Stockton Borough Council

Wynyard VISSIM Model

Option Testing Report

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ARUP

Contents

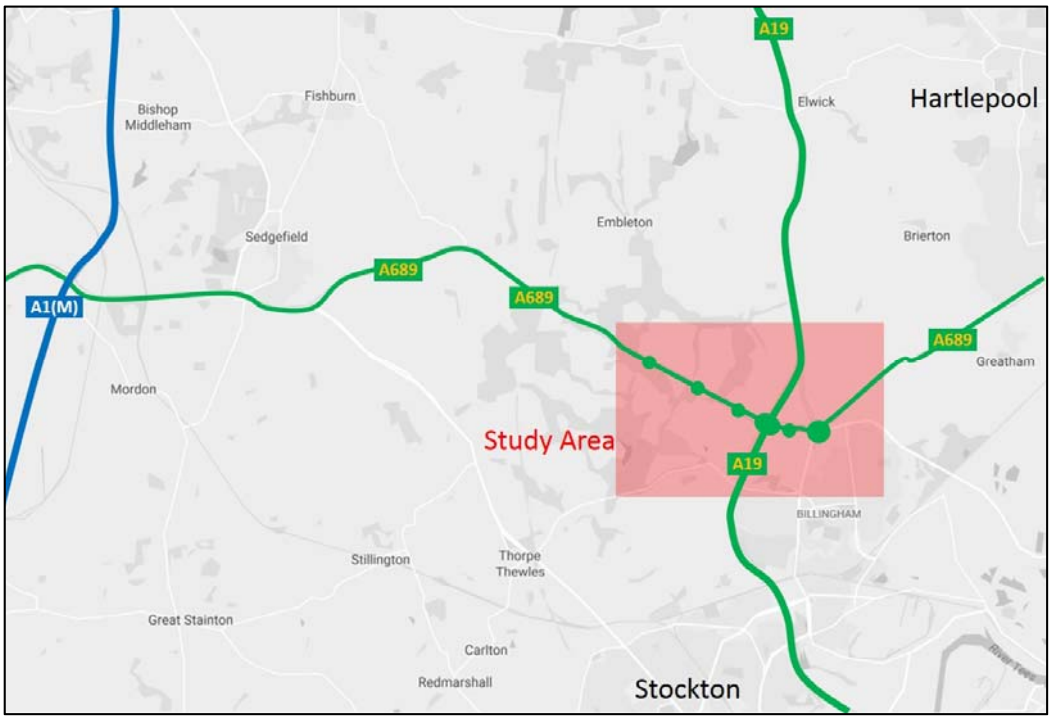
1 Introduction

1.1 Overview of scheme

Arup has been jointly commissioned by Stockton Borough Council (SBC) and Hartlepool Borough Council (HBC) to create a VISSIM micro-simulation model, to undertake option testing of various future development scenarios within the HBC and SBC areas. The model covers a section of the A689 and the A19 in Wynyard, which is bisected by the local authority boundary.

The A689 is an east-west link which connects the A1 and A19 trunk roads in north-east England. There are five roundabouts on the A689, plus a grade-separated junction at the A689 junction with the A19. The roundabouts are located on the A689, from west to east, at The Wynd, Hanzard Drive, Wynyard Avenue, the A19, local services and Wolviston Road as shown in **Figure 1**.

Figure 1: Location Plan



1.2 Outline of previous model development

The commission involved updating a previous 2013 Base model developed by Highways England (HE) and AECOM to create a 2016 base to use for future year scenario testing.

The VISSIM model was originally developed in 2009 by HE to assess how the local and strategic road network would perform when a new hospital was proposed at Wynyard Park. The model was subsequently updated in 2013 by AECOM to undertake the cumulative assessment of various housing development

proposals along the A689 corridor and to incorporate a Department for Transport (DfT) funded Pinch Point scheme at the A19/A689 roundabout junction, which included:

- Improving the layout at the merge of the A689 southbound entry slip and the A19;
- Widening of the A689 west approach to the roundabout to four lanes; and
- Introduction of traffic signal control on all approach arms of the junction.

It was noted by SBC that the 2013 model may not reflect the extensive queuing frequently observed at the junction, in particular during the AM peak.

This commission therefore sought to review the coding of the 2013 model, including the as-built Pinch Point scheme and to create a Base 2016 AM and PM peak model. It is intended that this version of the model allows SBC and HBC to test future development scenarios and to assess highway improvements.

1.3 Report Outline

This report outlines the methodology for updating the model, including amendments to the network, calibrating the matrices and the model outputs, and finally summarising the results of the option testing.

- The base modelling and results are detailed in Sections 3 and 4,
- The option testing is outlined in Section 5,
- Network development and coding are shown in Section 6,
- Results of option testing are summarised in Section 7,
- Some important items to consider are detailed in Section 8.

2 Data Collection

In order to update the model, a range of data collection surveys were undertaken from 14th July 2016, which included:

- Automatic Traffic Counts (ATCs) on the A689;
- A19 flow data from the Transport Research Information Services (TRIS) database;
- Journey times for travelling eastbound and westbound on the A689; and
- Queue length surveys at the A19 junction.

The locations of the surveys are shown in **Figure 2** to **Figure 4**.

The ATC data was collected over a seven day period, providing 24 hour count data for each day. Journey time and queue data was recorded in line with the modelled periods of 07:00 to 10:30 and 16:00 to 19:30.

Traffic flow data for the A19 was extracted from the TRIS online database, at locations on the mainline, just to the north and south of the A689 junction. TRIS data is available in one hour time periods. Data was extracted for three one-hour periods for the AM model, and three for the PM model.

Journey time data was undertaken using Bluetooth readers within four vehicles which travelled back and forth along the A689 throughout the modelled periods. Time intervals were recorded for each of the eight journey segments, and was totalled for the eastbound and westbound journey overall.

Queue data was recorded in five minute intervals. The back of the queue was measured in vehicle numbers, and included traffic moving at 4mph or less.

