The Norfolk County Council (Norwich Northern Distributor Road (A1067 to A47(T))) Order

5.7 Economic Appraisal Report

Planning Act 2008

Infrastructure Planning

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1 Key Summary

1.1.1 Funding approval for the Norwich Northern Distributor Road (NDR) was sought in 2011 through the Department for Transport's (DfT) Development Pool process. A business case was developed and submitted in accordance with the guidance in the Treasury Green Book. Ministerial decisions were made in December 2011 to award funding.

1.1.2 The NDR is a project of national significance which requires a Development Consent Order (DCO) under the Planning Act 2008.This report was prepared as part of the submission.

1.1.3 The Value for Money (VfM) and Scheme Affordability for the NDR has been re-assessed for the submission based on outputs from an updated transport model using economic parameters published by the DfT in October 2012.

1.1.4 The economic appraisal results show that the NDR is likely to deliver present value of benefits (including TUBA transport user benefits and COBA accident benefits) of £773m over a 60 year appraisal period in 2010 prices discounted to 2010. This compares with present value costs of £186m.

1.1.5 Additional benefits in relation to wider economic impacts (WEBs) and journey time reliability (JTR) amount to a further £216m in 2010 prices discounted to 2010 which improve the value for money assessment of the Scheme. The table below shows a summary of the economic appraisal results for the NDR.

	Scenario including Accidents	Scenario also including WEBS and JTR
Present Value of Benefits (PVB)	773,317	989,063
Present Value of Costs (PVC)	185,542	185,542
Net Present Value (NPV)	587,775	803,521
Benefit to Cost Ratio (BCR)	4.168	5.331

Notes: Both costs and benefits are in £'000, in 2010 prices discounted to 2010 and for a 60 year appraisal period

1.1.6 The scheme delivers a benefit-to-cost ratio (BCR) of 4.17 (inclusive of accident benefits) and a BCR of 5.33 when WEBs and JTR are included. Both of these represent very high value for money (BCR above 4) according to DfT's VfM criteria.

2 Introduction

2.1 Background

2.1.1 Mott MacDonald (MM) has been appointed by Norfolk County Council (NCC) to assist with the development and appraisal of the Norwich Northern Distributor Road, known as the NDR or referred to as the Scheme.

2.1.2 The Scheme would be a dual carriageway all-purpose strategic distributor road, to be classified as the A1270 Principal Road, which would link the A1067 Fakenham Road near Attlebridge, to the A47(T) Trunk Road at Postwick. This will be over a length of approximately 20.4km.

2.1.3 The NDR is a project of national significance which requires a Development Consent Order (DCO) under the Planning Act 2008 and this formal planning process began in early 2013. It is currently anticipated that the process will be completed in time for the NDR scheme to start construction in 2015 and to be opened in 2017.

2.1.4 This document is one of a number that support the DCO, each of which has its own unique document number, and should therefore be read in conjunction with the other documentation. The proposed layout of the NDR is shown in the General Arrangement Plans contained in document number 2.6, whilst the full needs case for the NDR is explained in the Statement of Reasons (document 4.1) and the Environmental Statement (document 6.1).

2.1.5 Funding approval for the NDR was sought in 2011 through the Department for Transport's (DfT) Development Pool process. A business case was developed and submitted in accordance with the guidance in the Treasury Green Book. Ministerial decisions were made in December 2011 to award funding.

2.1.6 For DCO submission the transport model used in 2011 was updated using fresh data collected in 2012 to comply with current DfT guidance.

2.1.7 The economic appraisal approach adopted in this work follows existing WebTAG guidance in unit 3.5. The variable demand model (VDM) forecasts, which make allowance for traffic generation, redistribution and mode choice effects arising from introduction of the scheme, have been prepared for the NDR proposed opening year of 2017 and the design year of 2032. It has been assumed in the appraisal that the benefits of the scheme do not change for each year beyond 2032 although traffic will continue to grow.

2.2 Purpose and Layout of Report

2.2.1 This report presents the economic appraisal for the NDR and focuses on the monetised impacts of the scheme. The report sets out to provide:

- An assessment of economic benefits for consumer and business users from the NDR scheme based on the VDM forecasts and the likely expenditure profile during the assessment period.
- An assessment of the scheme Value for Money (VfM) based on the VDM model outputs and the latest available scheme costs. The Guidance on Value for Money describes the criteria used to determine the VfM of various types of schemes.
- Examination of the stability and distribution of the economic assessment results so as to demonstrate that the economic appraisal is robust and reliable as required by WebTAG 3.10.4.

2.2.2 This report describes the methodology used to produce the economic appraisal using the TUBA version 1.9.1 computer program. This undertakes a matrix-based appraisal taking demand and cost matrices (time, distance and charges) from the transport model as inputs. The report describes how transport model issues highlighted by TUBA have been dealt with.

2.2.3 The report also discusses the calculation of accidents benefits, wider economic benefits and journey time reliability benefits. These comply with relevant WebTAG guidance in units 3.4.1, 3.5.14 and 3.5.7 respectively.

2.2.4 This report contains the following sections after the current introductory section:

- Section 3 – discusses the economic appraisal process followed and the assumptions that have been made;
- Section 4 – describes the derivation of scheme costs for inclusion in the economic appraisal;
- Section 5 - presents the results of the economic appraisal and discusses the levels of user benefits that are reported for the scheme;

- Section 6 – demonstrates that the economic results are robust, reliable and stable as required by WebTAG;
- Section 7 – presents results from accident benefit analysis;
- Section 8 – discusses wider economic impacts of the scheme calculated using WITA software;
- Section 9 – presents the journey time reliability assessment of the NDR scheme; and
- Section 10 – presents conclusions from the economic appraisal.

2.2.5 Supporting information is included in a number of appendices in Section 11:

- Appendix A – describes the calculation of annualisation factors adopted for the appraisal;
- Appendix B – describes in detail the TUBA setup; and
- Appendix C – documents the analysis of TUBA and COBA warnings

2.2.6 Sections 12 and 13 contain Abbreviations and Glossary.

3 Economic Appraisal

3.1 Overview

3.1.1 The transport economic appraisal has been undertaken using the TUBA (Transport Users Benefit Appraisal) program Version 1.9.1 which carries out an economic appraisal in accordance with published DfT guidance. TUBA implements elements of the Sugden method as described in Unit 3.5.3 of WebTAG and undertakes matrix-based appraisal taking trip, time, distance and toll/charge matrices from the transport model as inputs. Based on these trip and cost matrices from the traffic model, TUBA calculates user benefits discounted to the present value year (2010) and produces results for various degrees of disaggregation and summarises the outputs.

3.1.2 Assumptions for the economic appraisal including economic parameters and annualisation factors that form inputs to the TUBA economic appraisal process are discussed in Appendices A, B and C. The key assumptions that have been made in the appraisal are as follows:

- The NDR scheme will be opened in 2017 and is appraised over a 60 year period from the year of opening. User benefits of the scheme after the design year of 2032 are assumed not to grow and are subject to the normal discounting to 2010 present value year and changes to values of time (VOTs) and other economic parameters.
- The economic benefits of the NDR scheme are accrued over all days of the year (including weekends, bank holidays and overnight) although the transport model does not specifically model weekends and bank holidays. How this is done is discussed in Appendix A.
- The scheme will be developed and funded by the public sector and investment costs are subject to optimism bias of 15%.
- The economic appraisal has been carried out for a scenario that assumes the implementation of the Joint Core Strategy (JCS) plan for growth. The land use and development assumptions are consistent in the scenarios with and without the scheme intervention, termed the Do Something and Do Minimum scenarios.

- Changes in journey times and any economic benefits that are calculated are based on differences between the Do Minimum and the Do Something scenarios.

3.1.3 The main economic analysis is based on matrices from VDM assignments which makes allowance for the effects of suppressed and generated trips, destination choice, mode-choice and trip frequency. The impacts of the various demand modelling responses is considered in detail in section 6 of the Forecasting Report (Document Reference Number 5.6).

3.2 Modelling Framework

3.2.1 The Norwich Area Transportation Strategy (NATS) transport modelling framework used to assess the NDR consists of three main elements:

- Highway Traffic Model - This is a SATURN model with 413 zones with a network covering the greater Norwich area. It has a detailed simulation area covering the Norwich city urban area. The model has been validated to a 2012 base year in accordance with WebTAG unit 3.19.
- Public Transport Model - This is a VISUM public transport model covering bus and rail modes which has been developed using the guidance in WebTAG unit 3.11. The model covers the same area as the highway model plus the key rail routes into Norwich and has been calibrated to the same base year of 2012.
- Demand Model - DIADEM was used for demand modelling. The demand model is an incremental model, and is set up in Production-Attraction format as required by WebTAG unit 3.10.

3.2.2 The overall modelling framework and the individual elements of the framework have been developed to be consistent with the guidance set out in WebTAG.

3.2.3 The highway and public transport assignment models have been developed and validated for three time periods:

- AM Peak Hour (0800-0900hrs)
- Average Inter-Peak Hour (1000-1600hrs)
- PM Peak Hour (1700-1800hrs)

3.2.4 An Off-Peak model representing an average hour for the period 1900 to 0700hrs, has also been developed for the purposes of demand modelling, where costs are required for all times of the day. It should be noted that the off peak model is not a fully validated model. In terms of demand the overall levels of demand have been derived from observed counts, however there has been no flow validation at an individual link level. In terms of network performance, as the network has been calibrated for the other time periods the representation of network costs should be appropriate.

3.2.5 The NATS transport model is described in the Highway Local Model Validation Report (LMVR) of December 2013 (Report Reference Number 5.9) and in the Public Transport Local Model Validation Report, dated December 2013 (Report Reference Number 5.10). The traffic forecasts and demand modelling that form the basis of this economic appraisal are presented in the NDR Forecasting Report dated December 2013 (Report Reference Number 5.6).

3.3 Do Minimum Assumptions

3.3.1 A Do Minimum (DM) scenario is required as a reference upon which to assess the economic effects of the proposed scheme intervention. As such it includes schemes and measures that will be implemented between 2012 (the model base year) and 2017 to the existing transport system classified as 'near certain' or 'more than likely' in accordance with TAG Unit 3.15.5. Thus, the DM includes:

- Network changes - junction improvements, pedestrian improvements and traffic management and safety schemes within Norwich.
- Public transport changes - it is assumed that the public transport network remains as it is in the base year. Assumptions have been made in terms of how bus and rail fares change in the future. Overall, it should be noted that there are no major changes to the public transport network in the Do Minimum.
- Future housing and business developments
- Reference traffic growth based on DfT's data contained in TEMPRO using NTEM dataset 6.2 and RTF 2013.

3.3.2 A full description of the Do Minimum including location plans of Do Minimum transport schemes is given in the Forecasting Report.

3.4 Do Something Network

3.4.1 The Do Something (DS) scenario represents a scenario with the NDR dual carriageway from the A1067 to the north west of Norwich to the A47(T) east of Norwich at Postwick junction, and associated complementary traffic management measures. More specifically the DS includes:

- The preferred route option for the NDR consisting of a dual carriageway all-purpose strategic distributor road, which would link the A1067 Fakenham Road, near Attlebridge to the junction with the A47 (T) at Postwick. The total length of the NDR is approximately 20.4km.
- Upgrade of the A47(T) Postwick Trunk Road junction and access improvements to Postwick Park and Ride site.
- City Centre changes - complementary traffic management measures proposed for Norwich city centre, with the aim of discouraging through car trips and reducing the dominance of traffic.
- Traffic management measures at three locations to address local transport issues that arise with NDR.
- Public transport – there are no changes proposed between the DM and DS.

3.4.2 These are the measures that, together, are assessed in this economic appraisal. The impact of the NDR is, of course, by far the dominant factor. These measures represent the DS scenario.

3.4.3 A full description of the DS scenario including location plans of DS schemes is given in the Forecasting Report.

3.5 Delays during Construction and Maintenance

3.5.1 Delays during construction have not been calculated as the scheme is off line and therefore its construction would not have a major impact on the operation of the existing highway network. At locations where the scheme ties in to the existing highway network, construction sequences will be planned to minimise disruption to the existing network.

3.5.2 Delays during maintenance have not been assessed as the scheme provides more capacity in the network, and it is considered that the delays would be small.

3.6 NDR Scheme Costs

3.6.1 Base costs for construction, land, preparation, supervision, road maintenance and operation, including an allowance for risk were provided by Norfolk County Council (NCC) together with spend profiles. These costs have been modified for economic appraisal in line with WebTAG guidance, as described later in Chapter 4.

3.7 NDR Scheme Analysis of Monetised Costs and Benefits

3.7.1 The analysis of monetised costs and benefits compares the monetised costs of the scheme against the benefits of the scheme over a 60 year appraisal period. This takes into account the following costs and benefits:

- Construction costs
- Maintenance costs
- Operating costs
- Supervision costs
- Time savings
- Vehicle operating cost savings
- Private sector provider benefits
- Greenhouse gases benefits
- User charges (e.g. parking charges)
- Accidents

3.7.2 A number of metrics are then calculated to demonstrate the value of the scheme. These are the:

- Net Present Value (NPV) – the net set of all benefits and costs
- The Benefit to Cost Ratio (BCR) – The ratio of the Present Value of Benefits (PVB) to the Present Value of Costs (PVC).

