Appendix G. LMAP Stage 2 and 3 Report

ATKINS

Wealdstone Town Centre Transport Study

LMAP 2 and LMAP 3 LinSig Model Report

London Borough of Harrow

March 14 2017

Notice

This document and its contents have been prepared and are intended solely for London Borough of Harrow and Transport for London's information and use in relation to the Wealdstone Town Centre Transport Study

Atkins Limited assumes no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

This document has 37 pages including the cover.

Document history

Job number: 5147962			**Document ref:**			
Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
Rev 1.0	Issued for LMAP 2 Audit	LE	ND	CPG	CPG	24/08/16
Rev 2.0	Updated following LMAP 2 Audit	LE	ND	CPG	CPG	24/11/16
Rev 3.0	Updated for LMAP 3	LE	ND	JM		03/02/17
Rev 4.0	Updated following LMAP 3 Audit	LE	ND	JM	CPG	14/03/17

Client signoff

Client	London Borough of Harrow
Project	Wealdstone Town Centre Transport Study
Document title	LMAP 2 and LMAP 3 LinSig Model Report
Job no.	5147962

Table of contents

Tables

Figures

1. Introduction

1.1. Background

Atkins has been appointed by the London Borough of Harrow (LBH) to provide transport consultancy services as part of the Wealdstone Town Centre Transport Study.

LBH commissioned Atkins to develop a linked LinSig model, as part of the TfL Model Auditing Process (MAP), to support the assessment of the current highway network to inform proposed design options. The use of LinSig to assess the operation of the existing network and proposed schemes was agreed with TfL during the TfL MAP Stage 1 Meeting held on Tuesday 31st May 2016.

The aim of the LinSig modelling is to assess the current traffic conditions within the study area, which will be used to mitigate the impact of proposed future developments and test feasibility design options, therefore aligning with the overall study objectives.

This report provides details of the Calibrated Base LinSig model for the LinSig Model Auditing Process (LMAP) Stage 2 and the Validated Base LinSig model for the LMAP Stage 3.

1.2. Report Structure

The structure for remainder of this report as follows:

- Section 2 outlines the Existing Situation;
- Section 3 presents the LMAP Stage 2 Calibrated Base Model; and
- Section 4 presents the LMAP Stage 3 Validated Base Model.

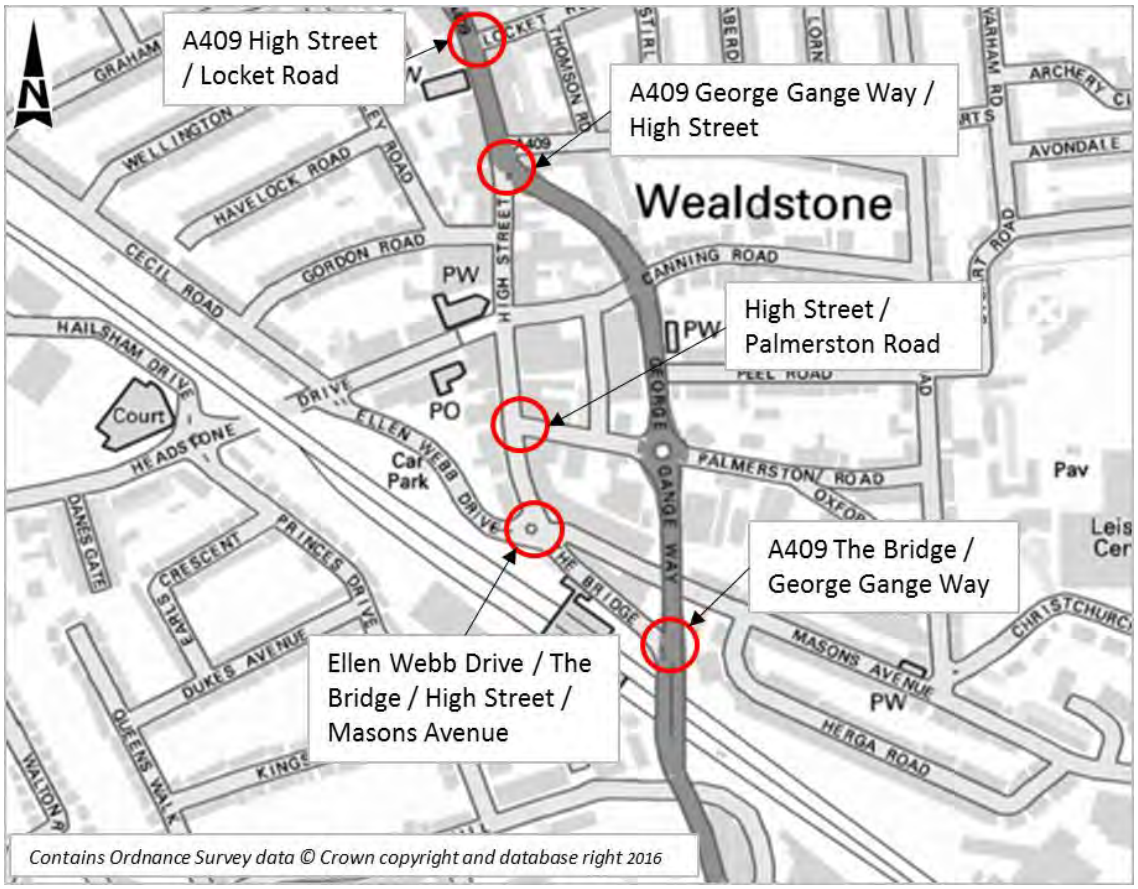
2. Existing Situation

2.1. Site Description

Wealdstone Town Centre is located in the centre of LBH and includes five signalised junctions between Locket Road and the A409 George Gange Way, with Wealdstone High Street located between the two. The site location and signalised junctions are shown in Figure 2-1.

Wealdstone High Street is located in the centre of the study area, and operates with all traffic permitted northbound, but High Street southbound (between the junction with the A409 George Gange Way and Palmerston Road) is restricted to buses and cycles only. The A409 provides two way traffic both northbound and southbound, and forms part of the strategic road network. The A409 is used by traffic to by-pass the town centre. A number of traffic management proposals are in place within the town centre, with right turns not permitted from Ellen Webb Drive, The Bridge, Masons Avenue or Locket Road.

Figure 2-1 Site Location



2.1.1. A409 High Street / Locket Road

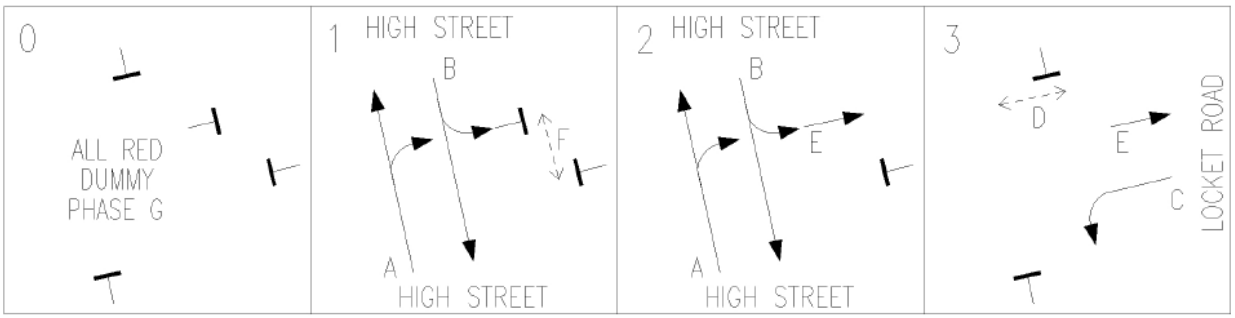
The A409 High Street / Locket Road junction is a three arm junction located at the north of the Study Area. It is a signal controlled junction with pedestrian crossings located on the High Street (North) and Locket Road arms. Right turns are restricted from Locket Road and the stop line is set back on this arm to allow buses to turn in. The junction currently operates on a Vehicle Actuated (VA) method of control.

Under typical traffic conditions, the junction operates with three signal stages as outlined below and shown in Figure 2-2. Note the pedestrian crossings are indicated by letters D and F. Stage 1 is only called when the pedestrian crossing is demanded. The stages are as follows:

- Stage 1 – Traffic from High Street (North) and High Street (South) arms. Right and left turn movements are stopped on Locket Road, and pedestrians crossing Locket Road;

- Stage 2 – Traffic from High Street (North) and High Street (South) arms; and
- Stage 3 – Left turning traffic from Locket Road and pedestrians crossing High Street (North).

Figure 2-2 A409 High Street / Locket Road Existing Junction Method of Control



There is also one UTC dummy stage (G) which is an all red stage for vehicles and pedestrians. This dummy stage is not part of the typical operation of the junction.

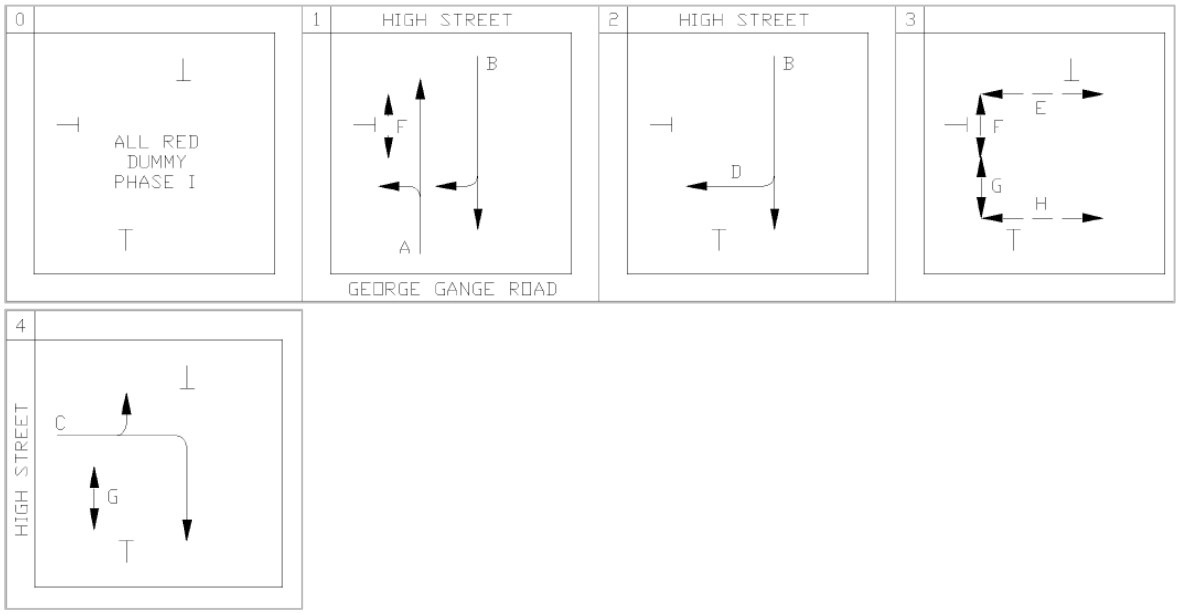
2.1.2. A409 George Gange Way / High Street

The A409 George Gange Way / High Street is a three arm junction with pedestrian crossings on all arms of the junction. The pedestrian crossing on High Street (South) is in two parts, separated by an island. Only buses and cycles are permitted to turn right from High Street (North) to travel southbound on the High Street. The junction currently operates on a Vehicle Actuated (VA) method of control.

Under typical traffic conditions, the junction operates with three signal stages as outlined below and shown in Figure 2-2. Phase D is a right turn indicative arrow to travel southbound on the High Street which is restricted to buses and cycles only. The junction was observed on-site and from video surveys undertaken on the 9th June 2016 during which Stage 2 was not demanded during the AM or PM peak hours. Note the pedestrian crossings are indicated by letters E to H. The stages are as follows:

- Stage 1 – Traffic from High Street (North) and George Gange Way and pedestrians crossing the northbound lane of High Street (South);
- Stage 2 – Traffic from High Street (North) with a right-turn indicative arrow;
- Stage 3 – ‘All red’ for pedestrians to cross all arms of the junction; and
- Stage 4 – Traffic from High Street (South) and pedestrians crossing the southbound lane of High Street (South).

Figure 2-3 A409 George Gange Way / High Street Existing Junction Method of Control



There is also one UTC dummy stage (I) which is an all red stage for vehicles and pedestrians. The dummy phase is not part of the typical operation of the junction.

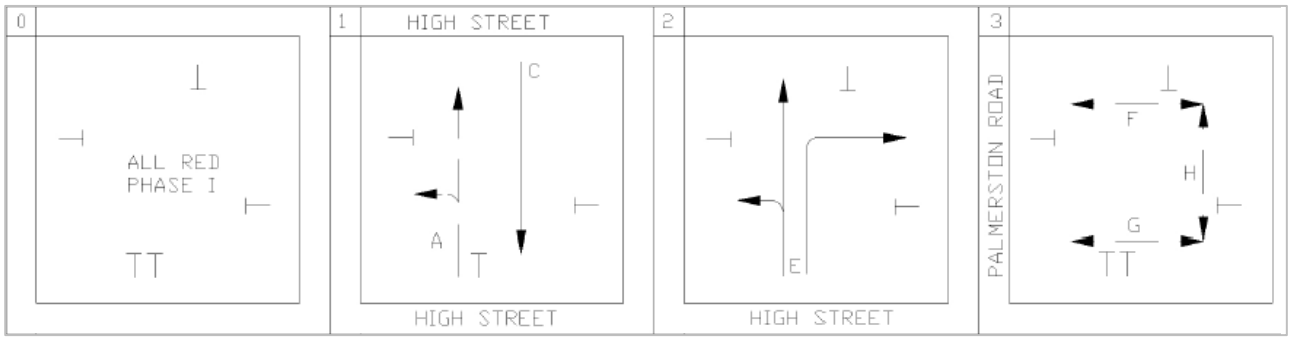
2.1.3. High Street / Palmerston Road

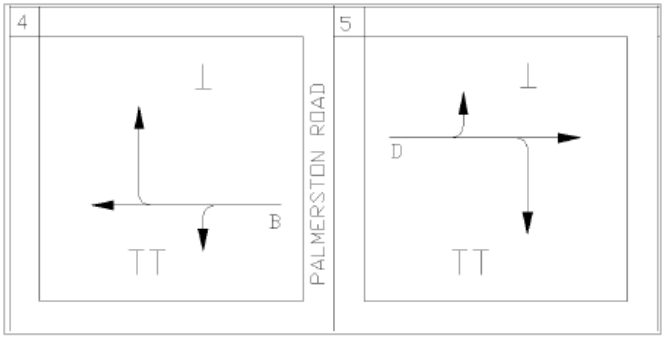
The High Street / Palmerston Road junction is a four arm junction with pedestrian crossings on the High Street and Palmerston Road arms. The fourth arm on the junction is a prior access to a public house which is currently utilised as a car wash. The junction currently operates on a Vehicle Actuated (VA) method of control.

Under typical traffic conditions, the junction operates with five signal stages as outlined below and shown in Figure 2-2. As the junction operates on a VA method of control, there was minimal demand for the public house access so this stage was not called during the peak hours. Note the pedestrian crossings are indicated by letters F to H. The stages are as follows:

- Stage 1 – Traffic from High Street (North) and ahead traffic from High Street (South);
- Stage 2 – Traffic from High Street (North) and right turning traffic from High Street (South);
- Stage 3 – 'All red' for pedestrians to cross all arms of the junction; and
- Stage 4 – Traffic from Palmerston Road; and
- Stage 5 – Traffic from the public house access road.

Figure 2-4 High Street / Palmerston Road Existing Junction Method of Control





There is also one UTC dummy stage (I) which is an all red stage for vehicles and pedestrians. This dummy stage is not part of the typical operation of the junction.

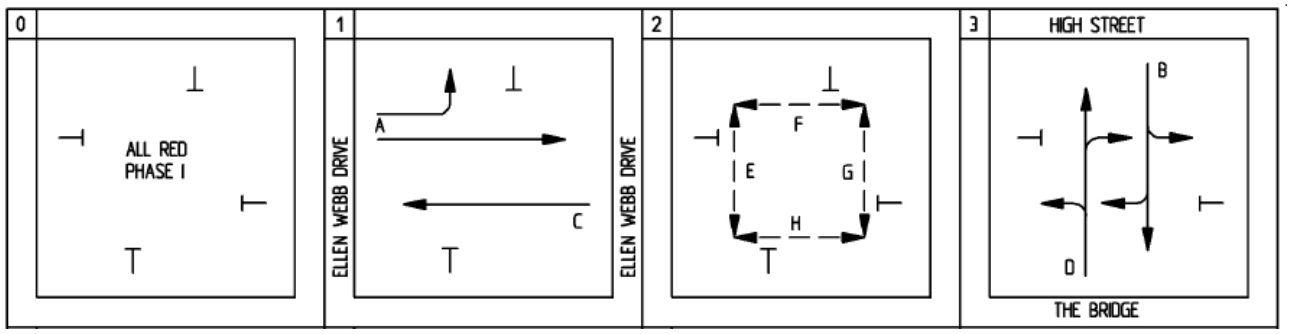
2.1.4. Ellen Webb Drive / The Bridge / High Street / Masons Avenue

The Ellen Webb Drive / The Bridge / High Street / Masons Avenue is a four arm junction with pedestrian crossings on all arms. There is a zebra crossing approximately 30 metres south of the junction on The Bridge. Traffic is not permitted to turn right from Ellen Webb Drive or Masons Avenue arms of the junction. Harrow and Wealdstone rail station is located on The Bridge to the south of this junction. The junction currently operates on a Fixed Time method of control.

Under typical traffic conditions, the junction operates with three signal stages as outlined below and shown in Figure 2-5. Note the pedestrian crossings are indicated by letters E to H. The stages are as follows:

- Stage 1 – Traffic from Ellen Webb Drive and Masons Avenue;
- Stage 2 – 'All red' for pedestrians to cross all arms of the;
- Stage 3 – Traffic from The Bridge and High Street.

Figure 2-5 Ellen Webb Drive / The Bridge / High Street / Masons Avenue Existing Junction Method of Control



There is also one UTC dummy stage (I) which is an all red stage for vehicles and pedestrians. This dummy stage is not part of the typical operation of the junction.

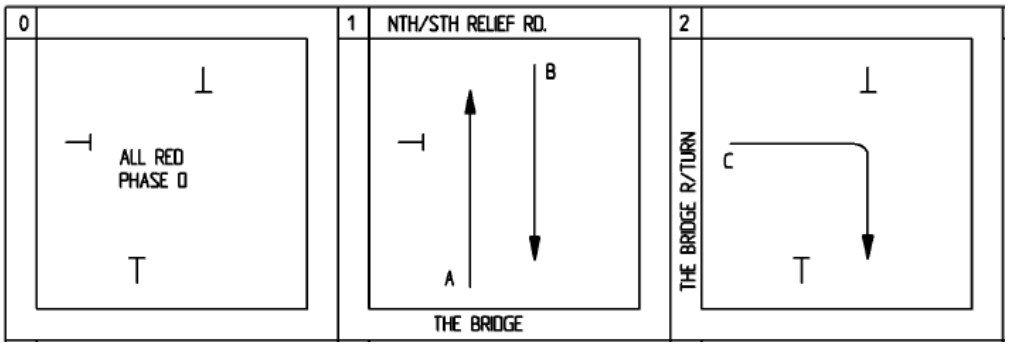
2.1.5. The Bridge / A409 George Gange Way

The Bridge / A409 George Gange Way is a three arm signalised junction at the south of the High Street. There are no signal controlled pedestrian crossings at this junction and right turns from The Bridge are restricted to buses and cycles only. The junction currently operates on a Vehicle Actuated (VA) method of control.

Under typical; traffic conditions, the junction operates with two signal stages as outlined below and shown in Figure 2-6. The stages are as follows:

- Stage 1 – Traffic on the A409 George Gange Way (North and South); and
- Stage 2 – Traffic turning right from The Bridge.

Figure 2-6 The Bridge / A409 George Gange Way Existing Junction Method of Control



There is also one UTC dummy stage (D) which is an all red phase for vehicles and pedestrians. This dummy stage is not part of the typical operation of the junction.

