilitate these aims as part of a wider transport strategy for South East Wales, as outlined within the Prioritised National Transport Plan.

1.2.3 The Transport Planning Objectives (TPOs), or goals, are:

TPO 1: Safer, easier and more reliable travel east-west in South Wales.

TPO 2: Improved transport connections within Wales and to England, the Republic of Ireland and the rest of Europe on all modes on the international transport network.

TPO 3: More effective and integrated use of alternatives to the M4, including other parts of the transport network and other modes of transport for local and strategic journeys around Newport.

TPO 4: Best possible use of the existing M4, local road network and other transport networks.

TPO 5: More reliable journey times along the M4 Corridor.

TPO 6: Increased level of choice for all people making journeys within the transport Corridor by all modes between Magor and Castleton, commensurate with demand for alternatives.

TPO 7: Improved safety on the M4 Corridor between Magor and Castleton.

TPO 8: Improved air quality in areas next to the M4 around Newport.

TPO 9: Reduced disturbance to people from high noise levels, from all transport modes and traffic within the M4 Corridor.

TPO 10: Reduced greenhouse gas emissions per vehicle and/or person kilometre.

TPO 11: Improved travel experience into South Wales along the M4 Corridor.

TPO 12: An M4 attractive for strategic journeys that discourages local traffic use.

TPO 13: Improved traffic management in and around Newport on the M4 Corridor.

TPO 14: Easier access to local key services and residential and commercial centres.

TPO 15: A cultural shift in travel behaviour towards more sustainable choices.

1.2.4 The scheme-specific environmental objectives (EO), as set out in the Strategic Environmental Assessment of the Plan, are as follows:

EO1 - Improved air quality in areas next to the existing M4 around Newport;

EO2a - Reduce greenhouse gas emissions per vehicle and/or person kilometre;

EO2b - Ensure that effective adaptation measures to climate change are in place;

EO3 - Reduce disturbance to people from high noise levels, from all transport modes and traffic within the existing M4 Corridor;

EO4 - Ensure that biodiversity is protected, valued and enhanced;

EO5 - Improved access to all services and facilities and reduce severance;

EO6 - Protect and promote everyone's physical and mental wellbeing and safety;

EO7 - Reduce transport related contamination and safeguard soil function, quality and quantity;

EO8 - Minimise transport related effects on surface and groundwater quality, flood plains and areas of flood risk;

EO9 - Ensure the prudent and sustainable use of natural resources and energy;

EO10 - Ensure that diversity, local distinctiveness and cultural heritage are valued, protected, celebrated and enhanced;

EO11 - Ensure that landscape and townscape is properly valued, conserved and enhanced;

1.2.5 In addition, the Wales Transport Strategy includes the following environmental outcomes (WTSEO):

Outcome 11: The sustainability of the transport infrastructure - Increase the use of more sustainable materials in our country's transport assets and infrastructure;

Outcome 12: Greenhouse gas emissions - Reduce the impact of transport on greenhouse gas emissions;

Outcome 13: Adapting to climate change - Adapt to the impacts of climate change;

Outcome 14: Air pollution and other harmful emissions - Reduce the contribution of transport to air pollution and other harmful emissions;

Outcome 15: The local environment - Improve the positive impact of transport on the local environment;

Outcome 16: Our heritage - Improve the effect of transport on our heritage;

Outcome 17: Biodiversity - Improve the impact of transport on biodiversity.

2 Introduction

2.1 Scope of this Report

2.1.1 The M4CaN transport model is used to understand current traffic conditions in the area, to provide evidence for the planning of changes to the transport network and to produce traffic forecasts that are used in the detailed economic, social and environmental appraisal of proposed interventions in the transport system. The model represents typical operating conditions on the highway network in terms of average flows and speeds on a normal day of operation. The model does not reflect those occasions when a major incident may have occurred which results in severe reduction in network performance. In such instances there are higher than usual levels of congestion, during which journey times significantly increase.

2.1.2 The validation of the M4CaN transport model to a May 2014 base year and its application for forecasting has been undertaken in accordance with the guidance set out in the Welsh Government's appraisal guidance WelTAG, which in turn refers to modelling guidance provided by the Department for Transport's WebTAG.

2.1.3 Traffic forecasts have been produced to inform the operational, economic and environmental evaluations of the new section of motorway to the south of Newport. The following scenarios have been tested:

- A 'Do Minimum' scenario, in which committed transport improvement schemes have been added to the base year network; and
- A 'Do Something' scenario, which includes the proposed new section of motorway to the south of Newport and reclassification of the existing M4 around Newport to an all-purpose road.

2.1.4 The purpose of this Traffic Forecasting Report is to document the development of these future year forecasts and to demonstrate that the methods and assumptions adopted are consistent with best practice and guidance to provide robust forecasts for the Scheme.

2.2 Report Structure

2.2.1 Following this introduction the report is structured as follows:

- Chapter 3 describes the technical model details;
- Chapter 4 provides an overview of the modelling of future year travel;
- Chapter 5 provides details of the Reference Case travel demand;
- Chapter 6 describes the future year highway networks;
- Chapter 7 described the forecast public transport model;
- Chapter 8 describes the variable demand modelling; and
- Chapter 9 provides in-depth information on the forecast assignments;

3 Model Overview

3.1 Introduction

3.1.1 This report presents the development of future year traffic forecasts, which provide inputs into the operational, social, economic and environmental assessments for the Scheme. It provides a description of the methods and assumptions used in preparing the forecasts. Scheme evaluation is undertaken through comparison of a 'Do Something' case (for example a future year scenario with the proposed new section of motorway south of Newport and the reclassification of the existing M4 north of Newport) against a 'Do Minimum' case (the future year scenario without the proposed new section of motorway south of Newport and without the reclassification of the existing M4 north of Newport).

3.1.2 The model used in the forecasting work is the M4CaN 2014 base year transport model which has been validated in accordance with the Department for Transport's WebTAG[1]. The development and validation of the base year model is detailed in the Local Model Validation Report (LMVR)[2]

3.1.3 The main component of the transport model is a highway model which provides a representation of the highway network within the study area, the traffic using it and the resulting traffic conditions. In order to incorporate a mode choice response, a separate public transport model was developed to replicate bus and rail services that compete with the M4 around Newport.

3.1.4 Two future years have been defined for the traffic forecasting in accordance with guidance, namely the assumed year of scheme opening, 2022, and a design year which is the fifteenth year after scheme opening, in this case 2037.

3.1.5 A large number of web-based Transport Analysis Guidance (WebTAG) documents are made available by the Department for Transport (DfT)[3]. TAG Unit M2[4] prescribes the use of Variable Demand Modelling (VDM) in forecasting work for schemes with a capital cost of more than £5 million. VDM has been used in the traffic forecasting for the proposed new section of motorway to the south of Newport.

3.2 Highway Assignment Model

3.2.1 The M4CaN highway model uses SATURN software (Simulation and Assignment of Traffic in Urban Road Networks), which is a 'congested assignment' software suite developed by the Institute for Transport Studies at the University of Leeds.

3.2.2 The suite provides software for combined traffic simulation and assignment modelling and analysis of road proposals ranging from traffic management

[1] Transport Analysis Guidance, Unit M3.1, Highway Assignment Modelling, Department for Transport, January 2014
[2] M4 Corridor Around Newport, Local Model Validation Report, Ove Arup & Partners, June 2015
[3] www.gov.uk/transport-analysis-guidance-webtag
[4] Transport Analysis Guidance, Unit M2, Variable Demand Modelling, Department for Transport, January 2014

schemes over relatively localised networks to major infrastructure improvements. One of the key features of SATURN is its ability to simulate the operation of junctions in some detail, including the prediction of queues and delays, the effect of queues blocking back on adjacent junctions, and the influence of congestion at specific points in the network on route choice.

3.2.3 The basic inputs to a SATURN model are the 'demand', in the form of a matrix of trip movements between zones, and the 'supply' in the form of a data file representing the road network. Following the network building procedure, the trip matrix is assigned to the network using an iterative series of loops between 'assignment' and 'simulation' until the model has converged.

3.2.4 SATURN version 11.3.10 was used for the highway modelling for the M4CaN.

3.3 Public Transport Model

3.3.1 A public transport model has been set up to provide the public transport demand, time and fare data which is required as input to the variable demand model used to predict the potential modal shift effects of the Scheme.

3.3.2 The public transport network and assignment model was developed using version 4.1.4 of the specialist transport modelling software EMME.

3.3.3 EMME is a multi-modal travel demand forecasting software, produced by INRO, which can be used to assess traffic and public transport network performance. It has been used to model bus and rail trips for east-west movements that are in competition with the MCaN. The basic inputs were matrices representing demand on these public transport services and a representation of the public transport network, including routes, locations of stops / stations, service frequency, journey time and fares.

3.3.4 Comprehensive details of the public transport model development are given in the Local Model Validation Report (LMVR).

3.4 Variable Demand Modelling

3.4.1 Transport schemes that have an impact on journey times and cost will, in principle, influence the level of demand for travel. The opening of a new scheme can elicit a number of responses by travellers including trip reassignment, re-timing, re-distribution and modal shift. These responses can result in additional trips and additional vehicle kilometreage on the road network, known as "induced traffic".

3.4.2 Conversely, in a 'Do-Minimum' scenario where there is likely to be limited investment in new sections of highway capacity, the effects of forecast traffic growth and the subsequent increase in traffic congestion can lead to "trip suppression" which could manifest itself as peak spreading, modal switching to public transport, and/or a reduction in the number, length or frequency of journeys. These responses, as well as re-distribution, can lead to reduced vehicle kilometreage on the road network.

3.4.3 TAG Unit M2 states that "the purpose of variable demand modelling is to predict and quantify these changes", and goes on to say that "there should be a

presumption that the effects of variable demand on scheme benefits will be estimated quantitatively unless there is a compelling reason for not doing so".

3.4.4 The guidance also states that under certain circumstances it is acceptable to base the assessment of a scheme on a fixed demand traffic model. This is the case when the scheme is quite modest either spatially or financially and also in terms of its effect on travel costs. However, scheme costs for options considered for the M4 corridor around Newport are significantly in excess of the £5 million limit defined within WebTAG.

3.4.5 A fixed demand traffic model would therefore only be deemed sufficient to assess the M4 corridor around Newport if the following criteria are met:

- No congestion on the network in the forecast years in the absence of the Scheme; and
- No appreciable effect on travel choices such as mode of travel or the distribution of travel patterns in the corridor containing the Scheme.

3.4.6 Assessing these criteria in the context of the M4CaN indicates the need for variable demand modelling because even under existing conditions traffic congestion is regularly observed and is forecast to worsen as a result of underlying growth in travel demand. It is anticipated that the Scheme will have an appreciable effect on the distribution of travel patterns and competition between private travel modes and public transport in the study area.

3.4.7 The variable demand modelling (VDM) was undertaken using the Department for Transport's DIADEM software (Version 5.0.9, 64-bit). Further details of the VDM are given in Section 8.1 of this report.

3.5 Model Time Periods

3.5.1 The variable demand model works on the basis of 24 hour trip productions and attractions, while the highway assignment model uses hourly trip origins and destinations covering the AM and PM peak hours and an average inter-peak hour.

3.5.2 Based on the analysis of traffic count data the assignment model time periods are as follows:

- AM peak hour – 08:00 to 09:00;
- Inter-peak hour – average hour between 10:00 and 16:00; and
- PM peak hour – 17:00 to 18:00.

3.5.3 For the peak period models, a pre-peak assignment was introduced, via the PASSQ function available within the SATURN software, as part of the calibration process. This enables any resultant queuing that may exist at the end of the pre-peak period to be passed through into the peak hour assignment. This helps to improve the route choice present within the assignment and the representation of journey times.

3.6 Demand Segments for VDM

3.6.1 Different types of journeys are likely to display different characteristics in terms of trip distribution, mode sensitivity, travel time sensitivity and growth patterns. For this reason, car demand was split into the following three trip purposes:

- Employer's business;
- Commuting; and
- Other purposes (including leisure, shopping and personal business trips).

3.6.2 Goods vehicles were separated into light goods vehicles (LGV) and heavy goods vehicles (HGV).

3.6.3 For the purposes of the VDM 'home-based' trips (trips starting or ending at home) were modelled in a 24 hour production/attraction (P/A) format, as recommended by WebTAG. This was necessary in order to retain the link between outbound and return legs when calculating the resulting demand response of a return trip starting and ending at home. There was therefore a requirement to develop separate demand segments within each trip purpose, depending on whether the trips were 'home-based' (for trips starting or ending at home) or 'non-home-based' i.e. neither end of the trip being home.

3.6.4 Long distance trips without at least one trip end located in the 'Area of Detailed Modelling' or Rest of Fully Modelled Area were also separated out in the demand model, as changes in travel costs are not fully modelled for these movements and they should therefore be treated as fixed within the VDM process.

3.6.5 The public transport demand was further split into 'car available' and 'no car available' to separate those trips that have the opportunity to switch to private car from those that do not have that opportunity. In this respect, 'No car available' trips are assumed to be captive to public transport. They are only included in the demand model to ensure that they are considered in the competition for trip ends in the doubly-constrained distribution model, which forms part of the variable demand model process.

3.6.6 The demand segments used in the VDM are specified in Table 3.1.

Table 3.1: Demand Segments in the Variable Demand Model

Demand Segment			Vehicle Type / Purpose
Highway	Public Transport		
	Car avail.	No car avail.	
1	1	11	Cars – Home-Based Employers' Business
2	2	12	Cars – Home-Based Others
3	3	13	Cars – Home-Based Work
4	N/A	N/A	Light Goods Vehicles (LGVs)
5	N/A	N/A	Heavy Goods Vehicles (HGVs)
6	6	14	Cars – Non-Home-Based Employers' Business,
7	7	15	Cars – Non-Home-Based Other
8	N/A	N/A	Cars – Employers' Business, Fixed
9	N/A	N/A	Cars – Other Purposes, Fixed
10	N/A	N/A	Cars – Commuting, Fixed

3.7 User Classes for Traffic Assignment

3.7.1 All demand matrices for the traffic assignment are required to be in origin-destination (O-D) format rather than the production/attraction (P/A) format used in the VDM. An O-D matrix stores trips according to the actual origin and destination zone of a trip. This information is needed so that the trips can be assigned onto the road network.

3.7.2 In the traffic assignments it is not necessary to retain the level of demand segmentation used in the VDM process. Instead, trip matrices for the traffic assignment are split into five different 'user classes'.

3.7.3 Table 3.2 lists the trip purposes and vehicle types that are used in the traffic assignment. Demand in the SATURN traffic assignment is expressed in terms of Passenger Car Units (PCU). The factors used to convert from vehicles to PCUs are also listed in this table.

Table 3.2: Modelled User Classes in the Traffic Assignment

User Class	Vehicle Type / Purpose	PCU Factor
1	Cars – Employers' Business	1.0
2	Cars – Other Purposes	1.0
3	Cars – Work	1.0
4	Light Goods Vehicles (LGVs)	1.0
5	Heavy Goods Vehicles (HGVs)	2.5

3.8 Assignment Method

3.8.1 The assignment process is an important element as it predicts the routes that drivers will choose taking into account the level of traffic demand and the available road capacity. The assignment technique used in the updated M4CaN model is the Wardrop equilibrium assignment method for multiple user classes. The principle of this assignment is that traffic arranges itself on the network such that the cost of travel on all routes used between each origin and destination is equal to the minimum cost of travel and all unused routes have equal or greater cost.

3.9 Generalised Costs

3.9.1 The generalised cost of travel is based on a combination of factors that drivers take into account when choosing routes, mainly time and distance. Generalised cost parameters are used in a SATURN model to represent travellers' value of time by pence per minute (PPM) and distance by pence per kilometre (PPK). Values of PPK and PPM can be set universally for the entire model or individually by user class. Where a choice of route exists (as in nearly all cases) these values are used to determine which available route has a lower 'cost' to the traveller. Thus if PPK value is high, low cost routes will be those which minimise distance, conversely if PPM is high low cost routes will be those that minimise the travel time.

3.9.2 The SATURN assignment procedure uses the following generalised time formulation:

*Generalised Time = Time + (PPK/PPM) * Distance + Toll / PPM.*

Where: PPM = pence per minute, and

PPK = pence per kilometre.

3.9.3 The generalised cost coefficients used in the base model are based on data given in TAG Unit A1.3[5], which provides Values of Time, occupancy figures, purpose splits, Gross Domestic Product (GDP) growth rates and vehicle operating costs that are recommended by the Department for Transport (DfT) for use in the economic appraisal of transport projects.

3.9.4 At the time of writing, the DfT has been out to consultation on new Values of Time. DfT is still to advise of the outcome of the consultation and whether the new Values of Time will be incorporated into WebTAG. It will be up to Welsh Ministers to decide whether to adopt any changes. The Values of Time used in the M4CaN Transport Model are those given in the current WebTAG Guidance, dated November 2014.

3.9.5 Unit A1.3 provides monetary values of time in 2010 prices for different transport users, which can be used to derive values of time in an assignment model in terms of pence per minute (PPM). The conversion from 2010 to the modelled years was made in accordance with the forecast annual rates of growth in the value of time set out in Unit A1.3. This states that the value of time is assumed to increase in line with income, measured for this purpose as GDP per head.

3.9.6 Similarly Unit A1.3 provides parameters for the calculation of fuel costs and non-fuel vehicle operating costs. These parameters were used to calculate the fuel costs per kilometre for each user class. In converting fuel costs from 2010 to the modelled years, account was taken of the forecast growth in the cost of fuel and the predicted rate of increase in fuel efficiency, as set out in Tables 13 and 14 of Unit A1.3. As noted in the guidance, the non-fuel vehicle operating costs are assumed to remain constant in real terms, and so no adjustment was applied.

3.9.7 When added together, the fuel and non-fuel elements give the total vehicle operating costs in terms of PPK for different transport users. The PPM and PPK parameters then give the overall generalised cost for each of the different user classes. The generalised costs (in 2014 prices) that were used in the forecast models are shown in Table 3.3.

[5] Transport Analysis Guidance Unit A1.3, User and Provider Impacts, Department for Transport, November 2014

Table 3.3: Base and Forecast Year Generalised Cost Parameter Values

2014	AM Peak		Inter-peak		PM Peak	
	PPM	PPK	PPM	PPK	PPM	PPK
Cars – Employers' Business	47.99	13.62	47.54	13.52	48.27	13.70
Cars – Other	15.59	7.52	17.12	7.45	17.07	7.54
Cars – Commuting	14.27	7.42	15.08	7.44	14.74	7.44
Light Goods Vehicle	25.92	16.29	23.95	16.45	24.71	16.29
Heavy Goods Vehicle	23.57	46.17	25.44	47.20	25.43	49.75
2022	**AM Peak**		**Inter-peak**		**PM Peak**	
	PPM	**PPK**	**PPM**	**PPK**	**PPM**	**PPK**
Cars – Employers' Business	55.45	12.62	54.99	12.43	55.68	12.67
Cars – Other	17.83	6.17	19.52	6.12	19.53	6.18
Cars – Commuting	16.46	6.10	17.35	6.11	17.01	6.11
Light Goods Vehicle	30.09	15.16	27.80	15.29	28.69	15.18
Heavy Goods Vehicle	27.36	47.29	29.54	47.98	29.53	50.54
2037	**AM Peak**		**Inter-peak**		**PM Peak**	
	PPM	**PPK**	**PPM**	**PPK**	**PPM**	**PPK**
Cars – Employers' Business	73.97	12.92	73.49	12.36	74.07	12.89
Cars – Other	23.36	6.34	25.43	6.11	25.60	6.31
Cars – Commuting	21.90	6.27	23.00	6.12	22.63	6.24
Light Goods Vehicle	40.49	15.81	37.41	15.91	38.61	15.78
Heavy Goods Vehicle	36.82	55.56	39.74	54.88	39.73	58.15

3.10 Annualisation Factors

3.10.1 In order to carry out environmental assessments, model data needs to be converted from peak hour to 18 hour traffic volumes. In addition, 24 hour traffic flows are required for reporting purposes. Historic Automatic Traffic Counter (ATC) data along the M4 corridor in the study area was used to derive a number of factors allowing the calculation of Annual Average Weekday Traffic (AAWT) and Annual Average Daily Traffic (AADT). The factors are given in Table 3.4.

Table 3.4: Annualisation Factors

Peak Hour to Peak Period			12 Hour (07:00-19:00) to AAWT	AAWT to 18 hr (06:00-24:00)	AAWT to AADT
AM	Inter-peak	PM			
2.844	6.000	2.798	1.232	0.961	0.935

3.11 Geographical Coverage of the Model

3.11.1 Four geographic areas have been defined for model zoning and network coverage comprising:

1. Area of Detailed Modelling
2. Rest of Fully Modelled Area
3. Wider Area of Influence
4. External Area

3.11.2 Figure 3.1 shows the first three modelled areas, while the external area comprises the rest of the UK outside these areas.

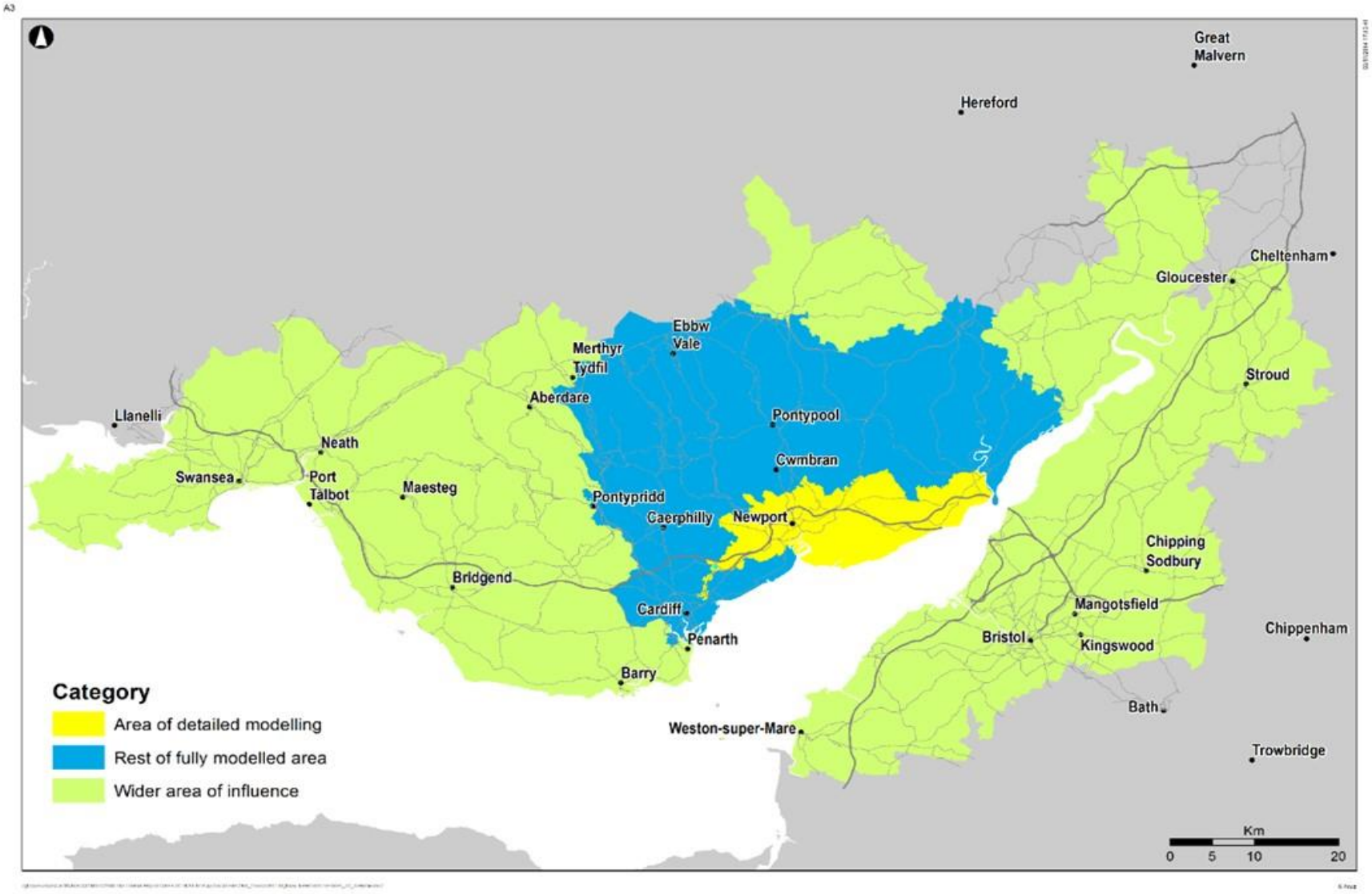


Figure 3.1: Model Coverage and Study Area

3.11.3 SATURN networks can comprise either a 'simulation' network, in which the operation of junctions is simulated, or a less detailed 'buffer' network, which essentially functions as a more conventional link-based model. Frequently, SATURN networks are set up as a combination of the two, with the less-detailed 'buffer' area on the periphery ensuring that traffic from more remote areas enters the simulation part of the network at the correct locations.

3.11.4 For the purpose of preparing traffic forecasts for the M4CaN model, the Area of Detailed Modelling comprises a Core Simulation Area that covers the M4 between Junction 30 in the west and Junction 21 in the east, as shown in Figure 3.1. This area includes Junctions 29 and 23a, which form the western and eastern ends respectively of the proposed new section of motorway. Within this core area are key roads and corridors of interest including:

- the existing M4 and proposed alternative routes;
- the M48 motorway;
- access routes to the existing M4 and M48 motorways from Cardiff, Newport, Chepstow and the hinterland north of Newport;
- the corridors on the east and west banks of the River Usk that could connect Central Newport to the Scheme via intermediate junctions; and
- east-west routes through Newport via Newport Bridge, George Street Bridge and the Southern Distributor Road (SDR).

3.11.5 Within this core area, all significant junctions are fully simulated, while links are coded where appropriate to give a representation of their speed and capacity. This level of detail reflects the significance of the key links and junctions in route choice decisions through the study network.

3.11.6 Outside the Core Simulation Area is the Rest of Fully Modelled Area, which includes Cardiff and is bounded north of Cardiff by the A470 to the west, the A465/A40 to the north, and the A466 to the east. While trips are fully represented, this area is modelled in less detail as buffer network only, with no simulation of junctions. All links in this area are allocated speed-flow curves.

3.11.7 Outside the Rest of Fully Modelled Area is a large area of influence where changes in traffic flow may be experienced following opening of a new scheme. This extends to Skewen (M4 Junction 43) in the west, the A465 Heads of the Valleys Road and M50 in the north, and the M5 J8 to 18a in the east. Major roads within this area-of-influence are also modelled as a 'buffer' network with a lower level of detail, using fixed speeds.

3.11.8 The traffic model includes all trips that travel within the Core Simulation Area and the Rest of Fully Modelled Area. The area of influence only includes trips that would travel through the first two areas or trips that would potentially divert to travel through these areas.

3.12 Zone System

Core Simulation Area

3.12.1 The Core Simulation Area of the model is centred around Newport, extending from the Severn River Crossings to the eastern edge of Cardiff. The zone system used in this area is shown in Figure 3.2. The zone boundaries have been drawn to ensure that they are consistent with both the DfT's National Trip End Model zones and the Census Output Areas. Some 'empty' zones have also been included to allow for future developments, particularly in South East Newport.

Rest of Fully Modelled Area

3.12.2 The Rest of Fully Modelled Area is bounded to the west by the A470 and the western edge of Cardiff, by the A465 and the A40 to the north, and by the River Wye to the east.

3.12.3 In order to represent all trips in this area, it is necessary that a sufficiently detailed network is coded that provides sufficient available route choice alternatives. Therefore, the zone system in this area is designed so that the zones represent the most likely loading points for these trips.

3.12.4 As with the Area of Detailed Modelling, zone boundaries have been drawn to coincide with the boundaries used in the DfT's National Trip End Model and the Census Output Areas. The zone system in this area is shown in Figure 3.3.

Wider Area of Influence

3.12.5 The 'Wider Area of Influence' is coded as a buffer network outside the Rest of Fully Modelled Area. It includes long-distance movements which could be influenced by a new route for the M4 motorway south of Newport. Fixed speeds are used on the links in this part of the network.

3.12.6 The zone system in the 'Wider Area of Influence' is shown in Figure 3.4 It is not as fine as those in the Core Simulation and 'Rest of Fully Modelled Area', but the zones have been drawn to ensure consistency with the DfT's National Trip End Model and Census Output Areas.

External Area

3.12.7 The external area comprises the rest of Great Britain outside the Wider Area of Influence, and does not have an explicit network representation. The external zones are connected to the network at the edge of the Wider Area of Influence by means of long distance centroid connectors, again using fixed speeds.

3.12.8 Because of the limited number of long distance routes available for this traffic to enter the main modelled areas, the zones in these areas are considerably larger. The external area zone system is consistent with DfT's National Trip End Model zones and Census Output Areas, and is shown in Figure 3.5.