3.8 Value for Money Criteria

3.8.1 The DfT Value for Money appraisal includes benefits and costs that can be counted in monetary terms. Under the DfT guidance, a project is generally considered to be:

- Poor VfM if BCR is less than 1
- Low VfM if BCR is between 1 and 1.5
- Medium VfM if BCR is between 1.5 and 2
- High VfM if BCR is between 2 and 4
- Very High VfM if BCR is greater than 4

3.8.2 The Value for Money Assessment includes the transport user appraisal, accident benefits and wider impacts of the scheme that include wider economic benefits and journey time reliability benefits.

3.8.3 We have also assumed in this appraisal that user benefits do not change beyond 2032 due to continued traffic growth beyond the design year – all changes in benefits only relate to discounting, value of time changes and other economic parameter changes. A less conservative approach that allowed for some growth in user benefits (in line with growth between the opening year and design year, for example) would significantly improve the BCR and VfM assessment.

4 Scheme Costs for Economic Appraisal

4.1 Scheme Costs

4.1.1 Total scheme costs sub divided by construction, land, preparation and supervision during construction were provided by the Norfolk County Council (NCC). These consisted of base costs and an allowance for risk calculated from a Quantitative Risk Assessment (QRA). All costs were presented in 2013 Quarter 1 prices.

4.1.2 Preparation costs that have already been incurred are considered to be sunk costs and therefore do not form part of the appraisal.

4.1.3 Land costs from years 2007/08 and 2012/13 are considered to be recoverable and therefore have been included in the economic appraisal. Land costs include an allowance for potential Part 1 claims.

4.1.4 A summary of scheme costs is provided in Table 4.1. For input to the economic appraisal these costs need to be adjusted to:

- Convert from financial year to calendar year
- Take into account construction inflation
- Reflect Optimism Bias

4.1.5 These processes are discussed in further detail below.

4.2 Conversion from Financial Year to Calendar Year

4.2.1 Information provided by NCC is by financial year whereas TUBA requires input by calendar year. Costs have been converted to calendar year by assuming that costs are distributed evenly throughout the year, for example 2015 costs consist of 25% of 2014/2015 costs and 75% of 2015/2016 costs.

4.2.2 The resulting costs in calendar years are shown in Table 4.2.

4.3 Adjustment for Construction Inflation

4.3.1 Construction inflation has been assessed at 2% per annum for the years 2013 to 2018. The use of 2% has been agreed with the County Council's appointed contractor Birse Civils and is considered appropriate for the following reasons:

- Construction inflation has probably peaked;
- Due to overall market conditions Birse Civils are finding it easier to negotiate with their supply chain to obtain discounts;
- Ability to use the buying power of a large organisation to obtain best value supply chain orders will also reduce our exposure to increased costs (Birse Civils is part of Balfour Beatty);
- There are number of inflation related risk allowances already included within the budget.

4.3.2 Building Cost Information Service (BCIS) and other relevant construction inflation indices show forecast construction inflation to be at a lower level than forecast background inflation from RPI over the 2013 to 2017 period. RPI forecasts for above period can be found in Table M3: Medium Term Forecasts for CPI and RPI, HM Treasury Document, Forecasts for the UK economy: a comparison of independent forecasts, August 2013.

4.3.3 As forecast construction inflation is less than the forecast of RPI, scheme costs for input to TUBA need to be adjusted by a constant price adjustment factor. The derivation of the constant price adjustment factor is shown in Table 4.3.

4.3.4 The constant price adjustment factor is applied to Construction costs, (including risk). They are not applied to land, preparation and supervision costs. The resultant scheme costs after the application of the constant price adjustment factor are included in Table 4.4 and Table 4.5.

4.4 Application of Optimism Bias

4.4.1 For the Best and Final Funding Bid submission in September 2011 an Optimism Bias of 20% was employed. For this submission a lower Optimism Bias of 15% has been adopted to reflect the further development that has been completed since September 2011. This is considered to be justified as the level of uncertainty has reduced as a result of the following:

- Detailed design of Postwick A47(T) Junction Improvement has been completed and a corresponding provisional target costing has been received from Birse Civils and this has been reviewed.

- Planning Permission for Postwick A47(T) Junction Improvement has been reconfirmed and the Orders have been the subject of a Public Inquiry in July 2013, though the outcome is still awaited.
- Design development for the remainder of the NDR scheme has since been progressed to a more advanced stage and Birse Civils have revised the budget costing accordingly. This has followed further public consultation in the summer 2013.
- Previous higher value risk items in relation to ground conditions, environmental aspects and utilities have all reduced significantly as a result of the ongoing Early Contractor Involvement (ECI) process and further surveys and investigations.

4.4.2 In addition the scheme is at order publication stage hence an optimism bias of 15% is recommended by Table 9 of WebTAG 3.5.9.

4.4.3 Optimism Bias has not been applied to land costs up to 2013 as these costs have already been expended. Final costs for inclusion in TUBA are presented in Table 4.6.

4.4.4 Central government funding for the scheme is £86.5m while the rest is funded by local government.

4.5 Maintenance Costs

4.5.1 Annual Maintenance Costs were reviewed in detail by the NCC for the DCO submission and assumed a constant profile over the 60 years appraisal period. Road maintenance costs have been assumed to increase in line with retail price inflation and therefore no construction price adjustment factors have been applied. Optimism bias has been applied at 15%, the same rate as applied to construction costs, and is considered to be appropriate following the detailed review of costs that was undertaken. All prices are in 2013 Quarter 1 prices. The assumed maintenance costs are shown in Table 4.7.

4.6 Operating Costs

4.6.1 Operating costs associated with the scheme have been split into:

- Landscaping costs
- Street lighting costs
- Structures Maintenance costs

4.6.2 Annual Operating Costs were provided by the NCC and assumed a constant profile over the 60 years appraisal period. WebTAG 3.5.9 states that there is currently insufficient evidence available to recommend any specific optimism bias uplifts for operating costs. In the absence of such guidance NCC's forecasts reflect the best possible estimate of operating costs. Therefore optimism bias has not been applied to operating costs. All costs have been provided in 2013 Quarter 1 prices. Table 4.8 shows the profile of operating costs received from the Norfolk County Council.

Table 4.1: Scheme Costs (£'s 2013 Q1 Prices)

Cost Item	Cost Expenditure Profile by year (£)										Total Item Cost (£)
	07/08	09/10	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	
Construction											
Base			1,687,135	19,254,233	19,286,914	53,913,587	9,207,016	552,500			103,901,385
Risk			140,028	1,169,030	1,012,073	3,440,812	589,146				6,351,089
Subtotal			1,827,163	20,423,263	20,298,987	57,354,399	9,796,162	552,500			110,252,474
Land											
Base	382,000	473,850	264,848	1,294,000	6,348,536	1,735,214	5,815,000	1,725,000	3,400,000	600,000	22,038,448
Preparation											
Base			5,144,346	2,221,545	297,358	102,000					7,765,249
Supervision											
Base			50,000	531,250	276,250	212,500	212,500				1,282,500
Total											141,338,671

Source: Norfolk County Council

Table 4.2: Scheme Costs by Calendar Year (£'s 2013 Q1 Prices)

Cost Item	Cost Expenditure Profile (£) by year													Total Item Cost (£)
	2007	2008	2009	2010	2013	2014	2015	2016	2017	2018	2019	2020	2021	
Construction														
Base					1,265,351	14,862,459	19,278,744	45,256,919	20,383,659	2,716,129	138,125			103,901,385
Risk					105,021	911,780	1,051,312	2,833,627	1,302,063	147,287				6,351,089
Subtotal					1,370,372	15,774,238	20,330,056	48,090,546	21,685,721	2,863,416	138,125			110,252,474
Land														
Base	286,500	95,500	355,388	118,463	198,636	1,036,712	5,084,902	2,888,545	4,795,054	2,747,500	2,981,250	1,300,000	150,000	22,038,448
Preparation														
Base					3,858,260	2,952,245	778,405	150,840	25,500					7,765,249
Supervision														
Base					37,500	410,938	340,000	228,438	212,500	53,125				1,282,500
Total														141,338,671

Table 4.3: Calculation of Constant Price Adjustment Factor

	2012	2013	2014	2015	2016	2017	2018	2019
Construction cost increase (p.a.)		2%	2%	2%	2%	2%	2%	2%
RPI increase (p.a.)		3.2%	2.8%	3.2%	3.6%	3.9%	4.0%	4.0%
Cumulative adjustment factor (construction cost)		1.020	1.040	1.061	1.082	1.104	1.126	1.149
Cumulative adjustment factor (RPI)		1.032	1.061	1.094	1.133	1.177	1.224	1.273
Constant price adjustment factor		0.988	0.981	0.970	0.955	0.938	0.920	0.902

Table 4.4: Scheme Costs after Adjustment for Construction Inflation (£'s 2013 Q1 Prices)

Cost Item	Cost Expenditure Profile by year (£)													Total Item Cost (£)
	2007	2008	2009	2010	2013	2014	2015	2016	2017	2018	2019	2020	2021	
Construction														
Base					1,250,638	14,575,323	18,695,505	43,230,825	19,115,044	2,498,103	124,595			
Risk					103,800	894,164	1,019,507	2,706,769	1,221,026	135,464				
Subtotal					1,354,438	15,469,487	19,715,012	45,937,594	20,336,070	2,633,567	124,595			105,570,763
Land														
Base	286,500	95,500	355,388	118,463	198,636	1,036,712	5,084,902	2,888,545	4,795,054	2,747,500	2,981,250	1,300,000	150,000	22,038,448
Preparation														
Base					3,858,260	2,952,245	778,405	150,840	25,500					7,765,249
Supervision														
Base					37,500	410,938	340,000	228,438	212,500	53,125				1,282,500
Total														136,656,960

Table 4.5: Summary Scheme Costs after Adjusting for Construction Price Inflation (£'s 2013 Q1 Prices)

	2007	2008	2009	2010	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Construction (C)					1,354,438	15,469,487	19,715,012	45,937,594	20,336,070	2,633,567	124,595			105,570,763
Land (L)	286,500	95,500	355,388	118,463	198,636	1,036,712	5,084,902	2,888,545	4,795,054	2,747,500	2,981,250	1,300,000	150,000	22,038,448
Preparation (P)					3,858,260	2,952,245	778,405	150,840	25,500					7,765,249
Supervision (S)					37,500	410,938	340,000	228,438	212,500	53,125				1,282,500
Total														136,656,960

Table 4.6: Summary Scheme Costs after Adjusting for Optimism Bias (£'s 2013 Q1 Prices)

	2007	2008	2009	2010	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Construction (C)					1,557,603	17,789,910	22,672,264	52,828,233	23,386,481	3,028,602	143,284			121,406,378
Land (L)	286,500	95,500	355,388	118,463	228,431	1,192,219	5,847,637	3,321,826	5,514,312	3,159,625	3,428,438	1,495,000	172,500	25,215,838
Preparation (P)					4,436,998	3,395,082	895,165	173,465	29,325					8,930,036
Supervision (S)					43,125	472,578	391,000	262,703	244,375	61,094				1,474,875
Total														157,027,127

Notes: For the purpose of entering into TUBA 2007-2010 land costs were included in for year 2013

Table 4.7: Maintenance Costs

	Cost (£'s) 2013 Q1 prices
Annual maintenance cost	452,850
Maintenance cost over appraisal period before optimism bias	27,771,023
Maintenance cost over appraisal period after optimism bias	31,936,677

Source: Norfolk County Council

Table 4.8: Operating Costs

	Cost (£'s) 2013 Q1 prices
Landscaping annual operating cost	180,940
Structures annual operating cost	72,717
Streetlighting annual operating cost	10,982
Total annual operating cost	264,639
Operating cost over appraisal period	15,878,344

Source: Norfolk County Council

5 Economic Appraisal Results

5.1 Overview

5.1.1 The economy objective identified within WebTAG is concerned with improving the economic efficiency of transport and the efficiency of economic activities, with the key aim of supporting sustainable economic activity and returning good value for money. It considers the following three sub-objectives:

- To improve transport economic efficiency for business users and transport providers;
- To improve transport economic efficiency for consumer users;
- To get good value for money in relation to impacts on public accounts;

5.2 Transport Economic Efficiency (TEE)

5.2.1 The results of the assessment of user benefits and user charges are shown in the TEE table of TUBA output file which is presented in Table 5.1. All values quoted are in 2010 prices, discounted to 2010. The TEE table shows that the NDR scheme achieves total transport economic efficiency benefits of about £700m in the 60 year assessment period.

5.2.2 The results of the Transport Economic Efficiency assessment, show significant efficiency benefits for all trip purposes. Business trips, constitute the highest proportion of the reported user benefits.

