Lincolnshire County Council

Grantham Transport Study

Technical Note 7: Traffic Modelling

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Jacobs Fairbairn House, Ashton Lane, Sale, Manchester M33 6WP
Tel: 0161 962 1214 Fax: 0161 905 5855

Lincolnshire County Council

Grantham Transport Study

Technical Note 7: Traffic Modelling

.....Project Director

.....TSP Project Leader

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Jacobs Fairbairn House, Ashton Lane, Sale, Manchester M33 6WP
Tel: 0161 962 1214 Fax: 0161 905 5855

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Non-Technical Executive Summary

Introduction

The Grantham Transport Study is looking at transport problems in Grantham and how to tackle them.

The aims of the Transport Strategy are:

- To improve the management of traffic into and through Grantham in both the short term (up to 2011) and the long term (beyond 2011)
- To try to tackle the issues associated with congestion in Grantham in the present and the future
- To look at the environmental impacts of existing and future traffic in Grantham, in particular air quality
- To support the sustainable economic growth of the town and the surrounding area

A very important part of the Study process is to understand how the traffic flows around Grantham both now and in the future. By doing this 'modelling' of traffic, we will know how the traffic will be affected by any improvements that are considered for Grantham. The purpose of this Technical Note is to set out the results of the modelling that has been done.

Data Collection

The first step was to count the traffic flowing through and around Grantham now. Traffic was counted at many junctions in the town by staff. Machines were used to count the amount of traffic travelling along some roads in the town. Staff also drove set journeys through the town many times to check how long it took and where the queues were along the way. These counts were done in the morning and evening rush hours, following government guidance, in September 2006.

The Traffic 'Models'

The traffic was modelled in Grantham using two different types of computer programs.

'SATURN' is the name given to the program which looks at all of the traffic in the 'built up' area of Grantham from the A1 in the west to Whalebone Lane in the east, and from Gonerby Moor in the north to Little Ponton in the south. It works out where all the traffic is going to and where it has come from. This means the computer can tell how many vehicles there will be on a particular stretch of road at a particular time. As with any computer program, although it will not be accurate down to the exact number, it gives a good idea and helps us to understand how this might change in the future.

'VISSIM' is the program which looks in more detail at specific areas. In Grantham, this program is set up to look at the town centre and major junctions into the town. This program takes the numbers of vehicles on the different stretches of roads from 'SATURN' and looks in more detail at where the queues are and how the vehicles use the different traffic lanes provided.

Both of these programs have to be set up to make sure that the way they show the traffic flowing around the town is very close to how it actually happens. Once this is as close as possible for how the

traffic looks now, the programs are set up to look at how traffic flows might change in the future. As well as changing the numbers of vehicles moving around the town to show how the numbers of vehicles will grow (using government guidance), we can see what happens when buildings, that are planned, will be finished. We can then see what improvements might be needed and what happens when they are made. Some improvements will reduce queues whilst others might mean the queues simply move to another junction in the town. It is important that an improvement has a good effect in reducing traffic queues overall.

Results

The two programs were set up to look at what the traffic flows would be like in the future (the year 2016 was carefully chosen). They were set up to see what would happen if we did nothing i.e. built no new roads and made no improvements to junctions etc. They were also used to see what the effect of some improvements might be.

The improvements that were looked at were:

1. 'High Street Shuttle Running' – this is the scheme to widen the pavements on the narrowest part of the High Street with traffic lights to control a single lane for traffic.

2. Inner Relief Road – Station Road north to east

3. Southern Bypass – (A1 to A52 Somerby Hill)

When these were all modelled on their own, it became clear that no single improvement on its own will address all the traffic problems in Grantham. Both the Inner Relief Road and Southern Bypass will relieve traffic queues on some routes and at some junctions, although neither have the answer to the problems on every route.

Looking at the new Harlaxton Road/Wharf Road/Station Road junction, it would appear that in the future as the number of vehicles in the town increases, traffic queues along Harlaxton Road into Grantham could get a lot worse.

The content of the remainder of this document is made up of technical reporting which is intended for a technical audience.

1.0 Introduction

1.1 Background

1.1.1 The Grantham SATURN traffic model was originally developed jointly by Lincolnshire County Council (LCC) and JMP in 1991. In 2000 it was updated with origin-destination data from roadside interviews collected at a cordon around the town. Widespread traffic counts collected throughout the town at the same time provided traffic information at a number of screenlines and were used to validate the model.

1.1.2 It was agreed with LCC that the existing 2000 model would be updated using 2006 counts and journey time data for both peak hours to inform the Grantham Transport Study and to provide origin-destination data for a VISSIM micro-simulation model of the town centre.

1.1.3 Development of the model involved refining and updating the AM and PM peak hour trip matrices to a new base year of 2006 and revalidating the model. This Technical Note therefore replaces the Local Model Validation Report (LMVR) dated April 2002, but still encompasses the same guidelines followed previously.

1.2 Report Structure

1.2.1 The structure of this Technical Note is as follows:

- Section 1 sets out the background and modelling approach
- Section 2 describes the updating process and survey data
- Section 3 describes the SATURN model calibration process
- Section 4 describes the SATURN model validation process
- Section 5 describes the VISSIM model calibration and validation
- Section 6 describes the traffic forecasting process
- Section 7 outlines the results of the modelling work
- Section 8 draws conclusions from the model update work

1.3 SATURN Modelling Approach

1.3.1 The main requirement of the Grantham traffic model is that it should be capable of reflecting existing travel patterns, particularly in the town centre, and be sensitive to route choice on the road network. The model has been developed to assess local schemes and uses a junction-based network with traffic demand representing typical peak hours during an average day in school term time.

1.3.2 All junctions are modelled in detail (simulation mode), with parameters such as roundabout entry arm capacities, traffic signal timings and priority junction characteristics being input explicitly. This allows SATURN to model delays due to general traffic congestion or signal timings.

1.3.3 The SATURN model covers all of the 'built up' area of Grantham, from the A1 in the west to Whalebone Lane in the east, and stretches from Gonerby Moor in the north to Little Ponton in the south. The SATURN model network showing the full extent of its geographical coverage is shown in Figure 1.1.

1.3.4 The zone system used in the 2000 model was refined to take account of sites allocated for proposed developments and to better represent a number of zones in the town centre. This allows a better distribution of traffic to be achieved in the assignment process in the updated base year model.

1.3.5 The 2000 model matrices represent "all vehicles" and were used as the basis for developing the 2006 base year matrices. These were updated using the 2006 manual and automatic traffic count data with some matrix estimation work being used to produce the validated AM and PM peak hour base year matrices.

1.3.6 A number of assignment techniques are available in SATURN and the original Grantham model used an equilibrium technique based on Wardrop's Equilibrium. This was still considered to be appropriate for modelling the peak hours in Grantham and was therefore used for the 2006 modelling work. This procedure provides a realistic spread of traffic across alternative routes in the study area. Traffic is assigned in an iterative manner so that the effects of traffic congestion can influence route choice in the network.

1.3.7 Vehicle trips are assigned to the network by connecting each zone in the matrix to the network as realistically as possible to reflect the way in which they are distributed.

1.3.8 During the SATURN modelling process an iterative assignment procedure is followed until the changes in the reassignment of traffic between each iteration is sufficiently small for the model to show acceptable convergence as indicated in the output statistics.

1.4 VISSIM Modelling Approach

1.4.1 A VISSIM microsimulation model was created as part of the Grantham Transport study. The model covered Grantham town centre and the major junctions into the town. The area modelled is shown in Figure 1.2.

1.4.2 The VISSIM model was calibrated using traffic from the 2006 Do Nothing SATURN model in order to replicate existing conditions. Both the AM and PM peak hours were modelled, as well as the half hours prior to and after the peak hours in order to ensure the correct traffic was on the network for the peak hour.

1.4.3 The calibrated networks were then used to model the Do Minimum situation in 2016 and three different Do Something scenarios, which were:

- DS1: High Street Shuttle Running
- DS2: Inner Relief Road
- DS3: Southern Bypass

1.4.4 The traffic data used for all these scenarios consisted of a series of matrices covering the town centre area, which were output from the SATURN model of Grantham.

1.4.5 As the traffic information was provided in the form of matrices, the assignment of traffic in the VISSIM model was carried out using VISSIM's Dynamic Assignment module.

1.4.6 The Dynamic Assignment module is designed to model the route choice behaviour of drivers, thus allowing the modelling of the network using the specification of origin-destination matrices as flow input. In VISSIM the assignment is done dynamically over time by an iterated application of the microscopic traffic flow simulation.

2.0 Data Collection

2.1 Introduction

2.1.1 As part of the Grantham Transport Study process, it was not envisaged that the SATURN model would be used to support a detailed funding application to the Department for Transport for a major infrastructure scheme, and so the need for a thoroughly robust model adhering to all guidance criteria was greatly reduced. As a result, consideration of the issues relating to the project budget, timescale and the intended model purpose within the study led to the decision that it would not be appropriate for the update to the model to include a full matrix update with roadside interview survey data.

2.1.2 A review of existing available data identified the need for a comprehensive data collection exercise involving Automatic Traffic Counts (ATCs), Manual Classified Turning Counts (MCTC's) and journey time surveys. New surveys and counts were subsequently undertaken by Jacobs in September 2006 to update traffic flows in the 2 peak hour SATURN models and were also used to check the start and finish times of the AM and PM peak hours. Additionally, data covering weekday periods outside of the 2 peak hours was collected for information if required for further analysis.

2.1.3 As in the previous 2000 Grantham SATURN model validation work, guidance on model validation in DMRB Volume 12 Section 2 "Traffic Appraisal in Urban Areas" was followed to demonstrate that the correct methods have been adhered to.

2.2 Survey Data

2.2.1 ATC data were collected over a 2 week period to provide average weekday traffic flows. The ATCs collectively form a number of screenlines which were used to validate the SATURN model (see Section 3.3).

2.2.2 MCTCs were carried out at key junctions to provide up to date link flows, turning counts and vehicle classifications. These were used primarily to obtain information about turning flows but also to provide details of link flows on each of the junction arms for use in calibrating and validating the SATURN model. Plans showing the locations of MCTCs and ATCs are shown in Figures 2.1 and 2.2.

2.2.3 The previous Grantham SATURN model did not include validation of journey times. In order to provide further network validation in this model update, journey time surveys were undertaken for 3 key routes across Grantham and are shown in Figure 2.3. Each route was surveyed in both directions over a number of days to ensure the information gathered was representative of a typical day.

2.2.4 The traffic count data was investigated to confirm that the observed AM and PM peak hours were the same as those represented in the 2000 model. There was no overwhelming evidence to suggest that the times should be changed and the modelled peak hours remain as 0800-0900 for the AM peak hour and 1630-1730 for the PM peak hour.

2.3 Logic Checks

2.3.1 The ATCs were checked for any inconsistencies in the 2 weeks of data and anything considered unacceptable was removed from the data set. MCTCs were compared against others at nearby locations to ensure that only sensible data was used in the model.

2.3.2 Although count data was collected for pedal cyclists, it was excluded from the traffic data used for the model update but is available for further analysis if required.

3.0 SATURN Model Calibration

3.1 Introduction

3.1.1 Calibration of the SATURN network and matrices was carried out to ensure that the model provides a sensible representation of observed traffic flows. The calibration process involved refinement of the network details to ensure assignment and route choice were well represented.

3.1.2 During this process, adjustments were made where necessary to link speeds and junction characteristics such as signal times and saturation flows in the simulation network. The trip matrices were also adjusted to achieve a reasonable distribution of trip origins and destinations in order to achieve link flows that satisfied DMRB criteria.

3.2 Network Calibration

3.2.1 Prior to the calibration process, the network was updated to take account of any changes that had taken place since the 2000 model was originally built such as the introduction of the new gyratory systems at Premier Court and Great Northern Court.

3.2.2 The network was also refined to accommodate potential developments such as those proposed at Poplar Farm, the Canal Basin and land between Belton Lane and Manthorpe Estate. This involved increasing the number of zones in the model so that traffic movements could be modelled more realistically.

3.2.3 The locations at which traffic loads onto the network via zone connectors were reviewed as they can influence route choice quite significantly, particularly if there is an alternative route nearby.

3.2.4 Most of the junction parameters used in the updated SATURN model were inherited from the 2000 model. Traffic signals followed the same phasing in both the AM and PM models but with some timing differences.

3.2.5 Route checking between key origins and destinations in the network was carried out during the calibration process to ensure that route choices in the model were sensible, however, no changes were found to be necessary.

3.2.6 Congestion and route choice in the model are influenced by delays in the simulation network. Initial link speeds represent free-flow speeds, reflecting speed limits, but were found to be too fast when compared with journey time survey data. Link speeds were generally reduced during the calibration process to ensure good correspondence between modelled and observed journey times on the routes surveyed as shown in Table 3.1 below.

3.2.7 DMRB requires modelled journey times on each route to be within 15% of observed times for at least 85% of all routes surveyed.

Table 3.1: Journey Time Comparison

	AM Peak Hour			PM Peak Hour		
Route Description	**Observed (sec)**	**Modelled (sec)**	**Diff (%)**	**Observed (sec)**	**Modelled (sec)**	**Diff (%)**
Route 1 (Blue)						
A52 EB	872	749	-14	942	726	-23
A52 WB	799	671	-16	717	718	0
Route 2 (Green)						
A607 NB	776	712	-8	846	687	-19
A607 SB	792	705	-11	619	615	-1
Route 3 (Red)						
B1174 NB	946	968	2	953	968	2
B1174 SB	1154	996	-14	976	954	-2

3.2.8 Table 3.1 shows a good comparison between observed and modelled journey times in the AM peak with only one of the journey time routes modelled (Route 1 Westbound) being marginally outside the 15% variability range. In the PM peak, the journey time comparison was not so good with two journey time routes out of the 6 falling outside of the 15% range.