Figure 3.2 Model Zones, Core Simulation Area

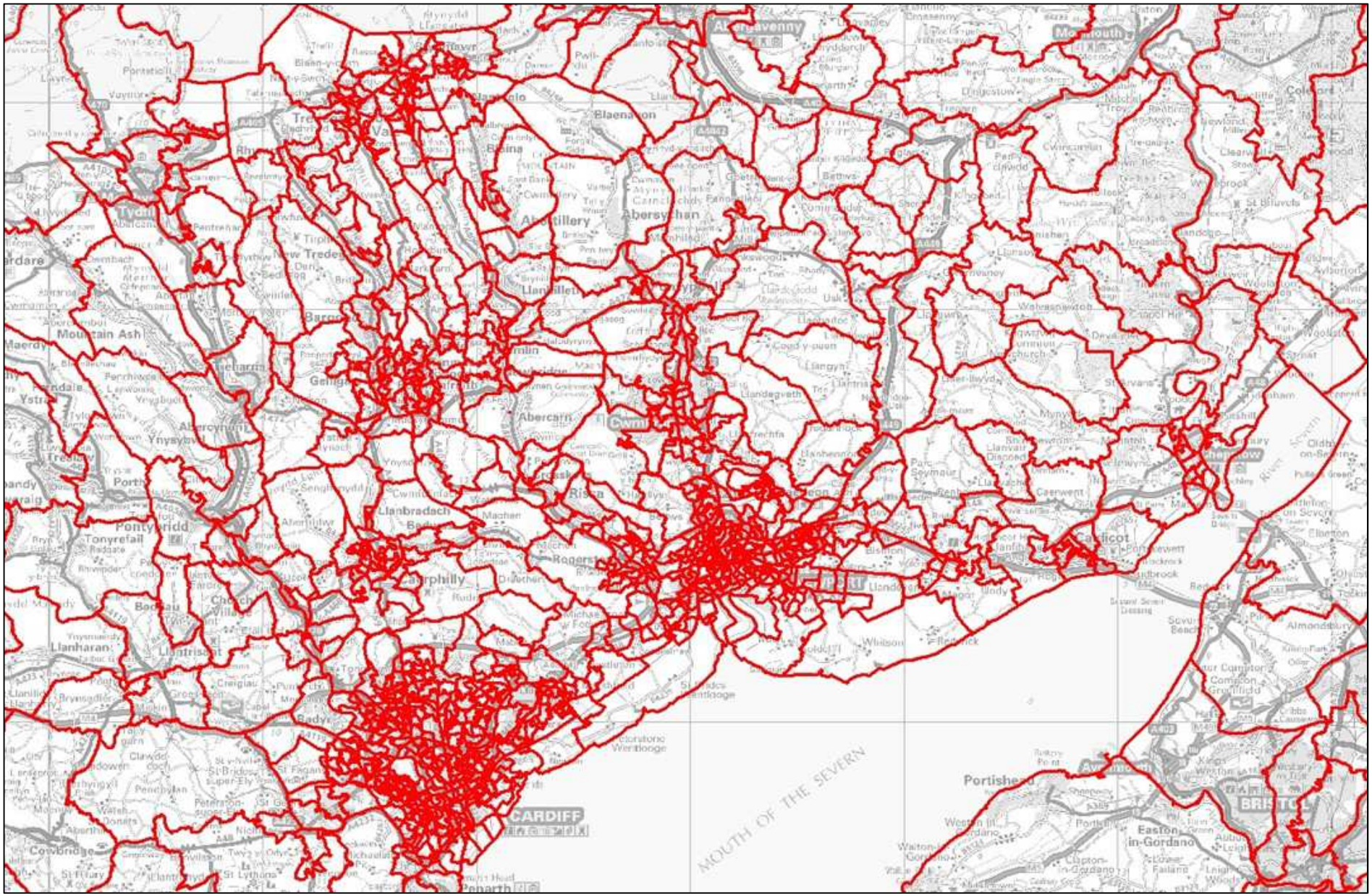


Figure 3.3: Model Zones, Rest of Fully Modelled Area

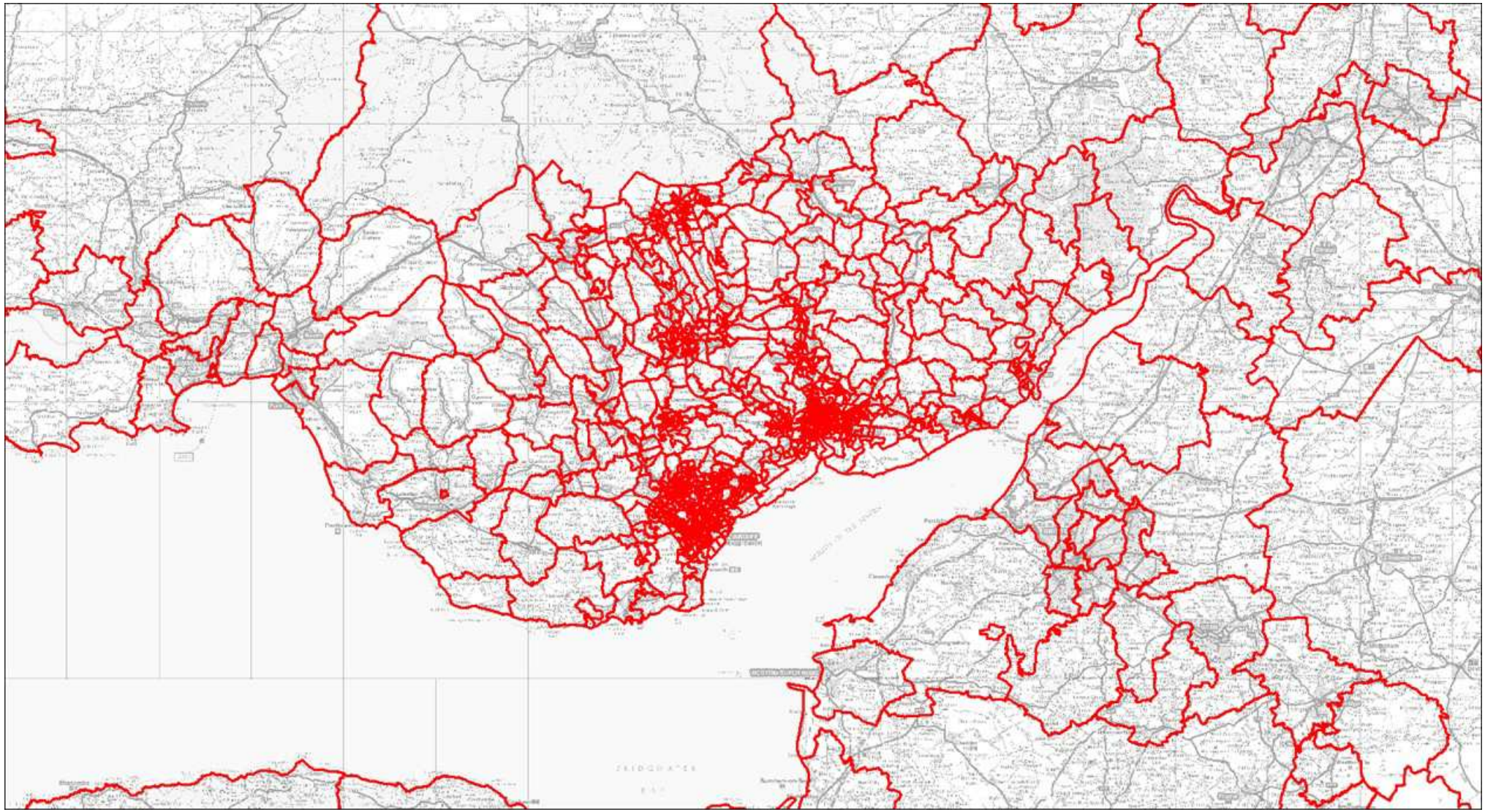


Figure 3.4: Model Zones, Wider Area of Influence

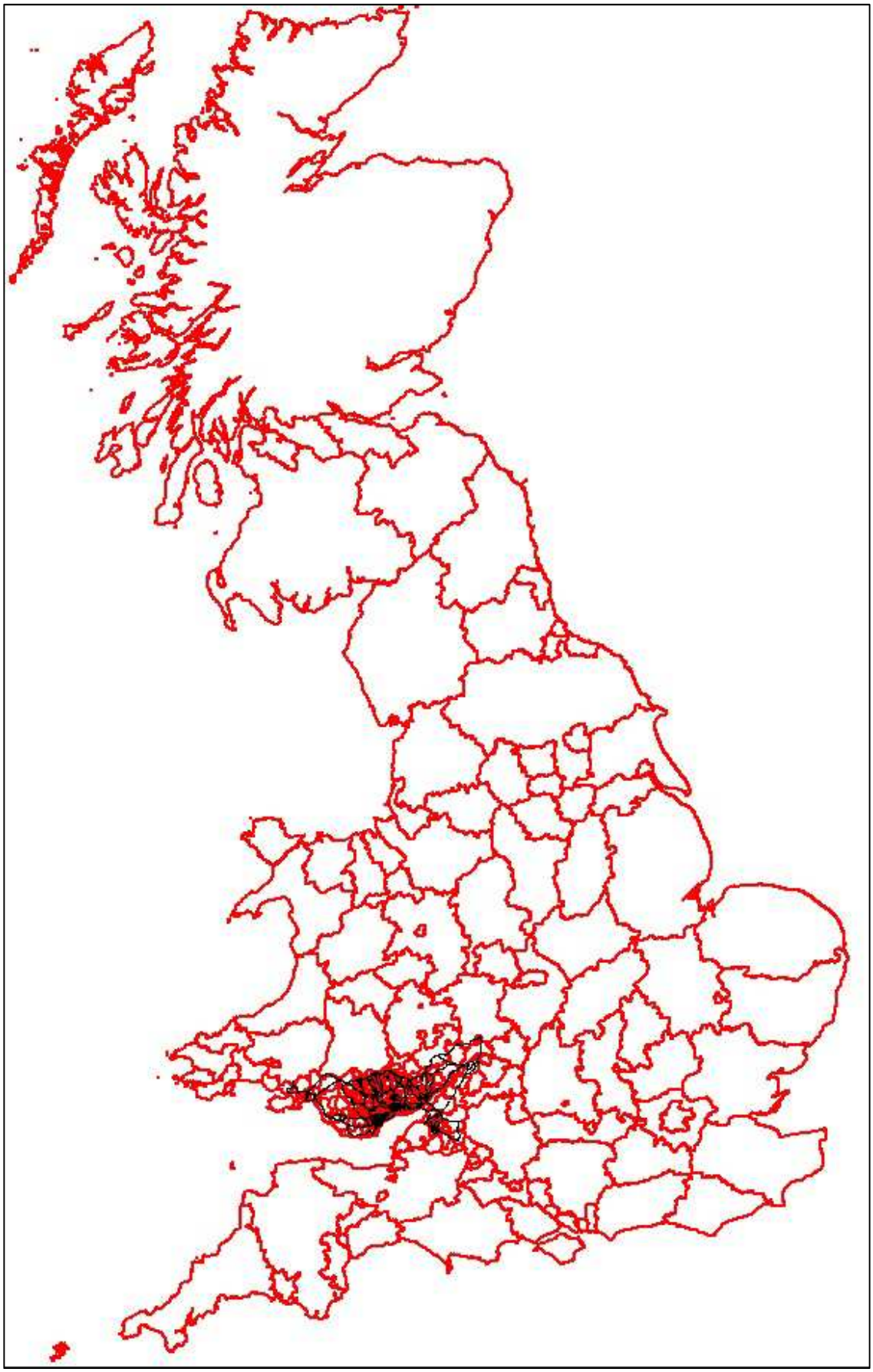
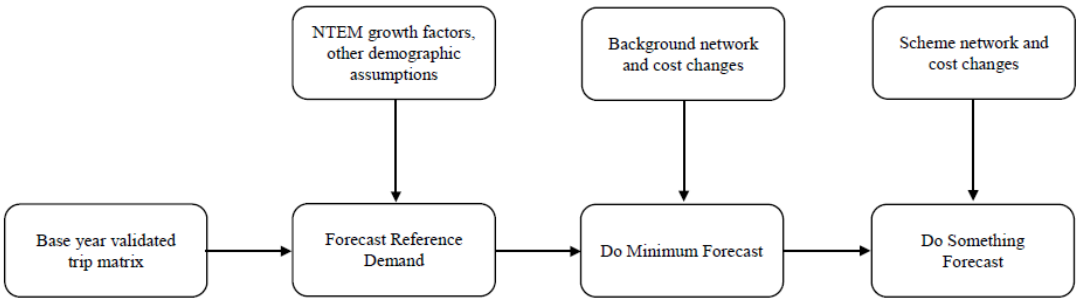


Figure 3.5: Model Zones, Wider Area of Influence

4 Modelling Future Year Travel

4.1 Overview of Demand Forecasting Procedure

4.1.1 Figure 1 of TAG Unit M4[6] describes the general outline of the methodology to be



followed to produce a set of forecasts. This figure is reproduced as Figure 4.1.

Figure 4.1: Basic Approach to Forecasting using a Transport Model

4.1.2 The base matrices were created from mobile phone, roadside interview data and synthesised demand, as described in the LMVR. These are termed the base year 'prior' matrices which form the input to the calibration and matrix estimation processes required for calibration. For the purpose of assignment and validation, these matrices were constructed in origin-destination (O-D) format.

4.1.3 As the variable demand model works on the basis of 24 hour trip productions and attractions (P/A format), the above basic methodology was modified and expanded to reflect the approach suggested in Appendix B of TAG Unit M2. This is necessary, because when dealing with matrices in P/A format within a demand model, the linkage between origin-destination (O-D) and production/attraction (P/A) data is not retained during the matrix estimation process.

4.1.4 The validated base matrix can therefore only be created at peak hour O-D and not at the 24 hour P/A level. As such, after converting the output of the forecast demand model from P/A to O/D, the resulting matrix is not directly assigned, but is compared with a base case, and the implied changes are used to adjust the independently validated base year matrix. This approach is shown in Figure 4.2.

4.1.5 The Reference Case forecast matrices form the starting point for the VDM process necessary to develop the Do Minimum and Do Something forecasts. This chapter describes the traffic growth and other demographic assumptions used to develop the reference forecasts.

[6] Transport Analysis Guidance Unit M4, Forecasting and Uncertainty, Department for Transport, November 2014

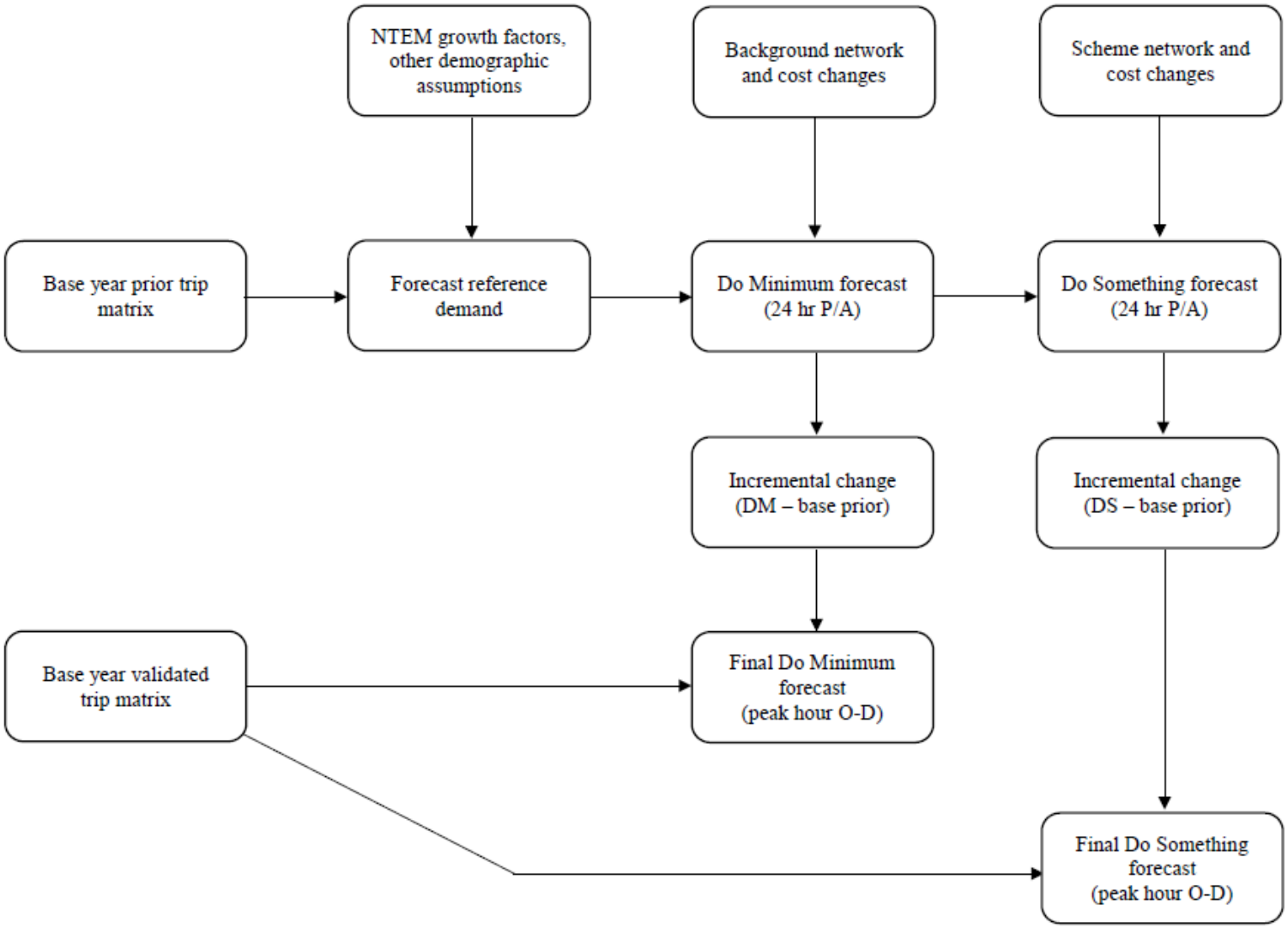


Figure 4.2: Approach to Forecasting when using P/A matrices in VDM

4.2 National Trip End Model

4.2.1 The National Trip End Model (NTEM) has been developed by the DfT and provides a set of predictions for growth in travel demand at trip end level for a range of different modes: walk, bicycle, car drivers, car passengers, bus and train. The results from NTEM are available through an interface called the Trip End Model Presentation Program (TEMPro).

4.2.2 TAG Unit M4 states that future year forecasts should be based on NTEM growth in demand thereby allowing local transport models to be developed on a fully consistent basis and through the medium of TEMPro. Version 6.2 of TEMPro, issued in 2013, represents the DfT's definitive version, and has been used to create the forecasts outlined in this report.

4.2.3 Within NTEM, Great Britain is broken down into a range of NTEM zones, which are groups of 2001 Census wards. These are, in general, a level below district level. Authorities are generally split into named urban zones and rural district remainders.

4.2.4 The predicted growth in 24-hour car trip productions and attractions was controlled to the growth forecast by the National Trip End Model for the spatial areas listed in Appendix A. NTEM forecasts were produced for the following car types:

- Home-based Work (HBW);
- Home-based Other (HBO);
- Non-Home-based Other (NHBO);
- Home-based Employer's Business (HBEB); and
- Non-Home-based Employer's Business (NHBEB).

4.2.5 Only one set of factors is provided in TEMPro, representing the central growth case of what is likely to happen to travel demand in the future based on the assumptions input to NTEM. The factors are based on predicted demographic changes and do not take account of the level of congestion or other factors (such as traffic restraint measures) which may limit the potential for all the demand to use the network without an unrealistic deterioration in travel conditions.

4.2.6 Correspondence between the model zones and NTEM areas was made at the finest level practicable. Within the core of the study area, model zones were allocated to the NTEM zones, while model zones further out were allocated to local authority zones or regions as appropriate.

4.2.7 The base year all–day trip end productions and attractions for the car user classes were factored to the two forecast years using the NTEM growth in car trip end productions and attractions, by trip purpose, for an average weekday. The demand matrix was then updated using a furnessing technique, controlled to trip productions, which are likely to be more reliable than trip attractions.

4.2.8 For a fixed demand approach, TAG Unit M4 makes provision for an additional global factor to take account of two further variables, income adjustment and fuel price variability. However, it also advises that a model which accounts for variable demand, as is the case with the M4CaN model, invalidates the use of these

additional variables, as these effects are modelled explicitly within the VDM process. Consequently, the NTEM car growth factors produced were not modified to include the income and fuel price factors, but were applied directly to the equivalent zone trip ends within the 2014 base matrices for car trips.

4.2.9 Further details of the NTEM traffic growth factors are given in Appendix A.

4.3 National Transport Model

4.3.1 NTEM does not produce growth factors for trips made by goods vehicles, and WebTAG advises that for modelling other vehicle types in highway models, growth factors from the National Transport Model (NTM) may be used. This incorporates the Great Britain Freight Model which expands base heavy goods vehicle (HGV) data by modelling the effects of macroeconomic variables and changes in generalised cost, while light goods vehicle (LGV) traffic is projected using a separate time series model related to changes in the Gross Domestic Product (GDP) and fuel price.

4.3.2 NTM provides estimates for the growth in road traffic between 2003 and 2040. The available data gives growth factors for light good vehicles (LGVs), articulated heavy vehicles and rigid heavy vehicles. The NTM growth factors were adjusted by the NTEM ratio of growth in the study area to national growth, in order to reflect the differential change in economic activity in the study area compared to other parts of the country.

4.3.3 The resulting NTM central growth factors for the change in vehicle-kilometres for LGVs and HGVs in Wales are shown in Table 4.1.

Table 4.1: Goods Vehicle Growth Factors from NTM

User Class	2014 to 2022	2014 to 2037
LGV	1.22	1.64
HGV	1.07	1.11

4.4 Uncertainty in Forecasting

4.4.1 An Uncertainty Log relating to the Scheme is given in Appendix B. The following sections provide details of how local uncertainty in travel demand and supply has been addressed in the forecasting process.

Development Proposals

4.4.2 Trips generated by specific development sites in Newport, Monmouthshire and Cardiff were taken into account and included within the NTEM growth. The developments were represented by a concentration of traffic growth in the zones that correspond to their geographical locations and loaded onto the modelled highway network at the development access points. To offset this, growth factors applied across the remainder of the NTEM area were reduced so that the overall level of growth was constrained to the NTEM forecasts.

4.4.3 Developments outside Newport, Cardiff and Monmouthshire were deemed to be too far from the study area to have a direct impact on the Scheme and as such were not considered for explicit inclusion in the traffic forecasting. Traffic

generated by these developments was encapsulated in the NTEM growth for that particular region.

4.4.4 Information regarding the detailed proposals and planning status of future developments in the study area was obtained from the local planning authorities in Newport, Monmouthshire and Cardiff. This takes on board information contained in:

- the Newport Local Development Plan, placed on deposit in April 2012 and subsequently adopted in January 2015; and
- the Monmouthshire Local Development Plan, which was placed on deposit in September 2011 and subsequently adopted in February 2014.
- the Cardiff Local Development Plan, which was placed on deposit in September 2013 and submitted for examination in August 2014. The Plan was adopted on 28th January 2016.

4.4.5 The planning departments at each of these local authorities were consulted regarding the proposed developments and any feedback that was provided has been incorporated. During these consultations it was confirmed that there are no 'dependant developments' within any of the programmes that would only go ahead if the proposed section of motorway to the south of Newport was constructed.

4.4.6 A 'screening' process was applied to determine which of the listed developments in Newport, Cardiff and Monmouthshire should explicitly be included in the model traffic forecasts. This removed housing sites of less than 100 units, so that traffic generated by these sites would be included within the background traffic growth as forecast by NTEM.

4.4.7 For Cardiff and Monmouthshire, only those developments situated within or adjacent to the Core Simulation Area were explicitly included within the Reference Case matrices. For any developments beyond this, it was assumed that the development traffic will be encapsulated within NTEM growth forecasts.

4.4.8 Each proposed development was considered in turn and classified in accordance with Table A2 of TAG Unit M4. Those developments which were the subject of a planning application or had been approved were classified as 'more than likely' and 'near certain' and were therefore taken into account in the future year Reference Case matrices.

4.4.9 The land use and quantum of each development was used to determine the total number of trips generated by each development. These were estimated using the Trip Rate Information Computer System (TRICS) database or, where available, were taken from development specific transport assessments.

4.4.10 The TRICS database contains over 2,100 site locations, 4,700 survey counts and 98 land use sub-categories, and is widely used for trip rate estimates for future year developments. In order to obtain a reasonable representation of future development generated trips, average trip rates were used for the relevant development land uses. The distribution of trips in such cases was based on that from the base year model for nearby 'reference' zones with a similar land use.

4.4.11 Table 4.2 lists the development proposals included in the forecast traffic models, together with the assumed proportion completed in each of the modelled forecast years.

Table 4.2: Development Proposals

Development		Land Use	Size	Completion	
				2022	2037
(A) Newport					
1	East Newport, north of railway line (Llanwern)	Housing	1100 units	65%	100%
2	Former Pirelli Works	Housing	250 units	100%	100%
3	Glebelands	Housing	153 units	100%	100%
4	Former Tredegar Park Golf Course	Housing	150 units	100%	100%
5	Allt yr Yn Campus	Housing	125 units	100%	100%
6	Monmouthshire Bank Sidings	Housing	575 units	42%	100%
7	Victoria Wharf	Housing	130 units	20%	100%
8	Penmaen Wharf	Housing	160 units	100%	100%
9	Former Sainsbury's site	Housing	140 units	96%	100%
10	City Vision	Housing	464 units	52%	68%
11	Lysaght Village (Orb Works)	Housing	517 units	46%	65%
12	Former Bettws Comprehensive	Housing	229 units	55%	55%
13	Lysaght Parc	Housing	100 units	100%	100%
14	East Newport, south of railway line (Glan Llyn)	Housing	4000 units	43%	100%
15	Whiteheads Works	Housing	400 units	45%	83%
16	Old Town Dock	Housing	350 units	60%	100%
17	Jubilee Park (Alcan Works)	Housing	1,064 units	50%	87%
18	Jigsaw site, Hartridge	Housing	200 units	80%	100%
19	Opposite Belmont Lodge	Housing	122 units	100%	100%
20	Panasonic	Housing	250 units	100%	100%
21	Duffryn	Industry	154,000m^2 GFA	-	100%
22	East of Queensway Meadows	Industry	108,000m2 GFA	-	100%
23	Celtic Springs Business Park	Offices	16,200m2 GFA	100%	100%
24	Gwent Europark	Warehousing	80,000m2 GFA	100%	100%
25	East Newport, south of railway line (Glan Llyn)	Industry	142,000m2 GFA	-	100%
26	Phoenix Park (former Pirelli works)	Industry	8,000m2 GFA	100%	100%
27	Newport City Centre redevelopment, Friars Walk	Mixed use	30,612m2 retail 2,314m2 cinema 3,440m2 restaurants	100%	100%

(B) Monmouthshire					
28	Crick Rd, Portskewett	Housing Offices	285 units 2,700m2 GFA	100%	100%
29	Fairfield Mabey, Chepstow	Housing Offices	350 units 8,100m2 GFA	100%	100%
30	Rockfield Farm, Undy	Housing Offices	270 units 5,600m2 GFA	100%	100%
31	Vinegar Hill, Undy	Housing	225 units	100%	100%
32	Sudbrook Paper Mill	Housing	190 units	100%	100%
33	Wales One, Magor	Offices	21,739m2 GFA	-	100%
34	Quay Point, Magor	Offices Industry Warehousing	10,584m2 GFA 23,520m2 GFA 49,000m2 GFA	-	100%
35	Gwent Europark, Magor	Warehousing	66,500m2 GFA	-	100%
36	Newhouse Farm, Chepstow	Industry	16,000m2 GFA	-	100%
37	Pill Row, Severnbridge Ind Est	Industry	4,000m2 GFA	-	100%
38	Beaufort Park, Chepstow	Offices	1,134m2 GFA	-	100%
(C) Cardiff					
39	NE Cardiff (west of Pontprennau)	Housing	4,500 units	66%	100%
40	East of Pontprennau Link Road (St. Edeyrns)	Housing	1,300 units	82%	100%
41	St Mellons Business Park	Offices	124,000m2 GFA	-	100%
42	Areas 9-12, St Mellons	Housing	150 units	-	100%
43	Cardiff Gate International Business Park	Offices	13,362m2 GFA	100%	100%

Highway Schemes

4.4.12 In addition to proposed developments, the treatment of uncertainty in model forecasting also needs to include any proposed highway infrastructure schemes.

4.4.13 The future year highway networks were developed for the years 2022 and 2037. Firmly proposed network improvements which are likely to be in place by the modelled forecast years are included in both the Do Minimum and Do Something networks.

4.4.14 The definition of the Do Minimum network requires the identification of any committed or probable highway schemes within the study area that should be included in the traffic model. The Welsh Government, together with Newport, Cardiff and Monmouthshire councils, were consulted to ascertain what transport schemes are likely to be implemented within the timeframes of the M4CaN traffic forecasts.

4.4.15 It was confirmed that there are no transport schemes that would be dependent on the proposed new section of motorway being constructed.

4.4.16 Following this consultation, the schemes described below were included in the Do Minimum network:

1. Tredegar Park Roundabout (Junction 28)

4.4.17 As part of the M4 Corridor Enhancement Measures (CEM) Programme, a scheme to improve the operation of the Junction 28 roundabout at Tredegar Park is being promoted by the Welsh Government. The proposed design for this scheme is shown in Figure 4.3, and comprises an enlarged at-grade signalised gyratory, incorporating through links between the M4 (west) and the A48 Southern Distributor Road.

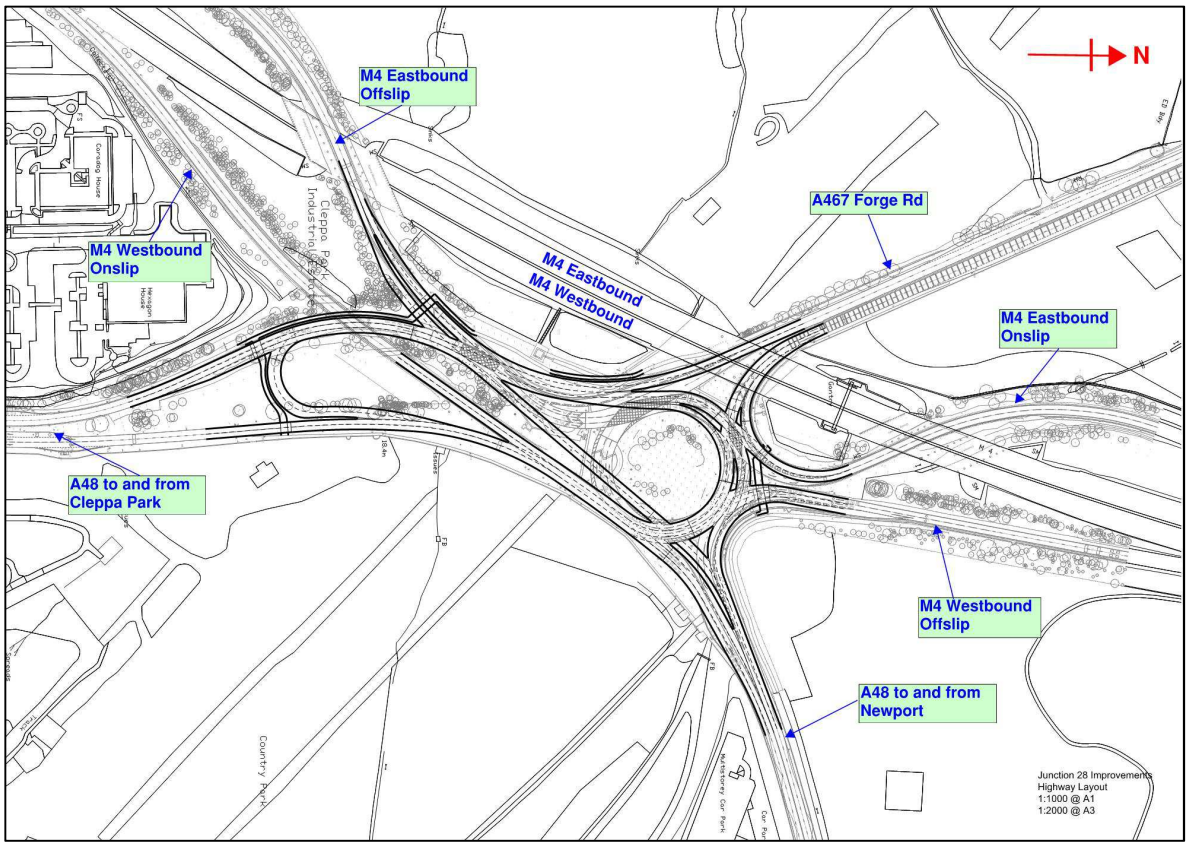


Figure 4.3: Tredegar Park Gyratory

2. A467 Bassaleg Roundabout

4.4.18 This improvement is also proposed as part of the CEM programme, and would convert the existing A467 Bassaleg roundabout into a signalised roundabout, as shown in Figure 4.4.

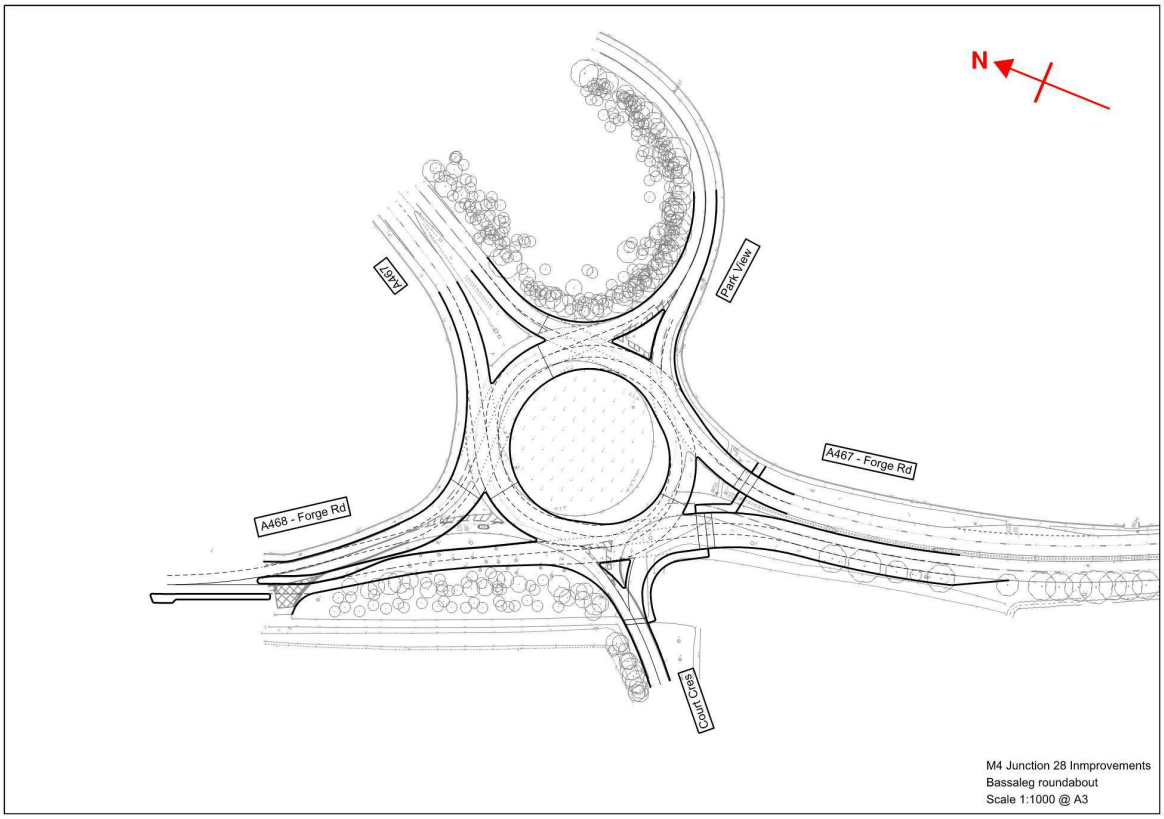
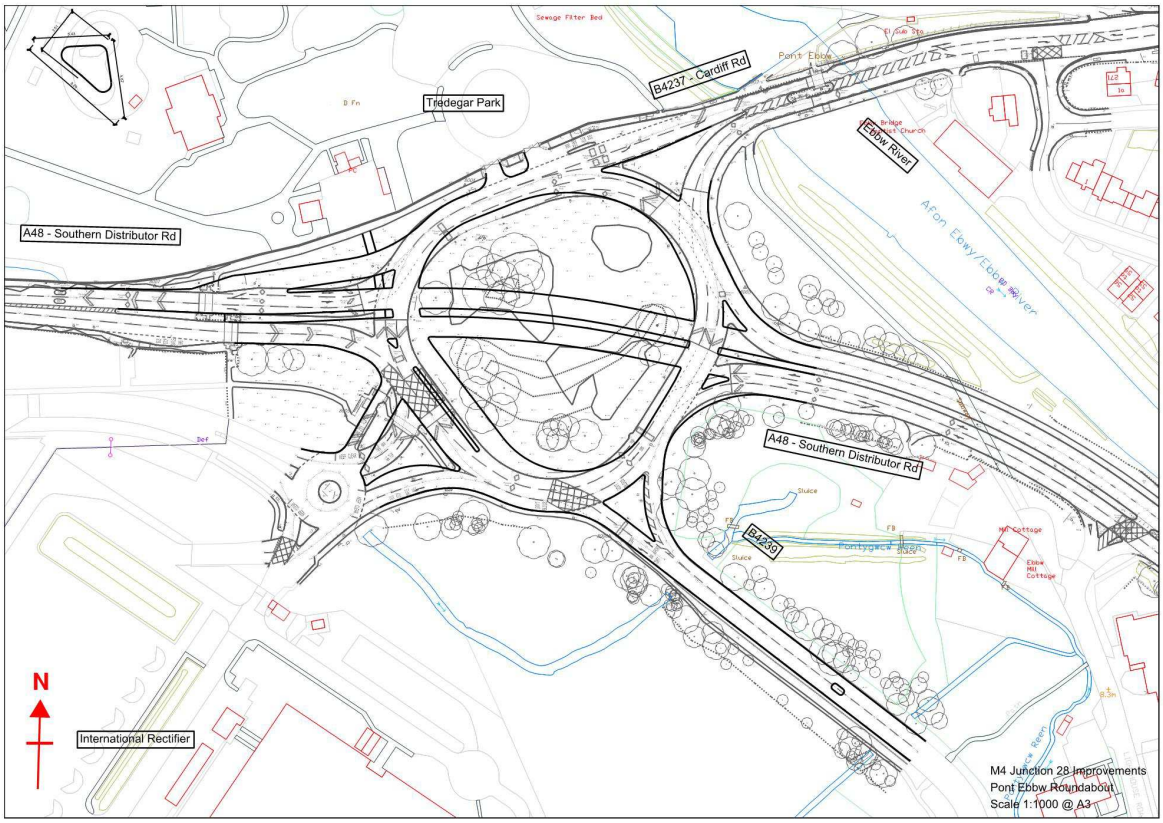


Figure 4.4: Bassaleg Roundabout Improvement

3. A48 Pont Ebbw Roundabout

4.4.19 This scheme would convert the existing signalised roundabout into a signalised 'throughabout', with a new link connecting the eastern and western arms of the A48 Southern Distributor Road. The design of this scheme is shown in Figure



4.5.

Figure 4.5: Pont Ebbw Roundabout Improvement

4. A465 Heads of the Valleys Dualling (Abergavenny to Hirwaun)

4.4.20 The A465 trunk road forms an alternative east-west strategic route to the M4, particularly for traffic travelling between the Midlands and West Wales. This improvement scheme comprises four sections:

- Section 3 (Brynmawr to Tredegar) was approved following a Public Inquiry in 2012, and was completed in 2015;
- Section 2 (Gilwern to Brynmawr) was approved following a Public Inquiry in spring 2014. Construction commenced in early 2015, and is scheduled for completion in 2018;
- Section 5 (Dowlais Top to A470) is not yet programmed, but is expected to commence in time for completion by 2022; and
- Section 6 (A470 to Hirwaun) is not yet programmed, but is expected to commence in time for completion by 2022.