Table 5.1: Transport Economic Efficiency (TEE)

Item	Benefit (£000s)
Consumer - Commuting user benefits	
Travel Time	61,783
Vehicle operating costs	-13,532
User charges	2,912
During Construction & Maintenance	0
NET CONSUMER - COMMUTING BENEFITS	51,164
Consumer - Other user benefits	
Travel Time	300,588
Vehicle operating costs	-115,467
User charges	195,502
During Construction & Maintenance	0
NET CONSUMER - OTHER BENEFITS	380,623
Business Impacts	
Travel Time	406,852
Vehicle operating costs	-21,768
User charges	2,669
During Construction & Maintenance	0
Sub Total	387,753
Private Sector Provider Impacts	
Revenue	-119,956
Operating costs	0
Investment costs	0
Grant/subsidy	0
Sub Total	-119,956
Other business Impacts	
Developer contributions	0
NET BUSINESS IMPACT	267,797
TOTAL	
Present Value of Transport Economic Efficiency Benefits (TEE)	699,584

Notes: All monetary values are expressed in 2010 prices discounted to 2010

5.3 Public Accounts

5.3.1 Table 5.2 below provides the public accounts summary in 2010 prices discounted to 2010. This shows that the local authority revenues reduce,

which occurs as a result of changes in car parking and P&R revenues. The Scheme results in an increase in road travel and hence there is an increase in indirect tax revenues to central Government. As mentioned before part of the investment costs of the scheme is funded by the central Government and the rest is funded by the NCC.

Table 5.2: Summary of Public Accounts

Item	Cost (£000s)
Local Government Funding	
Revenue	28,834
Operating Costs	17,806
Investment Costs	62,333
Developer Contributions	0
Grant/Subsidy Payments	0
NET IMPACT	108,974
Central Government Funding: Transport	
Revenue	0
Operating costs	0
Investment costs	76,568
Developer Contributions	0
Grant/Subsidy Payments	0
NET IMPACT	76,568
Central Government Funding: Non-Transport	
Indirect Tax Revenues	-55,270
TOTALS	
Broad Transport Budget	185,542
Wider Public Finances	-55,270

Notes: All monetary values are expressed in 2010 prices discounted to 2010.

5.4 Analysis of Monetised Costs and Benefits

5.4.1 Table 5.3 presents the analysis of monetised costs and benefits.

Table 5.3: Analysis of Monetised Costs and Benefits

Item	Accidents included (£000)
Accidents (not assessed by TUBA)*	41,219
Greenhouse Gases**	-22,756
Economic Efficiency: Consumer Users (Commuting)	51,164
Economic Efficiency: Consumer Users (Other)	380,623
Economic Efficiency: Business Users and Providers	267,797
Wider Public Finances (Indirect Taxation Revenues)	55,270
Present Value of Benefits (PVB)	773,317
Broad Transport Budget Present Value of Costs (PVC)	185,542
OVERALL IMPACTS	
Net Present Value (NPV)	587,775
Benefit to Cost Ratio (BCR)	4.168

Notes: All monetary values are expressed in 2010 prices discounted to 2010
* The lower conservative accident benefit is included based upon the use of local accident data, as explained in section 7.
* *Greenhouse gas impacts were calculated using TUBA1.9.2 since there was a bug in TUBA 1.9.1

5.4.2 The results show that the Present Value of Benefits (PVB) is estimated to be £773m (inclusive of accident benefits), outweighing the £186m Present Value of Costs (PVC).

5.4.3 The Benefit Cost Ratio (BCR) of the scheme is 4.17 including accidents. Under the DfT's value for money criteria, this represents a Very High value for money category.

5.5 Inclusion of Wider Benefits

5.5.1 The BCR is improved further to 5.33 once journey time reliability benefits (£28m) and wider economic benefits (£187m) are included in the appraisal as can be seen from Table 5.4 below. More details on wider economic impacts and journey time reliability can be found in Sections 8 and 9 respectively. These additional benefits amount to £216m (2010 prices discounted to 2010). The inclusion of these benefits increases the BCR to a higher level within the Very High value for money category.

Table 5.4 Summary of Economic Appraisal including Wider Benefits

Item	Scenario including Accidents	Scenario also including WEBS and JTR
Present Value of Benefits (PVB)	773,317	989,063
Present Value of Costs (PVC)	185,542	185,542
Net Present Value (NPV)	587,775	803,521
Benefit to Cost Ratio (BCR)	4.168	5.331

Notes: All monetary values are in £000's and expressed in 2010 prices discounted to 2010

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6 Analysis of User Benefits and Robustness of the Economic Appraisal

6.1 Total User Benefits by Time Period

6.1.1 Table 6.1 shows total user benefits by time period. This shows that the NDR scheme has a large impact on all time periods. The NDR will provide significant benefits to traffic movements in the inter peak as well as peak periods. The ratio of benefits per hour is about half in the inter peak compared with the AM peak and in the PM peak (2 hours) the benefits are little lower than the AM peak. Therefore the profile of the benefits matches expectations for a scheme such as NDR. The detailed annualisation is discussed in Appendix A.

Table 6.1: Total User Benefit by Time Period

Time Period	Annualisation	Total User Benefit (£m)
Weekday AM	246	77.8
Weekday PM	481	122.8
Weekday Inter Peak	2,298	333.5
Weekday Off Peak	3,056	80.6
Weekend (all hours)	3,667	204.9

Notes: All monetary values are expressed in 2010 prices discounted to 2010

6.1.2 Weekend benefits are derived from outputs from both the off peak and inter peak models. The allocation of weekend hours to the inter peak and off peak modelled time periods is presented in Appendix A.

6.2 Geographical Sectorisation of User Benefits

6.2.1 In order to confirm that the distribution/location of user benefits for the NDR is sensible and that the economic user benefits of the scheme are reliable and robust, a sector-to-sector analysis of user time benefits has been carried out. In order to do this Norwich and the surrounding areas covered by the transport model were split into 15 geographical sectors as shown in Figure 6.1 below.

6.2.2 Sectors 3, 4, 6, 8 and 11 are in the vicinity of the scheme and would naturally be expected to see significant beneficial impacts resulting from the scheme. In addition to these sectors that are close to the scheme, longer distance movements, would also have significant beneficial impacts on sectors 4, 991, 992, 994 and to a lesser extent sector 993.

6.2.3 Table 6.2 below shows the full breakdown of benefits by sector-to-sector movement. This confirms that trips from the key sectors identified above account for the vast proportion of benefits of the NDR scheme. Trips within these key areas account for about 85% of the benefits of the scheme. The other 15% (shaded in grey) is spread fairly evenly over the rest of the sector-sector movements.

6.2.4 The centre of Norwich city is subject to traffic management and control measures which are reflected in the totals of time benefits associated with movements from Sector 1.

6.2.5 There are no significant user benefits reported for movements that are well away from the scheme. This, together with the set of observations above, would appear to confirm that any impacts of model noise on reported user benefits is minimal and that the economic results presented are both robust and reliable.

Figure 6.1: Sectors for Analysis of Economic Benefits

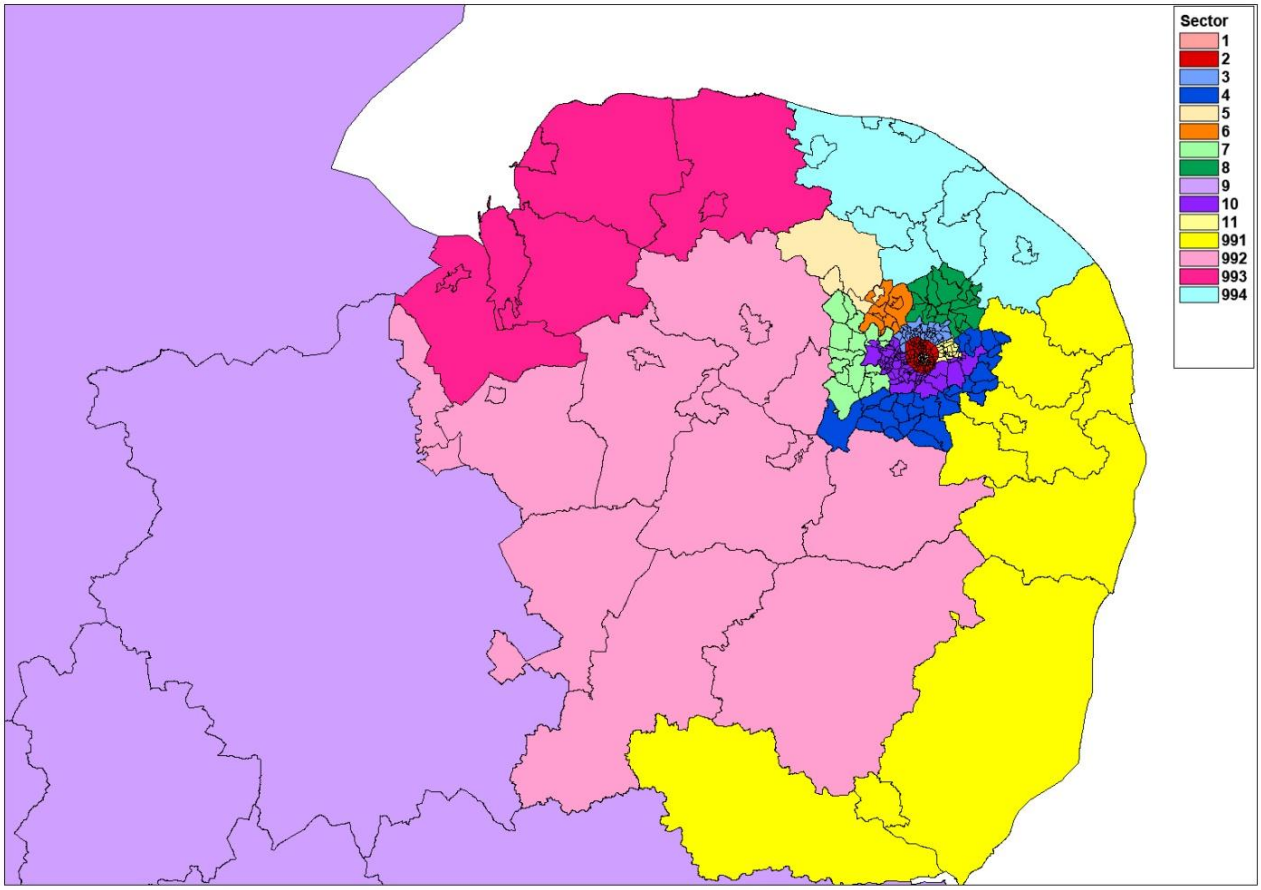


Table 6.2: Sector-to-sector Proportion (%) of Total Time Benefits

	Destination Sector															
Origin Sector	1	2	3	4	5	6	7	8	9	10	11	991	992	993	994	Grand Total
1	-1.0%	-1.3%	-1.1%	-0.4%	-0.1%	-0.1%	1.3%	0.3%	0.3%	0.3%	-0.8%	-1.4%	0.5%	0.0%	-0.2%	-3.6%
2	-1.0%	-0.7%	0.6%	-0.2%	0.1%	-0.1%	0.0%	1.0%	0.3%	0.4%	-0.4%	-0.8%	0.4%	0.4%	0.7%	0.7%
3	-0.5%	1.2%	1.1%	1.0%	0.4%	0.5%	1.1%	0.6%	1.2%	1.7%	0.6%	2.6%	2.6%	1.6%	-0.1%	15.4%
4	0.0%	0.0%	1.1%	0.1%	0.2%	0.9%	0.1%	0.9%	0.0%	0.2%	-0.3%	-0.2%	0.2%	0.2%	1.1%	4.4%
5	-0.1%	0.1%	0.4%	0.2%	0.0%	0.0%	0.0%	0.3%	0.0%	0.2%	0.5%	1.6%	0.0%	0.0%	0.1%	3.3%
6	-0.1%	0.1%	0.3%	1.0%	0.0%	0.0%	0.3%	0.7%	0.1%	0.8%	0.7%	5.5%	0.4%	0.1%	0.3%	10.1%
7	0.3%	0.1%	0.9%	0.2%	0.0%	0.2%	0.1%	1.0%	0.0%	0.1%	-0.5%	0.0%	0.1%	0.0%	0.9%	3.5%
8	0.3%	1.3%	1.3%	1.3%	0.3%	0.8%	1.2%	0.3%	0.5%	2.7%	1.1%	1.8%	2.2%	0.5%	0.2%	15.9%
9	0.7%	0.1%	0.9%	0.0%	0.0%	0.1%	0.0%	0.5%	0.0%	0.0%	-0.6%	0.0%	0.0%	0.0%	0.2%	1.8%
10	0.6%	0.4%	1.8%	0.2%	0.2%	0.7%	0.0%	2.5%	0.1%	0.2%	-0.5%	-0.3%	0.2%	0.4%	2.0%	8.5%
11	0.1%	0.4%	0.8%	-0.1%	0.6%	0.8%	0.2%	1.2%	0.1%	0.3%	0.1%	-0.4%	0.4%	0.4%	1.4%	6.4%
991	-0.5%	0.0%	2.6%	-0.1%	1.0%	3.7%	-0.1%	1.1%	-0.2%	-0.1%	-0.2%	-0.1%	-0.1%	0.7%	1.0%	8.7%
992	0.2%	0.4%	2.5%	0.3%	0.0%	0.3%	0.2%	1.8%	0.0%	0.4%	-0.6%	0.1%	0.0%	0.0%	1.7%	7.3%
993	0.1%	0.3%	1.5%	0.2%	0.0%	0.1%	0.0%	0.5%	0.0%	0.2%	0.5%	1.2%	0.0%	0.0%	0.3%	4.8%
994	-0.8%	0.4%	0.1%	1.8%	0.1%	0.3%	1.2%	0.3%	0.8%	2.3%	1.2%	2.7%	2.0%	0.2%	0.1%	12.6%
Grand Total	-1.7%	2.7%	14.9%	5.6%	2.7%	8.1%	5.7%	13.0%	3.3%	9.6%	0.7%	12.4%	9.0%	4.4%	9.6%	100.0%

6.3 User Benefits by WebTAG Time and Distance Bands

6.3.1 It is important to demonstrate that the concentrations of user benefits are of significant magnitude, that the savings are sensibly distributed over time and distance bands. In line with current WebTAG requirements we have examined time and distance bands within which user benefits fall.