Figure 2: ATC locations

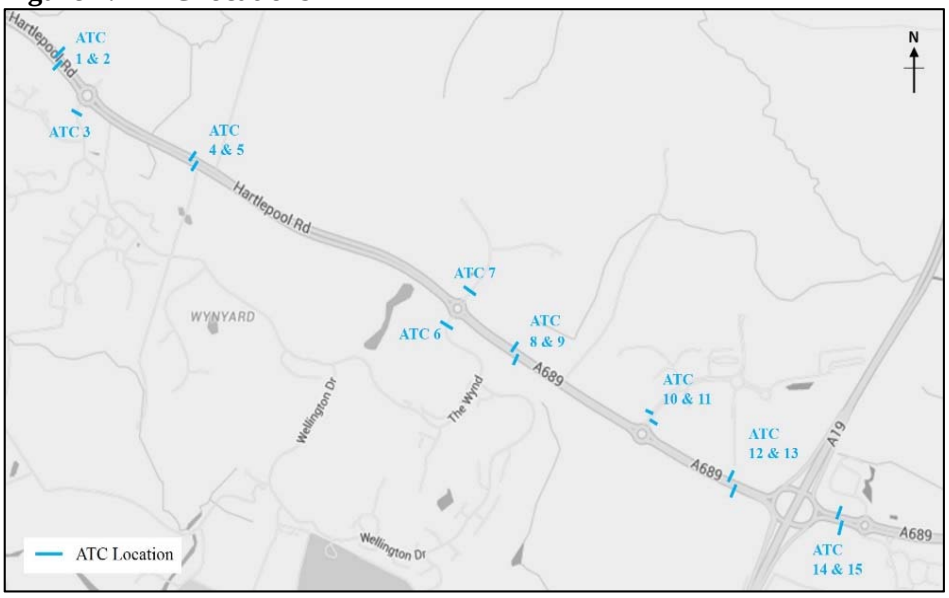


Figure 3: Journey time survey locations

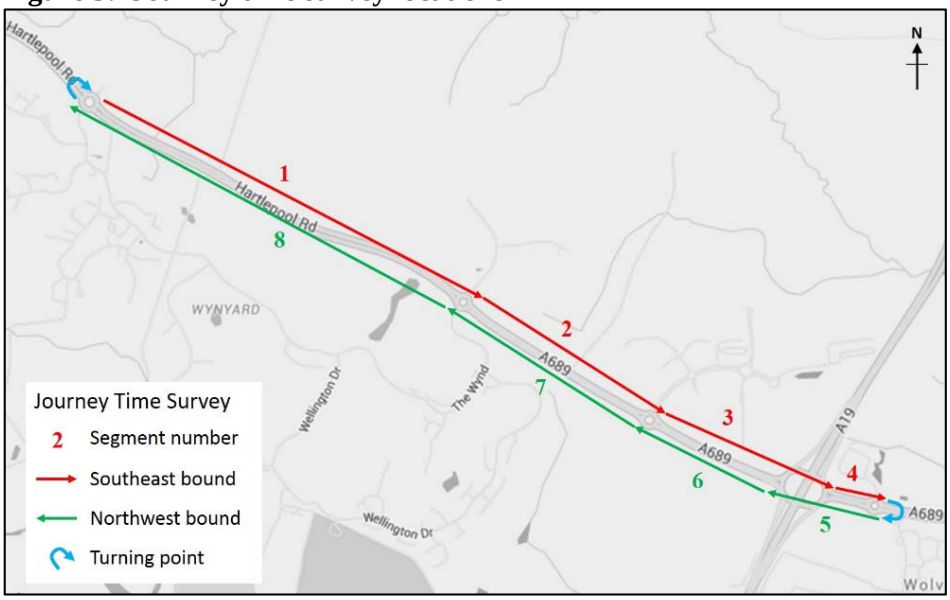
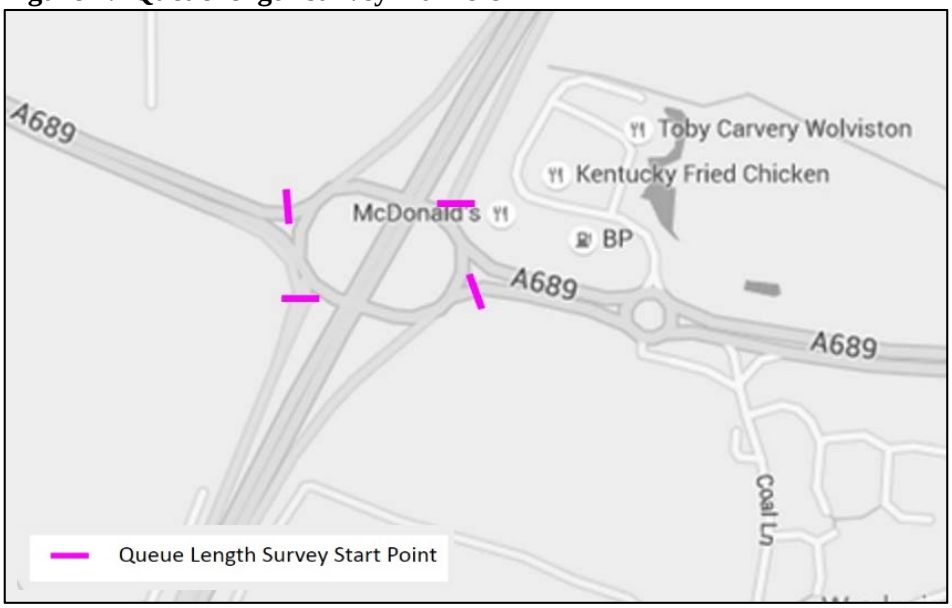


Figure 4: Queue length survey markers



Overall, the ATC data showed that traffic flows have not increased beyond the levels that were recorded in the 2013 surveys, and in some locations have decreased.

It should be noted that one ATC counter suffered a fault, and recorded around half the traffic observed at counters immediately to the east and to the west. This ACT was located on the A689 eastbound at Site 8, between The Wynd and Wynyard Avenue (Samsung Roundabout). The count was approximated using the data recorded at the adjacent counters.

3 Base Modelling

3.1 Assumptions

The model extents have been retained from the original model, and are shown in **Figure 5**. The modelled network includes the A689 from a point west of the roundabout with The Wynd, to a point east of the Wolviston junction. The model also includes the A19 junction and associated slip roads.

Figure 5: Model extents

The AM model reflects the time period from 07:00 to 10:30, and the PM model from 16:00 to 19:30. The final 15 minutes of the model act as a 'cool down' period in order to release all traffic and assess the overall model performance. This has been retained from the original model.

It was also agreed to retain a fixed signal cycle time during the development of the 2013 model, where stage times were based upon recorded data from the on-site signal controller box. While the Pinch Point Scheme includes MOVA control, which reacts to on-site conditions to minimise queue length, during the peak periods there is minimal change to phase times between cycles as the green times run to their maximum.

The trip assignment was developed during the 2013 model development based upon origin-destination turning counts, and has been agreed with SBC and Highways England. This has therefore been retained.

3.2 Network Amendments

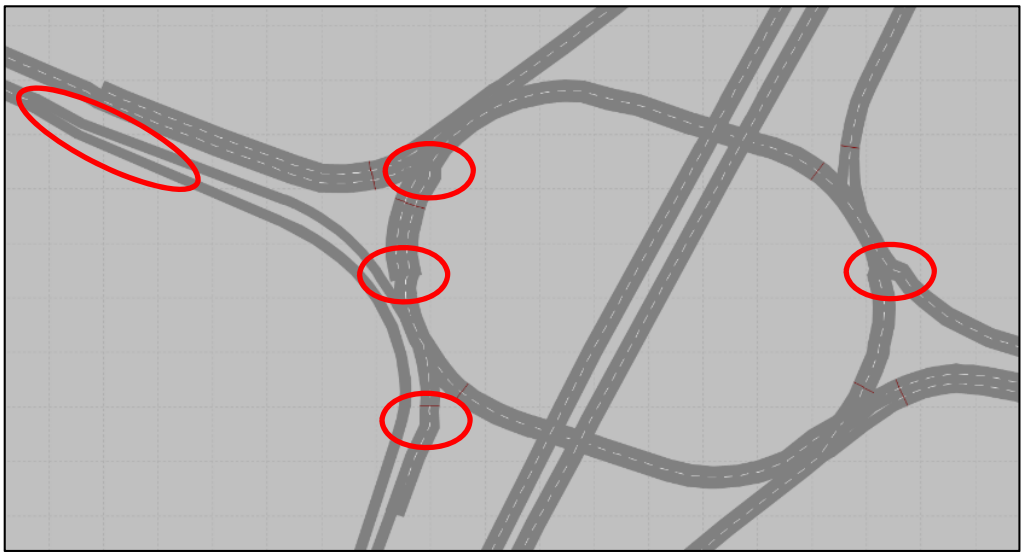
3.2.1 Links and Connectors

Following a review of the 2013 model, many of the links in the model were found to be misaligned, as shown in **Figure 6**. Some sections were coded inaccurately, particularly the slip roads at the A19 junction. There were also a large number of

redundant links and additional connectors which complicated the routing decisions of traffic moving through the network.

As a result, all links and connectors have been rationalised and, where appropriate, transition links smoothed out in order to make a more realistic simulation going forward. The extra sections were deleted, ensuring vehicles were able to make routing decisions on the link, rather than being forced into a certain lane. The network was correctly coded to reflect the on-street land configuration.

Figure 6: Network link adjustments – sample of misaligned links



3.2.2 Pinch Point Scheme – Lane Allocation

The A19/A689 junction link coding has been amended to reflect the lane allocation on the ground as per the Pinch Point Scheme, as shown in the images in **Figure 7** and **Figure 8**. Some changes to connectors were made to ensure traffic could not continue around the roundabout in two lanes, while two lanes exited the roundabout, as this was causing some over-running and conflicting movements.

Site observations indicate that, in general, traffic travelling eastbound on the A689 towards the A19 junction, is observed to remain in their designated lane while heading to either the A689 east or the A19 southbound on the over-bridge. This was replicated using the 'paths' analysis function within VISSIM. Ensuring the correct lane discipline behaviour enabled the calibration of the queuing at the stop lines on the approach to the A19 junction.