3.2.9 As stated in DMRB, the erratic nature of journey time observations in urban areas can necessitate a larger sample. It was found that the large variability in delays at specific points on the network made it harder to model these realistically, whilst still retaining a good comparison between observed and modelled link flows. However, this is not considered to be a significant issue in the context of the small congested urban network modelled.

3.3 Matrix Calibration

3.3.1 During the SATURN model update, large amounts of traffic count data were required to compare the performance of the model with observed vehicle movements. DMRB guidelines recommend that a proportion of the available count data is used for model calibration and the remainder is kept aside for the validation stage. Traffic counts forming 3 screenlines, shown in Figure 3.1, were used to calibrate the model.

3.3.2 Results from an initial assignment gave an indication of model performance and, as a result, an iterative process of model calibration and reassignment was carried out. After each assignment, modelled traffic flows were compared with observed counts to assess the "goodness of fit" and further model runs were then undertaken to improve the assignment where necessary. Both peak hour models were calibrated at the same time to retain as much consistency as possible between them.

3.3.3 As new RSI data was not available to replace origins and destinations in the 2000 matrix, any matrix updating took the form of producing 'selected link' matrices from the assignments and then adjusting the totals to better match the observed link counts before adding them back to the full o-d matrix.

3.3.4 Matrix and network calibration were carried out at the same time to produce link flows within the Design Manual for Roads and Bridges (DMRB) acceptability guidelines for assignment

validation referred to in Section 4. The matrices were further refined using matrix estimation but only after a satisfactory standard of network calibration had been achieved.

3.3.5 The AM and PM peak hour calibration tables in Appendix A show the location, count type, observed and modelled flow, percentage difference and the corresponding GEH value.

3.3.6 The calibration tables show that the model validates very well for screenlines in both peak hours and easily satisfies DMRB criteria for the GEH statistic. For total screenline flows, only one directional screenline in each of the peak hours marginally fails to meet the criteria with 83% of cases meeting the acceptability guidelines.

3.3.7 It should be noted here that the number of traffic count locations making up the individual screenlines in the model is relatively small and therefore small numbers of links failing to meet the acceptability guidelines causes a large % change. Also, in most cases the links failing to meet the guidelines are outside of the cordon used for the VISSIM model and will not therefore affect the town centre modelling.

3.4 Generalised Cost Calibration

3.4.1 The modelled generalised cost coefficients comprise values of time and distance. Changes in either parameter can influence the proportions of traffic that choose between alternative routes and reflect the degree to which time or distance (or both) are the key factors in route choice. In other words, do vehicles favour shorter routes over quicker routes or vice versa. Initial model runs used the 2000 model values of 1.00 for time and 0.5 for distance and there was no evidence to suggest that changing these values would improve the assignment. These values were therefore retained and used in the updated 2006 model.

3.5 Model Convergence

3.5.1 A run of the Grantham traffic model consists of a series of assignment iterations until an acceptable level of convergence is achieved. Convergence in SATURN demonstrates stability of the model and is measured as follows:

- By the difference in times between the chosen routes and the minimum time routes for the entire network (Delta %) and ideally this value should tend towards 0%.
- By the difference in total vehicle hours and total assignment costs between successive assignment iterations.

3.5.2 Overall, convergence of the model in the calibration stage is considered very good with a Delta value of less than 1 and a percentage of flows and delays of greater than 95% for the final iterations.

4.0 SATURN Model Validation

4.1 Introduction

4.1.1 Validation is the process of demonstrating the quality of the model by comparing model output with observed data which should be independent of data used for calibration. In accordance with DMRB guidance, validation of the model should comprise the network, matrix and assignment (link flows) as separate elements and this is covered in the following paragraphs.

4.2 Network Validation

4.2.1 The network has been validated by route checking to ensure that route choice in the SATURN model appears sensible. “All or nothing” paths through the network were built for selected origin-destination movements using the final iteration of the assignment procedure. Turning movements were used, where available, to further understand routeing in the model.

4.3 Matrix Validation

4.3.1 New RSIs were not undertaken for the Grantham SATURN model update. The approach adopted for the development of the base year matrices, as outlined in Section 3, used 2006 traffic count data to update the existing base year o-d matrices. There is therefore no independent data set which can be used to validate the matrices. The overall reliability of the matrices is demonstrated by reference to the validation tables shown in Appendix A.

4.4 Assignment Validation

4.4.1 The most important part of the validation process is assignment validation which compares observed and modelled traffic flows. The assignment convergence statistics are also used to demonstrate stability of the model and have been referred to in Section 3.5. A summary of the convergence statistics from the final SATURN assignment iteration are shown in Table 4.1 below. Overall, convergence of the model is considered very good with a Delta value of less than 1 and a percentage of OK flows and delays of greater than 95% for the final iterations.

Table 4.1: Model Convergence Statistics

Convergence Statistic	AM Peak Hour Model	PM Peak Hour Model
Delta	0.115%	0.117%
% of OK Flows	97.60%	99.43%
Previous 3 Loops	96.68% 97.73% 97.55%	98.60% 98.65% 96.98%
% of OK Delays	98.87%	99.30%
Mean GEH	0.061	0.028

4.4.2 The assigned flows are key model outputs and fundamental in any scheme assessment.

Differences between modelled and observed link flows may point to errors or inconsistencies in any part of the modelling process and are therefore important indicators of the overall accuracy of the model.

4.4.3 The criteria used in assignment validation in the 2006 model update are consistent with DMRB Volume 12, Section 2 "Traffic Appraisal in Urban Areas" and are shown in Table 4.2 below.

Table 4.2: DMRB Assignment Validation Acceptability Guidelines

Criteria and Measures	Acceptability Guideline
Assigned Hourly flows* compared with observed flows	
1. Individual flows within 15% for flows 700-2700 vph	> 85% of cases
2. Individual flows within 100 vph for flows < 700 vph	> 85% of cases
3. Individual flows within 400 vph for flows < 2700 vph	> 85% of cases
4. Total screenline flows (normally > 5 links) to be within 5%	> 85% of cases
5. GEH statistic:	
i) individual flows: GEH < 5	> 85% of cases
ii) screenline (+) totals: GEH < 4	All (or nearly all) screenlines
Notes + Screenlines containing high flow routes such as motorways should be presented both including and excluding such routes * links or turning movements	
Modelled journey times compared with observed times	
6. Times within 15% (or 1 minute if higher)	> 85% of routes

4.4.4 The GEH statistic is a measure of how closely a modelled flow matches the observed figure for that link or screen line. The lower the GEH statistic the better the match between modelled and observed flows. It is calculated to take account of the size of the flow, rather than making a comparison using percentages, as this can be misleading. It is widely accepted as the most accurate means of measuring flow validation.

4.4.5 Guidelines suggest that "a reasonable selection of links that carry traffic critical to the scheme appraisal" should be chosen as validation links. The primary purpose of the Grantham model update is to inform the Grantham Transport Study and provide origin-destination data for a VISSIM model of the town centre. It was therefore considered that assignment validation should cover a selection of links both in the town centre and in the wider network. Traffic counts on links forming 2 screenlines are shown in Figure 3.1 and were used to validate the model.

4.4.6 A series of tables were produced to show the level of validation achieved on the chosen links and screenlines. The results are presented in Appendix A, showing the location, count type, observed and modelled flow, percentage difference and the corresponding GEH value.

4.4.7 The validation tables show that the model validates very well for screenlines in both peak hours and easily satisfies DMRB criteria for the GEH statistic and total screenline flows. For individual link flows, the AM peak hour shows that both screenlines meet DMRB criteria with the exception of one southbound link which causes the town centre screenline to fail marginally with 83% of link flows validated.

4.4.8 In the PM peak, the town centre screenline narrowly fails the criteria with 76% of link flows validated in both directions. It should be noted that there are only 6 count locations in this screenline and one failure causes a large % change. Also, the links in question, namely Goodliff Road and Welham Street are outside of the cordon used for the VISSIM model and will not therefore affect the town centre modelling.

4.5 Correlation Analysis

4.5.1 In addition to the above validation work, a correlation analysis was carried out on the observed and modelled flows using all of the available count data from over 80 locations. This included 2006 counts that were not included in the screenlines and also any other counts from the LCC data base that were considered relevant and could be used to improve the overall robustness of the model.

4.5.2 The correlation coefficient (R) together with the slope of the best fit regression line is shown in Table 4.3 below. DMRB states that acceptable values of the correlation coefficient are above 0.95, and the slope of the best-fit line should lie between 0.9 and 1.10 with a value of 1.0 representing a perfect fit.

Table 4.3: Correlation Summary

	AM Peak Hour	PM Peak Hour
No of Observations	170	170
Correlation Co-efficient R	0.976	0.976
Slope of Regression Line	1.003	0.991

4.5.3 Appendix B shows the plots of modelled flows against observed traffic flows with the best-fit regression line superimposed. Data from the 80+ locations are treated as directional flows and are shown as separate observations on the same chart, amounting to 170 separate data points.

5.0 VISSIM Model Development

5.1 Base Model Calibration

5.1.1 The base VISSIM network (or Do Nothing model) in 2006 was used to calibrate the model so that existing traffic conditions could be replicated. As the traffic flows were taken from the calibrated SATURN model there was no need to calibrate the traffic flows themselves, any adjustments to achieve a calibrated model had to be made to the actual network or peak profile. These included changing parameters such as reduced speed areas, desired speed decisions, banned movements and signal timings.

5.1.2 A peak hour profile was applied to the traffic taken from the SATURN model rather than assuming a flat peak hour. The profile used was based on ATC surveys undertaken in September 2006. For the AM peak this profile was adjusted to represent demand rather than the actual flow as queuing traffic would not have been counted by an ATC possibly until the following 15 minute period. This process of converting the counted profile into a demand profile formed a major calibrating parameter for the AM peak, however the PM peak had a much flatter profile and the counted profile was assumed to match the demand profile.

5.1.3 The 2006 AM and PM models were accepted at a meeting held on 6th February 2007 by the JOG as an accurate representation of the existing network, this was further reinforced at a meeting to review the model with the LCC Signals team on 3rd March 2007.

5.1.4 LCC Signals also provided a queue length survey on the Harlaxton Road approach to its junction with Wharf Road undertaken on 27th April 2006 prior to the signalisation works at the junction. The survey was found to tie up with the VISSIM model for the majority of the modelled period, although the worst queue observed on site was underestimated by the VISSIM.

5.2 Future Year Model Development

5.2.1 The future year VISSIM network (or Do Minimum model) in 2016 was developed by including all of the committed schemes within a revised network. This included the revised Wharf Road/Harlaxton Road gyratory (fully signalled) and proposed changes to the layout and operation of the Wharf Road/London Road junction. The Pennine Way link was also included within the Do Minimum.

5.2.2 The traffic matrix for the Do Minimum 2016 model was taken directly from SATURN. Due to the way in which SATURN represents queues, it cannot represent reductions in junction capacity resulting from downstream queues blocking back through upstream junctions, something which is accurately modelled by VISSIM. As a result, within congested urban networks SATURN tends to overestimate the capacity of junctions when compared with VISSIM.

5.2.3 This was found to be an issue with the 2016 matrix, with SATURN overestimating the capacity of several junctions in the modelled network. The result of this was that when the

matrix from SATURN was applied to the VISSIM model, the model could not handle the traffic trying to get through the network and gridlock would occur in some iterations. In reality, the flows predicted by SATURN would be unlikely to materialise due to the effects of peak spreading and trip suppression resulting from excessive congestion.

5.2.4 To counter this problem, and create a more realistic situation, the traffic matrix used within the VISSIM models was reduced to 95% of the total volume in the SATURN 2016 matrices in order to represent the effect of peak spreading that would be likely to occur if peak period congestion reaches this level. This was considered to result in a more realistic level of demand on the network which did not lead to excessive over-saturation and exponential delay.

5.2.5 It was also assumed that the AM peak would spread with the increased volume of traffic. A flatter profile was applied to the traffic similar to the counted profile from the ATCs in both the AM and PM peaks.

5.2.6 The accepted level of convergence for the Dynamic Assignment process was 20%. When this was reached for the peak hour the model assignment was frozen and the data extracted from this converged model.

6.0 Traffic Forecasting

6.1 Introduction

6.1.1 The 2016 forecast matrices for Grantham were derived from the 2006 base year trip matrices by consideration of different sources of growth, as outlined below.

6.2 Known Developments

6.2.1 The known developments within Grantham covering both residential and employment sites were used to derive the traffic forecast. These were discussed and agreed with LCC Development Control. TRICS generation trip rates were then used to convert these known developments to trip ends required for the assignment matrix.

6.2.2 In total, new trips resulting from known developments made up around 65% of the total growth in the 2016 trip matrices. Appendix C contains a schedule of all developments included, which shows the individual sites together with the number of housing completions and the resulting number of 2016 trips.

6.2.3 A total of 2,131 dwellings have been assumed to be completed between 2006 and 2016. This equates to a population of 5,114 using a factor of 2.4 as shown in the Local Development Framework for South Kesteven. This still leaves almost as much again to be built post-2016 in order to meet current housing allocations, and so the high levels of traffic growth predicted in the model are set to increase even further. However, this growth is likely to be outside of the traditional peak hours.

6.3 Background Traffic Growth

6.3.1 Background traffic growth represents increases in traffic from unknown developments which will be completed before 2016. It also accounts for increases in car ownership due to general improvements in living standards, which were used for the forecast. This growth was applied uniformly across all zones where no site specific developments exist at present.

6.3.2 Background traffic growth for Grantham was taken from the latest version of TEMPRO (version 5.3) which reflects the government's National Trip End Model of traffic growth and uses planning data supplied by local authorities. By 'topping up' the known development growth to that in TEMPRO, a reference case was provided in line with best practice.

