



South Worcestershire Development Plan Review

Throckmorton SWDPR Modelling Report - Draft

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1. Introduction

1.1 Background

Worcestershire County Council (WCC) commissioned CH2M (now Jacobs) between 2014 and 2016 to develop transport models for Worcester (WTM), Pershore (PHAM) and Evesham (EHAM) to support various business cases, transport infrastructure improvements and to assess impacts of planned developments. The Worcester model was developed in SATURN/EMME whilst the Pershore and Evesham Models were developed in VISUM. The models were developed to different base year conditions.

The Throckmorton site development site is located to the north of A44 close to Pershore town and between Evesham and Worcester. The site is not detailed in any of the above three models developed but represented as zones in them. As a result, to assess the impacts of the development, the three models have been considered. This is because the development trips are likely to travel to the three urban areas of Pershore, Evesham and Worcester.

The three models were used to assess impacts of potential development allocations in the respective urban areas and their suburbs as part of the South Worcestershire Development Plan Review (SWDPR). These assessments were undertaken for a forecast year of 2041.

As the three models were developed to different base years and also had different forecast years and therefore were not consistent, the 2041 SWDPR models developed were considered as the baseline condition for assessing the Throckmorton development allocations. This ensured that the network is assessed on a consistent basis across the 3 model networks.

This report documents the testing of the Throckmorton development sites using EHAM, PHAM and WTM models for 2041 as requested by WCC.

1.2 Structure of the Report

This report is structured as follows:

- Section 2 summarises the forecasting approach;
- Section 3 details the development of the forecast year demand matrices;
- Section 4 details the impact of the development on Evesham networks;
- Section 5 details the impact of the development on Pershore networks;
- Section 6 details the impact of the development on Worcester networks; and
- Section 7 concludes the report.

2. Forecasting Approach

2.1 Overview of Travel Forecast Modelling Methodology

The forecast models were developed in accordance with guideline in the Department for Transport (DfT) Transport Analysis Guidance (TAG) document. This section explains the process followed for building the 2041 forecasts for Throckmorton development.

The Throckmorton development sites are represented in all the three models (WTM, EHAM and PHAM) in the buffer area and therefore not detailed. The lack of any significant trip generator in Throckmorton alludes to its representation with minimal detail. The distribution of trips from the Throckmorton sites were based on gravity distribution models developed as part of the Evesham model build. This takes into consideration travel patterns on the A44 that were captured as part of Road side interviews (between Pershore and Evesham) and therefore provides best representation of potential travel patterns from the Throckmorton site.

The distribution from the development sites are then factored into the three models based on their direction of travel and network impacts assessed.

2.2 Forecast Year and Time Periods

2.2.1 Forecast Years (FY)

Forecast year for the SWDPR is 2041 as per WCC's requirement to test the impacts of development allocations. The matrices developed for the SWDPR allocations in Pershore, Evesham and Worcester for 2041 assessments were used as the baseline to develop the matrices for the Throckmorton site.

2.2.2 Time Periods

The Base Year (BY) model represents typical weekday conditions. Three time periods were developed.

- AM peak hour (08:00 – 09:00);
- Interpeak hour (average hour between 10:00 and 16:00 hrs); and
- PM peak hour (17:00 – 18:00)

For the SWDPR assessment, only the periods with the highest traffic levels (AM and PM peak) were considered.

3. Forecast Year Matrix Development

3.1 Development Assumptions

The proposed SWDPR sites include the following assumptions:

- 2000 dwellings with access on a new link directly off the A44 East of the Pershore Northern Road;
- 10ha employment land with access on a new link directly off the A44 East of the Pershore Northern Road.

The developments considered for the forecast are illustrated in Figure 3.1 and listed in Table 3-1 and their proposed accesses are illustrated in Figure 3.2.

Table 3-1 List of proposed SWDPR developments

Type	Location	Quantum
Employment	Throckmorton	10ha (40,000 sq.m)
Residential Units	Throckmorton	2000 units

The forecast models have been developed to represent projected changes in both travel demand and network supply.

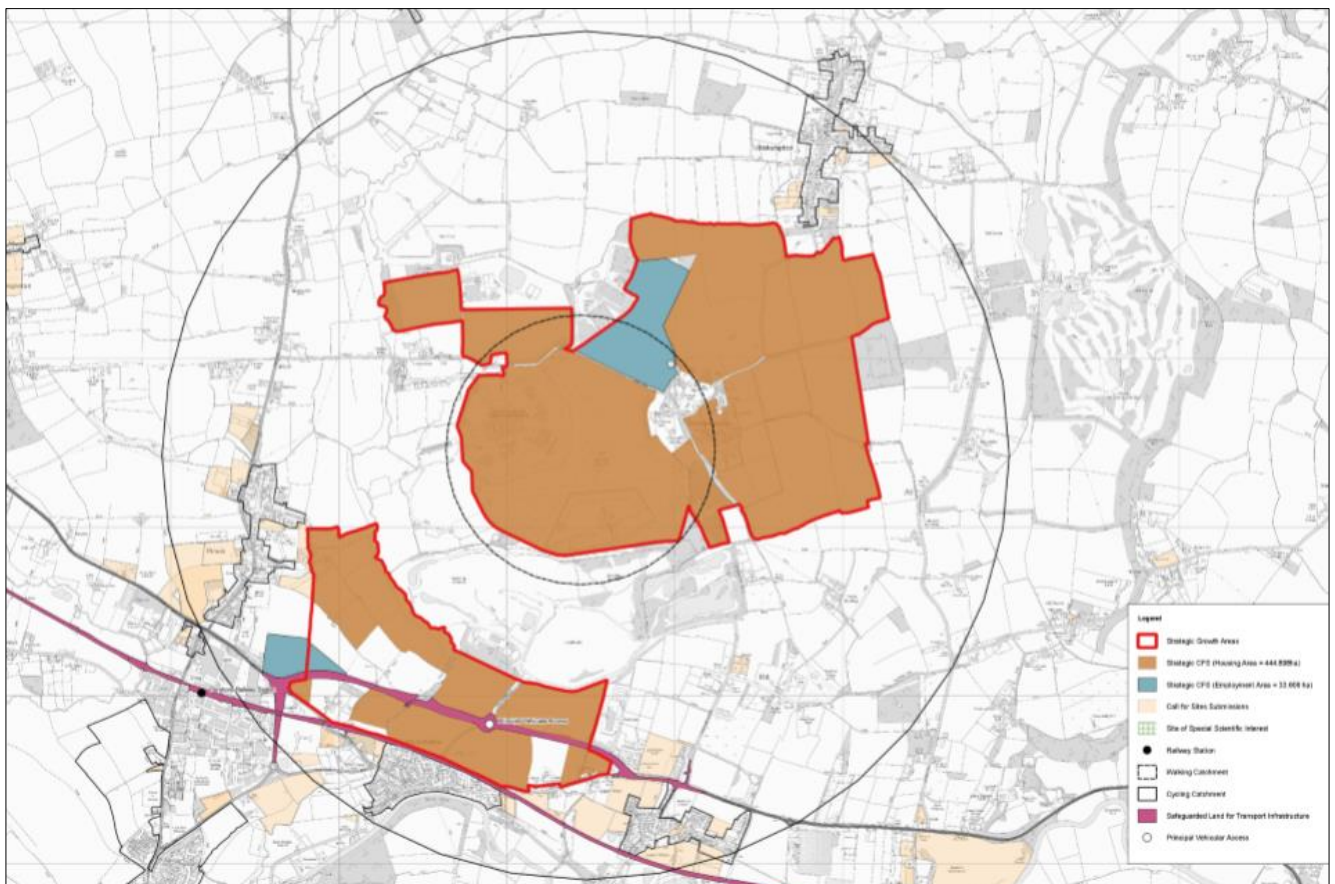


Figure 3.1 Proposed developments

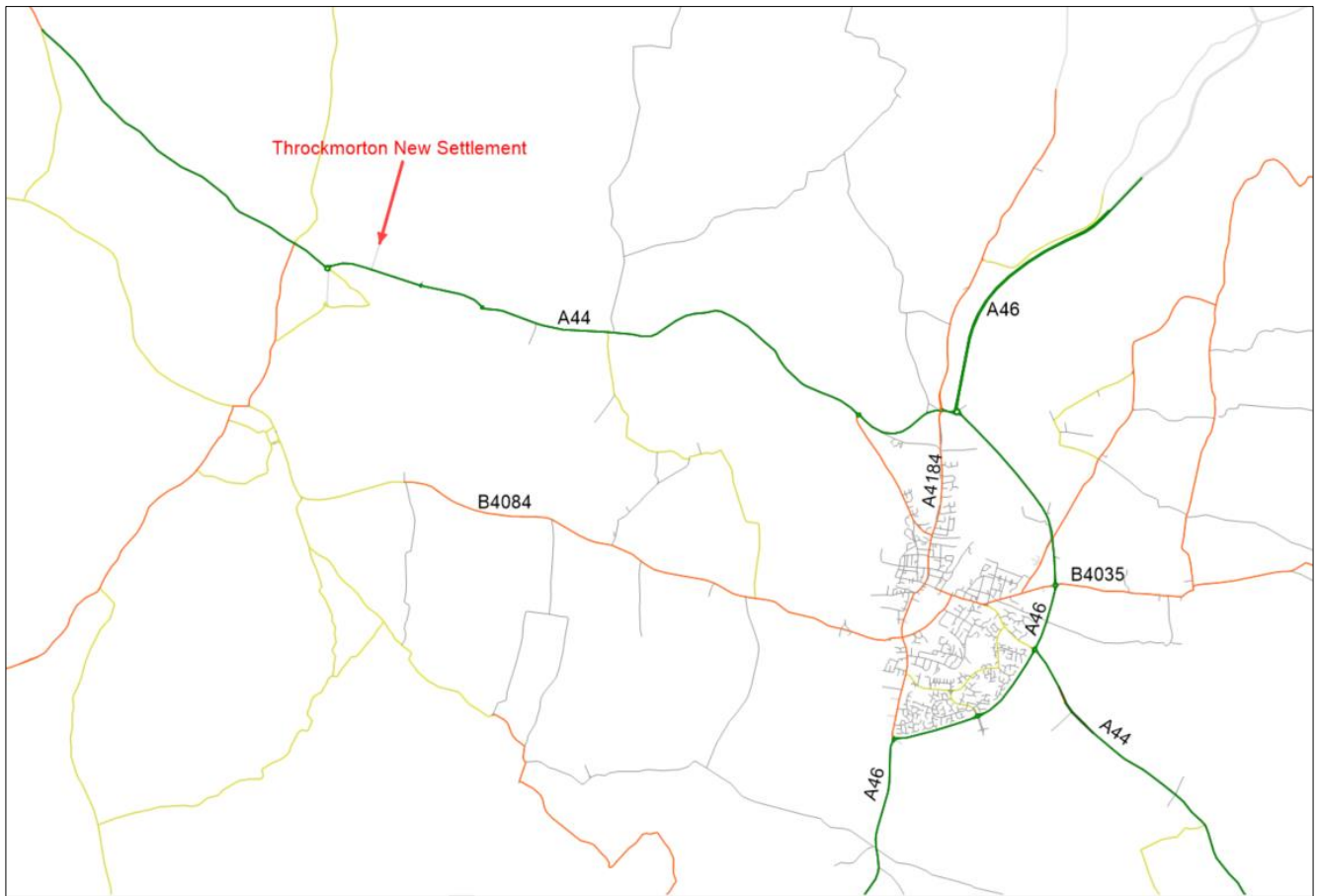


Figure 3.2 Proposed Development Accesses

3.2 Trip Rates and matrices

Trip demand for the development allocations was derived using vehicular trip rates (Table 3-2 & Table 3-3) agreed with WCC for residential (per dwelling) and employment (per 100sqm) developments sites as used for the Pershore forecast models to support the Pershore Infrastructure Improvement scheme.

Table 3-2 Residential Trip Rate

	AM Peak		PM Peak	
	Arrivals	Departures	Arrivals	Departures
Residential Trip Rate	0.156	0.395	0.366	0.225

Table 3-3: Employment Trip Rate

	AM Peak		PM Peak	
	Arrivals	Departures	Arrivals	Departures
B1	1.258	0.195	0.156	1.055
B2	0.499	0.267	0.133	0.378
B8	0.021	0.032	0.023	0.017

The total trips generated from the different SWDPR allocation sites are given in Table 3-4.

Table 3-4: Trips generated from SWDPR sites

Development Quantum	AM Peak		PM Peak	
	Origin	Destination	Origin	Destination
2000-unit Residential site	790	312	450	732
Employment site (10Ha)	76	283	231	48
Total	866	595	681	780

The calibrated 2016 Evesham gravity model which showed good fit to the observed distribution of Roadside Interview (RSI) was used to distribute traffic generated in Table 3-5 above. These trips were then added to the 2041 Evesham model matrices by journey purpose and furnished. The furnishing process reconciles the differences in origins and destinations totals through an iterative process. Table 3-5 shows the 'Matrix totals' of for 2041 forecast years for Evesham and with Throckmorton included. The table shows that the growth between scenarios to be between 2.6% and 3.0% in the AM and PM peak hours.

Table 3-5 All vehicle types - matrix totals

Matrix Totals – Scenario 1					% Diff	
	2041 Evesham		2041 with Throckmorton		2041-2016%	
	AM	PM	AM	PM	AM	PM
Commuters	15336	19732	16017	20399	4.4%	3.4%
Employer – Business	5613	7721	5845	7966	4.1%	3.2%
Other purposes	11471	16707	11845	17138	3.3%	2.6%
HGV	3641	2369	3648	2375	0.2%	0.2%
LGV	10511	7266	10600	7308	0.8%	0.6%
Total	46572	53795	47955	55187	3.0%	2.6%

4. Forecast Year Assessment on Evesham Network

4.1 Introduction

The 2041 forecast demand shown in Table 3-5 was assigned to the Evesham model network and the following model outputs were extracted to understand the impacts on the forecast networks:

- Flow Bundle Analysis
- Link flow differences against base year conditions;
- Link Volume-capacity ratios;
- Link queues;
- Network statistics
- Delays at key junctions; and
- Journey times along the A46, A4104 and A44.

4.2 Flow Bundle Analysis within Evesham

Flow bundles or Select Link analysis in VISUM are used to filter and graphically display loaded paths passing through specific link(s) or model zone(s) obtained from the assignment process. These paths are characterised by route paths from zone origins to zone destinations, mode of transport and traffic volume.

Flow bundle plots were extracted from the model forecasts to show distribution of traffic to and from proposed Throckmorton as shown in Figure 4.1 and Figure 4.2 for 2041 AM and PM Peak respectively

The plots show that the trips from the proposed Throckmorton sites primarily distribute traffic to Evesham using A44 with some rat-running through Fladbury and Charlton villages to get to or from Evesham.

4.3 Link flow difference

Link flow plots and flow difference plots were extracted for the model forecasts and compared against the 2041 baseline. The link flow plots are shown in Figure 4.3 to Figure 4.4 whilst the link flow difference plots against the base year are shown in Figure 4.5 to Figure 4.6.

Between 2041 with Throckmorton and the 2041 baseline (Evesham model with SWDPR scenario 1 allocations), there is an increase in traffic in both directions of the AM Peak of 100 and 666 veh/hr on B4084 and A44 respectively to the west of Fladbury. In the PM peak, traffic increases by 16 and 604 vehicles/hr on B4084 and A44 respectively to the west of Fladbury. Significant congestion in 2041 AM Peak at the A44 The Squares causes vehicles to rat run through Hill Furze Rd and B4088 to get back to A44 as shown in Figure 4.5. Traffic also increases through Evesham town in the PM due to the impact of Throckmorton development traffic displacing background traffic to choose better alternatives.