Figure 7: A689 approach to A19 junction, eastbound

Figure 8: A689 exit from A19 over-bridge, eastbound

3.2.3 Give Way Parameters

The parameters at some give way lines were considered to be set to represent a more aggressive driving behaviour than what is considered reasonable for this road network. The parameters (gap acceptance and headway) were extended to allow vehicles to find larger gaps in opposing flows at give way junctions. This gave a more realistic behaviour at the Wolviston junction and the A689 services junction, and again this also helped with the calibration of queuing on approach to the A19 junction.

3.2.4 Desired Speed Decisions

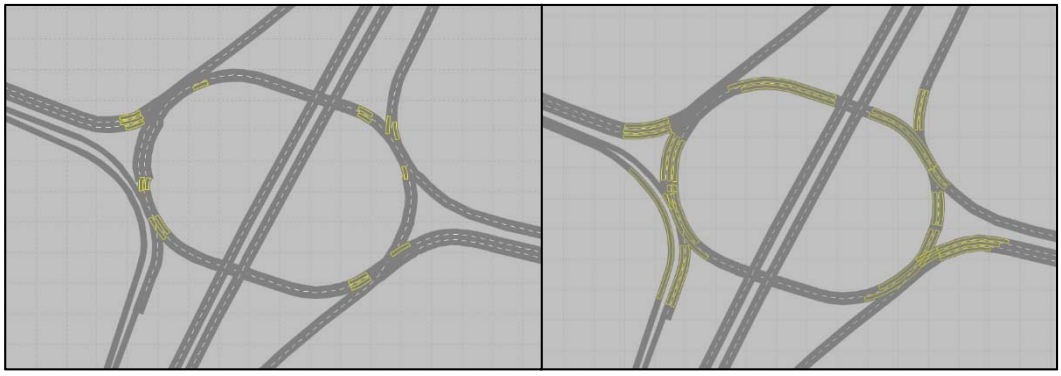
Desired speed decision markers within the model allow the posted speed limits to be set for the network. While vehicle behaviours are set to include a range of

permissible speeds, the desired speed decisions allow ranges to be set which align with the speed limit of the road. In some locations, the desired speed markers were set to different speeds for each lane on the A689, and for opposite directions of travel. These have been amended and are all now consistent across each lane, on each link, and for each direction.

3.2.5 Reduced Speed Areas

Reduced speed areas are installed to slow traffic on the approach to junctions, or on sections of carriageway where it is expected that speeds will be less than the posted speed limit. Some of these reduced speed areas were previously coded as very short sections, and did not represent the slowing of vehicles on the approach to junctions, particularly on the approach to the A19 junction. These were extended where required as shown in **Figure 9**, to help calibrate the model in terms of queuing and journey time data.

Figure 9: Extended restricted speed areas at junctions



3.2.6 Signal Timings on A19 Roundabout

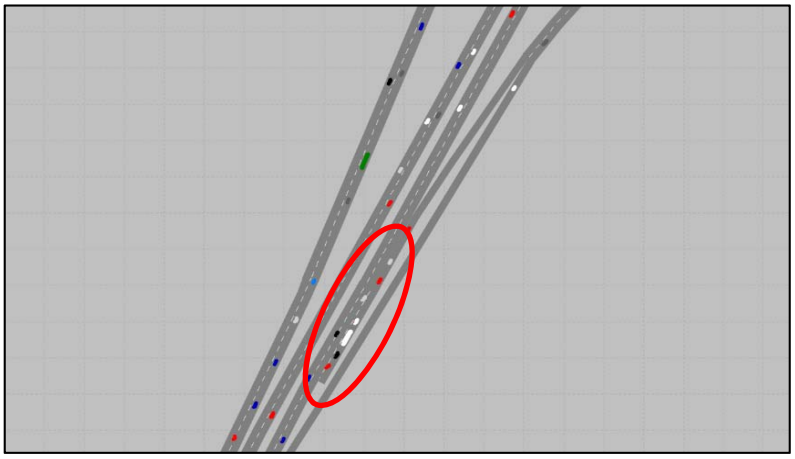
It was agreed with SBC that all traffic signals would remain as fixed cycle times, as per the 2013 model. Within the 2013 model however, each of the four approach stoplines on the A19 roundabout operated on a different cycle time, as this had been the best approximation of the MOVA site data from the on-site signal control box. This resulted in a lack of co-ordination, and led to queuing on some approaches at certain time periods and not in others. Fundamentally, this makes calibrating the queuing against site data more challenging.

Following discussions with Highways England, one overall cycle time for the A19 roundabout of 65 seconds was agreed for the 2016 base model, and this was applied to both peaks. This cycle time is based on the MOVA site data, and is the average from four separate nodes in the 2013 model. The green time for each pair of stoplines was interpolated from the 2013 timings to generate a 65 second cycle time, in order to maintain the functionality of the traffic signals at the junction on site.

3.2.7 A19 On-slip Merges

The A19 on-slips were incorrectly coded such that traffic was unable to merge smoothly (overly cautious), and therefore began queuing at the end of the merge link while seeking an appropriate gap in the mainline traffic. This is shown in **Figure 10**.

Figure 10: Poor merging representation eliminated



After consulting with Highways England, the gap acceptance parameters were adjusted to remove the queuing, and to improve the behaviours of conflicting vehicles, in line with their preferred modelling criteria.

3.3 Matrix Calibration

ATC data was collected for the A689, and adjacent link roads as shown in **Figure 2**. The ATC data provided classified link flows over a 24 hour period, for two weeks. There were 15 ATC sites; five eastbound sites on the A689, five westbound sites and five sites on the minor approach side roads. Overall, there was little variance in the weekday counts, and therefore an average (weekday) AM and PM hourly count was derived for the modelled time periods.

The matrices from the 2013 model were used to calibrate to the ATC data. There are 14 zones in the origin-destination matrices. Trips from each zone travelling through the A689 were adjusted until the link counts for each hour period matched the ATC data for each corresponding section, including the peak hour.

As VISSIM releases traffic from the zone based on the matrix files, the model traffic count on the links may have been released in the previous or next time segment. This makes it difficult to calibrate the matrix to hold the exact volume of traffic required to match the link ATC, however close approximations were achieved. Section 4 sets out these results.

Following discussions with Highways England, the A19 trips northbound and southbound were calibrated against TRIS data. Based on a review of the data, it is acknowledged that there has been an increase in flows on the A19 mainline since 2013, therefore the matrices were updated to reflect this increase in baseline

traffic. The new mainline traffic flows were received and approved by Highways England.

3.3.1 Red House School Trips

Trip Generation

As the traffic survey data was collected from the 14th July 2016, it was noted that Red House School had broken up for the summer holidays at this time. Concerns were raised that some traffic may not have been recorded by the ATC survey. To address this, traffic generation information from the Transport Assessment prepared in support of the Red House School planning application was manually included in the survey data. This planning application was approved in 2012.

The Transport Assessment shows the number of trips which were going past the proposed school entrance on the A689 to travel to the existing school, and these are shown in **Table 1**.

Table 1: Existing Red House School trips on A689

	AM	PM
A689 eastbound	91	16
A689 westbound	64	41

Trip Assignment

The school has approximately 40 staff on site during each day, and it is noted in the Transport Assessment that 45% of car trips use the A689. Assuming that all staff drive to work, this would equate to 18 staff members using the A689 each day.

In the AM peak, staff are likely to arrive in the 07:00-08:00 hour, and pupils/parents are likely to arrive and leave in the 08:00-09:00 hour. The eastbound trips on the A689 are staff and parents travelling to school. The westbound trips are assumed to be parents returning home or continuing to work. Therefore, of the 91 eastbound AM trips, 18 were added to the 07:00-08:00 hour to represent the staff arrivals. The remaining 73 eastbound trips and all of the westbound trips were added to the 08:00-09:00 hour.