6.3.3 National NRTF growth rates were applied to the relatively small amount of longer distance 'through traffic'. This amounts to 8% of the overall matrix total.

6.4 Summary

6.4.1 The overall effect by adding all of the above to the 2006 base year traffic of 11,944 trips for AM peak and 12,833 trips for PM peak is a forecast of 2016 traffic with 13,943 trips and 15,216 trips for AM peak and PM peak respectively.

7.0 Modelling Results

7.1 Introduction

7.1.1 The SATURN and VISSIM models developed for 2006 and 2016 were used to analyse the predicted travel patterns within Grantham, and to test the effect of three highway schemes considered during the study process. The various model scenarios created with SATURN and VISSIM were as follows:

- 2006 Do Nothing base model – existing network, observed trips
- 2016 Do Minimum future year model – committed changes to network, predicted trips
- 2016 Do Something scenario 1 – Do Minimum plus High Street shuttle running scheme
- 2016 Do Something scenario 2 – Do Minimum plus Inner Relief Road scheme
- 2016 Do Something scenario 3 – Do Minimum plus Southern Bypass scheme

7.2 Analysis of Travel Patterns

7.2.1 The 2016 Do Minimum AM and PM matrices used in the SATURN model were used to analyse traffic flow around Grantham. This was done by classifying each of the zones within the matrix as an external zone, an internal zone or a town centre zone, and then considering the level of traffic travelling to and from each one.

7.2.2 External zones were considered to be all zones not actually in Grantham itself, such as those which represent traffic entering Grantham from the A1, A52 and A607. Internal zones were considered to be zones within the urban area of Grantham but not including the town centre zones. The results of this analysis can be seen in Tables 7.1 and 7.2 below.

Table 7.1: 2016 AM Do Minimum Traffic Flow Summary

AM	Town Centre	Internal	External	**Total**
Town Centre	280	718	363	**1361**
Internal	1254	2204	2376	**5834**
External	1087	2786	874	**4747**
Total	**2621**	**5709**	**3612**	**11942**

Table 7.2: 2016 PM Do Minimum Traffic Flow Summary

PM	Town Centre	Internal	External	**Total**
Town Centre	710	1396	914	**3020**
Internal	1234	2783	2161	**6179**
External	494	2270	870	**3634**
Total	**2438**	**6449**	**3945**	**12832**

7.2.3 In the AM peak and in the PM peak, 7% of the traffic travels through Grantham between two external zones. This shows that 'through traffic' accounts for only a small proportion of journeys in the peak hours. Therefore building a bypass around Grantham would not have dramatic effects on the traffic situation in the town centre at peak times, since the vast majority of traffic within the town is travelling to or from internal zones or town centre zones.

7.2.4 The proportion of traffic travelling between an external and an internal zone (including the town centre) is 55% in the AM peak and 46% in the PM peak. This shows that approximately half of the journeys in peak hours are due to journeys between places outside of Grantham and Grantham itself. However, these journeys include locations throughout the urban area and not only the town centre.

7.2.5 In the AM peak 37% of traffic travels between internal zones. Of this traffic, 6% travels between town centre zones, 44% travels between an internal zone and a town centre zone and 49% travels between two internal zones, but not to or from the town centre. In the PM peak 45% of traffic travels between internal zones. Of this traffic, 12% travels between town centre zones, 43% travels between an internal zone and a town centre zone and 45% travels between internal zones, but not to or from the town centre.

7.2.6 Only 22% of all journeys in the AM peak are to the town centre, with 13% being from internal zones, including the town centre, and the remaining 9% being from external zones. In the PM peak, 24% of journeys originate in the town centre with 16% being to internal zones, including the town centre, and 7% being to the ten external zones.

7.2.7 These figures show that nearly a half of all internal journeys made in the peak hour are to other internal zones not including the town centre. In addition, the proportion of trips to the town centre from external zones is very small. Park & Ride sites on the edge of the town with services to the town centre are therefore highly unlikely to be viable, since less than a quarter of the traffic around Grantham is travelling to or from the town centre.

7.2.8 A further analysis was done by considering the external zones by route in turn. Of the traffic using the A52(E) in both peaks, 13% is travelling to or from the town centre, 52% to or from internal zones and 35% to or from external zones. As only 35% of the traffic using the A52(E) is through traffic, the Southern Bypass would not significantly reduce traffic in Grantham town centre at peak times, since 65% of traffic using the A52(E) would probably still be travelling into the internal zones of Grantham, whilst traffic on the A52(E) makes up only a very small proportion of total traffic in the town centre.

7.2.9 Of the traffic using the A607(NE), 17% is travelling to or from the town centre, 61% to or from internal zones and 21% to or from external zones. Due to this small proportion of traffic travelling to external zones, any northerly bypass of Grantham would have very little impact on the traffic in the town centre at peak times. A park and ride site near the A607 would also be of limited benefit as the number of possible users is small – only 17% of trips from the A607(NE) are to the town centre.

7.2.10 Of the traffic using the other east and north east external links, Harrowby Lane and Londonthorpe Lane, 25% is travelling to or from the town centre, 61% to or from internal zones and 14% to or from external zones. This again shows that the majority of traffic travelling to and from these external zones is not through traffic but has a destination somewhere within the urban area of Grantham.

7.3 SATURN Modelling Results

7.3.1 Data was taken from the SATURN model detailing the network performance in each scenario as well as queue and delay data for key junctions within Grantham. The network performance data extracted from the SATURN model can be found in Appendix D, which contains six indicators of network performance, as follows:

- Transient Queues – represents delay caused by reduced speeds approaching junctions and by waiting time at junctions, but does not include delay created whilst stopped in queues at over capacity junctions.
- Over Capacity Queues – shows the time spent queuing as a result of junctions operating over capacity.
- Link Cruise Time – Time spent travelling with neither type of delay experienced.
- Total Travel Time – Sum of time spent in transient queues, over capacity queues and link cruise time.
- Travel Distance – The total distance travelled by all the vehicles in the model.
- Average Speed – The average speed of all the vehicles in the network over the modelled period, calculated by dividing travel distance by total travel time.

7.3.2 Queue and delay data for key junctions within the town was also obtained. 'Average queue' data from SATURN is measured in vehicles and is calculated by adding together the mean queues on each arm (where the mean queue is calculated across all the lanes of that arm). 'Average delay' is measured in seconds and is calculated by summing all inbound delays across each queue and dividing this by the total number of vehicles passing through the junction.

Do Minimum 2016

7.3.3 In the Do Minimum network there were several changes made to the SATURN network compared to the 2006 model used for calibration, these were:

- Harlaxton Road/Wharf Road signalisation;
- Altered layout and staging at Wharf Road/London Road junction;
- One way system through Market Place and closing of Conduit Lane into Market Place;
- Completion of the Pennine Way Link.

7.3.4 Although the proposed scheme for Market Place was included within the Do Minimum scenario, commitment to the scheme is currently being reviewed.

7.3.5 In the AM peak the total delay caused by over capacity queues is 118.3 hours across the network, this increases to 191.4 hours in the PM peak. The impact of this increased delay in the PM peak is that the average speed across the network drops from 29.5 km/h in the morning peak to 27.3km/h in the evening peak.

7.3.6 The SATURN modelling shows that the Gainsborough Corner, Sankt Augustin Way/Dysart

Road, Barrowby Road/North Parade and Union Street/Premier Court Gyratory junctions operate with the most delay and queuing, Table 7.3 shows the performance data for these four junctions.

Table 7.3: 2016 AM Do Minimum Junction Performance

	Delay (secs)	Queue (vehs)
Gainsborough Corner	92	59
Sankt Augustin Way/Dysart Road	45	35
Barrowby Road/North Parade	41	26
Union Street/Premier Court Gyratory	76	23

7.3.7 During the evening peak three of the four junctions operating worse than the remainder of the network in the morning again are highlighted as junctions with capacity issues. The junction of Sankt Augustin Way/Dysart Road operates more in line with rest of the network during the PM peak.

7.3.8 However, the junction of Dysart Road and Westgate experiences much more delay during the evening peak hour, although queuing remains similar to other junctions. Table 7.4 shows the four worst performing junctions in the PM peak.

Table 7.4: 2016 PM Do Minimum Junction Performance

	Delay (secs)	Queue (vehs)
Gainsborough Corner	74	51
Dysart Road/Westgate	274	38
Barrowby Road/North Parade	38	36
Union Street/Premier Court Gyratory	47	25

Do Something 1 – High Street Shuttle Running

7.3.9 The Do Something 1 model includes all the schemes in the Do Minimum network as well as the shuttle running scheme at the north end of High Street (known elsewhere as option A2). This scheme would create better pedestrian provision along this street, which currently has narrow footways and no dedicated crossing facilities in this area.

7.3.10 The overall network data for this scenario shows a slight increase in both the transient queues and over capacity queues compared to the Do Minimum network in 2016. These increases account for the decrease in average speed to 29.3 km/h indicating a slightly more congested network.

7.3.11 In the morning the majority of junctions operate at a similar level in both the Do Minimum and Do Something 1 models. Exceptions to this are the junction of Westgate and Dysart Road, where the average delay increases by 22s to 36s with an increase in average queue from 7 to 12 vehicles, and the ADSA roundabout junction, where average delay increases by 12s to 30s and the average queue by 9 vehicles to 16 vehicles. The only junction that demonstrates a significant reduction in average delay is that of Union Street and the Premier Court Gyratory system. Here the delay is reduced by 13s to 63s, although the queue only declines by 3 vehicles.

7.3.12 In the evening peak hour the overall network results show that there are increases in both

the transient and over capacity queues, with a significant rise in over capacity queues of 52.8 hours from the Do Minimum model to 244.2 hours in the Do Something 1 model. The result of this is a reduction in average speed to 25.8 km/h from 27.3 km/h indicating an increasingly congested network.

7.3.13 The junction data indicates that the majority of this delay is experienced across two junctions, Harlaxton Road/Wharf Road (+20s) and Dysart Road/Westgate (+65s), which are both part of the Dysart Road Gyratory system. Only the Union Street/Premier Court Gyratory junction displays a significant reduction in delay in the PM peak, an 18s saving compared with the Do Minimum model. All other junctions across the network appear to operate similarly to the Do Minimum network.

Do Something 2 – Inner Relief Road

7.3.14 The Do Something 2 network comprises the Inner Relief Road scheme that would link the two ends of Station Road that are currently separated by a barrier and owned by Network Rail. The remainder of the network remains the same as the Do Minimum model.

7.3.15 During the AM peak hour there is a reduction in the over capacity queues whilst the transient queues remain relatively unchanged compared to the Do Minimum network. Overall there is a reduction in total travel time and an increase in the travel distance, therefore the average speed of vehicles in the network increases to 29.8 km/h, indicating a less congested network than previously.

7.3.16 Only two junctions demonstrate a change in delay of over ten seconds compared to the Do Minimum model. The average delay at the junction of Dysart Road and Westgate increases by 14s to 28s, and there is a 4 vehicle increase in the average queue length. Whilst the delay at Dysart Road's junction with Sankt Augustin Way decreases by 11s to 34s, there is a 7 vehicle reduction in the average queue.

7.3.17 In the PM peak both the transient queues and over capacity queues are reduced relative to the Do Minimum model. The result of this is an increase in average speed of 0.3 km/h, an increase that is not a large as the reductions in queues might have indicated, however the distance travelled through the network has also decreased by 104.5 km.

7.3.18 In the evening peak hour the individual junction data shows that only one junction has a change in delay greater than ten seconds, this is the sensitive junction of Dysart Road and Westgate, where delay increases by 14s. The remaining junctions do not show a significant change in average delays or queues.

Do Something 3 – Southern Bypass

7.3.19 The third and final option tested is the Southern Bypass. This is intended to relieve the town centre area of through traffic, especially the existing high proportion of HGVs that pass through Grantham.

7.3.20 In the AM peak there is a slight increase of 2.2 hours across the network in transient queues compared to the Do Minimum network, due to the increase of junctions in the network with the Southern Bypass in place. However, there is a more marked decrease in over-capacity queues of 13.8 hours. Along with an increase in total travel distance (+1572 km) the result is an increase in the average speed over the network of 1.2 km/h to 31 km/h, indicating reduced congestion.

7.3.21 On the whole the junctions in the town centre area operate with a very similar amount of delay compared with the Do Minimum network in the AM peak. The junction of Dysart Road and Sankt Augustin Way shows the largest change in delay with a reduction of 16s and a reduction in average queues of 14 vehicles.

7.3.22 During the PM peak the amount of delay in transient queues is reduced by 4 hours and there is also a reduction of 52.8 hours in the amount time spent in over capacity queues. These reductions in delay coupled with increases in link cruise time and travel distance lead to a relatively significant increase in the average speed across the network to 30.1 kph, indicating a significant improvement in network performance during the evening peak.

7.3.23 The individual junctions showing the largest improvement are Dysart Rd/Westgate, the Barrowby Road/Sankt Augustin Way/ASDA roundabout and Union Street/Premier Court Gyratory.

7.3.24 The Dysart Road/Westgate junction has a 160s reduction in average delay and 10 less vehicles in the average queue compared to the Do Minimum model. The delay at the ASDA roundabout is halved from 28s to 14s compared to the Do Minimum and there are 13 less vehicles in the average queue. At the junction of Union Street and the Premier Court Gyratory the average delay is reduced by 18s and the average queue is 9 vehicles less.

7.4 VISSIM Modelling Results

7.4.1 All queue lengths and travel times recorded from the VISSIM model can be found in Appendix E. Queue lengths were recorded at main junctions into the town centre cordon area to give an idea of constraints on the edge of the modelled area, whilst travel times were recorded to indicate the amount of time to make strategic movements through Grantham and therefore indicate the amount of congestion within the town centre area.