5. Newport Eastern Expansion Area

4.4.21 Additional infrastructure is proposed to serve the major residential developments planned on the former steelworks site (Glan Llyn, ref 14 and 25 in Table 4.2) and the area north of the railway around the village of Llanwern (ref 1 in Table 4.2). The proposals comprise:

- A new north-south link over the mainline railway, connecting the A48 SDR and Llanwern village to the A4810; and
- Upgrading of the A48 SDR / Cot Hill junction, from the existing left-in/left-out priority arrangement to an all-movement signal-controlled junction.

4.4.22 The phasing of the development proposals has been extended, and it is now assumed that these infrastructure proposals will be in place prior to the 2037 design year.

4.4.23 By the 2022 opening year, it is assumed that the only additional infrastructure will be the construction of a new junction on Cot Hill west of Llanwern village, to facilitate access for the initial development phases on the land north of the mainline railway.

6. Cardiff Eastern Bay Link, Phase 1

4.4.24 Construction of Phase 1 of the Eastern Bay link was due to commence in 2015. This will provide an at-grade dual two-lane all-purpose road connecting the Queensway roundabout at the southern end of Central Link with the existing roundabout at the southern end of Ocean Way, as shown in Figure 4.6.

4.4.25 There is currently no formal commitment to deliver the remainder of the Eastern Bay Link scheme.

Figure 4.3 Cardiff Eastern Bay Link, Phase 1

Severn Crossing Tolls

4.4.26 The traffic model network includes the two Severn River Crossings, which link Wales and South West England. These bridges are currently both tolled in the westbound direction. The tolls are collected via toll booths, at Aust on the first Severn Bridge and approaching Magor for the Second Severn Crossing. The tolls are represented in the base year model by a monetary penalty (in 2014 prices) to represent the toll charge for each of the different vehicle types and a time penalty to represent the delay at the toll booths.

4.4.27 The Severn Bridges Act 1992 established the conditions under which the current concession agreement will end, and both bridges crossing the River Severn will revert to public ownership. The Act notes that the concession agreement ends either at:

- The end of the period of 30 years beginning with the appointed day; or
- Where it appears to the Secretary of State that the revenue requirement has been met on a day, the right of the concessionaire to exercise the power to levy tolls shall end at such time after that day as the Secretary of State may determine.

4.4.28 On 6 March 1992 the Secretary of State signed the Order setting the start date of the concession as 26 April 1992.

4.4.29 It is therefore the case that, unless new legislation is agreed between the Department for Transport and the Welsh Government, the collection of Severn Crossing Tolls will cease by 2022 at the latest.

4.4.30 The removal of the Severn Crossing Tolls would be likely to result in increased demand. Previous work has indicated that this increase is likely to amount to 12% of the traffic using the crossings. Consequently, the forecast traffic volumes crossing the Severn have been increased by 12% to allow for this.

5 Reference Case Demand

5.1 Introduction

5.1.1 The Core Scenario has been developed in line with the principles outlined in TAG Unit M4, and are based on:

- NTEM growth in demand, at a suitable spatial area;
- Sources of local uncertainty that are likely to occur; and
- Appropriate modelling assumptions.

5.1.2 In addition to the Core Scenarios, alternative scenarios are required to allow decision makers to see how scheme performance varies depending on the assumptions made within the assessment. High and low growth scenarios are required to test the impact of uncertainty in projections such as demographic data (population, households and employment), GDP growth and fuel price trends.

5.1.3 Optimistic and pessimistic sensitivity tests may be used to consider the impact of local uncertainty. This typically depends on whether developments or other planned transport schemes go ahead in the vicinity of the Scheme being built. A review of all planned developments and highway schemes was undertaken at the time of preparing the forecasts, as described in Section 4.4.

5.1.4 At this stage, all developments to be included in the test scenarios were identified based on their size, nature of the development, phasing, planning status and likely impact on traffic patterns within the study area. As Newport is a concentrated area, it was decided that there would be no changes to these to account for pessimistic or optimistic development scenarios for incorporation into the low and high growth scenarios. TAG Unit M4 stipulates that with developments taken into account, total growth should be constrained to the NTEM/NTM forecasts and the totals adjusted to reflect national uncertainty for the Low and High Growth scenarios. This is the approach adopted for the M4CaN forecasting.

5.2 Core Scenario

5.2.1 TAG Unit M4 defines a 'Core Scenario' for forecasting as '*a scenario based on the most unbiased and realistic set of assumptions that will form the central case that is presented in the Appraisal Summary Table (AST)'*.

5.2.2 The Core Scenario for the Scheme has been identified based on the above guidance and comprises:

- NTEM/NTM Growth assumptions detailed in Sections 4.2 and 4.3;
- inclusion of the proposed developments listed in Section 4.4;
- inclusion of the highway schemes listed in Section 4.4; and
- removal of the Severn Crossing Tolls.

5.3 Construction of Reference Case Matrices

5.3.1 The 2022 forecast trip matrices were developed from the 2014 base year 'prior' trip matrices (which form the input to the base model calibration), and these in turn formed the basis for the development of the 2037 forecast trip matrices. The reason why the Reference Case forecast matrices could not be created using the validated base matrices is explained in section 4.1.

5.3.2 NTEM factors for the forecast years (excluding the adjustment for income and fuel cost growth) were extracted using TEMPro for the three car trip purposes in the AM peak, inter-peak and PM peak periods. For each user class the relevant set of growth factors from NTEM, as detailed in Appendix A, was applied to the corresponding model zones in the base year 'prior' trip matrices.

5.3.3 The trips generated by the development proposals listed in Table 4.2 were then added to the factored matrices. TAG Unit M4 states that model forecasts should be controlled to the benchmark provided by the NTEM data. In order to ensure that overall growth was constrained to the level set by the NTEM forecasts, the NTEM factored matrices were reduced by the equivalent number of development trips that were added separately.

5.3.4 This process ensures that the forecast trip matrices form a Reference Case for traffic growth that is consistent with NTEM growth forecasts at a district level while taking account of specific development proposals which would lead to pockets of higher growth in certain parts of the study area. A similar process is undertaken with the NTM growth applied to the LGV and HGV user class matrices.

5.3.5 The resulting forecast trip matrices, with the inclusion of the specific developments listed in Table 4.2, are therefore controlled to the overall growth factors obtained from NTEM and NTM. The growth in trips by user class from 2012 to 2022 is shown in Table 5.1, and that from 2022 to 2037 is shown in Table 5.2.

Table 5.1: Forecast Reference Trip Matrix Totals, 2022 (Central Growth)

User Class	2014	2022				
	Base Trips	NTEM Ref. Growth	Adjusted Dvlpt Trips (a)	Revised Base Growth (b)	Revised Growth with Dvlpts (a+b)	Total Growth from 2014
AM (07:00-10:00)						
Cars – EB	31,085	33,921	643	33,279	33,921	+9.1%
Cars – Other	287,290	310,239	6,213	304,025	310,239	+8.0%
Cars – Commuting	253,350	275,029	6,334	268,693	275,028	+8.6%
LGV	74,486	91,022	1,975	89,047	91,022	+22.2%
HGV	33,241	35,601	1,832	33,768	35,601	+7.1%
Total	**679,452**	**745,812**	**16,997**	**728,813**	**745,810**	**+9.8%**
IP (10:00-16:00)						
Cars – EB	76,895	83,804	1,493	82,311	83,804	+9.0%
Cars – Other	498,113	538,262	15,899	522,364	538,262	+8.1%
Cars – Commuting	123,410	133,939	3,444	130,496	133,940	+8.5%
LGV	116,766	142,688	2,497	140,191	142,688	+22.2%
HGV	59,584	63,815	3,592	60,223	63,815	+7.1%
Total	**874,768**	**962,508**	**26,924**	**935,586**	**962,509**	**+10.0%**
PM (16:00-19:00)						
Cars – EB	41,204	44,899	1,064	43,835	44,899	+9.0%
Cars – Other	300,480	324,564	9,533	315,029	324,562	+8.0%
Cars – Commuting	233,828	253,811	6,457	247,350	253,807	+8.5%
LGV	57,352	70,084	2,044	68,040	70,083	+22.2%
HGV	28,579	30,608	1,407	29,201	30,608	+7.1%
Total	**661,442**	**723,965**	**20,504**	**703,455**	**723,959**	**+9.5%**
OP (19:00-07:00)						
Cars – EB	30,981	33,751	693	33,058	33,751	+8.9%
Cars – Other	365,805	395,351	11,739	383,612	395,349	+8.1%
Cars – Commuting	151,845	164,749	5,441	159,307	164,747	+8.5%
LGV	57,719	70,533	1,797	68,736	70,533	+22.2%
HGV	23,495	25,163	3,493	21,669	25,163	+7.1%
Total	**629,844**	**689,546**	**23,164**	**666,382**	**689,543**	**+9.5%**

Table 5.2: Forecast Reference Trip Matrix Totals, 2037 (Central Growth)

User Class	2022	2037				
	Growth with Dvlpts	NTEM Ref Growth	Adjusted Dvlpt Trips (a)	Revised Growth from 2022 (b)	Revised Growth with Dvlpts (a+b)	Total Growth from 2022
AM (07:00-10:00)						
Cars – EB	33,921	39,863	810	39,060	39,870	+17.5%
Cars – Other	310,239	345,765	7,276	338,490	345,767	+11.5%
Cars – Commuting	275,028	320,991	7,874	313,121	320,994	+16.7%
LGV	91,022	122,231	2,892	119,339	122,231	+34.3%
HGV	35,601	36,798	1,606	35,192	36,797	+3.4%
Total	**745,810**	**865,649**	**20,457**	**845,202**	**865,659**	**+16.1%**
IP (10:00-16:00)						
Cars – EB	83,804	98,233	2,375	95,858	98,233	+17.2%
Cars – Other	538,262	599,701	19,279	580,420	599,699	+11.4%
Cars – Commuting	133,940	156,290	4,329	151,962	156,291	+16.7%
LGV	142,688	191,613	4,585	187,027	191,612	+34.3%
HGV	63,815	65,960	3,409	62,550	65,960	+3.4%
Total	**962,509**	**1,111,796**	**33,977**	**1,077,817**	**1,111,794**	**+15.5%**
PM (16:00-19:00)						
Cars – EB	44,899	52,579	971	51,608	52,579	+17.1%
Cars – Other	324,562	361,638	8,728	352,910	361,638	+11.4%
Cars – Commuting	253,807	296,182	7,398	288,786	296,184	+16.7%
LGV	70,083	94,114	2,662	91,452	94,114	+34.3%
HGV	30,608	31,636	1,236	30,400	31,636	+3.4%
Total	**723,959**	**836,149**	**20,995**	**815,155**	**836,151**	**+15.5%**
OP (19:00-07:00)						
Cars – EB	33,751	39,308	466	38,148	39,308	+16.5%
Cars – Other	395,349	440,821	6,925	422,157	440,820	+11.5%
Cars – Commuting	164,747	191,976	3,803	182,732	191,975	+16.5%
LGV	70,533	94,718	1,487	91,433	94,718	+34.3%
HGV	25,163	26,009	2,811	19,704	26,009	+3.4%
Total	**689,543**	**792,831**	**15,493**	**754,174**	**792,830**	**+15.0%**

6 Future Year Highway Networks

6.1 Do Minimum Scenario

6.1.1 A review of proposed highway schemes within the study area has been undertaken. From this, a list of highway improvements for inclusion in the M4CaN traffic model was identified, as detailed in Section 4.4 of this report. All of these schemes are coded into the forecast Do Minimum Scenario networks.

6.1.2 As noted in Section 4.4, the core scenario assumes that tolls on the two Severn River Crossings will cease by 2022. However the M4CaN is not able to model the full effect of this automatically, as it does not include sufficient model and travel demand detail on the English side of the crossings. Accordingly, the assessment of travel demand was carried out in two stages.

6.1.3 Firstly, the current tolls across the two Severn River Crossings were included in the forecast year scenarios and run through the Variable Demand Model. The toll charges in the forecast networks were retained at the same values, in real terms, as in the base year model. The underlying assumption for this is that the tolls would increase in line with inflation in future years and are kept constant in terms of 2014 prices which maintains consistency with the other route choice generalised costs, PPM and PPK, as detailed in Section 3.9. The VDM therefore accounted for all changes in travel demand except for those arising from the removal of the tolls.

6.1.4 Secondly, the demand resulting from the VDM process was reassigned in the M4CaN model with the crossing tolls and delays removed. The trips assigned to the two Severn River Crossings were then increased by 12%, as noted in Section 4.4.

6.2 Do Something Scenario

Proposed Section of Motorway South of Newport

6.2.1 In order to define the Do Something network, the Scheme was added to the Do Minimum network described in Section 6.1. The Scheme provides a new section of dual 3-lane motorway between Junction 23 (Magor) and Junction 29 (Castleton). The Scheme is some 24km in length, and is shown in Figure 6.1.

6.2.2 In addition to the junctions at Castleton and Magor, two new junctions would be provided along the route of the proposed new section of motorway (at Newport Docks and at Glan Llyn).

6.2.3 The proposed new section of motorway has been designed with a 120 kilometres per hour design speed and a mandatory 70 miles per hour enforced speed limit for all of its length. The speed limits at either end of the new section of motorway are generally 70 mph, with the exception of the toll booth area associated with the Second Severn Crossing.

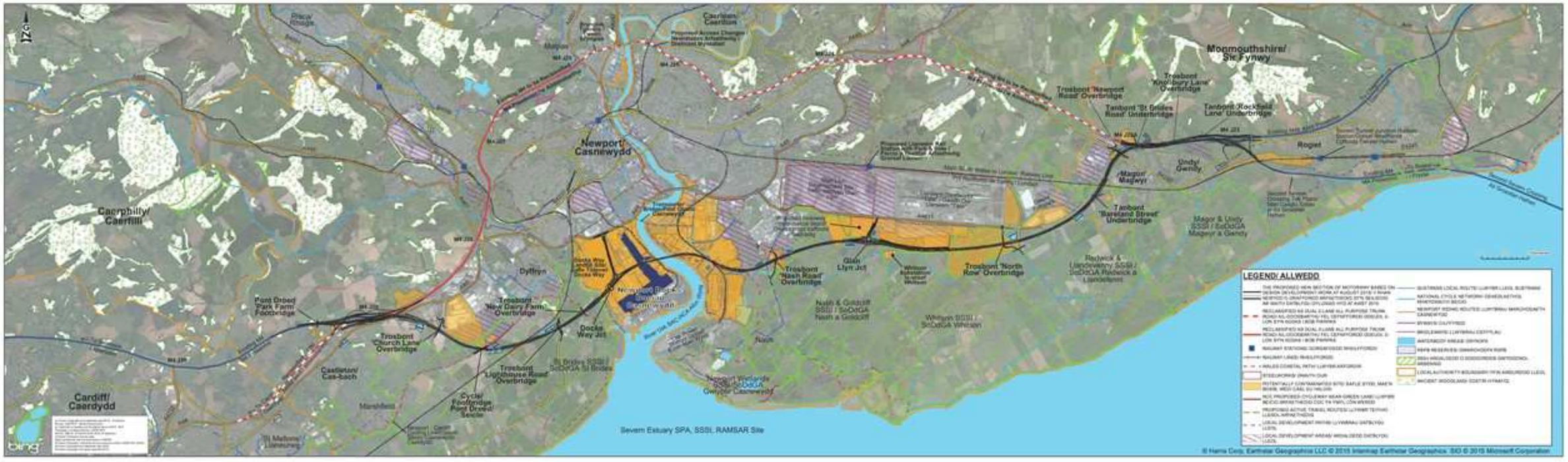


Figure 6.1: Proposed New Section of Motorway South of Newport

6.2.5 The existing Castleton junction on the M4 (J29) would be modified to incorporate the new section of motorway. The junction has been designed to provide a free flowing interchange giving priority to the M4 motorway (including the new section of motorway) with three lanes in both directions. The layout would also provide access to and from the A48(M) and the existing M4 motorway to the east, which would be reclassified following completion of the new section of motorway.

6.2.6 The alignment would follow the centreline of the existing M4 before curving away from the existing motorway corridor to the south east. To the east of the River Ebbw, the alignment would continue to the north east towards Newport Docks. A new junction would be provided in this location.

6.2.7 The Docks Way Junction has been designed to provide a grade-separated roundabout with four slip roads and a gyratory, which would be positioned beneath the new section of motorway. This junction would provide a connection from the new section of motorway onto the A48 Southern Distributor Road (SDR) and to the centre of Newport. This would be provided through a secondary roundabout to the north of the new section of motorway, which would connect to the gyratory via a short dual carriageway connector road (Docks Way Link Road).

6.2.8 The River Usk Crossing would cross the Newport Docks between the South Dock and North Dock, before straightening out over the main bridge crossing of the River Usk.

6.2.9 A new junction would be provided at Glan Llyn, in the form of a grade separated roundabout. This would provide a connection from the new section of motorway, via a link road, to the A4810. The new link road would connect with the existing SAR roundabout via a remodelled southern arm.

6.2.10 The alignment would then run in a north easterly direction towards Magor. In the vicinity of St Bride's Road to the north west of Magor, the new section of motorway would utilise the existing M4, but there would be no connection with the existing Junction 23A.

6.2.11 Junction 23 to the east of Magor and Undy would become an all-movement signalised roundabout. The M48 from Chepstow would connect into the roundabout directly, with slip road connections to the Scheme in both directions, and a link to the B4245. A new D2AP trunk road would link the Junction 23 roundabout to the existing M4 at Junction 23A, running alongside the proposed new section of motorway.

6.2.12 There would be a grade-separated westbound link from the Second Severn Crossing onto the J23 to J23A trunk road link to the existing M4, while in the eastbound direction traffic would travel through Junction 23 via a ‘throughabout’ link.

Reclassified M4

6.2.13 Reclassification works on the existing M4 would consist of the reconfiguration of Junction 25 for Caerleon and associated works, to reopen access to the existing M4 on the west side of the junction. This would require the closure of the existing slip roads at Junction 25A, so that traffic travelling between the A4042 Malpas Bypass and the existing M4 (east) would travel through the Junction 25 roundabout.

6.2.14 Works on the existing M4 as part of its reclassification to a trunk road would comprise installation of traffic control measures, such as changes to signage, lighting and road markings. Revised layout arrangements would include:

1. A48(M), Junction 29A to Junction 29 – D2AP Trunk Road;
2. Junction 29 to Junction 26 – Dual 3-lane All-Purpose (D3AP) Trunk Road but with a lane drop/lane gain between the slips at Junction 28 where it becomes D2AP;
3. Junction 26 to Junction 25 – D2AP (maximum speed limit 60mph);
4. Removal of Junction 25A slips, replaced by new west-facing slips from Junction 25 roundabout, with signalisation of roundabout;
5. Junction 25 to Junction 24 – All-Purpose Trunk Road, 3-lanes eastbound and 2-lanes westbound; and
6. Junction 24 to Junction 23A – D2AP Trunk Road.

6.2.15 There would be amendments to the merge and diverge layouts at all of the junctions.

6.2.16 The existing Variable Speed Limit would continue to operate along the existing M4 between Junction 24 (Coldra) and Junction 28 (Tredegar Park), but with a maximum speed limit of 60 miles per hour imposed at the Brynglas Tunnels, as identified at (3) above.

6.3 Forecast Network Checks

6.3.1 Checks of the future year networks were undertaken to ensure that all future year schemes are accurately represented. The future year schemes were coded using GIS. Link distances were derived directly from this software, and visual checks were also made.

6.3.2 Traffic signal information was not available for all of the schemes. In these cases, the initial assignments were checked, and signal timings manually adjusted to ensure the most efficient operation practicable at the junction. It should be noted that SATURN has not been used to optimise signal timings, as it is recognised that doing so can lead to questionable results within the SATURN assignment process.

6.3.3 In addition to the above, time and distance skim matrices were examined and any large differences between the 2014 base, Do Minimum and Do Something costs were checked to ensure that these are realistic given the network changes taking place in each scenario.

7 Public Transport Model

7.1 Overview

7.1.1 The public transport model has been designed specifically to provide public transport inputs to the M4CaN VDM. It is not designed to forecast public transport impacts, passenger volumes or benefits of other highway or public transport projects. The model provides the public transport demands and times/costs required to enable mode choice modelling within the VDM forecasting for the Scheme.

7.1.2 Forecast public transport trip demand matrices were derived starting with a set of base matrices developed specifically for this study using bus and rail passenger counts, surveys and existing models, as reported in the Local Model Validation Report.

7.2 Forecast Year Timetables and Fares

7.2.1 The future year public transport timetables were modified to reflect the increased service frequencies and improved journey times that could be achieved with Valley Lines Electrification and electrification of the Main Line, together with the opening of new stations on the Valley Lines.

7.2.2 However, the specifics of the metro proposals are still under development with further work being undertaken on the possible services and modes that may form part of metro. The inclusion of the improved rail services on the Valley Lines in the model means that account has been taken of the aspects of metro which are relevant in consideration of the M4 proposals. There are other potential elements of the metro proposals which include bus rapid transit services, bus lanes and trams within Cardiff itself, but these will not impact on traffic numbers on the M4 to any significant extent and have therefore not been included in the model.

7.2.3 Figure 7.1 shows the modified rail network assumed for the South Wales area in the forecast years, with changes compared to the base assumptions highlighted.

7.2.4 Forecast bus service timetables and timetabled bus stop locations were assumed to remain the same as in the base year scenario. This is based on the assumption that if traffic volumes grow sufficiently to slow buses down, then bus priority schemes would be likely to be put in place. Technological changes, such as smart ticketing, are also likely to reduce future bus dwell times and hence offset a likely increase in delay due to congestion increase.

7.2.5 Public transport fares were assumed to rise in line with the retail price index over the forecast period and as such were treated as being constant in real terms.

7.3 Demand Growth

7.3.1 The predicted growth in 24-hour bus and rail trip productions and attractions was controlled to the growth forecast by the National Trip End Model for the spatial areas listed in Appendix A. This data was extracted using TEMPro version 6.2.

7.3.2 NTEM forecasts were produced separately for the following public transport users:

- Home-based work (HBW);
- Home-based other (HBO);
- Non-home-based other (NHBO);
- Home-based employers' business (HBEB); and
- Non-home-based employers' business (NHBEB).

7.3.3 Total rail and bus person trips contained within the demand matrices in the base and forecast years are shown in Tables 7.1 and 7.2 respectively.

Table 7.1: Forecast Rail Person Trips (Central Growth)

User Class	2014	2022		2037	
	Base Trips	Ref. Case Trips	Total Growth from 2014	Ref. Case Trips	Total Growth from 2022
AM (07:00-10:00)					
HBW	3,063	3,133	+2.3%	3,372	+7.6%
HBEB	1,177	1,176	-0.1%	1,201	+2.1%
HBO	1,146	1,217	+6.2%	1,371	+12.7%
NHBEB	203	213	+5.1%	234	+9.5%
NHBO	275	285	+3.5%	301	+5.6%
Total	**5,864**	**6,024**	**+2.7%**	**6,478**	**+10.5%**
IP (10:00-16:00)					
HBW	1,283	1,311	+2.1%	1,405	+7.2%
HBEB	1,425	1,421	-0.3%	1,447	+1.9%
HBO	4,724	5,007	+6.0%	5,623	+12.3%
NHBEB	935	984	+5.3%	1,082	+9.9%
NHBO	788	816	+3.5%	862	+5.7%
Total	**9,155**	**9,538**	**+4.2%**	**10,420**	**+13.8%**
PM (16:00-19:00)					
HBW	2,926	2,993	+2.3%	3,213	+7.3%
HBEB	1,461	1,463	+0.1%	1,495	+2.2%
HBO	2,332	2,475	+6.2%	2,787	+12.6%
NHBEB	247	259	+5.1%	284	+9.5%
NHBO	337	349	+3.5%	368	+5.6%
Total	**7,303**	**7,540**	**+3.2%**	**8,148**	**+11.6%**
OP (19:00-07:00)					
HBW	967	989	+2.2%	1,059	+7.2%
HBEB	905	905	0.0%	927	+2.4%
HBO	2,648	2,808	+6.0%	3,151	+12.2%
NHBEB	617	650	+5.3%	713	+9.8%
NHBO	476	494	+3.7%	523	+5.8%
Total	**5,614**	**5,845**	**+4.1%**	**6,373**	**+13.5%**

Table 7.2: Forecast Bus Person Trips (Central Growth)

User Class	2014	2022		2037	
	Base Trips	Ref. Case Trips	Total Growth from 2014	Ref. Case Trips	Total Growth from 2022
AM (07:00-10:00)					
HBW	519	515	-0.9%	535	+4.0%
HBEB	20	20	-1.9%	19	-5.3%
HBO	338	347	+2.6%	374	+7.8%
NHBEB	0	0	0.0%	0	0.0%
NHBO	50	51	+1.8%	52	+1.2%
Total	**928**	**932**	**+0.5%**	**979**	**+5.6%**
IP (10:00-16:00)					
HBW	313	312	-0.5%	327	+4.8%
HBEB	24	24	-2.0%	22	-5.3%
HBO	1,109	1,138	+2.7%	1.230	+8.0%
NHBEB	0	0	0.0%	0	0.0%
NHBO	177	180	+1.8%	182	+1.2%
Total	**1,623**	**1,654**	**+1.9%**	**1,761**	**+8.5%**
PM (16:00-19:00)					
HBW	547	550	+0.5%	582	+5.8%
HBEB	21	21	-0.8%	20	-4.6%
HBO	356	367	+3.1%	397	+8.2%
NHBEB	0	0	0.0%	0	0.0%
NHBO	53	54	+2.0%	55	+1.0%
Total	**977**	**992**	**+1.5%**	**1,054**	**+7.8%**
OP (19:00-07:00)					
HBW	83	83	0.0%	87	+5.2%
HBEB	6	6	0.0%	6	0.0%
HBO	292	301	+3.0%	326	+8.4%
NHBEB	0	0	0.0%	0	0.0%
NHBO	47	47	+1.8%	48	+1.3%
Total	**427**	**437**	**+2.2%**	**467**	**+9.3%**

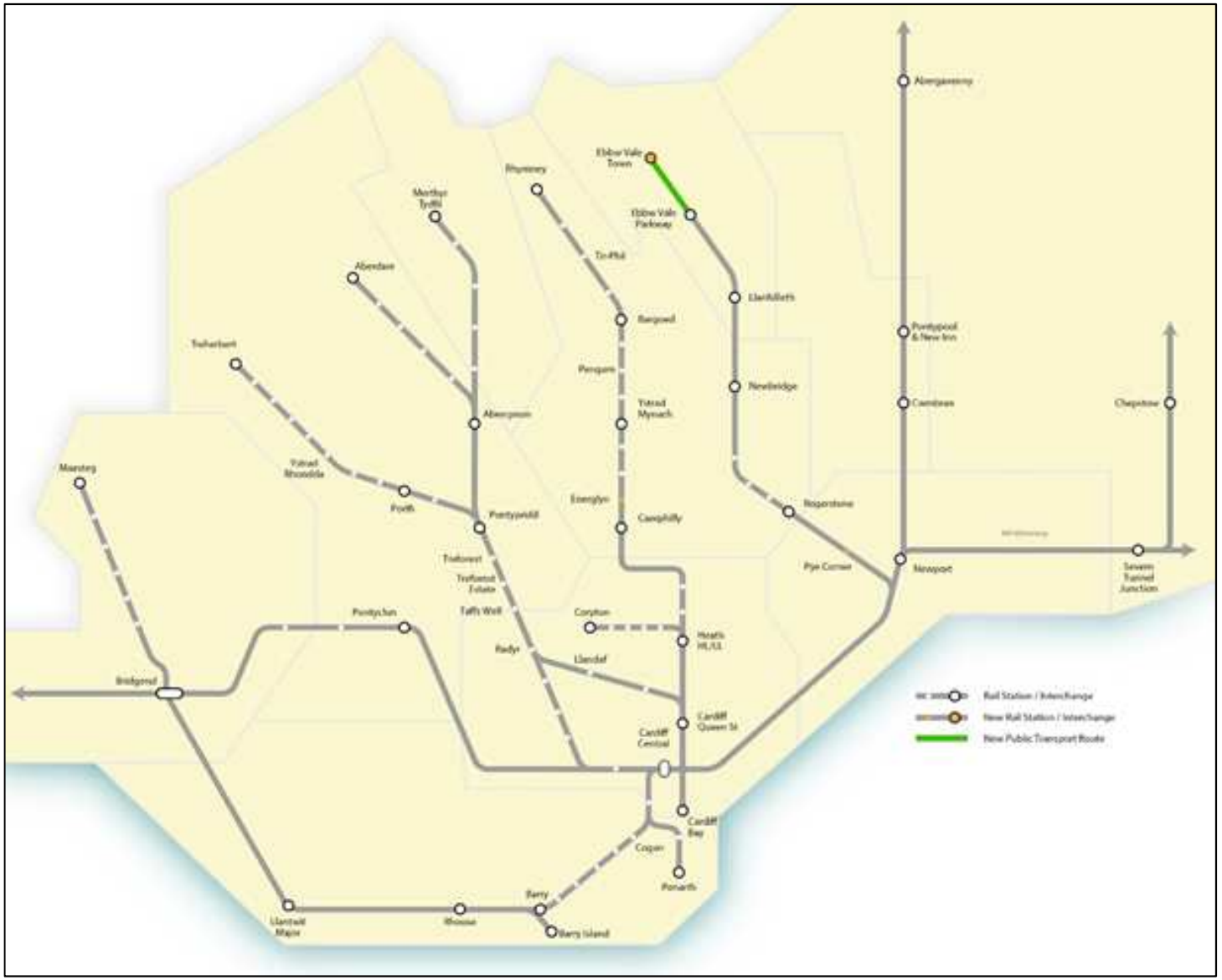


Figure 7.1: Forecast Rail Network

8 Variable Demand Model

8.1 VDM Methodology

The VDM Process

8.1.1 An overview and background to the variable demand model process is given in Section 3.4 of this report.

8.1.2 The DfT have a long-established preference for the use of incremental rather than absolute models, as outlined in TAG Unit M2 and so the M4 CaN uses an incremental model form.

8.1.3 The VDM was undertaken using the DfT's DIADEM software (version 5.0.9, 64-bit), which makes use of the SATURN highway assignment model. The acronym DIADEM stands for Dynamic Integrated Assignment and Demand Modelling. Figure 8.1 illustrates the variable demand modelling process in forecasting mode.

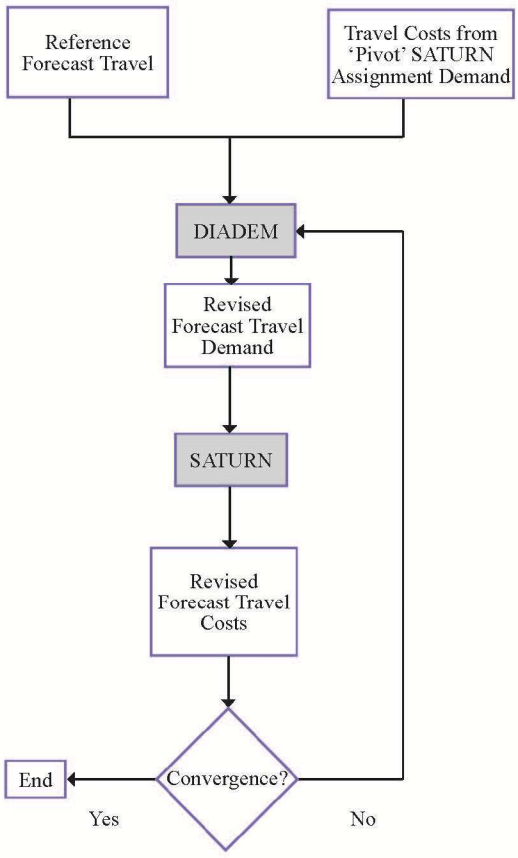


Figure 8.1: The Variable Demand Modelling Process

8.1.4 The variable demand modelling process for the M4CaN traffic model uses trip demand matrices in production/attraction (P/A) format rather than origin-destination (O-D) format as required in the traffic assignments. This is to retain the linkage between outbound and return journeys for home-based trips. Using this setup, demand response calculations take into account both legs of a home-based journey as part of the calculation of an overall resulting demand response.

8.1.5 The use of P/A matrices introduces additional complexities in the variable demand model runs, as the correlation between the prior matrix in 24 hour P/A format and the validated base matrices in peak hour O-D format are lost during the matrix estimation process. This is because matrix estimation is carried out at individual peak hour level and does not retain information about the home-end of home-based trips. For that reason it was necessary to run the variable demand model for the forecast Do Minimums by pivoting off an equilibrium assignment that used the base year prior matrices instead of the validated base matrices. The output from these DIADEM runs are used to calculate incremental changes between the base year and the forecast year, which are then applied to the validated base year 'assignment' matrices. This approach is shown in Figure 8.2. The methodology is consistent with Appendix B of TAG unit M2.

8.1.6 Chapter 4 provides a description of the derivation of the Reference Case forecast matrices, which are input to the demand model in the creation of future year Do Minimum scenarios. The Reference Case forecast matrices are also created using the base year 'prior' matrices rather than the validated base matrices for consistency with the overall approach mentioned above. These matrices reflect the changes in demand from the base year attributable to demographic changes such as the number of jobs in an area, the number of residents in an area and the number of cars they own. They represent the travel demand that would arise if there were no changes in travel costs from the base year model.

8.1.7 The demand model then creates forecast assignments using the Reference Case matrices to extract travel costs which are pivoted off the base year assignment. Using this methodology the Do Minimum forecast matrices are created accounting for:

- Transport interventions between the base year and the forecast year;
- Increases in the value of time resulting from real increases in income;
- Increases in levels of congestion arising from increased car usage; and
- Increases in fuel efficiency that make car travel cheaper.

8.1.8 The Do Something scenario is then generated by using travel costs from the converged Do Minimum Scenario as the pivot point. The variable demand model approach for the creation of Do Something scenarios is shown in Figure 8.3.