2.2. Traffic Flows

2.2.1. Turning Counts

Traffic surveys were conducted at the junction by Traffic Data Centre on Thursday 9th June 2016. The following data was recorded during the traffic surveys:

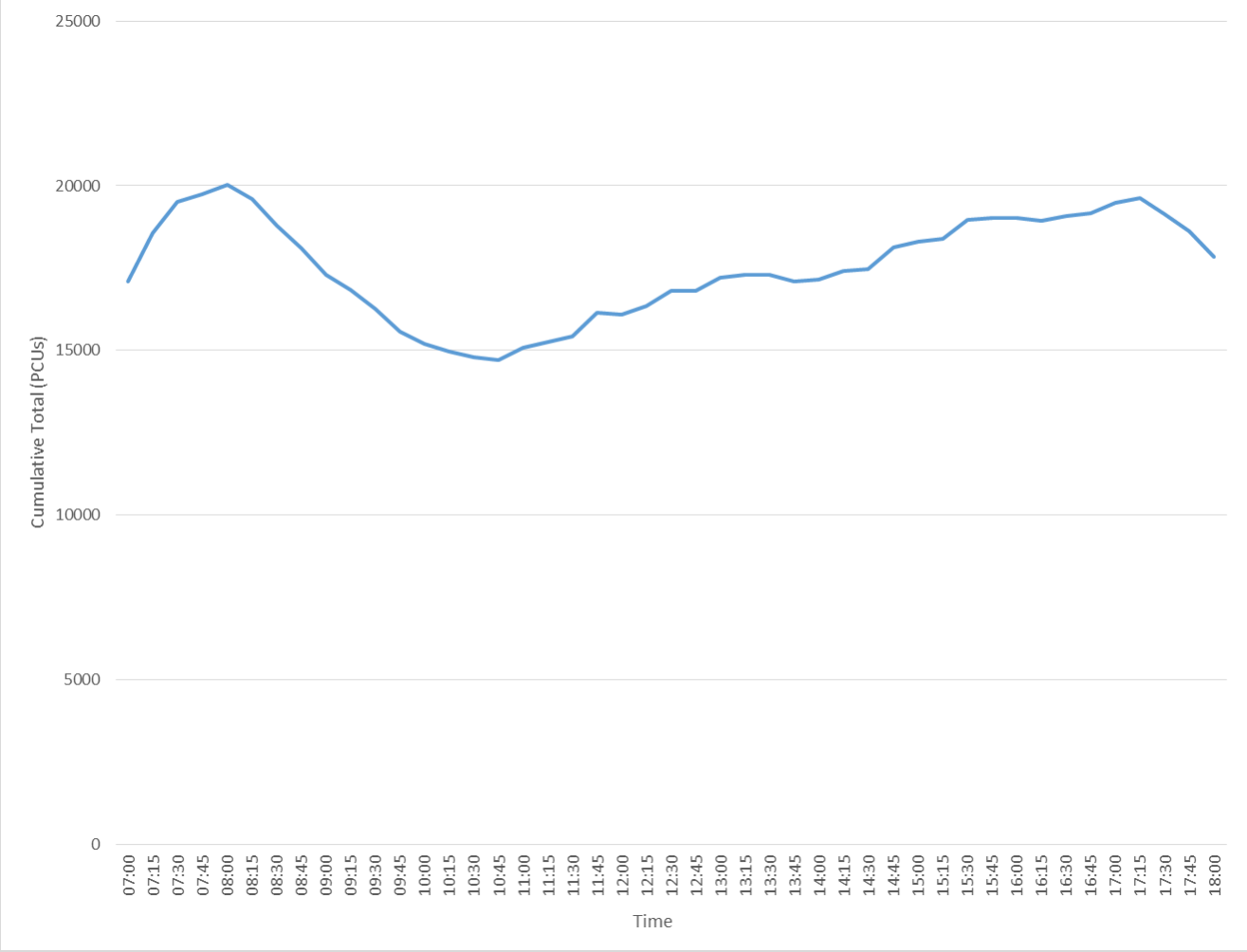
- Automatic Traffic Counts (ATC) recording volumetric traffic and speed data;
- Classified turning counts;
- Queue lengths;
- Cruise Times;
- Pedestrian crossing flows;
- Cycle crossing flows;
- Frequency of demand for pedestrian crossings;
- Pedestrian footfall counts;
- Degree of Saturation (DoS) / Underutilised Green Time (UGT); and
- Saturation flows.

The traffic peak hours identified within the network were as follows:

- Weekday AM Peak Hour 08:00 – 09:00; and
- Weekday PM Peak Hour 17:15 – 18:15.

The cumulative total PCUs recorded within the whole network are shown in Figure 2-7.

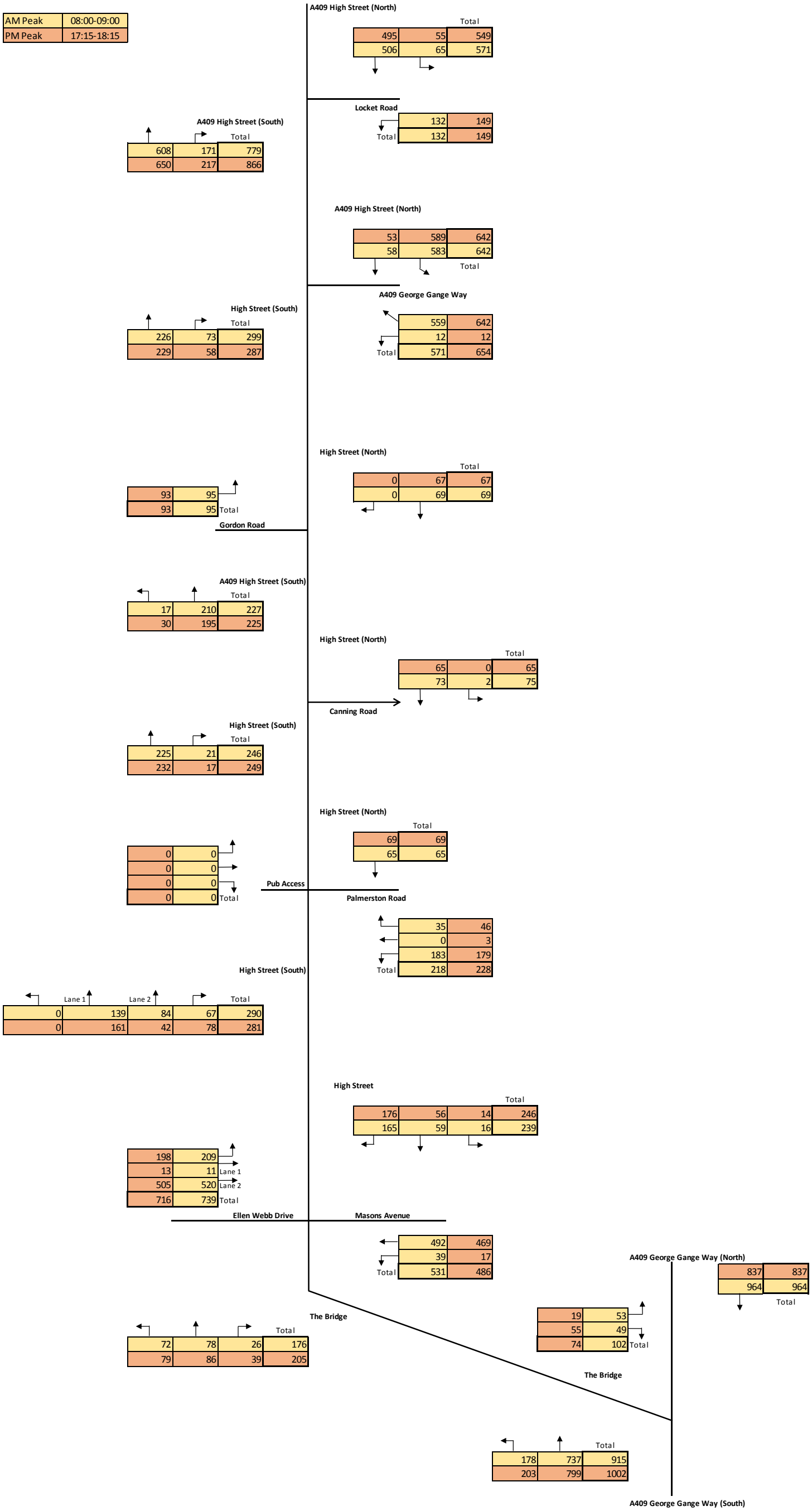
Figure 2-7 Weekday Total Network Traffic Flows 07:00 - 19:00 (PCUs)



The peak hour flows (in PCUs) are presented in Figure 2-8. The following trends were observed:

- High Street southbound has low traffic flows (around 70 PCUs in the peak hours) as it is restricted to buses and cycles only;
- A409 George Gange Way (North and South) have high volumes of traffic flow (around 1000 PCUs during the peak hours at the junction with The Bridge) as this is a by-pass route avoiding the High Street;
- The majority of traffic at the Ellen Webb Drive / The Bridge / Masons Avenue / High Street junction makes ahead movements on Ellen Webb Drive and Masons Avenue (around 500 PCUs in each peak hour in each direction);
- Right turn flows from The Bridge onto Masons Avenue are low (around 30 PCU per hour);
- The highest traffic flows were observed on A409 George Gange Way (North) travelling southbound during the AM peak (964 PCUs);
- Flows turning right from The Bridge onto the A409 are low as this movement is restricted to buses and cycles only (around 50 PCUs per hour);
- Traffic flows on the High Street are relatively low in both the AM and PM peak hours (around 200 PCU per hour northbound).

Figure 2-8 AM (08:00 – 09:00) and PM (17:15 – 18:15) Peak Hours Weekday Flow (PCUs)



2.2.2. Volumetric Counts

ATC data was recorded at the locations identified in Figure 2-9 for a seven day period from Saturday 4th June 2016 to Friday 10th June 2016.

Figure 2-9 ATC Locations

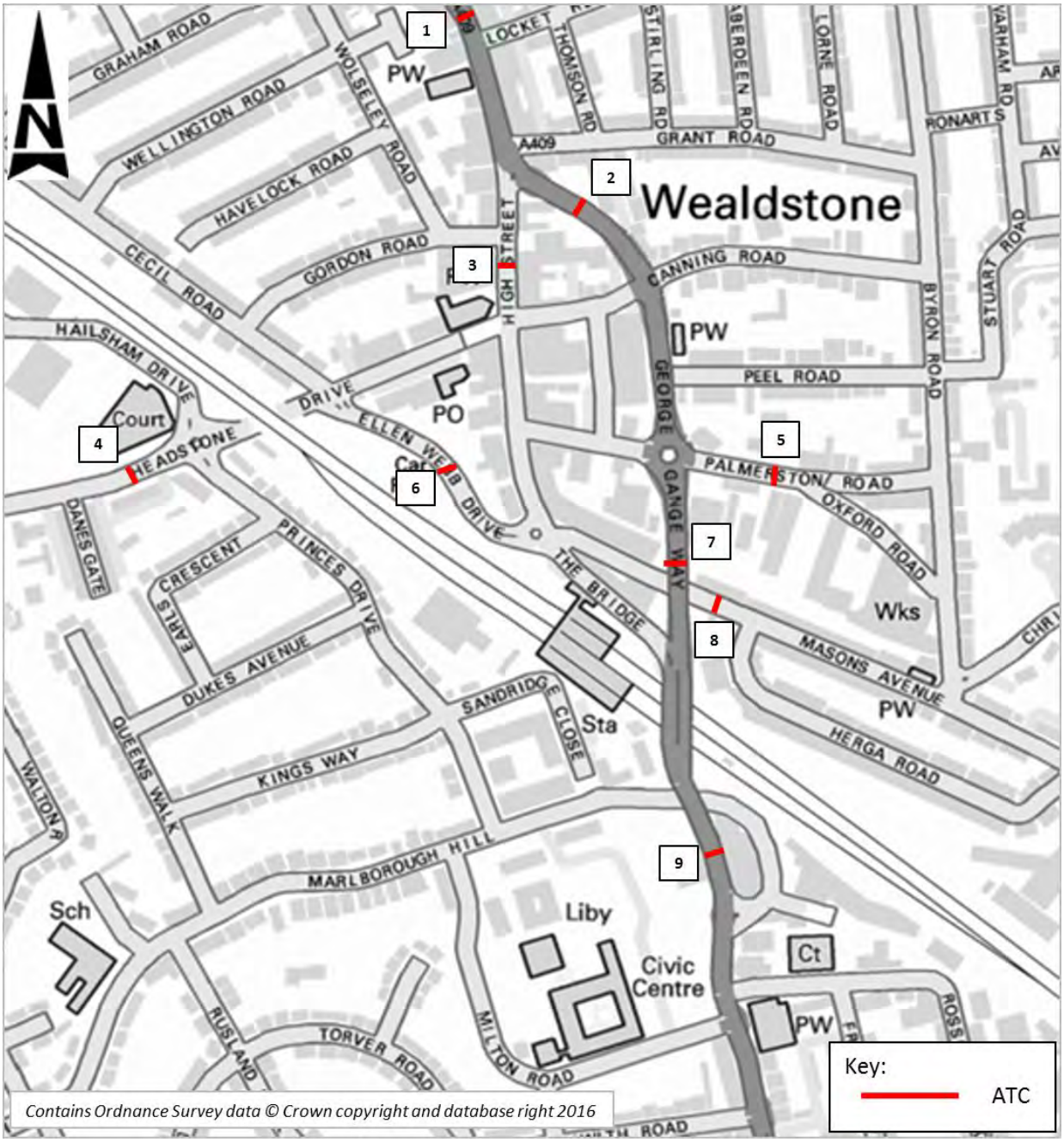
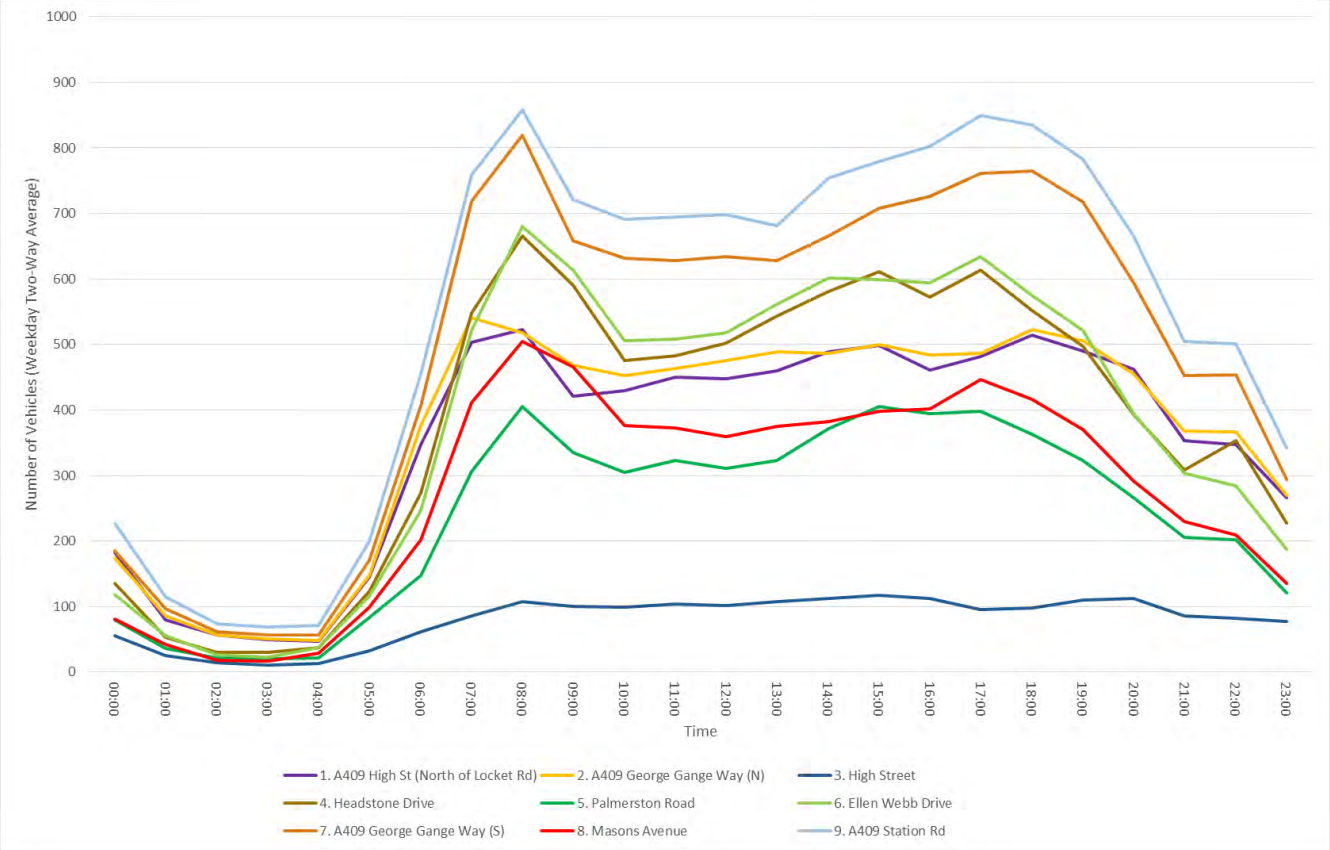


Figure 2-10 presents the results for the average weekday traffic flow profile with the peak flows occurring typically between 07:30 – 08:30 hours and 17:00 – 18:00 hours. The peak hours from the ATC data are similar to the peak hours observed during the weekday junction counts. Also, the average peak traffic flow recorded from the ATCs is similar to the flow recorded as part of the junction count survey. For example on Ellen Webb Drive (Eastbound) the ATCs recorded an average traffic flow during the AM and PM Peak hours of 679 and 633 vehicles respectively and the junction turning counts recorded an average traffic flow during the AM and PM peak hours of 739 and 716 PCUs. The slight difference in flow is because the ATC flow is a five-day average and is measured in vehicles whereas the junction turning flows were recorded for one day and are presented in PCUs. The results demonstrate that the junction turning count data recorded is representative of the typical mid-week data at the junction.

The highest average weekday traffic flows were recorded on the A409 Station Road (near the junction with Marlborough Hill). The lowest average volume of traffic was recorded on the High Street due to bus / cycle only restrictions southbound and the majority of traffic using the A409 George Gange Way to by-pass the town centre.

Figure 2-10 Two-way average weekday traffic flow profile



2.2.3. Vehicle Speeds

Table 2-1 presents the mean and 85th percentile speed average for the seven day week assessed. The highest speeds were recorded on the A409 George Gange Way which by-passes the High Street with an 85th percentile speed of 30.6mph recorded on the A409 south of Palmerston Road.

The section of the High Street between Palmerston Road and the A409 is within a 20mph zone. A speed limit of 30mph applies for the rest of the ATC locations within the study area.

Table 2-1 Seven Day Mean and 85th Percentile Speed

Road Name	Direction	Mean Speed (mph)	85th Percentile Speed (mph)
Headstone Drive	Eastbound	23.1	27.3
	Westbound	24.8	28.6
	Two way	**24.0**	**28.0**
Ellen Webb Drive	Eastbound	22.3	26.4
	Westbound	21.5	26.2
	Two way	**21.9**	**26.3**
High Street	Northbound	15.8	21.0
	Southbound	16.4	20.1
	Two way	**16.1**	**20.6**
Palmerston Road	Eastbound	24.0	28.0
	Westbound	20.9	26.6
	Two way	**22.5**	**27.3**
Masons Avenue	Eastbound	20.2	25.5
	Westbound	17.7	26.2
	Two way	**20.0**	**25.9**
A409 High Street (North of Locket Road)	Northbound	21.3	25.3
	Southbound	18.8	25.3
	Two way	**20.1**	**25.3**
A409 George Gange Way (North)	Northbound	18.9	24.8
	Southbound	23.8	27.5
	Two way	**21.4**	**26.2**
A409 George Gange Way (South)	Northbound	25.8	30.6
	Southbound	21.1	27.7
	Two way	**23.5**	**29.2**
A409 Railway Approach	Northbound	26.2	30.0
	Southbound	22.0	28.4
	Two way	**24.1**	**29.2**

2.3. Queues

A summary of average and maximum queue lengths (measured at five minute intervals) observed during the AM and PM peak hours within the network is presented in Table 2-2 Average and Maximum Queue Lengths.

The highest queue lengths were observed on Ellen Webb Drive during the AM peak hour with an average of 94 metres and a maximum queue of 170 metres. The longest queues during the PM peak hour were observed on the A409 George Gange Way at the junction with the High Street with an average queue length of 115

metres and a maximum of 155 metres. High queueing was observed on Masons Avenue during both the AM and PM peak hours.

The following observations were made whilst observing queues within the network:

- Long queues were observed for traffic making ahead movements on Masons Avenue and Ellen Webb Drive (an average queue of 16 PCUs recorded on both approaches). The queues did not clear in one cycle of green time;
- The maximum queue recorded on Ellen Webb Drive during the AM peak queued back past the pedestrian crossing near the junction with Headstone Drive (16.3 PCUs);
- Long queues were observed on A409 George Gange Way during both the AM and PM peak hours (a maximum queue of 15 PCUs during the AM Peak); and
- During a site visit, traffic was observed from High Street (S) at the Locket Road junction blocking back to the A409 George Gange Way / High Street junction.

Table 2-2 Average and Maximum Queue Lengths for the AM and PM Peak Hours

Junction	Approach	Queue Length (Metres)			
		AM Peak Average	AM Peak Maximum	PM Peak Average	PM Peak Maximum
A409 High Street / Locket Road	High Street (N)	70	144	62	106
	Locket Road	6	29	12	35
	High Street (S) Ahead	62	94	66	98
	High Street (S) Right	20	40	39	92
A409 George Gange Way / High Street	High Street (N) Ahead	76	83	70	89
	High Street (N) Right	14	23	11	23
	A409 George Gange Way	79	150	115	155
	High Street (S)	47	72	84	104
High Street / Palmerston Road	High Street (N)	13	23	17	35
	Palmerston Road	28	40	35	52
	High St (S) Ahead	18	36	23	35
	High St (S) Right	12	35	13	23
Ellen Webb Drive / The Bridge / High Street / Masons Avenue	High Street	39	69	41	52
	Masons Avenue Ahead	94	124	92	121
	The Bridge Ahead and Left	24	43	29	52
	The Bridge Right	7	17	6	17
	Ellen Webb Drive Left	36	63	25	37
	Ellen Webb Drive Ahead	94	170	61	75
The Bridge / A409 George Gange Way	A409 George Gange Way (N)	54	83	43	69
	A409 George Gange Way (S)	42	86	48	63
	The Bridge	6	23	10	35

2.4. Bus Routes

A number of bus routes travel through Wealdstone Town Centre. All routes travel north / south through the main section of the High Street which is restricted to buses and cycles only in the southbound direction. Route 186 travels along Locket Road, and routes H9 and H10 are circular routes and travel east-west along Palmerston Road, George Gange Way and Ellen Webb Drive.