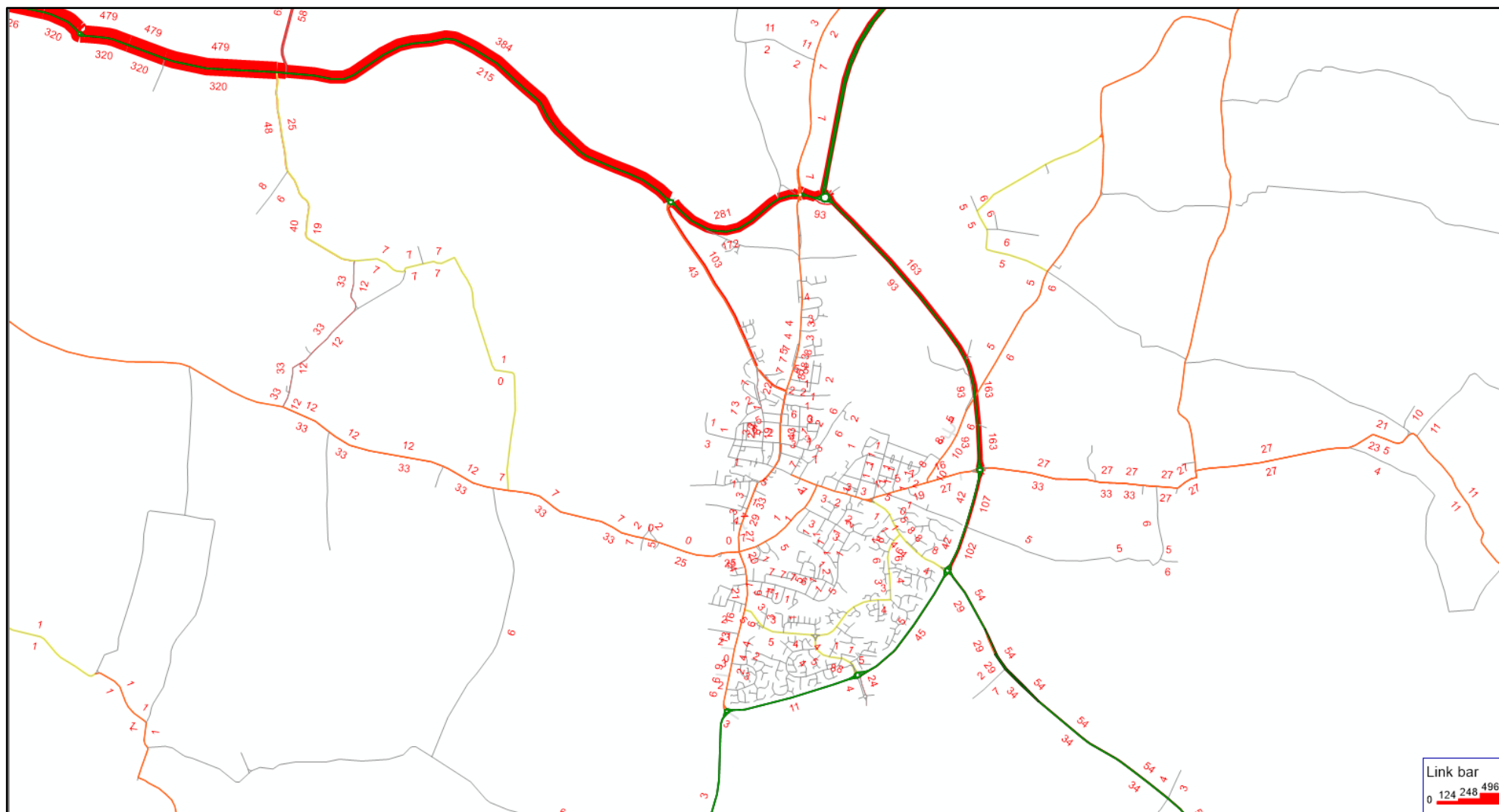


Figure 4.1 2041 AM Peak Flow Bundle for Proposed Throckmorton Development

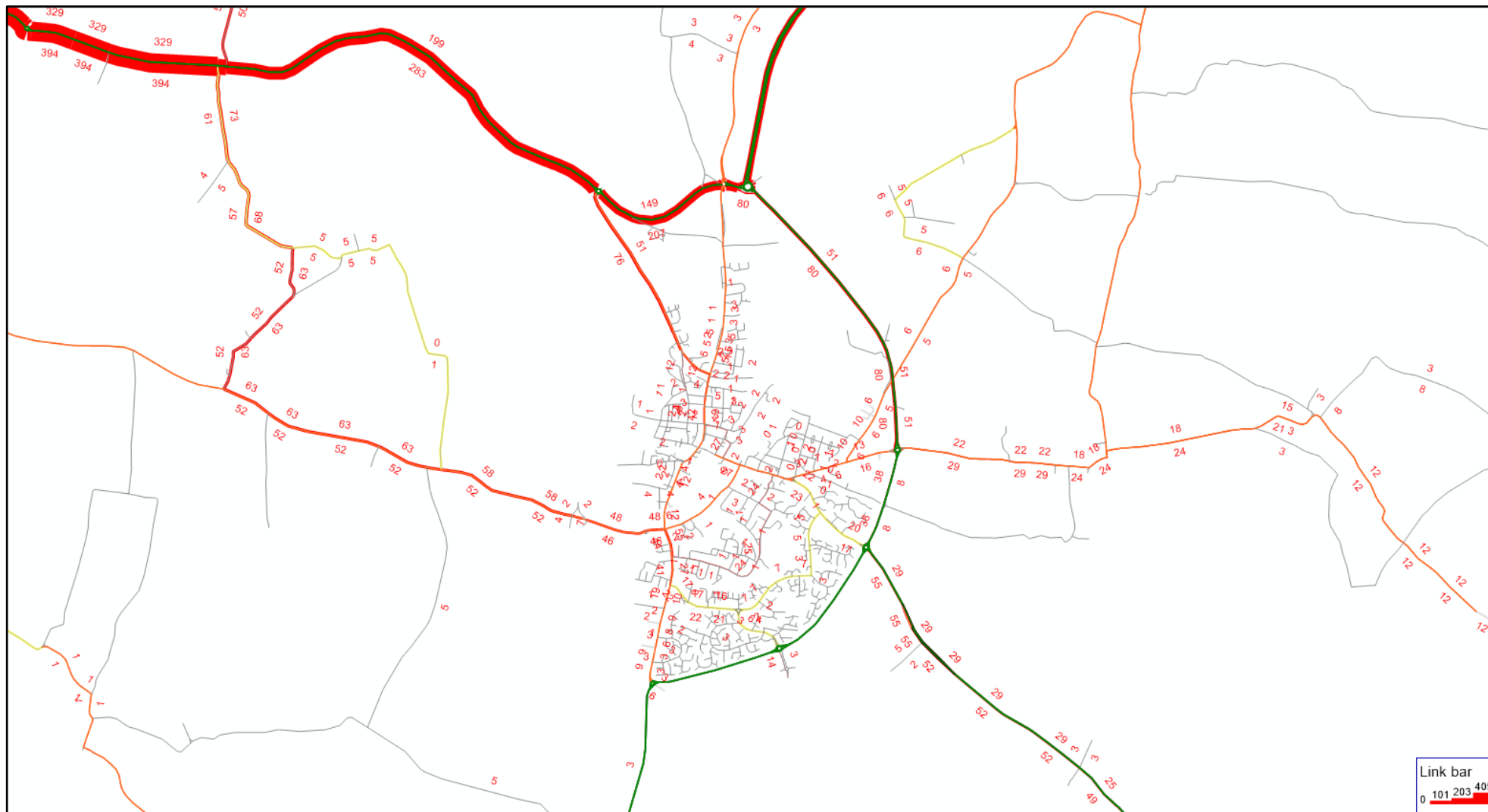


Figure 4.2 2041 PM Peak Flow Bundle for Proposed Throckmorton Development

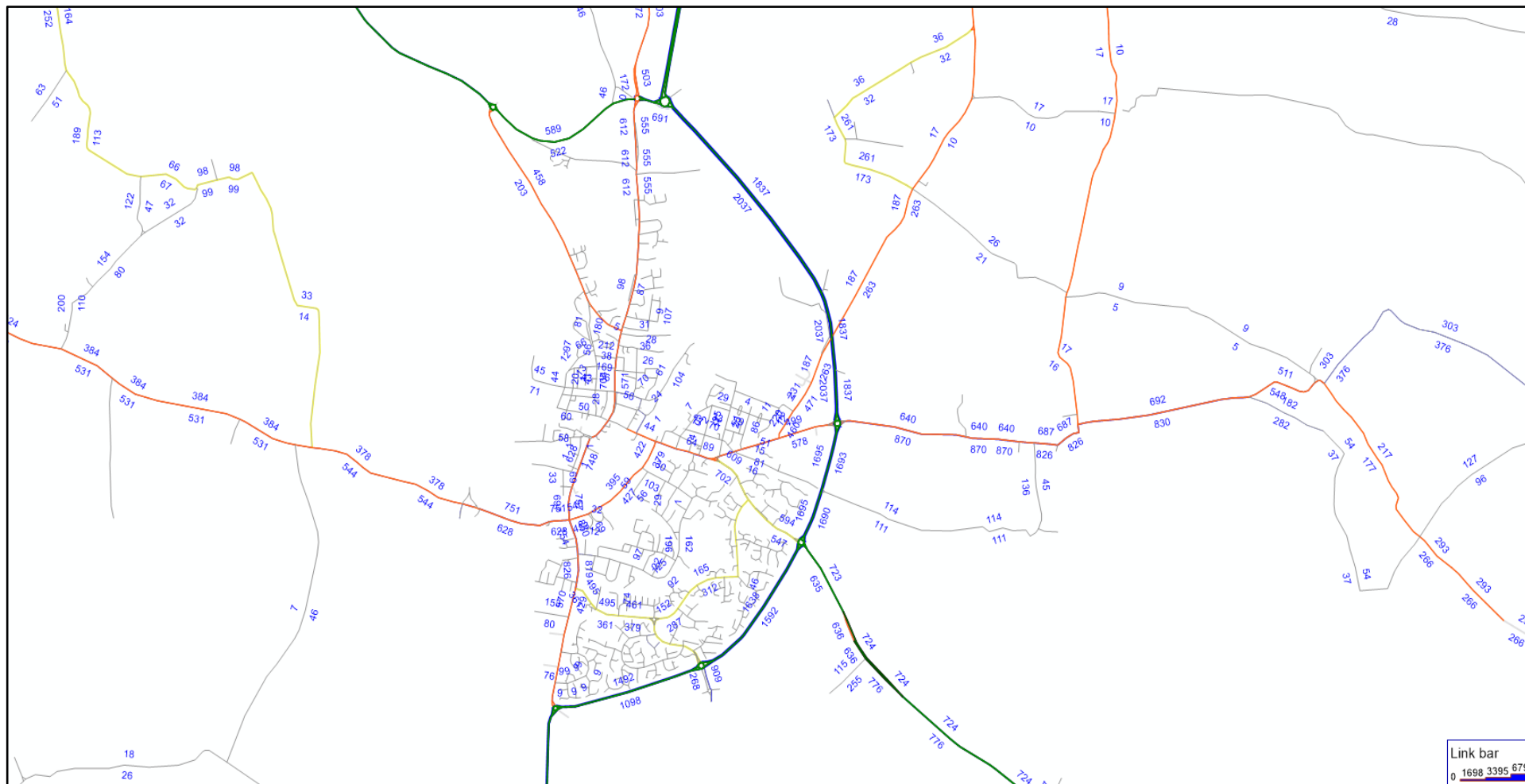


Figure 4.3 Link flow for 2041 AM with Throckmorton

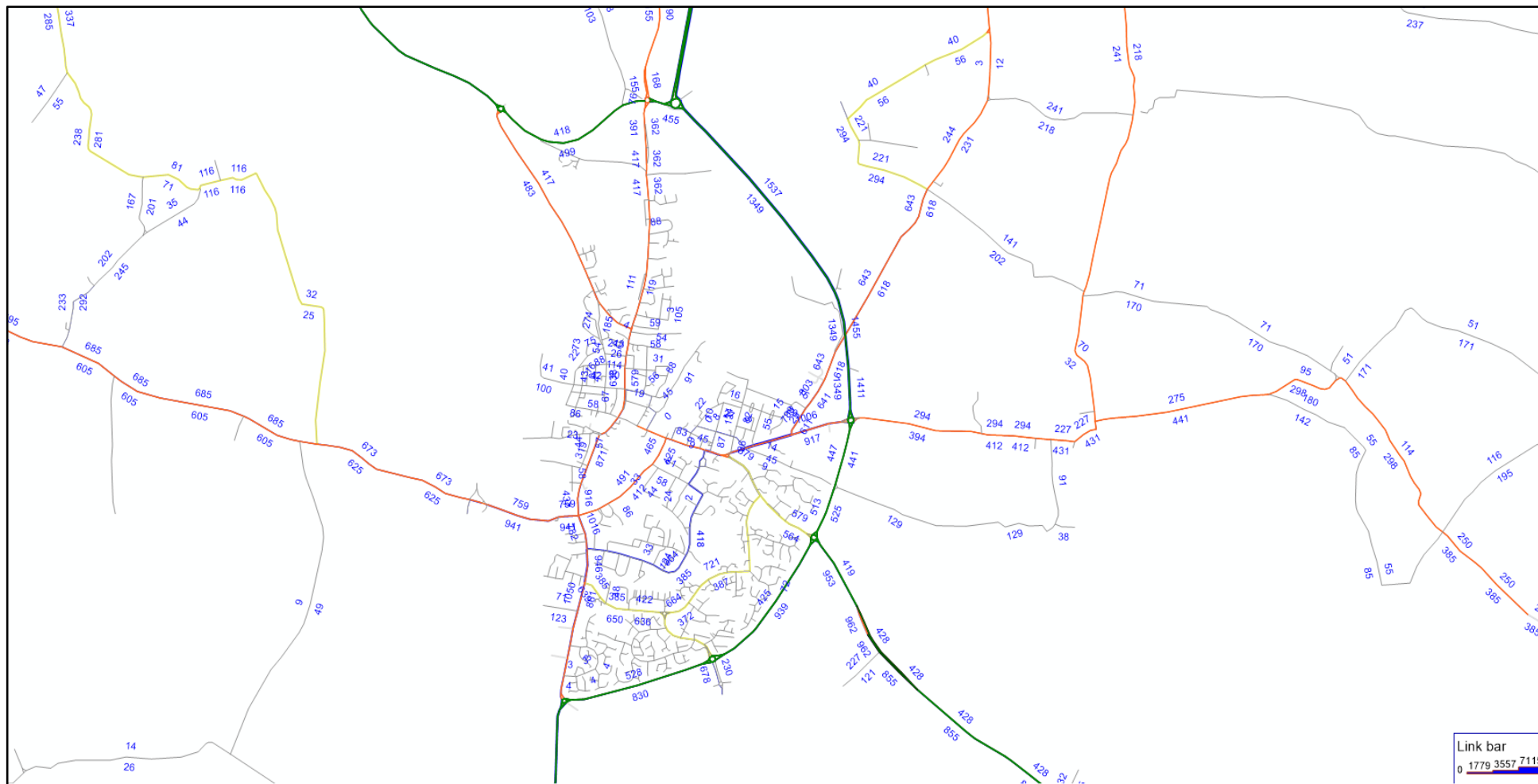


Figure 4.4 Link flow for 2041 PM with Throckmorton



Figure 4.5 Link flow difference between 2041 with Throckmorton and 2041 Baseline AM



Figure 4.6 Link flow difference between 2041 with Throckmorton and 2041 Baseline PM

4.4 Volume Capacity Ratio

Network stress based on link Volume to Capacity (V/C) Ratio is illustrated in Figure 4.7 and Figure 4.8 for AM and PM peak respectively.

The figures show the A46 and the high street through Evesham town to experience network stress during the AM and PM peak hours in 2041. The PM network has many links in Evesham that will operate over capacity. These network conditions in Evesham town and the A46 bypass were forecast to be significantly stress under the Evesham SWDPR assessments as well. Therefore, the inclusions of trips from the Throckmorton development site worsens those conditions.

4.5 Link Queue Lengths

Relative Queue lengths in the model as a result of junctions being over-capacity is shown in Figure 4.9 and Figure 4.10. The queue lengths denote the 'Relative' queue length which equates to the proportion of link length that is queued. Therefore, a value of 100 in a figure denotes traffic on a link along its entire length from its upstream node is in queue due to capacity constraints at its downstream node leading to blocking back. These plots do not include traffic queuing at junctions as they negotiate traffic based on the junction control type and have adequate capacity.

The figures show that the section between The Squires A44/B4088/A4184 Junction and A44/A46 to be significantly congested in the AM the 2041 Base scenario due to additional Throckmorton traffic. The queues in Figure 4.9 and Figure 4.10 at the A44 The Squares causes vehicles to run through Hill Furze Rd and B4088 to get back to A44 as shown in Figure 4.5. The A46 on the other hand is forecast to experience significant queueing in the PM peak across all of the junctions on the Evesham bypass as was forecast as part of the Evesham SWDPR assessments too.

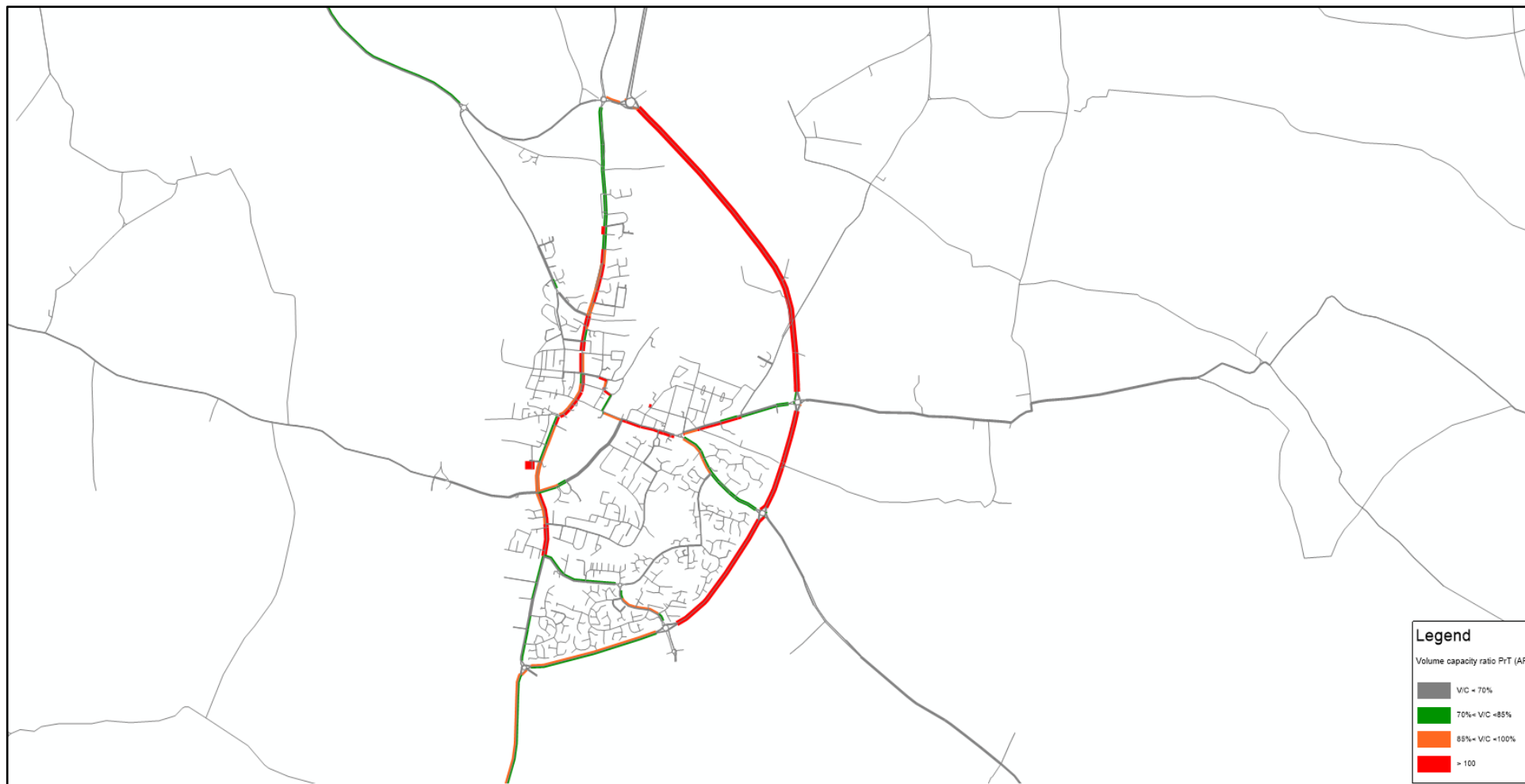


Figure 4.7 Link Volume Capacity ratio 2041 AM with Throckmorton Development

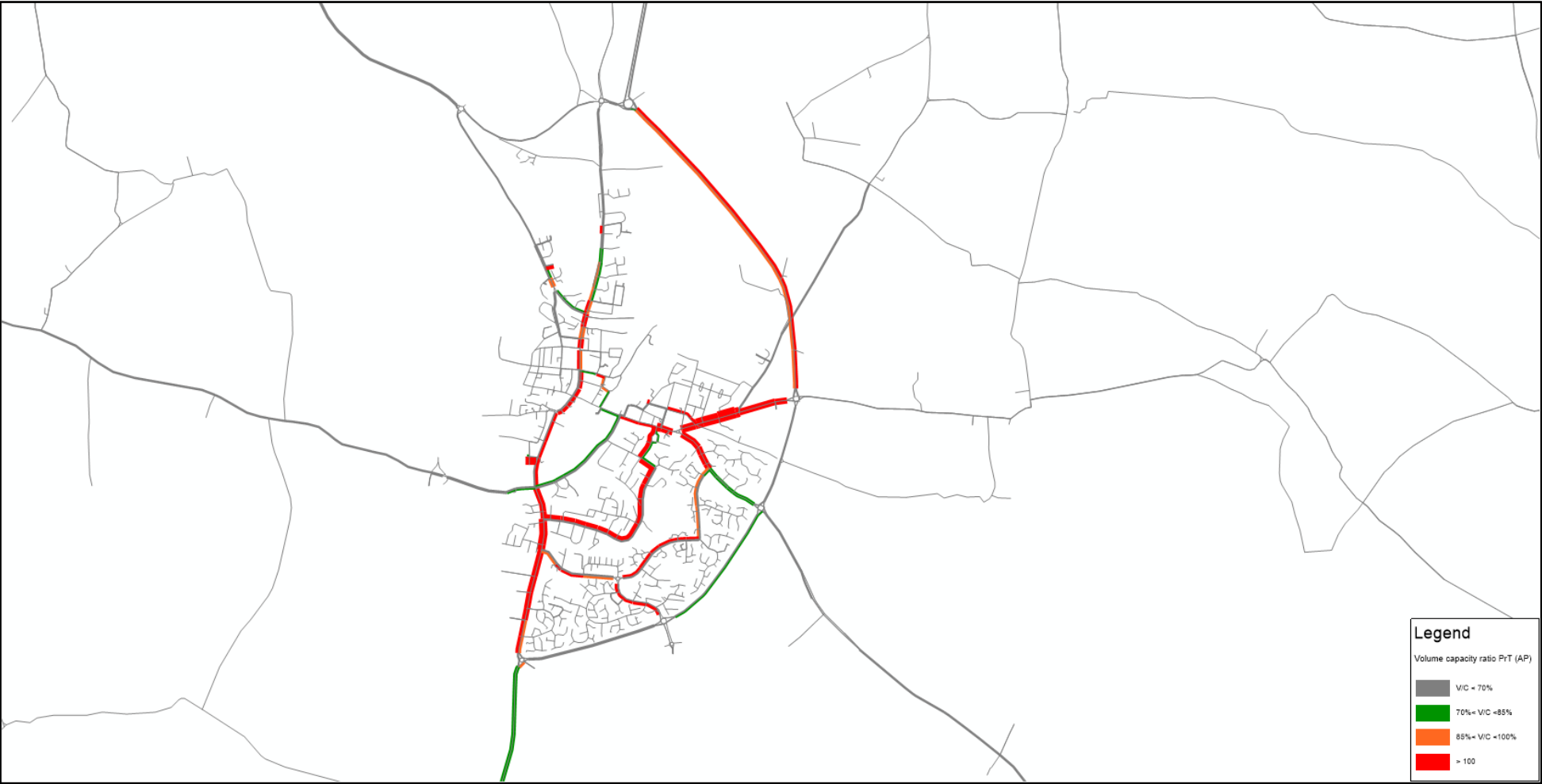


Figure 4.8 Link Volume Capacity ratio 2041 PM with Throckmorton Development



Figure 4.9 2041 Throckmorton AM Peak Relative Queue Length



Figure 4.10 2041 Throckmorton AM Peak Relative Queue Length

4.6 Network Statistics for Evesham Network

The result of the growth in traffic due to the 2041 background growth with Throckmorton development trips on the performance of the Evesham highway network is shown in Table 4-1. The table contains the network summary statistics for the following key elements of network performance for Evesham area:

- Total distance travelled (vehicle kilometres – Veh-km) – i.e. the total distance travelled on each part of the modelled highway network multiplied by the number of vehicles travelling on that part of the network
- Total travel time (vehicle hours – Veh-hrs) – the total time, including delays, travelled on the modelled network multiplied by the number of vehicles
- Speed (kilometres per hour – Avg Speed) – average speed of all vehicles in the Evesham network.

Table 4-1 Network summary statistics and Difference between 2041 Baseline and 2041 with Throckmorton Development

Network Performance Statistics	Baseline		2041 with Throckmorton		% Diff	
	2041					
	AM	PM	AM	PM	AM	PM
Veh-km	71818	69288	75134	72163	4.6%	4.1%
Veh-hrs	1584	1911	1736	2176	9.6%	13.9%
Aver. Speed (kph)	45.3	36.2	43.3	33.2	-4.54%	-8.29%

Table 4-1 shows network performance comparison between 2041 and base year. In 2041, vehicle-km increase in the range of 4.1% – 4.6% in comparison to the base year.

In 2041, vehicle-hrs increase in the range of 9.6% – 13.9% in comparison to the base year. The speeds drop by 4.4% - 8.4%

In both the AM peak and PM peak, the increase in vehicle-hours is significantly higher than the increase in vehicle-kms leading to significant drop in average speeds thus impacting the network performance in Evesham.

4.7 Delays at Junctions in Evesham

Forecast mean delays at major junctions in Evesham is shown Figure 4.2 for 2041 Base and with Throckmorton for both AM and PM peak periods.

Table 4-2 Junction Mean Delay/vehicle

Junction	2041 Baseline		2041 Throckmorton		%Diff	
	AM	PM	AM	PM	AM	PM
A44/B4624 Junction	22 sec	28 sec	35 sec	1 min 3 sec	59.1%	125.0%
B4035 Waterside /Bridge Strt junction	1 min 20 sec	1 min 42 sec	1 min 33 sec	1 min 53 sec	16.3%	10.8%
B4084/B4035/A4184 Junction	2 min 36 sec	2 min 42 sec	2 min 51 sec	3 min 1 sec	9.6%	11.7%

The tables show that mean delay per vehicle at A44/B4624 Worcester Rd Junction increases by between 59.1% and 125.0% in AM and PM Peak respectively compared to the 2041 Baseline. The speeds from the A46/A44 roundabout drop to below 10kph blocking back to the roundabout.

At the B4035 Waterside /Bridge Street junction, mean delays increase by 16.3% and 10.8% in AM and PM Peak respectively. Mean delays at the B4084/B4035/A4184 junction increase by 9.6% and 11.7% in AM and PM Peak respectively.

4.8 Analysis of Journey Time

Modelled journey time data through the town centre, along the A46 and along the A44/A46 routes were extracted for the forecast models and are presented in Table 4-3. The Route 1 section is between the A46/A44 roundabout to the north and A46/A4104 Cheltenham Road to the south along A46; Route 2 is along the high street from the A44 The Squires/B4088/A4184 Roundabout in the north to A46 Cheltenham Rd/Bevans Ln Junction in the south; and Route 3 on the A44 from Fladbury via the A44/A46 roundabout to the A46 junction at Salford Priors. The routes are shown in Figure 4.11.

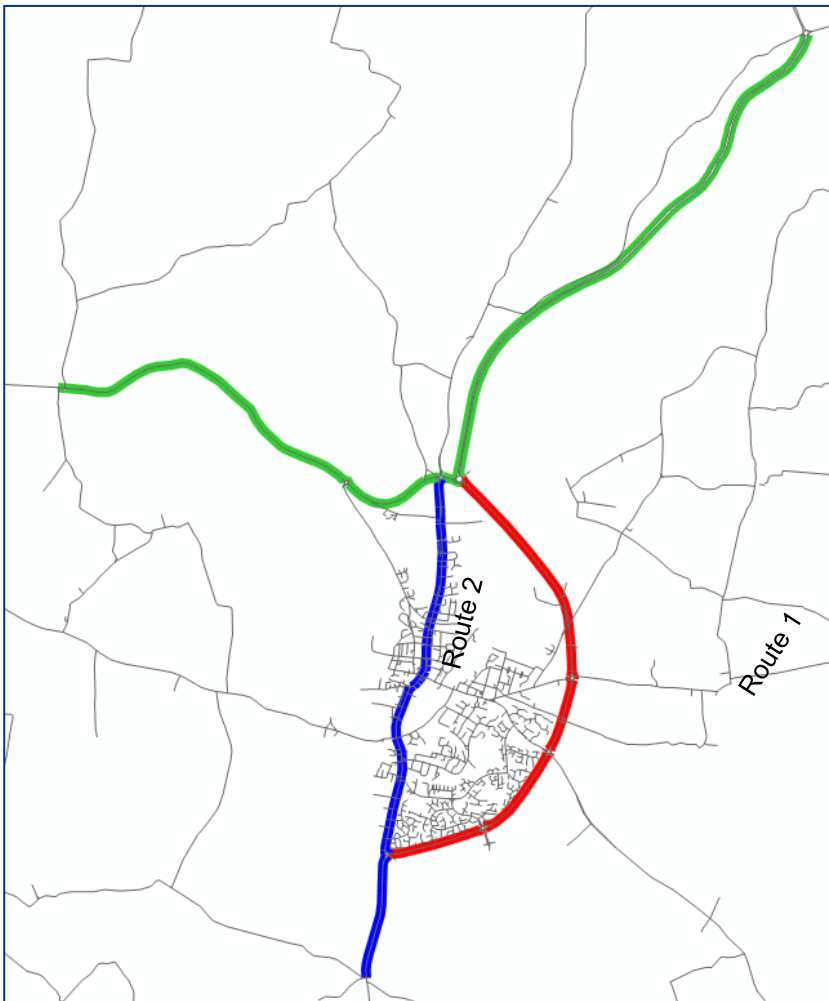


Figure 4.11 Journey time routes

Table 4-3 Forecast Journey time on A46 percentage change compared to base year (2016)

Journey Time (sec)		2016		2041 Throckmorton		% Diff	
		AM	PM	AM	PM	AM	PM
Route 1 – A46	Northbound	451	736	449	784	-0.4%	6.5%
	Southbound	436	792	441	814	1.1%	2.8%
Route 2 via High Street	Northbound	708	824	731	924	3.2%	12.1%
	Southbound	759	827	818	839	7.8%	1.5%
Route 5 – A44	Eastbound	623	836	751	912	20.5%	9.1%
	Westbound	588	672	687	779	16.8%	15.9%

The tables show that journey times for route 1 northbound direction on A46 Bypass changes by -0.4% and 6.5% in the AM peak and PM Peak respectively due to delays on the section between the junctions A44 Broadway Rd and B4035. The changes in route 1 southbound direction is only 1.1% for AM peak and 2.8% in PM Peak respectively.

For Route 2 through the town centre, the northbound journey time decreases slightly by 3.2% and 12.1% in AM and PM Peak respectively. The changes in route 2 southbound direction is 7.8% for AM peak and 1.5% in PM Peak respectively.

Along Route 5 on the A44 and A46, the travel time in both directions increase appreciably in the AM by between 16% and 21%. In the PM peak, the travel time in the westbound direction increases by 15.9% and in the eastbound direction by 9.1%.

The above analysis shows that the Throckmorton site impacts on the A44 leading towards Evesham with a knock-on impact on Route 2 and to some extent on the A46 Evesham bypass.

5. Forecast Year Assessment on Pershore Network

5.1 Introduction

Following the analysis of Throckmorton development impact on the Evesham network, the flow bundles data from Figure 4.1 and Figure 4.2 were used to extract OD matrices for the Throckmorton development which matched zones in Pershore model. This resulted in the 2041 demand in the Pershore model to increase by 19.3% and by 20.4% in AM and PM Peak compared to the 2041 Baseline forecast. The updated OD demand was assigned to the Pershore model network and key statistics extracted.

This section explains the forecast results for the 2041 with proposed Throckmorton development using PHAM based on development flow bundles, link flow differences, volume-capacity ratios, network performance statistics and mean delays at key junctions. The results have also been compared with the 2041 baseline scenario for Pershore.

5.2 Access Junction

Access to the Throckmorton development site is a new junction off the A44 to the east of the Pershore Northern Link Road. The access junction has been coded as a signalised junction to cater to the significant demand from the development site as well as traffic volumes on the A44. The junction approach is assumed to be 2-lanes with no shared lanes for movements through the junction.

The assignment of development trips to the PHAM network result in flows at the junction as shown in Table 5-1

Table 5-1: Throckmorton Development Access junction flows - 2041

Access Junction	Movement	Vehicles	
		AM	PM
A44 West	Left	188	340
	Ahead	898	771
Development Access	Left	390	336
	Right	265	279
A44 East	Ahead	967	832
	Right	271	398

5.3 Flow Bundle Analysis

Flow bundle plots were extracted from the Pershore Highway model forecasts to show distribution of traffic to and from proposed Throckmorton development as shown in Figure 5.1 and Figure 5.2 for 2041 AM and PM Peak respectively

The development distributions show the trips from Throckmorton development site will use the A44 to head towards Worcester and Evesham with some trips destined to A4104 and Pershore Town Centre, along new Pershore Link Road.

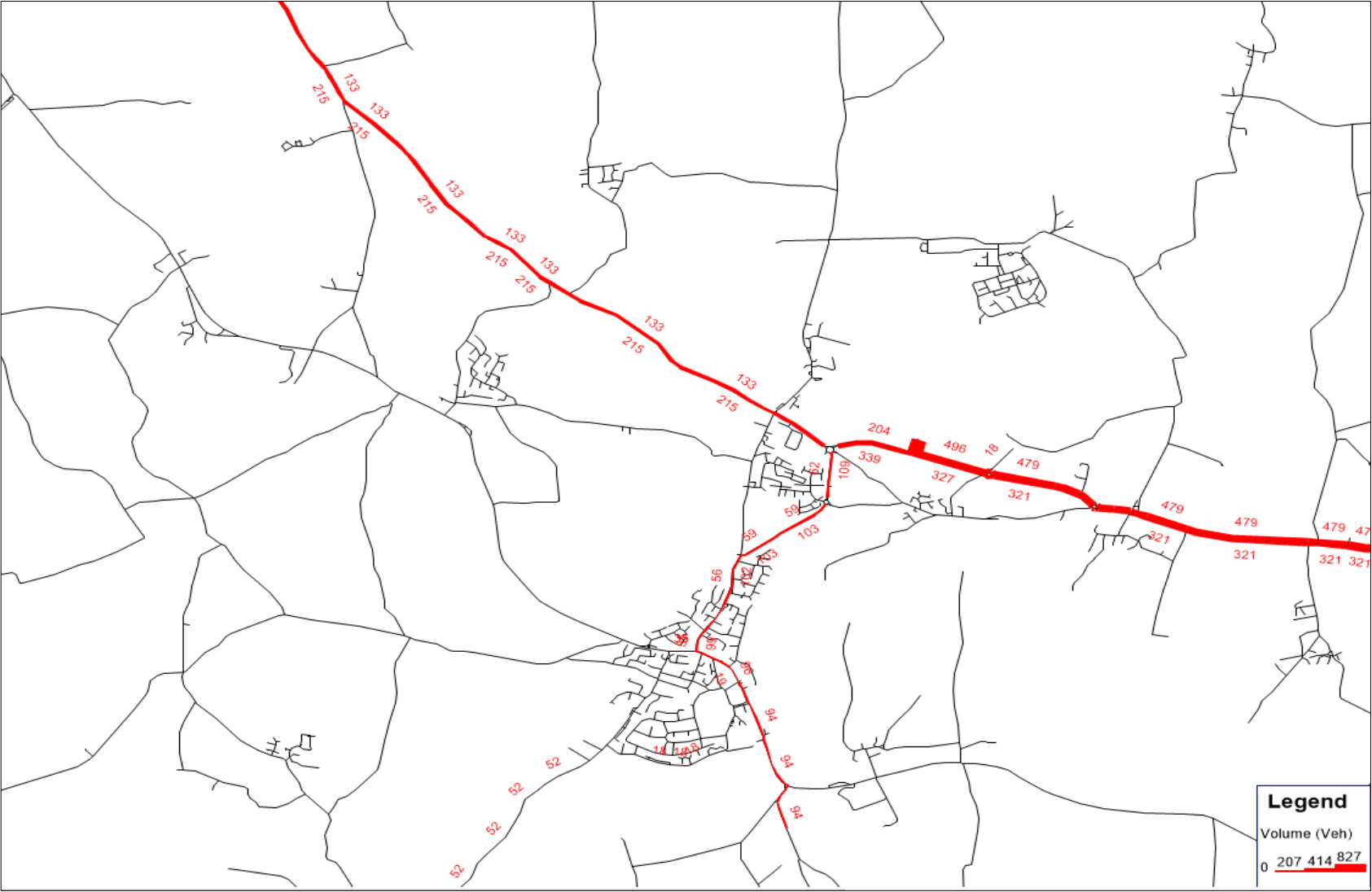


Figure 5.1 2041 AM Peak Flow Bundle for Proposed Throckmorton Development

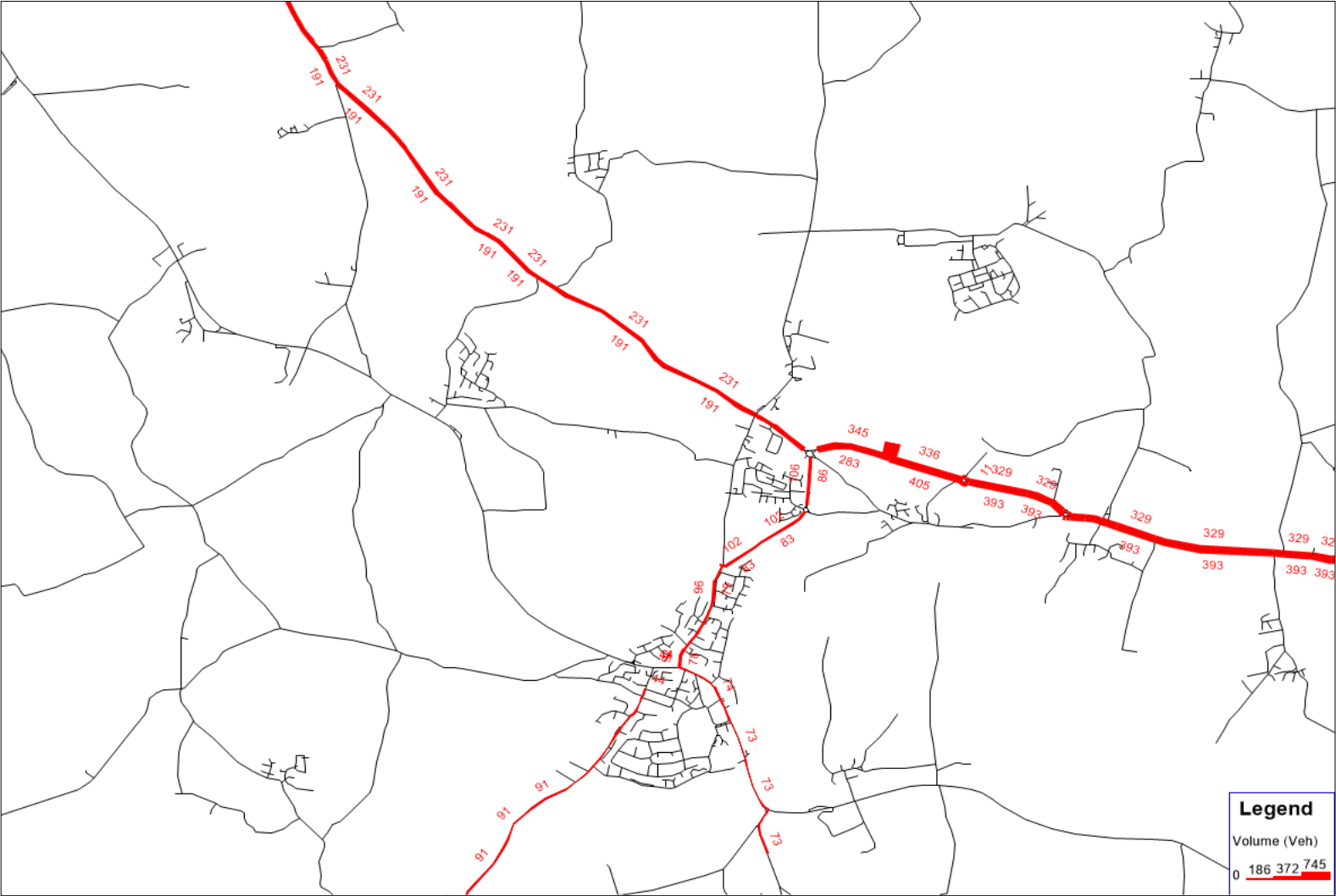


Figure 5.2 2041 PM Peak Flow Bundle for Proposed Throckmorton Development

5.4 Link Flow Changes

Figure 5.3 and Figure 5.4 illustrate the link flows for 2041 AM and PM Peak respectively while Figure 5.5 and Figure 5.6 display the differences between 2041 flows with and without Throckmorton development trips. The link bar/text in green highlights the traffic flow increases in 2041 and red bar/text shows the decrease of traffic flow compared to 2041 baseline conditions.