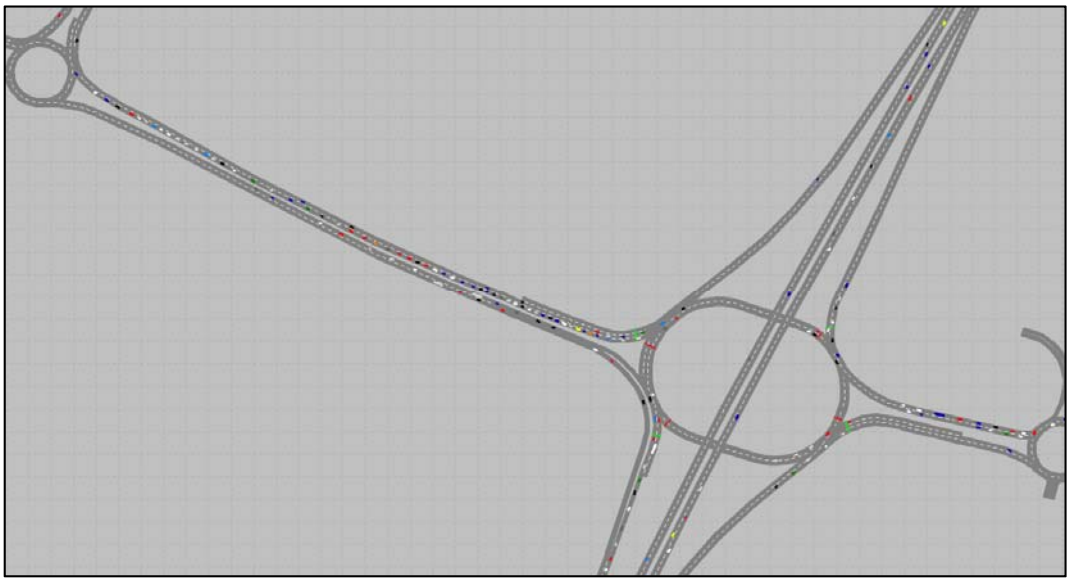
In the PM peak, the Transport Assessment noted that the school peak travel time is 15:15-16:15, so this equates to the model 16:00-17:00 hour. Parents picking up pupils are likely to arrive and leave in the 16:00-17:00 hour, whereas teachers are likely to leave across the 16:00-17:00 hour and the 17:00-18:00 hour. Based on the above, the eastbound trips are assumed to be parents travelling to the school. The westbound trips are assumed to be staff and parents returning home from the school. Therefore, 18 of the westbound trips were added to the 17:00-18:00 hour to represent the staff departures. The remaining 23 westbound trips and all of the eastbound trips were added to the previous 16:00-17:00 model hour.

4 Base Model Results

4.1 AM Peak

From the ATC data on the A689, and the TRIS data for the A19, the AM peak hour was found to be between 07:30 and 08:30. A screen shot of the model running at 08:00 is shown in **Figure 11**. The model shows the queuing eastbound on the A689 towards the A19 junction which accurately represents on-site observations.

Figure 11: AM Base model screen shot



4.1.1 Flows

The GEH statistic has been used to assess the 'fit' of the modelled data to the data collected on site. The statistic gives an empirical value, which if below 5.0 demonstrates the modelled data is a good fit to observed data. Results found between 5.0 and 10.0 show a fair fit, and those above 10.0 show a poor fit.

The results for the AM peak hour show that the GEH value for all links demonstrate a GEH of below 5.0 (**Table 2**) and are therefore a good fit to the observed data.

Table 2: AM peak hour flows

	07:30-8:30am			
	MODEL **TOTAL**	observed **TOTAL**	**diff**	GEH
A689 EB west of The Wynd	1067	984	83	2.59
A689 WB west of The Wynd	720	779	-59	2.16
A689 EB east of The Wynd	1206	1243	-37	1.06
A689 WB east of The Wynd	882	862	20	0.68
A689 EB west of samsung rbt	1339	1327	12	0.33
A689 WB west of Samsung Rbt	773	839	-66	2.32
A689 EB west of A19 rbt	1301	1232	69	1.94
A689 WB west of A19 Rbt	937	912	25	0.82
A689 EB east of A19 rbt	1347	1278	69	1.90
A689 WB east of A19 Rbt	1187	1035	152	4.56

The A19 data from TRIS is recorded in one hour time periods, and has been included in the analysis of the hourly traffic flows within the model. The GEH results for the flows show that in the AM peak, the A19 flows demonstrate a good fit to the observed data from TRIS, as shown in **Table 3**.

Table 3: AM Peak flows by modelled hour

	7-8am				8-9am				9-10am			
	MODEL **TOTAL**	observed **TOTAL**	**diff**	GEH	MODEL **TOTAL**	observed **TOTAL**	**diff**	GEH	MODEL **TOTAL**	observed **TOTAL**	**diff**	GEH
A689 EB west of The Wynd	1154	1010	144	4.38	891	916	-25	0.83	613	710	-97	3.77
A689 WB west of The Wynd	605	670	-65	2.57	799	728	71	2.57	554	511	43	1.86
A689 EB east of The Wynd	1179	1163	16	0.47	1037	1153	-116	3.51	660	793	-133	4.93
A689 WB east of The Wynd	571	695	-124	4.93	769	798	-29	1.04	541	549	-8	0.34
A689 EB west of samsung rbt	1228	1126	102	2.97	1198	1287	-89	2.52	729	848	-119	4.24
A689 WB west of Samsung Rbt	565	631	-66	2.70	903	799	104	3.57	647	528	119	4.91
A689 EB west of A19 rbt	1146	1098	48	1.43	1085	1177	-92	2.74	838	879	-41	1.40
A689 WB west of A19 Rbt	874	728	146	5.16	979	854	125	4.13	634	507	127	5.32
A689 EB east of A19 rbt	1189	1151	38	1.11	1234	1212	22	0.63	894	860	34	1.15
A689 WB east of A19 Rbt	1136	1064	72	2.17	1131	993	138	4.23	935	885	50	1.66
A19 south NB	3174.8	2962	212.8	3.84	3029.4	3221	-191.6	3.43	2239	2148	90.8	1.94
A19 south SB	3743.2	3801	-57.8	0.94	3108.4	3346	-237.6	4.18	2642	2426	216	4.29
A19 north NB	2114.2	2175	-60.8	1.31	1936.8	1909	27.8	0.63	1543	1512	30.8	0.79
A19 north SB	3146.6	2954	192.6	3.49	2434	2411	23	0.47	1545	1682	-137.2	3.42

The results for the local network links show that almost all of the links across all three modelled hours have a GEH of less than 5.0, demonstrating a good fit with observed data. The only section which falls above the 5.0 value is westbound on the A689, travelling away from the A19 roundabout. There is a good fit (GEH below 5.0) for the peak hour and from 08:00-09:00, however the shoulder periods show a GEH of 5.1 and 5.3, where the model has more traffic on this link during this hour compared to observed flows. This westbound link is less critical in assessing the performance of the A689 and the A19 junction operation, and therefore the GEH results are considered appropriate. The slightly increased model flows will demonstrate a more robust assessment of the network.

4.1.2 Journey Times

The journey times in the AM peak are reflective of the level of queuing in the model and were used as a means of validating the model. The observed queuing is regularly observed extending back to the Samsung roundabout, and this was coded into the base model, albeit showing longer queuing in comparison to the data collected during the site survey. The maximum journey time recorded on site is a match to the model, however, the average journey time over the peak hour

reflects the extensive queuing observed regularly on the eastbound entry to the A19 roundabout. This was agreed with SBC. Results are shown in **Table 4**.

Table 4: AM model journey times in seconds

		Model	Survey
Eastbound	Average	210	172
	Max	278	284
	Average peak hour	260	203
Westbound	Average	194	221
	Max	202	197
	Average peak hour	194	175

4.1.3 Queuing

Queuing in the model was calibrated by adjusting the signal timings in order to achieve the correct queue, once the routing decisions and lane configuration was updated to match on-site operation.