Table 2-3 Bus Routes Travelling Through Wealdstone Town Centre

Route	From	To	AM Peak Hour Frequency (buses per hour)
140 (24 hour service)	Harrow Weald Bus Garage	Heathrow Central Bus Station	10
182	Bannister Playing Fields	Brent Cross Shopping Centre	7
186	St Mark's Hospital	Brent Cross Shopping Centre	5
258	Watford Junction Railway Station	South Harrow Bus Station	4
340	Edgware Bus Station	Harrow Bus Station	5
640 (school service)	South Harrow Bus Station	Bentley Wood High School	2*
H9	Harrow Bus Station	Harrow Bus Station	6**
H10	Harrow Bus Station	Harrow Bus Station	6**
N18	Harrow Weald Bus Garage	Trafalgar Square	4

**Route 640 is a school service operating during term time only, with no service on weekends or during school holidays.*
***Route H9 and H10 are circular routed, with H9 operating anticlockwise only and H10 operating clockwise only.*

3. LMAP Stage 2 Calibrated Base Model

3.1. Introduction

A calibrated LinSig model has been developed for Wealdstone Town Centre, comprising of five signalised junctions. The base model has been produced for the AM and PM peak hours. The purpose of this model is to ensure an accurate representation of the existing traffic network structure and performance is represented in the LinSig models.

The calibrated LinSig model (LMAP 2) will form the basis for the development of the validated models for the respective peak hours in the LMAP 3 stage.

3.2. TfL Node in LinSig Model

All of the junctions currently operate on a Vehicle Actuated (VA) method of control, apart from Controller 4 29/000112 Ellen Webb Drive / The Bridge / High Street / Masons Avenue which operates on a Fixed Time method of control.

There are five controllers within the linked model as follows:

- Controller 1 – 29/000086 A409 High Street / Locket Road signalised junction;
- Controller 2 – 29/000079 A409 George Gange Way / High Street signalised junction;
- Controller 3 – 29/000111 High Street / Palmerston Road signalised junction;
- Controller 4 – 29/000112 Ellen Webb Drive / The Bridge / High Street / Masons Avenue signalised junction; and
- Controller 5 – 29/000080 The Bridge / A409 George Gange Way signalised junction.

3.3. Site Observations

The following observations were made during a site visit and from video recordings at the junction:

High Street / Locket Road

- Vehicles were observed jumping the red lights at this junction during a site visit; and
- When High Street (south) is being held at a red light, and the A409 / High Street junction is green, traffic queues back and blocks the A409 / High Street junction.

A409 George Gange Way / High Street

- Vehicles were observed jumping the red lights;
- An all-red phase applies when the crossing on High Street(north) was called;
- Long queues were observed on the A409 George Gange Way;
- Traffic flows from the High Street (south) approach were relatively low; and
- Traffic phases ran together when the pedestrian crossing was not called.

High Street / Palmerston Road

- Signals are present on the public house access, but as the junction operated on a VA method of control, this stage was not called due to low flows during the AM or PM peak hours;
- Buses were observed using the right-turn lane to travel straight ahead; and
- There are relatively low flows turning right from High Street (S) onto Palmerston Road.

High Street / Masons Avenue / The Bridge / Ellen Webb Drive

- Long queues were observed on Masons Avenue. The queues did not clear in one green cycle;
- There were very low flows of traffic turning left from Masons Avenue onto The Bridge;
- The majority of traffic on Ellen Webb Drive makes the ahead movement; and
- Right turning traffic from The Bridge / High Street cleared the junction easily.

A409 George Gange Way / The Bridge

- The right turn stage for buses / cycles runs every cycle, even if there is no demand;
- Traffic other than buses and cycles were observed using the right-turn lane from The Bridge; and
- When the right-turn stage is called, queues build up on the northbound and southbound approaches of the A409.

3.4. L202 Network Settings and Network Layout

The network settings and network layout parameters have been applied as per the TfL Traffic Modelling Guidelines.

3.5. L203 Lane Data

Saturation flows at the junction were measured on site during weekday traffic. An average of the recordings was used for each lane. Observations with full demand of under 12 seconds were excluded from the calculations.

Note that some arms had low flows meaning inadequate saturation flow calculations were made using RR67. In this case, saturation flows were calculated according to lane width and turning radius. Observed values were also measured and the difference calculated and applied to the arms with low flows. For lanes which were restricted to buses and cycles only, a default saturation flow value of 1800 pcu/hr was used.

The saturation flows observed and applied in the model are summarised in Table 3-1.

Table 3-1 Saturation flows applied to Base LinSig model

Junction	Approach	Method of Measurement	Saturation Flow (PCUs)
A409 High Street / Locket Road	Locket Road	Adjusted RR67	1624
	High Street (S) Ahead	Site Observation	1816
	High Street (S) Right	Adjusted RR67	1785
	High Street (N)	Site Observation	1743
A409 George Gange Way / High Street	A409 George Gange Way	Site Observation	1840
	High Street (S)	Site Observation	1827
	A409 High Street (N)	Site Observation	1858
	A409 High Street (N) Right *(bus / cycle only)*	Default Assumed	1800
High Street / Palmerston Road	Palmerston Road	Adjusted RR67	1641
	High Street (S) Ahead and Left	Adjusted RR67	1772
	High Street (S) Right	Adjusted RR67	1654
	High Street (N) *(bus / cycle only)*	Default Assumed	1800
Ellen Webb Drive / The Bridge / High Street / Masons Avenue	Masons Avenue	Site Observation	1919
	The Bridge Ahead and Left	Adjusted RR67	1759
	The Bridge Right	Adjusted RR67	1582
	Ellen Webb Drive Ahead	Adjusted RR67	1936
	Ellen Webb Drive Left	Adjusted RR67	1697
	High Street	Site Observation	1859
The Bridge / A409 George Gange Way	A409 George Gange Way (N)	Site Observation	1666
	The Bridge Right *(bus / cycle only)*	Default Assumed	1800
	A409 George Gange Way (S)	Site Observation	1808

Table 3-2 presents the summary of parameters for the right turn storage and maximum turners during the intergreen observed from a site visit and from video recordings from the traffic survey at junctions within the Base LinSig model.

Table 3-2 Summary of Site Observations applied in Model

Junction	Arm	Right Turn in Front of Stopline	Maximum Turners During Intergreen
A409 High Street / Locket Road	High Street (S)	3	3
A409 George Gange Way / High Street	High Street (N)	4	4
High Street / Palmerston Road	High Street (N)	2	2
High Street / Palmerston Road	High Street (S)	2	2
High Street / Masons Avenue / The Bridge / Ellen Webb Drive	High Street	4	2
High Street / Masons Avenue / The Bridge / Ellen Webb Drive	The Bridge	2	2

3.6. L204 Connector Data

Cruise times were recorded through the model network during the off peak hours. Cruise time data was provided which excludes all stopping delays (e.g. at signalised junctions). Ten runs were recorded for the route indicated in Figure 3-1 as follows:

- From / To the High Street / Locket Road junction and The Bridge / A409 George Gange Way junction. The start points on either arm should be at a distance of approximately 200 metres from the junction.

The travel speed of 10m/s was used as a guide to check the cruise time recordings and to discount any recordings which were not considered typical.

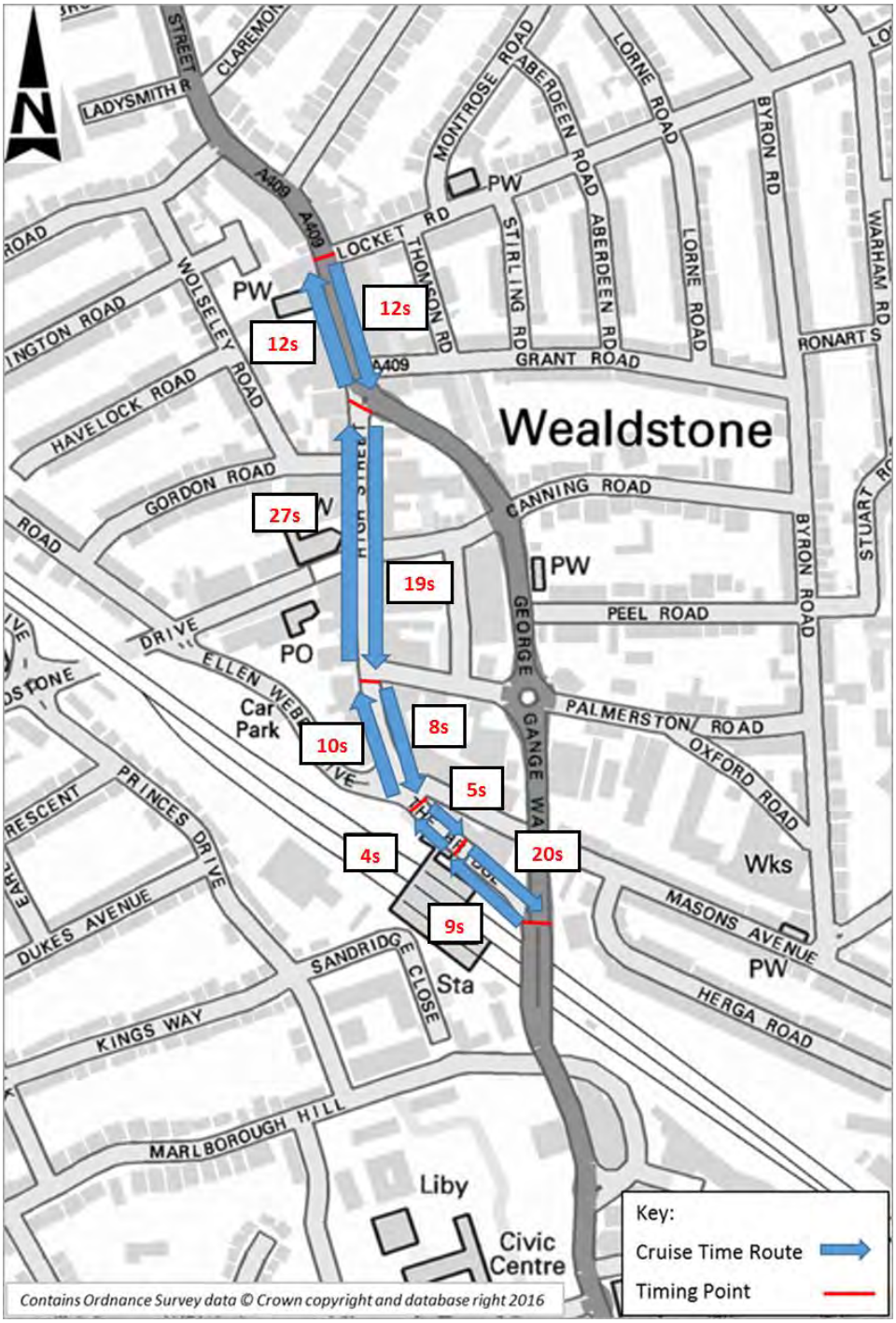
The measured cruise times are shown in Figure 3-1. For the section of the network where cruise times were not measured, the cruise times were calculated by using a combination of the measured cruise times, average travel speed of 10m/s and taking into account turning movements vehicles have to make. Cruise time for calculated for the network are presented in Table 3-3:

Table 3-3 Calculated Cruise Times

Junction	From	To	Cruise Time
A409 High Street / Locket Road	Locket Road (J1:1/1)*	A409 High Street (J2:3/1)	15 seconds
	A409 High Street (J1:3/1)	Locket Road Exit (J1:4/1)	6 seconds
A409 High Street / A409 George Gange Way	A409 George Gange Way (J2:1/1)	A409 High Street (J1:2/1)	14 seconds
	A409 George Gange Way (J2:1/1)	High Street (J6:1/1)	10 seconds
High Street / Palmerston Road	Palmerston Road (J3:3/1)	High Street (J4:4/1)	9 seconds
	Palmerston Road (J3:3/1)	High Street (J7:3/1)	11 seconds
High Street / Masons Avenue / The Bridge / Ellen Webb Drive	Ellen Webb Drive (J4:3/1)	High Street (J3:2/1)	11 seconds

*Note – text in brackets denotes the link number in the LinSig models

Figure 3-1 Cruise Time Measurements – Both directions*



3.7. L205 Controller Data

The Controller Name, Signal Controller Number (SCN) and Controller Type have been set as per the TfL Signal Timing Sheets as follows:

- A409 High Street / Locket Road – 29/000086.
- A409 George Gange Way / High Street – 29/000079
- High Street / Palmerston Road – 29/000111
- Masons Avenue / The Bridge / Ellen Webb Drive / High Street – 29/000112
- A409 George Gange Way / The Bridge – 29/000080

3.8. L206 Phase Data

Phase data has been assigned as per the TfL Signal Timing Sheet, see Table 3-4 to Table 3-11 below.

Table 3-4 Phase Details for Controller 29/000086

Phase Name	Phase Description	Phase Type	Phase Minimum (secs)
A	High Street (S) Ahead and Right	Traffic	7
B	High Street (N) Ahead and Left	Traffic	7
C	Locket Road Left	Traffic	7
D	High Street (N) Crossing	Pedestrian	6
E	Locket Road Eastbound	Traffic	7
F	Locket Road Crossing	Pedestrian	5
G	Dummy Phase	-	3

Table 3-5 Phase Delays for Controller 29/000086

Stage From	Stage To	Phase Associated	Delay Period
1	3	A	2
1	3	B	2
3	1	C	6
3	2	C	6

Table 3-6 Phase Details for Controller 29/000079

Phase Name	Phase Description	Phase Type	Phase Minimum (secs)
A	A409 George Gange Way Ahead and Left	Traffic	7
B	A409 High Street (N) Ahead and Right	Traffic	7
C	High Street (S) Ahead and Right	Traffic	7
D	A409 High Street (N) Right	Indicative Right	4
E	High Street (N) Crossing	Pedestrian	6
F	High Street (S) Northbound Crossing	Pedestrian	6
G	High Street (S) Southbound Crossing	Pedestrian	6
H	A409 George Gange Way Crossing	Pedestrian	6
I	Dummy Phase	-	3

Table 3-7 Phase Delays for Controller 29/000079

Stage From	Stage To	Phase Associated	Delay Period
4	1	C	3
1	4	A	2
1	4	B	3

Table 3-8 Phase Details for Controller 29/000111

Phase Name	Phase Description	Phase Type	Phase Minimum (secs)
A	High Street (S) Ahead and Left	Traffic	4
B	Palmerston Road	Traffic	7
C	High Street (N) Ahead	Traffic	7
D	Public House Site Access	Traffic	7
E	High Street (S)	Traffic	7
F	High Street (N) Crossing	Pedestrian	5
G	High Street (S) Crossing	Pedestrian	5
H	Palmerston Road Crossing	Pedestrian	5
I	Dummy Phase	-	3

There are no phase delays applicable for this junction.

Table 3-9 Phase Details for Controller 29/000112

Phase Name	Phase Description	Phase Type	Phase Minimum (secs)
A	Ellen Webb Drive Ahead and Left	Traffic	7
B	High Street	Traffic	7
C	Masons Avenue Ahead and Left	Traffic	7
D	The Bridge	Traffic	7
E	Ellen Webb Drive Pedestrian Crossing	Pedestrian	7
F	High Street Pedestrian Crossing	Pedestrian	5
G	Masons Avenue Pedestrian Crossing	Pedestrian	5
H	The Bridge Pedestrian Crossing	Pedestrian	5
I	Dummy Phase	-	3

Table 3-10 Phase Delays for Controller 29/000112

Stage From	Stage To	Phase Associated	Delay Period
1	3	A	6
1	3	C	6

Table 3-11 Phase Details for Controller 29/000080

Phase Name	Phase Description	Phase Type	Phase Minimum (secs)
A	A409 George Gange Way (S)	Traffic	7
B	A409 George Gange Way (N)	Traffic	7
C	The Bridge Right	Bus / Cycle	7
D	Dummy Phase	-	3

There are no phase delays applicable for this junction.

3.9. L207 Lane Behaviour and Control Data

As per the method of control, right turning traffic on the relevant approaches within the model is opposed by traffic from the opposite approach and has to give way accordingly. Each opposed approach was therefore

modelled as a signal controlled give-way lane with the recommended values for the Maximum flow while giving way (1440 pcu/hr) and Give way co-efficient (1.09) applied to each lane.

3.10. L208 Intergreen and Interstage Data

Table 3-12 to Table 3-25 show the Phase Intergreen data applied in the Base LinSig model as per the TfL Timing sheets.

Table 3-12 Phase Intergreen Data for Controller 29/000086 (secs)

	A	B	C	D	E	F	G
A		-	-	7	-	-	3
B	-		5	5	-	-	3
C	-	5		-	-	5	3
D	11	11	-		-	-	6
E	-	-	-	-		5	3
F	-	-	9	-	9		4
G	2	2	2	2	2	2	

Table 3-13 Phase Intergreen Data for Controller 24/000079 (secs)

	A	B	C	D	E	F	G	H	I
A		-	6	5	9	-	7	5	3
B	-		5	-	5	-	10	9	3
C	5	5		5	8	5	-	9	3
D	7	-	5		5	-	10	-	3
E	11	11	11	11		-	-	-	6
F	-	-	8	-	-		-	-	3
G	8	8	-	8	-	-		-	3
H	11	11	11	-	-	-	-		6
I	2	2	2	2	2	2	2	2	

Table 3-14 Phase Intergreen Data for Controller 29/000111 (secs)

	A	B	C	D	E	F	G	H	I
A		5	-	5	-	7	5	-	3
B	5		5	5	5	7	7	5	3
C	-	5		5	5	5	7	-	3
D	5	5	5		5	7	8	7	3
E	-	5	6	5		8	5	7	3
F	12	12	12	12	12		-	-	5
G	12	12	12	12	12	-			5
H	-	12	-	12	12	-	-		5
I	2	2	2	2	2	2	2	2	

Table 3-15 Phase Intergreen Data for Controller 29/000112 (secs)

	A	B	C	D	E	F	G	H	I
A		5	-	5	5	8	9	-	3
B	5		6	-	10	5	9	8	3
C	-	5		5	8	-	5	-	3
D	5	-	5		8	8	8	5	3
E	14	14	14	14		-	-	-	7
F	11	11	-	11	-		-	-	5
G	9	9	9	9	-	-		-	4
H	-	11	-	11	-	-	-		5
I	2	2	2	2	2	2	2	2	

Table 3-16 Interstage Data for Controller 29/000086 (secs)

	1	2	3
1		9	9
2	5		7
3	11	11	

Table 3-17 Interstage Data for Controller 29/000079 (secs)

	1	2	3	4
1		5	10	13
2	7		10	10
3	11	11		11
4	8	8	9	

Table 3-18 Interstage Data for Controller 29/000111 (secs)

	1	2	3	4	5
1		5	7	5	5
2	6		8	5	5
3	12	12		12	12
4	5	5	7		5
5	5	5	8	5	

Table 3-19 Interstage Data for Controller 29/000112 (secs)

	1	2	3
1		9	11
2	14		14
3	6	10	

Table 3-20 Interstage Data for Controller 29/000080 (secs)

	1	2
1		5
2	5	

3.11. L209 Stage Data

Figure 3-2 shows the Stage Sequence which operates at the junctions under the typical operating conditions.