The diagrams illustrate a general increase in traffic with the Throckmorton development trips in both the AM Peak and PM peak as would be expected. Around Pershore town centre, traffic tends to reassign along B4084 Worcester Road as the demand on the A44 increases due to the Throckmorton development trips.

It is worth noting that the change in traffic flow on links between Pershore and Evesham as shown in Figure 5.5 and Figure 5.6 do not necessarily correspond with the flow changes in the Evesham model network (Figure 4.5 and Figure 4.6) for the common links. This is to be expected as they are two different models with different base years; varying levels of network detail and zone systems, with only the Throckmorton development trips common in them.

5.5 Volume Capacity Ratio

Links volume capacity ratios for 2041 are illustrated in Figure 5.7 to Figure 5.8. They show that the Pershore highway network in 2041 operates within 70% of capacity on most routes except for few sections on the A44 around Pinvin junction in both peaks and around Three Springs junction in the PM peak where they are higher and in some cases near capacity (on the A44 west of Pinvin).

5.6 Highway Network Performance Statistics

The section below illustrates the network performance summary of the forecast scenarios for 2041 with Throckmorton forecast and 2041 Pershore Baseline conditions.

Table 5-2 2041 Network summary statistics and Difference between 2041 Baseline and 2041 with Throckmorton Development

Network Statistics (absolute)	Model year and period				% Diff	
	2041 Base		2041 Throckmorton			
	AM	PM	AM	PM	AM	PM
Veh-km	62930	66250	76229	80721	21.1%	21.8%
Veh-hrs	1986	2285	2733	2841	37.6%	24.3%
Avg Speed (kph)	31.7	29.0	27.9	28.4	-12.0%	-2.1%

The table shows vehicle-hours increases by 37.6% and 24.3% for both AM and PM peak hours respectively in 2041 forecast year. Vehicle-kms also increases in both peaks by 21.1% to 21.8% in comparison to 2041 Baseline conditions resulting in average speeds reducing by 12.0% in AM Peak and 2.1% in PM Peak.

5.7 Delay at Key Junctions in Pershore

Forecast mean delays at major junctions is shown in Figure 5.9 and Figure 5.10 for 2041 with Throckmorton development or both AM and PM peak periods. The differences in forecast mean delays between 2041 Base and 2041 with Throckmorton at major junctions is shown Table 5-3.



Figure 5.3 Link flow for 2041 AM with Throckmorton

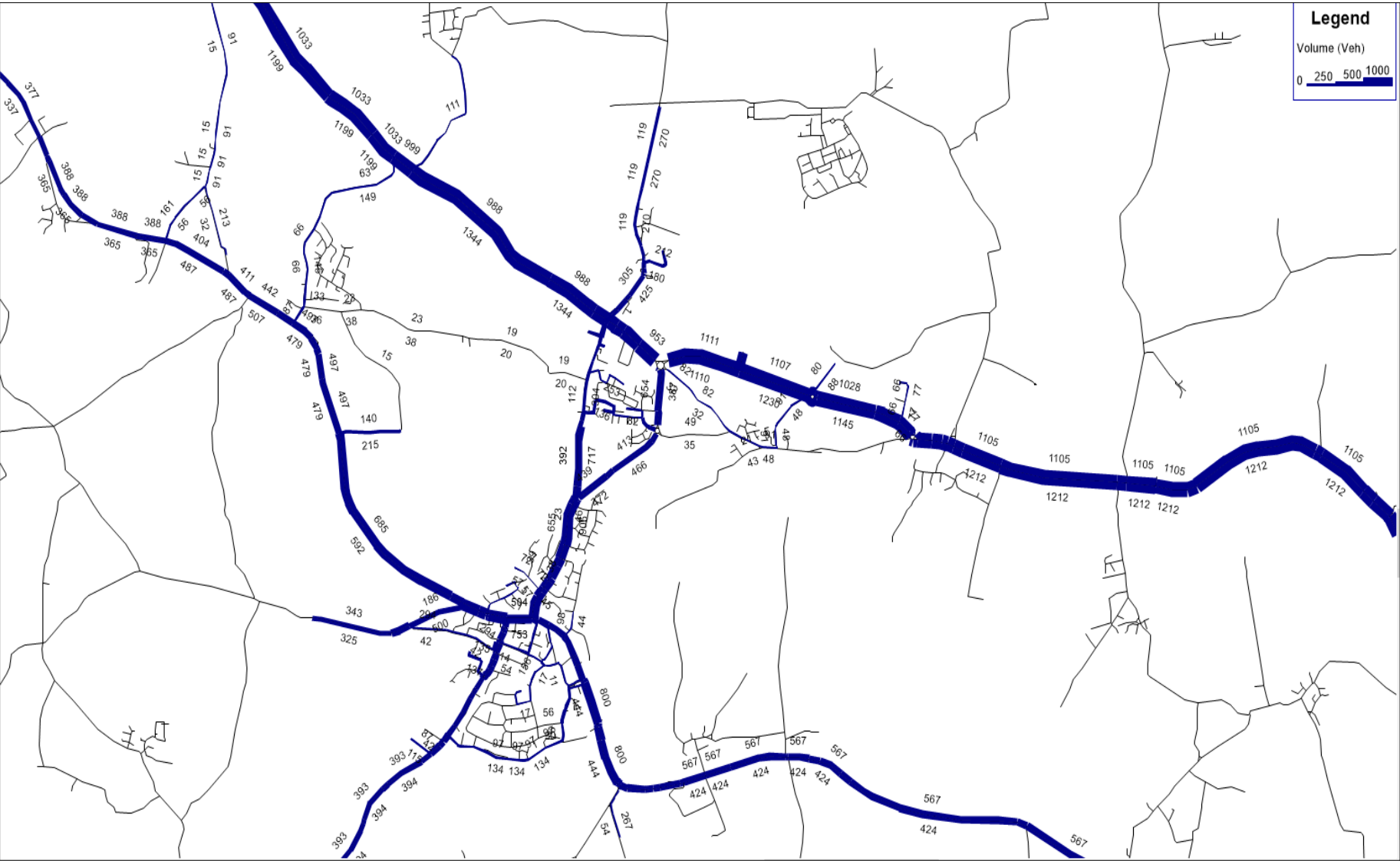


Figure 5.4 Link flow for 2041 PM with Throckmorton



Figure 5.5 Link flow difference between 2041 with Throckmorton and 2041 Baseline AM



Figure 5.6 Link flow difference between 2041 with Throckmorton and 2041 Baseline PM