Do Minimum 2016

7.4.2 As with the SATURN model, the Do Minimum VISSIM network comprised changes to the Harlaxton Road/Wharf Road junction, changes at the Wharf Road/London Road junction and the creation of a one way system through Market Place that also involved the closing of Conduit Lane at its junction with Westgate in Market Place. External to the VISSIM network the Pennine Way Link is completed in this scenario which relieves some of the traffic moving between North Parade and Barrowby Road.

7.4.3 In the AM peak hour the longest average queues into the town centre are found on Harlaxton Road (1154m), Dysart Road (365m), Springfield Road (483m) and Barrowby Road (164m). In the PM peak hour the Dysart Road approach is no longer a problem, however the queues on North Parade (611m) and Barrowby Road (1239m) become much worse.

7.4.4 From the VISSIM some overall network data was collected to give an idea of how the network as a whole operates. In the 2016 Do Minimum case the average delay per vehicle travelling through the network was 559s in the AM peak (compared with 275s in the 2006 existing case) and 613s during the PM peak (compared with 235s in 2006). The average speeds of the vehicles in the network during the AM and PM peaks were 12.9kmh and 11.2kmh respectively (compared with 18.9kmh and 17.7kmh in 2006). These two

parameters give an indication of the amount of congestion and queuing found in the town centre in 2016 when compared with the existing traffic conditions in the town.

Do Something 1 – High Street Shuttle Running

7.4.5 The Do Something 1 model is the same network as the Do Minimum with the inclusion of a shuttle running system on High Street which allows the widening of the footpaths through the narrowest part of High Street and the inclusion of pedestrian facilities at the junction of Westgate, Watergate and High Street (known elsewhere as option A2).

7.4.6 The overall network performance data suggests the network works less efficiently with the introduction of the High Street shuttle running scheme. Delay per vehicle increases in the AM peak by 9.8s and by 5.6s in the PM peak and the average speed per vehicle decreases in both peaks by 0.2 km/h and 0.1 km/h respectively. It appears that in the already more congested PM network the shuttle running will have a less noticeable effect.

7.4.7 Despite the poorer network performance, the average queue lengths during the AM peak into the model appear to have reduced on the majority of routes into Grantham, apart from a 359m increase in the queue along Barrowby Road approaching the ADSA roundabout and a small increase along St Catherine's Road and Belton Lane. The routes with the longest queues in the Do Minimum scenario (Harlaxton Road, Dysart Road and Springfield Road) show the most significant reduction in average queue lengths. However, this is likely to be associated to the transfer of traffic to routes outside of the VISSIM network more than the introduction of the shuttle running scheme.

7.4.8 Travel times through the town centre are shown to increase travelling both from the South to the North and from the North to the South. This is due to the congestion and reduced capacity along High Street that occurs when the shuttle running scheme is in place.

7.4.9 During the PM peak there are no large changes to the queue lengths on most routes into the town centre. The most noticeable decreases in average queue length are on North Parade (-199m) and Springfield Road (-88m). However, other routes do suffer an increase in queue lengths, Harlaxton Road (+660m) and Barrowby Road (+121) suffer the most significant increases.

Do Something 2 – Inner Relief Road

7.4.10 The Do Something 2 model is based on the same network as the Do Minimum model with the inclusion of the Inner Relief Road (known elsewhere as Option E3). The Inner Relief Road follows the route of Station Road East and Station Road West from the Harlaxton Road end to the junction with London Road, and would be created by upgrading the existing roads and joining the two legs of Station Road. In the model the junction with London Road has been signalised and the signal times at Harlaxton Road adjusted to transfer some green time from Wharf Road to Station Road.

7.4.11 The indicators of network performance suggest that in the AM peak vehicles encounter greater delay travelling through the network. The average delay per vehicle is 26.7s greater than in the Do Minimum scenario and the average speed of vehicles has dropped 0.6km/h.

In the PM peak the delay suffered by vehicles has decreased by 11.0s per vehicle in comparison to the Do Minimum model. However, the average speed per vehicle has decreased by 0.2km/h, but this minor change could be due to the introduction of a new signalised junction or by traffic routing along slower roads. It therefore appears that the Inner Relief Road would have a more beneficial effect in the evening peak hour.

7.4.12 The queues on routes into the modelled area are reduced at all junctions in the AM peak, with the exception of the Harlaxton Road approach to the junction of Wharf Road, Station Road and Harlaxton Road. At this junction the average queue increases by 786m relative to the Do Minimum, and will contribute to a large amount of the additional delay recorded in the overall network performance.

7.4.13 The average travel time of vehicles travelling through the town centre from north to south or vice versa also increases in the AM peak, so although a large amount of the delay recorded could be on the one approach there is also additional delay in the town centre itself.

7.4.14 Unlike the AM peak model, the model of the PM peak shows increases in queue length on four approaches to the modelled town centre area. The three routes with the longest queues in the Do Minimum all suffer increases in the queue length, these are Harlaxton Road (+879m), Barrowby Road (+382) and North Parade (+145m). Like the AM model it is Harlaxton Road that appears to be the most sensitive route to changes in traffic distribution.

7.4.15 Once inside the cordon of the VISSIM model the average travel times through the town centre appear to have dropped on average in the PM peak. However, traffic travelling from Gainsborough Corner to the north of Grantham appears to suffer slightly due to the introduction of the new signalised junction with Station Road.

Do Something 3 – Southern Bypass

7.4.16 The Do Something 3 network is exactly the same as the Do Minimum network in the VISSIM modelling, the only change is to the traffic demand matrix resulting from reassignment of traffic in the SATURN model with the Southern Bypass in place (known elsewhere as Option E7).

7.4.17 In the AM peak the bypass results in an overall decrease in traffic within the VISSIM model network of 5.3% and 2.2% in the PM peak. The Southern Bypass will also result in the diversion of a large number of heavy goods vehicles away from the town centre. The AM peak would see a 41% decrease in the number of HGVs and the PM peak sees a 44% decrease.

7.4.18 The overall network performance in the AM peak appears to have improved in the Do Something 3 model relative to the Do Minimum. The average delay per vehicle has decreased by 11s, although the average speed has dropped very slightly. The PM peak shows similar trends in the overall network performance, although not as marked. Average delay has decreased by 1.5s and the average speed has also decreased by 0.2 km/h, the difference between the two peaks is likely to be due to the higher amount of traffic rerouted away from the town centre in the AM peak.

7.4.19 The queue lengths on routes into the town centre reduce at every junction apart from the Manthorpe Road approach to the junction with Belton Lane, where there is an increase in average queue length of 17m. Harlaxton Road (-434m), Dysart Road (-285m), Barrowby Road (-142m) and Springfield Road (-321m) all experience significant reductions in queue length relative to the Do Minimum scenario in 2016. Theses benefits are likely to be largely related to the 5.3% decrease in traffic and the reduction of heavy vehicles.

7.4.20 Despite the reduction in queue length the travel times for traffic heading through the town centre increase slightly in the AM peak. The reason for this increase could be due to the increased throughput at some junctions on the edge of the town centre, as a result of the diversion of traffic that previously opposed these flows. The Do Something 3 option gives shorter travel times for traffic heading from south (Harlaxton Road and London Road) to north than the other two Do Something scenarios.

7.4.21 In the PM peak, queues increase on two routes into Grantham. The first is a small increase of 18m on the South Parade approach to Gainsborough Corner, the second is a large increase of 1051m on Harlaxton Road (see below for further discussion of this issue). All the other routes into Grantham have a reduction in the length of queues, with Barrowby Road (-233m) and North Parade (-74m) benefiting the most.

7.4.22 Through routes from the North and South of Grantham all have a reduction in their travel times suggesting the town centre is less congested. This could be due to the 2.2% decrease in total traffic in the demand matrix, or possibly due to the additional traffic held in the queue on Harlaxton Road at its junction with Wharf Road.

Harlaxton Road

7.4.23 At the time that the VISSIM model was being developed, construction work at the new signalised junction was incomplete and so there was no opportunity to observe and calibrate the new junction's operation within the Do Minimum model. Queuing and delays along Harlaxton Road on its approach to the junction with Wharf Road appeared to be extremely sensitive to small variations in traffic conditions elsewhere on the network.

7.4.24 The overall delays on Harlaxton Road within the model were found to be disproportionately large when compared with other links and junctions in the network, heavily skewing the overall results of each scenario. As a result, the models were re-run to extract the network performance data, ignoring the impact this queue has on the overall results.

7.4.25 During the AM peak the average delay per vehicle decreased by 23s to 536s in the Do Minimum scenario when not taking into account Harlaxton Road. With the High Street shuttle running in the model the average delay per vehicle had initially increased by 10s this increase remains the same in the model rerun. This suggests that the decrease in the queue on Harlaxton Road had a minimal impact on the overall network performance.

7.4.26 With the inclusion of the Inner Relief Road there is a large increase in the queue on Harlaxton Road during the AM peak hour. The initial overall network results indicated a 27s increase in average delay per vehicle in the network. However, when the effects of the Harlaxton Road congestion were not taken into account the result was only a 4s increase in

delay per vehicle.

7.4.27 The same comparison was carried out for the model including the Southern Bypass, which in initial modelling had saved 11s of delay relative to the Do Minimum model. In the rerun this came out as an increase of 2s. This would have been due to the fact that the queue on Harlaxton Road decreases in the Do Something 3 option and the beneficial effects of this are not taken into account when not including Harlaxton Road in the results.

Table 7.5: Comparison of Delay in AM Peak

Scenario	Original Run		Rerun (exc. Harlaxton Rd Queue)	
	Ave. delay per vehicle (s)	Change Relative to Base	Ave. delay per vehicle (s)	Change Relative to Base
Do Min	559		536	
Do Som 1	569	+10	546	+10
Do Som 2	586	+27	540	+4
Do Som 3	548	-11	538	+2

7.4.28 The same model reruns were undertaken for the PM peak hour, the effect of removing the Harlaxton Road queue from the analysis in the Do Minimum was to reduce the average delay per vehicle to 564s, a reduction of 49s.

7.4.29 Like in the AM peak the effect of removing Harlaxton Road from the network analysis in the High Street shuttle running model is minimal, the increase in delay has risen by one second between the first (+6s) and second model (+7s) runs.

7.4.30 Again like the AM peak there is a significant improvement in the delay per vehicle across the network when the Inner Relief Road is included in the model. Originally the increase in delay had been 11s, however the Harlaxton Road queue accounted for so much of this delay that the overall change in network delay compared to the second run of the Do Minimum has become a saving of 20s per vehicle on average.

7.4.31 Unlike the AM peak the Southern Bypass resulted in an increased queue on Harlaxton Road, therefore by not including the queue in the network analysis the result was that the average delay per vehicle improved in the second run. Initially it had been a 2s saving on delay per vehicle compared to the Do Minimum, this then increased to a 6s saving on delay in the rerun of the Southern Bypass model.

Table 7.6: Comparison of Delay in PM Peak

Scenario	Original Run		Rerun (exc. Harlaxton Rd Queue)	
	Ave. delay per vehicle (s)	Change Relative to Base	Ave. delay per vehicle (s)	Change Relative to Base
Do Min	613		564	
Do Som 1	619	+6	571	+7
Do Som 2	602	+11	544	-20
Do Som 3	611	-2	558	-6

8.0 Conclusions

8.1 SATURN Model

8.1.1 The Grantham SATURN model has been updated using 2006 count and journey time data covering the town centre and the wider road network. The validation work was carried out using DfT guidance in DMRB Volume 12, Section 2 "Traffic Appraisal in Urban Areas". A series of tables were produced to show the level of validation achieved on the chosen links and screenlines.

8.1.2 Good convergence and validation has been achieved throughout the area covered by the model. There is some small variation in the assignment validation in certain areas of the model but these were not considered critical to the purpose for which the model was built.

8.1.3 A large number of traffic counts have been used in updating and validating the Grantham traffic model throughout the town and the Correlation Summary shows that it easily exceeds DMRB acceptable values.

8.1.4 The validation work has shown that both the AM and PM peak hour models continue to work sensibly, and as such can be considered to provide a sound basis for traffic forecasting and assessment of highway and development proposals in Grantham.

8.1.5 Forecasting work has been carried out to produce future year matrices for 2016. These are based on a detailed knowledge of proposed developments in the town and also consider background traffic growth.

8.1.6 The 2016 SATURN model has been successfully used to test the effect of three proposed schemes on traffic movements within the town.

8.2 VISSIM Model

8.2.1 From the modelling it is not obvious that any one of the proposals will provide a solution to all of Grantham's existing and future road network issues. Both the Inner Relief Road and Southern Bypass will provide relief to certain routes and junctions, although neither have the answer to the problems on every route.

8.2.2 The modelling of the new Harlaxton Road/Wharf Road/Station Road junction has indicated that the congestion issues along Harlaxton Road into Grantham could worsen dramatically. Unfortunately the completion of the junction has come just at the end of this study and it has not been possible to observe the junction operating on site and calibrate the model accordingly. It may be the case that the junction will operate differently on site with the optimisation of signal times and drivers behaviour at the give way on Harlaxton Road. If the junction does operate more efficiently than anticipated then the queues on Harlaxton Road could be over estimates. However, the additional traffic that gets through the junction could have detrimental knock-on effects at downstream junctions.