Figure 3-2 Stage Diagram for Controller 29/000086

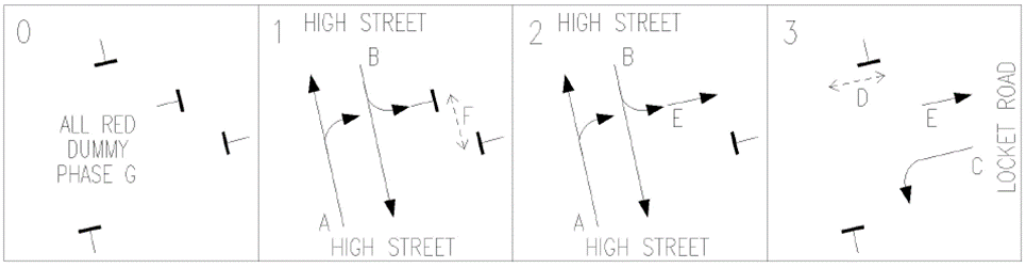


Figure 3-3 Stage Diagram for Controller 29/000079

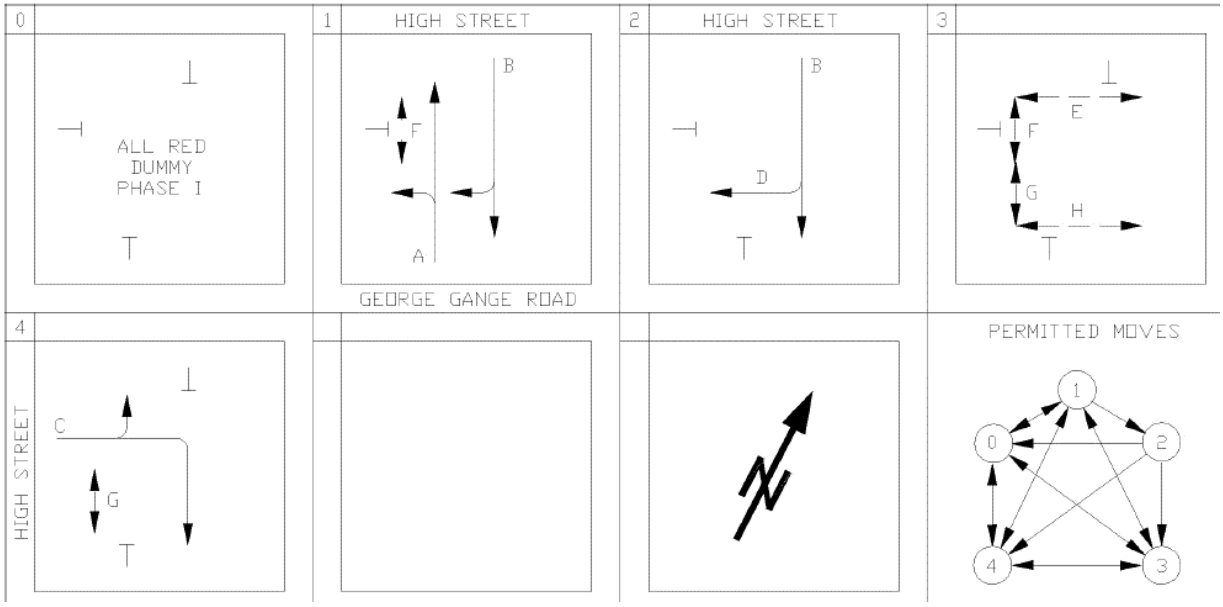


Figure 3-4 Stage Diagram for Controller 29/000111

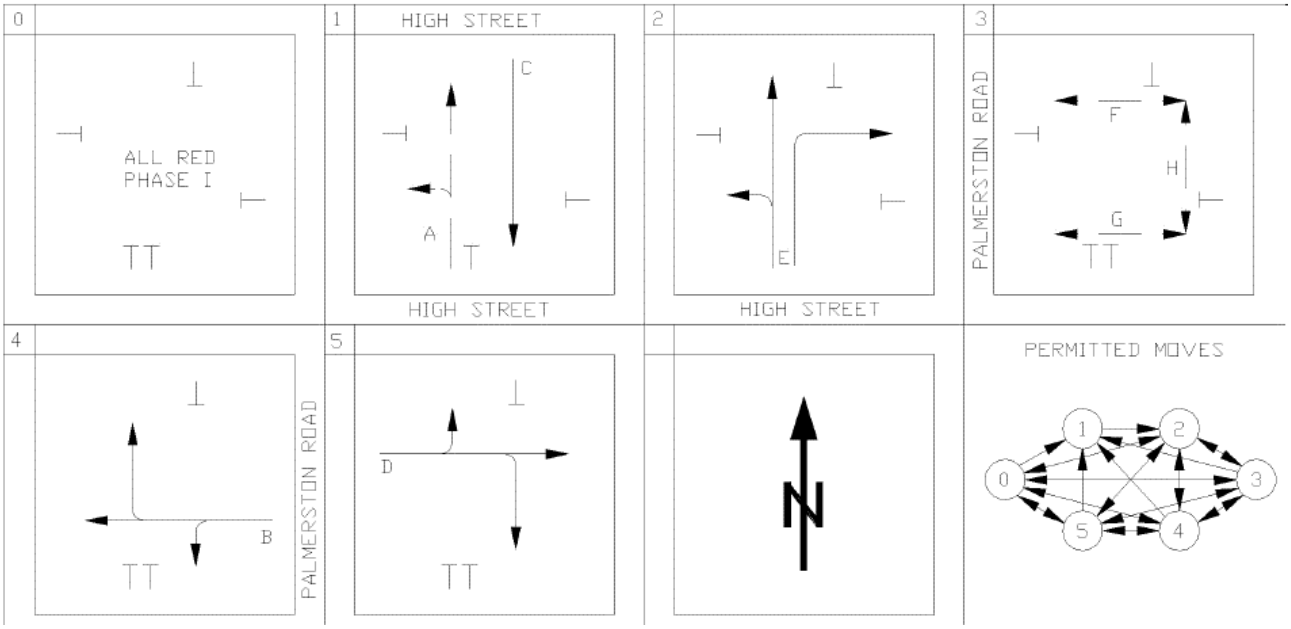


Figure 3-5 Stage Diagram for Controller 29/000112

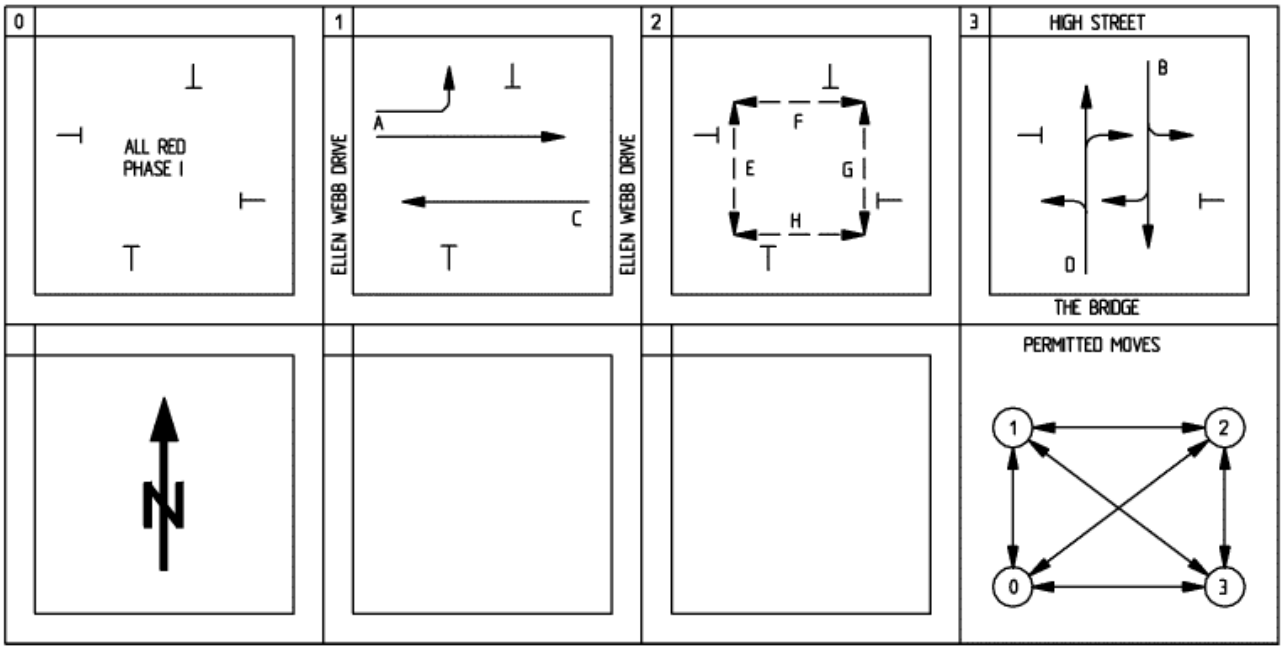
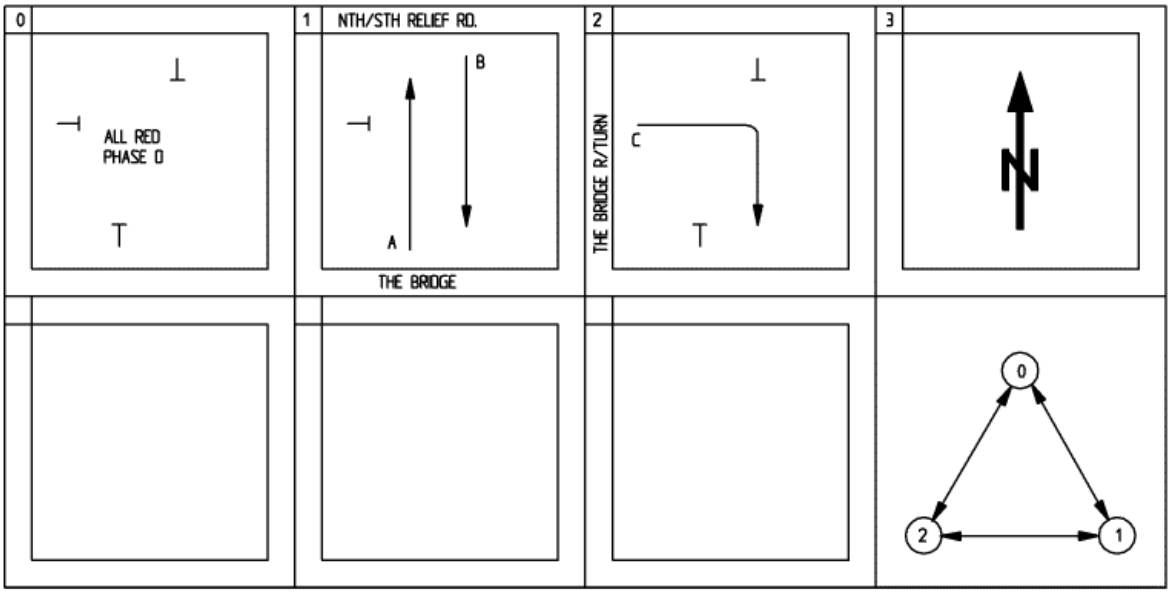


Figure 3-6 Stage Diagram for Controller 29/000080



3.12. L210 Stage Sequence and Signal Timings

There are four controllers within the network that operate on a VA method of control, which varies signal timings in response to traffic demand. In order to obtain average green timings, observations were made on site and using video footage during the peak hours and a minimum of 10 readings were recorded for each approach.

Table 3-21 to Table 3-25 shows the observed average signal timings and cycle times for the two peaks assessed which were inputted into the model. Cycle times have been calculated using observed green times as controllers operating on a VA method of control did not always call demand dependant stages. Note, the green and cycle times presented do not take into account demand dependency adjustments which result when demand depend stages are not called. Demand dependency adjustments will be considered at the LMAP 3 stage.

Table 3-21 Observed Cycle Times for Controller 29/000086 (secs)

Peak	Stage 1	Intergreen	Stage 2	Intergreen	Stage 3	Intergreen	Cycle Time from Average Green Time
AM	36	9	5	7	15	11	83
PM	41	9	5	7	15	11	88

Table 3-22 Observed Cycle Times for Controller 29/000079 (secs)

Peak	Stage 1	Intergreen	Stage 3	Intergreen	Stage 4	Intergreen	Cycle Time from Average Green Time
AM	27	10	6	11	13	8	75
PM	30	10	6	11	11	8	76

Table 3-23 Observed Cycle Times for Controller 29/000111 (secs)

Peak	Stage 1	Intergreen	Stage 2	Intergreen	Stage 3	Intergreen	Stage 4	Intergreen	Cycle Time from Average Green Time
AM	12	5	10	5	7	12	11	5	67

Peak	Stage 1	Intergreen	Stage 2	Intergreen	Stage 3	Intergreen	Stage 4	Intergreen	Cycle Time from Average Green Time
PM	11	5	10	5	7	12	12	5	67

Table 3-24 Observed Cycle Times for Controller 29/000112 (secs)

Peak	Stage 1	Intergreen	Stage 2	Intergreen	Stage 3	Intergreen	Cycle Time
AM	25	9	6	14	20	6	80
PM	21	9	6	14	14	6	70

Table 3-25 Observed Cycle Times for Controller 29/000080 (secs)

Peak	Stage 1	Intergreen	Stage 2	Intergreen	Cycle Time from Average Green Time
AM	59	5	8	5	77
PM	77	5	9	5	96

3.13. L211 LinSig Scenarios

Base LinSig model scenarios were prepared for the AM Peak and PM Peak hours.

3.14. L212 Other Modelling Issues

There were no other modelling issues to highlight.

4. LMAP Stage 3 Validated Base Model

4.1. Introduction

The calibrated Base LinSig Model developed and approved by TfL for the LMAP 2 stage was adjusted for Demand Dependency and Underutilised Green Time to ensure a better fit of the Base LinSig results with the observed operation at the junction and also to validate the model against the key validation parameters, namely the Degree of Saturation (DoS) and queue length.

4.2. L302 Adjustments from Calibrated Model

No adjustments have been made to the calibrated Base LinSig Model approved at the LMAP 2 stage.

4.3. L303 Appropriate Peak-Specific Signal Timings

Four of the five signal controllers at the junctions within the network operate a VA method of control and the remaining controller operates a Fixed Time method of control with set green times and cycle times. The signal timings for all the junctions were observed from traffic surveys and a site visit to determine the peak hour operation.

Table 4-1 shows the average green time by phase and cycle time recorded at each junction during the traffic surveys for the AM and PM peak hours. These average timings are based on the observations which were recorded for every cycle during both the AM and PM peak hours.

Table 4-1 Average Cycle Time and Green Times by Phase

		A409 / Locket Road		A409 George Gange / High St		High St / Palmerston Rd		High St / Masons Ave / The Bridge / Ellen Webb Dr		A409 / The Bridge	
		AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
Average Green Time by Phase (secs)	A	36	41	27	30	27	26	26	21	59	77
	B	36	41	27	30	11	12	20	14	59	77
	C	15	15	13	11	12	11	25	21	8	9
	D	5	5	-	-	-	-	20	14		
	E	-	-	6	6	10	10	7	7		
	F	5	5	6	6	5	5	5	5		
	G			6	6	5	5	5	5		
	H			6	6	5	5	5	5		
Average Cycle Time (secs)		61	66	66	69	56	60	80	70	77	96

4.4. L304 Adjustments for Demand Dependency & Underutilised Green Time

An analysis of the average phase and cycle timings recorded at the VA controlled junctions which also operate demand dependent stages (i.e. namely the A409 High Street / Locket Road, the A409 George Gange Way / High Street and the High Street / Palmerston Road junctions) indicated that the average cycle time recorded at these junctions did not match with the total cycle time when the average green time recorded for the individual phases was applied in signal timings at these junctions. Applying the individual average phase green times resulted in cycle times which were higher than the average cycle times observed at the junction. These differences are a result of demand dependent traffic and pedestrian stages that operate at these junctions. For the High Street / Masons Avenue / The Bridge junction which operates a Fixed Time method of control and the A409 George Gange Way / The Bridge junction which operates a VA method of control but with no demand dependent stages, the average green times corresponded with the average cycle times recorded during the surveys.

Signal timings (phase green and cycle times) were recorded for each cycle during the AM and PM peak hours and therefore provide an accurate reflection of the total and average green times allocated at each junction approach (including the impact of demand dependent stages). These timings were therefore used as the basis for defining the signal timings for the junctions within the LinSig models.

As discussed, for the A409 High Street / Locket Road, the A409 George Gange Way / High Street and the High Street / Palmerston Road junctions, the application of the observed average green times resulted in cycle times which were higher than the observed average cycle times. In order to reconcile this apparent discrepancy, the approach adopted was to retain the average cycle times in the LinSig models which then meant it was not possible to apply the full value of the observed average green time for some phases. Therefore, to achieve the full value of the observed green time, bonus greens were then applied.

Also at the High Street / Locket Road junction, the frequency of demand at the pedestrian crossing on Locket Road was recorded in order to calculate the bonus greens to be added to the traffic phase E when the pedestrian stage is not demanded. Table 4-2 shows the total number of cycles, the demand for the Locket Road pedestrian crossing and the bonus green added during both the AM and PM peak hours.

Table 4-2 Bonus Greens at A409 High Street / Locket Road Junction

Peak Hour	Demand Dependent Stage	Total Number of Cycles	Cycles Locket Road Crossing Called	Stage Benefitting	Bonus Green Added
AM	1	59	14	2	10
PM		54	19		9

Table 4-3 presents the green times, including the bonus green adjustments applied in the LinSig model for the AM and PM peak periods.

Table 4-3 Bonus Greens Added to Match Observed and Modelled Green Times

Junction	Approach	AM Peak			PM Peak		
		Observed Average Green Time (secs)	Modelled Green Time		Observed Average Green Time (secs)	Modelled Green Time	
			Phase Green Time (secs)	Bonus Green Added (secs)		Phase Green Time (secs)	Bonus Green Added (secs)
A409 High Street / Locket Road	A409 High Street (N)	36	36	-	41	41	-
	Locket Road (WB left)	15	15	-	15	15	-
	Locket Road (EB ahead)	36	36	10	41	41	9

Junction	Approach	AM Peak			PM Peak		
		Observed Average Green Time (secs)	Modelled Green Time		Observed Average Green Time (secs)	Modelled Green Time	
			Phase Green Time (secs)	Bonus Green Added (secs)		Phase Green Time (secs)	Bonus Green Added (secs)
	A409 High Street (S) Ahead	36	36	-	41	41	-
	A409 High Street (S) Right	36	36	-	41	41	-
A409 George Gange Way / High Street	A409 High Street (N)	27	22	5	30	24	6
	A409 George Gange Way	27	22	5	30	24	6
	High Street (S)	13	13	-	11	11	-
High Street / Palmerston Road	High Street (N)	12	7	5	11	7	4
	Palmerston Road	11	7	4	12	11	-
	High Street (S) Ahead	27	19	8	26	19	7
	High Street (S) Right	10	7	3	10	7	3

Underutilised green time values for all approaches were measured during the Degree of Saturation (DoS) surveys using the TfL methodology and DoS/UGT template. The UGT was applied on the appropriate lanes. Table 4-4 shows the UGT applied on approaches during the AM and PM peak hours. Note, negative UGT values were not applied in the model.

Table 4-4 Underutilised Green Time

Junction	Approach	Underutilised Green Time (UGT)	
		AM Peak	PM Peak
A409 High Street / Locket Road	Locket Road	0	0
	High Street (S) Ahead	-1	1
	High Street (N)	0	0
A409 George Gange Way / High Street	A409 George Gange Way	0	0
	High Street (S)	-1	-1
	A409 High Street (N)	1	1
High Street / Palmerston Road	Palmerston Road	0	0
	High Street (S) Ahead and Left	0	0
	High Street (N)	-1	-1
Ellen Webb Drive / The Bridge / High Street / Masons Avenue	Masons Avenue	-1	0
	The Bridge Ahead and Left	-2	-1
	Ellen Webb Drive Ahead	2	0
	High Street	0	0
The Bridge / A409 George Gange Way	A409 George Gange Way (N)	0	1
	The Bridge Right	0	0
	A409 George Gange Way (S)	0	0

4.5. L305 Traffic Flows and Flow Consistency

Traffic flows were derived from the classified junction counts conducted at the junction. The traffic flows were entered using Fixed Lane Flow Group. Separate traffic flow layers were prepared for general traffic and public transport (i.e. TfL buses).

4.6. L306 Public Transport Modelling

Public transport flows were derived from the classified junction turning counts.

4.7. L307 LinSig Scenarios

Base LinSig Scenarios were prepared for the AM and PM peak hours which were identified from the traffic counts at the junction.

4.8. L308 Degree of Saturation (DoS) Validation

Table 4-5 shows the comparison of DoS recorded on-street and in the model. The results indicate that the modelled DoS matched closely with the observed DoS data. The model results for the DoS validated within five percent of the observed DoS for all lanes within the modelled network.

The DoS results for flare lanes have not been compared as the LinSig model does not provide a separate DoS for the flare lane but reports the same values as the adjacent long lane.

Table 4-5 Comparison of Observed and Modelled Degree of Saturation

Junction	Approach	Degree of Saturation (DoS) %			
		AM Peak		PM Peak	
		Observed	Modelled	Observed	Modelled
A409 High Street / Locket Road	Locket Road	28.9	31.0	35.8	37.8
	High Street (S) Ahead	60.7	56.5	70.4	70.3
	High Street (N)	48.8	46.5	52.5	49.5
A409 George Gange Way / High Street	A409 George Gange Way	72.7	73.1	81.3	79.1
	High Street (S)	73.3	78.7	85.6	91.0
	A409 High Street (N)	78.7	81.9	75.9	77.9
High Street / Palmerston Road	Palmerston Road	64.8	62.0	65.5	69.5
	High Street (S) Ahead and Left	33.5	29.1	35.4	31.0
	High Street (N)	22.1	17.5	21.1	18.1
Ellen Webb Drive / The Bridge / High Street / Masons Avenue	Masons Avenue	89.0	85.5	83.8	80.9
	The Bridge Ahead and Left	33.7	34.2	48.8	48.0
	Ellen Webb Drive Ahead	95.1	99.0	86.4	89.8
	High Street	52.9	53.0	78.4	77.1
The Bridge / A409 George Gange Way	A409 George Gange Way (N)	78.5	74.3	63.3	62.6
	The Bridge Right	25.8	24.5	26.6	29.3
	A409 George Gange Way (S)	61.1	63.2	61.9	66.1

4.9. L309 Queue Length Validation

Table 4-6 shows the comparison of queue lengths recorded on-street and in the model. The results also indicate that the modelled queue lengths correlate well with the observed queue lengths on most approaches within the model.

There are disparities between the observed and modelled queue lengths at A409 High Street / Locket Road (29/086) and A409 George Gange Way / High Street (29/079). Using the traffic survey video footage, the following observations have been made:

- The main reason for longer observed queueing is due to the interaction between the two junctions. Queues build up on A409 High Street (South), High Street (South) and A409 George Gange Way when the green signals at junction 29/079 coincide with a red phase on High Street (South).
- Bus stops to the north and south of the A409 High Street / Locket Road junction exacerbates queues.

In general, the queues which build up during the red phase clear fairly quickly and all queues clear during the green phase.

Table 4-6 Comparison of observed average maximum queue lengths to LinSig mean maximum queue lengths (PCUs)

Junction	Approach	Queue Length (PCUs)			
		AM Peak		PM Peak	
		Observed	Modelled	Observed	Modelled
A409 High Street / Locket Road	Locket Road	1	2	2	3
	High Street (S) Ahead	11	5	12	9
	High Street (S) Right	3	-	7	-
	High Street (N)	12	5	11	6
A409 George Gange Way / High Street	A409 George Gange Way	14	10	20	12
	High Street (S)	8	7	15	9
	A409 High Street (N) Ahead	13	12	12	11
	A409 High Street (N) Right	3	-	2	-
High Street / Palmerston Road	Palmerston Road	5	4	6	5
	High Street (S) Ahead and Left	3	2	4	2
	High Street (S) Right	2	-	2	-
	High Street (N)	2	1	3	1
Ellen Webb Drive / The Bridge / High Street / Masons Avenue	Masons Avenue	16	14	16	11
	The Bridge Ahead and Left	4	3	5	3
	The Bridge Right	1	-	1	-
	Ellen Webb Drive Ahead	16	25	11	14
	Ellen Webb Drive Left	6	-	4	-
	High Street	7	5	7	6
The Bridge / A409 George Gange Way	A409 George Gange Way (N)	9	12	8	10
	The Bridge Right	1	1	2	2
	A409 George Gange Way (S)	7	8	8	11

5. Summary and Conclusion

A validated LinSig Base model (for the LMAP 3 Stage) has been developed for Wealdstone Town Centre for the AM (0800 – 0900 hours) and PM peak (1715 – 1815 hours) hours.