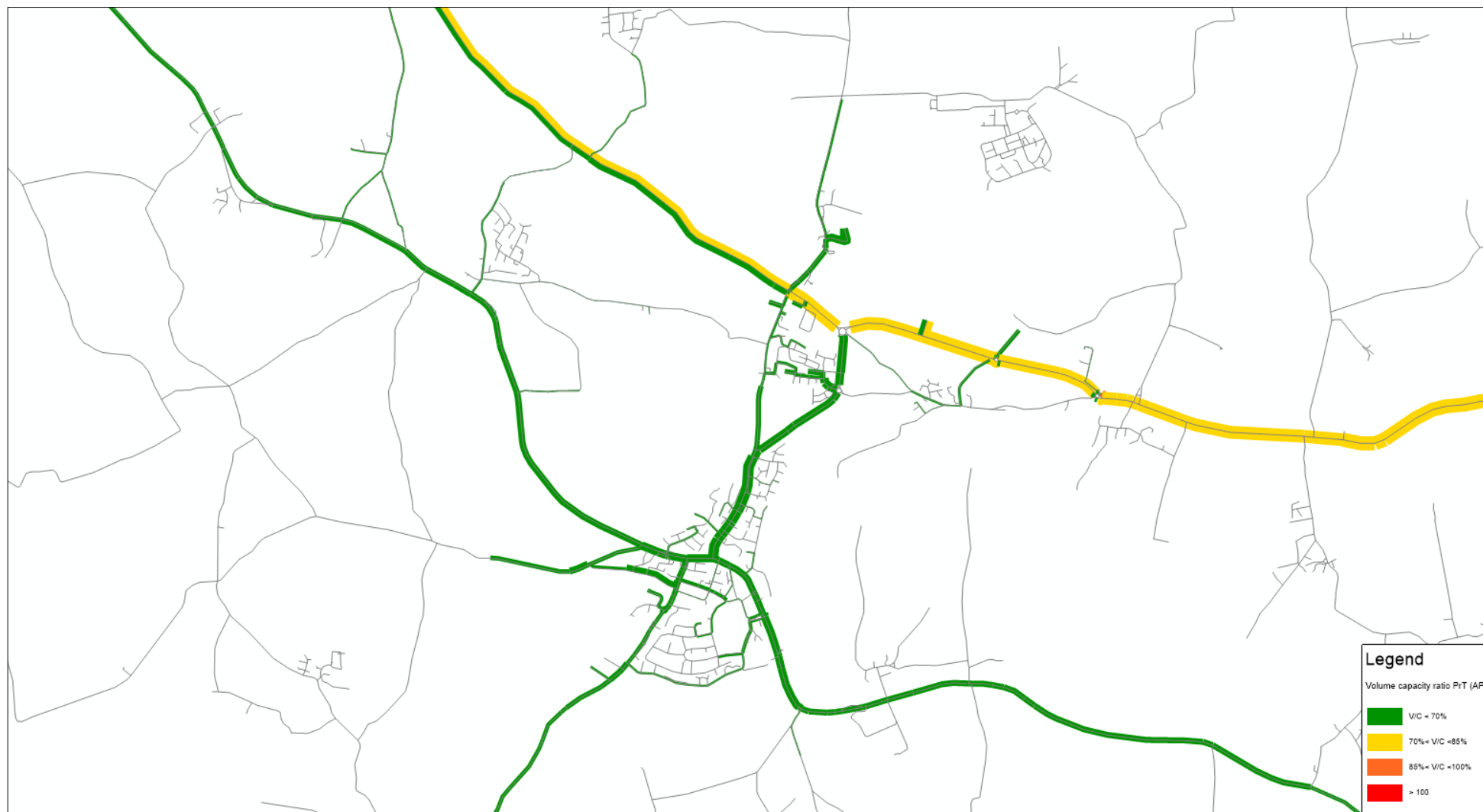


Figure 5.7 Link Volume Capacity ratio 2041 AM with Throckmorton Development

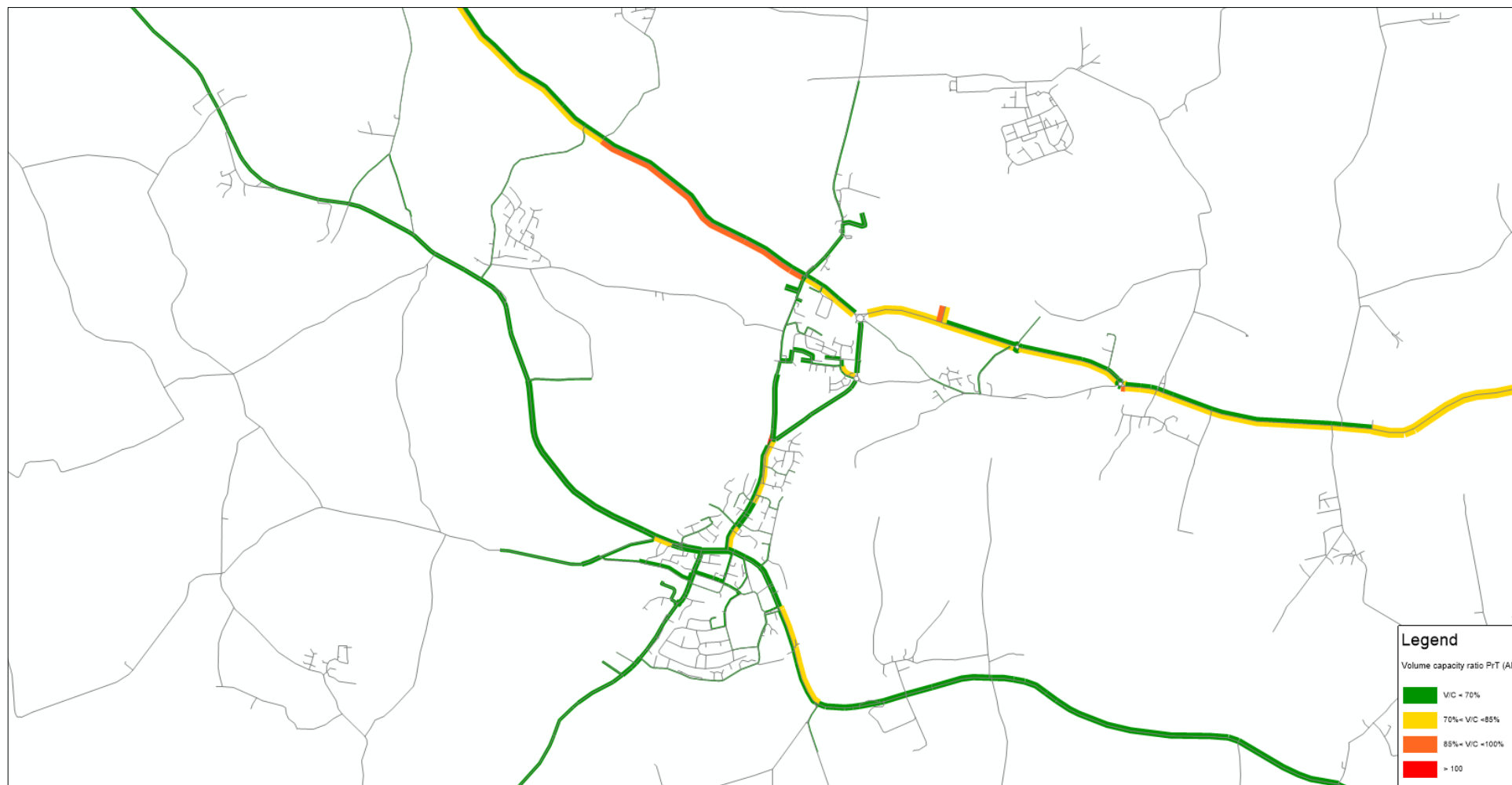


Figure 5.8 Link Volume Capacity ratio 2041 PM with Throckmorton Development

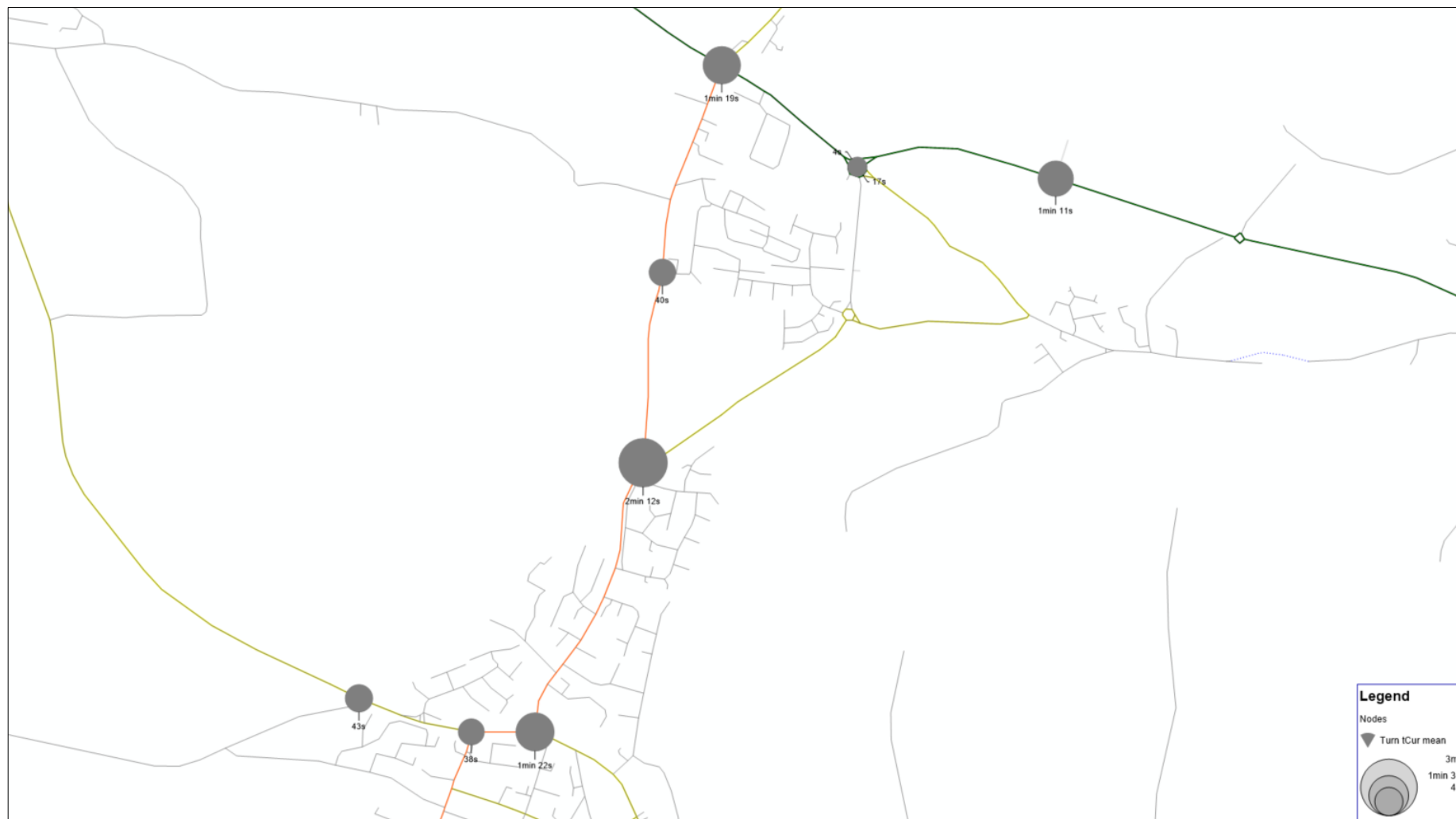


Figure 5.9 Key Junction Delays for 2041 AM Peak with Throckmorton

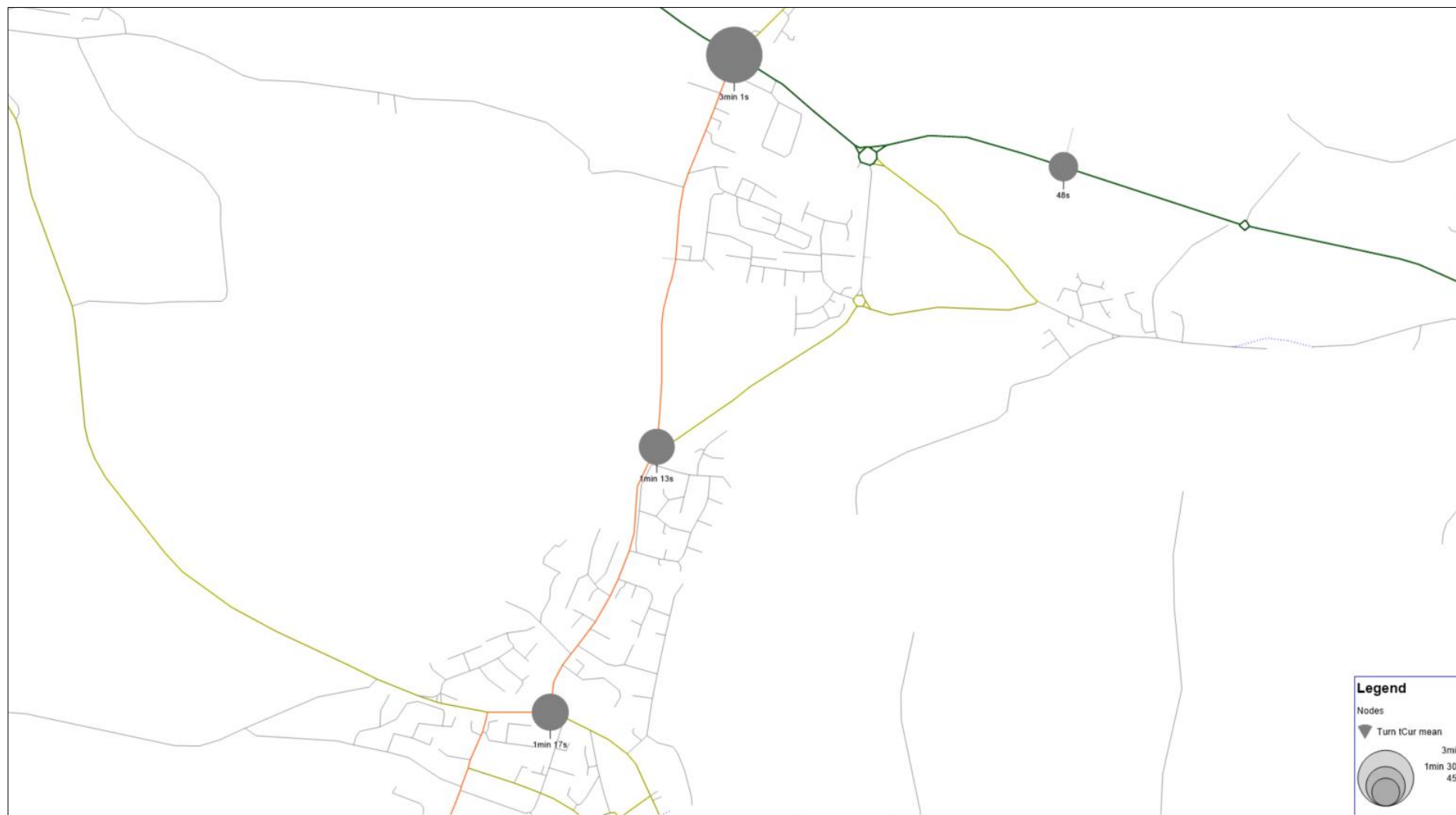


Figure 5.10 Key Junction Delays for 2041 PM Peak with Throckmorton

Forecast mean delays at major junctions is shown Table 5-3 for 2041 Base and with Throckmorton for both AM and PM peak periods.

Table 5-3 Junction Mean Delay/vehicle

Junction	2041 Baseline		2041 Throckmorton		%Diff	
	AM	PM	AM	PM	AM	PM
Pinvin junction	1 min 14 sec	1 min 40 sec	1 min 38 sec	3 min 7 sec	32.4%	87.0%
Wyre Road junction	1 min 14 sec	48 sec	2 min 12 sec	1 min 13 sec	78.4%	52.1%
High Street junction	1 min 26 sec	51 sec	1 min 22 sec	1 min 17 sec	-4.7%	51.0%
Throckmorton junction	-	-	1 min 11 sec	48 sec	-	-

The tables show that mean delay per vehicle at Pinvin increases by between 32.4% and 87.0% in AM and PM Peak respectively compared to the 2041 Baseline. At the Wyre Road/Station Road junction, mean delays increase by 78.4% and 52.1% in AM and PM Peak respectively. Mean delays at the High Street junction in the AM Peak by reduces by 4.7% but increase in PM peak by 51.0% primarily due to the switching of traffic from A44 to B4084 to local routes to avoid congestion at New access junction for Throckmorton development where the mean delays are 1 min 11 sec in the AM peak and 48 sec in the PM peak.

5.8 Analysis of Journey Times

This section shows travel time for major routes going through Pershore. Travel time on A44 through Pinvin Crossroad Junction and B4084 through High Street Junction were extracted from the models for AM and PM Peak periods.

Table 5-4 A44 and B4084 Journey time between 2041 Baseline and 2041 with Throckmorton Development

Route	Length	Journey Times (min)				%Diff	
		2041		2041 Throckmorton		%Diff	
		AM	PM	AM	PM	AM	PM
B4084 EB	16.39	27min 16s	29min 0s	28min 12s	30min 31s	3.4%	5.2%
B4084 WB	16.39	26min 49s	27min 26s	27min 25s	29min 57s	2.3%	9.2%
A44 EB	15.67	24min 19s	23min 40s	29min 10s	27min 49s	20.0%	17.5%
A44 WB	15.68	23min 29s	23min 47s	29min 25s	28min 4s	25.3%	18.0%

Table 5-4 shows that journey times increases in both 2041 AM and PM Peak compared to 2041 Baseline. The changes vary between 2.3% - 9.2% for B4084 and 17.5% - 25.3% for A44. The A44 changes in journey time are considered significant.

6. Forecast Year Assessment on Worcester network

6.1 Introduction

The 2041 forecast demand shown in Table 3-5 was assigned to the Evesham model network. Based on the assigned traffic, it was identified that development traffic as shown in Table 6-1 interacts with M5 and Worcester along A44. As neither the Evesham model nor Pershore model covers the Worcester area in detail, it was decided to assess the impact of the Throckmorton development using the Worcester SATURN model. The development impact was assessed using the 2041 WTM model that includes the Parkway development, Rushwick development, Worcester Business park and other proposed development within Worcester city as the baseline condition in line with the impacts on the Evesham and Pershore networks.

Table 6-1 Throckmorton Development Trip Impacting M5 and Worcester

	AM		PM	
	Commuter & Others	Business	Commuter & Others	Business
WB Trip to Worcester	176	39	143	47
EB Trip from Worcester	106	27	190	41

The development trips heading towards M5 and Worcester were allocated to a WTM model zone. The distribution pattern of trips on the A44 was used as a basis to distribute the Throckmorton development trips towards M5 and Worcester.

6.2 Trip Distribution

Figure 5.1 to Figure 5.4 shows the trip distribution of the Throckmorton development in the WTM model. The distribution shows that majority of trips (65%-69%) from the development trips interacting with west will use M5 J6 for Worcester and M5 North, 20 to 22% will use A44 for Worcester and only 9-15% will use A422.

Figure 6.1 2041 AM Peak Origin Flow Bundle from Proposed Throckmorton Development

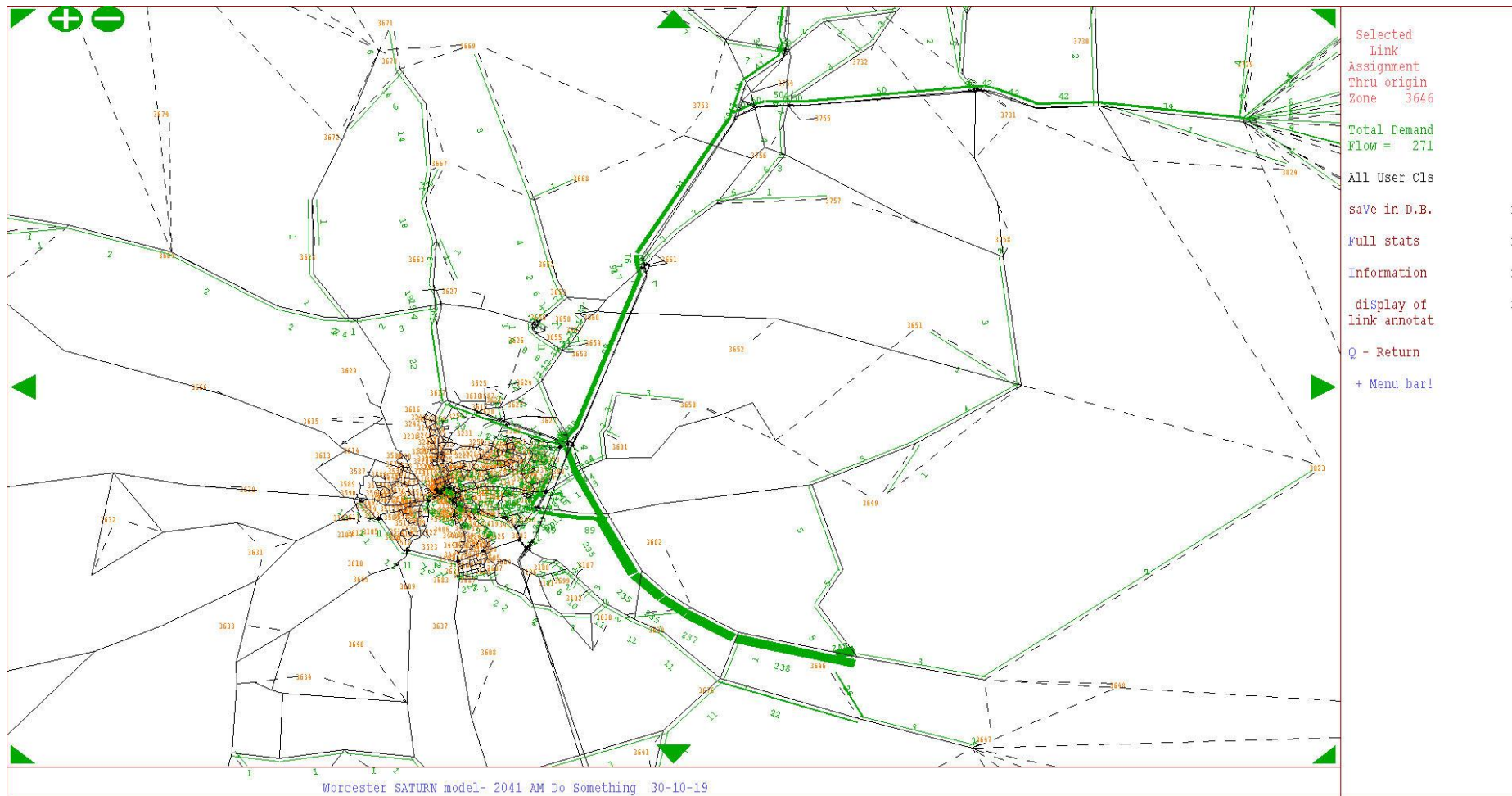


Figure 6.2 2041 AM Peak Destination Flow Bundle to Proposed Throckmorton Development

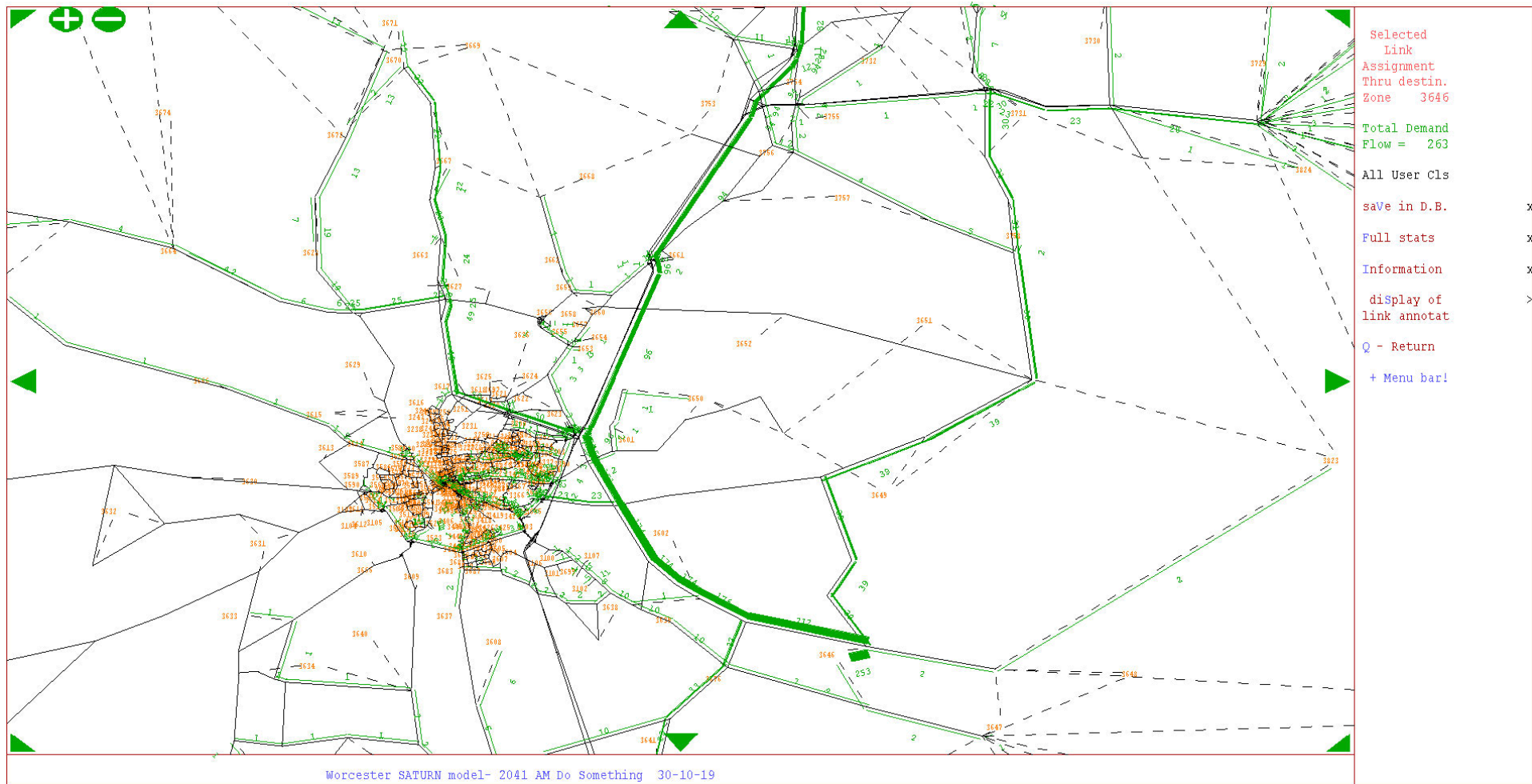


Figure 6.3 2041 PM Peak Origin Flow Bundle from Proposed Throckmorton Development

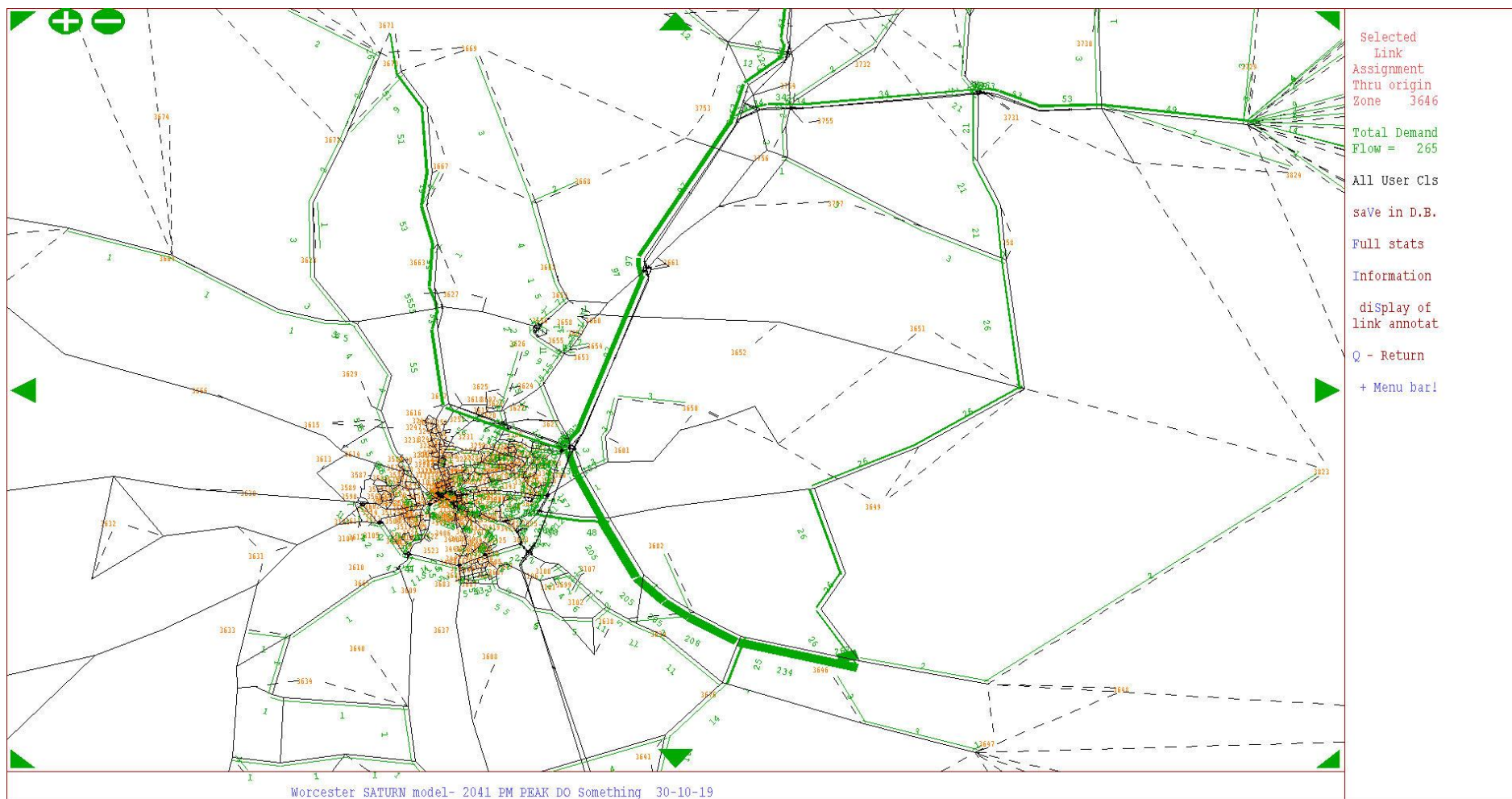
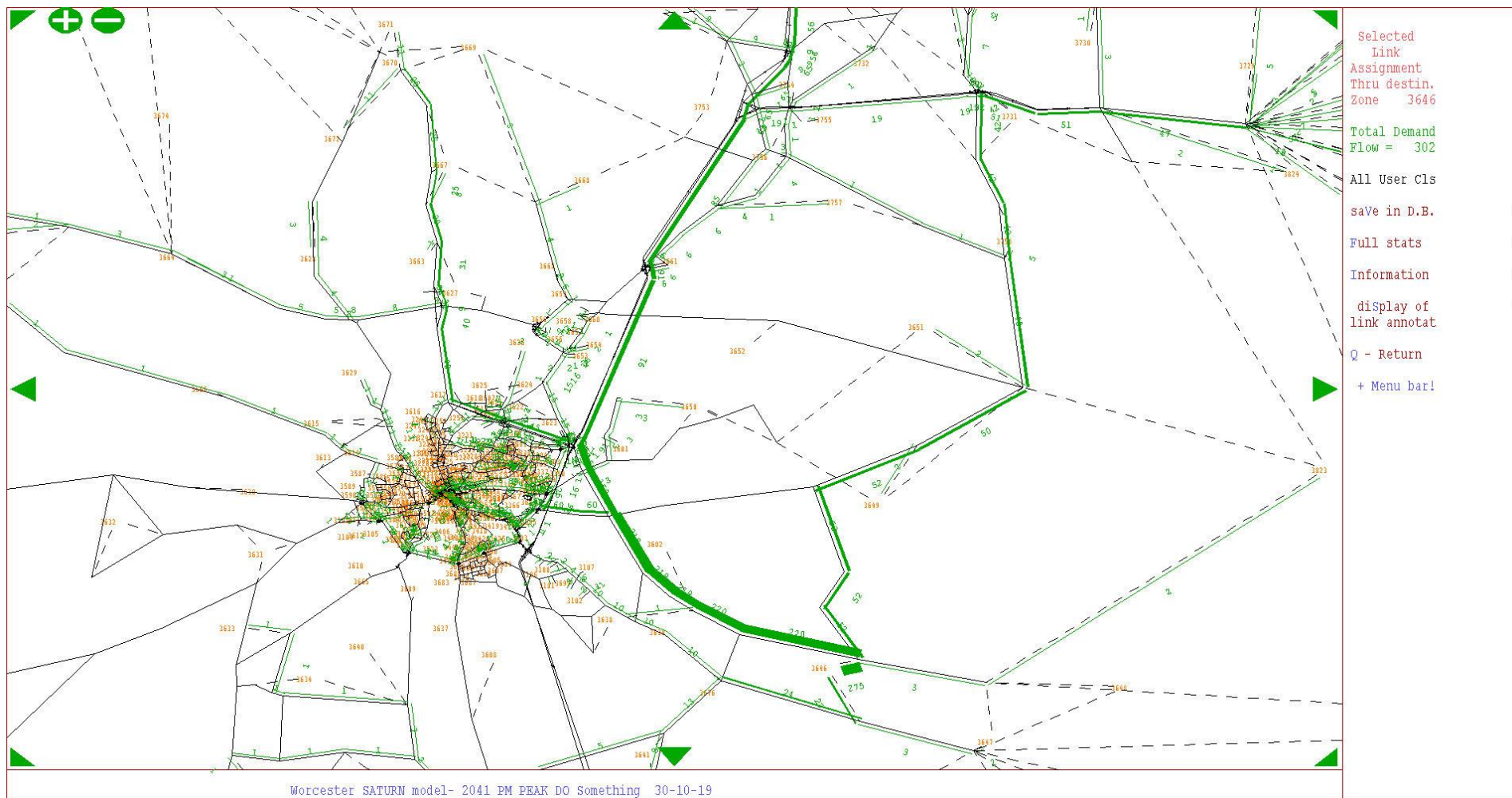