It was noted by SBC officers that observed eastbound queuing on site is regularly back to the Samsung roundabout in the AM peak, and this has been represented in the model. This was agreed with SBC and HBC during a meeting on the 19th January 2017. The surveyed queue data may have been lower due to Red House School having broken up for the summer holidays.

The observed A689 westbound and the A19 northbound off slip queuing observed during the traffic survey is represented in the model.

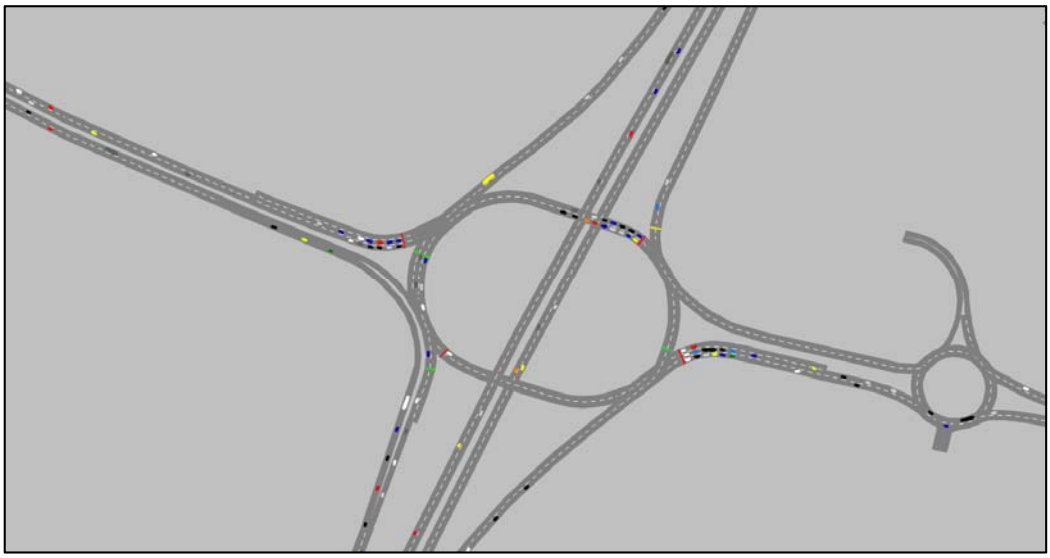
Table 5: AM peak hour A19 roundabout queue length comparison (vehs)

	Average		Max	
Arm	**Model**	**Survey**	**Model**	**Survey**
A689 Eastbound	86	44	98	58
A19 Northbound off-slip	9	12	18	19
A689 Westbound	13	12	26	21

4.2 PM Peak

From the ATC data on the A689, and the TRIS data for the A19, the PM peak hour was found to be between 16:30 and 17:30. A screen shot of the model running at 17:00 is shown in **Figure 12**.

Figure 12: PM peak model snapshot



4.2.1 Flows

Similar to the AM scenario, the GEH statistic has been used to assess the 'fit' of the modelled data compared to observed data collected on site. The results from the PM peak hour at 16:30-17:30 are shown in **Table 6**. The GEH results are below 5.0 (a good fit) for all links with the exception of the A689 westbound between The Wynd and the Samsung roundabout, which is showing a GEH of 6.3. Overall, the GEH results demonstrates a good level of fit between survey and model flows.

Table 6: PM peak hour flows

	16:30-17:30pm			
	MODEL **TOTAL**	observed **TOTAL**	**diff**	GEH
A689 EB west of The Wynd	854	812	42	1.46
A689 WB west of The Wynd	987	1056	-69	2.16
A689 EB east of The Wynd	846	855	-9	0.31
A689 WB east of The Wynd	1044	1258	-214	6.31
A689 EB west of samsung rbt	780	656	124	4.63
A689 WB west of Samsung Rbt	1078	1024	54	1.67
A689 EB west of A19 rbt	1213	1200	13	0.37
A689 WB west of A19 Rbt	1026	985	41	1.29
A689 EB east of A19 rbt	1306	1271	35	0.98
A689 WB east of A19 Rbt	1256	1187	69	1.97

The results of the hourly model flows are shown in **Table 7**. The results show that all links, for each of the one hour time periods, demonstrate a GEH of less than 5.0, a good fit, with the exception of the A689 westbound between The Wynd and the Samsung roundabout. Here the maximum GEH is found in the 16:00-17:00 hour of 7.0, which remains a fair fit.

The A19 data from TRIS is included in the analysis of the hourly traffic model flows. The GEH results show that in the PM peak, the A19 flows demonstrate a good fit to the observed data from TRIS, this is summarised below.

Table 7: PM Peak flows by modelled hour

	4-5pm				5-6pm				6-7pm			
	MODEL TOTAL	observed TOTAL	diff	GEH	MODEL TOTAL	observed TOTAL	diff	GEH	MODEL TOTAL	observed TOTAL	diff	GEH
A689 EB west of The Wynd	778	770	8	0.29	746	820	-74	2.64	500	615	-115	4.87
A689 WB west of The Wynd	856	988	-132	4.35	935	954	-19	0.62	583	546	37	1.56
A689 EB east of The Wynd	750	842	-92	3.26	745	846	-101	3.58	546	667	-121	4.91
A689 WB east of The Wynd	911	1137	-226	7.06	978	1145	-167	5.13	535	659	-124	5.07
A689 EB west of samsung rbt	875	776	99	3.45	694	578	116	4.60	563	515	48	2.07
A689 WB west of Samsung Rbt	1035	937	98	3.12	1051	968	83	2.61	665	554	111	4.50
A689 EB west of A19 rbt	1073	1182	-109	3.25	1061	1159	-98	2.94	699	812	-113	4.11
A689 WB west of A19 Rbt	966	991	-25	0.80	1086	1082	4	0.12	595	538	57	2.39
A689 EB east of A19 rbt	1153	1194	-41	1.20	1272	1253	19	0.53	795	833	-38	1.33
A689 WB east of A19 Rbt	1347	1219	128	3.57	1184	1101	83	2.46	728	858	-130	4.62
A19 south NB	3847	3822	24.6	0.40	3585	3574	10.8	0.18	2421	2258	163	3.37
A19 south SB	3246	3183	63	1.11	2762	2992	-229.6	4.28	2153	2097	56	1.21
A19 north NB	2813	2845	-32.4	0.61	2636	2452	184.4	3.66	1793	1625	168	4.06
A19 north SB	2341	2224	117	2.45	2181	2163	17.6	0.38	1545	1554	-9	0.23

The results for the local network illustrate that almost all of the links across all three modelled hours have a GEH of less than 5.0, demonstrating a good fit with observed data. The only section which reported a GEH above 5.0 is westbound on the A689, travelling away from the Samsung Roundabout. On this link, the three hour periods show a GEH of 7.0, 5.1 and 5.0 respectively, and therefore remain a fair to good fit, where the model has fewer vehicles on this link compared to observed flows. During the calibration of the flows in the model, increasing the traffic count at this location had a negative impact on the GEH result for all other sections of the westbound route. On this basis, no further correction was introduced, with the results considered as a best fit for the PM model.

The westbound link discussed above is viewed as being less critical on the network for assessing the performance of the A689 and the A19 junction operation, and therefore the GEH value is considered acceptable.

4.2.2 Journey Times

The journey time data was used to validate the model. The PM journey times from the model are consistent with those recorded on site as shown in **Table 8**, and therefore represent a good fit.

Table 8: PM model journey times in seconds

		Model	Survey
Eastbound	Average	179	156
	Max	252	210
	Average peak hour	194	168
Westbound	Average	196	178
	Max	205	201
	Average peak hour	197	179

4.2.3 Queuing

The PM queuing in the model reflects the data recorded from the surveys, as shown in **Table 9**. The number of vehicles recorded queuing in the model, both on average and the maximum queue recorded, are of the same magnitude on the critical entries into the A19 junction, as observed data. Queuing in the model was

calibrated by adjusting the signal timings in order to achieve the correct queue, once the routing decisions and lane configuration was modelled correctly.