Table 6.3: Net User Benefits by Time Saving Bands (£000)

Time saving bands	0-2mins	2-5mins	>5mins	Total
All user benefits (£000s)	215,113	241,028	363,398	819,539
Proportion of benefits	26%	29%	44%	100%

Notes: All monetary values are expressed in 2010 prices discounted to 2010

Table 6.4: Net User Benefits by Distance Bands (£000)

Distance Bands	Up to 5 kms	5 to 10 kms	10 to 15 kms	15 to 20 kms	20 to 50 kms	50 to 100 kms	>100 kms	Total
All user benefits	46,137	120,176	100,650	65,018	298,899	149,311	39,354	819,545
Proportion	6%	15%	12%	8%	36%	18%	5%	100%

Notes: All monetary values are expressed in 2010 prices discounted to 2010

6.3.2 73% of benefits are due to time savings of more than 2 minutes, and approximately 44% are longer than 5 minutes. The allocation of user benefits to distance bands, shows that longer trips into or around the city account for the majority of the scheme's generated benefits, reflecting its function of providing ease of access to the A47(T) trunk road, providing alternative route for cross city trips and providing benefit to other longer journeys into the city.

6.3.3 Table 6.2 to Table 6.4 confirm further that the economic benefits reported in the appraisal are robust and represent realistic impacts of the NDR scheme together with the city centre traffic management measures.

6.4 Reliability and Stability of the Economic Appraisal Results

6.4.1 WebTAG requires that the economic results are robust and stable based on stability ratios. The impact of transport model convergence noise should be shown to be minimal. In order to do this the demand/supply model convergence (%GAP) is compared against the proportion of user benefits relative to total costs in the appraisal as calculated in TUBA. A ratio of 10 between the two values is recommended in WebTAG.

6.4.2 Table 6.5 shows the total user benefits as a proportion of total do-minimum user costs by mode for the Norwich transport model.

Table 6.5: Total User Benefits as a Proportion of Total User Costs

Mode	2017	2032
Road	0.52%	0.56%
Bus	0.00%	0.00%

6.4.3 Table 6.6 shows the level of convergence of the demand and assignment models.

Table 6.6: Demand and Assignment Model Convergence (% GAP)

	2017		2032	
	Demand model (Target = 0.2%)	Assignment model (Target = 0.1%)	Demand model (Target = 0.2%)	Assignment model (Target= 0.1%)
Do Minimum	0.06	N/A	0.1	-
AM	-	0.036	-	0.0018
IP	-	0.0014	-	0.0014
PM	-	0.0043	-	0.003
OP	-	0	-	0
Do Something	0.1	-	0.08	-
AM	-	0.0037	-	0.0033
IP	-	0.0007	-	0.001
PM	-	0.0041	-	0.004
OP	-		-	0

6.4.4 Convergence (%GAP) statistics of the demand-supply model shown in Table 6.6 fall well below the acceptable value of 0.20% from WebTAG (values smaller than the target values means that the model is better converged). User benefits as a percentage of total costs are around 0.5% for both 2017 and 2032 for the Norwich transport model. The resultant stability ratios are close to 5 for 2017 (0.52/0.1) and close to 6 for 2032 (0.56/0.1). These stability ratios would suggest that the economic results are robust and do not suffer from convergence noise influences. Although these ratios are lower that the value of 10 recommended in WebTAG, taken together with our earlier observations regarding sector location of benefits and time and distance band concentration of benefits, it is clear that the economic benefits reported are robust and not subject to model noise in any significant way. The ratio of 10 is also very difficult to achieve with a large scale model, and thus it is very important that the model is well converged which has been successfully achieved for the NATS transport model.

6.5 Warnings in the TUBA Appraisal

6.5.1 Warnings that were produced by TUBA 1.9.1 during the appraisal were used to improve the network and transport model in general. This is described in Appendix C.

6.5.2 All warning messages are consistent with the impacts of the NDR scheme and other traffic control measures that have been introduced in other parts of the Norwich model.

7 Accident Benefits

7.1.1 Accident benefits were calculated using COBA software (Version 11 Release 15) which is consistent with the most up to date economic parameters in WebTAG 3.5.6. Accident benefits have been calculated for the whole of the modelled highway network.

7.2 Data Sources

7.2.1 Data was extracted from the NATS highway model for the model years of 2017 and 2032 for input into the COBA assessment. This data included network structure and forecast traffic flows. The SATURN program SATCOBA was used to convert the DM SATURN highway model data to the required COBA input data files. In the DS, network restructuring was applied to the network as defined for the DM to make sure the common links/nodes between DM and DS SATURN networks correspond with the same COBA links/nodes.

7.2.2 Two NDR COBA assessments were undertaken:

- Applying locally derived accident rates. Norfolk County Council provided accident data for the years between 2008 to 2012 inclusive covering the area of detailed modelling. The observed accidents were allocated to the nearest modelled links/junctions within 10 metres of the accident by GIS tool. This data was used by COBA to calculate observed link and junction accident rates. Outside the area of detail modelling, and for the NDR links, default COBA accident rates were applied.

- Applying COBA default accident rates to the whole of the modelled highway network. Observed data can only be applied to existing links and junctions. Any new links or junctions added in the Do Minimum or Do Something scheme must take on default rates derived from national data. A review of the accident data received from NCC reveals that 51% of all current links in the area of detailed modelling had no accidents recorded on them over the five-year period, and hence over the entire 60-year appraisal period will be assumed to be free of accidents. On this basis the relative propensity for accidents on NDR (default data) compared against the rest of the detailed modelled area (observed data) may be distorted. To counter this, an appraisal has been undertaken using COBA default accident rates to the whole of the modelled highway network in both the Do Minimum and Do Something. The

default accident rates are those presented in Section 2 of DMRB Volume 13, Section 2.

7.3 Traffic growth rates

7.3.1 COBA is most suitable for fixed demand modelling where the travel demand remains the same for the Do Minimum and Do Something scenarios. Therefore, a slightly different process was adopted to accommodate NDR variable demand model. This deals with, for example, the reflected 'different' traffic growth rates for Do Minimum and Do Something (with impact on vehicle-kilometres) between the assessment years of 2017 and 2032.

7.3.2 The COBA assessment had to be divided into two separate data files for the Do Minimum and Do Something. The compound annual growth in vehicle-kilometres between the two forecast years 2017 and 2032 is used as the traffic growth rates for the period between these years.

7.3.3 No further traffic growth is assumed post-2032. The Do Minimum annual traffic growth rate is 1.20% for light vehicle and 1.15% for HGV; and the Do Something annual traffic growth rate is 1.28% for light vehicle and 1.19% for HGV. As the HGV demand matrix is fixed for the Do Minimum and Do Something scenarios, the higher growth rate in Do Something indicates that the HGVs will travel further as a result of the scheme.

7.4 Network Structure and Link Flows

7.4.1 Link numbers are allocated to the SATURN A-B node references so that A-B and B-A has the same link number with Park and Ride links and zone connector links excluded from the assessment. Links are allocated link types and are given appropriate accident type in the normal way. In the assessment with local accident rates, observed accident rates are calculated from the accident numbers received which are applied to the existing links and junctions within the area of detailed modelling, and future year scheme links in Do Minimum and Do Something scenarios are applied with default accident rates.

7.4.2 Link traffic flows are coded in the data files as 2-way AADT flows for both assessment years of 2017 and 2032. The conversion from model period (AM, Inter-Peak, PM and Off-Peak) hourly October flows (which is the validation month of the transport model) to AADT uses suitable, calculated factors.

7.4.3 Links that are common to both the Do Minimum and Do Something scenarios are given the same link numbers so that link attributes and observed data can

be accurately transferred from the DM to DS data files. New links are given the unused link number available. Link attributes are allocated on a case by case basis for new links, the NDR scheme is given accident type 11 (modern dual two lane road with 1 metre Hard Strips) and link class 2 (rural all-purpose dual two lane carriageway).

7.5 Junction Assessment

7.5.1 In the assessment with local accident data, junctions and links are assessed separately. However, this assessment can only be performed on junctions where observed data is available. This means that at any new junctions that form part of the Do Minimum and Do Something schemes, accidents at junctions will not be taken into account.

7.5.2 Attributing default junction accident rates in these locations is not possible due to the manner in which junctions are represented in the SATURN model as a series of nodes. To overcome this, the default data in DMRB Volume 13 for *combined* link and junction accident rates was used for all new links in the Do Minimum and Do Something.

7.5.3 In the assessment with default accident data, the accident rates and cost attribute all accidents to links.

7.6 Results Summary

7.6.1 Table 7.1 summarises the results of the COBA accident assessment with local accident rates. This shows that the NDR scheme reduces the numbers of accidents in the Norwich area.

7.6.2 The reduction in accidents represents £41.2m of monetary benefits in 2010 prices and discounted to 2010.

Table 7.1: Accident Assessment with Local Accident Rates

		60 Year Appraisal Period
		Do Minimum
Number of Personal Injury Accidents		70,984
Casualties	Fatal	1,890
	Serious	12,597
	Slight	91,490
Accident Costs (£000's in 2010 prices discounted to 2010)		5,999,332
		Do Something
Number of Personal Injury Accidents		69,944
Casualties	Fatal	1,898
	Serious	12,488
	Slight	90,226
Accident Costs (£m in 2010 prices discounted to 2010)		5,958,113
		Accident Benefits
Number of Personal Injury Accidents savings		1,041
Casualties	Fatal	-7
	Serious	109
	Slight	1,263
Accident Savings (£000s in 2010 prices discounted to 2010)		41,219

7.6.3 Table 7.2 summarises the results of the COBA accident assessment with default COBA accident rates applied to the whole network. This shows that the NDR scheme reduces both the numbers of accidents in the Norwich area and the severity of those accidents.

7.6.4 The reduction in accidents represents £205.7m of monetary benefits in 2010 prices and discounted to 2010.

Table 7.2: Accident Assessment with COBA Default Accident Rates

		60 Year Appraisal Period
		Do Minimum
Number of Personal Injury Accidents		109,530
Casualties	Fatal	2,309
	Serious	17,300
	Slight	145,423
Accident Costs (£000's in 2010 prices discounted to 2010)		8,418,232
		Do Something
Number of Personal Injury Accidents		106,006
Casualties	Fatal	2,288
	Serious	16,866
	Slight	140,986
Accident Costs (£m in 2010 prices discounted to 2010)		8,212,557
		Accident Benefits
Number of Personal Injury Accidents savings		3,524
Casualties	Fatal	21
	Serious	434
	Slight	4,437
Accident Savings (£000s in 2010 prices discounted to 2010)		205,675

7.6.5 The different assessments yield quite different results in terms of:

- The level of benefit reported. When COBA default rates are used, the overall benefits are £205.7m and significantly greater than local rates case, which reports benefits of £41.2m.
- The impact on casualties. Whilst both assessments lead to an overall reduction in casualties, it can be seen that the application of local rates in the assessment leads to an increase of seven fatalities, whilst using default rates leads to a decrease of 21.

7.6.6 A limitation of the COBA approach when observed data is used is that all new links and junctions take on default accident rates and severity splits. A review of the accident data received from NCC reveals that 51% of all current links in the area of detailed modelling had no accidents recorded on them over the five-year period, and hence over the entire 60-year appraisal period will be assumed to be free of accidents. It is likely that assessment using locally observed data has under-estimated the level of benefit since the representation of accidents on NDR will be unrealistically high compared to the rest of the network.