Figure 6.4 2041 PM Peak Destination Flow Bundle to Proposed Throckmorton Development



The 2041 forecast year flow and the following model outputs were extracted to understand the impacts on the forecast networks:

- Link flow differences against 2041 baseline including other SWDPR developments;
- Link Volume-capacity ratios;
- Junction Capacities (VCR);
- Junction Delays (in seconds); and
- Network statistics.

6.3 Link flow difference

Link flow plots were extracted from the model forecasts and compared against the 2041 baseline model. The link flow difference plots against the baseline case are shown Figure 5.5 to Figure 5.6. From the analysis it is clear that A44, Pershore Lane and A422 will experience increase in traffic flow. A44 Evesham Road will experience additional traffic up to 233 vehicles/hour and A422 will see an increase up to 119 vehicles/hour in both directions compared to 2041 baseline conditions.

6.4 Volume Capacity Ratio

Network stress based on link Volume to Capacity (V/C) Ratio is illustrated in Figure 5.7 and Figure 5.8 for AM and PM peak respectively.

The figures show that A44 Evesham road generally will experience capacity problems but the stretch between the A422 and Egdon lane will have critical capacity problem where V/C is over 100% in AM peak. Similarly, the A449 EB towards M5 J6 may have critical capacity problem in both AM and PM peak.

Figure 6.5 2041 AM Peak Flow Difference Plot

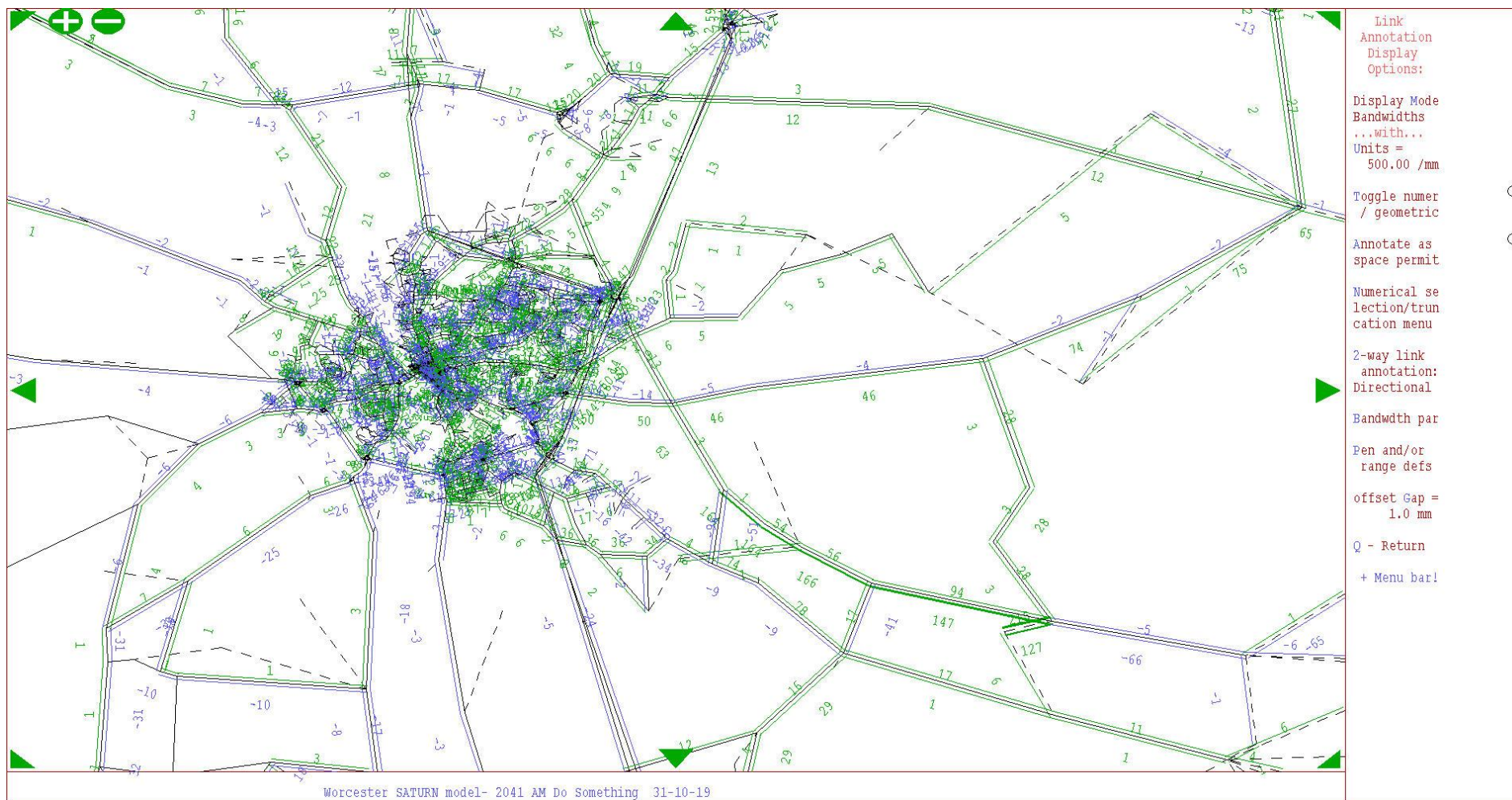


Figure 6.6 2041 PM Peak Flow Difference Plot

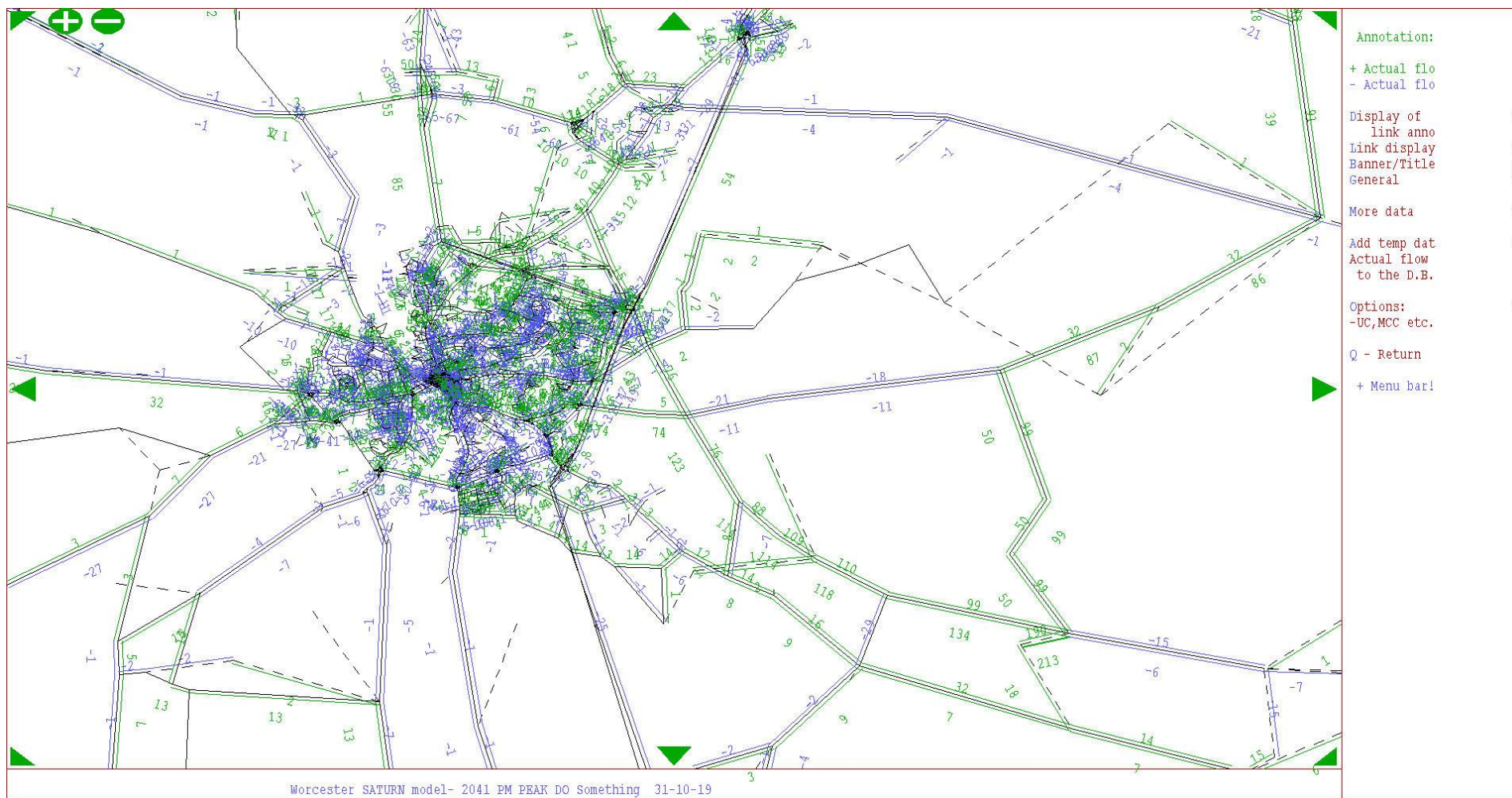


Figure 6.7 Link Volume Capacity ratio >75% for 2041 AM with Throckmorton Development

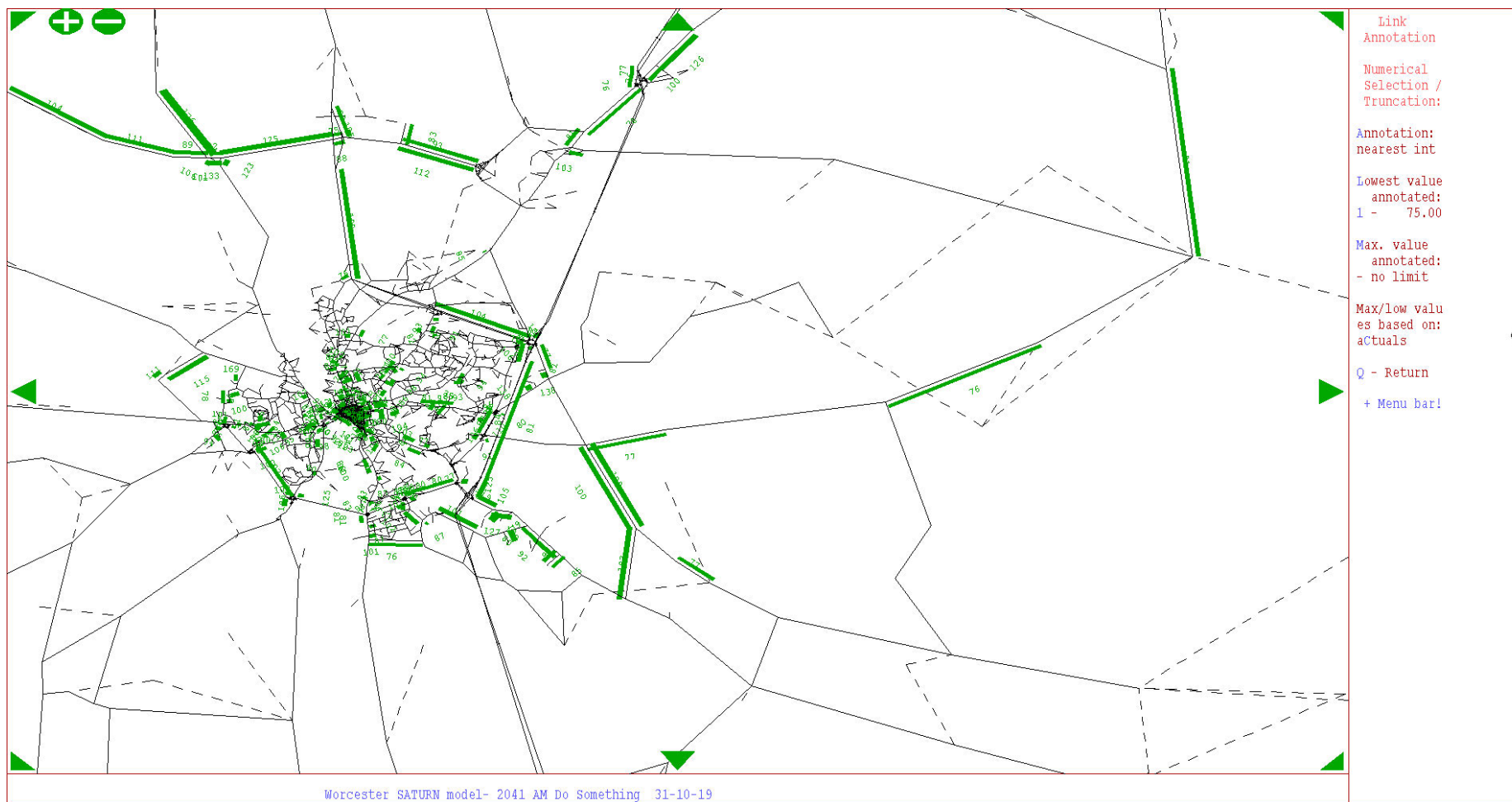
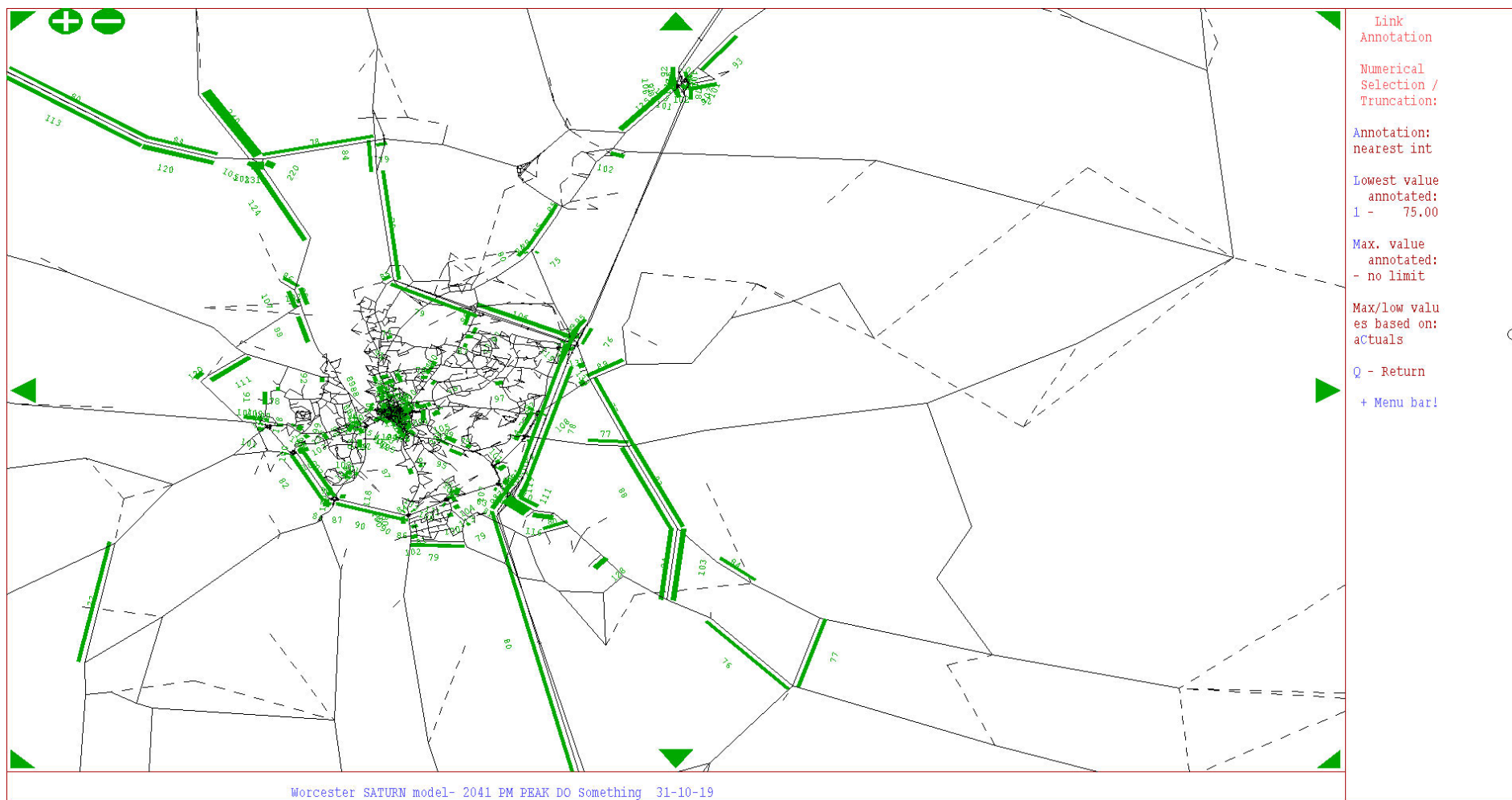


Figure 6.8 Link Volume Capacity ratio >75% for 2041 PM with Throckmorton Development



6.5 Junction Delays and Stress

Figure 6.9 to Figure 6.14 shows major junction delays (more than 60 seconds) at key locations within Worcester. Table 5-3 shows the impact of the developments while compared to 2041 baseline scenario. It should be noted that many of the junctions are already predicted to be operating at capacity in 2041 baseline scenario (Figure 6.15 and Figure 6.16) and traffic are expected to be held back in queue. The additional traffic makes the junction conditions worse mainly along A44, Pershore lane and importantly M5 J6.