The model was developed in accordance with the TfL requirements for LinSig. The AM and PM base models were validated against key validation criteria: Degree of Saturation (DoS). In addition, validation against queue length was undertaken.

The results indicate that the modelled DoS on all arms at each junction within the network validate within five percent of the observed values during each of the peak hours. There is a good correlation between the modelled and observed queue lengths at most junctions, other than at the A409 High Street / Locket Road and A409 George Gange Way / High Street junction. The reasons for the disparities have been outlined in section L309.

Therefore, the Base LinSig model is considered to be an accurate representation of the existing conditions in operation at each junction within the network.

Nii Dodoo
Atkins Limited
Woodcote Grove
Ashley Road
Epsom
Surrey
KT18 5BW

Email Nii.Dodoo@atkinsglobal.com

Appendix H. WeLHAM Modelling Technical Note

Internal Technical note

Project:	Wealdstone Town Centre	**To:**	LB Harrow and Transport for London
Subject:	WeLHAM Model -Base Year 2012	**From:**	Atkins
Date:	20 February 2017	**cc:**	

1. Introduction

Atkins was commissioned by London Borough of Harrow (LBH) to develop design options that will facilitate regeneration by identifying measures to:

- Mitigate the impact of proposed development on the road network
- Improve pedestrian and cycle access to the town centre, particularly east-west connections
- Enhance connections to public transport and maintain journey times
- Enhance the public realm
- Reduce street clutter
- Improve air quality

Ultimately the objective of the scheme is to enhance the economic vitality of the town centre by enabling and supporting developments through the provision of improved infrastructure for all modes and an enhanced public realm.

Wealdstone is located near the centre of the London Borough of Harrow (LBH). There is good accessibility to public transport with the Harrow and Wealdstone railway and tube station located close to the main high street and bus routes/stops adjacent to the station and on High Street. The A409 is a single carriageway and is the main road travelling north to south through Wealdstone, although it by-passes Wealdstone town centre itself. Wealdstone town centre and the nearby Harrow town centre, have been collectively named as the 'Heart of Harrow' by LBH in the 2013 Harrow and Wealdstone Area Action Plan (H&W AAP).

Figure 1 shows the agreed study area which will be further assessed using local traffic models prepared by the team. The figure also shows the planned developments between 2016 and 2021.

Figure 2 shows the modelling area identified based on the criteria given in the West London Highway Assignment Model (WeLHAM) guidelines which is 2 km around the interventions approach.

Atkins received the WeLHAM transport model during September 2016 for base year 2012 and forecast years 2021, 2031 and 2041 (AM, IP and PM peaks). As the proposed schemes are likely to change the traffic management in the town centre, it is intended to use the WeLHAM model to determine the future year traffic flows and turning volumes at key junctions in the study area as a result of the proposed schemes. These will then be used to inform the local traffic modelling of the junctions. Atkins reviewed the WeLHAM base year model files as part of this study to identify the essential changes to the model especially for the forecast year (specifically 2021) including the fitness of purpose for this study. The findings of this review are described in the next section.

Also the technical note describes the following:

- Section 3: The base year 2012 model update to year 2016 and the results compared to the latest traffic survey dated 2016.
- Section 4: Way-forward including forecast year modelling approach.

Internal Technical note

Figure 1– Wealdstone Study Area

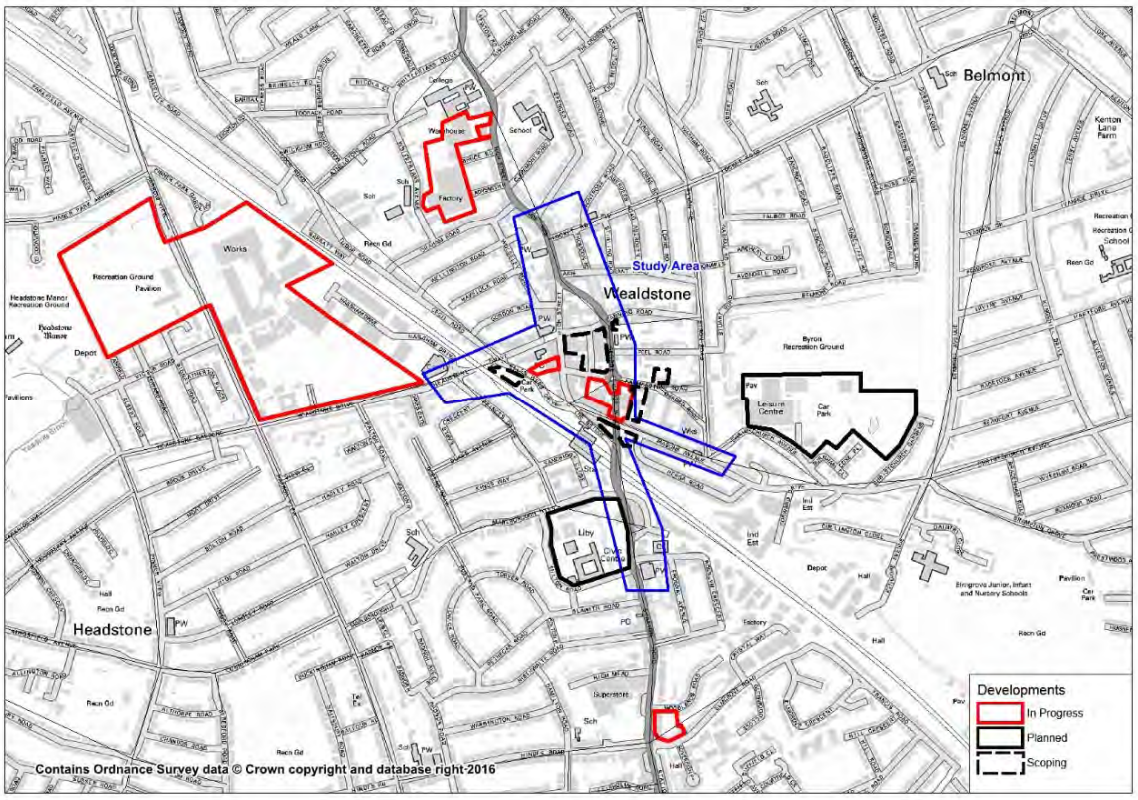
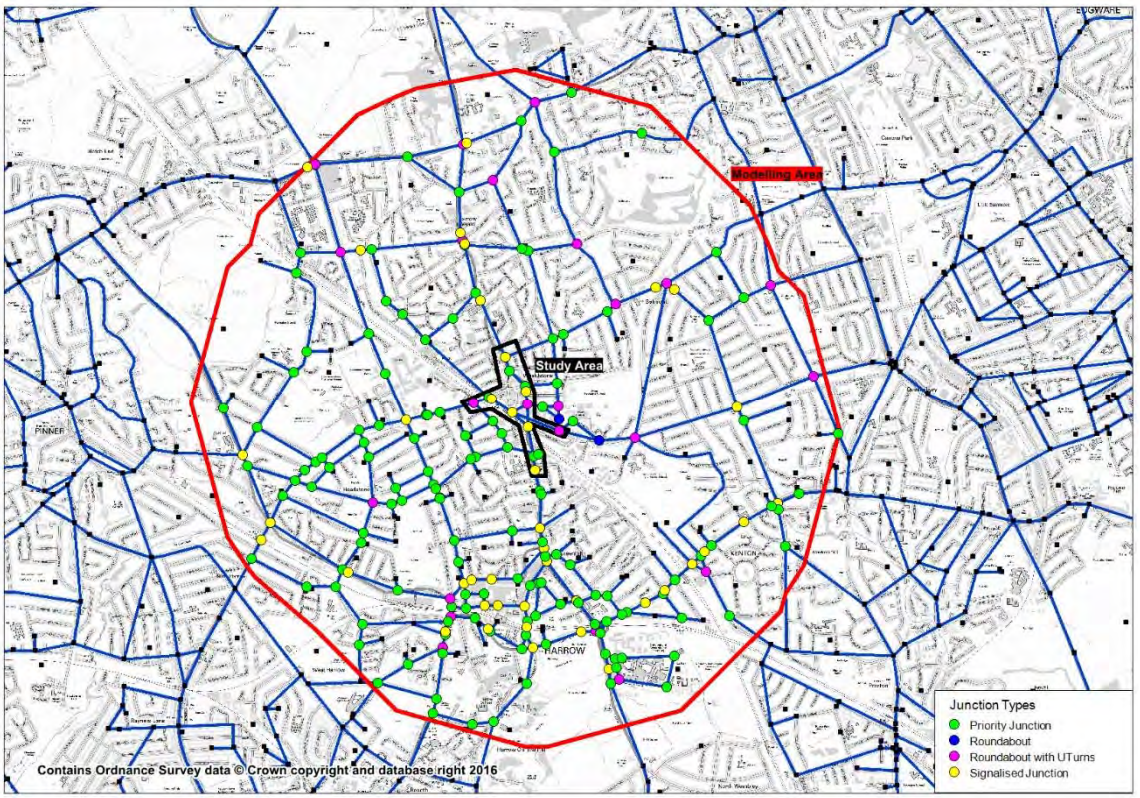


Figure 2– Modelling Study Area



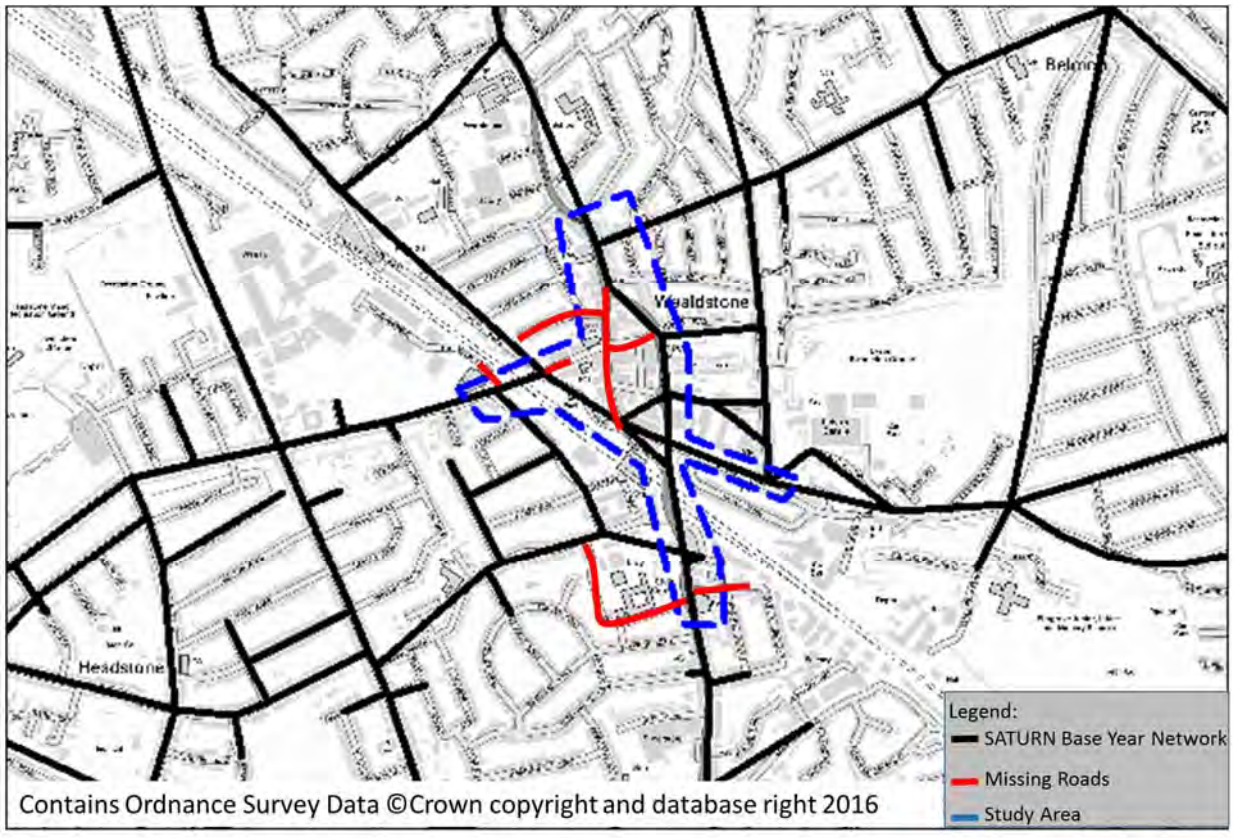
2. Base Year 2012 "As Is" Review

2.1. Network

The base year 2012 network was reviewed and compared against the existing road network and found that the base year network, for the purposes of this study, needed to be updated in order to provide adequate coverage for testing the interventions being developed.

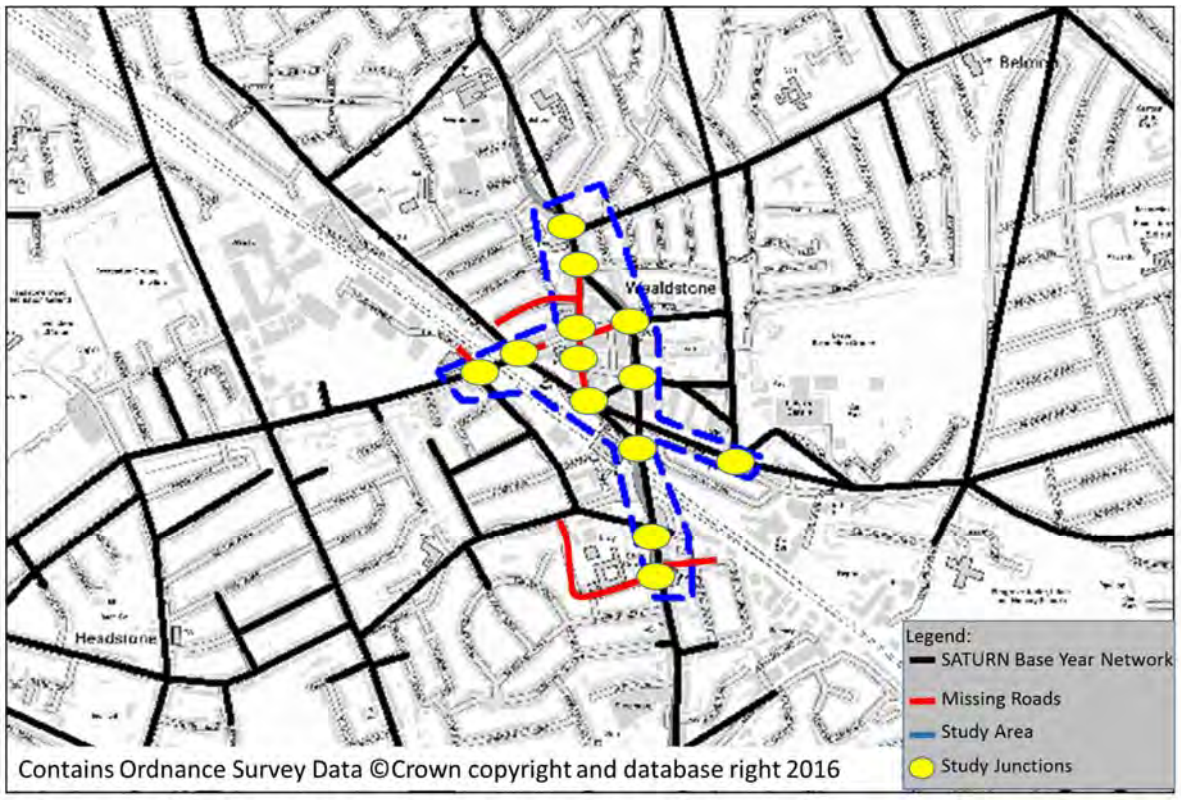
Figure 3 shows the roads in red that need to be included as part of the base year update to provide the required additional network coverage. Specifically, the eastern arm of the Headstone Drive / Ellen Webb Drive junction, which is currently a stub, Hailsham Drive, High Street, Gordon Road, Canning Road with Gladstone Way connection to Palmerston Road), Palmerston Road connection to the High Street and the Milton Road connection from Marlborough Hill to A409 Station Road.

Figure 3– Missing Roads in Wealdstone Area



As a result of the missing roads, many junctions did not exist or are incorrectly presented in the study area network. The junctions shown in Figure 4 were reviewed in detail as part of the base year network update.

Figure 4– Junctions in Wealdstone Area



2.2. "As Is" Review Findings

A review of the model convergence settings found that the overall model failed to meet one of the two WebTAG criteria. A further review of the model run logs indicated that despite this, the model was reasonably well converged and that the impact of making these settings to comply with WebTAG should not have a significant impact on the overall results. Therefore, to maintain the existing runtimes, no changes were made to the convergence settings.

A comparison of traffic volume between the traffic survey completed in 2016 and the modelled traffic volumes from the latest run for the available junctions in the base year network "As Is" was completed for both morning and evening peaks hours.

An initial comparison (where possible) of the modelled traffic volumes for year 2012 against these counts reported 15 of 43 turns that are modelled and have a GEH of less than 7.5 in the AM Peak. In the PM Peak 8 of 43 turns modelled have a GEH of less than 7.5. Table 1 and 2 show the results for the AM and PM peaks respectively. The use of the GEH less than 7.5 is based on the advice provided in version 2.5 of the TfL Sub-regional Highway Assignment Models - Guidance on Model Use (July 2016).

Table 1 – Year 2012 AM Peak Observed Traffic vs. Model traffic

Junction Name	Road Name	Modelled Flows BY 2012 (PCU)	Observed Flows (PCU)	GEH
A409 Station Road / Milton Road / Rosslyn Crescent	Milton Road	Not Modelled	74	Not Modelled
	A409 Station Approach (North Approach)	Not Modelled	1045	Not Modelled
	Rosslyn Crescent	Not Modelled	32	Not Modelled
	A409 Station Approach (South Approach)	Not Modelled	950	Not Modelled
A409 Station Road / Marlborough Hill (priority junction)	A409 Station Approach (North Approach)	1060	911	5
	A409 Station Approach (South Approach)	1376	1012	11
	Marlborough Hill	60	119	6
A409 The Bridge / George Gange Way (signalised junction)	The Bridge	241	102	11
	George Gange Way	1169	964	6
	A409 Station Road	1060	915	5
A409 George Gange Way / Palmerston Road roundabout (priority roundabout)	Palmerston Road (West Approach)	Not Modelled	96	Not Modelled
	George Gange Way (North Approach)	828	870	1
	Palmerston Road (East Approach)	418	469	2
	George Gange Way (South Approach)	922	796	4
A409 George Gange Way / High Street (signalised junction)	High Street (South Approach)	Not Modelled	299	Not Modelled
	High Street (North Approach)	764	642	5
	George Gange Way	813	571	9
A409 High Street / Locket Road (signalised junction)	High Street (North Approach)	791	571	8
	Locket Road	8	132	15
	High Street (South Approach)	813	779	1
Christchurch Avenue / Masons Avenue / Byron Road (priority roundabout)	Masons Avenue (West Approach)	490	555	3
	Byron Road	368	592	10
	Christchurch Avenue	422	14	28
	Masons Avenue (East Approach)	507	862	14
Headstone Drive / Princes Drive / Hailsham Drive (priority roundabout)	Headstone Drive (South Approach)	319	785	20
	Hailsham Drive	Not Modelled	34	Not Modelled
	Headstone Drive (North Approach)	1035	880	5
	Princes Drive	221	65	13
High Street / Palmerston Road (signalised junction)	High Street (North Approach)	Not Modelled	65	Not Modelled
	Palmerston Road	Not Modelled	218	Not Modelled
	High Street (South Approach)	Not Modelled	290	Not Modelled
Ellen Webb Drive / The Bridge / High Street / Masons Avenue (signalised junction)	Ellen Webb Drive (West Approach)	469	739	11
	High Street	Not Modelled	239	Not Modelled
	Masons Avenue	716	531	7
	The Bridge	92	176	7
Ellen Webb Drive / Headstone Drive /Cecil Road (priority junction)	Headstone Drive (North Approach)	Not Modelled	33	Not Modelled
	Ellen Webb Drive	745	719	1
	Headstone Drive (South Approach)	358	760	17
	Cecil Road	501	398	5
Canning Road / High Street	High Street (North Approach)	Not Modelled	75	Not Modelled
	High Street (South Approach)	Not Modelled	246	Not Modelled
High Street / Gordon Road	High Street (North Approach)	Not Modelled	69	Not Modelled
	High Street (South Approach)	Not Modelled	227	Not Modelled
Summary	**Number of Link Considered**	**27**	**43**	
	% Links GEH <7.5			**56% (15 Links)**

Table 2 – Year 2012 PM Peak Observed Traffic vs. Model traffic

Junction Name	Road Name	Modelled Flows BY 2012 (PCU)	Observed Flows (PCU)	GEH
A409 Station Road / Milton Road / Rosslyn Crescent	Milton Road	Not Modelled	88	Not Modelled
	A409 Station Approach (North Approach)	Not Modelled	942	Not Modelled
	Rosslyn Crescent	Not Modelled	46	Not Modelled
	A409 Station Approach (South Approach)	Not Modelled	968	Not Modelled
A409 Station Road / Marlborough Hill (priority junction)	A409 Station Approach (North Approach)	1375	996	11
	A409 Station Approach (South Approach)	1376	869	15
	Marlborough Hill	73	122	5
A409 The Bridge / George Gange Way (signalised junction)	The Bridge	203	74	11
	George Gange Way	1180	837	11
	A409 Station Road	1375	1002	11
A409 George Gange Way / Palmerston Road roundabout (priority roundabout)	Palmerston Road (West Approach)	Not Modelled	145	Not Modelled
	George Gange Way (North Approach)	847	773	3
	Palmerston Road (East Approach)	445	468	1
	George Gange Way (South Approach)	1141	821	10
A409 George Gange Way / High Street (signalised junction)	High Street (South Approach)	Not Modelled	287	Not Modelled
	High Street (North Approach)	760	642	4
	George Gange Way	999	654	12
A409 High Street / Locket Road (signalised junction)	High Street (North Approach)	832	549	11
	Locket Road	6	149	16
	High Street (South Approach)	999	866	4
Christchurch Avenue / Masons Avenue / Byron Road (priority roundabout)	Masons Avenue (West Approach)	511	536	1
	Byron Road	190	469	15
	Christchurch Avenue	331	13	24
	Masons Avenue (East Approach)	440	903	18
Headstone Drive / Princes Drive / Hailsham Drive (priority roundabout)	Headstone Drive (South Approach)	425	664	10
	Hailsham Drive	Not Modelled	110	Not Modelled
	Headstone Drive (North Approach)	550	766	8
	Princes Drive	182	88	8
High Street / Palmerston Road (signalised junction)	High Street (North Approach)	Not Modelled	69	Not Modelled
	Palmerston Road	Not Modelled	225	Not Modelled
	High Street (South Approach)	Not Modelled	281	Not Modelled
Ellen Webb Drive / The Bridge / High Street / Masons Avenue (signalised junction)	Ellen Webb Drive (West Approach)	362	716	15
	High Street	Not Modelled	246	Not Modelled
	Masons Avenue	511	486	1
	The Bridge	189	205	1
Ellen Webb Drive / The Bridge / High Street / Masons Avenue (signalised junction)	Headstone Drive (North Approach)	Not Modelled	103	Not Modelled
	Ellen Webb Drive	344	723	16
	Headstone Drive (South Approach)	386	789	17
	Cecil Road	0	205	20
Canning Road / High Street	High Street (North Approach)	Not Modelled	65	Not Modelled
	High Street (South Approach)	Not Modelled	249	Not Modelled
High Street / Gordon Road	High Street (North Approach)	Not Modelled	67	Not Modelled
	High Street (South Approach)	Not Modelled	195	Not Modelled
Summary	**Number of Link Considered**	**27**	**43**	
	% Links GEH < 7.5			**30% (8 Links)**

There are many possible reasons for the differences between modelled and observed flows at the above locations, including the network representation in SATURN (which focuses primarily on the strategic network) resulting in a different traffic distribution, difference in the zonal trip ends due to variation in land use assumptions and network loading points which relates to network connectivity.