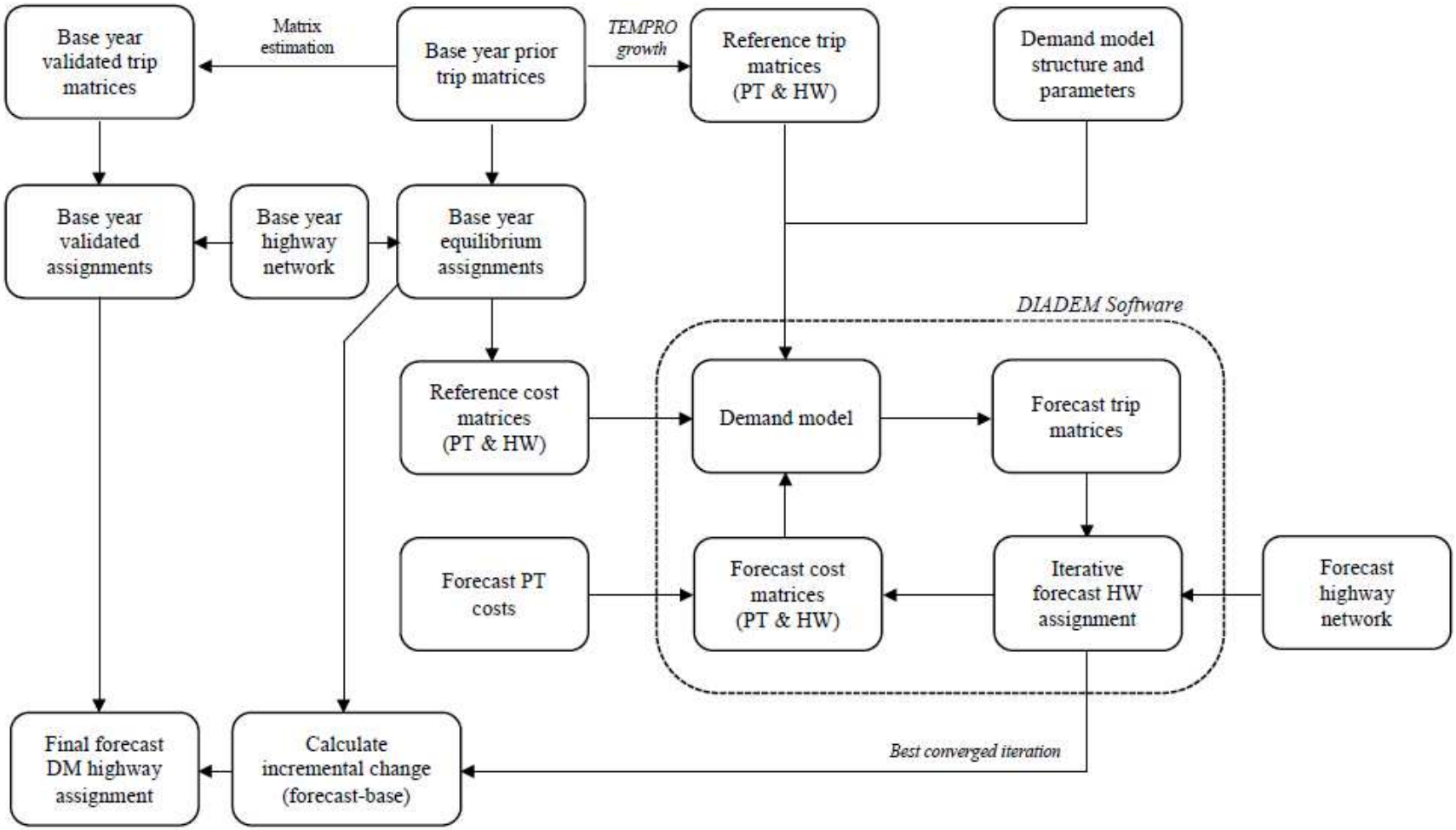


Figure 8.2: The Structure of a Do Minimum Forecast Model run

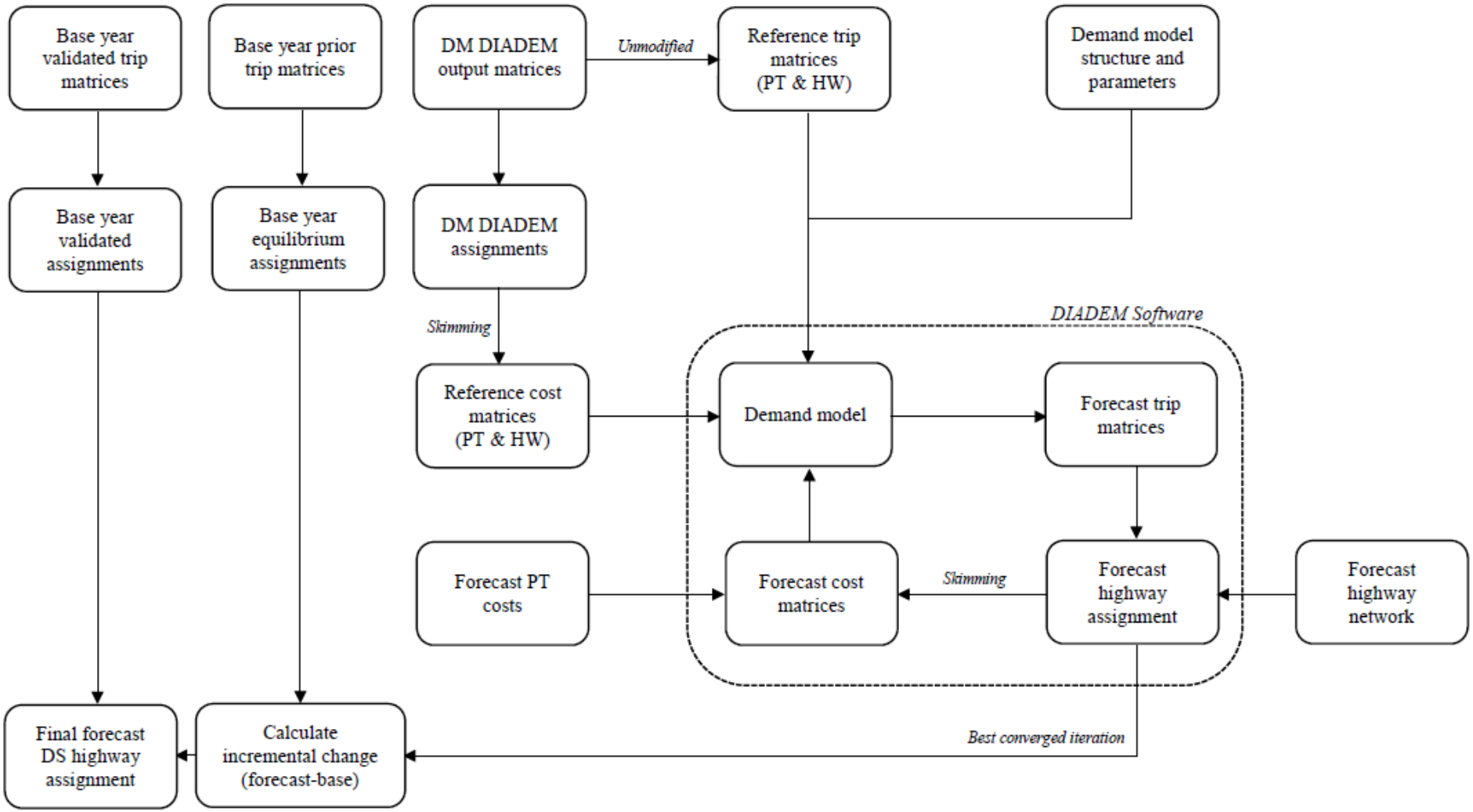


Figure 8.3: The Structure of a Do Something Forecast Model run

8.1.9 The responses in the variable demand model are such that, if the generalised cost for a trip is greater than the cost in the reference assignment, then there would be some degree of trip suppression. Similarly, a decrease in travel cost would lead to trip induction. The extent of trip suppression or induction is governed by the spread parameter λ and the scaling parameter θ, for which, in the absence of local data, illustrative values are provided in TAG Unit M2.

8.1.10 Prior to the traffic forecasting using VDM, realism testing on the base year traffic model was undertaken to ensure that the M4CaN transport model responded to changes in travel costs in a realistic way. Further details of the calibration of the VDM and base year realism tests carried out to demonstrate realistic model responses are given in the Local Model Validation Report (LMVR).

8.1.11 In developing the variable demand model parameters to be used in forecasting, the initial values were based on the median illustrative values of λ by journey purpose quoted in WebTAG. A systematic approach was then followed to calibrate the parameters. This process also involved the incorporation of cost damping parameters to weaken the response of long distance journeys, as advised in WebTAG guidance.

Elastic / Fixed Demand Segments

8.1.12 Variable Demand Modelling is only carried out for certain private trips, both by car and by public transport, but not for freight trips, as it is assumed that the total freight traffic is fixed, but susceptible to re-routeing.

8.1.13 For private trips, the variable demand parameters (the spread parameter λ and scaling parameter θ) can vary significantly between different trip purposes. This reflects the likelihood that the number, mode and distribution of more essential trips, such as employers' business trips, are less affected by congestion than discretionary travel, such as leisure trips.

8.1.14 Some private trips are also treated as fixed. This is the case for long distance external-external movements without one or both trip ends in the South East Wales area and for trips that are classed as 'no car available', which are therefore captive to public transport.

8.2 VDM Convergence

8.2.1 DIADEM software undertakes the variable demand modelling process in response to changing travel times or costs. The process is iterative and modifies the model demand matrices between SATURN assignments until a balance is achieved between demand and the capacity of the road network. The success in achieving this balance or equilibrium is defined using convergence criteria such as the demand/supply gap, commonly termed '%Gap'.

8.2.2 The objective of this process is to achieve well converged models with realistic demand responses, thereby improving the accuracy of the Scheme benefit calculations. TAG Unit M2 recommends, where possible, to aim to achieve a demand/supply gap of less than 0.1%. If that cannot be reached then a demand/supply gap of no greater than 0.2% is recommended.

8.2.3 The results achieved from the convergence of the variable demand model for the Core Scenarios are shown in Table 8.1.

Table 8.1: Variable Demand Model Convergence – Core Scenario

Year	Demand / Supply Gap	
	Do Minimum	Do Something
2022	0.09%	0.09%
2037	0.09%	0.09%

8.2.4 The results show that the variable demand model achieves the recommended demand/supply gap for the Do Minimum and the Do Something for the both 2022 and 2037 forecast years.

8.3 VDM Results

8.3.1 The output matrix resulting from VDM varies between the Do Minimum and Do Something scenarios. This is because the travel cost for vehicle trips affected by the new section of motorway to the south of Newport is likely to reduce due to a faster and shorter route for east-west movements along the M4 corridor in the Do Something scenario and consequently could lead to induced traffic. Similarly, reclassification of the existing M4 has an impact on travel costs along the motorway corridor north of Newport. The difference in vehicle trips, kilometres and hours travelled between the Do Minimum and Do Something scenarios represents the impact of the proposed new section of motorway to the south of Newport as well as the reclassification of the existing M4 to the north of Newport on network wide traffic levels.

8.3.2 The relative change in vehicles, kilometres and hours travelled between the key scenarios is summarised in Tables 8.2 to 8.4.

Table 8.2: Changes in Trips in the Core Scenario

Year	Scenario	AM Peak Hour	Inter-peak Hour	PM Peak Hour
2022	Base to Do Minimum	+10.5%	+10.8%	+10.3%
	Do Minimum to Do Something	-0.3%	-0.1%	-0.6%
2037	Base to Do Minimum	+29.3%	+29.1%	+28.5%
	Do Minimum to Do Something	-0.2%	-0.2%	-0.5%

8.3.3 The increase in trips between the base year and forecast Do Minimum is largely a result of traffic growth. Slightly counteracting this is a modal shift response from car to public transport as people would respond to changes in highway network congestion.

8.3.4 The difference in highway trips between the Do Minimum and Do Something captures the modal shift response that is predicted to result from the introduction of the Scheme. As the Do Something also includes the reclassification of the existing M4 this also impacts on modal shift.

Table 8.3: Changes in Vehicle-Kilometres in the Core Scenario

Year	Scenario	AM Peak Hour	Inter-peak Hour	PM Peak Hour
2022	Base to Do Minimum	+12.7%	+13.0%	+12.6%
	Do Minimum to Do Something	-0.3%	-0.3%	-0.5%
2037	Base to Do Minimum	+32.1%	+31.9%	+31.3%
	Do Minimum to Do Something	+0.2%	-0.3%	-0.2%

8.3.5 The increase in vehicle-kilometres between the base year and forecast Do Minimum in both forecast years is predicted to be slightly higher than the growth in number of trips cited above as average trip lengths are increasing slightly over time. This response is linked to the reducing cost of car travel in real terms as a result of factors such as increased fuel efficiency and also increases in average income levels.

8.3.6 The difference in highway vehicle-kilometres between the Do Minimum and Do Something captures the distance savings that are predicted to result from the introduction of the Scheme. This results in a large number of trips experiencing shorter journeys on the motorway around Newport. The vehicle-kilometre savings are achieved despite the number of trips increasing slightly and trips lengthening in response to the Scheme.

Table 8.4: Effects of VDM on Vehicle-Hours in the Core Scenario

Year	Scenario	AM Peak Hour	Inter-peak Hour	PM Peak Hour
2022	Base to Do Minimum	+17.1%	+14.6%	+15.7%
	Do Minimum to Do Something	-0.8%	-0.5%	-1.0%
2037	Base to Do Minimum	+53.8%	+36.4%	+47.6%
	Do Minimum to Do Something	-0.5%	-0.9%	-0.9%

8.3.7 The increase in vehicle-hours between the base year and forecast Do Minimum in 2022 is predicted to be slightly higher than the growth in number of vehicle-kilometres discussed above. By 2037 this difference is forecast to become significant. This illustrates the increasing level of traffic congestion predicted to result from general traffic growth.

8.3.8 There is a slight decrease in vehicle-hours predicted between the Do Minimum and Do Something scenarios in both forecast years. This is despite a small increase in the number of highway trips.

9 Core Scenario Traffic Forecasts

9.1 Introduction

9.1.1 This chapter presents the Core Scenario traffic forecasts and an assessment of the likely future traffic patterns and journey times in forecast years within the M4CaN model area.

9.1.2 Traffic forecasts have been prepared for two future years, 2022 and 2037. These cover the three modelled periods of the AM peak hour, the average inter-peak hour and the PM peak hour.

9.2 Model Convergence

9.2.1 The assignment of the trip matrix onto the model network is an iterative process, with each successive iteration converging upon the optimum equilibrium situation. The completed assignment is then based upon the final iteration. The better the convergence, the more stable the model, with less variation between successive iterations.

9.2.2 Guidance on the degree of model convergence is given in TAG Unit 3.1. The convergence of a traffic assignment is measured by the following two statistics:

- %FLOW, or the proportion of links in the overall network with flows changing less than 5% from the previous iteration; and
- Delta, or the duality gap, a measure of the difference between the assignment and the equilibrium situation.

9.2.3 A %FLOW value of above 95% and a Delta value of less than 0.1% are the criteria given in WebTAG for stable and robust assignment results. For the M4CaN traffic forecasts, the duality gap was under 0.1% and the %FLOW value was above 95% for all forecast scenarios, indicating acceptable convergence.

9.2.4 In addition to the above, the Wardrop equilibrium gap function (%GAP) is monitored to ensure good convergence of the overarching assignment-simulation loops within the SATURN process.

9.2.5 A comparison of the convergence statistics from each of the forecast scenarios with those achieved in the 2014 base model is given in Appendix C. This shows that the level of convergence achieved in the forecast models is consistent with that achieved in the validated base model and that the convergence for all of the forecast scenarios is acceptable.

9.3 Traffic Flows

9.3.1 The traffic flows from the 2014 base model are shown in Figures 9.1 and 9.2 to enable a comparison of forecast traffic flows with current volumes. These Figures show that the most heavily trafficked sections of the M4 around Newport are those between Junctions 27 and 29, with between 4,300 and 5,300 vehicles travelling in each direction during the peak hours and in excess of 100,000 vehicles per day on these sections. The least trafficked part of the motorway is the two-lane section through the Brynglas Tunnels (Junctions 25a to 26). At this location there are around 2,600 to 3,300 vehicles travelling in each direction

during the peak hours and around 68,000 daily two-way trips. The figures show little tidality in traffic patterns, with the peak hour volumes being roughly equal in each direction along the M4 around Newport.

9.3.2 The forecast Do Minimum and Do Something traffic flows for the central growth Core Scenario are presented in Figures 9.3 to 9.10 for the AM peak hour, inter-peak, PM peak hour and Annual Average Daily Traffic (AADT) in 2022 and 2037.

9.3.3 The AADT flows shown in Figures 9.6 and 9.10 indicate that, with the new section of motorway in place, traffic flows would reduce on the existing route by about 30 to 45%. There would also be a reduction in traffic on the local roads within Newport. Through traffic travelling between east of Junction 23 and west of Junction 29 would use the proposed new section of motorway to the south of Newport, which is shorter and better aligned than the existing M4 and which would be operating within capacity. In addition, some traffic accessing Newport would also use the proposed new section of motorway, utilising the intermediate junctions.

9.3.4 Traffic from the Valleys communities to the north of Newport and strategic traffic from the A449 corridor joining the existing M4 at Junction 24 (Coldra) would continue to use the existing M4 as this traffic would not have direct access onto the new section of motorway. There would also be reassignment within Newport as traffic on local roads could divert onto other roads that would be relieved by the new section of motorway, such as the existing M4 or Southern Distributor Road.

9.3.5 Traffic forecasts for the scenario with the proposed new section of motorway south of Newport indicate that, in 2037, around 62,000 vehicles per day (AADT) will use the Brynglas Tunnels compared to around 91,000 vehicles per day (AADT) for the Do Minimum Scenario; whilst around 71,000 vehicles per day (AADT) would be likely to use the Usk River Crossing on the proposed new section of motorway south of Newport.

9.4 Motorway Level of Service

9.4.1 The traffic forecast flow diagrams referred to above also provide an indication of the level of service on the motorway network around Newport, based on the ratio of flow to capacity (RFC) and the congestion reference flow (CRF).

9.4.2 There is no absolute measure of ‘congestion’, in the same way as there is no trigger point of capacity at which the network fails. It is simply a matter of increased traffic flows leading to decreasing speeds, deterioration of operating conditions or a declining level of service as perceived by road users. The Design Manual for Roads and Bridges (DMRB) uses the concept of the CRF as a measure against which to judge acceptable performance for rural roads, while the performance of urban roads is assessed by comparing the peak hour flows with theoretical capacity, where a three-lane motorway has an estimated capacity of 5,600 vehicles per hour in each direction, reducing to 4,000 vehicles per hour on two-lane sections.

9.4.3 In addition to its rural nature, the M4 around Newport also displays characteristics of an urban motorway, as defined in DMRB, passing through a built up area with closely spaced junctions. The assessment of the existing corridor has therefore been based on both CRF and theoretical capacity.

9.4.4 When the ratio of the AADT flow to CRF reaches 100% it is estimated that congestion will occur in approximately half of the weekday peak periods, in the peak direction. However, some problems may occur before the ratio reaches 100%. In the assessment of journey time reliability for rural roads, Transport Analysis Guidance adopts a stress-based approach, which considers the change in the ratio of flow to CRF between 75% and 125%.

9.4.5 The operational assessment has also included analysis of the one-way capacity, or maximum hourly throughput, of the M4 compared with the peak hour forecasts. It is generally accepted that once hourly flows reach about 80% of the theoretical capacity, operational problems can also be expected.

9.4.6 For the purposes of this assessment of level of service, 80% of CRF or hourly capacity has been taken as the point at which journey time reliability becomes adversely affected and congestion begins to be experienced.

9.4.7 Congestion, with frequent incidents, is currently an everyday occurrence on the existing M4 between Junctions 23 and 29. Figure 9.1 shows that some sections of the motorway, particularly between the Brynglas Tunnels and Junction 29 (Castleton), are approaching peak hour capacity on a regular basis under current conditions, while Figure 9.2 shows a similar picture with the CRF assessment. The restricted capacity of the Tunnels forms a regular bottleneck on the motorway at peak times, while traffic queuing to leave the motorway at Junctions 26 and 28 frequently extends onto the mainline, exacerbating the problems presented by the poor alignment of the motorway between these junctions.

9.4.8 Under the Do Minimum Scenario, congestion would be expected to worsen as traffic volumes increase over time and 'peak spreading' is likely to occur where the duration of peak periods gets longer. Higher traffic flows will also lead to unstable conditions where a higher number of incidents and accidents are likely to occur, which in turn could produce increasing stop-start conditions on the motorway on a more regular basis. This would lead to a deterioration of journey time reliability.

9.4.9 Figures 9.3 and 9.5, showing the peak hour traffic flows for 2022, indicate that the existing M4 around Newport could be expected to experience frequent peak period congestion. The situation is expected to worsen between 2022 and 2037 due to traffic volumes growing over time, as demonstrated in Figures 9.7 and 9.9. These trends are reinforced by Figures 9.6 and 9.10 which show the AADTs increasing over time to exceed the threshold CRF values along the whole route between Junctions 24 and 28.

9.4.10 Under the Do Something scenario, the proposed new section of motorway would be expected to operate within capacity. The reclassification of the existing motorway north of Newport includes a reduction of the number of lanes from three to two lanes on some sections where three lanes are currently in place. This reduction in capacity leads to some sections of the existing motorway corridor being flagged as likely to experience some traffic congestion even with the new motorway to the south of Newport in place. However, traffic conditions on the existing M4 would still be expected to be better in the Do Something situation compared to the Do Minimum situation due to the traffic relief provided by the new section of motorway.

9.4.11 In practical terms, the lower degree of saturation on the existing M4 coupled with the provision of a new motorway corridor operating within capacity would lead to

smoother operation of the highway network around Newport. A lower frequency of incidents would be expected with the provision of an alternative route for east-west traffic further improving network resilience when incidents do occur.

9.5 Motorway Traffic Patterns

9.5.1 Analysis of the forecast traffic patterns in 2037 for the Do Minimum Scenario has shown that around 51% of the 91,000 daily traffic (AADT) passing through the Brynglas Tunnels (Junctions 25a to 26) would be likely to be 'through' trips travelling along the full length of the existing M4 north of Newport between Junctions 23 and 29. A further 36% would be likely to either join or leave the motorway between Junctions 23 and 29. The remaining 13% of daily traffic would be likely to both join and leave the motorway between Junctions 23 and 29. Figure 9.11 illustrates this breakdown of traffic movements through the Brynglas tunnels for the 2037 scenario without the proposed new section of motorway to the south of Newport.

9.5.2 Analysis of the forecast traffic patterns in 2037 for the scenario with the proposed new section of motorway to the south of Newport has shown that around 65% of daily traffic (AADT) on the River Usk Crossing would be likely to be 'through' trips travelling along the full length of the proposed new section of motorway between Junctions 23 and 29, with no 'through' trips using the existing M4. A further 27% of daily traffic using the proposed new section of motorway would be likely to either join or leave the motorway at Newport, either via the Docks Junction or Glan Llyn Junction. Some 8% of daily traffic using the proposed new section of motorway would be likely to both join and leave the motorway around Newport, travelling between the Docks Junction and Glan Llyn Junction. This breakdown of traffic movements using Brynglas tunnels and the proposed new section of motorway Usk River crossing is illustrated in Figures 9.12 and 9.13 respectively.

9.6 Journey Times

9.6.1 Information on journey times through the network was extracted from the Core Scenario traffic forecasts. The journey times between Junction 30 of the M4 and the toll plaza at the Second Severn Crossing were analysed in order to ascertain the journey time changes on the motorway that would result from the construction of the proposed new section of motorway to the south of Newport. The results of the journey time analysis are presented in Table 9.1.

9.6.2 The journey times along the existing M4 in the Do Something scenario in comparison to the Do-minimum are provided as an indicative benchmark only. In practice, traffic travelling the full length of M4 between Junction 30 and the Second Severn Crossing would use the full motorway. Traffic travelling along the existing M4 when the new M4 is in place, would therefore only be travelling on part of the route between Junctions 23 and 29.

9.6.3 Journey times along the existing M4 would be affected by the following components of the Do Something as follows;

- a slight increase in distance due to the realignment of the existing M4 to accommodate the tie-in with the proposed new section of motorway. Eastbound traffic would need to negotiate a roundabout to access the M4 approach to the Second Severn Crossing, whilst westbound traffic would be

free flow. In consequence, this is likely to result in a slight localised increase in journey times on these sections.

• reclassification of the existing M4 includes a speed limit reduction and capacity reduction on some sections of the motorway which leads to a slight increase in journey time on those sections.

• reduced volumes of traffic arising from the relief provided by the proposed new section of motorway reduces journey times on those sections not affected by reclassification.

9.6.4 The motorway journey times in 2022 along the existing M4 north of Newport would reduce slightly in both directions at peak times by up to 1.5 minutes. A slight increase in journey time occurs during the inter-peak period up to a maximum of 18 seconds when travelling the full distance on the existing M4 between Junction 30 and the M4 Toll, which diminishes in subsequent years as traffic growth occurs. For intermediate travel on the existing M4 in the inter-peak period between the same points, the maximum delay of 18 seconds decreases as a function of the shorter distances travelled, which also diminishes in subsequent years. By 2037, the journey time analysis shows that travel times along the existing M4 would reduce in both directions during all times of the day up to 4.5 minutes.

9.6.5 Through traffic using the proposed new section of motorway to travel east-west between Magor and Castleton would experience more significant journey time savings due to the shorter distance and reduced congestion levels. During the inter-peak, the time savings would be expected, on average, to be around 2.5 minutes in 2022, increasing to between 3 and 4 minutes by 2037. During the peak hours, the journey time savings could be expected to be, on average, between around 3.5 to 5 minutes in 2022, increasing to between 4.5 and 9 minutes in 2037.

Table 9.1: Journey Time between Junction 30 and M4 Toll Plaza (min:sec)

Direction	Time	Route	2022 Central Growth		2037 Central Growth	
			Do Min	Do Som	Do Min	Do Som
East	AM	Via existing M4	20:12	19:15	24:02	20:07
	IP	Via existing M4	17:49	18:07	19:33	18:29
	PM	Via existing M4	18:29	18:25	20:23	19:00
	AM	Via new motorway		15:12		16:04
	IP	Via new motorway		14:58		15:31
	PM	Via new motorway		14:59		15:32
West	AM	Via existing M4	20:37	18:48	24:34	20:38
	IP	Via existing M4	17:33	17:36	18:18	18:00
	PM	Via existing M4	20:30	19:40	26:07	21:32
	AM	Via new motorway		15:55		17:02
	IP	Via new motorway		14:50		15:16
	PM	Via new motorway		15:56		17:04

9.6.6 It should be noted that the traffic model assumes 'typical' conditions without any incidents to disrupt traffic. In reality, as traffic volumes increase on the existing M4 without the proposed new section of motorway in place, conditions are likely to become more unstable leading to a higher frequency of incidents. Incidents on the existing M4 have been seen to result in stop-start conditions, sometimes even bringing traffic to a standstill. These impacts on journey time reliability are not taken into account by the traffic model.

9.7 Low and High Growth Forecasts

9.7.1 As noted in Section 5.1, scenarios for low and high growth assumptions were also tested in addition to the central growth Core Scenario.

9.7.2 Trip matrices for the low and high growth scenarios were developed from the central growth assignment matrices after completion of the variable demand process. This followed the guidelines contained in TAG Unit M4, in which a proportion of the base year matrix is subtracted from or added to the central growth matrix. This proportion changes in proportion to the square root of the number of years from the base. Table 9.2 shows the calculated proportion of the base matrix added to or subtracted from the central growth matrices.

Table 9.2: Adjustment of Central Growth Matrices for Low and High Growth

	Low Growth	High Growth
2022	-7.07%	+7.07%
2037	-11.99%	+11.99%

9.7.3 Figures showing the forecast traffic flows for the low growth scenario are given in Appendix D, together with the results of the journey time analysis. Corresponding results and figures for the high growth scenario are shown in Appendix E.

9.7.4 The motorway journey times in 2022 show that travel times along the existing M4 north of Newport could increase slightly in the low growth scenario due to the realignment around Junction 23a. This is especially the case in the eastbound direction due to the need to negotiate a roundabout for traffic to access the M4 approach to the Second Severn Crossing. By 2037, the effects of the increased travel distance would be expected to be countered by further traffic growth and travel times along the existing M4 would be expected to reduce compared to the Do Minimum scenario.

9.7.5 Under high growth assumptions, travel times along the existing M4 would be expected to reduce in both directions in all time periods, with peak hour time savings of around 1 minute eastbound and 2 to 3 minutes westbound in 2022. The peak hour time savings could be expected to increase to over 7 minutes by 2037.

9.7.6 During the inter-peak, the time savings by 2037 for through traffic using the proposed new section of motorway between Magor and Castleton would be expected, on average, to be around 3 minutes at low growth, and up to 6 minutes at high growth. During the 2037 peak hours, the journey time savings could be expected to be, around 5 minutes at low growth, increasing to between 7 and 12 minutes at high growth.

9.7.7 As for the central growth core scenario, it should be noted that the high and low growth forecast scenarios represent average conditions on a typical weekday. The effect of incidents and unusually busy periods are not taken into account in the forecasting.

9.8 Summary

9.8.1 The M4CaN transport model has been used to produce traffic forecasts that will inform the operational, economic and environmental evaluations of the proposed new section of motorway to the south of Newport. The following scenarios were tested:

- A ‘Do Minimum’ scenario, in which committed transport improvement schemes have been added to the base year network; and
- A ‘Do Something’ scenario, which includes the proposed new section of motorway to the south of Newport and reclassification of the existing M4 around Newport to a 2-lane dual carriageway.

9.8.2 The traffic forecasts for the Do Minimum Core Scenario indicate that future traffic growth will result in severe congestion on the existing M4 which will result in increased journey times. The results indicate that one-way flows on the M4

motorway links would be constrained by the capacity of the motorway (theoretically, some 5,600 vehicles per hour for the three-lane sections and 4,000 vehicles per hour on two-lane sections).

9.8.3 For the Do Something Core Scenario, with the inclusion of the proposed new section of motorway to the south of Newport, the traffic volumes on the existing M4 between Junctions 23 to 29 would be reduced. Unlike the Do Minimum Scenario, this section of the route around Newport is not expected to be congested by the year 2037. Journey times along the existing M4 would be expected to reduce during peak hours as a result of the relief provided by the new motorway. However, in the specific case of inter-peak journey times along the existing M4 in 2022, a slight increase in journey times occurs which subsequently diminishes in subsequent years for the reasons explained in 9.6.4.

9.8.4 The proposed new section of motorway is also expected to reduce traffic flows on local roads within Newport as capacity is released on the existing M4 and the Newport Southern Distributor Road. Journey times along the proposed new section of motorway would be expected to reduce compared to those on the existing M4 in the Do Minimum scenario.

9.8.5 It should be noted that the model represents typical operating conditions during the AM, PM and Inter-Peak periods of a normal day. It does not therefore take into account conditions on those occasions when an incident takes place on the network and the resultant disruption, increasing congestion and increased journey times that arise. In such instances, the improved network resilience and relief offered by the Scheme, which provides an alternative route and an increase in network capacity, would minimise the disruption caused by the incident.

9.9 Conclusions

9.9.1 This Traffic Forecasting Report has documented the development of the future year forecasts for the Scheme. The methods and assumptions adopted in developing the same are consistent with best practice and guidance.

9.9.2 Traffic forecasts have been produced for the AM peak, inter-peak and PM peak hours for the forecast years of 2022 (the opening year for the proposed new section of motorway south of Newport) and 2037 (the design year). The approach used in developing the forecasts and undertaking variable demand modelling has been undertaken in accordance with Department for Transport Guidance (WebTAG).