Table 6-2 Junction Mean Delay (s) /vehicle

Junction	2041 Baseline		2041 with Throckmorton		%Diff	
	AM	PM	AM	PM	AM	PM
Stonebow/A44 Junction	25	25	34	35	36.0%	40.0%
Egdon Lane/A44 junction	83	9	128	14	54.2%	55.6%
A44/A422/Pershore Lane Junction	18	17	23	19	27.8%	11.8%
Plough Road /Pershore Lane Junction	11	12	12	12	9.1%	0.0%
Pershore Lane Approach to M5 J6 Junction	61	158	67	170	9.84%	7.59%
A4449 Approach to M5 J6 Junction	63	81	67	84	6.35%	3.70%

Figure 6.9 Junction Delays > 60 Seconds 2041 AM with Throckmorton Development

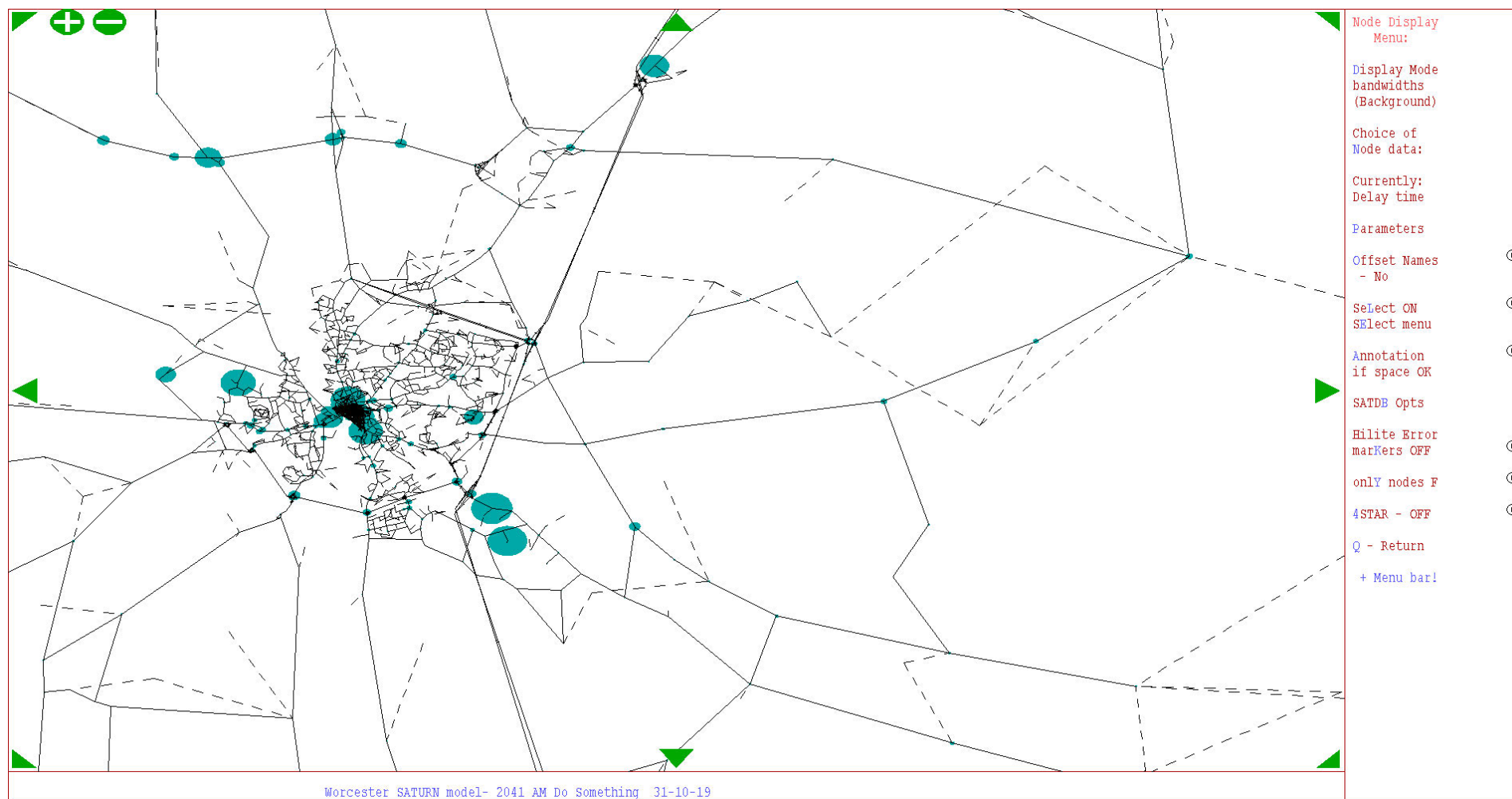


Figure 6.10 Junction Delays>60 Seconds 2041 PM with Throckmorton Development

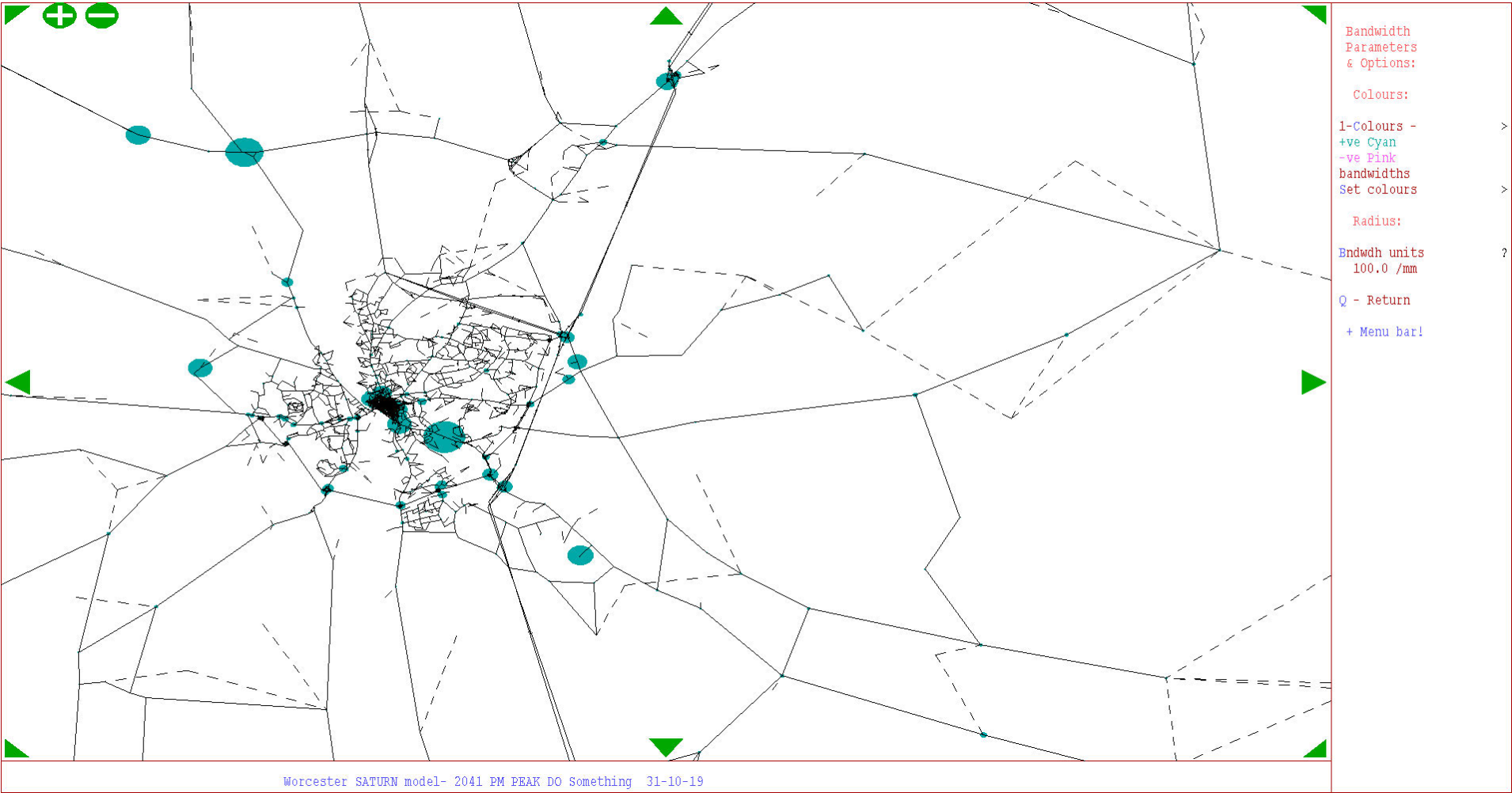


Figure 6.11 Junction Delays > 60 Seconds 2041 AM with Throckmorton Development along A44

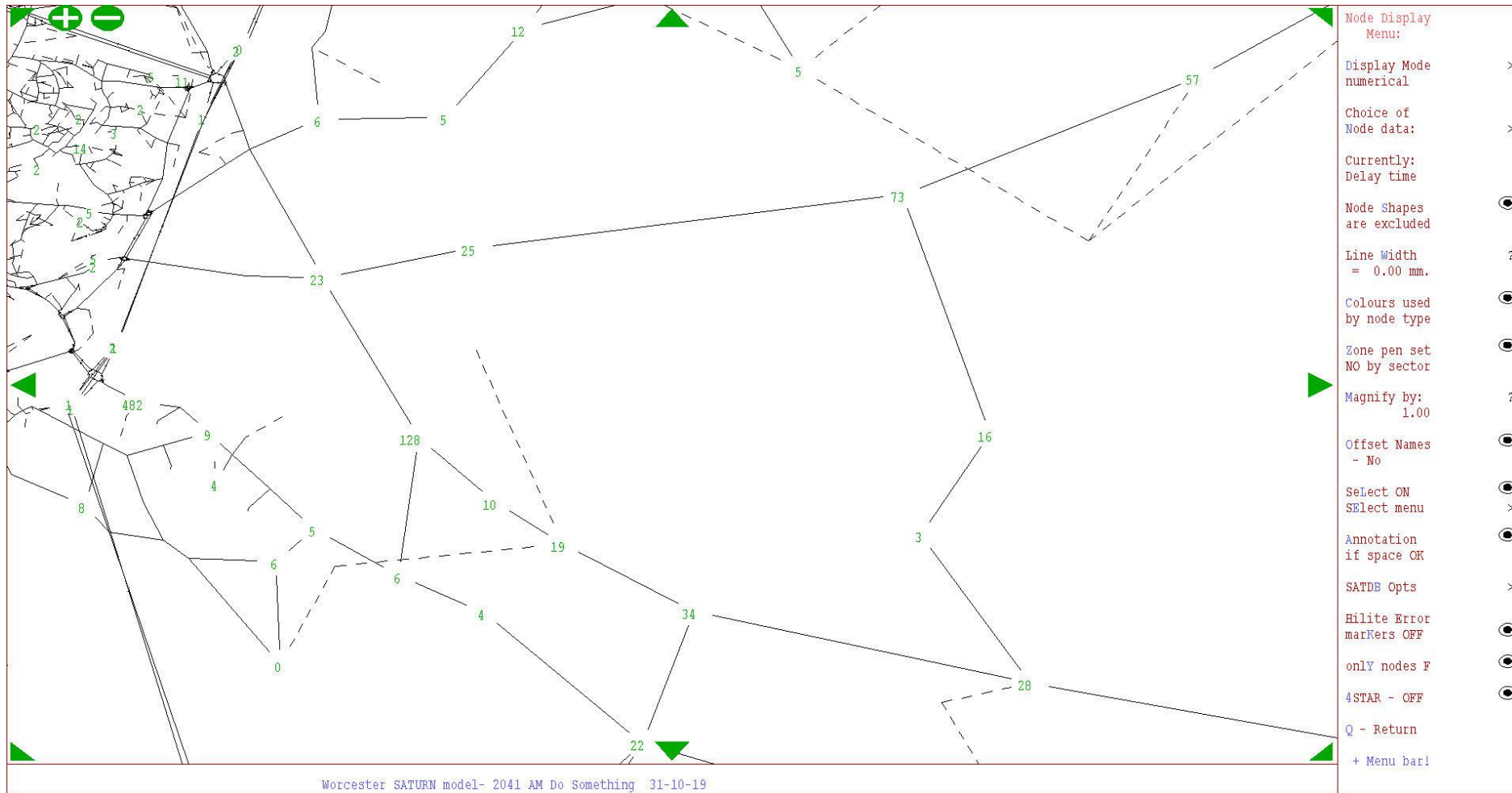


Figure 6.12 Junction Delays > 60 Seconds 2041 PM with Throckmorton Development along A44

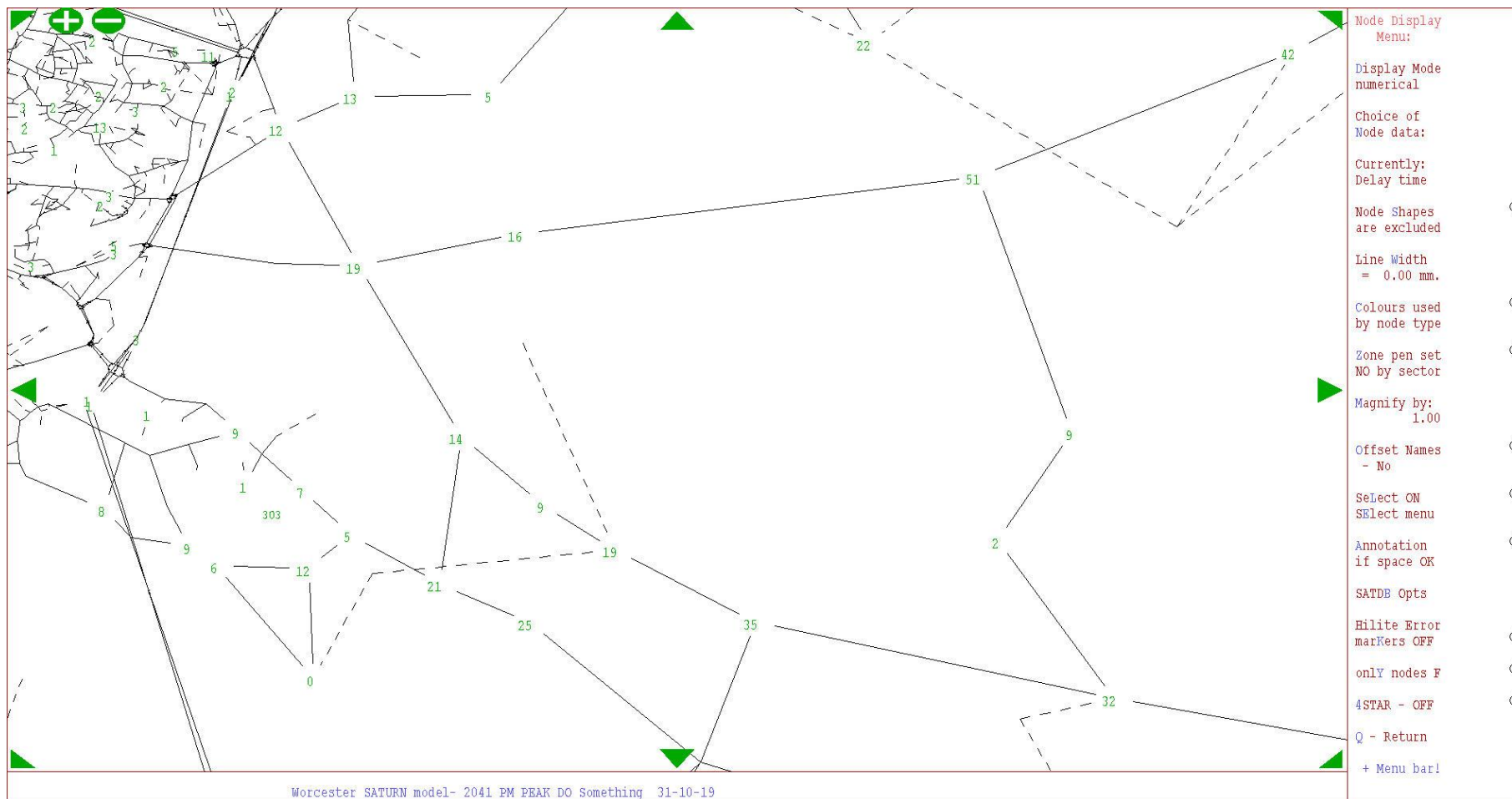


Figure 6.13 Junction Delays>60 Seconds 2041 AM with Throckmorton Development at M5 J6