3. Base Year Update to 2016

3.1. Highway Network

As result of the review described above, Atkins has updated the base year network to reflect the latest road network for year 2016 using external sources such as Google Earth and site visit observations. The network was reviewed in detail for the modelling and study area networks.

LBH provided a list of highway schemes that have been completed between 2012 and 2016. These are:

- Stanmore Broadway / Uxbridge Road – amendments to the traffic signals by incorporating an all red pedestrian phase;
- Long Elms – inset parking bays bus priority;
- Eastcote Lane / Roxeth Green Avenue / Rayners Lane – new roundabout;
- Common Road / The Common / Bushey High Road– localised widening;
- Rayners Lane – inset parking bays;
- Mollison Way – inset parking bays;
- Station Road / Hindes Road – removal of bus by pass signals; and,
- The Ridgeway - inset parking bays.

These changes are localised and generally should not be included in a strategic model for most cases except for:

- Stanmore Broadway / Uxbridge Road – amendments to the traffic signals by incorporating an all red pedestrian phase;
- Eastcote Lane / Roxeth Green Avenue / Rayners Lane – new roundabout; and
- Common Road / The Common / Bushey High Road– localised widening.

These were reviewed and it was found that the impact of updating these was unlikely to be sufficient to have a significant impact on the Wealdstone town centre study area.

In line with the TfL modelling guidance regarding modelling area definition, the network with a 2km buffer around the study area where interventions are being considered, has been reviewed including the missing roads and junction coding to be able to improve the base year assignment for the Wealdstone study area. Some of these changes/updates will also be carried to the future network (2021) where suitable.

There are more than 200 nodes (excluding external nodes) within the modelling area, these were checked and adjusted as necessary. To manage the checks and updates a detailed log file was maintained, with each junction being categorized by level of change required. The “error” classification indicates junctions where the supplied coding was sufficiently different from the London Highway Assignment Model (LoHAM) coding templates (and calibration range) in the model development report or mapping, as to lead to a material change in the results. The “warning” classification was applied to junctions where, despite the coding being outside the calibration ranges prescribed by the LoHAM development report or different to the mapping, a correction was deemed to be insufficient to materially change the resulting assignment. These have been mapped in Figure 5 and the “errors” are presented in Table 3.

Figure 5–Junction Review Notes

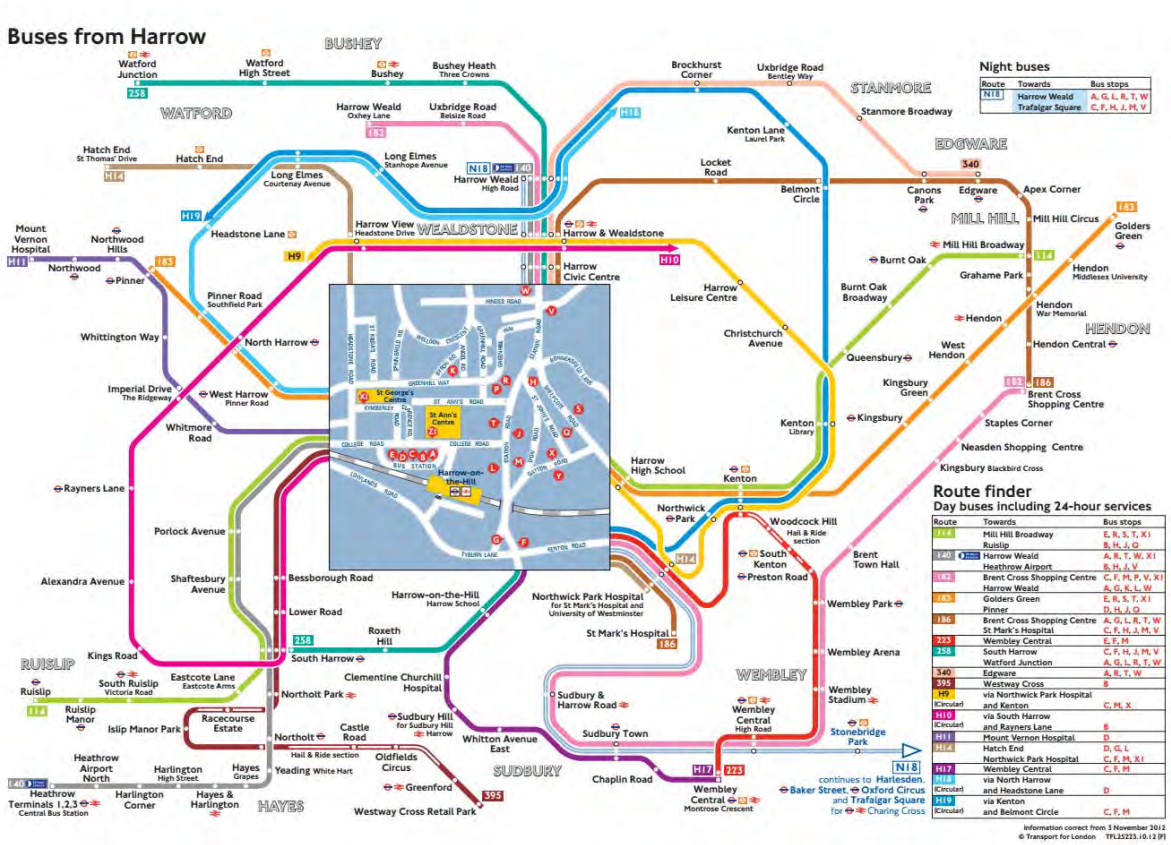
Table 3- Modelling Area Junctions Review – Junctions with 'Errors'

Junction Name	Commentary
High St / West St	Right turn from West Street is banned in the mapping, but allowed in the model.
A404 Lowlands Rd / A404 Junction Rd	Layout is consistent with mapping and turning saturation flows consistent with template. Circulatory capacity is much lower than the calibration range (1800, range is 2550-3050).
Headstone Dr / Harrow View	Saturation flows are outside of the calibration range.
Kenton Ln / Christchurch Av	Some very low saturation flows, with eastern and western arms having double the number of mapped lanes.
Belmont Circle	Kenton Lane approach modelled as flared, but not consistent with mapping. Other arms are consistent with mapping. This results in a larger than expected circulating capacity of 2657, instead of 2044.
The Bridge / George Gange Way	Within main study area. Northbound left turn has two lanes and a saturation flow below the calibration range, right turn from The Bridge is bus only.
Palmerston Rd / Byron Rd	Not a roundabout, a T junction to a small number of houses. This node should not even be modelled.
Eastcote Ln / Alexandra Av	Bus lane becomes inside lane at the traffic signals, modelled as two lanes plus bus lane. Saturation flows seem low, in this case all arms have V/C > 95%.
Christchurch Av. / Kenmore Av	Westbound Christchurch Avenue coded as two lanes, mapping indicates one.
Wetheral Dr / Crowshott Av	Southern Wetheral Drive arm not modelled. Give way markings not correctly modelled, resulting in incorrect saturation flows being applied.
Palmerston Rd / Oxford Rd	Not a through route, a fire path according to local mapping.

A409 High Rd / College Av.	Pedestrian crossing, follows approach outlined in section 5.4.2 of the model development report. 88s cycle time, 20s intergreen. Saturation flows below calibration range, resulting in V/C > 100% being observed on the southbound.

The junction checks identified a possible limitation in the routing of buses within Harrow, where the southbound bus lane along Station Road is not coded and therefore the buses that use this link are not modelled in WeLHAM. The bus spider map shown in Figure 6 was downloaded from TfL to understand the potential impact. Based on this, it was concluded that while some bus routes would require adjustment and the link recoded to include a southbound bus lane, the impact of making these corrections was unlikely to have a material impact on the study area results.

Figure 6- Bus spider map for Harrow



© Transport for London

3.2. Demand Matrices

One of the possible factors preventing a match between the observed flows and the modelled flows is that the modelled flows are validated to a November 2012 base, while the counts were taken in June 2016. As a result, the matrix was examined and adjusted to uplift the flows to 2016 levels based on London Transport System Model (LTS) and WeLHAM data.

The existing base year 2012 matrix consists of 5 user classes which are:

- Car (In Work Time);
- Car (Out Work Time);
- Taxi;
- Light Good Vehicles (LGV); and
- Other Good Vehicles (OVG).

It is noted from the model guidelines that the pre-peak assignments are carried out using the same matrices as the main assignments but in the AM (08:00 – 09:00) and PM (17:00 – 18:00) peaks a pre-peak factor of 0.98 is used to factor the peak hour demand for use in the pre-peak model run. This is used to provide an estimate of the queues from the preceding hour, to "pre-load" some traffic onto the network prior to the peak hour assignment.

Table 4 and Table 5 show the base year 2012 demand by user class for the AM and PM peak hours. The car trips are split into two trip purposes within the HAM models, "In Work Time" (also referred to as "Employers business trips") and "Out of Work Time" (also referred to as "personal based/other trips"). The wider strategic nature of the model is shown by the overall volume of traffic from LBH as a proportion of the total matrix which is less than 1% of the total for both peaks. As such, local detail in terms of local network coverage and trip distribution is limited.

Table 4- Base year 2012 Demand AM Peak (PCU)

User Class	London Borough of Harrow	Rest of Areas	Total Model Matrix
Car (In Work Time)	2514	408373	410887
Car (Out Work Time)	19416	4860830	4880246
Taxi	69	23792	23861
LGV	1133	142328	143461
OGV	607	117633	118240

Table 5- Base year 2012 Demand PM Peak (PCU)

User Class	London Borough of Harrow	Rest of Areas	Total Model Matrix
Car (In Work Time)	2181	350813	352994
Car (Out Work Time)	19083	4704140	4723223
Taxi	214	38658	38872
LGV	1092	126769	127861
OGV	354	72254	72608

2012 model demand matrices were reviewed and adjusted to reflect the demand for year 2016 in order to develop a more accurate base year simulation. The adopted approach was to adjust demand based on the available data, where Atkins has received LTS population and employment figures (years 2011 to 2041 in five years interval and year 2050) from TfL for LBH zones. Outside of LBH an interpolation was made between the WeLHAM base year model and the WeLHAM 2021 forecast demand.

Factors for each matrix were estimated for each peak to Furness the existing 2012 matrix to 2016 and the process is summarised as follows:

- For LBH Zones (Total 130 zones)
  - Determine growth factors from population and employment demand of year 2011 -2016;
  - Population growth factors were applied to Car Out Work Time and Taxi matrices for both AM and PM Peaks hour; and
  - Employment growth factors were applied to the other matrices (Levels 1, 4 and 5).
- For Rest of WeLHAM model zones (Total 2175 zones)
  - Growth factors for each matrix level were estimated by interpolating year 2016 demand from TfL demand matrices for years 2012 and 2021; and
  - The growth factor for each matrix level was generated with respect to each peak hour.

The Furness was singly constrained for AM peak matrices of levels 1, 4 and 5 by destination and origin constrained for the remaining levels. The PM matrices were constrained to the reverse of the AM peak.

The resulting 2016 and 2012 matrix totals are shown in Table 6 and Table 7 for AM and PM peak hours. Overall the demand model was increased by 3% for both peak hours.

Table 6 Year 2016 Demand AM Peak (PCU)

User Class	AM Peak Demand		Ratio of 2016 matrix to 2012 matrix
	Year 2016	Year 2012	
Car (In Work Time)	418773	410887	102%
Car (Out Work Time)	5013385	4880247	103%
Taxi	24012	23861	101%
LGV	153396	143461	107%
OGV	120026	118240	102%
Total	5729593	5576696	103%

Table 7 Year 2016 Demand PM Peak (PCU)

User Class	PM Peak Demand		Ratio of 2016 matrix to 2012 matrix
	Year 2016	Year 2012	
Car (In Work Time)	358943	352994	102%
Car (Out Work Time)	4846872	4723223	103%
Taxi	39099	38872	101%
LGV	136804	127861	107%
OGV	74027	72608	102%
Total	5455745	5315558	103%

3.3. Assignment

A new assignment was run to the WeLHAM revised network and demand for year 2016 for both the AM and PM peak hours. The assignment was completed using the same assignment parameters without any change.

As shown in Table 8 and Table 9, the assignments converged at the 25th and 26th loop with a gap of 0.012% and 0.020% for AM and PM peak respectively. This is well within the 0.1% requirement for %GAP set out by WebTAG M3.1. The second criteria is that 98% of links (%FLOW) should have a change in flow between loops of less than 1% for the last four iterations. The current convergence settings relax the reported results to the percentage of links with a change of less than 2% in flows and in the PM peak, less than 98% achieve that target.

Table 8 AM Peak Hour Run - Last Four Loops

Last 4 Loops	%FLOW	%GAP
22	98.7	0.014
23	98.5	0.015
24	98.9	0.013
25	99.0	0.012

Table 9 PM Peak Hour Run - Last Four Loops

Last 4 Loops	%FLOW	%GAP
23	96.8	0.023
24	97.4	0.019
25	97.9	0.023
26	97.6	0.020

For the purpose of updating the base year no changes to the convergence targets have been made.

3.4. Comparison to Traffic Survey

Atkins carried out turning traffic count surveys at the junctions shown in Figure 7 within the study area in June 2016. The observed traffic was compared to the 2016 model resultant traffic to give us a better understanding of the accuracy of the base year model including the network and demand updates. Table 10 and Table 11 show the traffic comparison and the GEH for the 13 junctions in the study area. The GEH of 7.5 or less is acceptable based on the WeLHAM dashboard checks and as per modelling guidelines the turning or link traffic flows should be within the criteria for at least 85% of the total number of turning volumes at junctions. Base year 2016 assignment results indicates that just over 60% of the junctions turning volumes at junction arm level for the AM peak hour meet the criteria, with 42% of the junctions turning volumes at junction arm level for the PM peak hour meet the criteria.

Figure 7- Traffic Survey Junctions Location

Table 10 – Year 2016 AM Peak Observed Traffic vs. Model traffic

Junction Name	Road Name	Modelled Flows BY 2016 (PCU)	Observed Flows (PCU)	GEH
A409 Station Road / Milton Road / Rosslyn Crescent	Milton Road	156	74	7.6
	A409 Station Approach (North Approach)	1498	1045	12.7
	Rosslyn Crescent	64	32	4.7
	A409 Station Approach (South Approach)	961	950	0.4
A409 Station Road / Marlborough Hill (priority junction)	A409 Station Approach (North Approach)	1057	911	4.7
	A409 Station Approach (South Approach)	1193	1012	5.5
	Marlborough Hill	305	119	12.8
A409 The Bridge / George Gange Way (signalised junction)	The Bridge	56	102	5.2
	George Gange Way	1245	964	8.5
	A409 Station Road	1058	915	4.6
A409 George Gange Way / Palmerston Road roundabout (priority roundabout)	Palmerston Road (West Approach)	114	96	1.7
	George Gange Way (North Approach)	987	870	3.8
	Palmerston Road (East Approach)	336	469	6.7
	George Gange Way (South Approach)	893	796	3.4
A409 George Gange Way / High Street (signalised junction)	High Street (South Approach)	67	299	17.1
	High Street (North Approach)	798	642	5.8
	George Gange Way	839	571	10.1
A409 High Street / Locket Road (signalised junction)	High Street (North Approach)	847	571	10.3
	Locket Road	11	132	14.4
	High Street (South Approach)	882	779	3.6
Christchurch Avenue / Masons Avenue / Byron Road (priority roundabout)	Masons Avenue (West Approach)	282	555	13.3
	Byron Road	488	592	4.5
	Christchurch Avenue	3	14	3.8
	Masons Avenue (East Approach)	704	862	5.6
Headstone Drive / Princes Drive / Hailsham Drive (priority roundabout)	Headstone Drive (South Approach)	539	785	9.5
	Hailsham Drive	31	34	0.5
	Headstone Drive (North Approach)	1194	880	9.7
	Princes Drive	154	65	8.5
High Street / Palmerston Road (signalised junction)	High Street (North Approach)	68	65	0.4
	Palmerston Road	71	218	12.2
	High Street (South Approach)	181	290	7.1
Ellen Webb Drive / The Bridge / High Street / Masons Avenue (signalised junction)	Ellen Webb Drive (West Approach)	0	16	5.6
	High Street	138	239	7.3
	Masons Avenue	553	531	1
	The Bridge	165	176	0.9
Ellen Webb Drive / The Bridge / High Street / Masons Avenue (signalised junction)	Headstone Drive (North Approach)	249	33	18.3
	Ellen Webb Drive	690	719	1.1
	Headstone Drive (South Approach)	563	760	7.7
	Cecil Road	446	398	2.3
Canning Road / High Street	High Street (North Approach)	68	75	0.8
	High Street (South Approach)	67	246	14.3
High Street / Gordon Road	High Street (North Approach)	68	69	0.2
	High Street (South Approach)	67	227	13.1
Summary	**Number of Link Considered**	**43**	**43**	
	% Links GEH < 7.5			**60% (26 Links)**

Table 11 – Year 2016 PM Peak Observed Traffic vs. Model traffic

Junction Name	Road Name	Modelled Flows BY 2016 (PCU)	Observed Flows (PCU)	GEH
A409 Station Road / Milton Road / Rosslyn Crescent	Milton Road	72	88	1.8
	A409 Station Approach (North Approach)	1427	942	14.1
	Rosslyn Crescent	64	46	2.4
	A409 Station Approach (South Approach)	1328	968	10.6
A409 Station Road / Marlborough Hill (priority junction)	A409 Station Approach (North Approach)	1410	996	11.9
	A409 Station Approach (South Approach)	1228	869	11.1
	Marlborough Hill	241	122	8.8
A409 The Bridge / George Gange Way (signalised junction)	The Bridge	56	74	2.2
	George Gange Way	1196	837	11.3
	A409 Station Road	1413	1002	11.8
A409 George Gange Way / Palmerston Road roundabout (priority roundabout)	Palmerston Road (West Approach)	98	145	4.2
	George Gange Way (North Approach)	943	773	5.8
	Palmerston Road (East Approach)	337	468	6.5
	George Gange Way (South Approach)	1166	821	10.9
A409 George Gange Way / High Street (signalised junction)	High Street (South Approach)	68	287	16.4
	High Street (North Approach)	746	642	3.9
	George Gange Way	995	654	11.9
A409 High Street / Locket Road (signalised junction)	High Street (North Approach)	837	549	10.9
	Locket Road	6	149	16.2
	High Street (South Approach)	1039	866	5.6
Christchurch Avenue / Masons Avenue / Byron Road (priority roundabout)	Masons Avenue (West Approach)	374	536	7.6
	Byron Road	226	469	13
	Christchurch Avenue	4	13	3.2
	Masons Avenue (East Approach)	579	903	11.9
Headstone Drive / Princes Drive / Hailsham Drive (priority roundabout)	Headstone Drive (South Approach)	445	664	9.3
	Hailsham Drive	191	110	6.6
	Headstone Drive (North Approach)	858	766	3.2
	Princes Drive	97	88	0.9
High Street / Palmerston Road (signalised junction)	High Street (North Approach)	68	69	0.1
	Palmerston Road	0	225	21.2
	High Street (South Approach)	167	281	7.7
Ellen Webb Drive / The Bridge / High Street / Masons Avenue (signalised junction)	Ellen Webb Drive (West Approach)	387	716	14
	High Street	68	246	14.2
	Masons Avenue	383	486	4.9
	The Bridge	248	205	2.9
Ellen Webb Drive / The Bridge / High Street / Masons Avenue (signalised junction)	Headstone Drive (North Approach)	253	103	11.3
	Ellen Webb Drive	488	723	9.5
	Headstone Drive (South Approach)	679	789	4.1
	Cecil Road	410	205	11.7
Canning Road / High Street	High Street (North Approach)	68	65	0.3
	High Street (South Approach)	67	249	14.4
High Street / Gordon Road	High Street (North Approach)	68	67	0.2
	High Street (South Approach)	68	195	11.1
Summary	**Number of Link Considered**	**43**	**43**	