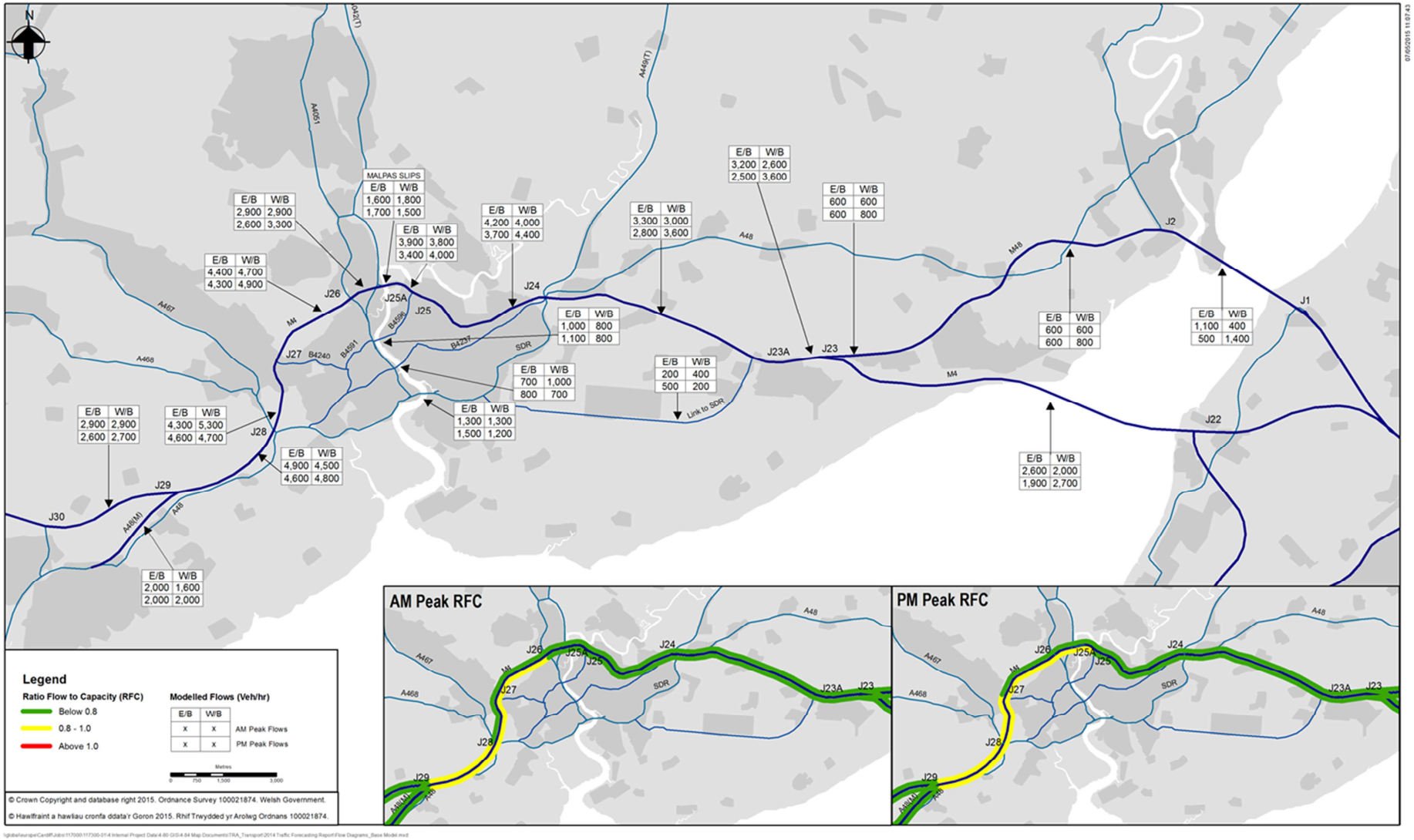


Figure 9.1: Base Year Peak Hour Traffic Flows

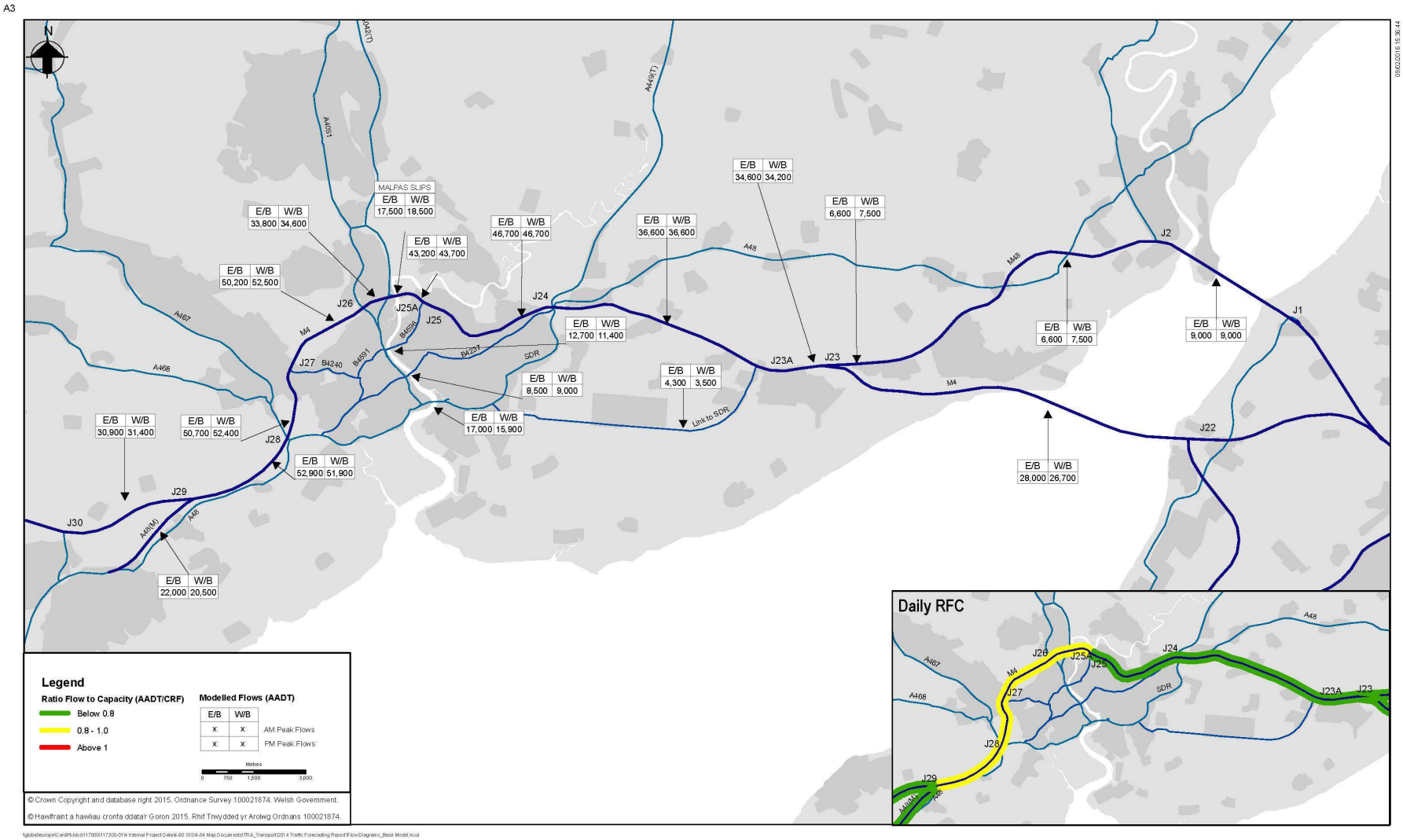


Figure 9.2: Base Year Annual Average Daily Traffic Flows

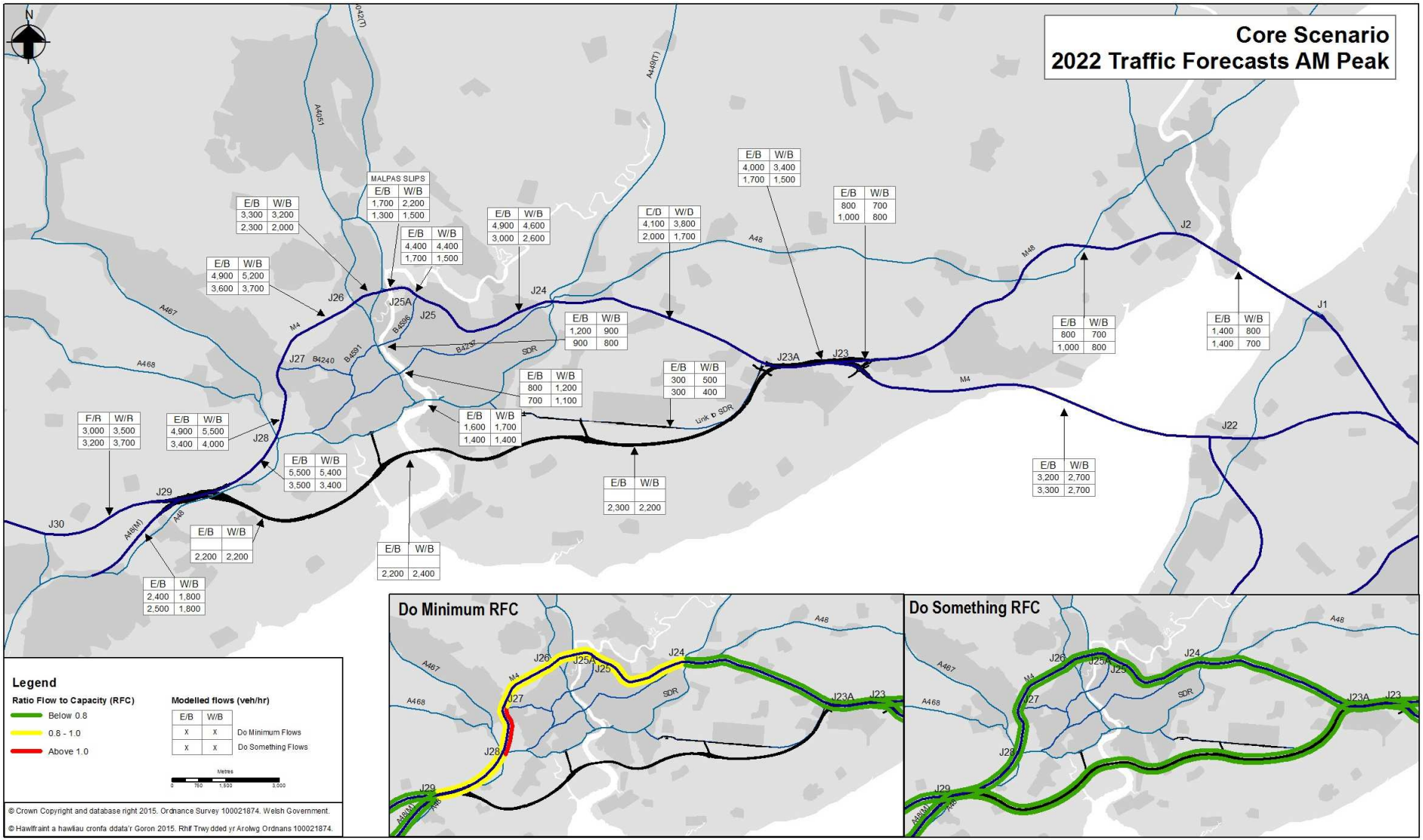


Figure 9.3: 2022 Forecast AM Peak Hour Traffic Flows, Core Scenario

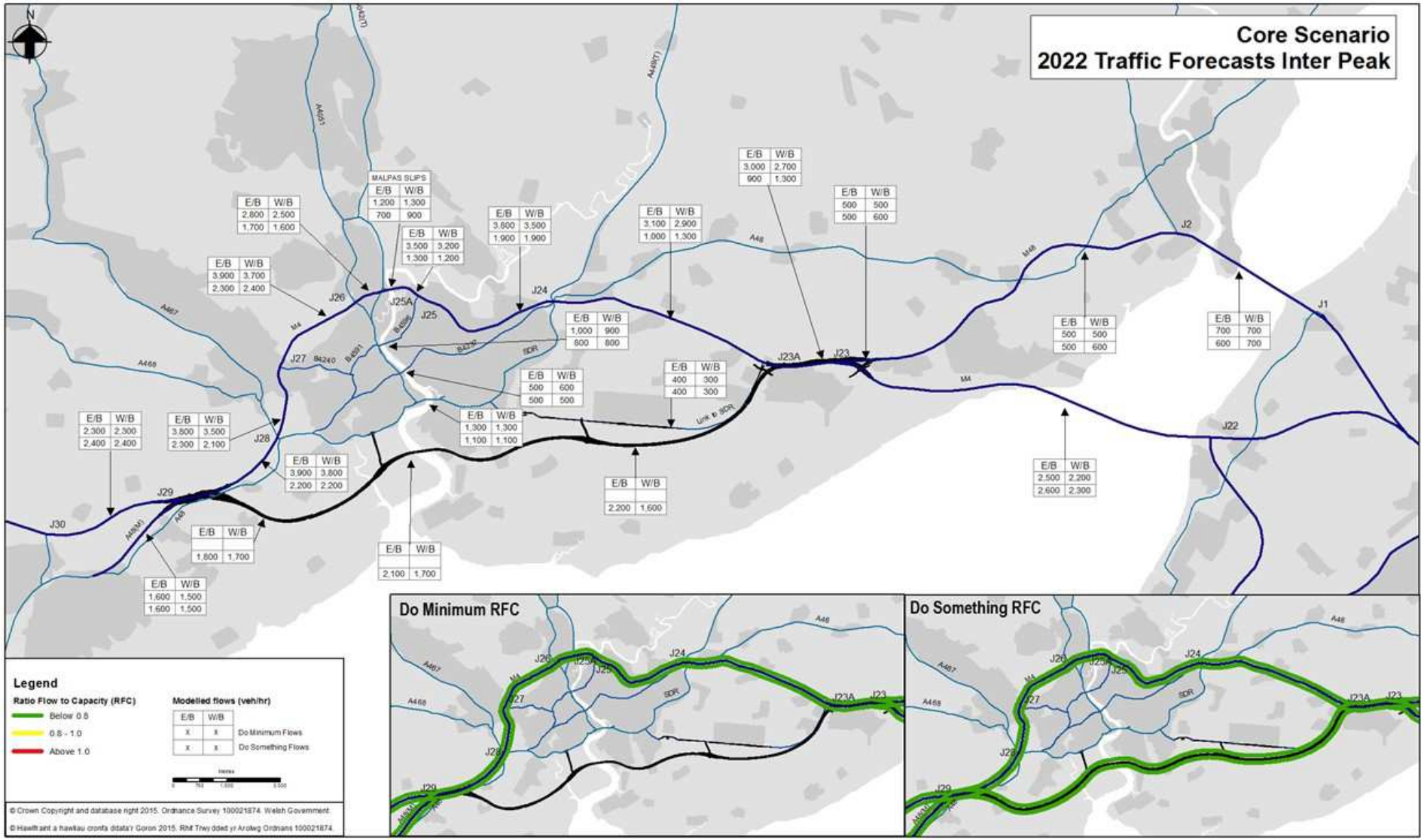


Figure 9.4: 2022 Forecast Inter-peak Hour Traffic Flows, Core Scenario

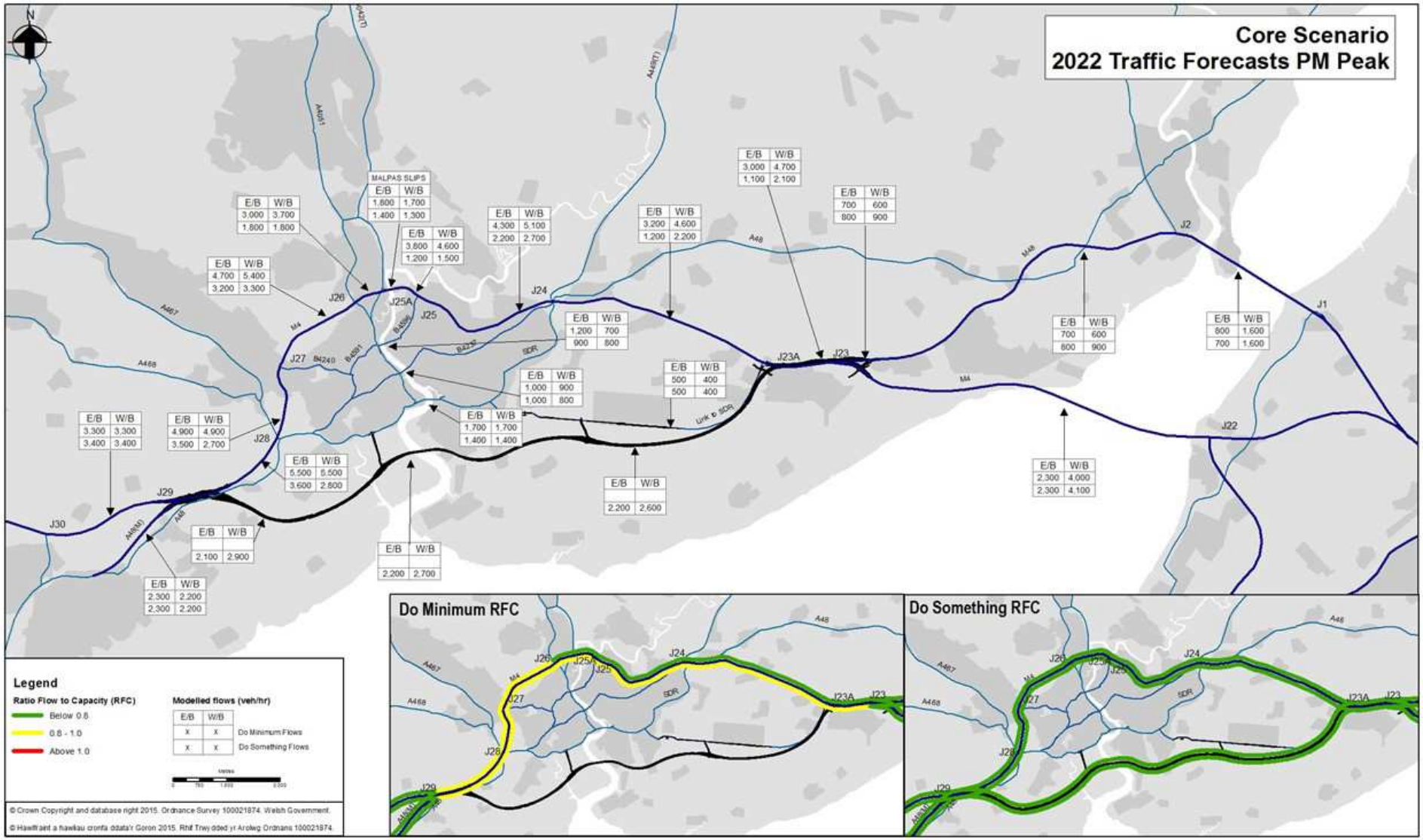


Figure 9.5: 2022 Forecast PM Peak Hour Traffic Flows, Core Scenario

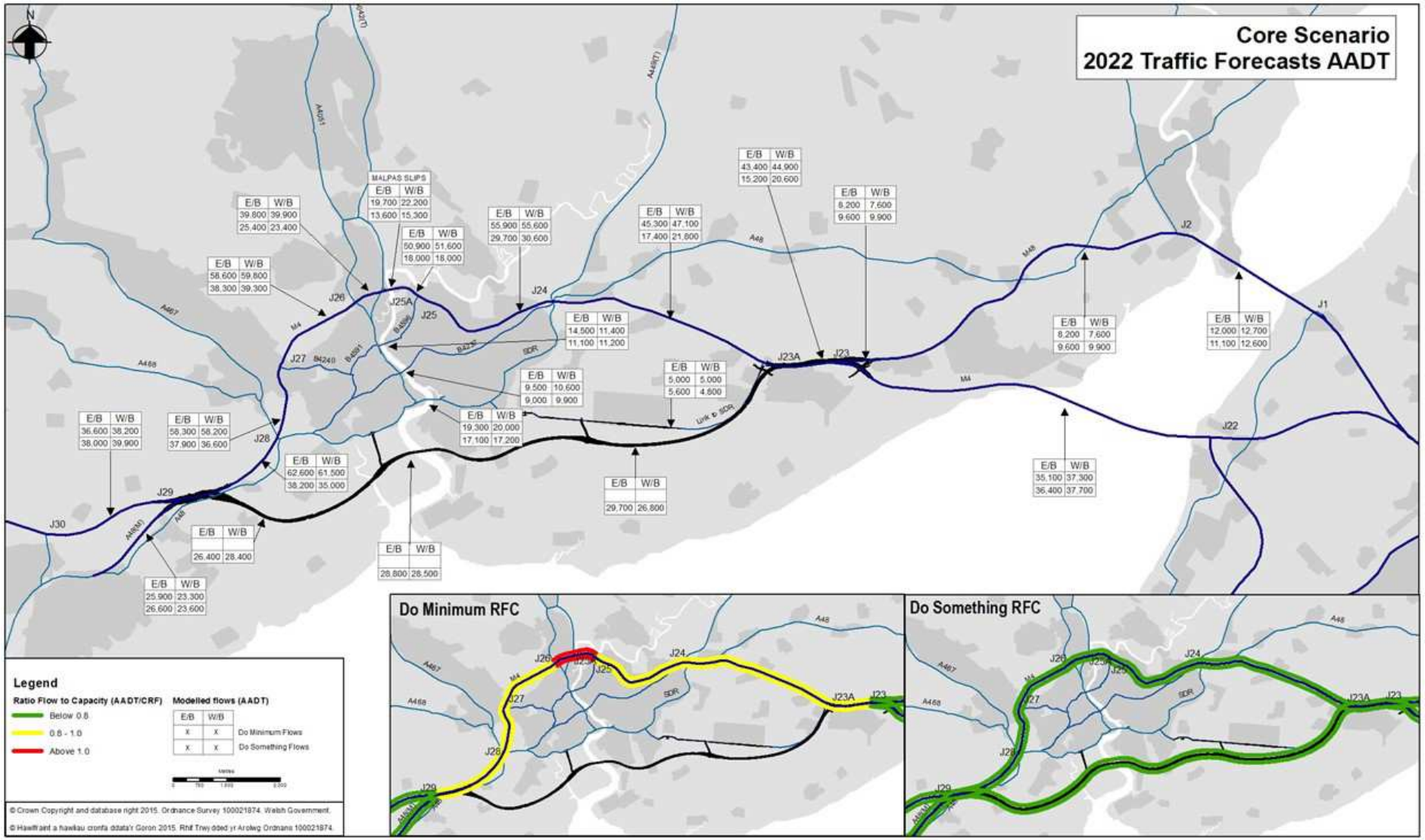


Figure 9.6: 2022 Forecast Annual Average Daily Traffic Flows, Core Scenario

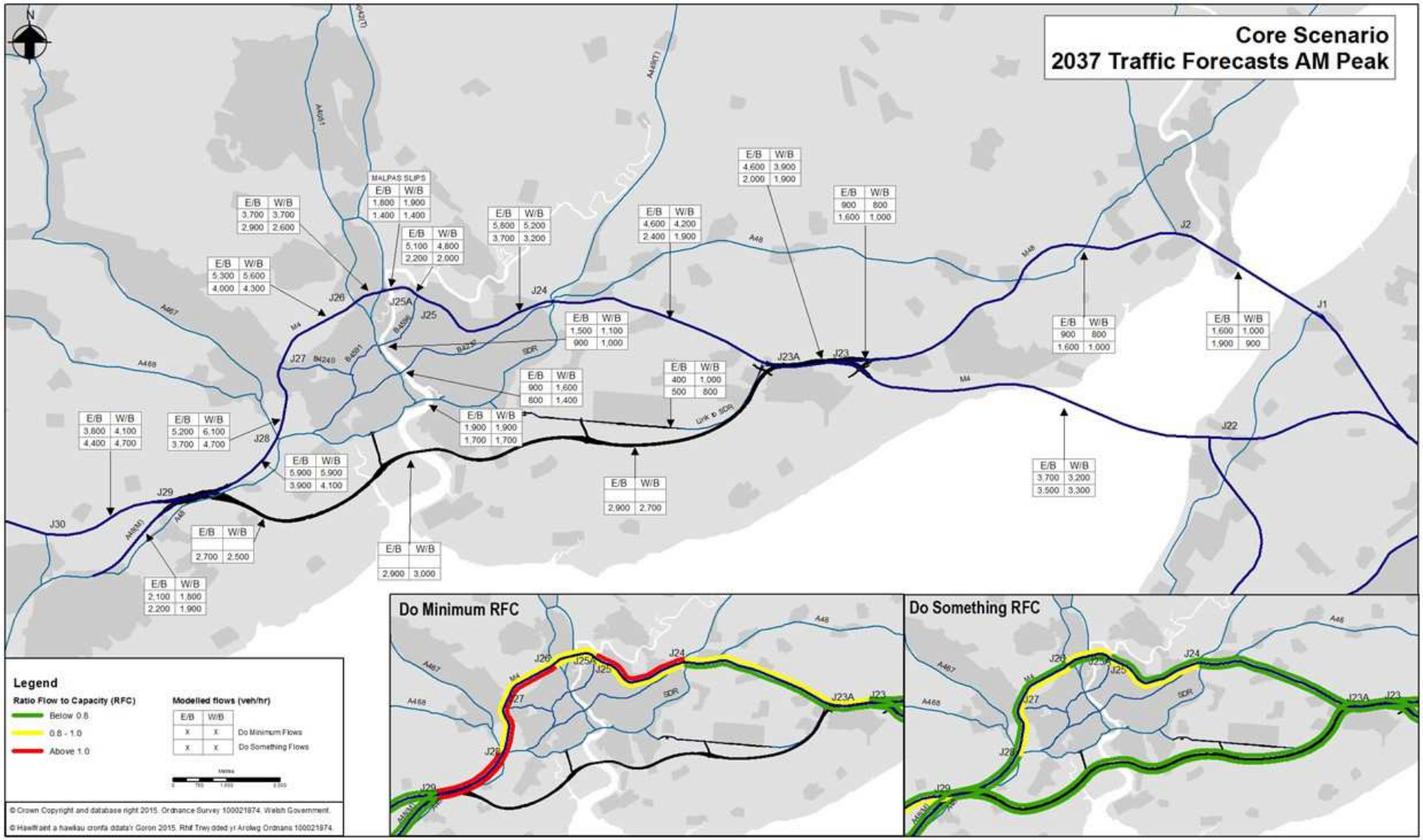


Figure 9.7: 2037 Forecast AM Peak Hour Traffic Flows, Core Scenario

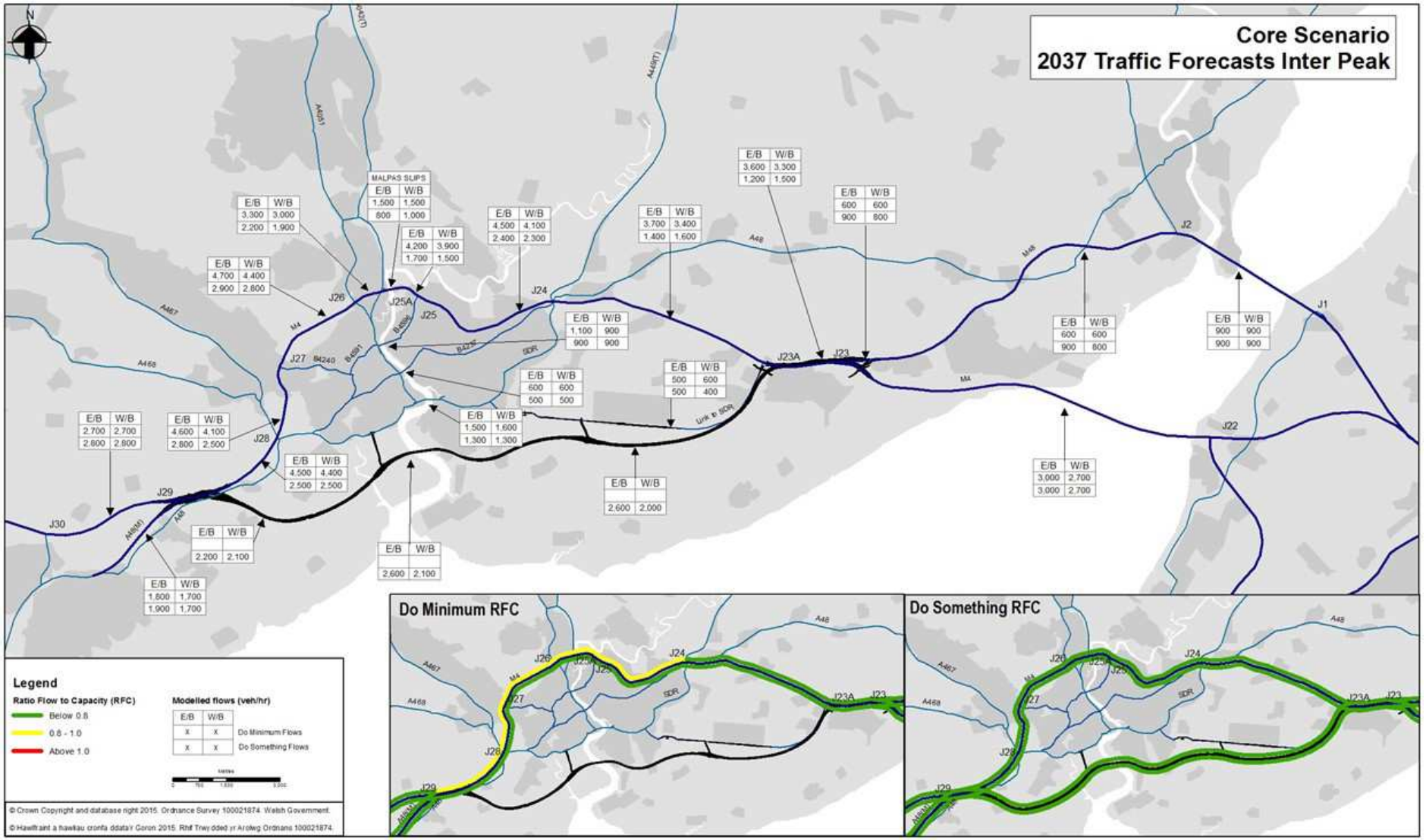


Figure 9.8: 2037 Forecast Inter-Peak Hour Traffic Flows, Core Scenario

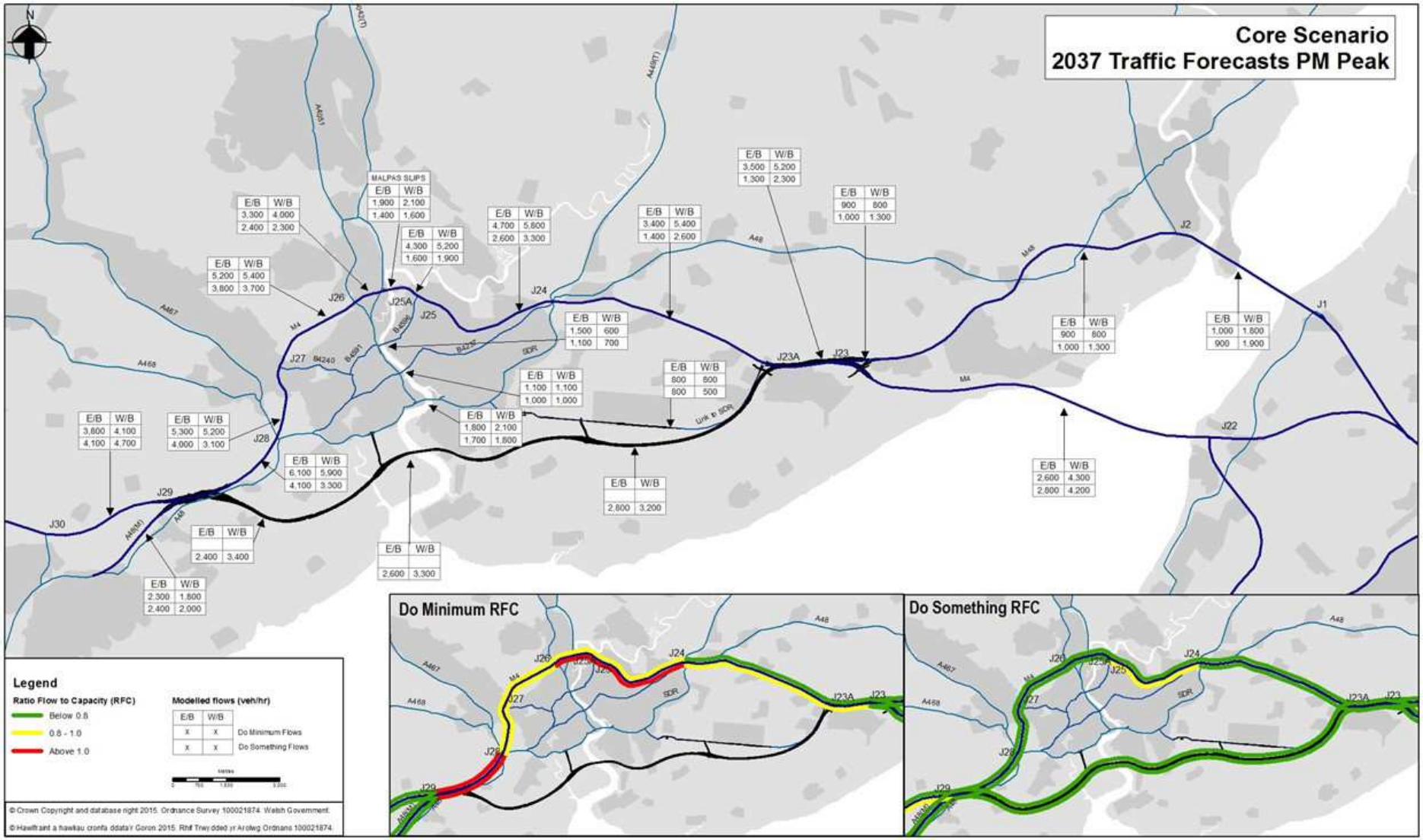


Figure 9.9: 2037 Forecast PM Peak Hour Traffic Flows, Core Scenario

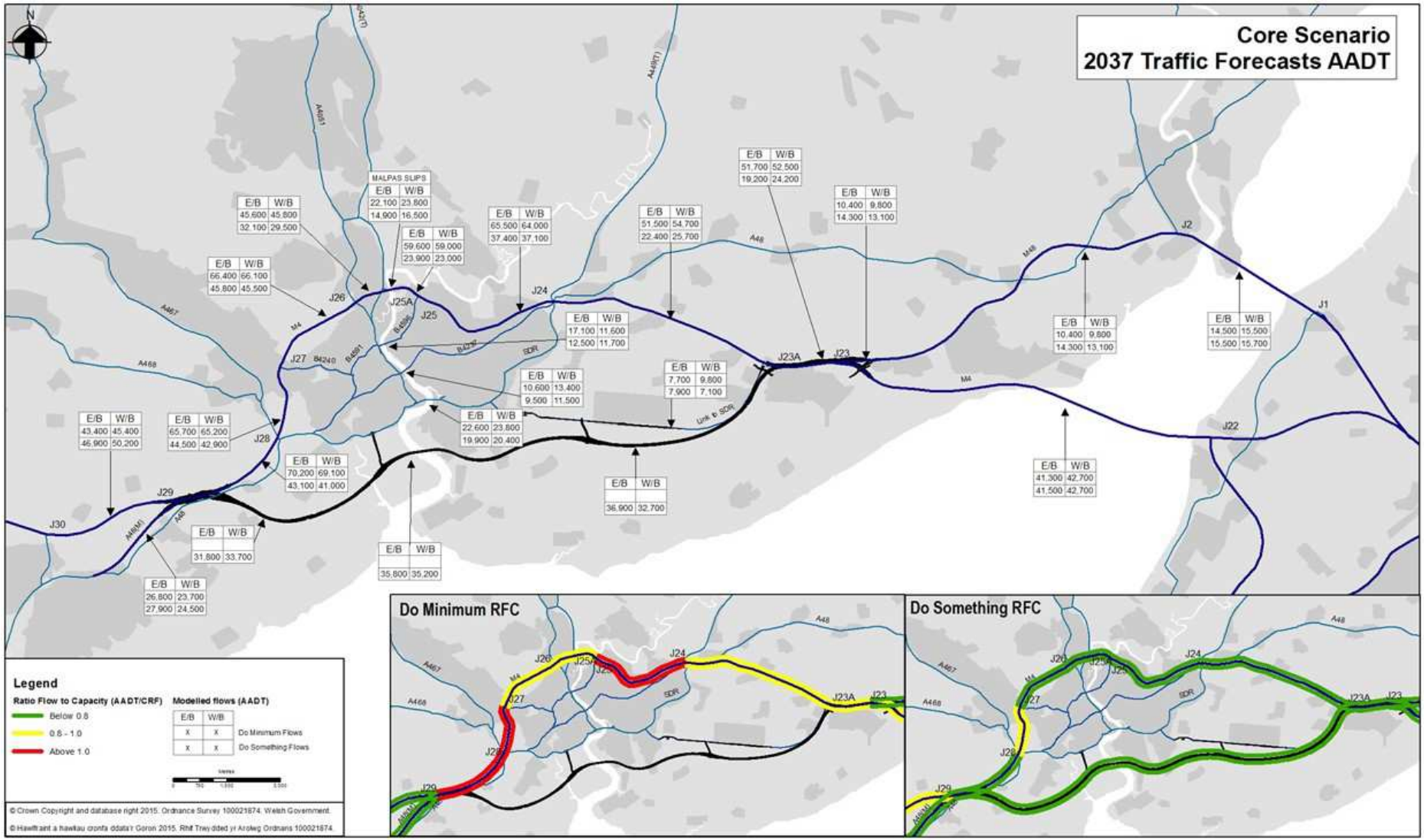


Figure 9.10: 2037 Forecast Annual Average Daily Traffic Flows, Core Scenario

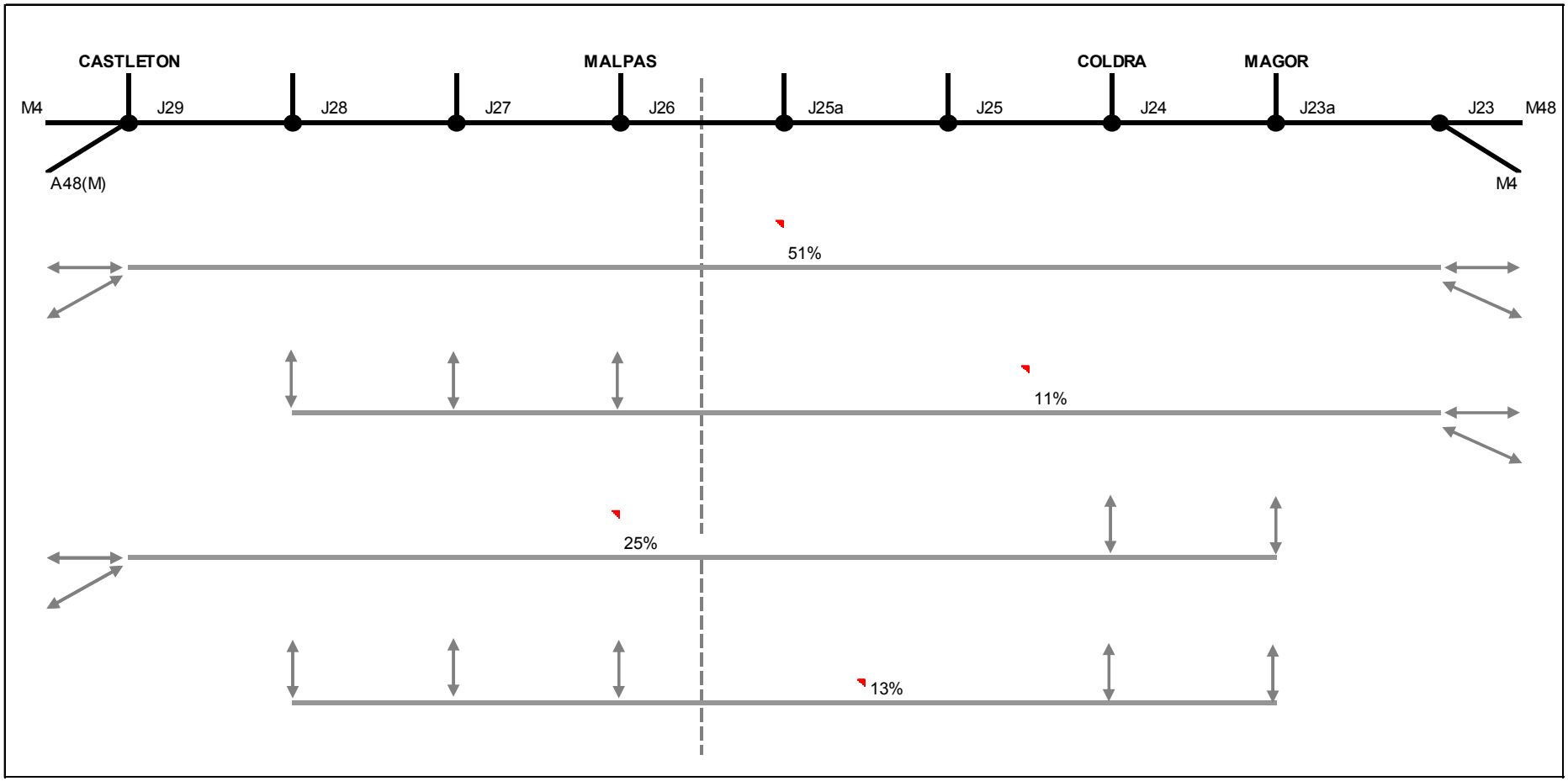


Figure 9.11
Analysis of Traffic Through Brynglas Tunnels 2037
Do Minimum
(vehicles/day)