Table 9: PM peak hour queuing in vehicles

	Average		Max	
Arm	**Model**	**Survey**	**Model**	**Survey**
A689 Eastbound	37	41	41	46
A19 Northbound off-slip	13	16	29	30
A689 Westbound	9	12	22	21

4.3 Model Convergence

The AM and the PM models were run to convergence based on journey time data used for validation. The AM model converged after three runs. The PM model converged after two runs. While there is minimal route choice in the modelled network, this shows a very good fit for the data. It should be noted that the results are based on an average after 10 runs of each model.

4.4 Summary

Arup were commissioned by Stockton Borough Council (SBC) to audit an existing base 2013 VISSIM model of a section of the A689 through Wynyard, and update to simulate a 2016 base scenario.

Traffic data has been collected on site during July 2016, including ATCs, queuing and journey time data.

The network and traffic matrices have been calibrated to better reflect the driving behaviours observed on site, and have been validated using journey times. The A19 merge behaviour has been adjusted to better reflect cooperative braking and lane changing as observed on site.

Traffic signal timings have been coded into the model based upon MOVA data from the signal controller box, and configured to operate on a consistent fixed cycle time across the junction.

Traffic flows were calibrated using ATC and TRIS data. The GEH statistical results for traffic flows demonstrate a good fit for A19 traffic, and for almost all of the local road links.

Queue lengths were calibrated using consistent link speeds, reduced speed areas at braking zones, and adjustments to the signal green times. Queuing observed on site by road users and the highway authority are represented in the model.

Observed journey times are reflected in the model for the AM and PM peaks, and this was used to validate the flow and queuing data.

The Base 2016 VISSIM model outputs show a good fit overall when compared to the 2016 data collection exercise. It can therefore be concluded that the base 2016 model is fit for purpose for testing future schemes in this area.

5 Option Testing

5.1 Introduction

This section provides details on the development sites included in the VISSIM model, as well as data sources and the methodology used to determine the trip generation and assignment associated with the committed development.

The following options were proposed for testing in the VISSIM model:

- Option 1 – current committed development, including approved network mitigation
- Option 2 – adds the proposed development with live planning applications yet to be determined
- Option 3 – adds the Local Plan allocations for both HBC and SBC

All options include the approved network mitigation (outlined in Section 6) as approved as part of Section 106 agreements for the committed development.

Options 2 and 3 also test a three-lane over-bridge option for the A19 grade separated junction as part of their network mitigation, which is outlined in Section 6.

5.2 Development sites

The committed developments listed in this section have been provided by both HBC and SBC. The locations of the developments are shown in **Figure 13**. Each site is colour coded. These colours link to the details of the development sites as shown in **Table 10**. All of these sites have been included in the VISSIM modelling as part of one, or all, of the options.

Figure 13: Locations of all development sites

Table 10: Committed Development, proposed Development and Local Plan allocations

Map ref	Outline consent		SITE NAME	Full Planning App Number	Housing	Hotel	Pub	B1	B2	B8
					Units	beds	sqm	sqm	sqm	sqm
	H/2011/0102	**200**	Pentagon north Taylor Wimpey	H/2016/0185	109					
			Pentagon south Taylor Wimpey	H/2012/0360	168					
			Manorside (self builds) 12 + 15 units	H/2014/0581 & H2015/0270	27					
	H/2013/0033	**200**	Beaumont - SITE C	H/2015/0374	12					
			Wellington Gardens - SITE B	H/2015/0373	30					
			Rose Garden Lane - was 18 units now 19 units	H/2015/0372	19					
			Rose Garden (23)	H/2015/0048	23					
	H/2014/0176	**134**	Wynyard Woods Ph1		69					
			Wynyard Woods Ph 2							
			Wynyard Village Western Extension	13/0342/EIS	**500**					
	10/2430/OUT	50bed+44units	Golf Club - East end of the Wynd - 150 bed hotel	13/0710/RNW & 16/1248/REM	0	**150**				
		398	HBC383 + Local centre (A1/A2/A3/A4/A5)	H/2015/0332	**383**					
	H/2014/0405	1116	HBC SW Extension		**720**					
			Barratts - The Grove - David Wilson Homes	14/3308/FUL	**100**					
	15/2164/OUT	200	SBC200 Application - SBC1100		**200**					
	12/2784/OUT	**400**	Avant-Storey - part of outline for 400 - SBC1100	14/2993/EIS	240					
			part of outline for 400-SBC1100		160					
			Red House School - 770 pupils	12/0067/FUL						
	16/0383/OUT and H/2016/0069	99bed+684sqm	Hotel - Wynyard Avenue			**99**				
			Public House and Restaurant - Wynyard Avenue				**684**			
			Cell B1 commercial					**0**		
			Cell B2 & C2 Commercial					**0**		
			Cell C2 & D1 Commercial					**5974**		
			Cell D2 Commercial					**8961**		
			NG Bailey, Zones L & Q					**10287**	**19493**	**8361**
			Wynyard Avenue commercial					**7018**	**0**	**15577**
	SBC		Local plan site		**400**					
	HBC		Local plan site		**240**					

** Committed Dev Model includes those numbers/volumes in **red bold** type*
*Applications seeking planning permission to be tested in as a Committed+Developments model shown in **green bold** type*
*Sites proposed for Local Plan housing allocations to be tested in as a Committed+Developments+Local Plan model shown in **orange bold** type*

5.2.1 Committed Development Trip Distribution/Assignment Data Sources

The data sources used to extract the trip assignment for each committed development are listed in **Table 11**.

Table 11: Committed Development Data Sources

Development	Data Source	Trip Distribution/Assignment Dataset
Pentagon north Taylor Wimpey	Woodland View Transport Assessment Addendum 1 (AECOM, February 2014)	Wynyard 3 residential distribution
Pentagon south Taylor Wimpey		
Manorside (self builds) 12 + 15 units		
Beaumont - SITE C	Woodland View Transport Assessment Addendum 1 (AECOM, February 2014)	Wynyard 3 residential distribution
Wellington Gardens - SITE B		
Rose Garden Lane - SITE A		
Rose Garden	Woodland View Transport Assessment Addendum 1 (AECOM, February 2014)	Wynyard 3 residential distribution
Wynyard Woods Phase 1	Wynyard Woods West Hartlepool Transport Assessment (SAJ Transport Consultants, April 2014)	Distribution derived from proposed development trip assignment
Wynyard Woods Phase 2		
Wynyard Village Western Extension	Wynyard Village Extension Stockton-on-Tees Transport Aassessment Revision C (SAJ Transprot Consultants, February 2014)	Residential trip assignment used to derive trip distribution. School trip assignment extracted from TA
Golf Club - East end of the Wynd	Transport Assessment Mixed-Use Development Wynyard Golf Club (Tim Speed Consulting, September 2010)	Proposed development trip assignment used to derive distribution
HBC383 + Local centre (A1/A2/A3/A4/A5)	Woodland View Transport Assessment Addendum 1 (AECOM, February 2014)	Wynyard 3 residential distribution
HBC SW Extension	Hartlepool South West Extension Environmental Statement Appendix A Transport Assessment (Milestone Transport Planning, August 2014)	TA trip assignment used to derive distribution (adjusted for 720 units)
Barratts - The Grove - David Wilson Homes	Woodland View Transport Assessment Addendum 1 (AECOM, February 2014)	Wynyard 2 residential distribution
SBC200 Application - SBC1100	Woodland View Transport Assessment Addendum 1 (AECOM, February 2014)	Wynyard 2 residential distribution

Avant-Storey - part of outline for 400 - SBC1100	Woodland View Transport Assessment Addendum 1 (AECOM, February 2014)	Wynyard 2 residential distribution
part of outline for 400-SBC1100		
Red House School	Relocation of Red House Scholl Wynyard, Stockton-on-Tees Proposed School Site Access Operational Assessment (SAJ Transport Consultants, April 2012) and Transport Assessment Red House School Relocation Wynyard, December 2011)	Trip assignment extracted from TA
Hotel - Wynyard Avenue	Wynyard Park Hotel & Pub/Restaurant Transport Statement (Fore Consulting, February 2016)	Hotel and Pub/restaurant trip distributions extracted from TA
Public House and Restaurant - Wynyard Avenue		
Commercial Developments (Wynyard 1, 2 and 3)	Woodland View Transport Assessment Addendum 1 (AECOM, February 2014)	Wynyard 1,2 and 3 commercial trip distribution respectively

5.2.2 Methodology and Assumptions

Committed development demand matrices for the VISSIM model have been developed separately for each development and each peak period. The individual site demand matrices have then been combined to provide a total committed development demand matrix.