7.6.7 When default rates are used throughout, the assumption is made that all links in the model will have accidents on them over the appraisal period, which might create a rather pessimistic view of the Do Minimum case (especially given the above comment on the number of links where zero accidents have been observed in-situ), and, hence, an over-estimation of the benefits that a new, high standard road can provide when traffic transfers to it.

7.6.8 As such, it is reasonable to consider the results presented above as either end of a range of possible outcomes. For the calculation of scheme benefits, the lower value of accident savings were taken forward as this represents a conservative estimate of the benefits. The appraisal also indicates that there will be fewer accidents and casualties overall as a result of the scheme.

8 Wider Economic Impacts

8.1.1 The NDR is forecast to generate wider economics benefits additional to journey time and accident savings reported in previous sections, and is also expected to generate significant job creation and labour movement benefits. The estimation of these wider economics benefits is the subject of DfT's WebTAG unit 3.5.14 'The Wider Impacts Sub-Objective'. This chapter summarises the wider impacts appraisal method adopted and the results that have been obtained for the NDR model.

8.1.2 The guidance sets out wider economic impacts that can be estimated and prescribes how they should be calculated. The wider economic benefits include:

- Agglomeration impacts. These are the impacts of a scheme on concentration of economic activity over an area or region and reflects the accessibility of firms and workers to each other. Transport improvements will lead to increased accessibility and thus a higher level of agglomerated activity and thus improved productivity for firms and workers.
- Increased or decreased output in imperfectly competitive markets. In most cases, markets are not 'perfectly competitive' and this can lead to lower production and higher prices than would exist in the case of a competitive market, normally to the detriment of consumers and the economy as a whole. A reduction in transport costs allows for an increase in production or output in the goods or service markets that use transport.
- Labour market impacts from more/less people working. Transport costs are likely to affect the overall costs and benefits to an individual from working. A change in transport costs is therefore likely to affect the incentives of individuals to work and hence the overall level of labour supplied in the economy.
- Labour market impacts from moves to more/less productive jobs. Transport can affect the incentives for firms and workers to locate and work in different locations which is likely to have implications for productivity, as workers are often more or less productive in different locations.

8.1.3 WebTAG methodology seeks to capture only that part of the above impacts that is not already included in the conventional user benefit calculations for

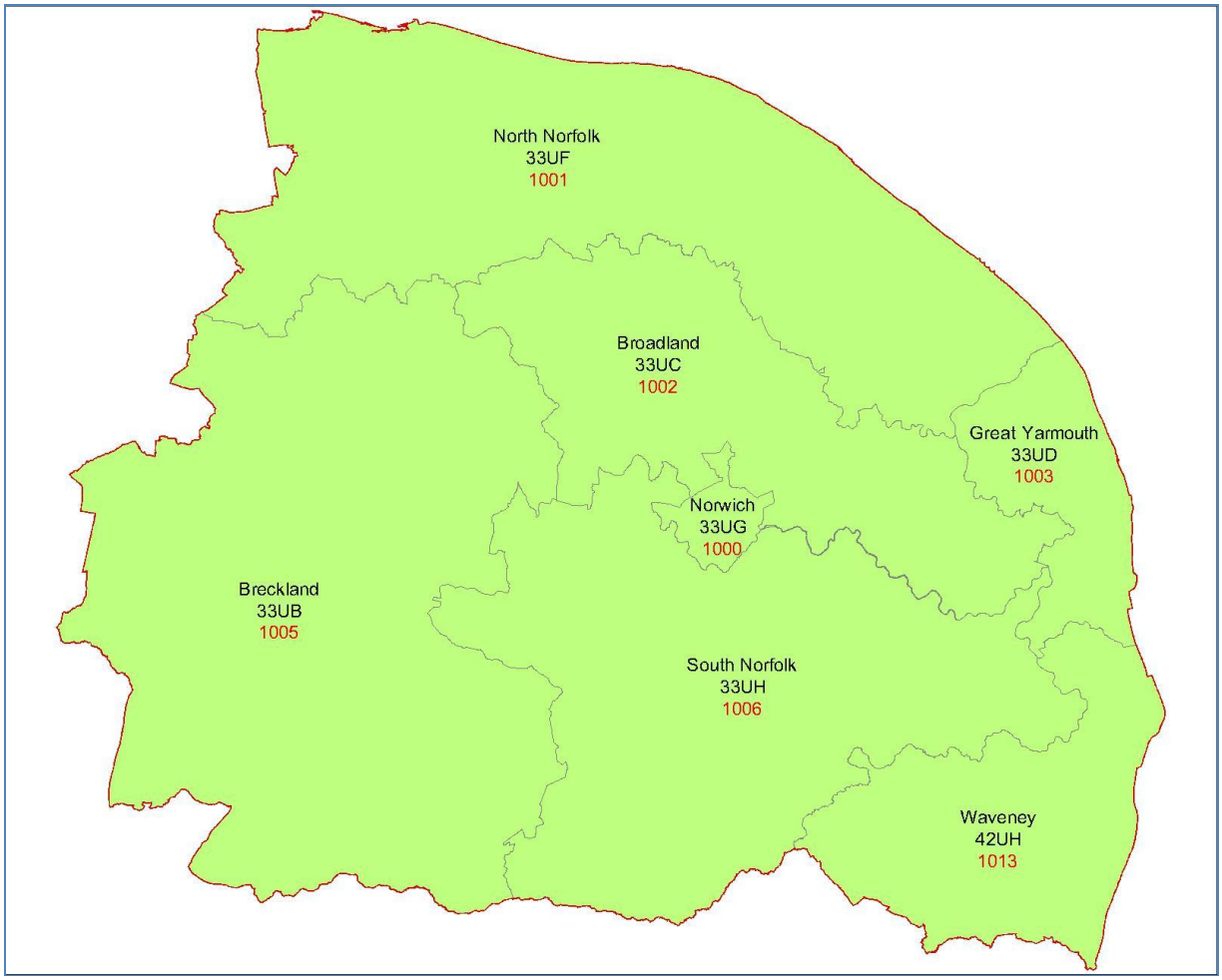
transport schemes as presented in the main economic appraisal report. The formulae and detailed description of the processes can be found in WebTAG 3.5.14.

8.2 Approach Adopted for NDR Wider Impacts Appraisal

8.2.1 Figure 8.1 below shows how the Norwich area was sectored for wider benefits appraisal using Wider Impacts in Transport Appraisal (WITAv1.1i-4 Be) software. The local authority districts in the figure correspond to the area from which wider economic benefits were extracted. All local authority zones more distant from the detailed model area are excluded from wider impact benefit appraisal.

8.2.2 Economics and employment data for each WITA analysis zone come from the DfT local authority district economics and employment files (data set v2.4, July 2012). Economic data includes GDP per worker by four employment sectors (manufacturing, construction, consumer services and producer services), average wage per worker and index of labour productivity. Employment data contains employment data for four employment sectors described above and for two forecast years 2017 and 2032.The generalised cost of travel between WITA zones comes from transport model data extracted from the main economic appraisal (i.e. TUBA files) – a combination of time, distance and charges (DM and DS scenarios and for the two forecast years 2017 and 2032). Other inputs include the TUBA economics file, several zone correspondence files, global data and a commuting production-attraction data file. More information on WITA can be found in Wider Impacts in Transport Appraisal, User Manual for Version 1.1 beta (Mott MacDonald, 2009).

Figure 8.1: Wider Impacts Analysis Zones and Local Authority Areas



8.3 Wider Economic Benefits Results

8.3.1 Summarised below are wider economic benefits calculated using the DfT's WITA software (version 1.1). Table 8.1 shows that agglomeration benefits make up the bulk of the £187m total wider benefit impacts.

8.3.2 Increased output in imperfect competitive markets is calculated as a proportion of the total business user benefits of the main economic appraisal.

Table 8.1: Summary Wider Economic Benefits of NDR

	Year 2017 (£)	Year 2032 (£)	Full Appraisal Period (£)
Agglomeration – manufacturing	376,864	218,217	12,099,287
Agglomeration – construction	308,611	190,741	10,433,028
Agglomeration - consumer services	946,115	724,016	38,054,835
Agglomeration - producer services	2,413,810	1,577,908	85,351,823
Agglomeration – Total	4,045,400	2,710,882	145,938,973
Labour supply impact	44,195	71,134	2,634,209
Increased output in imperfectly competitive market			38,775,300
The move to more/less productive jobs			Not assessed
Total	4,089,595	2,782,016	187,348,482

Notes: All entries are in £ in 2010 prices discounted to 2010

8.3.3 The estimated benefits of £187m for wider economic impacts feed into the overall VfM consideration.

9 Journey Time Reliability Benefits

9.1.1 This Section provides an estimate of journey time reliability benefits for the NDR. 'Reliable journeys' is one of the sub-objectives within the 'Economy' section of scheme appraisal; and the estimate provided in this Section is aimed at addressing this sub-objective for the NDR scheme. The term 'reliability' is often used interchangeably with 'travel time variability' or 'journey time variability'. The definition of journey time variability is provided in WebTAG Unit 3.5.7 - it represents unpredictable variations in journey times, i.e. it excludes predictable variations such as those associated with different times of day, days of the week, or times of the year.

9.1.2 WebTAG 3.5.7 recommends the use of the standard deviation (SD) of travel time as the measure of reliability. The standard deviation is a measure of how travel times are distributed around the average, with increasing standard deviation associated with increasing variability. In the appraisal, a monetary value is applied to the standard deviation of travel time. Reliability ratios are used to relate the value of one minute of standard deviation to one minute of average travel time (where the latter is defined by the values of time given in WebTAG Unit 3.5.6 Values of Time and Operating Costs).

9.2 Assumptions

9.2.1 WebTAG 3.5.7 methodologies that are used for estimating variability benefits are dependent on the dominating road types in the area where a particular scheme lies. The NDR scheme lies in an area dominated by the city of Norwich which the scheme is designed to positively impact upon. On that basis, the urban road variability methodology described in WebTAG 3.5.7 (section 3.3) is the most appropriate for calculating reliability benefits for the NDR scheme.

9.2.2 The NDR reliability assessment uses trip, time and distance matrices originally extracted from the Norwich transport model for purposes of economic appraisal. Time and distance matrices are trip-weighted average matrices across used routes, and do not always represent one selected route. As the methodology for urban variability appraisal assumes no or small distance changes between each OD-pair as a result of the scheme, an average of the Do Minimum and Do Something journey distances have been used in the calculations here.

9.2.3 A reliability ratio of 0.8 has been used for cars as recommended in WebTAG 3.5.7, meaning that one minute of standard deviation has the same value as 0.8 minutes of average travel time. A reliability ratio of 1.2 has been used for OGVs and LGVs in the reliability calculations.

9.2.4 In line with appraisal tools and published DfT guidance, the reliability benefits for the NDR have been calculated for a period of 60 years, discounted to 2010 and reported in 2010 values.

9.2.5 Highway reliability is estimated for the AM, PM and IP time periods only, because OP journey times are usually close to free-flow journey times and there is no significant impact on reliability. Sector to sector journey time reliability results were extracted and those movements within Norwich or benefit from going through Norwich are included in the benefit calculations. This is because urban journey time reliability calculations are applicable for urban areas where free flow speed is less than 30mph.

9.3 Method Adopted for Calculation of Reliability Benefits

9.3.1 Because of the size of input matrix files involved in the NDR, a simple software tool has been developed to calculate journey time reliability benefits which, in principle, may be used for assessments of any scheme dominated by urban roads. The NDR reliability benefits are calculated for each OD-movement, time period, user class and model year.

9.3.2 The core of the calculations use trip matrices, time matrices, distance matrices, VOTs by purpose, reliability ratios and discount rates as the inputs. The calculations proceed as follows:

9.3.3 For each of the OD-pair, 2 modelled years, 3 time periods and 7 appraisal user classes in the NDR traffic model, the program

- Calculates changes in standard deviation between Do Minimum and Do Something using the urban road variability equation given in WebTAG 3.5.7 (Paragraph 3.3.2);
- Calculates variability benefits by applying VOTs (2010 values by purpose), reliability ratios (by vehicle type) and trips as discussed in WebTAG 3.5.7. The results are at 2010 level and 2010 prices.
- Generates values for each year in the appraisal period by applying interpolation between the two modelled years, and extrapolation beyond the

last modelled year and also applying VOT growth. These values are in corresponding future year level and 2010 prices.

- Discount all values to 2010 prices and annualise to obtain yearly benefits for each year in the model period and for each OD-pair, time period and user class.

- Aggregate values to produce overall variability benefits for a 60 year period and prepare sectorised benefits.

9.3.4 The NDR reliability benefits are annualised using the same annualisation factors that have been applied in the economic appraisal and reported in 2010 prices discounted to 2010.

9.4 Journey Time Reliability Benefits

9.4.1 WebTAG 3.5.7 indicates that reliability benefits should not be included in estimating the Net Present Value (NPV) and the Benefit to Cost Ratio (BCR) because the methodology is still subject to further research. However, reliability benefits may be taken into account in the assessment of the overall value for money.