Junction Name	Road Name	Modelled Flows BY 2016 (PCU)	Observed Flows (PCU)	GEH
	% Links GEH < 7.5			42% (18 Links)

In conclusion, from the above analysis, the update of base year 2012 to 2016 did result in an improved simulation of the traffic in LBH however there are some junctions where the comparison to the traffic survey were outside the targeted level of correlation which could be due to several reasons, such as but not limited to:

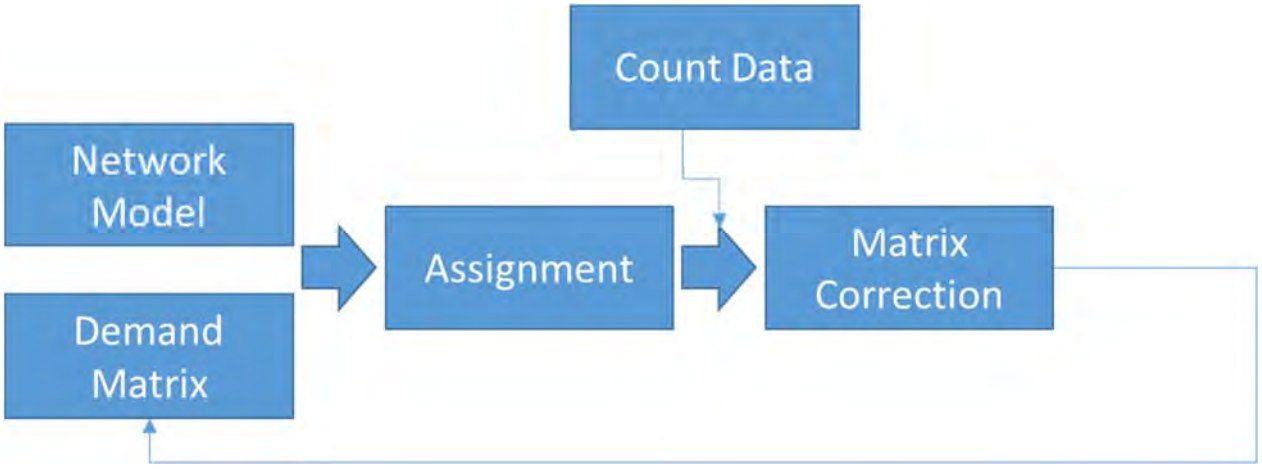
- The systematic differences between the road network and the approximation techniques used by SATURN to model a large network area with acceptable run times;
- Lack of planning data and not running the demand model which will result in more accurate demand and distribution; and
- The matrix estimation was applied to the 2012 prior matrix using the unchanged TfL network, this may have skewed the traffic distribution to account for limitations in the network which have now been rectified.

In order to address some of the reasons mentioned above, a matrix estimation process was carried out for both model peaks and described in the below section.

3.5. Matrix Estimation

Matrix Estimation (ME) is a technique that is used to adjust an existing demand matrix from a “prior” demand matrix (base matrix) using current traffic counts values as a control target for flows through specific locations within the network and adjusting the matrix to meet these targets. This process assumes that all differences between the modelled and observed values are the result of errors in the matrix. As such, before starting this process it is necessary to minimise errors in the network coding and eliminate other errors which may cause the modelled and observed values to differ. Figure 8 shows the matrix estimation workflow.

Figure 8- ME work flow



3.5.1. Setting Up and ME Runs

An existing WeLHAM matrix estimation process, including suitable prior matrix, was provided by TfL as part of the standard model pack. For the purpose of this study, the ME process was adapted to include ATCs collected for this study as part of the count set used to update the prior matrix. DfT count data between 2016 and 2012 was examined for local links within the area. This data indicated that traffic levels locally have been consistent between 2012 and 2016, therefore no adjustment was applied to the count data used by the matrix estimation process, to account for annual variation between 2012 and 2016. For this reason, the matrix growth process used in the previous section, has not been carried forward into the matrix estimation process. The data was adjusted for seasonality, converting from June to November data, using seasonality factors given in the LoHAM development report stated in Appendix B. The ME process files were updated to include the new 2016 data and the process was run using:

1. The update 2016 network including the network updates for the scheme and the corrections listed in Table 3;
2. TfL prior matrix; and
3. Updated process control files to include Wealdstone town centre counts.

3.5.2. ME Results

The final ME outputs for AM and PM peaks were compared against counts of traffic routing through the 13 junctions in study area. The results are shown in Table 12 and Table 13 for AM and PM peaks respectively. The results show significant reduction in the difference between modelled to the 2016 observed traffic flows. However for better comparison the counts were adjusted to reflect the traffic model season which is November. The TfL report suggest a factor of 0.96 is applied for counts from June to November. The resulting adjusted counts are presented in Table 12 and Table 13.

The result is that for 74% of the junction arms the GEH is less than 7.5 for both AM and PM peaks from 56% in the AM peak and 36% in the PM peak, observed in the models as provided.

Table 12 – Year 2016 AM Peak Observed Traffic vs. ME Model traffic

Junction Name	Road Name	ME Modelled Flows BY (PCU)	Observed Flows (PCU) Adjusted to November	GEH
A409 Station Road / Milton Road / Rosslyn Crescent	Milton Road	175	78	9
	A409 Station Approach (North Approach)	1444	1089	10
	Rosslyn Crescent	55	33	3
	A409 Station Approach (South Approach)	700	990	10
A409 Station Road / Marlborough Hill (priority junction)	A409 Station Approach (North Approach)	833	949	4
	A409 Station Approach (South Approach)	1193	1054	4
	Marlborough Hill	259	124	10
A409 The Bridge / George Gange Way (signalised junction)	The Bridge	56	106	6
	George Gange Way	1194	1004	6
	A409 Station Road	834	953	4
A409 George Gange Way / Palmerston Road roundabout (priority roundabout)	Palmerston Road (West Approach)	157	100	5
	George Gange Way (North Approach)	896	906	0
	Palmerston Road (East Approach)	437	489	2
	George Gange Way (South Approach)	736	829	3
A409 George Gange Way / High Street (signalised junction)	High Street (South Approach)	68	311	18
	High Street (North Approach)	634	668	1
	George Gange Way	726	595	5
A409 High Street / Locket Road (signalised junction)	High Street (North Approach)	681	595	3
	Locket Road	6	138	16
	High Street (South Approach)	770	812	1
Christchurch Avenue / Masons Avenue / Byron Road (priority roundabout)	Masons Avenue (West Approach)	470	578	5
	Byron Road	494	617	5
	Christchurch Avenue	4	14	3
	Masons Avenue (East Approach)	776	898	4
Headstone Drive / Princes Drive / Hailsham Drive (priority roundabout)	Headstone Drive (South Approach)	685	817	5
	Hailsham Drive	29	35	1
	Headstone Drive (North Approach)	1083	917	5
	Princes Drive	113	68	5

Junction Name	Road Name	ME Modelled Flows BY (PCU)	Observed Flows (PCU) Adjusted to November	GEH
High Street / Palmerston Road (signalised junction)	High Street (North Approach)	68	68	0
	Palmerston Road	47	227	15
	High Street (South Approach)	224	302	5
Ellen Webb Drive / The Bridge / High Street / Masons Avenue (signalised junction)	Ellen Webb Drive (West Approach)	639	770	5
	High Street	115	249	10
	Masons Avenue	519	553	1
	The Bridge	99	183	7
Ellen Webb Drive / The Bridge / High Street / Masons Avenue (signalised junction)	Headstone Drive (North Approach)	298	34	21
	Ellen Webb Drive	622	749	5
	Headstone Drive (South Approach)	741	792	2
	Cecil Road	413	415	0
Canning Road / High Street	High Street (North Approach)	68	78	1
	High Street (South Approach)	68	256	15
High Street / Gordon Road	High Street (North Approach)	68	72	0
	High Street (South Approach)	68	236	14
Summary	**Number of Link Considered**	**43**	**43**	
	% Links GEH < 7.5			**74% (32 Links)**

Table 13 – Year 2016 PM Peak Observed Traffic vs. ME Model traffic

Junction Name	Road Name	ME Modelled Flows BY (PCU)	Observed Flows (PCU) Adjusted to November Month	GEH
A409 Station Road / Milton Road / Rosslyn Crescent	Milton Road	117	92	2
	A409 Station Approach (North Approach)	813	981	6
	Rosslyn Crescent	77	48	4
	A409 Station Approach (South Approach)	884	1008	4
A409 Station Road / Marlborough Hill (priority junction)	A409 Station Approach (North Approach)	999	1038	1
	A409 Station	896	905	0

Junction Name	Road Name	ME Modelled Flows BY (PCU)	Observed Flows (PCU) Adjusted to November Month	GEH
	Approach (South Approach)			
	Marlborough Hill	62	127	7
A409 The Bridge / George Gange Way (signalised junction)	The Bridge	56	77	3
	George Gange Way	841	871	1
	A409 Station Road	1002	1044	1
A409 George Gange Way / Palmerston Road roundabout (priority roundabout)	Palmerston Road (West Approach)	240	151	6
	George Gange Way (North Approach)	564	805	9
	Palmerston Road (East Approach)	350	487	7
	George Gange Way (South Approach)	820	856	1
A409 George Gange Way / High Street (signalised junction)	High Street (South Approach)	68	299	17
	High Street (North Approach)	439	669	10
	George Gange Way	812	681	5
A409 High Street / Locket Road (signalised junction)	High Street (North Approach)	457	572	5
	Locket Road	6	155	17
	High Street (South Approach)	856	903	2
Christchurch Avenue / Masons Avenue / Byron Road (priority roundabout)	Masons Avenue (West Approach)	356	558	9
	Byron Road	372	488	6
	Christchurch Avenue	4	14	3
	Masons Avenue (East Approach)	738	940	7
Headstone Drive / Princes Drive / Hailsham Drive (priority roundabout)	Headstone Drive (South Approach)	520	692	7
	Hailsham Drive	209	114	7
	Headstone Drive (North Approach)	659	798	5

Junction Name	Road Name	ME Modelled Flows BY (PCU)	Observed Flows (PCU) Adjusted to November Month	GEH
	Princes Drive	47	91	5
High Street / Palmerston Road (signalised junction)	High Street (North Approach)	68	72	0
	Palmerston Road	0	235	22
	High Street (South Approach)	308	293	1
Ellen Webb Drive / The Bridge / High Street / Masons Avenue (signalised junction)	Ellen Webb Drive (West Approach)	608	746	5
	High Street	68	256	15
	Masons Avenue	393	506	5
	The Bridge	182	213	2
Ellen Webb Drive / The Bridge / High Street / Masons Avenue (signalised junction)	Headstone Drive (North Approach)	296	107	13
	Ellen Webb Drive	532	753	9
	Headstone Drive (South Approach)	708	822	4
	Cecil Road	284	214	4
Canning Road / High Street	High Street (North Approach)	68	68	0
	High Street (South Approach)	68	259	15
High Street / Gordon Road	High Street (North Approach)	68	69	0
	High Street (South Approach)	68	204	12
Summary	**Number of Link Considered**	**43**	**43**	
	% Links GEH < 7.5			**74% (32 Links)**

4. Forecast Modelling Approach

The WeLHAM model will be used to forecast the traffic for year 2021 on the proposed interventions, including testing the proposed schemes for the study area road network. Therefore, Do-Nothing and Do-Something options will be developed based on the outputs of the base year 2016 review and the data provided including the planning data for the development opportunities and committed road schemes from LBH.

4.1. Highway Network

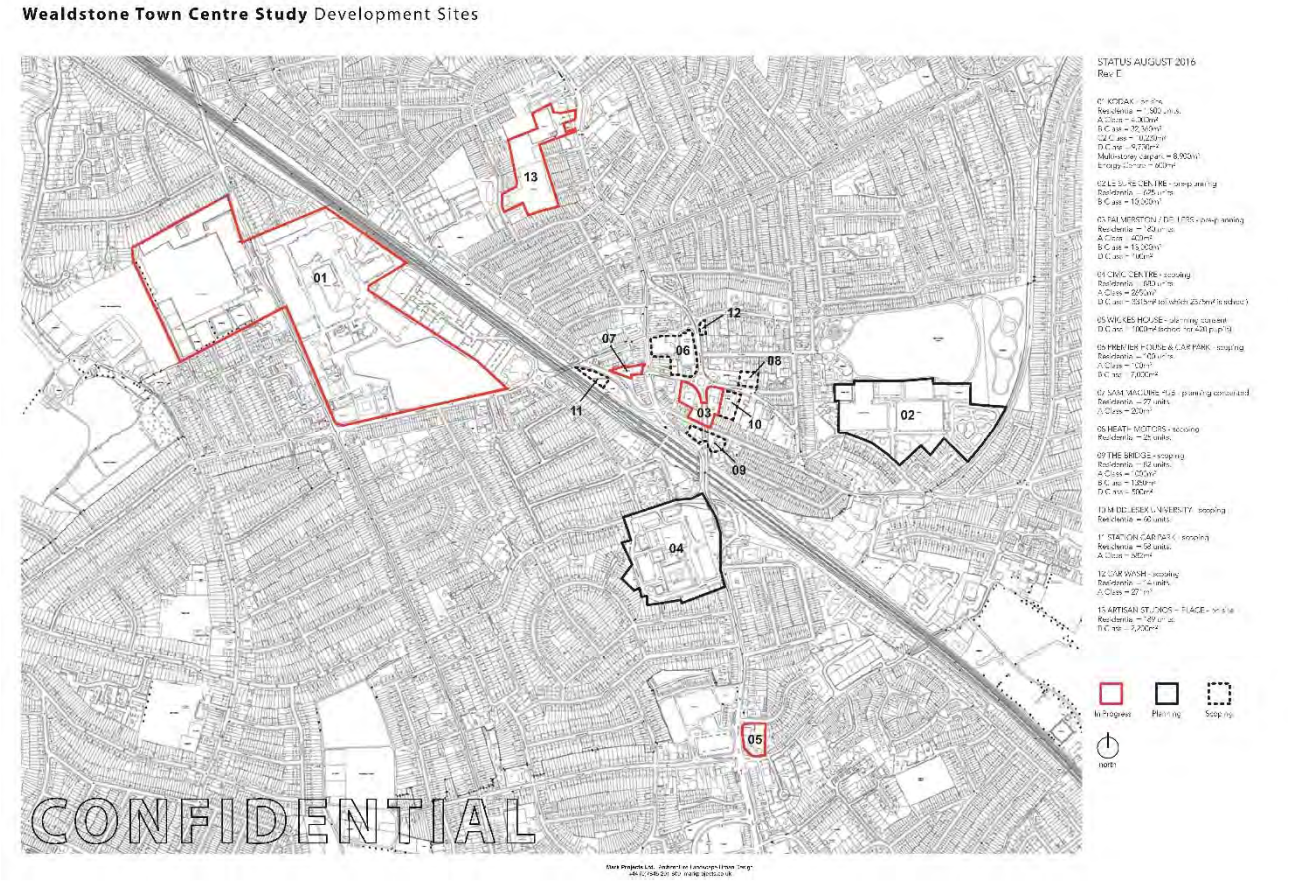
In addition to the network updates that will be carried from base year review updates, Atkins has received from LBH the committed schemes to be implemented by year 2021 which are the following:

- Cecil Road / Headstone Drive – new signalised junction;
- Harrow View / Parkside Way – Localised widening of existing signalised junction; and
- Whitchurch Lane / Wemborough Road - Localised widening of existing signalised junction.

4.2. Demand Matrices

There are about 13 development opportunities planned for LBH as shown in Figure 9.

Figure 9- Development Locations



The planning data for these new developments has been collated and the trip generation has been calculated, the modelling will be adjusted to include the new development traffic. The suggested approach to update the demand model matrices for year 2021 is summarised below.

Growth in the WeLHAM 2021 (reference case) forecast matrices is based upon LTS forecasts. LTS forecasts are calculated from projections of employment and population. From the information available of the data

used to prepare the forecasts, the definition within the data is not sufficient to determine which proposed developments have been explicitly included within the forecasts.

To ensure that trips associated with proposed developments within the study area, are included in the correct zones within the HAM study area it is proposed to undertake a two stage process.

- Stage 1 is to calculate background growth for study area zones and apply this to all study area HAM zones. Estimates of employment and population generated by local development proposals, will be used to adjust TEMPRO forecasts for the study area, thereby calculating background growth.

  Background growth will be applied to all study area HAM zones.

- Stage 2 is to then add trips associated with identified development proposals to the HAM zones in which the developments are proposed.

This method controls the overall growth to TEMPRO forecast totals, whilst attributing growth locally to the HAM zones within which it is proposed. Ensuring that the local highway effects of development traffic are not diluted across all zones in the study area.

Outside the study area the model zone growth will be controlled to WeLHAM 2021 (Reference case) totals.

Atkins will review zones connectivity if required to ensure that demand is loaded sensibly.

4.3. Assignment

The updated model for year 2021 will be run with the same parameters as assumed by WeLHAM unless we are advised otherwise.

5. Conclusions

The overall impact of extending and improving the network with the demand adjustment using matrix estimation has improved significantly the results to increase the number of junctions arms with a GEH less than 7.5 to 74% in both peaks from 56% in the AM peak and 36% in the PM peak.

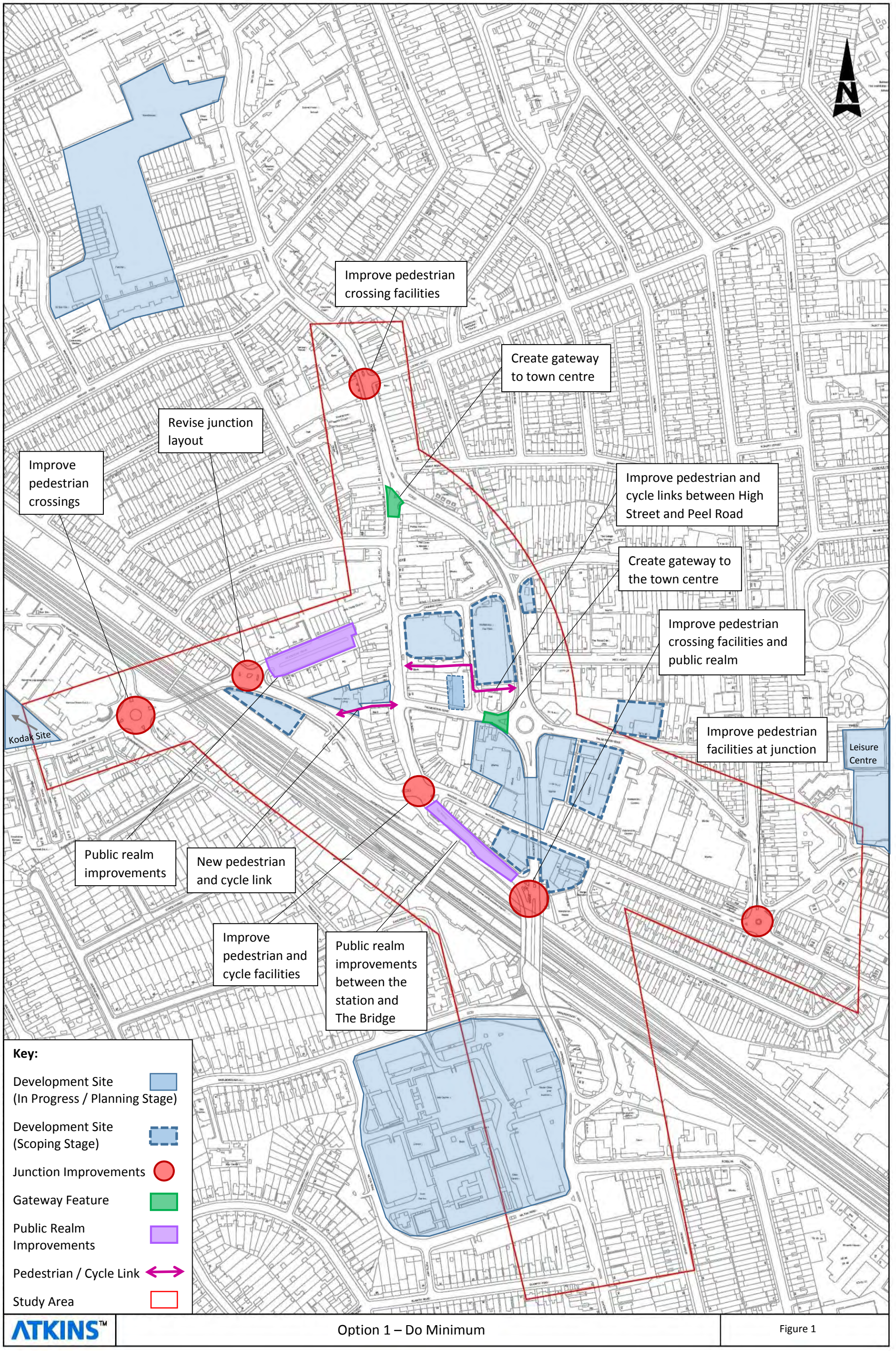
With regards to use of WeLHAM strategic model outputs for use in junction modelling of local schemes, the guidelines of TfL reads:

"The HAMs are strategic models so local movements are of reduced importance. This may be seen in a number of different ways:

- *Some local roads present in a local model may not be represented at a strategic level*
- *Model calibration is often only against a limited number of screenline counts, not to every link in a local area*
- *A lesser degree of link flow accuracy may be tolerated in the model validation*
- *Turning flows are unlikely to have been calibrated and/or checked for accuracy*
- *Zoning in the local area may not be compatible with the detail expected for local models. "*

Therefore, as per the guidelines we are proposing that a pivot based approach will be adopted when applying the WeLHAM traffic flows in the local models. The difference in the traffic flows between year 2016 and 2021 at junctions in the WeLHAM will be added to the 2016 observed traffic counts used in the local base models to generate 2021 forecast year flows for both peaks hours. This approach can be applied additively by adding the difference in flows from the model or multiplicatively as a percentage change. The most appropriate approach is dependent on local circumstances and the preferred approach will be determined once results become available.