The methodology and assumptions applied to calculate the trip assignment associated with each committed development is presented below.

Wynyard Park Residential Developments

Trip assignment for the Wynyard Park residential developments has been calculated based on the respective trip distribution included in the *Woodland View Transport Assessment Addendum 1* (AECOM, February 2014) document, trip rates provided by AECOM for the AM and PM assessment periods and the proposed number of units. It is understood that residential trips only refer to journeys to work. Trips associated with schools have been included in the Red House School and Wynyard Village Extension School trip assignment.

Additionally, it has been agreed that 10% of journeys to work generated from residential units at Wynyard Park will be internal (to commercial units at Wynyard Park). Therefore, a 10% reduction has been applied to the total residential journeys to work generated from Wynyard Park to reflect the internal journey to work. These have been assumed to use the internal networks within Wynyard Park, therefore no reassignment has been undertaken. The resulting Wynyard Park residential development matrices therefore only include external trips.

Wynyard Park Commercial Developments

Trip assignment for the Wynyard Park commercial developments has been calculated using the commercial trip distribution for Wynyard Park 1, 2 and 3, extracted from the *Woodland View Transport Assessment Addendum 1* (AECOM, February 2014), trip rates provided by AECOM for the AM and PM assessment periods for staff and HGV trips and the total floor area of the proposed units. It is understood that residential trips only refer to journeys to work. Trips associated with schools have been included in the Red House School and Wynyard Village Extension School trip assignment.

The 10% reduction in residential journeys to work to account for people working in Wynyard Park equates to a 6% reduction in total commercial trips (staff trips). No reassignment has been applied to the total trips, as it is assumed that staff trips associated with Wynyard Park would use the internal road network. The resulting Wynyard Park commercial developments therefore only include external staff trips and total HGV trips.

Wynyard Village Extension and Wynyard Woods Residential Developments

The trip assignment for the Wynyard Village Extension and Wynyard Woods developments has been extracted from the *Wynyard Village Extension Stockton-on-Tees Transport Assessment Revision C* (SAJ Transport Consultants, February 2014) and the *Proposed Residential Development, Wynyard Woods West Hartlepool Transport Assessment* (SAJ Transport Consultants, April 2014) documents respectively. It is understood that residential trips only refer to journeys to work. Trips associated with schools have been included in the Red House School and Wynyard Village Extension School trip assignment.

The TA assignment includes a 10% reduction and reassignment of traffic due to internal commercial trips to Wynyard Park. More specifically, 8% of residential journeys to work have been assumed to move to/from zone 2 (straight through movements) and the remaining 2% move to/from zone 6. The trip assignment has been used to calculate a trip distribution for the site, which has been combined with trip rates provided by their transport assessments for the AM and PM periods and number of proposed number of units, to derive a trip assignment for the site.

Red House and Wynyard Village Extension Schools

- Red House School trip assignment has been extracted from the *Relocation of Red House School Wynyard, Stockton-on-Tees Proposed School Site Access Operational Assessment Final* (SAJ Transport Consultants, April 2012) document. There are positive and negative trips associated with the development, taken from the development Site Access Operational Assessment. Negative trips represent the reduction and reassignment of traffic due to the school relocation. Positive and negative trips have been assigned onto the remaining assessment network junctions using the base traffic distribution. The resulting net school trips have only been included in the

development matrices for the AM and PM peak hours only (08:30-09:30 and 16:00-17:00); and

- Wynyard Village Extension (school) trip assignment has been extracted from the *Wynyard Village Extension Stockton-on-Tees Transport Assessment Revision C* (SAJ Transport Consultants, February 2014) for the "With Woodland View" scenario. Positive and negative trips generated from the site, extracted from the development TA, have been distributed onto the assessment network using the distribution of the base traffic data, as per the Red House School calculations. The resulting net school trips have been included in the AM and PM peak hour matrices (08:30-09:30 and 16:00-17:00).

HBC South West Extension

The HBC South West Extension trip assignment, extracted from the *Hartlepool South West Extension Environmental Statement Appendix A – Transport Assessment* (Milestone Transport Planning, August 2014) document includes employment, leisure and shopping trips generated from the development. Based on the trip assignment, no employment trips associated with the proposed development will access the western part of the study network (all employment trips from/to the west enter/exit from the A19). Therefore no discount for the 10% internal employment trips has been applied to the HBC South West Extension development. The TA also identifies that no school trips associated with the development will access the assessment network.

The development trip assignment was used to derive the trip distribution, which was combined with residential trip rates provided by their transport assessments for the AM and PM periods and number of proposed number of units, to derive a trip assignment for the site.

Golf Club Hotel

Trip assignment for the Golf Club development has been extracted from the *Transport Assessment Mixed-Use Development Wynyard Golf Club* (Tim Speed Consulting, September 2010) document to derive a trip distribution for the site. The distribution has been combined with trip rates extracted from the *Wynyard Park Hotel & Pub/Restaurant Transport Statement* (Fore Consulting, February 2016) for AM and PM periods to calculate the resulting trip assignment.

Wynyard Avenue Pub/Restaurant and Hotel

The pub/restaurant and hotel trip distributions were extracted from the *Wynyard Park Hotel & Pub/Restaurant Transport Statement* (Fore Consulting, February 2016) and combined with trip rates for AM and PM periods and the proposed development size, extracted from the development TA.

6 Network Development

6.1 Committed Mitigation

The proposed network mitigation plans have been provided by SBC from Section 106 agreements for the following junctions:

1. A689 Hartlepool Road / The Meadows / The Wynd roundabout;
2. A689 Hartlepool Road / Hanzard Drive / A689 Coal Lane / The Wynd roundabout;
3. A689 Coal Lane / Wynyard Avenue / Red House School Access;
4. A689 / Services access road roundabout; and
5. A689 / Wynyard Park / A689 Stockton Road / A1185 / Wolviston Road

The junction locations are shown in **Figure 14**.

Figure 14: Locations of proposed mitigation

The network mitigation involves signalising each of the roundabouts, along with some local lane widening. Junction 3 gains a 4 lane entry for west bound traffic, one lane of which is allocated to traffic accessing Red House School.