9.4.2 Table 9.1 below shows reliability benefits of around £28m (in 2010 prices discounted to 2010) for the 60 year appraisal period . This is equivalent to around 4% of the time benefits generated by the scheme.

Table 9.1: NDR Reliability Benefits

Model Year	Reliability Benefits (£000s)
Full (60yrs) Appraisal	28,398

Notes: Benefits are in 2010 prices and discounted to 2010

9.4.3 Table 9.2 shows the distribution of these benefits over the whole traffic model area. This shows that, although the journey time reliability benefits are concentrated on cross city movements, overall, all areas covered by the transport model do experience some journey time reliability improvements from the NDR scheme.

Table 9.2: Proportion of Sector to Sector Journey Time Reliability Benefits

	Destination Sector															
Origin Sector	1	2	3	4	5	6	7	8	9	10	11	991	992	993	994	Total
1	-0.8%	-7.0%	-2.8%	-1.3%	-0.1%	-0.4%	0.3%	-0.3%	0.0%	-1.6%	-2.6%	-1.4%	0.2%	0.0%	-0.3%	-18.1%
2	-3.3%	-4.3%	2.3%	-0.2%	0.2%	0.1%	0.7%	1.7%	0.1%	2.2%	-1.1%	-0.7%	0.5%	0.3%	0.6%	-1.0%
3	-1.2%	5.1%	4.8%	1.6%	0.7%	0.8%	1.9%	1.2%	0.4%	4.8%	1.9%	2.0%	2.3%	1.0%	-0.2%	27.2%
4	-0.4%	0.2%	1.8%	0.1%	0.1%	1.2%	0.1%	0.8%	0.0%	0.2%	-0.2%	-0.2%	0.1%	0.1%	0.8%	4.9%
5	-0.1%	0.2%	0.6%	0.2%	0.0%	0.0%	0.0%	0.3%	0.0%	0.2%	0.6%	0.9%	0.0%	0.0%	0.0%	2.9%
6	-0.3%	0.7%	0.8%	1.2%	0.0%	0.1%	0.5%	1.1%	0.0%	1.5%	1.1%	3.3%	0.3%	0.0%	0.2%	10.6%
7	-0.3%	0.4%	1.5%	0.1%	0.0%	0.3%	0.2%	1.4%	0.0%	0.2%	-0.3%	0.0%	0.1%	0.0%	0.6%	4.3%
8	0.3%	3.1%	3.0%	1.5%	0.3%	1.2%	1.4%	0.5%	0.1%	4.2%	1.7%	1.3%	1.8%	0.3%	0.2%	21.0%
9	0.2%	0.1%	0.3%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	-0.2%	0.0%	0.0%	0.0%	0.2%	0.9%
10	-0.5%	0.7%	4.2%	0.2%	0.1%	1.2%	0.0%	3.5%	0.0%	1.1%	-0.3%	-0.3%	0.2%	0.2%	1.6%	12.0%
11	-0.3%	1.6%	2.7%	0.1%	0.7%	1.5%	0.3%	1.6%	0.0%	1.0%	0.6%	-0.2%	0.4%	0.3%	1.2%	11.6%
991	-0.3%	0.1%	2.2%	-0.2%	0.5%	2.2%	0.0%	0.8%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	0.4%	0.7%	5.9%
992	0.1%	0.4%	2.4%	0.2%	0.0%	0.2%	0.2%	1.5%	0.0%	0.5%	-0.2%	0.1%	0.0%	0.0%	1.1%	6.5%
993	0.1%	0.3%	0.9%	0.1%	0.0%	0.0%	0.0%	0.4%	0.0%	0.1%	0.3%	0.7%	0.0%	0.0%	0.2%	3.1%
994	-1.1%	0.5%	0.0%	1.4%	0.0%	0.2%	0.8%	0.3%	0.4%	1.8%	1.0%	1.6%	1.3%	0.1%	0.1%	8.4%
Total	-7.9%	2.1%	24.8%	5.1%	2.5%	8.7%	6.4%	14.7%	1.1%	16.2%	2.4%	7.0%	7.1%	2.8%	6.9%	100.0%

10 Conclusion

10.1.1 An economic appraisal for the proposed NDR with proposed complementary measures has been undertaken. The NATS transport model provides the required transport inputs for the appraisal. The variable demand model (VDM) forecasts, which make allowance for traffic generation, redistribution and mode choice effects arising from introduction of the scheme, have been prepared for the NDR proposed opening year of 2017 and the design year of 2032.

10.1.2 The costs of the proposed NDR (including preparation, operation, maintenance, land and construction costs) are shared between local authority and central government. The economic appraisal complies with guidance in WebTAG. It has been assumed in the appraisal that the benefits of the scheme do not change for each year beyond 2032 although traffic will continue to grow which suggests that the PVB and the NPV presented in the table below will be conservative.

10.1.3 Table 10.1 shows a summary of the economic appraisal results:

Table 10.1: Summary of Economic Appraisal (£000's)

	Scenario including Accidents	Scenario also including WEBS and JTR
Present Value of Benefits (PVB)	773,317	989,063
Present Value of Costs (PVC)	185,542	185,542
Net Present Value (NPV)	587,775	803,521
Benefit to Cost Ratio (BCR)	4.168	5.331

Notes: All monetary values expressed in 2010 prices discounted to 2010

10.1.4 The BCR of 4.17 represents Very High value for money under the DfT's VfM criteria. The PVB includes accident benefits but does not include wider economic benefits or journey time reliability benefits. When these are included the BCR increases to 5.33.

10.1.5 It has been demonstrated in this report that the economic benefits calculated are robust and reliable. This has been done by:

- Demonstrating high stability ratios
- Providing sector-to-sector benefits that look realistic, logical and convincing

- Showing plausible breakdown of user benefits by WebTAG time and distance bands
- Providing a sensible breakdown of benefits by time period.

11 Appendices

11.1 Appendix A – Annualisation Factors

11.1.1 Different annualisation factors have been used in the economic appraisal for different time periods. These annualisation factors have been calculated based on one year counts for a selected number of sites in the Norwich area. Days and time periods that are not specifically part of the transport model (e.g. weekends and bank holidays) have been 'fitted' into the modelled time periods as described later in this section.

11.1.2 **Selection of Count Sites:** The following two-way Automatic Traffic Count (ATC) sites were selected from within the urban area of Norwich for the purpose of producing annualisation factors.

- Site 318 – A1151 Rackheath
- Site 337 – A1074 Dereham Road
- Site 345 – B1332 Poringland
- Site 352 – A1074 Dereham Road
- Site 361 – A140 Sweet Briar Road
- Site 363 – A140 Ipswich Road
- Site 367 – Reepham Road
- Site 386 – B1150 Crostwick
- Site 412 – A1067 Attlebridge
- Site 413 – A147 Koblenz Avenue
- Site 419 – C283 Salhouse Road
- Site 426 – B1113 Keswick

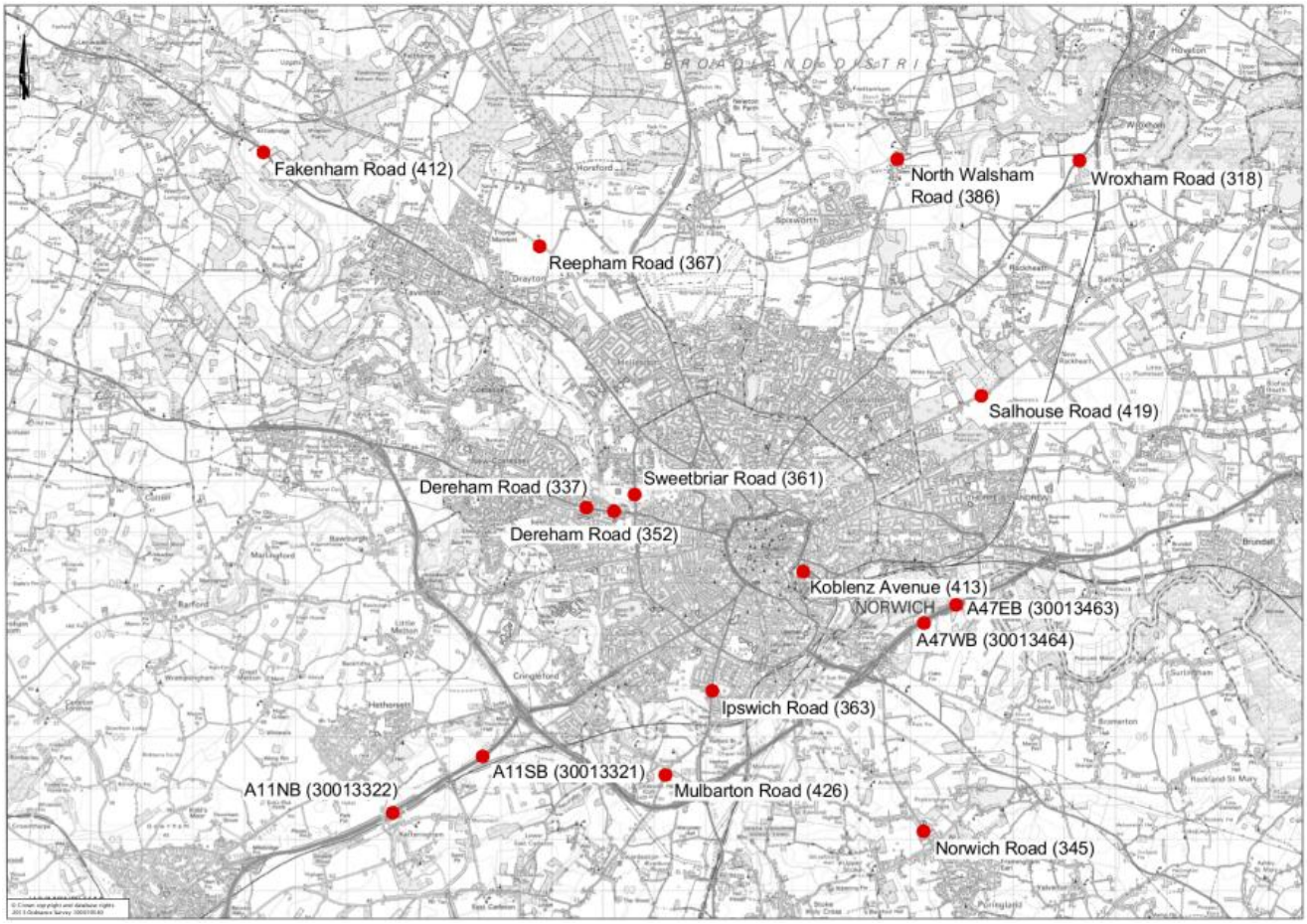
11.1.3 In addition to above ATC sites, the following TRADS sites were also used in deriving annualisation factors.

- Site 30013463 – A47(T) eastbound between A146 and A1042

- Site 30013464 – A47(T) westbound between A146 and A1042
- Site 30013321 – A11 southbound between A47(T) and B1135
- Site 30013322 – A11 northbound between A47(T) and B1135

11.1.4 Figure 11.1 shows the location of ATC and TRADS sites.

Figure 11.1: Map showing Count Sites Used for Production of Annualisation Factors

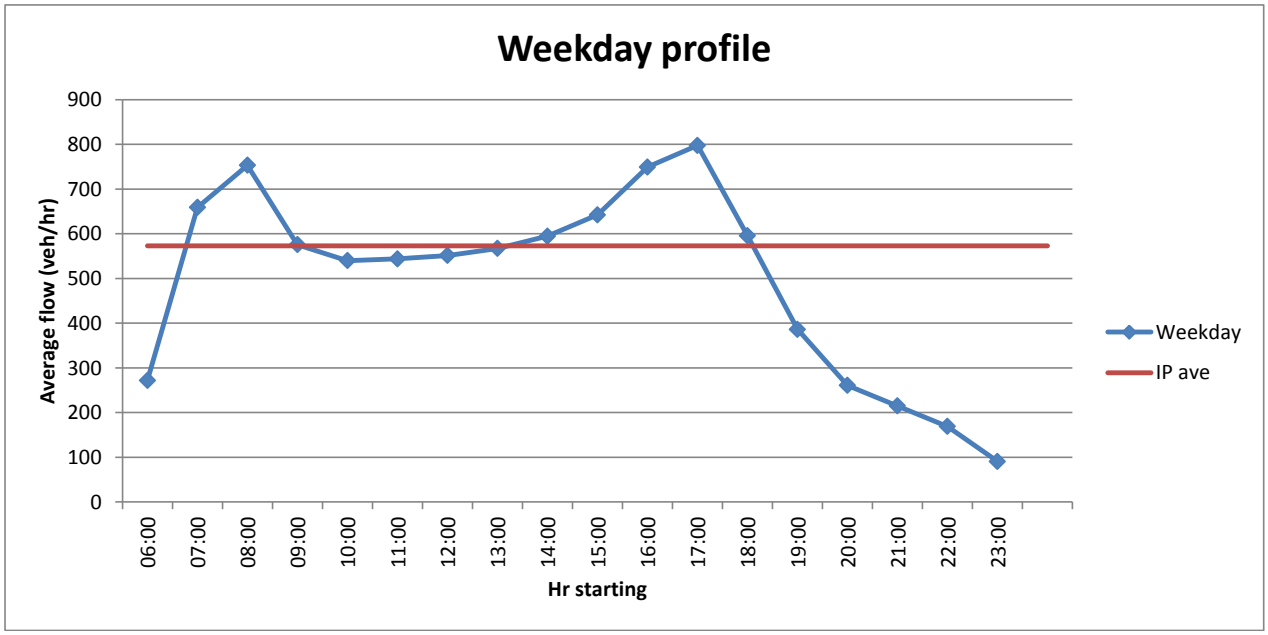


11.1.5 **Calculation of Average Flows - For Each Site:** Each of the selected sites contains almost an entire full year of 2012 hourly traffic flow data. As is commonly the case with traffic data from ATCs/TRADS, there were small amounts of missing data. For each site, any day that has any missing data has been excluded entirely from the analysis. The following data was calculated for each site:

- October average traffic flows were found for each hour of the day for weekdays, Saturdays and Sundays.
- Whole year 2012 average flows were found for each hour of the day for weekdays, Saturdays, Sundays and Bank Holidays.