Figures

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Figure 1.1:
SATURN Model Network

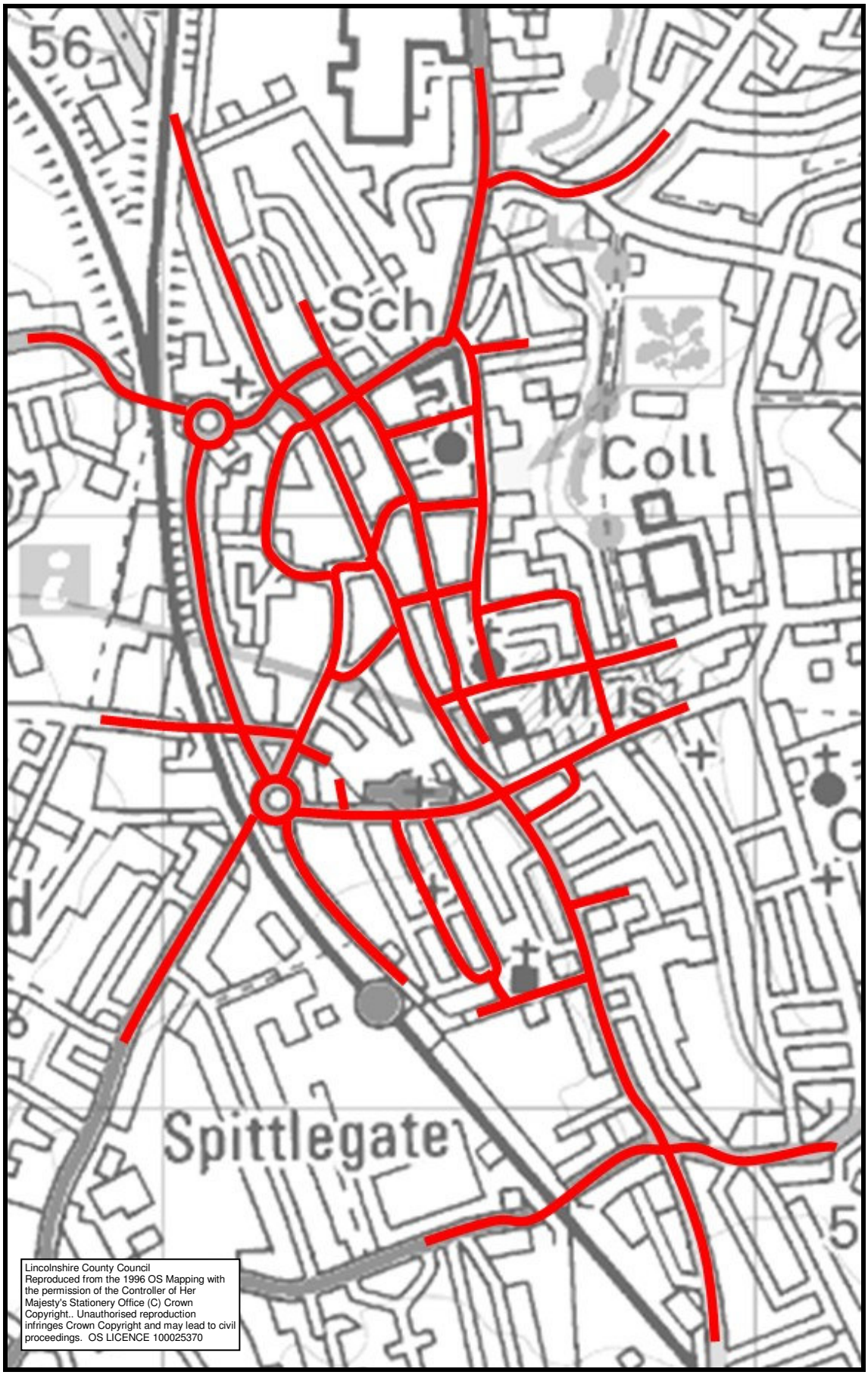


Figure 1.2: VISSIM Model Network

Figure 2.1: Traffic Count Locations – Wider Area

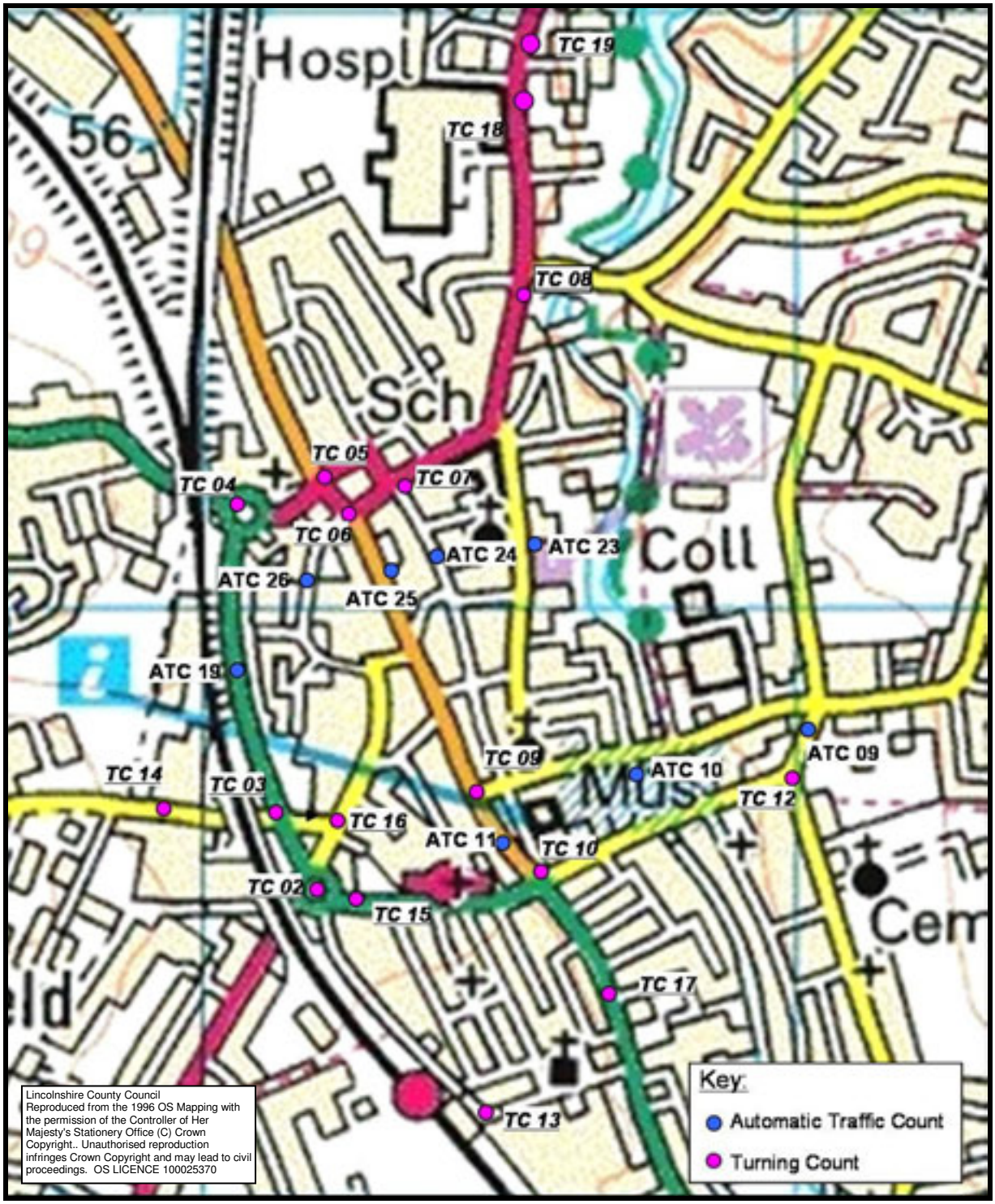


Figure 2.2: Traffic Count Locations – Town Centre

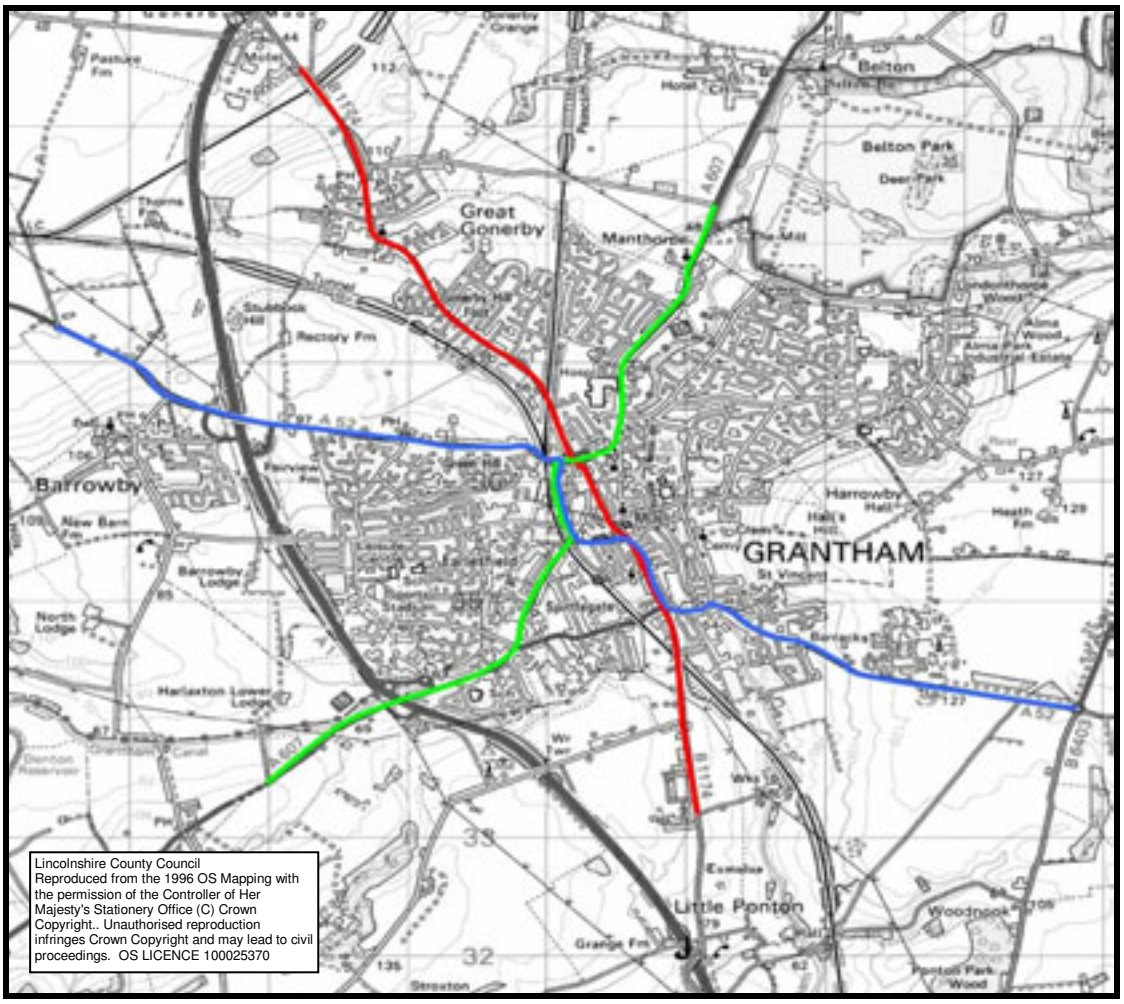


Figure 2.3: Journey Time survey Routes

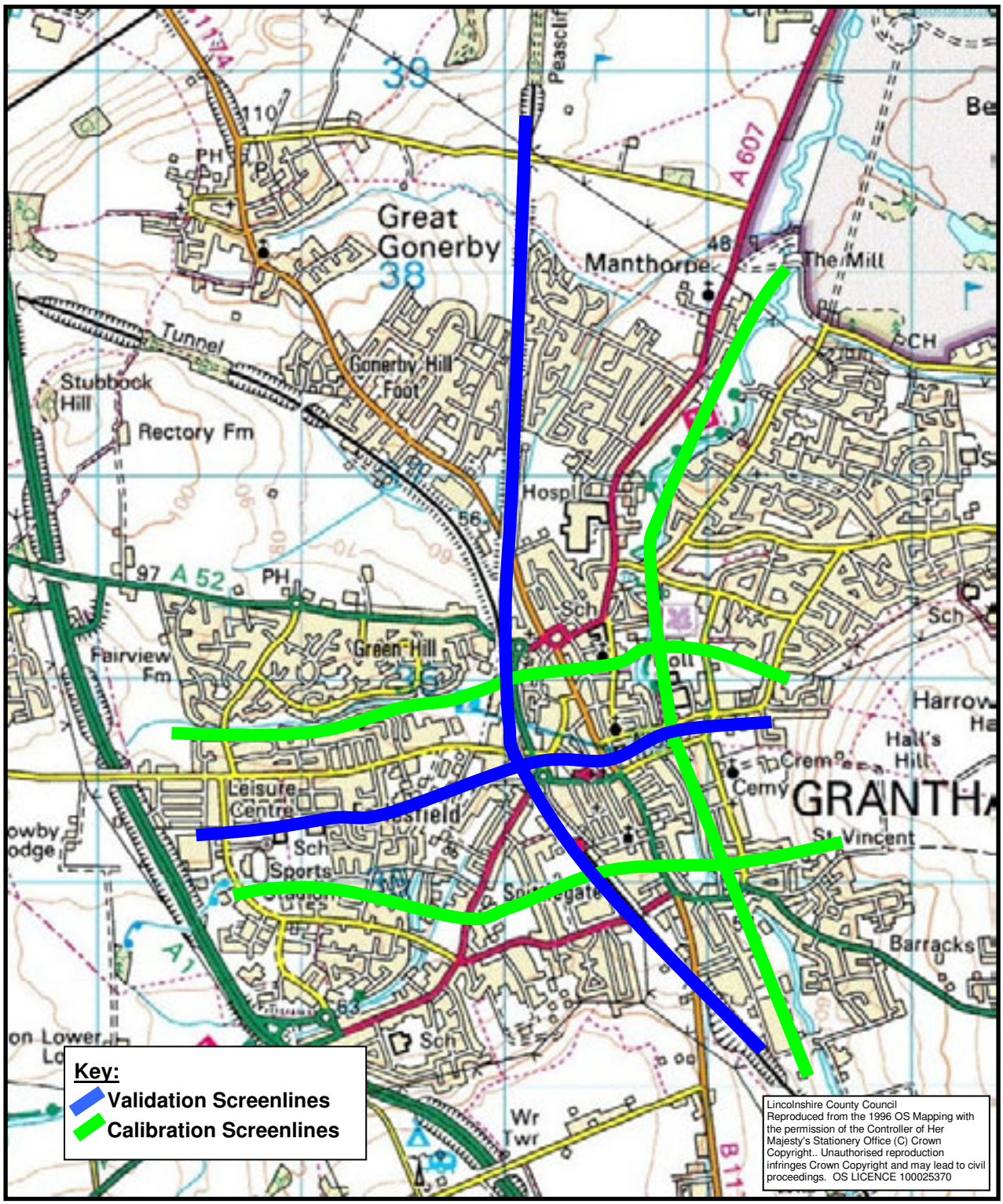


Figure 3.1: SATURN Model Calibration and Validation Screenlines

Appendix A: SATURN Model Calibration/Validation Tables

Grantham Traffic Model 2006 AM Peak Hour Calibration

Link Description	A Node	B Node	Direction	Observed	Modelled	Difference	% Diff	GEH	Direction	Observed	Modelled	Difference	% Diff	GEH
Barrowby Gate	501	328	Nbound	237	221	-15	-6.3	1.0	Sbound	478	357	-120	-25.1	5.9
A52 Sankt Augustine Wa	191	192	Nbound	359	456	97	27	4.8	Sbound	460	517	57	12.4	2.6
Union Street	116	337	Nbound	64	86	22	34.4	2.5	Sbound	91	90	0	0	0.0
Watergate	113	147	Nbound	390	331	-58	-14.9	3.1	Sbound	585	557	-27	-4.6	1.1
Swinegate N/Castlegate S	338	109	Nbound	134	31	-102	-76.1	11.2	Sbound	431	471	40	9.3	1.9
Sandon Road	400	324	Nbound	289	387	98	33.9	5.3	Sbound	412	271	-140	-34	7.6
New Beacon Road	400	401	Nbound	368	351	-16	-4.3	0.8	Sbound	445	463	18	4	0.8
Upper Town Centre Screenline Total (n/s)			Nbound	1841	1863	26	1.4	0.6	Sbound	2902	2726	-172	-5.9	3.2
Trent Road	503	653	Nbound	261	198	-62	-23.8	4.1	Sbound	394	316	-77	-19.5	4.1
Goodliff Road	504	505	Nbound	186	121	-64	-34.4	5.2	Sbound	169	123	-45	-26.6	3.7
A607 Harlaxton Road	507	591	Nbound	677	699	22	3.2	0.8	Sbound	492	467	-24	-4.9	1.1
Huntingtower Road	332	331	Nbound	48	77	29	60.4	3.7	Sbound	63	62	0	0	0.0
B1174 London Road	403	334	Nbound	705	788	83	11.8	3.0	Sbound	509	567	58	11.4	2.5
Harrowby Road	335	402	Nbound	378	481	103	27.2	5.0	Sbound	114	153	39	34.2	3.4
Lower Town Centre Screenline Total (n/s)			Nbound	2255	2364	111	4.9	2.3	Sbound	1741	1688	-49	-2.8	1.2
Belton lane	306	307	Ebound	472	459	-12	-2.5	0.6	W bound	776	787	11	1.4	0.4
Stonebridge Road	173	806	Ebound	279	402	123	44.1	6.7	W bound	308	251	-56	-18.2	3.4
St Catherines Road	172	402	Ebound	172	135	-36	-20.9	2.9	W bound	391	397	6	1.5	0.3
A52 Bridge End Road	333	404	Ebound	690	567	-122	-17.7	4.9	W bound	718	716	-1	-0.1	0.0
River Screenline Total (e/w)			Ebound	1613	1563	-47	-2.9	1.2	W bound	2193	2151	-40	-1.8	0.9

Grantham Traffic Model 2006 PM Peak Hour Calibration

Link Description	A Node	B Node	Direction	Observed	Modelled	Difference	% Diff	GEH	Direction	Observed	Modelled	Difference	% Diff	GEH
Barrowby Gate	501	328	Nbound	433	443	10	2.3	0.5	Sbound	381	275	-105	-27.6	5.9
A52 Sankt Augustine Way	191	192	Nbound	696	739	43	6.2	1.6	Sbound	405	450	45	11.1	2.2
Union Street	116	337	Nbound	194	182	-11	-5.7	0.9	Sbound	75	105	30	40	3.2
Watergate	113	147	Nbound	619	626	7	1.1	0.3	Sbound	390	363	-26	-6.7	1.4