51%	Through traffic travelling betw een east of J23 and w est of J29
11%	Tw o w ay traffic Joining or Leaving at J28,27,26 travelling through tunnels to east of 23a
25%	Tw o w ay traffic travelling from w est of J28 through tunnels and joining or leaving at 24 or 23a
13%	Tw o w ay traffic both joining and leaving betw een junctions 23 and 29
100%	**Total Brynglas tunnels flow**

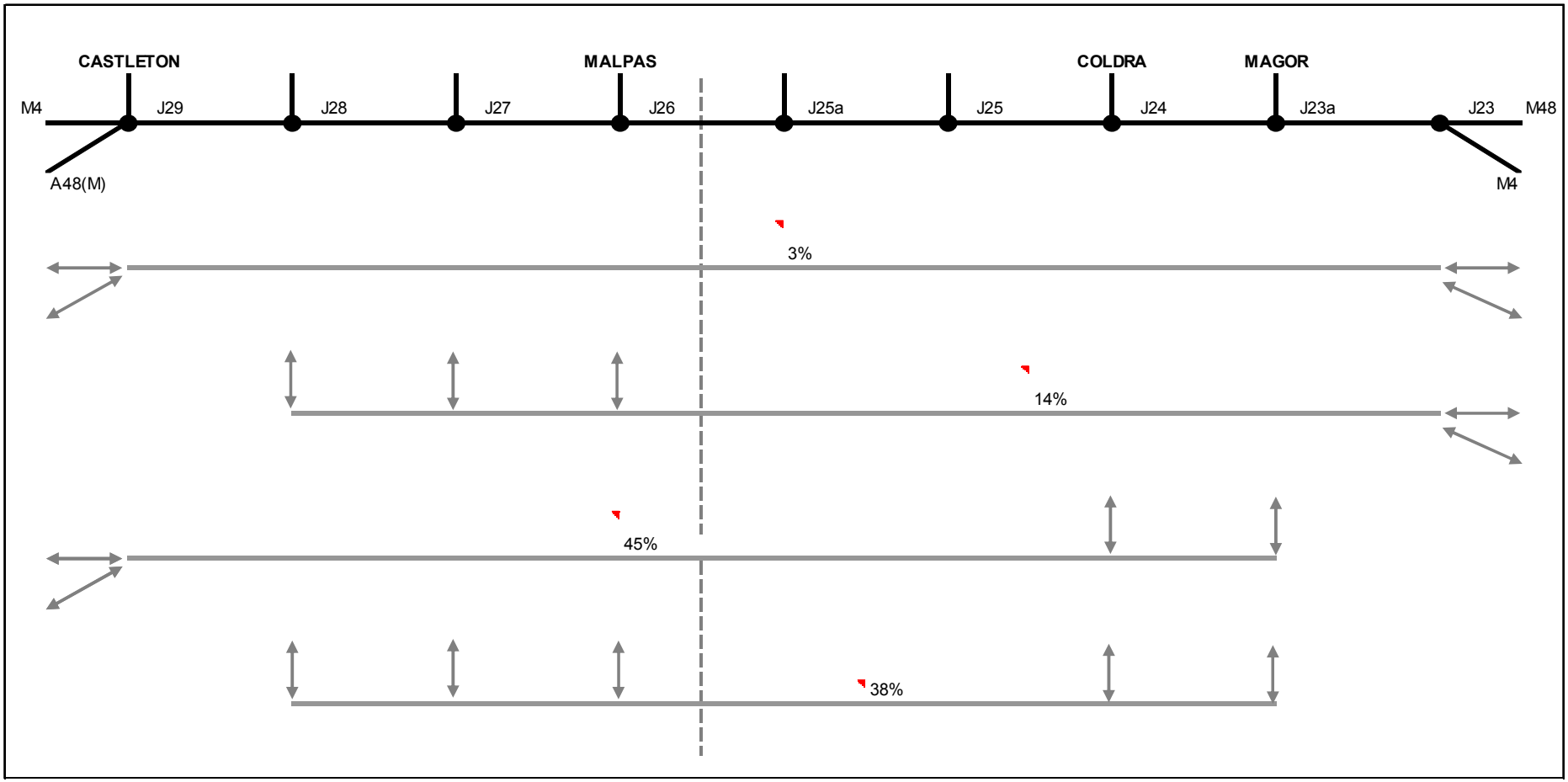


Figure 9.12
Analysis of Traffic Through Brynglas Tunnels 2037
Do Something
(vehicles/day)

3%	Through traffic travelling between east of J23 and west of J29
14%	Two way traffic Joining or Leaving at J28,27,26 travelling through tunnels to east of 23a
45%	Two way traffic travelling from west of J28 through tunnels and joining or leaving at 24 or 23a
38%	Two way traffic both joining and leaving between junctions 23 and 29
100%	**Total Brynglas tunnels flow**

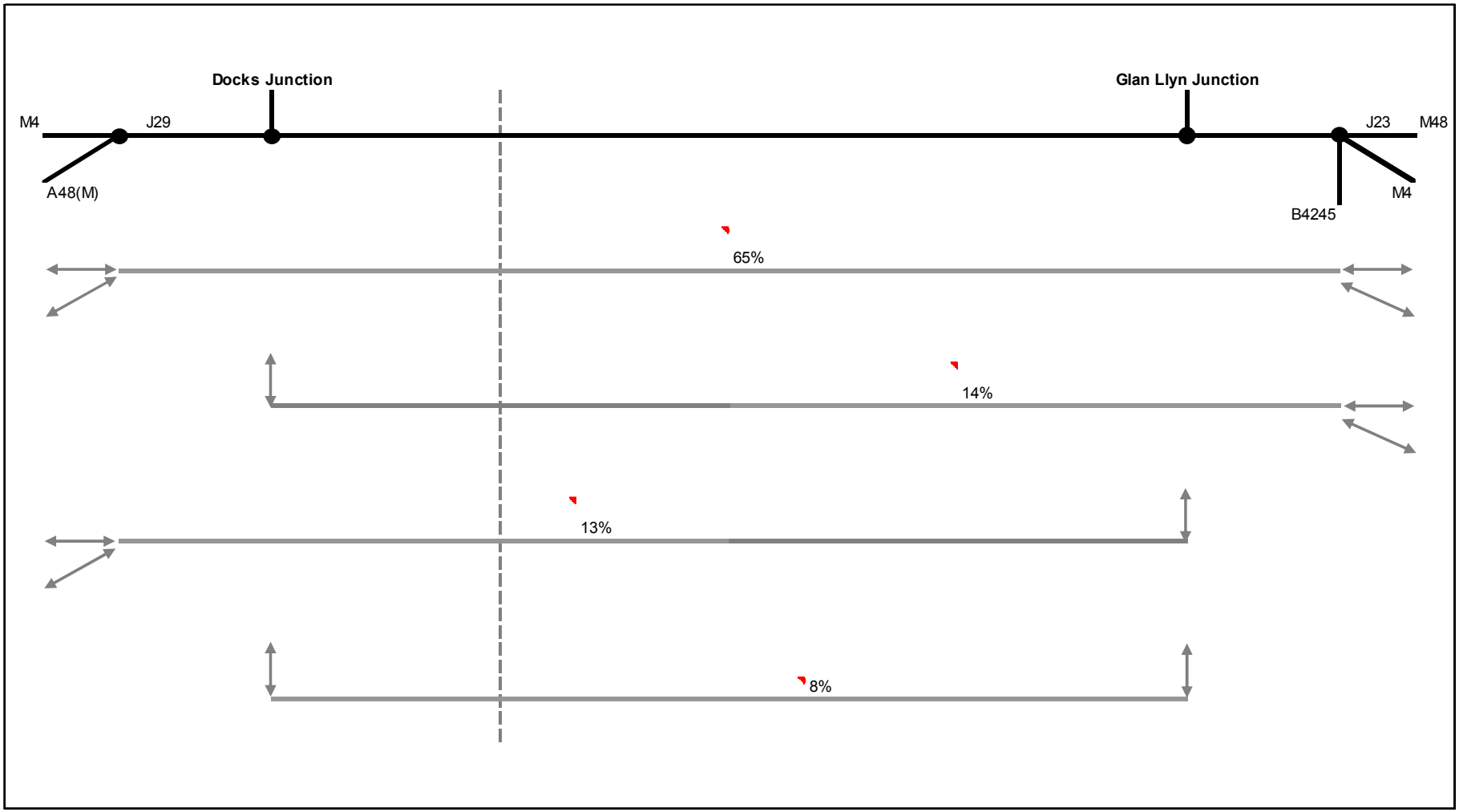


Figure 9.13
Analysis of Traffic on Proposed New Section of Motorway, 2037
Do Something
(vehicles/day)

65%	Through traffic travelling whole length of proposed new section of motorway
14%	Two way traffic Joining or Leaving at Docks Junction and using proposed new section of motorway to East of J23
13%	Two way traffic Joining or Leaving at Glan Llyn Junction and using proposed new section of motorway to West of J29
8%	Two way traffic travelling between Docks Junction and Glan Llyn Junction on proposed new section of motorway
100%	**Total Usk River crossing flow on proposed new section of motorway**

Appendix A– NTEM Growth Factors

A1 Car Driver

Table A1: NTEM Car Driver Growth, 2014 to 2022, Average Weekday

		Car Driver Growth, 2014 to 2022									
		HB Work		HB Employers' Business		HB Other		NHB Employers' Business		NHB Other	
		Production	Attraction	Production	Attraction	Production	Attraction	Production	Attraction	Production	Attraction
Newport 00PR0	Rural	1.177	1.112	1.190	1.125	1.127	1.122	1.116	1.105	1.115	1.118
Newport 00PR1	Newport	1.109	1.113	1.132	1.127	1.085	1.080	1.113	1.110	1.089	1.083
Newport 00PR4	Caerleon	1.134	1.118	1.148	1.134	1.099	1.099	1.120	1.119	1.098	1.093
Monmouthshire 00PP0	Rural	1.078	1.125	1.086	1.148	1.069	1.099	1.128	1.138	1.102	1.100
Monmouthshire 00PP1	Chepstow	1.054	1.123	1.070	1.147	1.056	1.085	1.126	1.137	1.096	1.094
Monmouthshire 00PP2	Abergavenny	1.065	1.127	1.088	1.152	1.076	1.078	1.129	1.144	1.092	1.086
Monmouthshire 00PP3	Caldicot	1.053	1.123	1.068	1.146	1.053	1.080	1.125	1.137	1.092	1.090
Monmouthshire 00PP4	Monmouth	1.054	1.126	1.071	1.150	1.065	1.078	1.127	1.142	1.090	1.085
Monmouthshire 00PP5	Magor	1.028	1.118	1.032	1.139	1.010	1.082	1.121	1.127	1.098	1.102
Blaenau Gwent		1.089	1.097	1.106	1.117	1.072	1.103	1.105	1.105	1.109	1.120
Bridgend		1.057	1.056	1.064	1.069	1.071	1.068	1.059	1.063	1.061	1.060
Caerphilly		1.095	1.058	1.112	1.073	1.081	1.060	1.061	1.058	1.055	1.061
Cardiff		1.106	1.100	1.117	1.104	1.091	1.084	1.098	1.091	1.089	1.087
Merthyr Tydfil		1.077	1.061	1.087	1.078	1.090	1.077	1.066	1.078	1.065	1.063
Rhondda Cynon Taff		1.083	1.060	1.092	1.074	1.090	1.088	1.065	1.071	1.075	1.082
The Vale of Glamorgan		1.047	1.103	1.053	1.120	1.063	1.094	1.106	1.119	1.094	1.087
Torfaen		1.090	1.074	1.107	1.093	1.079	1.060	1.078	1.081	1.060	1.058
Carmarthenshire		1.062	1.076	1.069	1.087	1.073	1.092	1.080	1.081	1.085	1.086
Neath Port Talbot		1.055	1.080	1.063	1.089	1.066	1.087	1.083	1.080	1.088	1.094
Pembrokeshire		1.073	1.069	1.083	1.077	1.095	1.093	1.073	1.073	1.083	1.083
Swansea		1.091	1.069	1.103	1.077	1.077	1.056	1.069	1.068	1.057	1.054
Mid Wales		1.031	1.028	1.036	1.034	1.062	1.056	1.032	1.033	1.045	1.045
North Wales		1.043	1.044	1.053	1.054	1.056	1.057	1.048	1.048	1.052	1.052
East of England		1.047	1.061	1.050	1.066	1.096	1.109	1.065	1.065	1.090	1.091
East Midlands		1.044	1.044	1.049	1.049	1.087	1.087	1.048	1.048	1.070	1.070
Greater London		1.071	1.049	1.081	1.056	1.093	1.078	1.053	1.053	1.065	1.060
North East England		1.038	1.038	1.043	1.043	1.068	1.068	1.041	1.041	1.055	1.055
North West England		1.040	1.040	1.048	1.048	1.056	1.056	1.043	1.043	1.048	1.048
South East England		1.044	1.049	1.048	1.056	1.072	1.075	1.053	1.055	1.063	1.064
South West England		1.034	1.034	1.039	1.039	1.086	1.086	1.039	1.039	1.065	1.065
West Midlands		1.045	1.045	1.049	1.049	1.067	1.067	1.047	1.047	1.057	1.057
Yorkshire & Humberside		1.059	1.059	1.067	1.067	1.096	1.096	1.063	1.063	1.080	1.080
Scotland		1.042	1.042	1.053	1.053	1.065	1.065	1.047	1.047	1.054	1.054

		Car Driver Growth, 2014 to 2037									
		HB Work		HB Employers' Business		HB Other		NHB Employers' Business		NHB Other	
		Production	Attraction	Production	Attraction	Production	Attraction	Production	Attraction	Production	Attraction
Newport 00PR0	Rural	1.490	1.289	1.531	1.326	1.283	1.245	1.295	1.263	1.251	1.254
Newport 00PR1	Newport	1.328	1.295	1.401	1.338	1.201	1.150	1.293	1.283	1.191	1.172
Newport 00PR4	Caerleon	1.362	1.313	1.410	1.362	1.219	1.198	1.314	1.312	1.212	1.195
Monmouthshire 00PP0	Rural	1.189	1.447	1.214	1.527	1.137	1.297	1.454	1.492	1.328	1.321
Monmouthshire 00PP1	Chepstow	1.131	1.441	1.177	1.521	1.110	1.262	1.447	1.489	1.313	1.304
Monmouthshire 00PP2	Abergavenny	1.167	1.446	1.234	1.533	1.167	1.234	1.450	1.506	1.293	1.276
Monmouthshire 00PP3	Caldicot	1.137	1.438	1.182	1.519	1.105	1.241	1.443	1.486	1.303	1.295
Monmouthshire 00PP4	Monmouth	1.137	1.444	1.189	1.528	1.140	1.236	1.446	1.500	1.291	1.275
Monmouthshire 00PP5	Magor	1.049	1.429	1.069	1.501	0.995	1.245	1.435	1.460	1.328	1.323
Blaenau Gwent		1.293	1.291	1.345	1.349	1.174	1.245	1.308	1.304	1.284	1.320
Bridgend		1.168	1.166	1.187	1.208	1.180	1.176	1.177	1.195	1.161	1.165
Caerphilly		1.281	1.146	1.333	1.186	1.190	1.116	1.153	1.139	1.115	1.134
Cardiff		1.369	1.339	1.401	1.352	1.274	1.239	1.329	1.305	1.270	1.261
Merthyr Tydfil		1.235	1.156	1.265	1.207	1.204	1.152	1.168	1.206	1.137	1.134
Rhondda Cynon Taff		1.231	1.170	1.262	1.215	1.203	1.210	1.185	1.203	1.190	1.216
The Vale of Glamorgan		1.155	1.343	1.177	1.398	1.165	1.270	1.351	1.394	1.283	1.267
Torfaen		1.243	1.205	1.292	1.257	1.152	1.112	1.212	1.217	1.135	1.130
Carmarthenshire		1.210	1.265	1.238	1.304	1.192	1.256	1.275	1.279	1.256	1.259
Neath Port Talbot		1.194	1.242	1.217	1.274	1.174	1.224	1.250	1.242	1.240	1.260
Pembrokeshire		1.233	1.252	1.267	1.287	1.212	1.222	1.259	1.259	1.231	1.229
Swansea		1.297	1.229	1.335	1.254	1.209	1.142	1.225	1.223	1.159	1.150
Mid Wales		1.117	1.099	1.139	1.122	1.148	1.130	1.107	1.110	1.113	1.114
North Wales		1.153	1.154	1.182	1.183	1.132	1.134	1.160	1.160	1.139	1.139
East of England		1.106	1.138	1.115	1.153	1.273	1.307	1.154	1.150	1.238	1.243
East Midlands		1.090	1.090	1.103	1.103	1.245	1.245	1.105	1.105	1.182	1.182
Greater London		1.166	1.120	1.196	1.138	1.252	1.222	1.133	1.131	1.178	1.166
North East England		1.089	1.089	1.099	1.099	1.191	1.191	1.096	1.096	1.143	1.143
North West England		1.082	1.082	1.105	1.105	1.147	1.147	1.093	1.093	1.118	1.118
South East England		1.091	1.099	1.101	1.119	1.201	1.201	1.112	1.117	1.155	1.157
South West England		1.081	1.081	1.092	1.092	1.242	1.242	1.095	1.095	1.176	1.176
West Midlands		1.127	1.127	1.139	1.139	1.184	1.184	1.133	1.133	1.157	1.157
Yorkshire & Humberside		1.166	1.166	1.190	1.190	1.269	1.269	1.181	1.181	1.223	1.223
Scotland		1.139	1.139	1.172	1.172	1.160	1.160	1.149	1.149	1.146	1.146

Table A2: NTEM Car Driver Growth, 2014 to 2037, Average Weekday

A2 Rail

Table A3: NTEM Rail Passenger Growth, 2014 to 2022, Average Weekday

		Rail Passenger Growth, 2014 to 2022									
		HB Work		HB Employers' Business		HB Other		NHB Employers' Business		NHB Other	
		Production	Attraction	Production	Attraction	Production	Attraction	Production	Attraction	Production	Attraction
Newport 00PR0	Rural	1.149	1.056	1.174	1.097	1.064	1.034	1.099	1.092	1.068	1.094
Newport 00PR1	Newport	1.031	1.056	1.082	1.099	0.968	0.990	1.085	1.096	1.036	1.033
Newport 00PR4	Caerleon	1.093	1.061	1.126	1.106	1.029	1.000	1.095	1.106	1.038	1.034
Monmouthshire 00PP0	Rural	1.060	1.067	1.079	1.119	1.004	0.991	1.110	1.124	1.038	1.032
Monmouthshire 00PP1	Chepstow	1.015	1.066	1.048	1.118	0.953	0.973	1.105	1.124	1.014	1.047
Monmouthshire 00PP2	Abergavenny	1.005	1.069	1.052	1.123	0.967	0.976	1.108	1.130	1.033	1.027
Monmouthshire 00PP3	Caldicot	1.011	1.065	1.044	1.117	0.956	0.984	1.101	1.123	1.024	1.021
Monmouthshire 00PP4	Monmouth	1.005	1.068	1.047	1.122	0.972	0.967	1.111	1.128	1.000	1.000
Monmouthshire 00PP5	Magor	1.021	NaN	1.030	NaN	0.952	0.889	1.113	NaN	1.000	1.000
Blaenau Gwent		1.017	1.040	1.064	1.089	0.956	1.014	1.089	1.092	1.068	1.072
Bridgend		1.017	0.981	1.044	1.031	0.989	0.969	1.046	1.035	1.018	1.006
Caerphilly		1.034	1.002	1.076	1.046	0.972	0.940	1.037	1.045	1.002	1.010
Cardiff		1.017	1.022	1.081	1.065	0.929	0.957	1.063	1.061	1.027	1.030
Merthyr Tydfil		1.013	0.986	1.052	1.041	0.992	0.979	1.052	1.050	1.031	1.000
Rhondda Cynon Taff		1.024	0.985	1.062	1.038	0.985	0.976	1.049	1.043	1.033	1.023
The Vale of Glamorgan		1.011	1.027	1.037	1.083	0.991	0.984	1.091	1.092	1.035	1.013
Torfaen		1.033	1.019	1.074	1.065	0.975	0.967	1.061	1.068	1.009	1.016
Carmarthenshire		1.024	1.027	1.051	1.063	1.001	1.010	1.065	1.064	1.041	1.044
Neath Port Talbot		1.010	1.031	1.038	1.066	0.981	0.993	1.066	1.065	1.042	1.058
Pembrokeshire		1.041	1.035	1.065	1.061	1.042	1.038	1.062	1.062	1.054	1.059
Swansea		1.032	1.020	1.072	1.051	0.976	0.968	1.048	1.050	1.018	1.017
Mid Wales		1.004	1.003	1.025	1.024	1.008	1.005	1.024	1.027	1.019	1.022
North Wales		1.007	1.009	1.033	1.035	0.994	0.996	1.036	1.036	1.022	1.023
East of England		1.012	1.030	1.040	1.050	1.074	1.091	1.061	1.058	1.083	1.082
East Midlands		1.011	1.011	1.035	1.035	1.042	1.042	1.040	1.040	1.052	1.052
Greater London		1.033	1.028	1.058	1.046	1.067	1.063	1.038	1.040	1.045	1.049
North East England		0.988	0.988	1.017	1.017	0.989	0.989	1.023	1.023	1.017	1.017
North West England		0.996	0.996	1.025	1.025	0.984	0.984	1.028	1.028	1.016	1.016
South East England		1.021	1.033	1.037	1.042	1.040	1.045	1.047	1.048	1.050	1.047
South West England		1.010	1.010	1.028	1.028	1.065	1.065	1.033	1.033	1.055	1.055
West Midlands		1.006	1.006	1.032	1.032	1.003	1.003	1.035	1.035	1.029	1.029
Yorkshire & Humberside		1.016	1.016	1.043	1.043	1.037	1.037	1.049	1.049	1.051	1.051
Scotland		0.985	0.985	1.023	1.023	0.969	0.969	1.026	1.026	1.008	1.008

Table A4: NTEM Rail Passenger Growth, 2014 to 2037, Average Weekday

		Rail Passenger Growth, 2014 to 2037									
		HB Work		HB Employers' Business		HB Other		NHB Employers' Business		NHB Other	
		Production	Attraction	Production	Attraction	Production	Attraction	Production	Attraction	Production	Attraction
Newport 00PR0	Rural	1.410	1.150	1.481	1.262	1.083	1.009	1.247	1.244	1.127	1.176
Newport 00PR1	Newport	1.118	1.155	1.259	1.274	0.892	0.913	1.221	1.263	1.051	1.046
Newport 00PR4	Caerleon	1.249	1.171	1.344	1.297	0.985	0.943	1.250	1.292	1.038	1.069
Monmouthshire 00PP0	Rural	1.145	1.291	1.194	1.454	0.957	1.000	1.399	1.469	1.135	1.136
Monmouthshire 00PP1	Chepstow	1.036	1.285	1.119	1.448	0.894	0.967	1.384	1.466	1.110	1.125
Monmouthshire 00PP2	Abergavenny	1.014	1.290	1.138	1.459	0.893	0.952	1.386	1.483	1.100	1.108
Monmouthshire 00PP3	Caldicot	1.030	1.283	1.117	1.446	0.878	0.960	1.373	1.463	1.098	1.125
Monmouthshire 00PP4	Monmouth	1.013	1.288	1.122	1.455	0.901	0.967	1.394	1.477	1.095	1.053
Monmouthshire 00PP5	Magor	1.038	NaN	1.061	NaN	0.881	0.889	1.409	NaN	1.167	1.000
Blaenau Gwent		1.103	1.151	1.224	1.284	0.872	0.986	1.262	1.284	1.144	1.203
Bridgend		1.065	0.969	1.134	1.094	0.967	0.924	1.141	1.106	1.030	0.994
Caerphilly		1.115	1.020	1.231	1.130	0.898	0.817	1.096	1.121	0.980	1.005
Cardiff		1.141	1.112	1.298	1.223	0.879	0.915	1.224	1.207	1.095	1.088
Merthyr Tydfil		1.073	0.961	1.170	1.094	0.949	0.912	1.130	1.120	1.019	0.977
Rhondda Cynon Taff		1.077	0.975	1.177	1.104	0.934	0.928	1.140	1.119	1.058	1.052
The Vale of Glamorgan		1.065	1.119	1.133	1.272	0.978	0.978	1.303	1.299	1.105	1.058
Torfaen		1.094	1.074	1.201	1.196	0.886	0.873	1.168	1.199	1.005	1.008
Carmarthenshire		1.107	1.132	1.183	1.231	0.984	1.031	1.230	1.231	1.123	1.129
Neath Port Talbot		1.071	1.114	1.148	1.208	0.941	0.969	1.203	1.202	1.112	1.135
Pembrokeshire		1.136	1.144	1.213	1.233	1.001	0.994	1.218	1.218	1.122	1.132
Swansea		1.136	1.097	1.243	1.182	0.942	0.914	1.168	1.173	1.050	1.044
Mid Wales		1.033	1.029	1.103	1.097	0.956	0.947	1.083	1.096	1.035	1.041
North Wales		1.055	1.059	1.128	1.131	0.942	0.945	1.125	1.126	1.049	1.048
East of England		1.015	1.055	1.091	1.116	1.224	1.263	1.143	1.134	1.217	1.216
East Midlands		1.017	1.017	1.071	1.071	1.164	1.164	1.087	1.087	1.142	1.142
Greater London		1.059	1.050	1.133	1.104	1.187	1.181	1.087	1.092	1.114	1.123
North East England		0.972	0.972	1.038	1.038	1.020	1.020	1.056	1.056	1.050	1.050
North West England		0.985	0.985	1.052	1.052	1.004	1.004	1.060	1.060	1.043	1.043
South East England		1.036	1.060	1.076	1.087	1.140	1.139	1.101	1.100	1.125	1.116
South West England		1.023	1.023	1.068	1.068	1.206	1.206	1.084	1.084	1.151	1.151
West Midlands		1.033	1.033	1.095	1.095	1.028	1.028	1.103	1.103	1.081	1.081
Yorkshire & Humberside		1.062	1.062	1.130	1.130	1.126	1.126	1.144	1.144	1.143	1.143
Scotland		0.988	0.988	1.090	1.090	0.879	0.879	1.091	1.091	1.005	1.005

A3 Bus

		Bus Passenger Growth, 2014 to 2022									
		HB Work		HB Employers' Business		HB Other		NHB Employers' Business		NHB Other	
		Production	Attraction	Production	Attraction	Production	Attraction	Production	Attraction	Production	Attraction
Newport 00PR0	Rural	1.109	0.999	1.119	1.035	1.083	1.029	1.074	1.058	1.048	1.053
Newport 00PR1	Newport	0.973	0.999	1.015	1.037	0.972	0.984	1.054	1.062	1.014	1.016
Newport 00PR4	Caerleon	1.047	1.004	1.074	1.044	1.023	1.002	1.072	1.071	1.027	1.036
Monmouthshire 00PP0	Rural	1.035	1.010	1.057	1.056	1.011	0.989	1.095	1.089	1.033	1.028
Monmouthshire 00PP1	Chepstow	0.976	1.008	1.010	1.055	0.972	0.975	1.089	1.089	1.026	1.017
Monmouthshire 00PP2	Abergavenny	0.955	1.012	1.006	1.060	0.971	0.969	1.089	1.095	1.020	1.015
Monmouthshire 00PP3	Caldicot	0.970	1.008	1.004	1.054	0.965	0.968	1.091	1.088	1.022	1.000
Monmouthshire 00PP4	Monmouth	0.963	1.011	1.012	1.058	0.971	0.971	1.090	1.093	1.016	1.000
Monmouthshire 00PP5	Magor	1.010	1.003	1.012	1.048	0.965	0.961	1.090	1.079	1.056	1.000
Blaenau Gwent		0.971	0.984	1.012	1.027	0.963	1.010	1.064	1.058	1.046	1.053
Bridgend		0.985	0.955	1.016	0.994	0.982	0.966	1.027	1.019	1.004	0.993
Caerphilly		0.984	0.949	1.024	0.987	0.966	0.946	1.019	1.012	0.987	0.991
Cardiff		0.986	0.995	1.021	1.027	0.968	0.977	1.045	1.044	1.017	1.021
Merthyr Tydfil		0.975	0.961	1.015	1.004	1.001	0.982	1.022	1.035	1.003	0.996
Rhondda Cynon Taff		0.985	0.959	1.022	1.001	0.984	0.989	1.029	1.027	1.020	1.013
The Vale of Glamorgan		0.982	0.999	1.015	1.043	0.997	0.986	1.073	1.073	1.029	1.017
Torfaen		0.986	0.964	1.025	1.005	0.978	0.951	1.037	1.035	0.992	0.989
Carmarthenshire		0.991	0.990	1.025	1.027	0.995	0.996	1.054	1.050	1.034	1.031
Neath Port Talbot		0.976	0.993	1.007	1.029	0.974	0.996	1.051	1.051	1.033	1.040
Pembrokeshire		1.010	1.006	1.042	1.042	1.031	1.033	1.051	1.052	1.049	1.053
Swansea		0.988	0.982	1.023	1.016	0.983	0.977	1.030	1.037	1.003	1.007
Mid Wales		0.982	0.983	1.016	1.015	1.006	1.003	1.018	1.021	1.016	1.019
North Wales		0.971	0.972	1.005	1.005	0.989	0.990	1.023	1.023	1.012	1.012
East of England		1.003	1.018	1.038	1.050	1.070	1.087	1.057	1.055	1.084	1.083
East Midlands		0.989	0.989	1.025	1.025	1.044	1.044	1.032	1.032	1.050	1.050
Greater London		1.021	1.011	1.034	1.029	1.069	1.059	1.035	1.036	1.049	1.056
North East England		0.958	0.958	0.990	0.990	0.990	0.990	1.009	1.009	1.008	1.008
North West England		0.963	0.963	0.994	0.994	0.989	0.989	1.014	1.014	1.008	1.008
South East England		0.996	1.002	1.026	1.028	1.037	1.039	1.040	1.042	1.049	1.042
South West England		0.991	0.991	1.026	1.026	1.061	1.061	1.029	1.029	1.056	1.056
West Midlands		0.977	0.977	1.010	1.010	1.004	1.004	1.024	1.024	1.022	1.022
Yorkshire & Humberside		0.980	0.980	1.019	1.019	1.037	1.037	1.035	1.035	1.045	1.045
Scotland		0.948	0.948	0.987	0.987	0.971	0.971	1.008	1.008	0.997	0.997