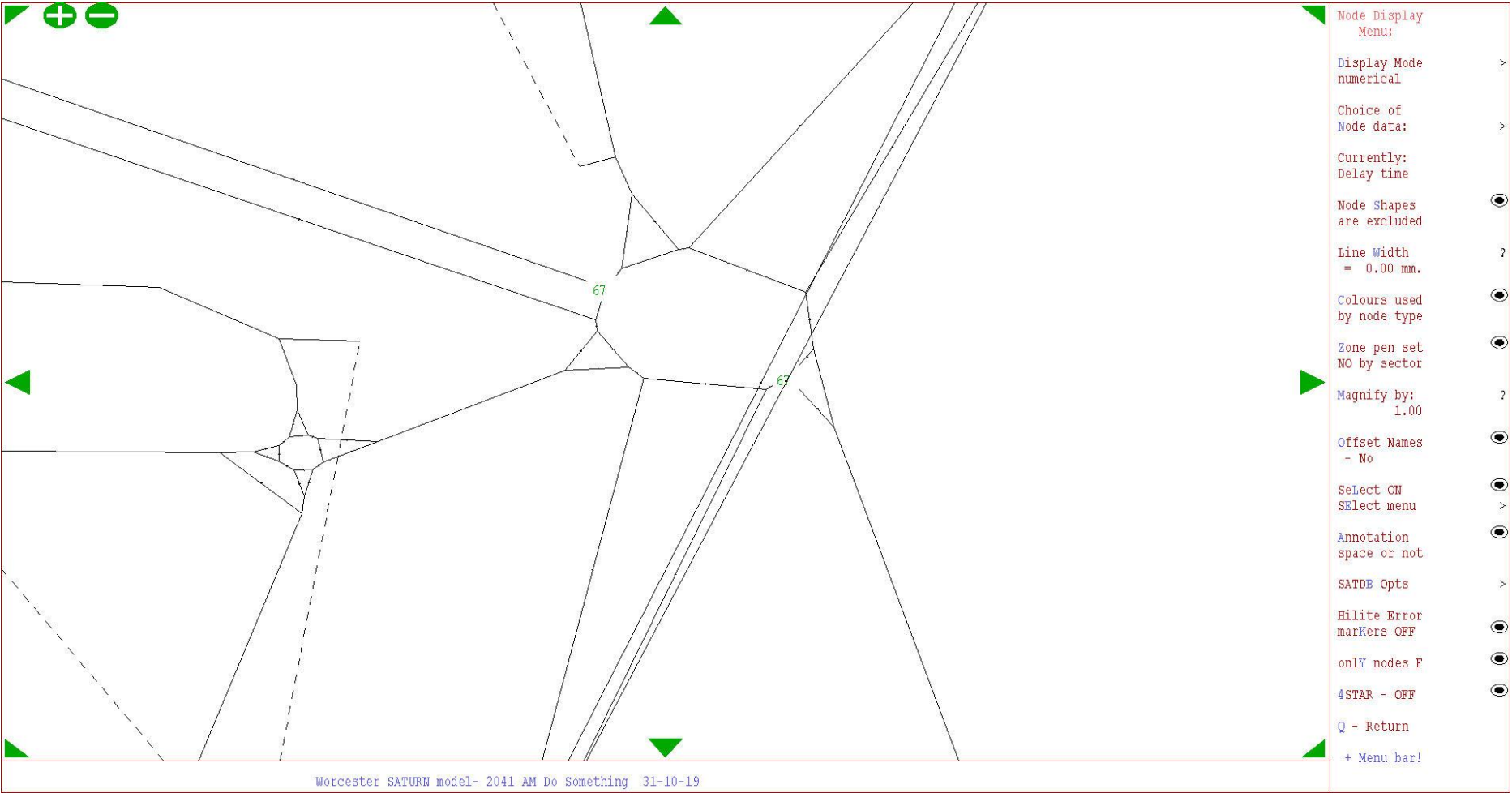


Figure 6.14 Junction Delays>60 Seconds 2041 PM with Throckmorton Development at M5 J6

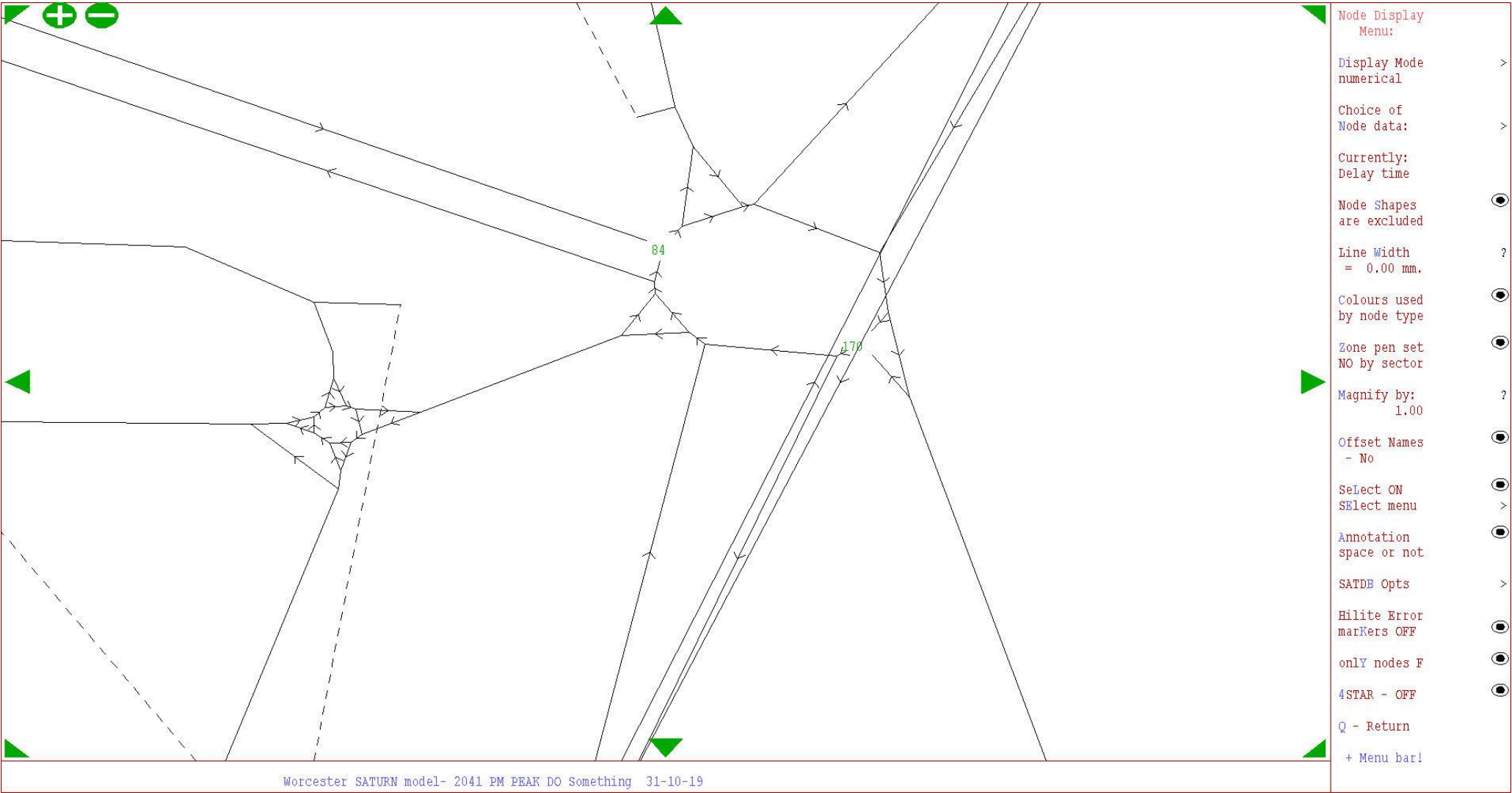


Figure 6.15 Junction Volume Capacity Ratio >75% 2041 AM with Throckmorton Development

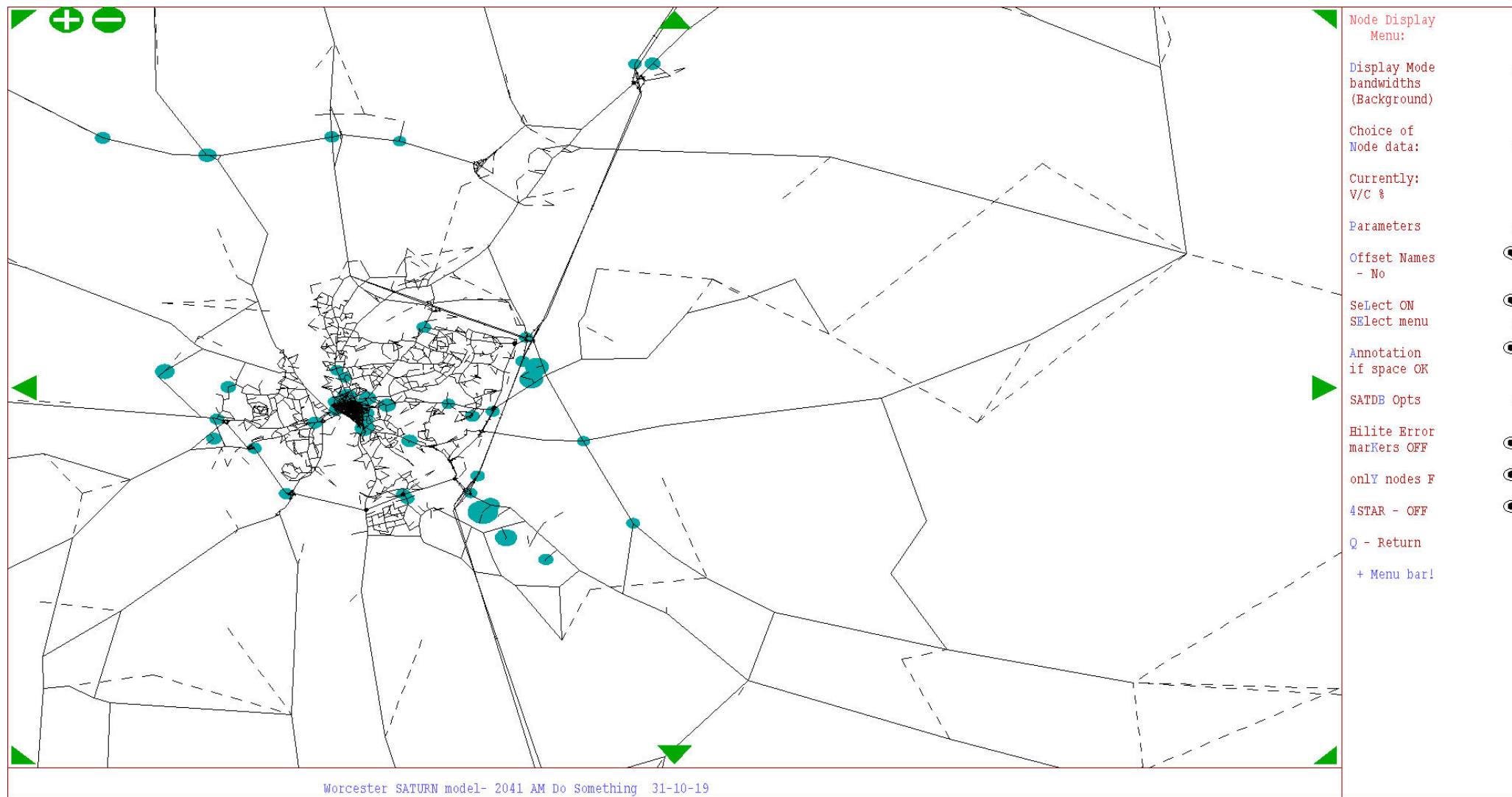
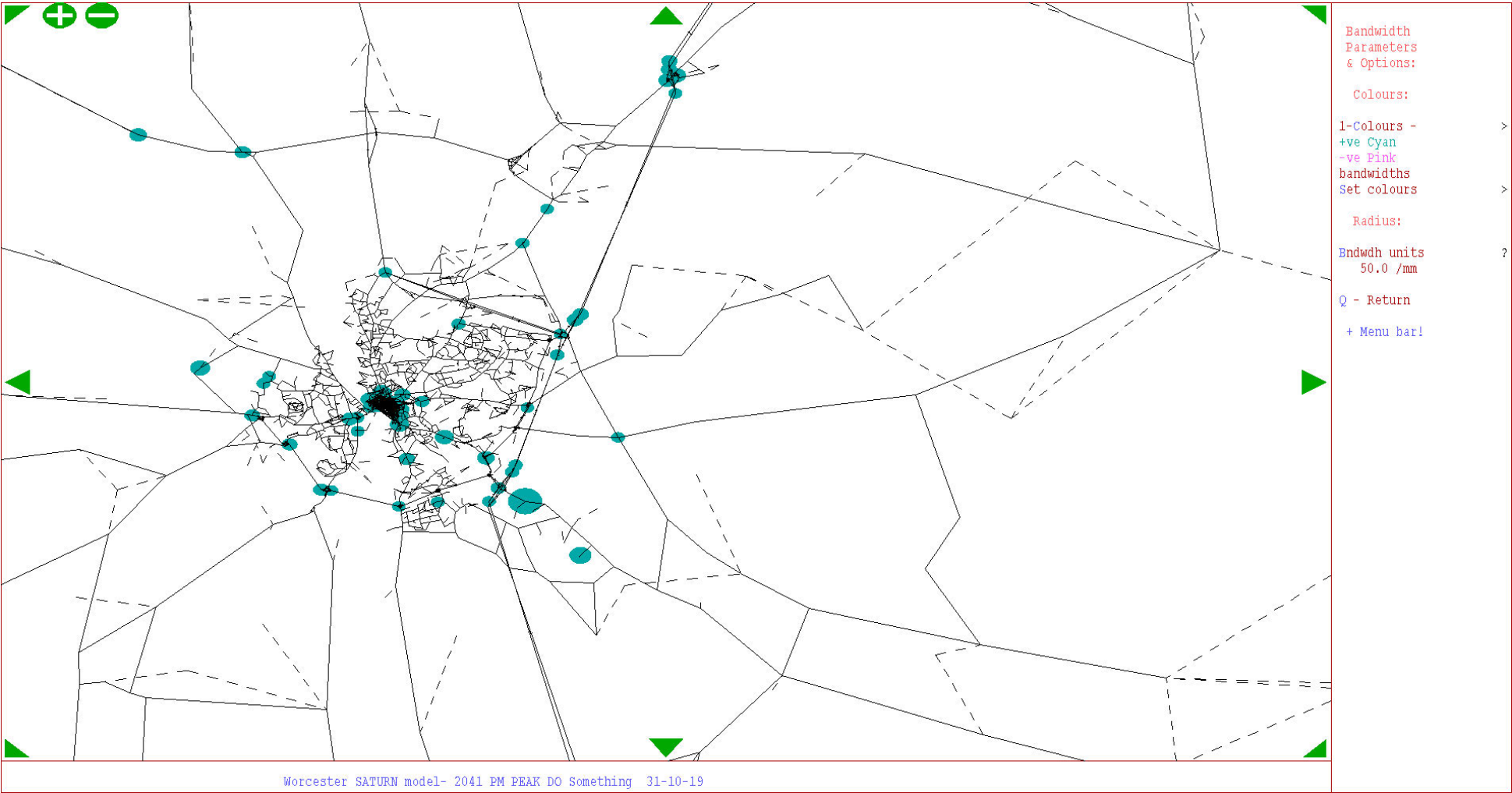


Figure 6.16 Junction Volume Capacity Ratio >75% 2041 PM with Throckmorton Development



6.6 Network Statistics on Worcester Network

The result of the growth in traffic due to the Throckmorton development trips on the performance of the Worcester highway network is shown in **Table 6-3**. The analysis shows that the additional development trips make the network conditions worse without any future network mitigation.

Across the model area, the impact of Throckmorton development trips is relatively minor as evident from the network statistics, where the average travel times increases, and speeds reductions are marginal.

Table 6-3 Network summary statistics and Difference between 2041 Reference Case and 2041 with Throckmorton Development

Description	Units	2041 Baseline		2041 with Throckmorton	
		AM	PM	AM	PM
Transient Queues	pcu. hrs./hr.	3418	3450	3447	3510
Over-capacity Queues	pcu. hrs./hr.	4371	5223	4551	5305
Delays	in hour	3029	2853	3004	2860
Total Travel Time	pcu. hrs./hr.	22056	23000	22264	23176
Travel Distance	pcu. kms/hr.	930105	959773	931641	961722
Overall Average Speed	kph	42.2	41.7	41.8	41.5
Total Trips Loaded	pcu/hr	97055	94922	97365	95261
Average Travel Time	mins/pcu	13.6	14.5	13.7	14.6
Description	Units	2031		2031 to 2041	
		AM	PM	AM	PM
Transient Queues	pcu. hrs./hr.	-	-	0.8%	1.7%
Over-capacity Queues	pcu. hrs./hr.	-	-	4.1%	1.6%
Delays	in hour	-	-	-0.8%	0.2%
Total Travel Time	pcu. hrs./hr.	-	-	0.9%	0.8%
Travel Distance	pcu. kms/hr.	-	-	0.2%	0.2%
Overall Average Speed	kph	-	-	-0.9%	-0.5%
Total Trips Loaded	pcu/hr	-	-	0.3%	0.4%
Average Travel Time	mins/pcu	-	-	0.6%	0.4%

7. Conclusions of Throckmorton Development on the highway network

This report described the development of 2041 forecast models to inform the impact of Throckmorton development on the highway network.

Given the location of the development site and the absence of any specific model to assess the development impacts, the assessment was based on three different transport models developed for Worcester, Pershore and Evesham. As the three models were developed to different base years and also had different forecast years and therefore were not consistent, the 2041 SWDPR models developed using each of the three models were considered as the baseline condition for assessing the Throckmorton development allocations. This ensured that the network is assessed on a consistent basis across the 3 model networks

The development site generates over 1400 trips in both AM and PM peak hours. The distribution of trips from the Throckmorton sites were based on gravity distribution models developed as part of the Evesham model build.

Future year traffic generated by Throckmorton development have been added explicitly to 2041 Evesham Transport model. The 2041 demand is forecast to increase by 2.6% and 3.0% in AM and PM Peak respectively compared to the 2041 baseline conditions in Evesham. The increase in demand results in increased delay across the network and the average speeds drop by 4.4% in AM and 8.4% in PM Peak compared to 2041 base year conditions.

The section between The Squires A44/B4088/A4184 Junction and A44/A46 is forecast to experience significant congestion in the AM due to the additional Throckmorton traffic with speeds forecast to drop below 10kph. This causes vehicles to rat run through Hill Furze Rd and B4088 to get back to A44 to avoid the delays. Traffic along the A46 is forecast to experience increased congestion with journey times increasing by maximum of 6.5% compared to the 2041 base conditions. Route 5 through A44 Worcester Road shows a significant increase in travel time as a result of congestion leading to the A46.

Flow bundles generated by Throckmorton development have been cordoned and then added explicitly to 2041 Pershore Transport model. The 2041 demand is forecast to increase by nearly 19.3% and by 20.4% in AM and PM Peak compared to the 2041 Baseline forecast. The high increase in demand results in increased delay and the average speeds dropping by up to 12.0% in AM and 2.1% in PM Peak and compared to 2041 Baseline forecast conditions.

Journey time along A44 will increase significantly by 17.5% to 25.3% in both peak periods. The network capacity along most sections are likely to be under 70% during the peaks except for few sections on the A44 around Pinvin and around Three Springs junction in the town centre. Mean delays/vehicle are forecast to increase at key junctions with the Pinvin and Wyre Rd junctions likely to experience the greatest increase. The new access junction will have a delay of 1 min 11 sec in the AM peak and 48 sec in the PM peak

The Development trips using the A44 west of Pinvin will use mainly M5 J6 and the A44/A4440 junctions for trips to Worcester or M5 and vice versa. The M5 J6 and the other junctions along A44 that are already predicted to experience capacity problem in 2041 under the baseline conditions will be further impacted by the Throckmorton development trips.

The analysis discussed in this report provides a robust indication of forecast network impacts under the planned allocations as per SWDPR. It helps identify potential congestion hot spots for WCC and the planning authorities to consider developing mitigation strategies across various transport solutions including highway improvements.