Swinegate N/Castlegate S	338	109	Nbound	201	154	-46	-22.9	3.6	Sbound	226	221	-4	-1.8	0.3
Sandon Road	400	324	Nbound	338	298	-39	-11.5	2.2	Sbound	264	295	31	11.7	1.9
New Beacon Road	400	401	Nbound	496	443	-52	-10.5	2.5	Sbound	306	376	70	22.9	3.8
Upper Town Centre Screenline Total (n/s)			Nbound	2977	2885	-88	-3	1.6	Sbound	2047	2085	41	2	0.9
Trent Road	503	653	Nbound	458	359	-98	-21.4	4.9	Sbound	321	295	-25	-7.8	1.5
Goodliff Road	504	505	Nbound	188	186	-1	-0.5	0.1	Sbound	179	147	-31	-17.3	2.5
A607 Harlaxton Road	507	591	Nbound	514	488	-25	-4.9	1.2	Sbound	613	475	-137	-22.3	5.9
Huntingtower Road	332	331	Nbound	44	69	25	56.8	3.4	Sbound	88	107	19	21.6	2.0
B1174 London Road	403	334	Nbound	615	632	17	2.8	0.7	Sbound	711	778	67	9.4	2.5
Harrowby Road	335	402	Nbound	435	390	-44	-10.1	2.2	Sbound	222	282	60	27	3.8
Lower Town Centre Screenline Total (n/s)			Nbound	2254	2124	-126	-5.6	2.7	Sbound	2134	2084	-47	-2.2	1.0
Belton lane	306	307	Ebound	620	567	-52	-8.4	2.2	W bound	694	658	-35	-5	1.4
Stonebridge Road	173	806	Ebound	236	252	16	6.8	1.0	W bound	218	177	-40	-18.3	3.0
St Catherines Road	172	402	Ebound	287	261	-25	-8.7	1.6	W bound	346	420	74	21.4	3.8
A52 Bridge End Road	333	404	Ebound	902	979	77	8.5	2.5	W bound	451	516	65	14.4	2.9
River Screenline Total (e/w)			Ebound	2045	2059	16	0.8	0.4	W bound	1709	1771	64	3.7	1.5

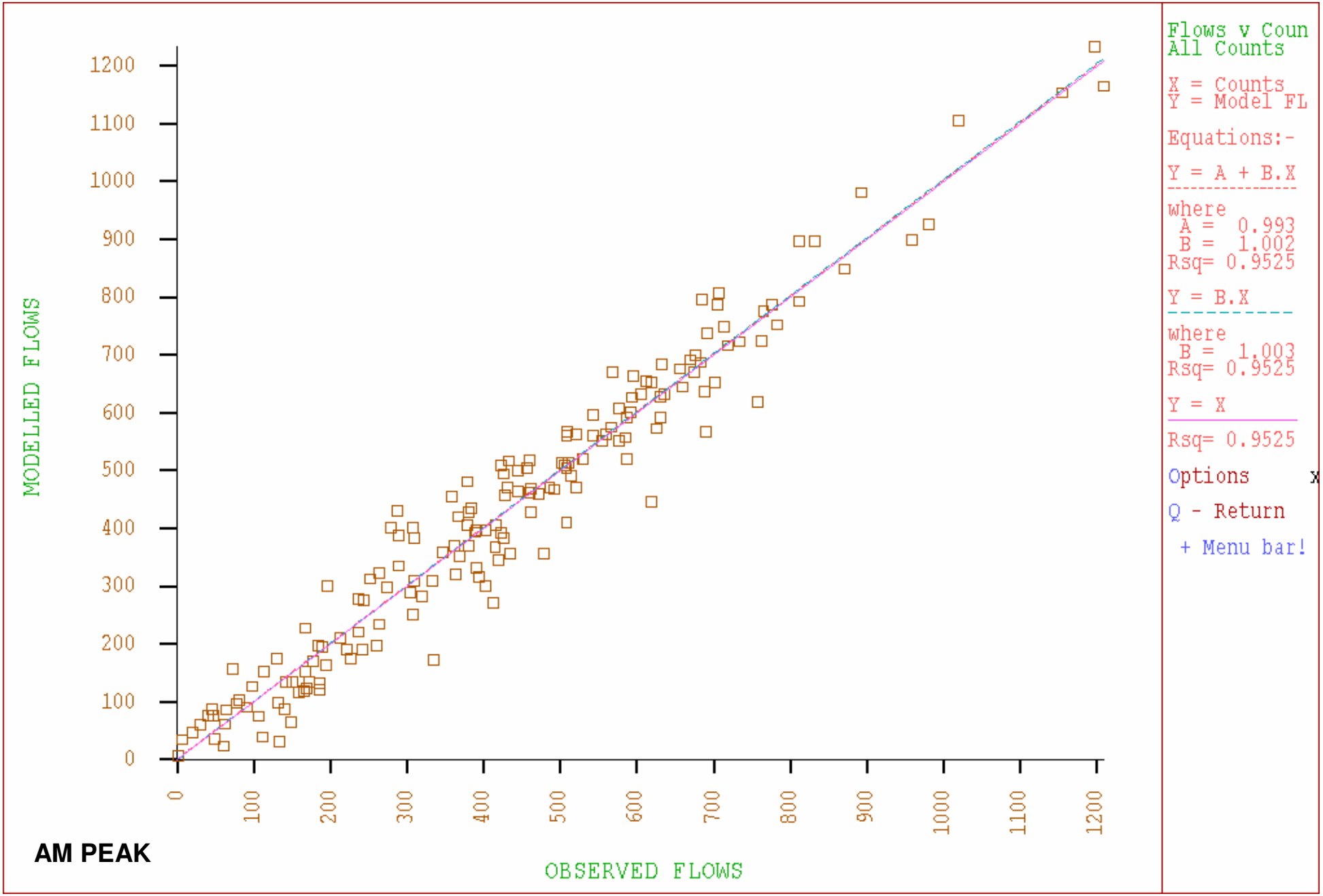
Grantham Traffic Model 2006 AM Peak Hour Validation

Link Description	A Node	B Node	Direction	Observed	Modelled	Difference	% Diff	GEH	Direction	Observed	Modelled	Difference	% Diff	GEH
Trent Road	653	502	Nbound	226	174	-51	-22.6	3.6	Sbound	379	405	26	6.9	1.3
Goodliff Road	350	500	Nbound	142	134	-7	-4.9	0.6	Sbound	159	116	-42	-26.4	3.6
A52 Sankt Augustine Way	180	190	Nbound	831	896	65	7.8	2.2	Sbound	812	896	84	10.3	2.9
B1174 High Street	185	131	Nbound	530	519	-10	-1.9	0.4	Sbound	486	470	-15	-3.1	0.7
Welham Street	341	173	Nbound	81	103	22	27.2	2.3	Sbound	72	156	84	116.7	7.9
Sandon Road	402	400	Nbound	426	495	69	16.2	3.2	Sbound	462	429	-32	-6.9	1.5
Town Centre Screenline Total (n/s)			Nbound	2236	2321	88	3.9	1.8	Sbound	2370	2472	105	4.4	2.1
Belton Lane	212	319	Ebound	335	173	-161	-48.1	10.1	W bound	221	190	-30	-13.6	2.1
B1174 North Parade	292	146	Ebound	576	552	-23	-4	1.0	W bound	289	335	46	15.9	2.6
A52 Barrowby Road	326	193	Ebound	734	723	-10	-1.4	0.4	W bound	586	520	-65	-11.1	2.8
Dysart Road	358	190	Ebound	380	428	48	12.6	2.4	W bound	288	430	142	49.3	7.5
A607 harlaxton Road	186	174	Ebound	765	775	10	1.3	0.4	W bound	630	628	-1	-0.2	0.0
Old Wharf Road	512	174	Ebound	20	47	27	135	4.7	W bound	30	60	30	100	4.5
Springfield Road	412	403	Ebound	508	410	-97	-19.1	4.5	W bound	426	383	-42	-9.9	2.1
B1174 South Parade	463	403	Ebound	422	510	88	20.9	4.1	W bound	346	358	12	3.5	0.6
Railway Screenline Total (n/s)			Ebound	3740	3618	-118	-3.2	2.0	W bound	2816	2904	92	3.3	1.7