11.1.6 **Calculation of Average Flows - For all Sites Combined:** To form overall average flows for all the sites combined, a straight average traffic flow was taken for every hour in the day for the 2012 October and 2012 whole year datasets. For sites with counts in two directions, each direction has effectively been treated as an individual site for the averaging process. Figure 11.2 shows the average October weekday profile calculated from the count sites and also displays the inter-peak average flow.

Figure 11.2: October Weekday Profile for Count Sites



11.1.7 **Designation of Weekday Hours:** The data suggests that following can be applied in the derivation of weekday annualisation factors:

- AM period (0800-0900) benefits have been derived from the AM peak hour model (0800-0900)
- PM period (1600-1800) benefits have been derived from the PM peak hour model (1700-1800)

- Inter Peak period (0700-0800, 0900-1600, 1800-1900) benefits have been derived from the inter peak model (average hour 1000-1600)
- Off Peak period benefits have been derived from the off peak model (average hour 1900-0700)

11.1.8 **Designation of Saturday, Sunday and Bank Holiday Hours as Inter-peak or Off-peak:** As there is no weekend assignment model, it was necessary to designate weekend hours as either weekend inter-peak or weekend off-peak in order to produce a full annualisation. 2012 October weekday average flows for the inter-peak average hour and the off-peak average hour were calculated and compared with October average Saturday and Sunday hourly traffic flows, see Figure 11.3 below. It was found that the October inter-peak average hour was 573vehicles/hour and the October off-peak average hour was 137vehicles/hour. The designation of Saturday and Sunday hours as inter-peak or as off-peak is shown in Table 11.1. Saturday and Sunday 19:00-07:00 hours are designated as off-peak. All Bank Holiday hourly flows were designated as weekend off-peak.

Figure 11.3: October Saturday and Sunday Profile for Count Sites

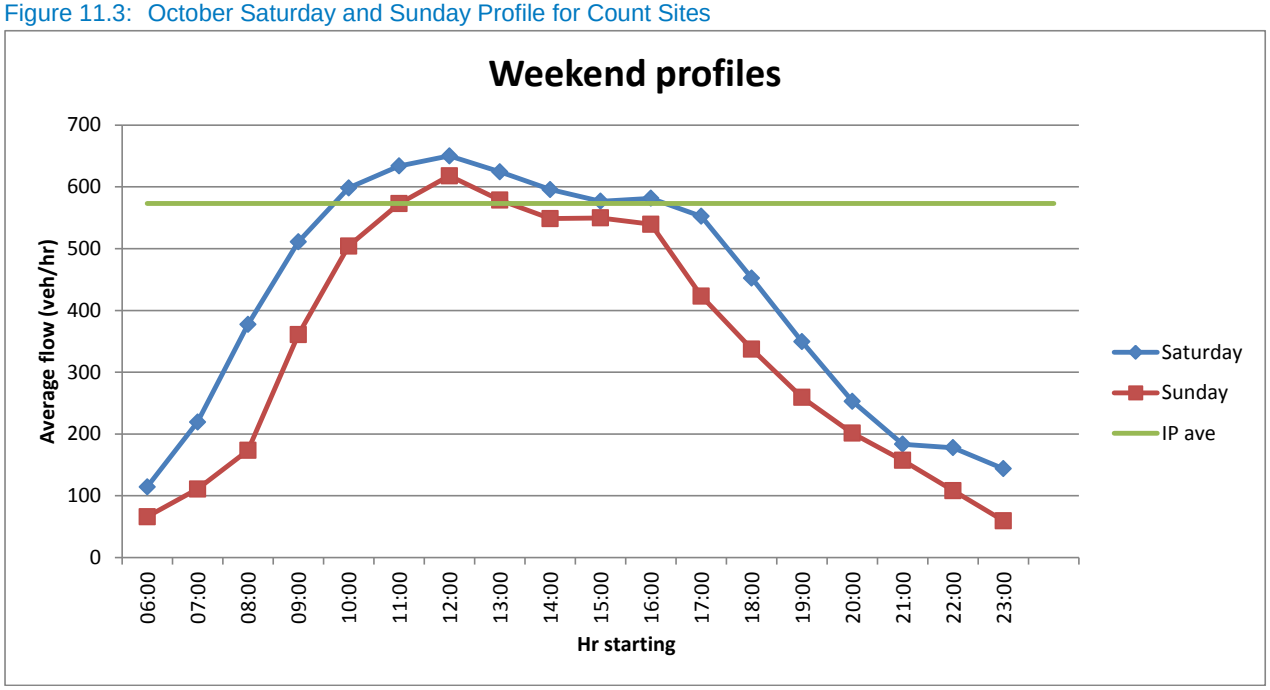


Table 11.1: Designation of Saturday and Sunday 07:00 - 19:00 Hours

Hour	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00
Flow - Sat	219	377	511	598	634	650	624	596	577	582	552	452
Flow - Sun	111	173	360	504	573	618	579	549	550	540	423	337
Designation - Sat	OP	OP	OP	IP	IP	IP	IP	IP	IP	IP	IP	OP
Designation - Sun	OP	OP	OP	OP	IP	IP	IP	IP	IP	OP	OP	OP

Notes: IP – interpeak, OP – off peak

11.1.9 **Calculation of Annualisation Factors:** The annualisation factors were calculated by dividing the total flow in 2012 by the average October 2012 hourly flow for each time period. The annualisation factors are shown below in Table 11.2.

Table 11.2: Annualisation Factors

Time Period	Annualisation
AM	246
IP	2,298
PM	481
OP	3,056
Weekend IP	693
Weekend OP	2,974

11.1.10 **Journey Purpose Splits for Weekend Time Periods:** The composition of non-freight car/ personal LGV was adjusted for the weekend inter-peak and off-peak time periods so that each journey purpose represented the following proportion of total non-freight demand:

- Commute: 8.5%
- Employers Business: 3.2%
- Other 88.3%

11.1.11 In a similar way the weekend inter-peak and off-peak demand was adjusted for public transport so that each purpose represented the following proportion of total public transport demand: The journey purpose proportions were obtained from WebTAG 3.5.6 Table 7: Proportion of Trips Made in Work and Non-Work Time.

- Commute: 6.4%
- Employers Business: 1.5%
- Other 92.1%

11.1.12 **Weekend Adjustment for Freight:** Annualisation factors derived from total ATC/TRADS traffic flows, as described above, do not provide an accurate representation of freight demand, particularly due to differences between traffic composition in weekend hours and during weekday inter-peak and off-peak average hours. The 2012 ATC/TRADS used to derive anualisation factors were not classified. Classified data was available for the ATC sites for 2012 October. Using the classified traffic data, freight weekend demand adjustment factors were calculated by comparing the proportion of traffic that is freight during the average weekday inter-peak and off-peak with the designated inter-peak and off-peak weekend periods. Table 11.3 shows the calculated freight weekend demand adjustment factors. The freight demand adjustment factors are affected through the matrix factoring process in the TUBA setup.

Table 11.3: Freight Weekend Demand Adjustment Factors

Time Period	LGV	OGV
Weekend IP	0.42	0.23
Weekend OP	1.05	0.73

11.1.13 **Factors to Disaggregate Light Vehicles to Car and LGV Personnel:** For assignment purposes car and LGV personnel are included into a single user class for commuting and other purposes. However for the purpose of economics it was necessary to disaggregate these so that appropriate economic parameters can be applied. This was done using purpose proportions given in WebTAG 3.5.6, COBA Volume 13 Section 1 (Table 1/1) and NTM road traffic forecasts for east of England for base year of 2012. These proportions are given below in Table 11.4. Same factors were used for home based and non-home based other purposes.

Table 11.4: Car and LGV Personnel Proportions for Different Time Periods

		Proportion			
Purpose	Vehicle type	AM	IP	PM	OP
Commuting	Car	0.9901	0.9611	0.9888	0.9874
	LGV personnel	0.0099	0.0389	0.0112	0.0126
Other	Car	0.9556	0.9763	0.9652	0.9687
	LGV personnel	0.0444	0.0237	0.0348	0.0313

11.2 Appendix B – TUBA Setup

11.2.1 **Demand:** The DIADEM variable demand model provides TUBA with input demand matrices for highway and public transport modes. Highway demand is provided as Passenger Car Units (PCUs) and the public transport demand

is provided as passengers. Table 11.5 and Table 11.6 show the input demand segmentation.

Table 11.5: Highway Demand Segmentation

User Class	Vehicle Type	Purpose
1	Car/LGV	Home Based Commute
2	Car	Home Based Employers Business
3	Car/LGV	Home Based Other
4	Car/LGV	Non-Home Based Other
5	Car	Non-Home Based Employers Business
6	LGV	Employers Business
7	OGV	Employers Business

Table 11.6: Public Transport Demand Segmentation

User Class	Purpose
1	Home Based Commute
2	Home Based Employers Business
3	Home Based Other
4	Non-Home Based Other
5	Non-Home Based Employers Business

11.2.2 **Skims:** The DIADEM demand model, in combination with the highway and public transport assignment models produces skims of time, distance and cost as shown in Table 11.7 and Table 11.8 below.

Table 11.7: Summary of Highway Skims

Highway Skim	Assignment Unit	TUBA Unit
Vehicle Trips	PCUs/Hour	Vehicles/Hour
Distance	Metres	Kilometres
Time	Seconds	Hours
Car Parking (Local Authority)	Pence	Pence
Car Parking (Private)	Pence	Pence

Table 11.8: Summary of Public Transport Skims

Highway Skim	Assignment Unit	TUBA Unit
Passenger Trips	Passengers/Hour	Passengers/Hour
Time	Seconds	Hours
Fare	Pounds	Pence

11.2.3 **Adjustment to Economics File for Purpose:** The latest TUBA 1.9.1 standard economics file, based on October 2012 WebTAG 3.5.6 values, was used with an adaptation for purposes. Purposes were adjusted to enable separate TUBA analysis for each assignment user class. Table 11.9 shows the new purpose table in the economics file. All of the tables have been

adjusted to include the new purposes shown in the table. The adjustment to the purpose definitions necessitated further changes to the following tables: The changes to the tables listed above, involved only the reformatting of the tables and no adjustment to the default Business, Commute and Other values was made.

- Value of Time
- Value of Time Growth
- Default Person Factors
- Default Person Factors Change

Table 11.9: Revised Purposes

Purpose No.	Purpose Type	Purpose Description
1	B	HB-EB
2	C	HB-Commute
3	O	HB-Other
4	B	NHB-Business
5	O	NHB-Other

11.2.4 **Current, Modelled and Appraisal Years:** TUBA requires a minimum of two years to be modelled and interpolates/extrapolates benefits for other years over the 60 year appraisal period. For each modelled year, demand and skim matrices for do-minimum and do-something scenarios were input to TUBA. The following years have been included in the scheme file:

- Current Year – 2013
- Modelled Years – 2017, 2032
- Appraisal Period – 2017 – 2076 (60 years)

11.2.5 **User Classes:** In order to split each TUBA Purpose as defined in the economics file into each possible TUBA Vehicle Type, the following user class structure, as shown in Table 11.10 was devised.