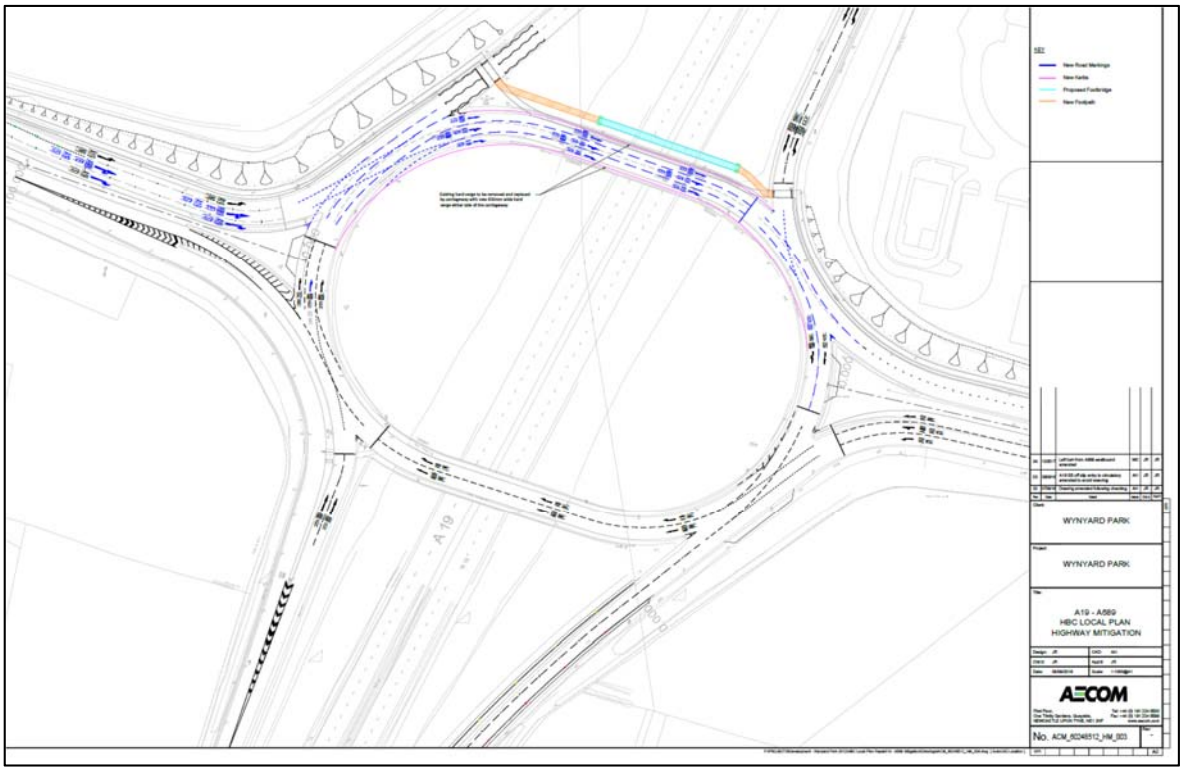
Junction 1 includes for a signalised pedestrian crossing on the eastern arm of the A689, which facilitates pedestrians accessing the new primary school in Wynyard Village from houses on the northern side of the A689 in Wynyard Park.

6.2 Three-lane A19 Over-bridge Option

The work undertaken in 2013 identified that a third lane on the A19 over-bridge would release capacity for traffic turning right, from both the A689 eastbound, and the A19 northbound. Part of the work undertaken for this study, investigated the benefits in journey times that this third lane on the over-bridge could bring.

The construction of the third lane would be funded from developer contributions, and therefore a design has been proposed by AECOM, who are acting as the developers' consultant. This plan is shown in Figure 15.

Figure 15: Proposal for three lane A19 Over-bridge



6.3 LinSig Modelling

Individual junction capacity assessments have been undertaken using LinSig 3.2.33, for the following junctions:

- A689 / The Meadows / The Wynd roundabout
- A689 / Hanzard Drive / A689 Coal Lane / The Wynd roundabout
- A689 / Wynyard Avenue / Red House School Access roundabout
- A689 / Stockton Road / A1185 / Wolviston Road (Wolviston roundabout)
- A689 / A19 signalised grade separated junction (has existing signals)

Junction 4 has not been assessed using LinSig as it is expected to be operating within capacity.

The optimised signal timings have also been used to inform the VISSIM model.

7 Results of Option Testing

7.1 Journey Times

The results of the journey times for each scenario are shown in **Table 12** for the AM peak, and **Table 13** for the PM peak.

Table 12: AM peak Journey Times - All scenarios (mins:sec)

	2026 Base	Option 1 (+2254 units) **2026 Base+ Committed**		Option 2 (+583 units) **2026 Base+ Committed+Proposed**	Option 3 (+640 units) **2026 Base+Committed +Proposed+Local Plan**
		Without mitigation	With mitigation	With 3 lane over-bridge	With 3 lane over-bridge
Eastbound	4:20	13:20	14:04	8:38	9:10
Westbound	3:15	5:23	5:39	5:27	5:26

As the traffic associated with the committed developments is added to the network (Option 1), and without any mitigation in place, the journey times increase from those observed in the Base model. This option however also restricts the egress of traffic from the development sites. Once the mitigation measures are in place, the development traffic is released, which inevitably leads to a slight increase in journey times eastbound as the network tries to actively manage more traffic.

The addition of the third lane on the A19 over-bridge releases capacity for those using the A689 eastbound, travelling ahead and right at the A19 junction, as shown for Option 2 and 3.

The results show that in the AM peak, the average journey time for the eastbound route along the A689 increases beyond the ten minute threshold which was unacceptable by officers. This is greatly improved with the introduction of the third lane on the A19 over-bridge, as traffic is reallocated over two lanes for ahead, and two lanes for right turning traffic.

Table 13: PM peak Journey Times - All scenarios (mins:sec)

	2026 Base	Option 1 (+2254 units) **2026 Base+ Committed**		Option 2 (+583 units) **2026 Base+ Committed+Proposed**	Option 3 (+640 units) **2026 Base+Committed +Proposed+Local Plan**
		Without mitigation	With mitigation	With 3 lane over-bridge	With 3 lane over-bridge
Eastbound	3:13	5:35	9:57	5:39	6:00
Westbound	3:17	4:54	6:27	5:31	5:44

The results of the PM peak testing for all options mirrors the AM peak results, however the eastbound journey time does not exceed the 10 minute threshold in any of the scenarios.

7.2 Queuing

The results of the queue lengths in PCU for each scenario are shown in **Table 14** for the AM peak, and **Table 15** for the PM peak.

Table 14: AM peak queue lengths - All scenarios

			Option 1 (+2254 units)				Option 2 (+583 units)		Option 3 (+640 units)	
	2016 Base		2026 Base + Committed				2026 Base + Committed + Proposed		2026 Base + Comm + Proposed + LP	
			without mitgation		with mitigation		with 3lane overbridge		with 3lane overbridge	
Queuing Results in pcu AM	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
A689 EB	86	98	98	104	73	92	13	31	45	60
A19 NB off-slip	6	18	2	10	5	9	2	10	3	15
A689 WB	13	26	4	14	4	14	6	17	8	21

Table 15: PM peak queue lengths - All scenarios

			Option 1 (+2254 units)				Option 2 (+583 units)		Option 3 (+640 units)	
	2016 Base		2026 Base + Committed				2026 Base + Committed + Proposed		2026 Base + Comm + Proposed + LP	
			without mitgation		with mitigation		with 3lane overbridge		with 3lane overbridge	
Queuing Results in pcu PM	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
A689 EB	37	41	99	104	67	86	12	26	17	35
A19 NB off-slip	13	29	3	13	2	12	3	12	3	15
A689 WB	9	22	4	12	3	12	3	13	4	15

The results of the queuing mirror those of the journey times, where improvements are shown once the over-bridge is in place on the A19 junction. For Option 3, the queue lengths are an improvement on those recorded in the base assessment.

7.3 Summary

The Committed Development (Option 1), Proposed Developments (Option 2) and Local Plan allocation (Option 3) sites were tested in the VISSIM model to determine journey time and queue lengths for each scenario.

Trip rates and distribution was taken from each Transport Assessment submitted to SBC and HBC planning portals for the committed development sites. Similarly, the Transport Assessments for live applications for proposed development sites (yet to be determined) were used to determine their distribution. These trip rates and distributions were utilised for sites identified in the Local Plan allocation, as they were deemed the most suitable for assessment purposes.

Option 1 was tested with and without the network mitigation on the five local roundabouts (i.e. signalisation). Options 2 and 3 included all committed mitigation, plus an additional lane on the A19 over-bridge northern circulatory, which facilitates the eastbound traffic on the A689.

The results show that the addition of the third lane on the A19 over-bridge releases capacity on the network which reduces the critical eastbound journey time to below ten minutes.

8 Items to Consider

It should be noted that during the analysis of the developments at Wynyard, the following points should be considered to demonstrate that the future developments beyond the committed phase can be supported:

- The feasibility of the third lane on the over-bridge will need to be established by undertaking further detailed design and cost evaluation;
- The timescales and schedule for the over-bridge work, and any closures or possession of the A19, are possible and are within those already scheduled for the A19 North to Wynyard scheme;
- Consideration of the A689 as a strategic link between the A1 and the A19 and network performance in the event of a diversion;
- Future delivery of community facilities which may reduce the number of trips from the residential developments, which could reduce the impact of traffic on the A689.