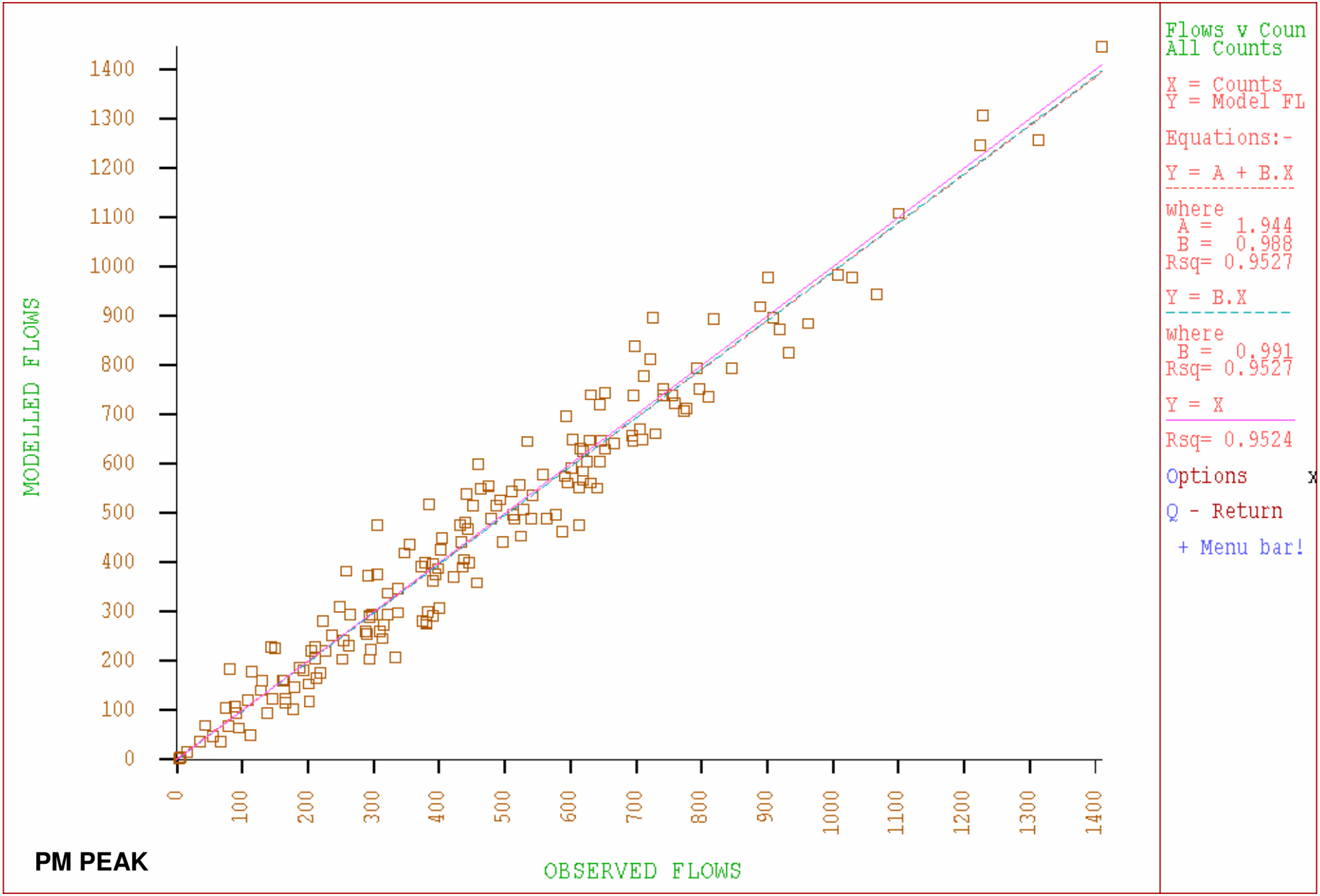
Grantham Traffic Model 2006 PM Peak Hour Validation

Link Description	A Node	B Node	Direction	Observed	Modelled	Difference	% Diff	GEH	Direction	Observed	Modelled	Difference	% Diff	GEH
Trent Road	653	502	Nbound	398	388	-9	-2.3	0.5	Sbound	322	338	16	5	0.9
Goodliff Road	350	500	Nbound	144	230	86	59.7	6.3	Sbound	178	102	-75	-42.1	6.5
A52 Sankt Augustine Way	180	190	Nbound	1100	1109	9	0.8	0.3	Sbound	918	873	-44	-4.8	1.5
B1174 High Street	185	131	Nbound	541	488	-52	-9.6	2.3	Sbound	596	561	-34	-5.7	1.4
Welham Street	341	173	Nbound	80	185	105	131.3	9.1	Sbound	112	50	-61	-54.5	6.9
Sandon Road	402	400	Nbound	513	498	-14	-2.7	0.7	Sbound	463	549	86	18.6	3.8
Town Centre Screenline Total (n/s)			Nbound	2776	2898	125	4.5	2.4	Sbound	2589	2473	-112	-4.3	2.2
Belton Lane	212	319	Ebound	294	204	-89	-30.3	5.7	W bound	213	166	-46	-21.6	3.4
B1174 North Parade	292	146	Ebound	510	545	35	6.9	1.5	W bound	604	649	45	7.5	1.8
A52 Barrowby Road	326	193	Ebound	592	575	-16	-2.7	0.7	W bound	1067	944	-122	-11.4	3.9
Dysart Road	358	190	Ebound	338	346	8	2.4	0.4	W bound	259	383	124	47.9	6.9
A607 harlaxton Road	186	174	Ebound	695	648	-46	-6.6	1.8	W bound	644	605	-38	-5.9	1.6
Old Wharf Road	512	174	Ebound	35	37	2	5.7	0.4	W bound	15	15	0	0	0.1
Springfield Road	412	403	Ebound	432	475	43	10	2.0	W bound	445	400	-44	-9.9	2.2
B1174 South Parade	463	403	Ebound	479	489	10	2.1	0.5	W bound	310	261	-48	-15.5	2.9
Railway Screenline Total (n/s)			Ebound	3375	3319	-53	-1.6	0.9	W bound	3557	3423	-129	-3.6	2.2

Appendix B: SATURN Model Correlation Analysis


Flows v Coun
All Counts
X = Counts
Y = Model FL
Equations:-
Y = A + B.X
where
A = 0.993
B = 1.002
Rsq= 0.9525
Y = B.X
where
B = 1.003
Rsq= 0.9525
Y = X
Rsq= 0.9525
Options
Q - Return
+ Menu bar!
MODELLED FLOWS
OBSERVED FLOWS
0
100
200
300
400
500
600
700
800
900
1000
1100
1200

AM PEAK


Flows v Coun
All Counts
X = Counts
Y = Model FL
Equations:-
Y = A + B.X
where
A = 1.944
B = 0.988
Rsq= 0.9527
Y = B.X
where
B = 0.991
Rsq= 0.9527
Y = X
Rsq= 0.9524
Options
Q - Return
+ Menu bar!
MODELLED FLOWS
OBSERVED FLOWS
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400

PM PEAK

Appendix C: Traffic Forecasting Schedule of Development

Known Developments in Grantham - Conversion to Trip Ends
To be used for 2016 forecast (from updated 2006 base)

Site	Zone	Description	Total Site Units	Ind Site Sqm	Occup at 2006	Not started at 2006 Base yr	Completions 2006 > 16	Not started at 2016 HorizYr	AM Peak Extra traffic 2006 > 16 Gens	AM Peak Extra traffic 2006 > 16 Atts	PM Peak Extra traffic 2006 > 16 Gens	PM Peak Extra traffic 2006 > 16 Atts
	25	Dwellings (Autumn Park, Dysart Road - under const)	107			107	107	0	83	22	32	65
12	114	Dwellings (D Wilson, N of Springfield Rd)	355		75%	89	89	0	48	12	21	43
	95	Dwellings (Derwent Road)	50		50%	25	25	0	14	4	6	12
	99	Dwellings (Dysart Road Road) -same site as Zone 95					0	0	0	0	0	0
14	96	Dwellings (Londonthorpe Lane)	300		50%	150	150	0	81	21	36	72
10	103	Dwellings (Poplar Farm - 2000 in Total, was 1456)	1000			1000	440	560	182	36	133	212
10	104	Dwellings (Poplar Farm - dev proposal fact by 1.37)	1000			1000	440	560	182	36	133	212
	105	Dwellings (Springfield Road, 120 pa)	600		20%	480	480	0	182	46	79	174
	105	**B1/B8 Development**		**?**			**0**	**0**	10	64	56	8
	115	Dwellings (Impress site, Springfield Rd - west of railway on old factory site)	170			170	170	0	92	24	41	82
	116	Dwellings (Station Rd, opp St Johns Church)	100			100	100	0	54	14	24	48
	117	**Starter Units (East of London Street)**		**1088**			**0**	**0**	12	23	12	11
	97	Res Units (Kwiksave Site)	30			30	30	0	16	4	7	14
	181	Dwellings (Aveling Barford Site access to existing roads)	100			100	100	0	54	14	24	48
	182	Dwellings (Aveling Barford Site access to southern bypass)	856			856	0	856	0	0	0	0
		Total	**4668**			**4107**	**2131**	**1976**	**1009**	**319**	**604**	**999**

Appendix D: SATURN Model Output

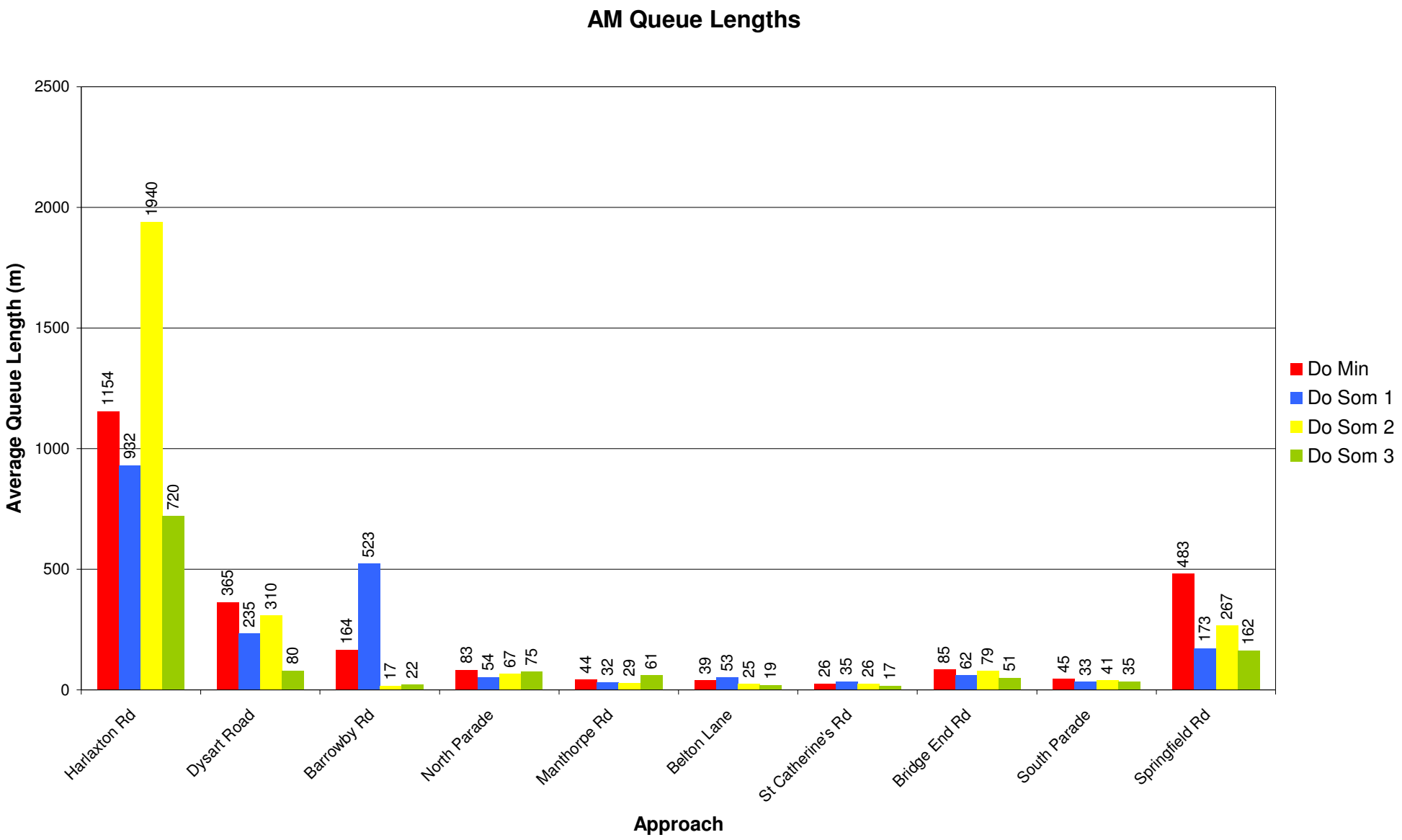
Parameter (see below for definitions)	Units	Base Network AM Peak 2006	PublicConsNet AM Peak 2006	Do Minimum AM Peak 2016	DoSomething 1 AM Peak 2016	DoSomething 2 AM Peak 2016	DoSomething 3 AM Peak 2016
Transient Queues :	Veh.Hrs	118.5	123	**177.3**	183.5	177.7	179.9
Over-Capacity Queues :	Veh.Hrs	26.5	16	**118.3**	119	109.3	104.5
Link Cruise Time :	Veh.Hrs	524.4	520.5	**629.6**	631.3	628.4	645.4
Total Travel Time :	Veh.Hrs	669.3	659.5	**925.3**	933.8	915.4	929.8
Travel Distance :	Veh.Kms	22729.9	23181.9	**27266.2**	27383.5	27279.5	28837.7
Average Speed :	**Kph**	**34**	**35.1**	**29.5**	**29.3**	**29.8**	**31**
	Units	**Base Network PM Peak 2006**	**PublicConsNet PM Peak 2006**	**Do Minimum PM Peak 2016**	**DoSomething 1 PM Peak 2016**	**DoSomething 2 PM Peak 2016**	**DoSomething 3 PM Peak 2016**
Transient Queues :	Veh.Hrs	139.1	144.7	**217.5**	226.2	214.3	213.5
Over-Capacity Queues :	Veh.Hrs	22.5	30.8	**191.4**	244.2	184.4	138.6
Link Cruise Time :	Veh.Hrs	510.5	494.2	**617**	617.7	610.7	632.7
Total Travel Time :	Veh.Hrs	663.1	669.7	**1025.8**	1088.2	1009.4	984.8
Travel Distance :	Veh.Kms	23081.1	23141.2	**28011.1**	28127	27906.6	29632
Average Speed :	**Kph**	**34.8**	**34.6**	**27.3**	**25.8**	**27.6**	**30.1**