Table A5: NTEM Bus Passenger Growth, 2014 to 2022, Average Weekday

Table A6: NTEM Bus Passenger Growth, 2014 to 2037, Average Weekday

		Bus Passenger Growth, 2014 to 2037									
		HB Work		HB Employers' Business		HB Other		NHB Employers' Business		NHB Other	
		Production	Attraction	Production	Attraction	Production	Attraction	Production	Attraction	Production	Attraction
Newport 00PR0	Rural	1.286	0.999	1.294	1.079	1.113	0.981	1.178	1.150	1.056	1.079
Newport 00PR1	Newport	0.957	1.004	1.051	1.089	0.881	0.889	1.135	1.168	0.985	0.995
Newport 00PR4	Caerleon	1.116	1.018	1.177	1.109	0.996	0.927	1.181	1.194	1.000	1.036
Monmouthshire 00PP0	Rural	1.081	1.122	1.129	1.242	0.994	0.989	1.345	1.358	1.106	1.092
Monmouthshire 00PP1	Chepstow	0.941	1.117	1.020	1.238	0.913	0.959	1.327	1.355	1.090	1.070
Monmouthshire 00PP2	Abergavenny	0.886	1.121	1.012	1.247	0.910	0.939	1.323	1.371	1.069	1.059
Monmouthshire 00PP3	Caldicot	0.925	1.115	1.008	1.236	0.898	0.935	1.331	1.353	1.076	1.027
Monmouthshire 00PP4	Monmouth	0.904	1.119	1.026	1.244	0.910	0.942	1.320	1.366	1.064	1.036
Monmouthshire 00PP5	Magor	1.011	1.107	1.014	1.221	0.909	0.930	1.333	1.329	1.167	1.000
Blaenau Gwent		0.971	1.000	1.058	1.098	0.854	0.963	1.188	1.188	1.090	1.115
Bridgend		0.982	0.915	1.056	0.993	0.943	0.895	1.086	1.070	0.990	0.968
Caerphilly		0.980	0.887	1.067	0.966	0.873	0.824	1.043	1.036	0.930	0.948
Cardiff		1.043	1.049	1.118	1.109	0.923	0.938	1.176	1.166	1.052	1.055
Merthyr Tydfil		0.967	0.909	1.047	0.996	0.923	0.883	1.051	1.086	0.959	0.945
Rhondda Cynon Taff		0.969	0.920	1.053	1.002	0.911	0.928	1.086	1.082	1.020	1.012
The Vale of Glamorgan		0.984	1.054	1.061	1.151	0.980	0.961	1.248	1.251	1.076	1.044
Torfaen		0.968	0.933	1.049	1.022	0.875	0.834	1.101	1.108	0.944	0.951
Carmarthenshire		1.011	1.024	1.091	1.113	0.965	0.986	1.193	1.187	1.089	1.086
Neath Port Talbot		0.977	1.007	1.048	1.091	0.910	0.963	1.155	1.159	1.071	1.094
Pembrokeshire		1.044	1.049	1.117	1.132	0.980	0.988	1.173	1.175	1.088	1.091
Swansea		1.009	0.993	1.089	1.068	0.939	0.919	1.112	1.132	0.997	1.009
Mid Wales		0.964	0.962	1.052	1.045	0.965	0.956	1.058	1.064	1.016	1.023
North Wales		0.958	0.958	1.033	1.034	0.930	0.931	1.084	1.084	1.011	1.010
East of England		1.002	1.034	1.104	1.128	1.200	1.247	1.135	1.128	1.222	1.222
East Midlands		0.975	0.975	1.067	1.067	1.138	1.138	1.074	1.074	1.137	1.137
Greater London		1.041	1.020	1.075	1.070	1.206	1.178	1.084	1.086	1.138	1.152
North East England		0.909	0.909	0.983	0.983	0.988	0.988	1.024	1.024	1.025	1.025
North West England		0.911	0.911	0.984	0.984	0.989	0.989	1.027	1.027	1.021	1.021
South East England		0.982	0.993	1.067	1.066	1.115	1.121	1.086	1.090	1.124	1.108
South West England		0.983	0.983	1.076	1.076	1.173	1.173	1.075	1.075	1.152	1.152
West Midlands		0.967	0.967	1.041	1.041	1.007	1.007	1.074	1.074	1.056	1.056
Yorkshire & Humberside		0.971	0.971	1.066	1.066	1.094	1.094	1.107	1.107	1.117	1.117
Scotland		0.884	0.884	0.978	0.978	0.860	0.860	1.039	1.039	0.958	0.958

Appendix B – Uncertainty in Forecasting

B1 Uncertainty Log

Table B1: Uncertainty Log for M4CaN Traffic Forecasts

Input	Forecast Year	Description of Model Core Scenario Assumption	Uncertainty Assumption (Alternative Scenario Options)	Comments
National Uncertainty				
Growth in Demand	2022	NTEM	+ or – 7.07%	Able to apply quantitative range
	2037	NTEM	+ or – 11.99%	
Local Uncertainty: Factors Affecting Underlying Demand				
Future Land Use and Development Assumptions	2022	As described in Chapter 4	Uncertainty relating to this encapsulated within low and high growth forecasts.	
	2037			
Local Uncertainty: Factors Affecting Supply for Transport				
Highway schemes within study area	2022	As described in Chapter 4	All schemes included in the forecast 'Do Minimum' scenario are considered highly likely to happen. No other potential highway schemes within study area are considered significant or likely to happen.	
	2037			
Severn Bridge Tolls	2022	Tolls removed	The current concession is likely to end in 2018. There is strong likelihood of reduced tolls or no tolls in both forecast years. This would increase highway travel demand around Newport.	
	2037			

Appendix C – Convergence Statistics

C1 Traffic Assignment Convergence

Table C1: Central Growth Assignment Convergence Statistics

AM Peak	2014	2022		2037	
		Do Minimum	Do Something	Do Minimum	Do Something
Number of Assignment / Simulation Loops	14	19	20	41	30
Wardrop Equilibrium Gap Function (%Gap)	0.045	0.020	0.025	0.014	0.017
Percentage of Link Flows changing by <1% - final four iterations	98.0 98.4 99.0 99.0	98.1 98.4 98.7 98.9	98.0 98.5 98.4 98.7	98.8 98.3 98.9 98.3	98.2 98.2 98.0 98.8
Inter Peak					
Number of Assignment / Simulation Loops	16	17	26	21	26
Wardrop Equilibrium Gap Function (%Gap)	0.0026	0.0032	0.0013	0.0024	0.0065
Percentage of Link Flows changing by <1% - final four iterations	98.4 98.5 98.8 99.1	98.9 98.8 99.2 99.4	98.1 98.2 98.2 98.7	98.8 98.7 98.8 99.0	98.4 99.0 98.0 98.7
PM Peak					
Number of Assignment / Simulation Loops	15	14	19	27	22
Wardrop Equilibrium Gap Function (%Gap)	0.022	0.024	0.020	0.025	0.022
Percentage of Link Flows changing by <1% - final four iterations	98.3 98.3 98.7 98.9	98.4 98.4 99.0 98.9	98.5 98.6 98.4 98.8	98.5 98.7 98.4 98.9	98.6 98.5 99.0 99.1

Appendix D– Low Growth Scenario

D1 Low Growth Traffic Forecasts

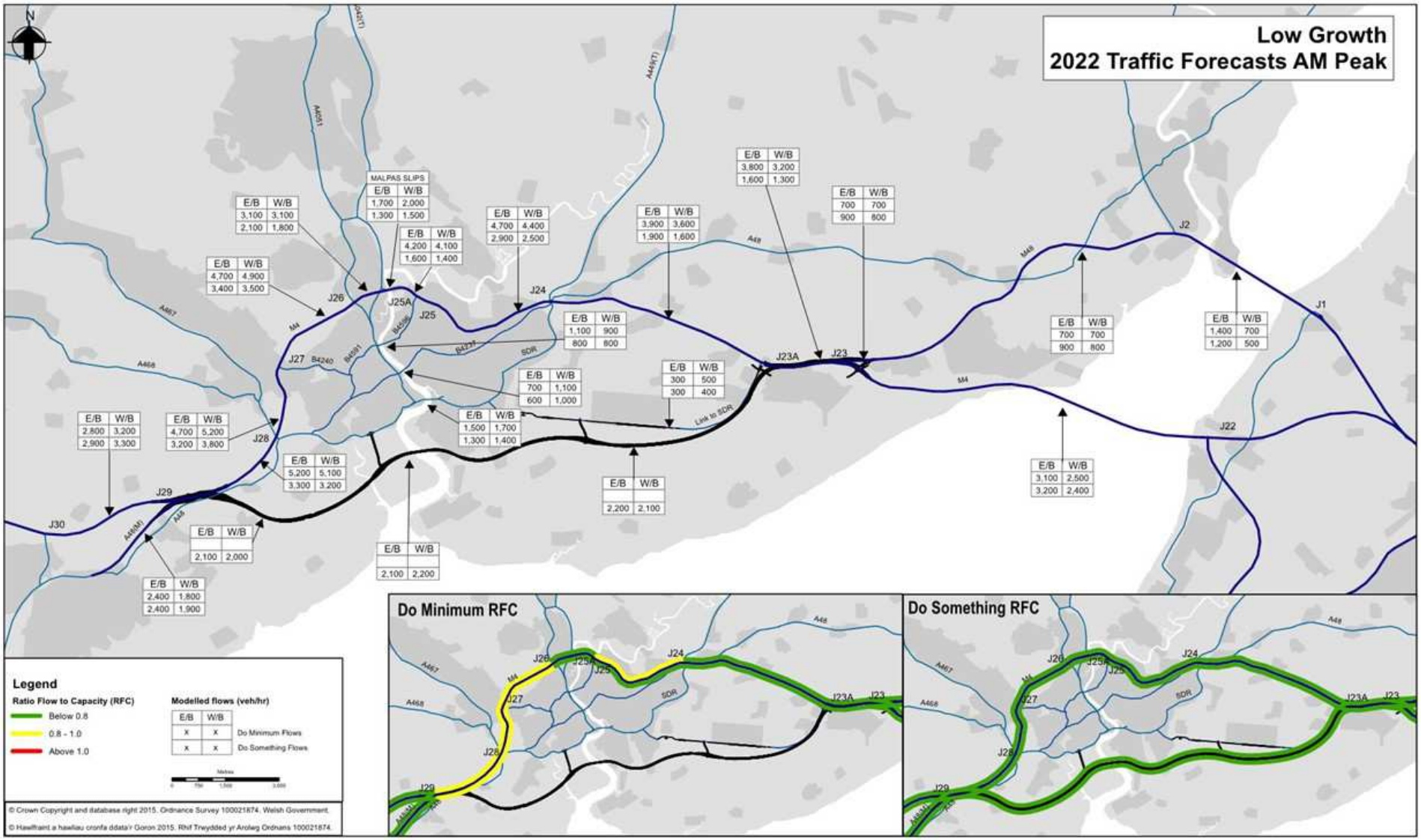


Figure D1: 2022 Forecast AM Peak Hour Traffic Flows, Low Growth

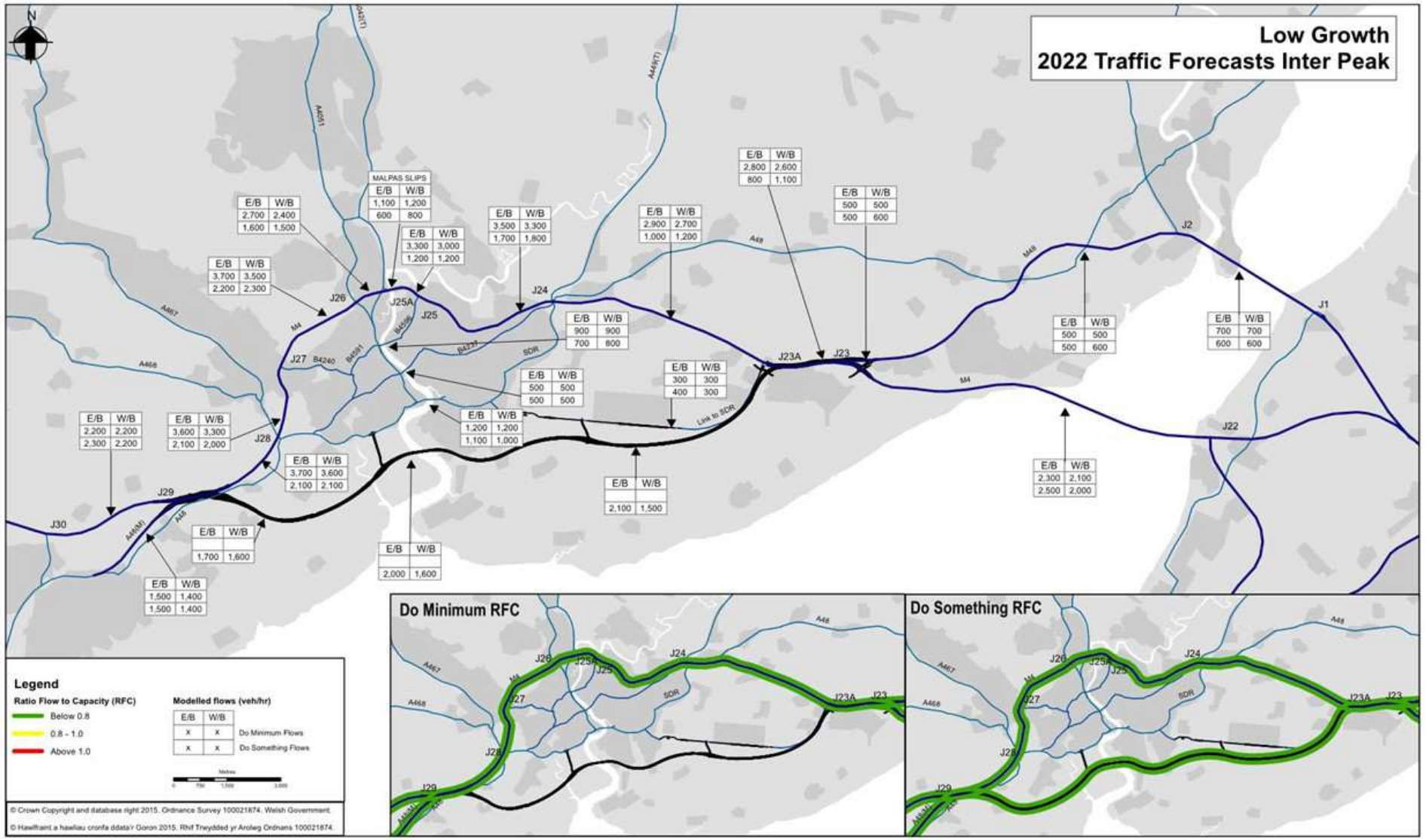


Figure D2: 2022 Forecast Inter Peak Hour Traffic Flows, Low Growth

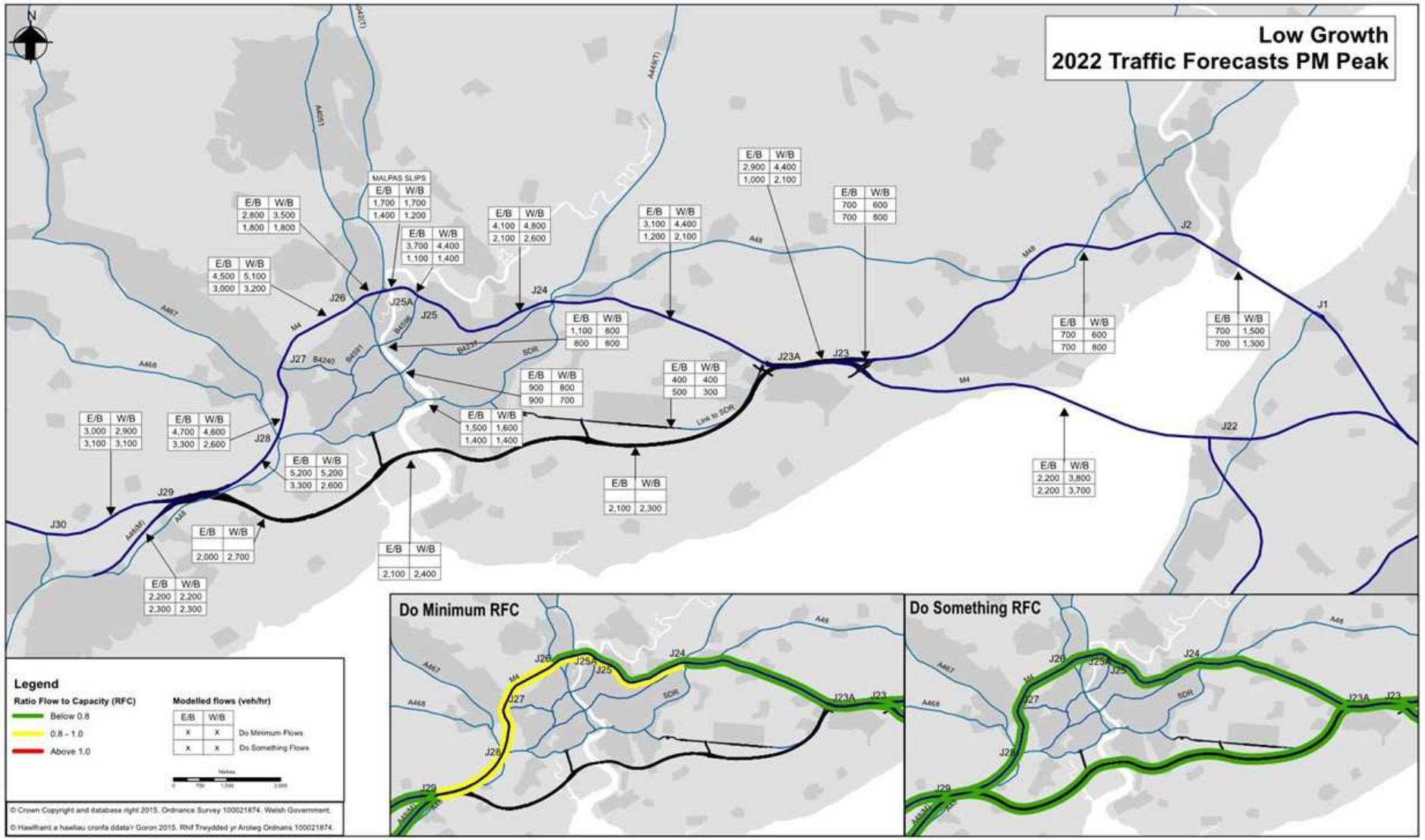


Figure D3: 2022 Forecast PM Peak Hour Traffic Flows, Low Growth

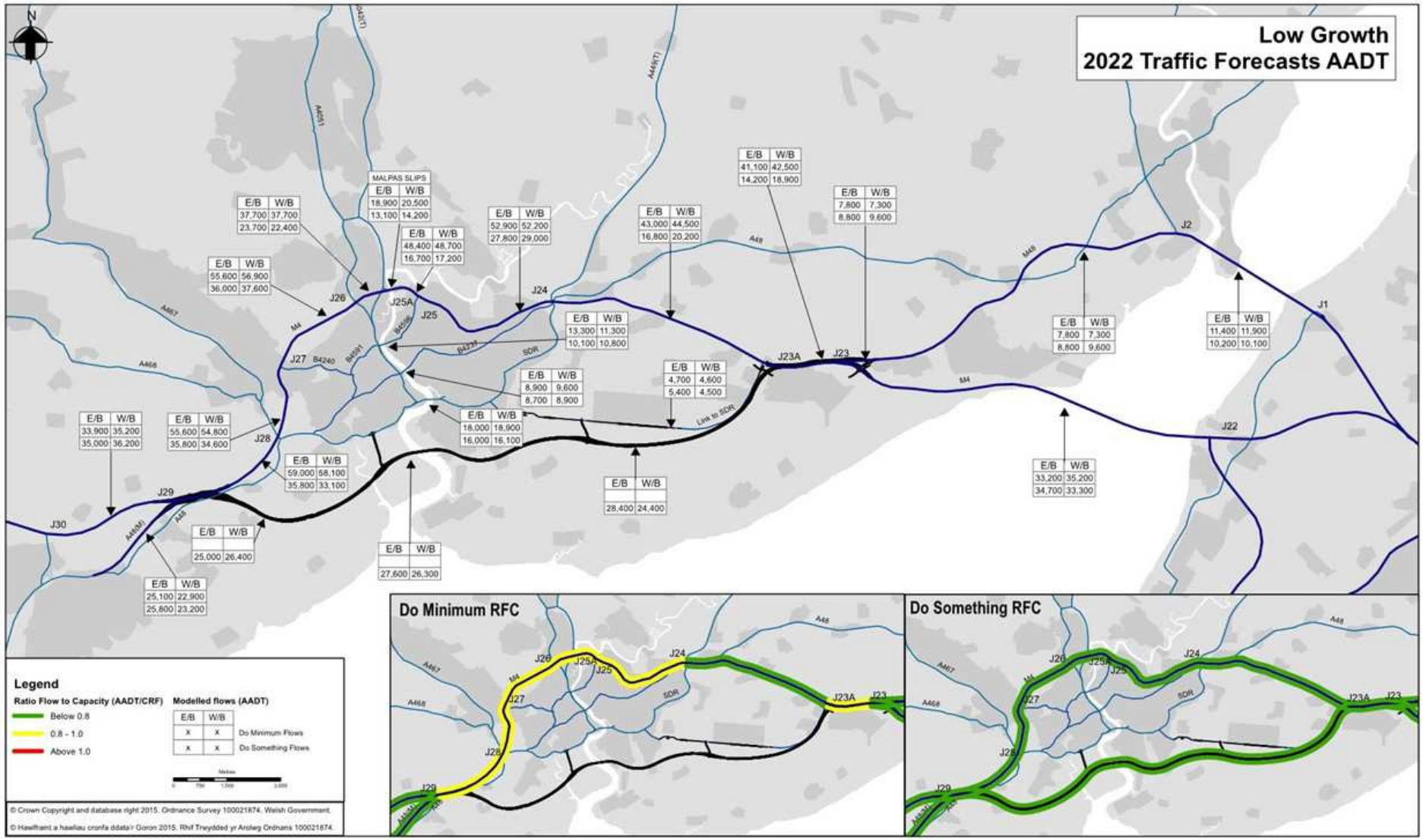


Figure D4: 2022 Forecast Annual Average Daily Traffic Flows, Low Growth

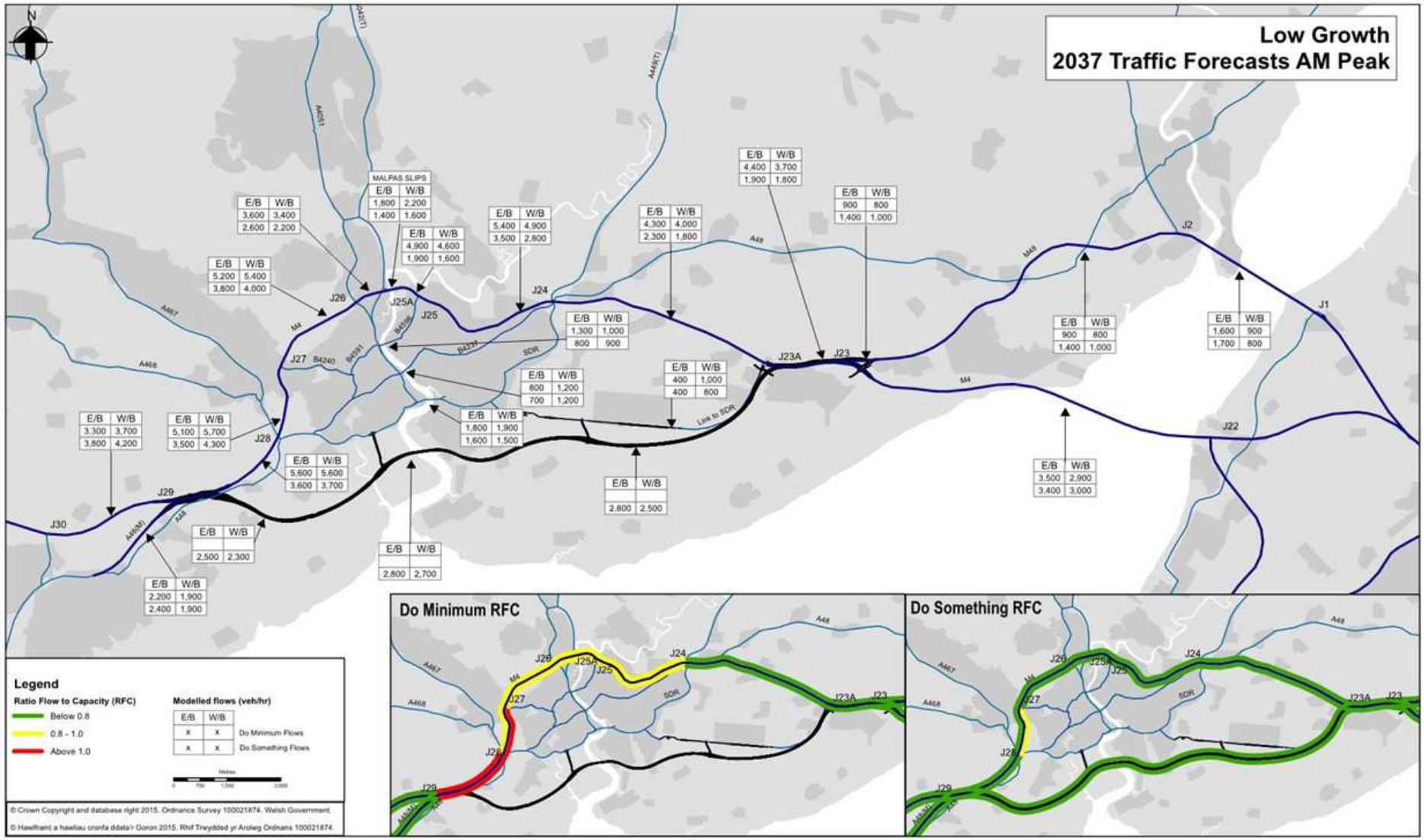


Figure D5: 2037 Forecast AM Peak Hour Traffic Flows, Low Growth

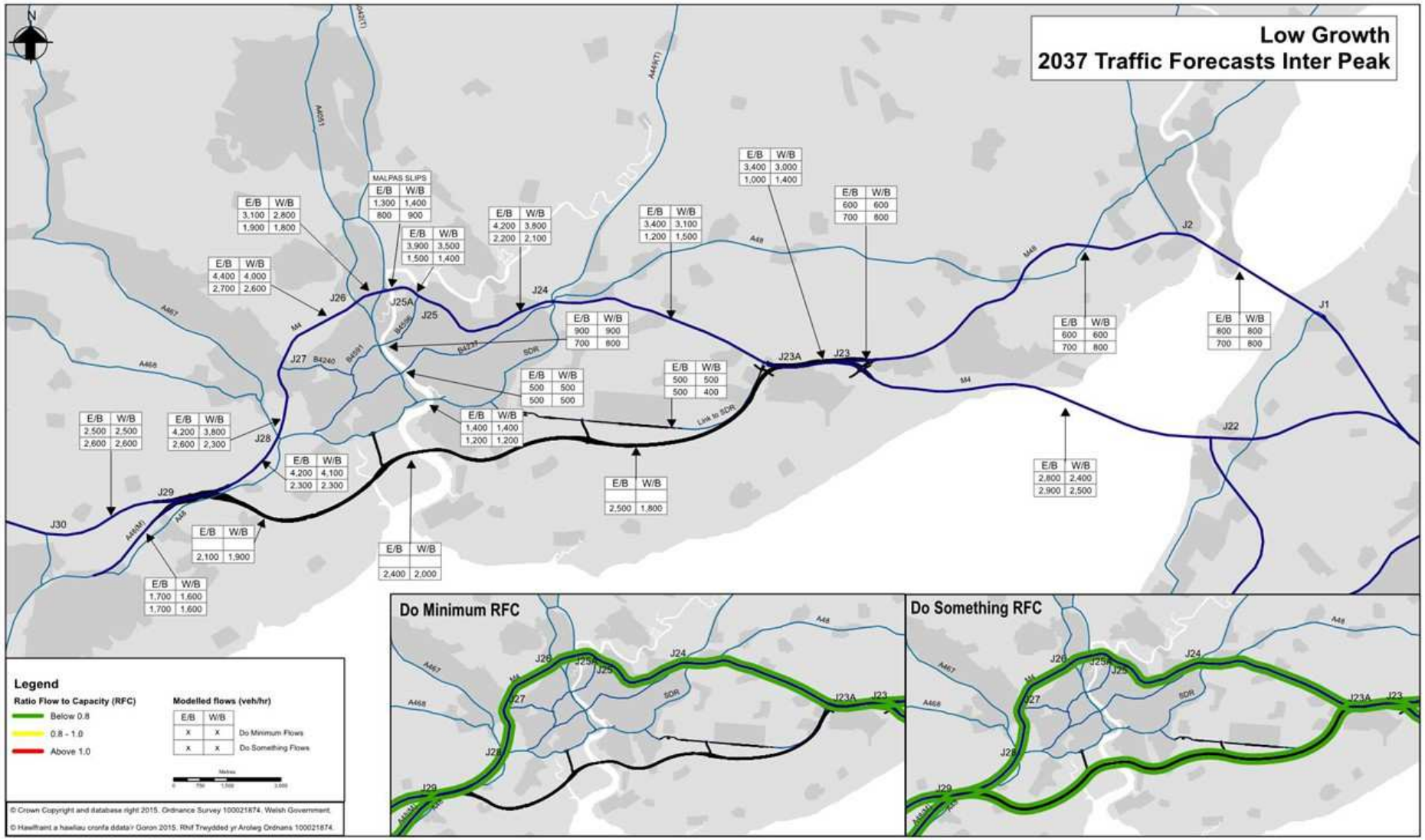


Figure D6: 2037 Forecast Inter Peak Hour Traffic Flows, Low Growth

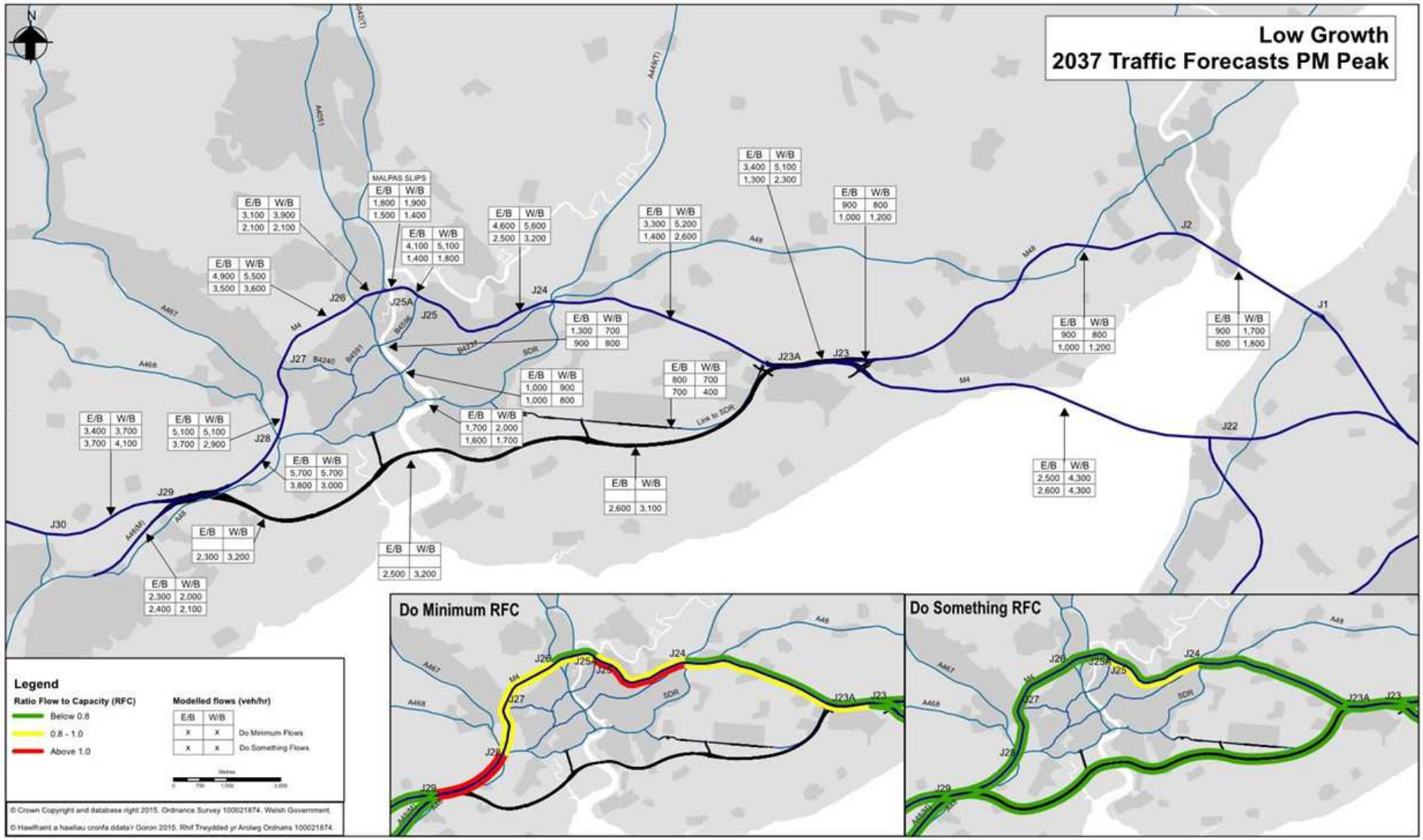


Figure D7: 2037 Forecast PM Peak Hour Traffic Flows, Low Growth

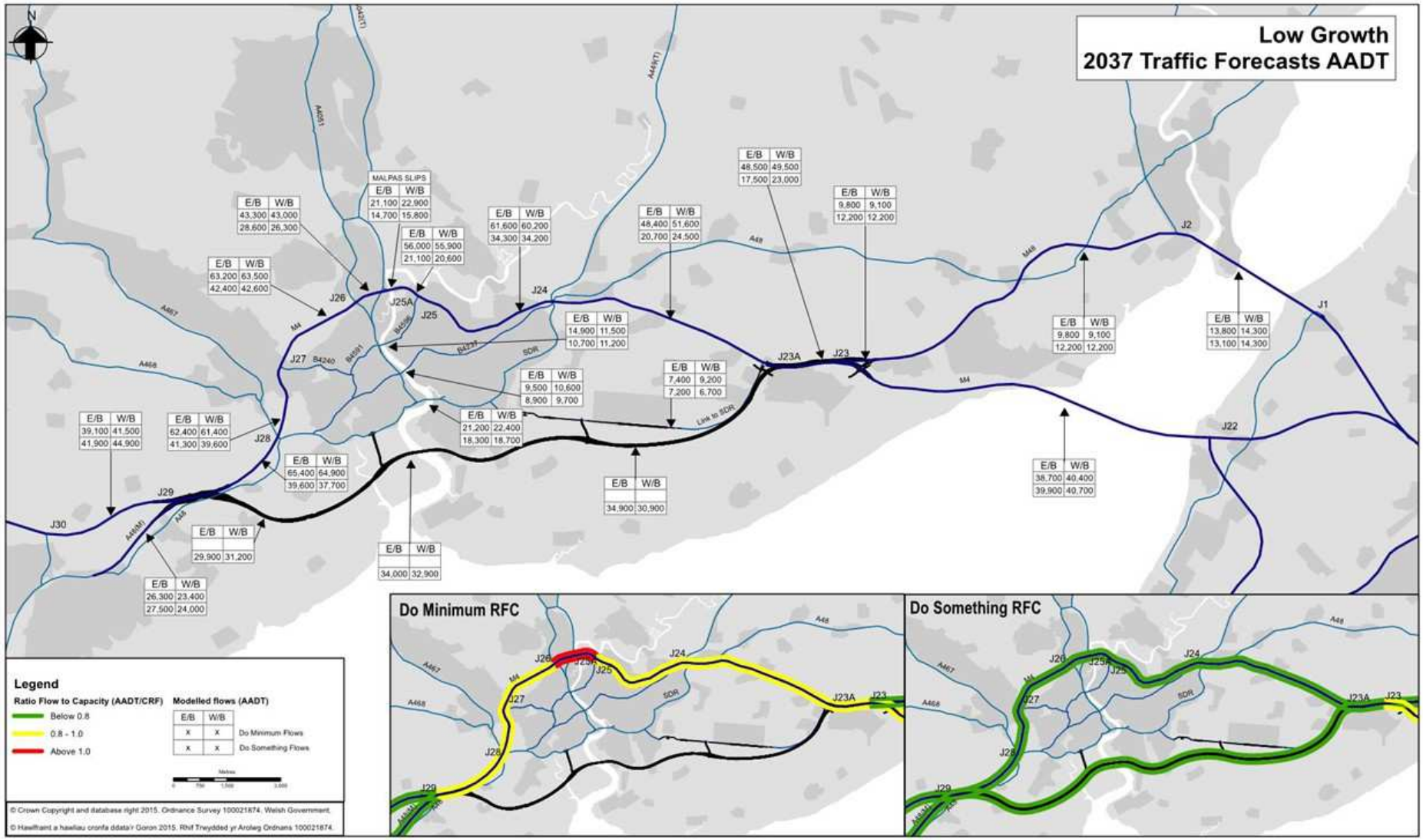


Figure D8: 2037 Forecast Annual Average Daily Traffic Flows, Low Growth

D2 Low Growth Journey Time Analysis

Table D1: Low Growth - Journey Time between Junction 30 and M4 Toll Plaza (min:sec)