Table 11.10: TUBA User Classes

TUBA User Class	TUBA Vehicle Type	TUBA Purpose	TUBA Person Type
1	Car (1)	Home Based Commute (2)	All* (0)
2	LGV (personal) (2)	Home Based Commute (2)	All* (0)
3	Car (1)	Home Based Employers Business (1)	All* (0)
4	Car (1)	Home Based Other (3)	All* (0)
5	LGV (personal) (2)	Home Based Other (3)	All* (0)
6	Car (1)	Non-Home Based Employers Business (4)	All* (0)
7	Car (1)	Non-Home Based Other (5)	All* (0)
8	LGV (personal) (2)	Non-Home Based Other (5)	All* (0)
9	LGV (freight) (3)	Non-Home Based Employers Business (4)	All* (0)
10	OGV1 (4)	Non-Home Based Employers Business (4)	All* (0)
11	OGV2 (5)	Non-Home Based Employers Business (4)	All* (0)
12	Public Transport (6)	Home Based Commute (2)	Passenger (2)
13	Public Transport (6)	Home Based Employers Business (1)	Passenger (2)
14	Public Transport (6)	Home Based Other (3)	Passenger (2)
15	Public Transport (6)	Non-Home Based Employers Business (4)	Passenger (2)
16	Public Transport (6)	Non-Home Based Other (5)	Passenger (2)

Notes: *All TUBA person type split by TUBA into drivers and passengers using default proportions from the economics file

11.2.6 **Demand Factors:** The combined car/ personal LGV user classes as supplied by the DIADEM demand model were split into the separated car and personal LGV user class as used in TUBA using factors derived in Appendix A. The following factors, shown in Table 11.11, were used to convert the OGV (all) user class in PCUs supplied by the DIADEM demand model to the OGV1 and OGV2 user classes in vehicles as used by TUBA.

Table 11.11: Vehicular Conversion of OGV User Class

Factor	OGV1	OGV2
PCU to vehicle factor	0.448	0.448
OGV1/ OGV2 Split	53%	47%
OGV (all) PCU to Vehicle Factor	0.237	0.211

Notes: OGV1 and OGV2 splits are from NTM 2013 data set for an average year between 2017 & 2032

11.2.7 **Skim Factors:** Table 11.12 and Table 11.13 show the unit conversion factors used in TUBA.

Table 11.12: Unit Conversion of Highway Skims

Highway Skim	Assignment Unit	TUBA Unit	Unit Conversion Factor
Distance	Metres	Km	0.001
Time	Seconds	Hours	0.00028
Car Parking (Local Authority)*	Pence	Pence	1
Car Parking (Private)*	Pence	Pence	1

Notes: *Charges are in base price values

Table 11.13: Unit Conversion of Public Transport Skims

Highway Skim	Assignment Unit	TUBA Unit	Unit Conversion Factor
Time	Seconds	Hours	0.00028
Fare*	Pounds	Pence	100

Notes: *Fares are in base price values

11.2.8 **Split Public/ Private Parking Charges:** Parking charges have been split as 80% private sector, 20% public sector. Parking charges are in price base year (2010) values.

11.2.9 **Sectorisation of User Benefits:** A sector file was referenced in the scheme file in order to facilitate detailed analysis of the TUBA outputs at 15-sector level shown in Figure 6.1. The sector system has been used to confirm that user benefits accrue in areas of the network that are impacted by the NDR scheme.

11.3 Appendix C – TUBA and COBA Warnings

11.3.1 **Summary of TUBA Warnings:** Table 11.14 below provides a summary of the warnings produced by TUBA.

Table 11.14: Summary of TUBA Warnings

Warning Type	Number of warnings (Serious Warnings)
Ratio of DM to DS Journey Time too Low	58062 (3070)
Ratio of DM to DS Journey Time too High	124609 (1095)
Ratio of DM to DS Distance too Low	208541 (8876)
Ratio of DM to DS Distance too High	49205 (49205)
DM Speed too Low	190728
DS Speed too Low	194705

11.3.2 Investigation of Serious TUBA Warnings

- *Ratio of DM to DS Journey Time too Low:* These warnings occur where there is a significant rise in journey time from Do Minimum to Do Something scenarios. The majority of the serious warnings relate to travel involving a trip

end in Sector 1, which are as expected due to the city centre traffic management measures which discourage traffic movement in the city centre.

- *Ratio of DM to DS Journey Time too High:* These warnings occur where there is a significant decrease in journey time from Do Minimum to Do Something scenarios. A large proportion of these serious warnings have a trip end in sectors 10, 4, 8 and 6 which are at either end of the proposed highway scheme and therefore significant decreases in journey time would be expected for these movements. The majority of other serious warnings are for trips having both trip ends in Sector 1. It is considered that these warnings occur because of local reassignment issues concerning the city centre measures in Sector 1.

- *Ratio of DM to DS Distance too Low:* These warnings occur where there is a significant rise in trip distance from Do Minimum to Do Something scenarios. The majority of the serious warnings have a trip end in Sector 1 and it is considered that these warnings are caused by local reassignment issues concerning the city centre measures in Sector 1. Also in the modelling of Park and Ride, for the bus leg of the journey the bus journey time is included in the time skims but there is no distance included in the distance skims.

- *Ratio of DM to DS Distance too High:* These warnings occur where there is a significant decrease in journey distance from Do Minimum to Do Something scenarios. All of the serious warnings have a trip end in Sector 1 and it is considered that these warnings are caused by local assignment issues associated with the city centre improvements. Also in the modelling of Park and Ride, for the bus leg of the journey the bus journey time is included in the time skims but there is no distance included in the distance skims.

- *DM Speed too Low & DS Speed too Low:* These warnings occur where speeds are low. The vast majority of these warnings have a trip end in Sector 1. Investigation of these warnings has found that they relate to travel on Park and Ride and are acceptable. In the modelling of Park and Ride, for the bus leg of the journey the bus journey time is included in the time skims but there is no distance included in the distance skims.

11.3.3 **COBA Warning Messages:** The COBA results file contained instances of the following warning messages. An explanation of the warning is given in the sub-bullet point.

- *Additional header or delimiter (9999) lines have been inserted by the program:* Additional header information is inserted by the COBA program to ensure the successful running of the model
- *Some link lengths were greater than 10 km (classes 1-6 and 9-12) or 3 km (classes 7-8):* These long links relate to the external links at the periphery of the model.
- *Link overcapacity was detected:* Refers to a level of link flow that is beyond COBA defaults for a given link type. These have been checked and are acceptable.
- *There was link or node overcapacity in the do-minimum/do-something scheme:* As above.
- *Respecifications or reclassifications caused overcapacity junctions or roads to become undercapacity:* These have been checked and are acceptable. Explicit link flows are given for each forecast years, 2017 and 2032, rather than applying forecast growth rates.
- *Entry link flows have been changed:* As above.
- *Accident rates were given which exceeded the warning limit:* This warning message only appear when an assessment is carried out with local accident data. Accident rates for some links in the period 2008 – 2012 exceed COBA defaults for a given link type. These have been checked and are acceptable.

12 Abbreviations

AADT	Annual Average Daily Traffic
ARCADY	Assessment of Roundabout Capacity and Delay software
AST	Appraisal Summary Table
ATC	Automatic Traffic Count
B1/B2/B8	Development categories: business (including office) / general industrial / storage and distribution
BAFB	The Best And Final funding Bid submitted by Norfolk County Council to the Department for Transport in 2011 for the combined Postwick and NDR schemes
BCIS	Building Cost Information Service
BCR	Benefit Cost Ratio
BGBP	Broadland Gate Business Park development
COBA	Cost Benefit Appraisal – software released by the Department of Transport that has been used to undertake an accident appraisal
DfT	Department for Transport
DIADEM	Dynamic Integrated Assignment and Demand Modelling - software released by the Department for Transport
GDP	Gross Domestic Product
GEH	A comparison statistic named after GE Havers
GNDP	Greater Norwich Development Partnership
GPS	Global Positioning System
GVA	Gross Value Added
HA	Highways Agency
HB	Home Based (trips)
HBEB	Home Based Employers' Business (trips)
HBO	Home Based Other (trips)
HBW	Home Based Work (commuter trips)
HGV	Heavy Goods Vehicle
IP	Inter-peak
JCS	Joint Core Strategy
JTR	Journey Time Reliability
LGV	Light Goods Vehicle
LINSIG	Traffic signal analysis software
LMVR	Local Model Validation Report
MCC	Manual Classified Count (for a link)
MCTC	Manual Classified Turning Counts
NATS	Norwich Area Transportation Strategy
NCC	Norfolk County Council

NDR	Norwich Northern Distributor Road
NHB	Non-Home Based (trips)
NPV	Net Present Value – given by subtracting the Present Value Costs (PVC) from Present Value Benefits (PVB)
NTEM	National Trip End Model – a database containing trip-end, journey mileage, car ownership and population/workforce planning data
NTM	National Transport Model
OD	Origin Destination
OE	Other Externalities
OGV	Other Goods Vehicle (sometimes called HGV)
PA	Production Attraction
PCU	Passenger Car Unit
PDL	Previously Developed Land
PG	Planning Gain
PIA	Personal Injury Accident
PPK	Pence Per Kilometre
PPM	Pence Per Minute
PT	Public Transport
PVB	Present Value Benefits – the stream of benefits over the appraisal period (60 years) that are converted to 2010 prices and discounted to 2010 to give a 'present value'
PVC	Present Value Costs – the costs of the scheme over the construction period as well as maintenance and operational costs that are converted to 2010 prices and discounted to 2010 to give a 'present value'
PYV	Present Year Validation
P&R	Park and Ride
QRA	Quantified Risk Assessment
RFC	Ratio of Flow to Capacity
RPI	Retail Price Index
RSI	Road Side Interview
RTF	Road Transport Forecasts
SATME2	Matrix estimation module of the SATURN software
SATURN	Simulation – Assignment model of Traffic on Urban Road Networks software
TA	Transport Assessment
TEC	Transport Externality Cost
TRADS	Traffic flow Data System – the Highways Agency's database of traffic count data
TRICS	National Trip Generation database
TEMPRO	Trip End Model presentation Program is software released by the Department for Transport to allow detailed analysis of NTEM data
TUBA	Transport User Benefit Appraisal – software released by the Department for Transport that is used to assess transport user benefits of transport schemes

VDM	Variable Demand Modelling
VfM	Value for Money
VISUM	Transport modelling software used (in this case) for public transport modelling
VOC	Vehicle Operating Costs
VOT	Value Of Time
WEBs	Wider Economic Benefits
WebTAG	Web-based Transport Appraisal Guidance produced by the Department for Transport
WITA	Wider Impacts in Transport Appraisal

13 Glossary

Assignment	A process of loading a trip matrix onto routes through a network that accounts for travel costs on the network in identifying the optimum route choice for every trip
Buffer network	The external part of a highway network in which travel is represented by speed/ flow relationships or cruise speeds
Calibration	A process of adjusting the model input data or model parameters to improve the model and its validation
Convergence	An equilibrium between model outputs, in assignment between the flows and travel costs and in demand models between the demand and the costs from the supply model
Cost matrix	A table of travel costs for journeys that may include travel time, operating costs and charges such as tolls or fares
Cruise speeds	Average travel speed along a network link
Demand model	See variable demand model
Demand segment	Travel demand is divided into a number of segments for the purposes of applying different demand modelling procedures. The division is usually by trip purpose and whether the trips are home-based or non-home-based
DMRB	Design Manual for Roads and Bridges – a Highways Agency publication setting out guidance and good practice for design and appraisal of road schemes
Dependent development	Housing or commercial development that can only proceed with the implementation of a transport intervention
Discounting	Discounting is a technique used to compare costs and benefits that occur in different time periods. It is based on the principle known as time preference that people prefer goods and services now rather than later. This preference for goods and services now rather than later applies to both individuals and society. By applying a discount rate, streams of costs and benefits are reduced to their present values.
Do Minimum	The forecast scenario without the proposed transport scheme, but that includes committed transport network improvements and developments
Do Something	The Do Minimum network but with the proposed transport scheme and developments added
Generalised cost	A combination of time and money costs (operating costs and charges) that are expressed in time or money units which are used to represent the total travel costs for a journey within the assignment or demand models
Journey purpose	Trips are divided into different travel purposes, usually work (or commute), employers' business and other. These trip purposes have different generalised costs applied and different demand model responses
Matrix estimation	A process used to adjust an initial or 'prior' matrix so that the resulting assignment of the adjusted matrix matches count data as closely as possible
Network	A mathematical representation of a transport network in a supply-side assignment model, either a highway network which represents vehicle travel, or a public transport network that represents bus and rail services
Speed / flow relationships	Relationship between traffic speed and traffic flow on a network link

Reference trip matrix	A forecast reference matrix based on applying growth from national (or other) datasets, but before the application of adjustments due to the impact of how travel costs will change with growth in travel
User classes	Trips are aggregated into several user classes for the purposes of assignment. These usually represent different types of vehicle (e.g. car, HGV) and different trip purposes
Trip matrix	A table representing travel in a model area between land areas or zones
Validation	A process of comparing the model data with independent data
Variable demand modelling	A model that forecasts changes in travel behaviour such as trip frequency, choice of mode, time of travel and trip distribution
Zone	An area of land or development which is used in a transport model to aggregate individual households or commercial premises into a manageable number of units that can be used to represent journey patterns in the study area. Usually the zone size will be relatively small in the study area, but progressively larger further away from it.