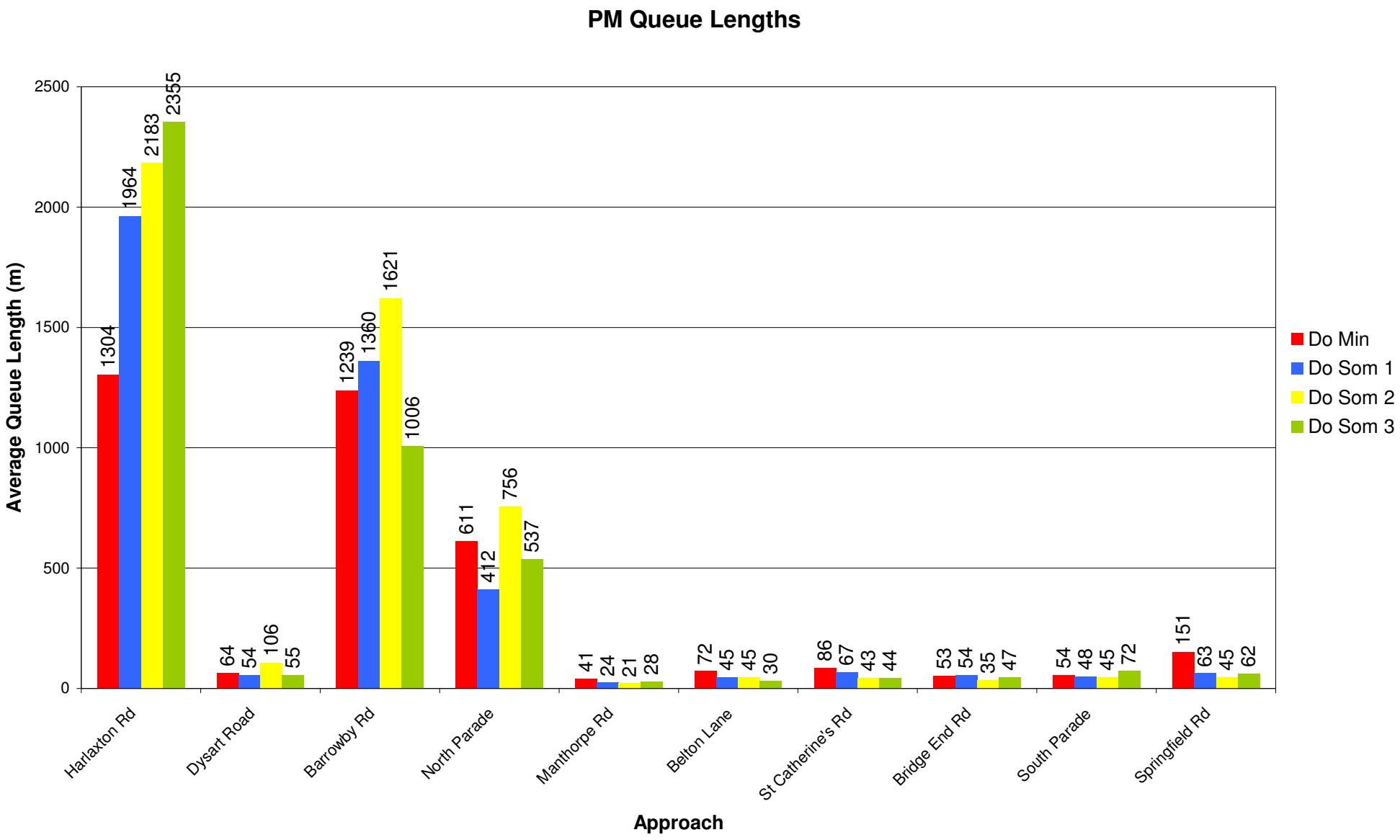
Network KEY :-

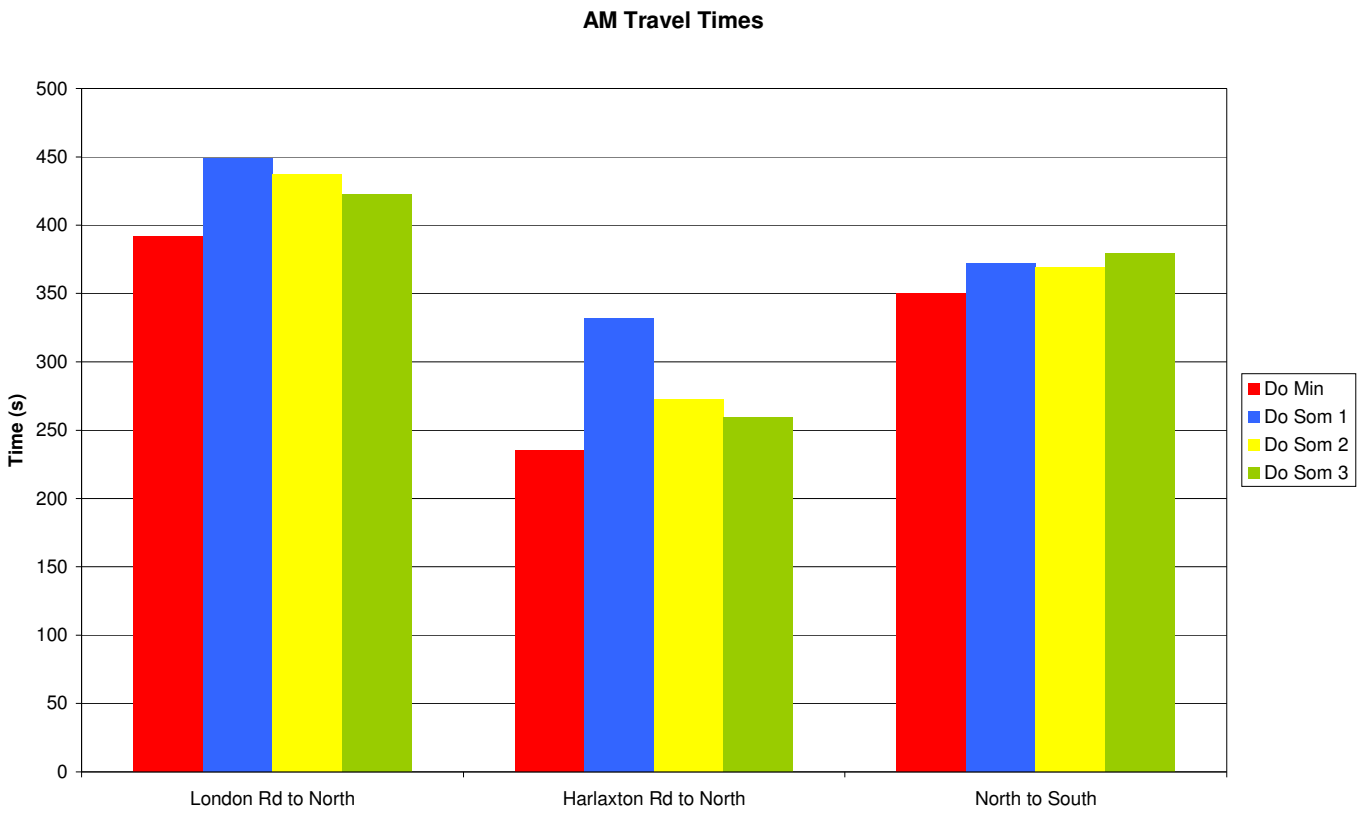
Base Network	as seen autumn 2006
PublicConsNet	(PCN) all schemes defined in emailed table from Tim Munday (24/1/07)
Do Minimum	"committed" schemes defined in emailed table from Tim Munday (24/1/07)
DoSomething 1	Do Min + High Street Shuttle Traffic Lights
DoSomething 2	Do Min + Inner Relief road
DoSomething 3	Do Min + Southern Bypass

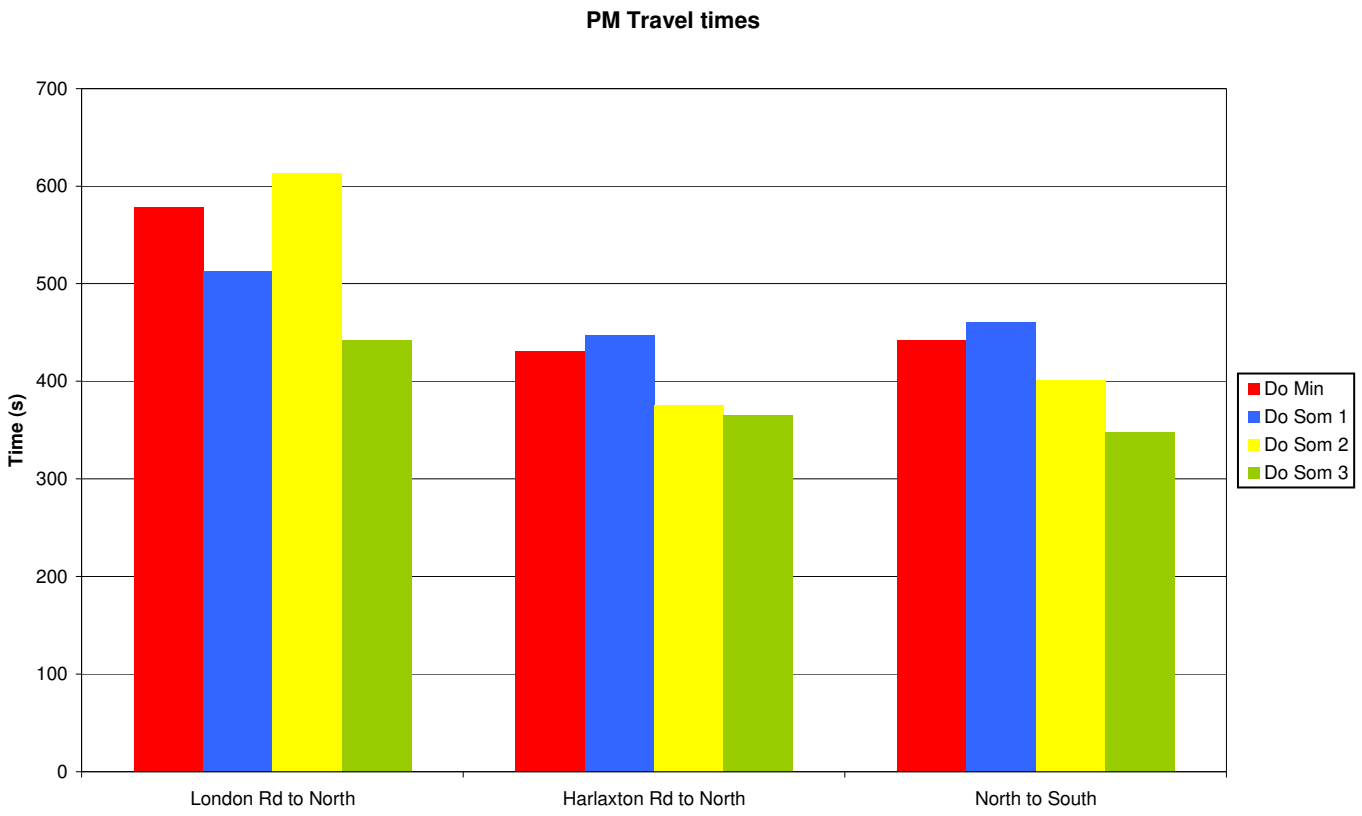
Transient Queues :	represents reduced speeds approaching junctions but excludes time stopped in queues at overloaded junctions
Over-Capacity Queues :	time spent in queues approaching overloaded junctions
Link Cruise Time :	times between junctions excluding both sort of delays at those junctions defined above
Total Travel Time :	sum of the above 3 across all vehicle journeys included in the matrix
Travel Distance :	sum of the total distance travelled by all the vehicles in the matrix
Average Speed :	calculated by dividing Travel Distance (v.kms) by Total Travel Time (v.hrs) to give average speed across the area.

Appendix E: VISSIM Model Output


AM Queue Lengths
Average Queue Length (m)
2500
2000
1500
1000
500
0
1154
932
1940
720
365
235
310
80
164
523
17
22
83
54
67
75
44
32
29
61
39
53
25
19
26
35
26
17
85
62
79
51
45
33
41
35
483
173
267
162
Harlaxton Rd
Dysart Road
Barrowby Rd
North Parade
Manthorpe Rd
Belton Lane
St Catherine's Rd
Bridge End Rd
South Parade
Springfield Rd
Approach
Do Min
Do Som 1
Do Som 2
Do Som 3


PM Queue Lengths
Average Queue Length (m)
2500
2000
1500
1000
500
0
1304
1964
2183
2355
64
54
106
55
1239
1360
1621
1006
611
412
756
537
41
24
21
28
72
45
45
30
86
67
43
44
53
54
35
47
54
48
45
72
151
63
45
62
Harlaxton Rd
Dysart Road
Barrowby Rd
North Parade
Manthorpe Rd
Belton Lane
St Catherine's Rd
Bridge End Rd
South Parade
Springfield Rd
Approach
Do Min
Do Som 1
Do Som 2
Do Som 3


AM Travel Times
Time (s)
500
450
400
350
300
250
200
150
100
50
0
London Rd to North
Harlaxton Rd to North
North to South
Do Min
Do Som 1
Do Som 2
Do Som 3


PM Travel times
Time (s)
700
600
500
400
300
200
100
0
London Rd to North
Harlaxton Rd to North
North to South
Do Min
Do Som 1
Do Som 2
Do Som 3