Direction	Time	Route	2022 Low Growth		2037 Low Growth	
			Do Min	Do Som	Do Min	Do Som
East	AM	Via existing M4	19:00	19:03	21:30	19:34
	IP	Via existing M4	17:22	18:00	18:23	18:18
	PM	Via existing M4	17:42	18:14	19:03	18:40
	AM	Via new motorway		15:01		15:43
	IP	Via new motorway		14:50		15:16
	PM	Via new motorway		14:49		15:14
West	AM	Via existing M4	19:36	18:23	21:15	19:15
	IP	Via existing M4	17:19	17:26	17:48	17:45
	PM	Via existing M4	19:23	18:44	23:00	20:42
	AM	Via new motorway		15:30		16:15
	IP	Via new motorway		14:38		15:00
	PM	Via new motorway		15:29		16:36

Appendix E– High Growth Scenario

E1 High Growth Traffic Forecasts

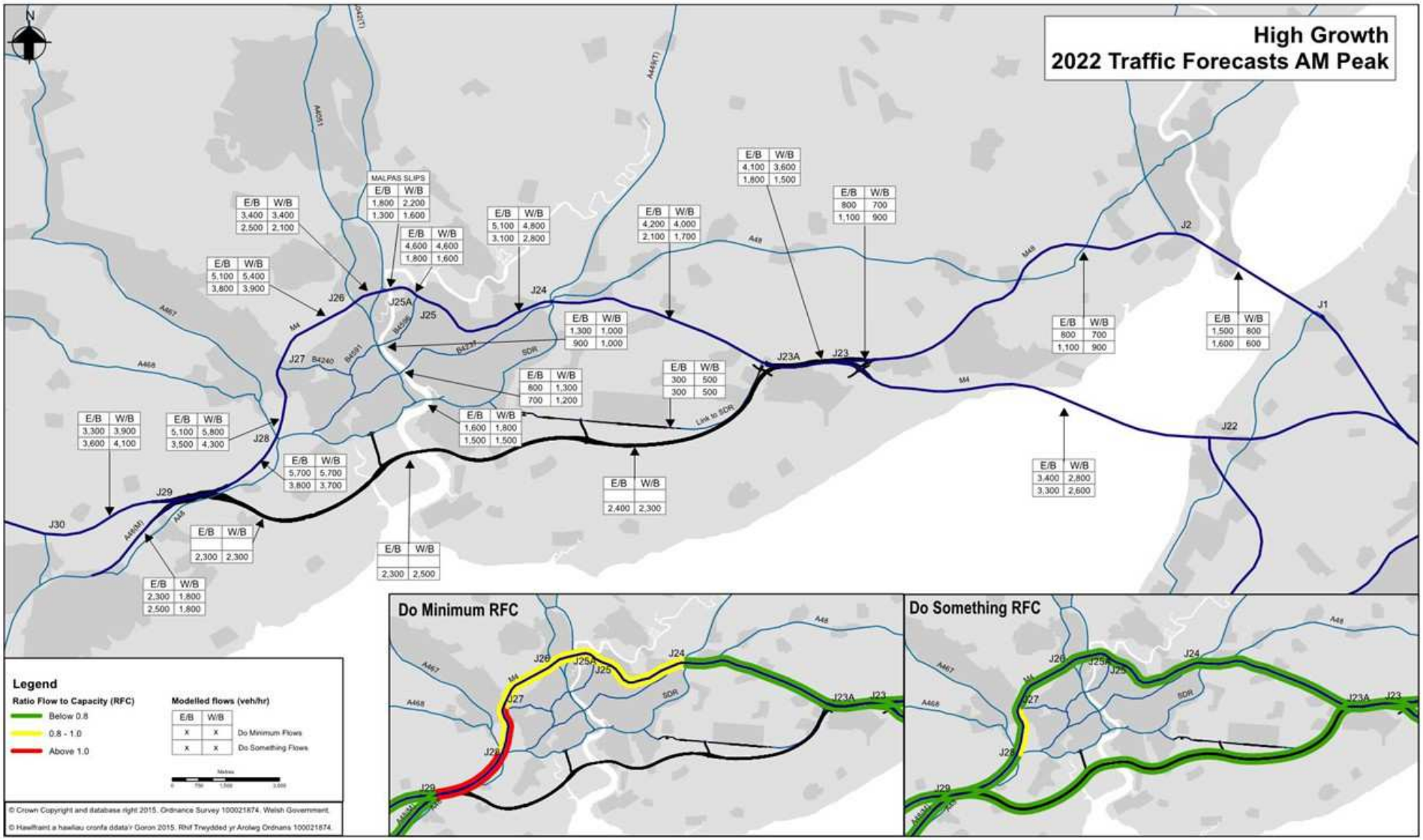


Figure E1: 2022 Forecast AM Peak Hour Traffic Flows, High Growth

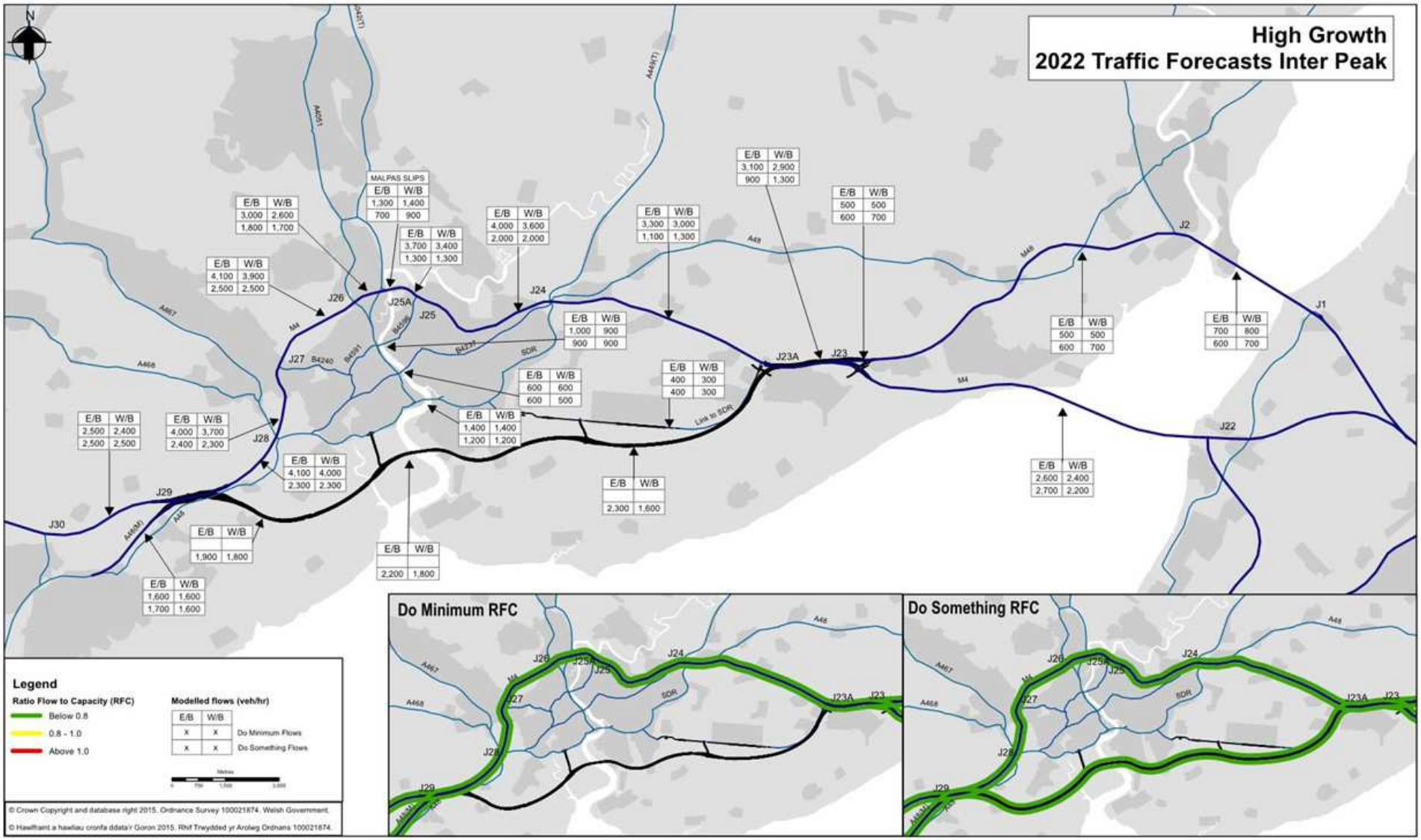


Figure E2: 2022 Forecast Inter Peak Hour Traffic Flows, High Growth

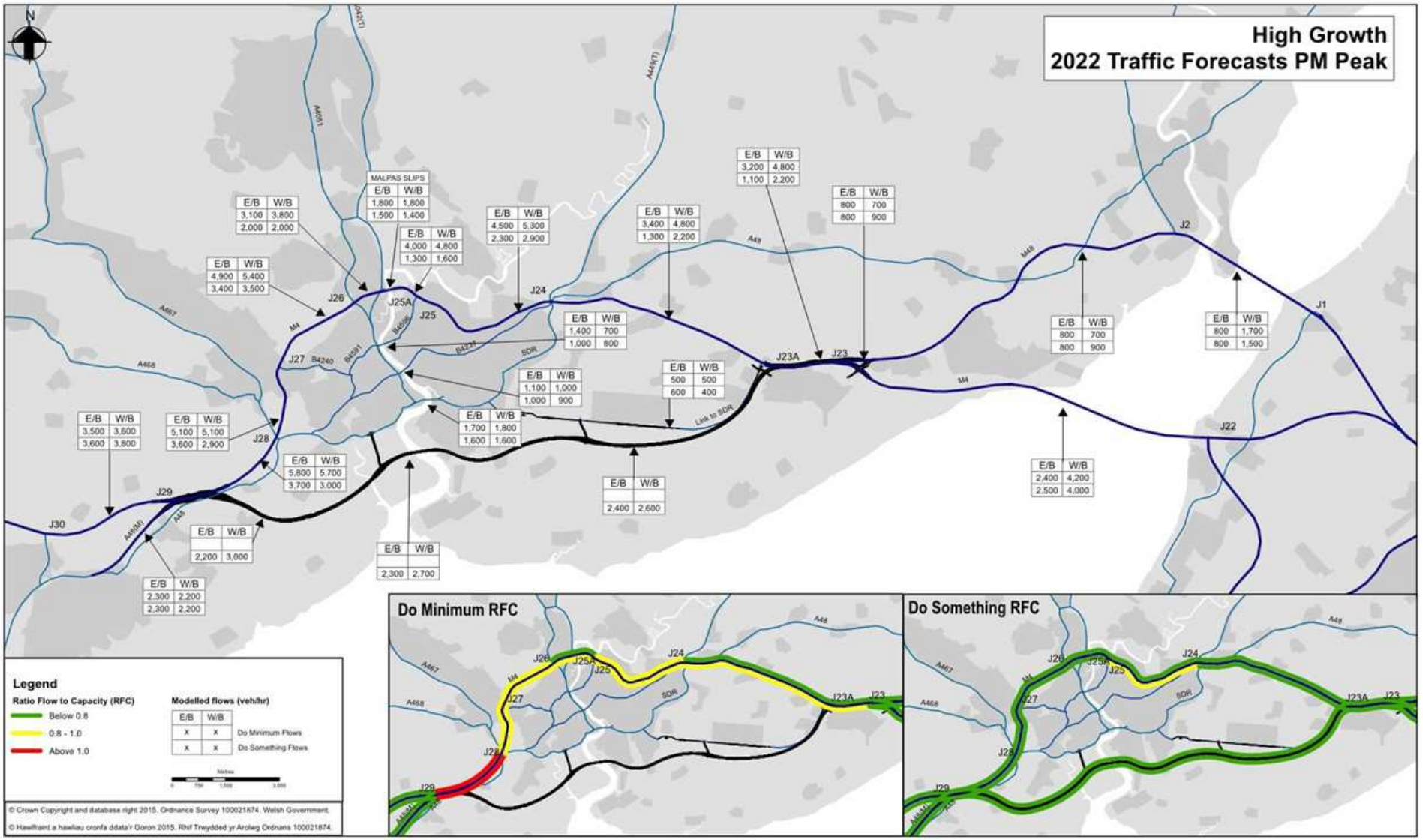


Figure E3: 2022 Forecast PM Peak Hour Traffic Flows, High Growth

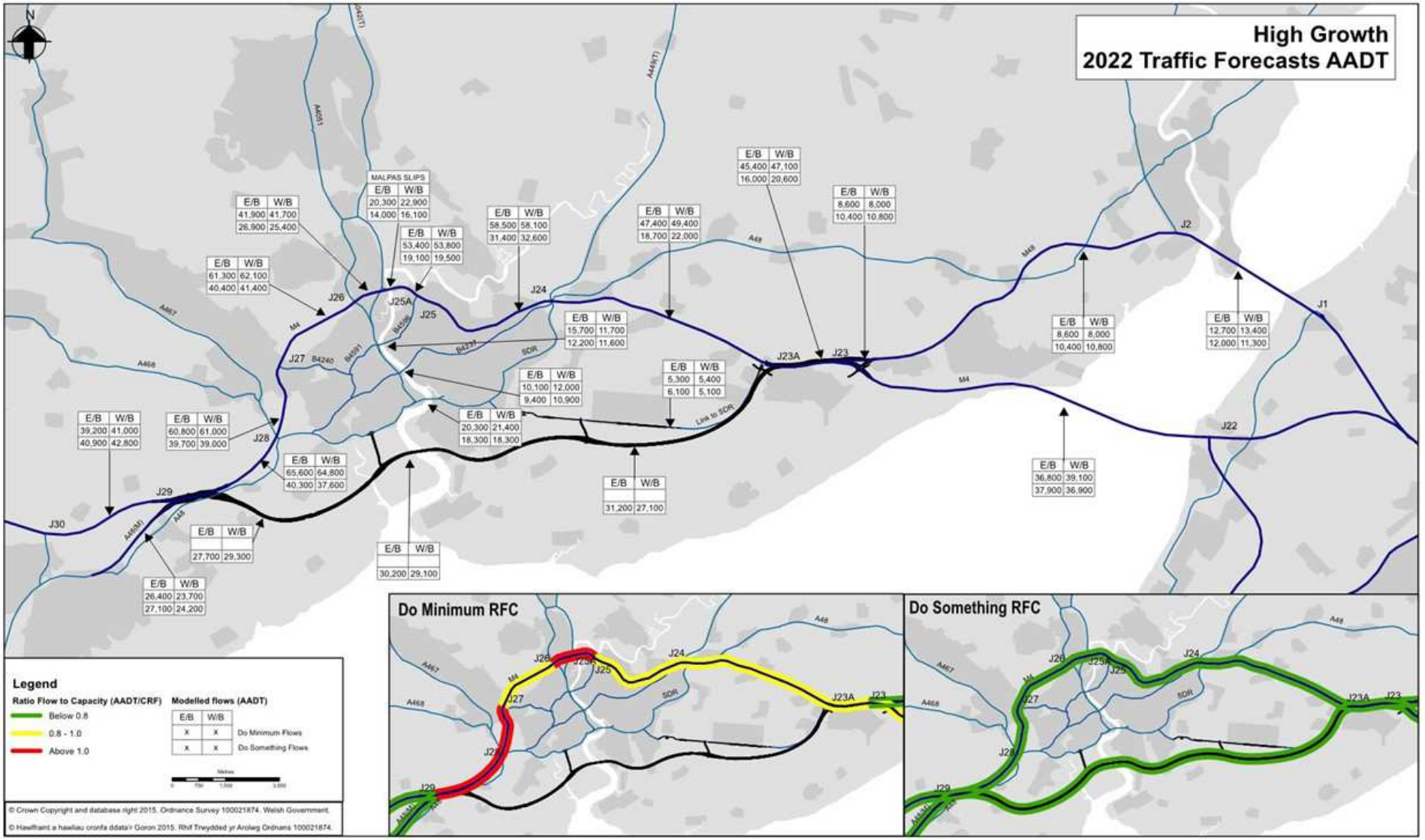


Figure E4: 2022 Forecast Annual Average Daily Traffic Flows, High Growth

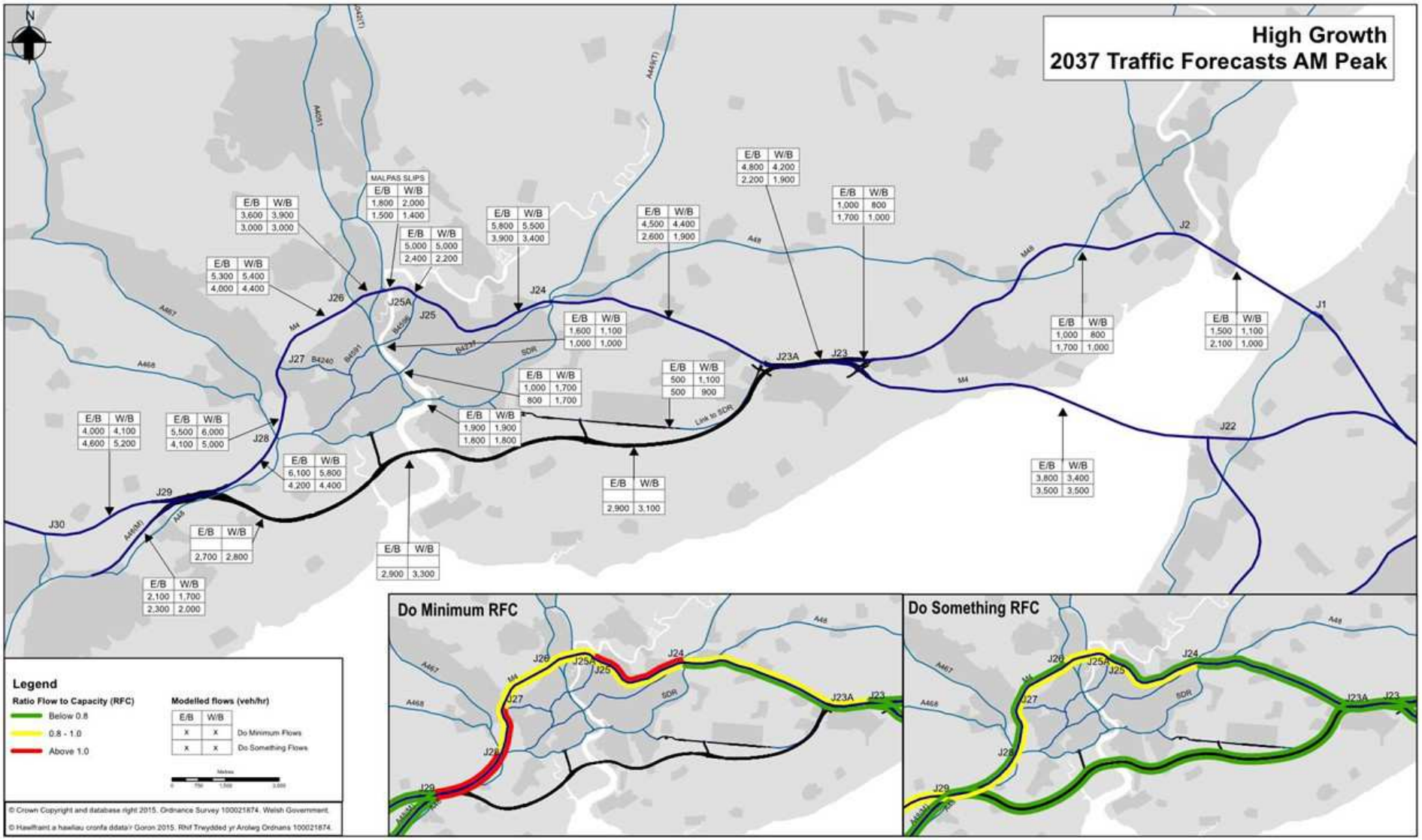


Figure E5: 2037 Forecast AM Peak Hour Traffic Flows, High Growth

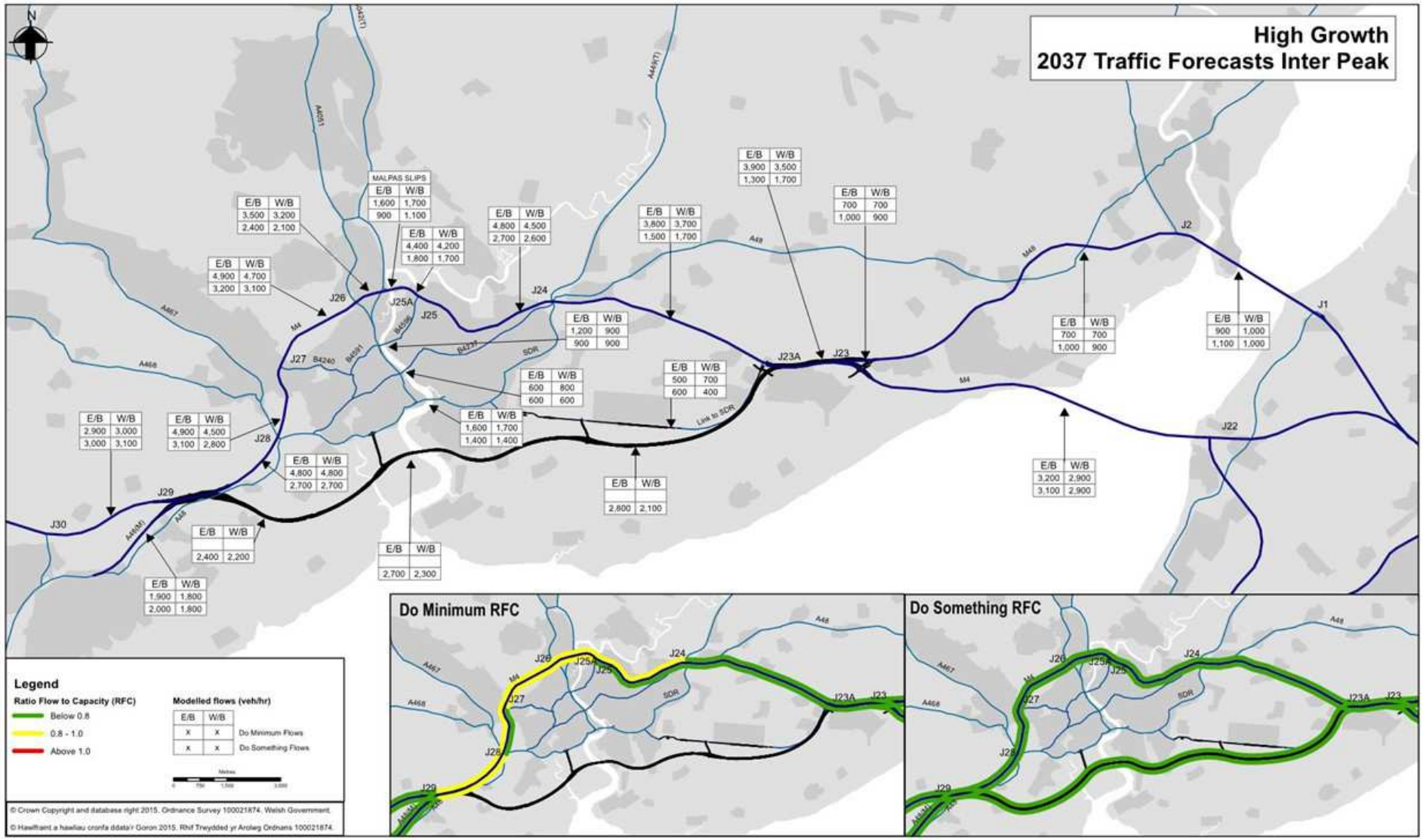


Figure E6: 2037 Forecast Inter Peak Hour Traffic Flows, High Growth

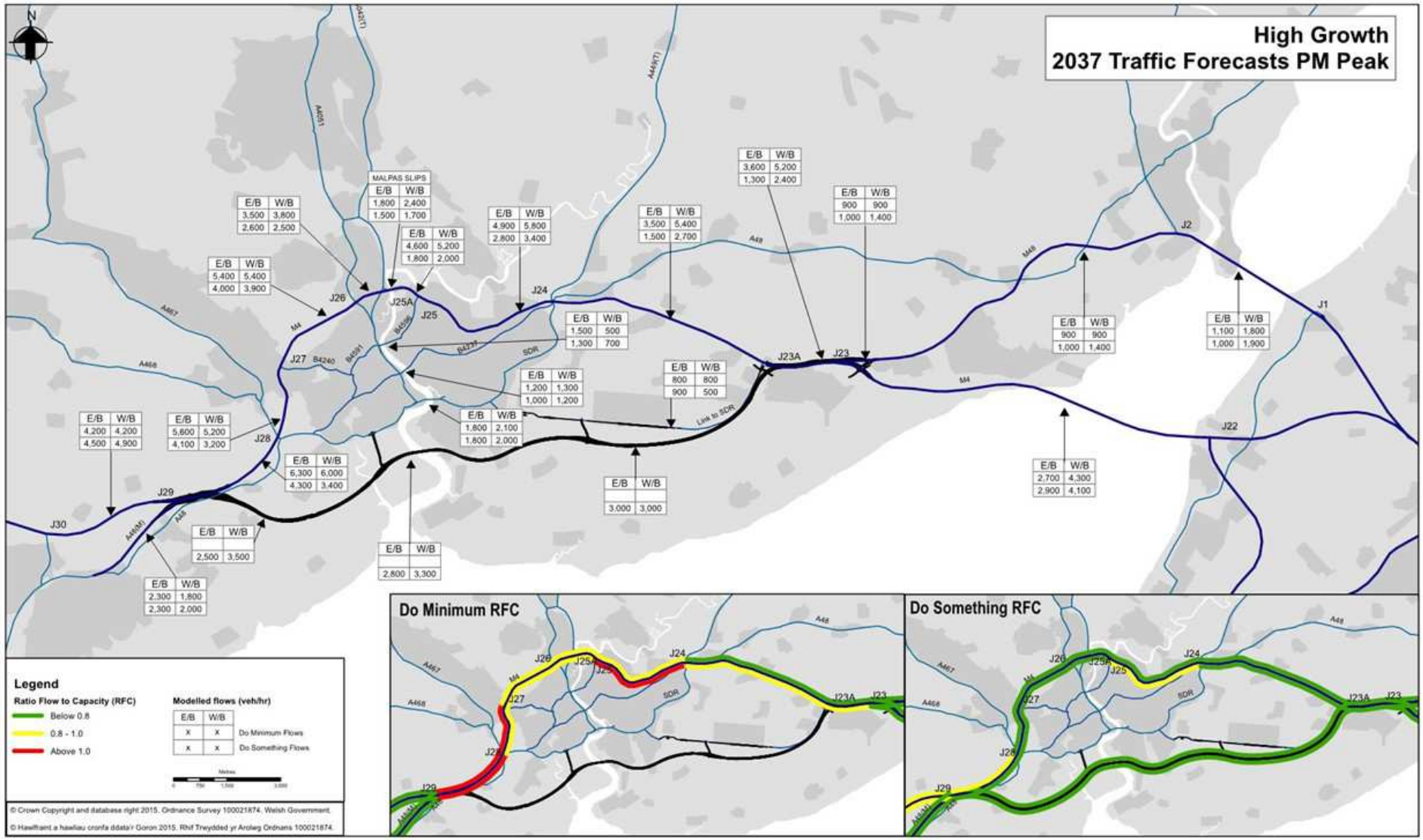


Figure E7: 2037 Forecast PM Peak Hour Traffic Flows, High Growth

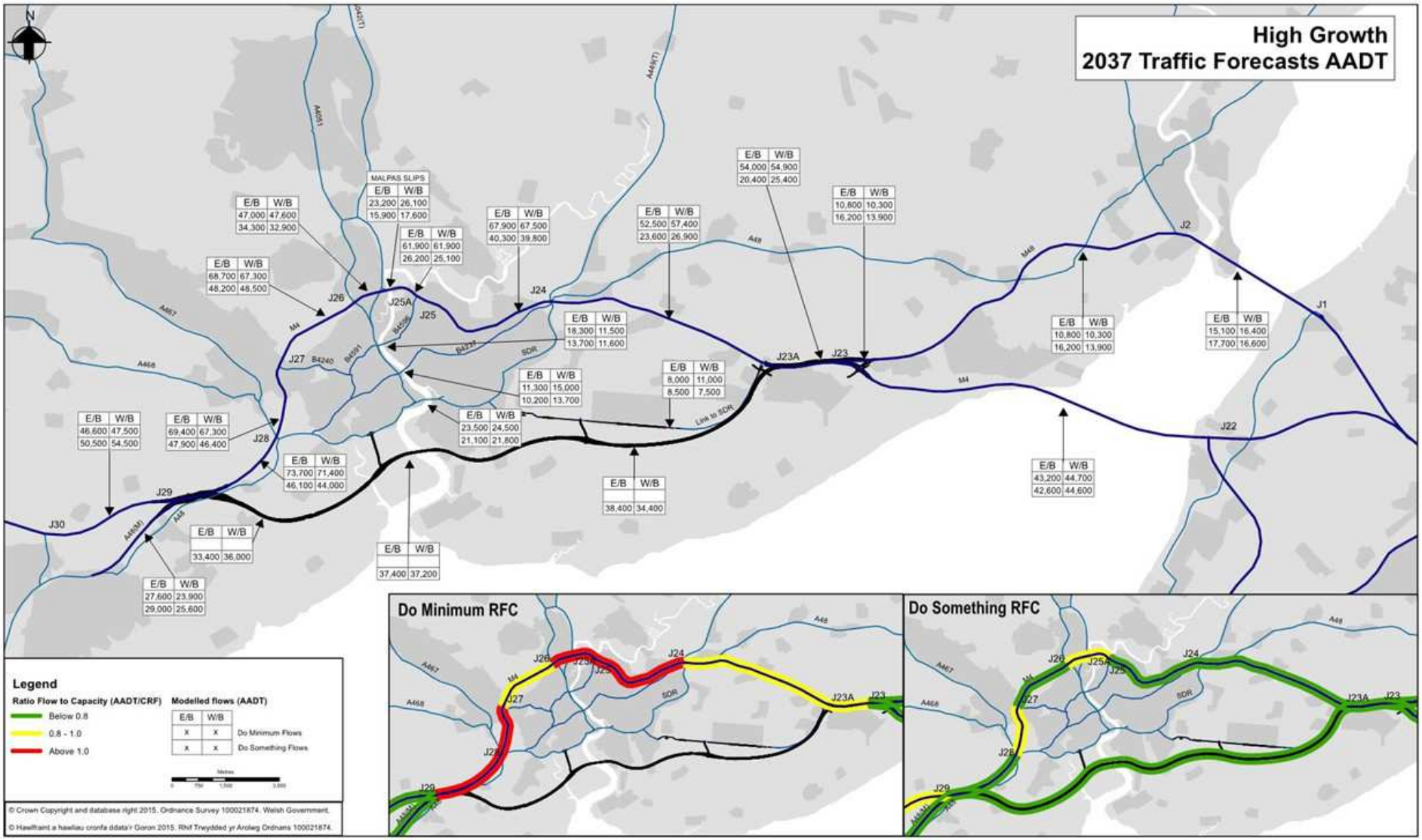


Figure E8: 2037 Forecast Annual Average Daily Traffic Flows, High Growth

E2 High Growth Journey Time Analysis

Table E1: Low Growth - Journey Time between Junction 30 and M4 Toll Plaza (min:sec)

Direction	Time	Route	2022 High Growth		2037 High Growth	
			Do Min	Do Som	Do Min	Do Som
East	AM	Via existing M4	21:19	19:30	26:12	20:49
	IP	Via existing M4	18:18	18:15	21:53	18:38
	PM	Via existing M4	19:19	18:34	22:55	19:21
	AM	Via new motorway		15:24		16:07
	IP	Via new motorway		15:07		15:48
	PM	Via new motorway		15:09		15:53
West	AM	Via existing M4	21:51	19:12	30:56	22:38
	IP	Via existing M4	17:45	17:40	19:07	18:19
	PM	Via existing M4	22:03	19:33	30:03	22:15
	AM	Via new motorway		16:10		18:10
	IP	Via new motorway		14:52		15:32
	PM	Via new motorway		16:03		17:27