Appendix I. Concept Options Plans



ATKINS™

Option 1 – Do Minimum

Figure 1

ATKINS™

Option 2 – High Street Two-Way and Palmerston Road Closed

Figure 2

ATKINS™

Option 3 – Headstone Drive Two-Way

Figure 3

ATKINS™

Option 4 – New Link to Palmerston Road

Figure 4

High Street restricted to bus and cycle only in both directions and servicing restricted to off-peak

Remove parking bays on High Street

Kodak Site

Leisure Centre

The Bridge restricted to bus and cycle only in both directions

Key:

Development Site (In Progress / Planning Stage)

Development Site (Scoping Stage)

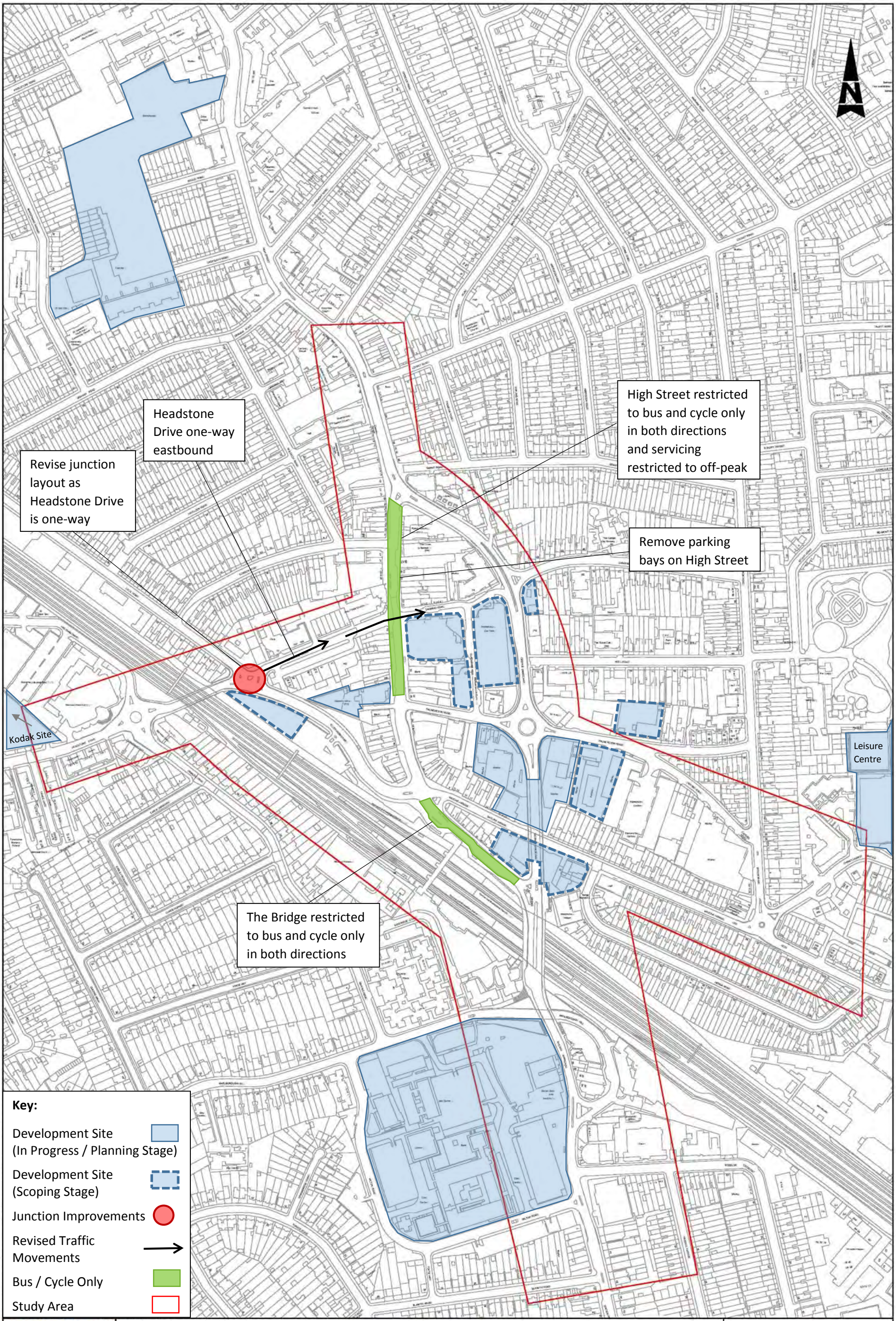
Bus / Cycle Only

Study Area

ATKINS™

Option 5a – The Bridge and High Street (Palmerston Road to A409) Bus Only

Figure 5



ATKINS™

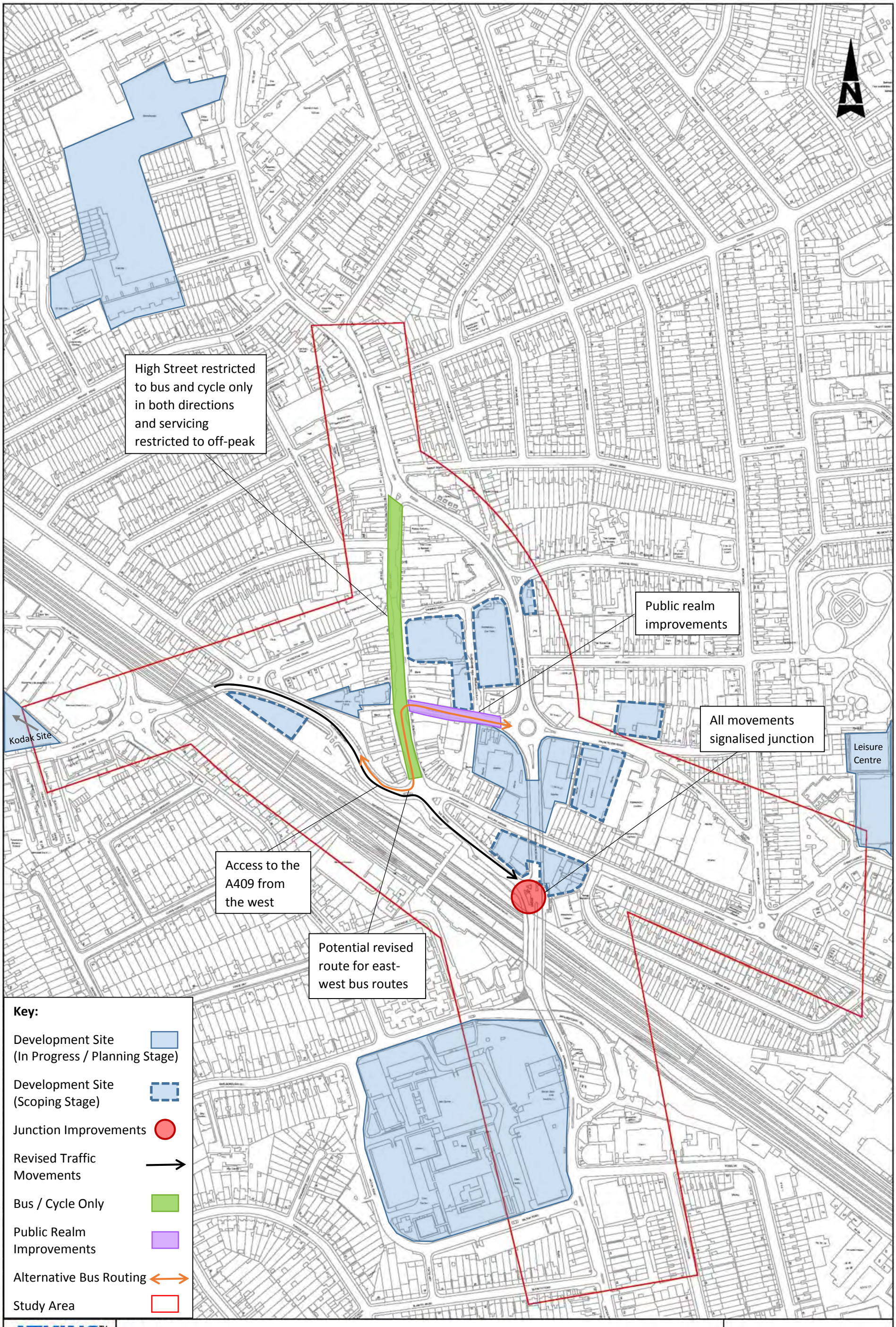
Option 5b – The Bridge and High Street (Palmerston Road to A409) Bus Only and Headstone Drive one-way

Figure 6

ATKINS™

Option 5c – The Bridge and High Street (Palmerston Road to A409) Bus Only and Masons Avenue Eastbound Only

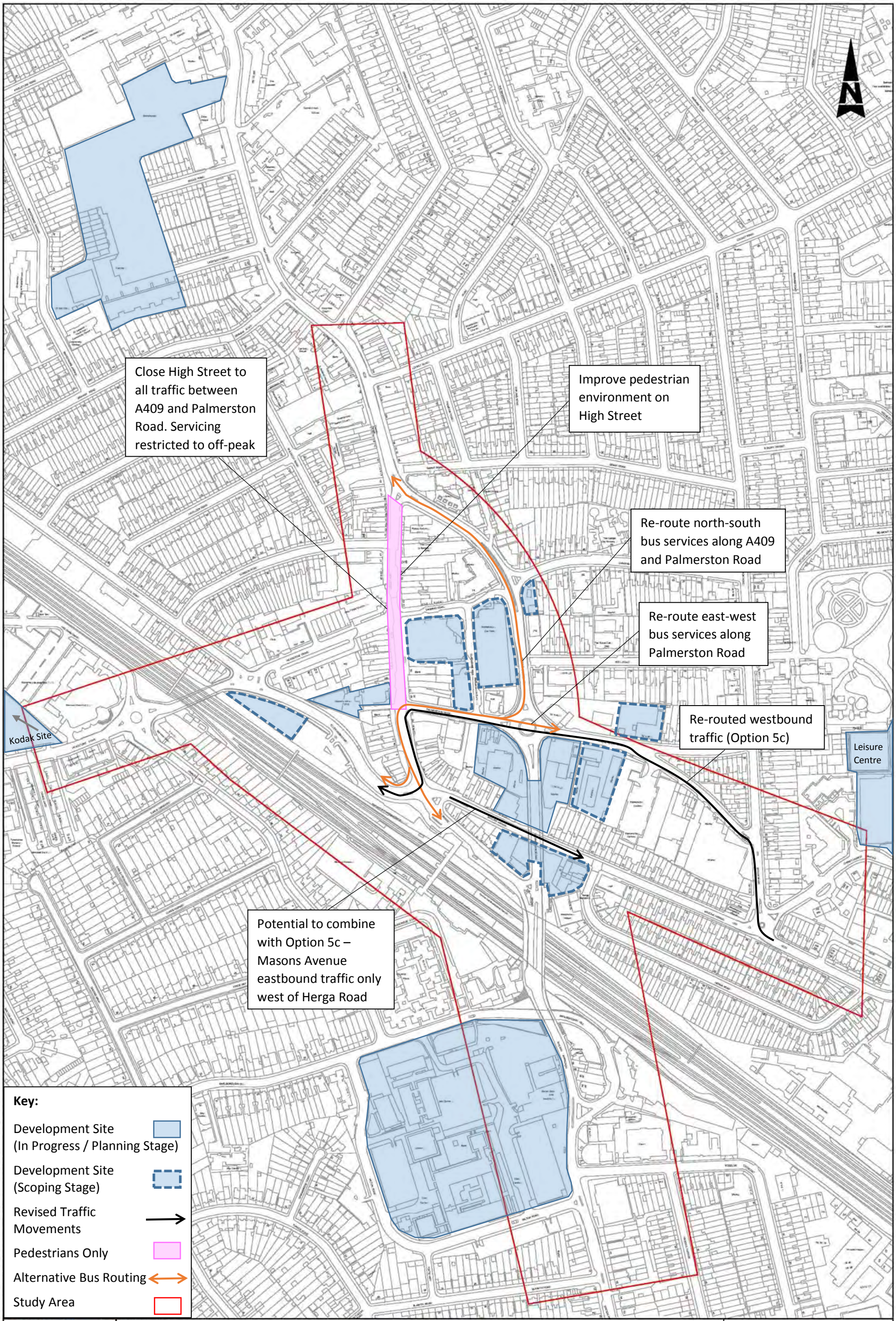
Figure 7



ATKINS™

Option 6 – High Street Bus Only (Masons Avenue to A409)

Figure 8



ATKINS™

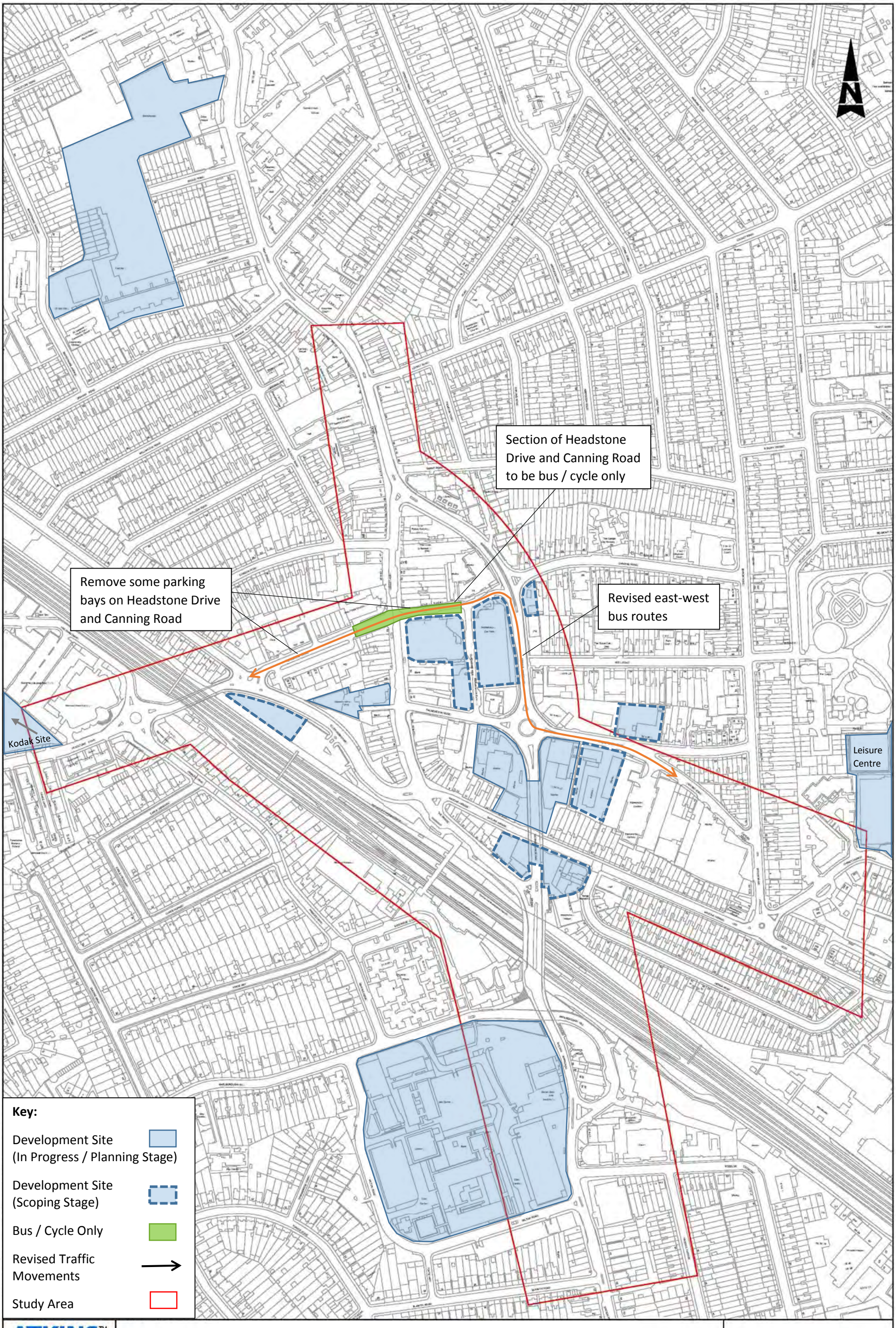
Option 7 – High Street Pedestrianisation (Palmerston Road to A409)

Figure 9

ATKINS™

Option 8 – High Street Two-Way and The Bridge Bus / Cycle Only

Figure 10

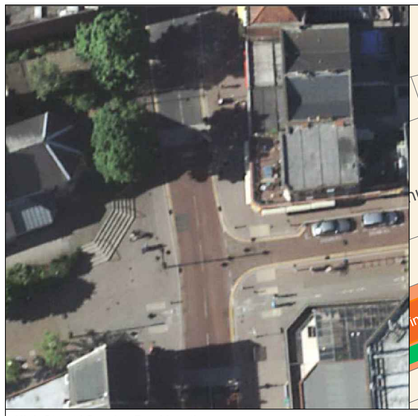


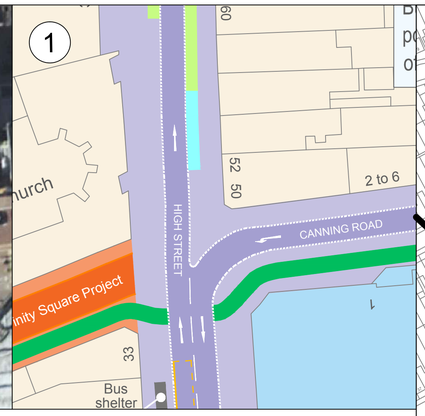
ATKINS™

Option 9 – Headstone Drive and Canning Road Bus / Cycle Only

Figure 11

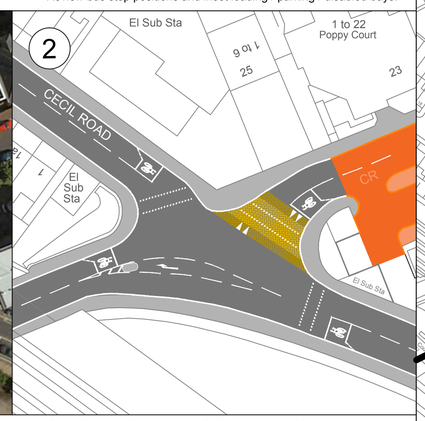
Appendix J. Major Scheme Proposal





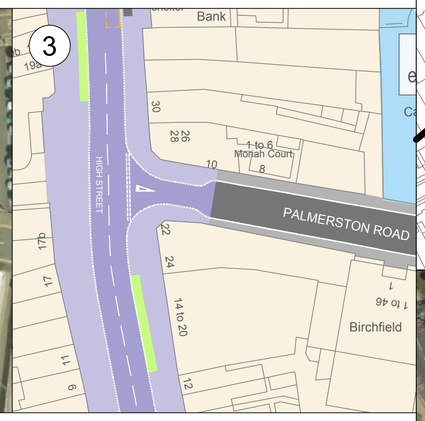
High Street / Canning Road junction

- One way operation in Canning Road (westbound) - Exit onto High Street only - buses / cycles only - 20 mph speed limit.
- Existing 2-way cycle route remains.
- High Street north of Canning Road is one way northbound - all traffic.
- No vehicular access to Trinity Square area via High Street.
- High Street and Canning Road has wide footways, minimum width carriageway, low kerbs and minimal street furniture.
- Review bus stop positions and inset loading / parking / disabled bays.



Complimentary scheme (not part of bid) - Cecil Road / Ellen Webb Drive / Headstone Drive junction and Trinity Square project (shaded in red)

- Implement a 4 arm signalised junction, remove existing "toucan" crossing east of junction (funded from S106 developer contributions).
- Realign carriageway / footways.
- Improve east / west, pedestrian / cycle links.
- Advance cycle stop lines, reduce guard railings along Headstone Drive, street furniture, widen footway areas.
- Access / egress to Trinity Square proposal via speed platform.



High Street / Palmerston Road junction

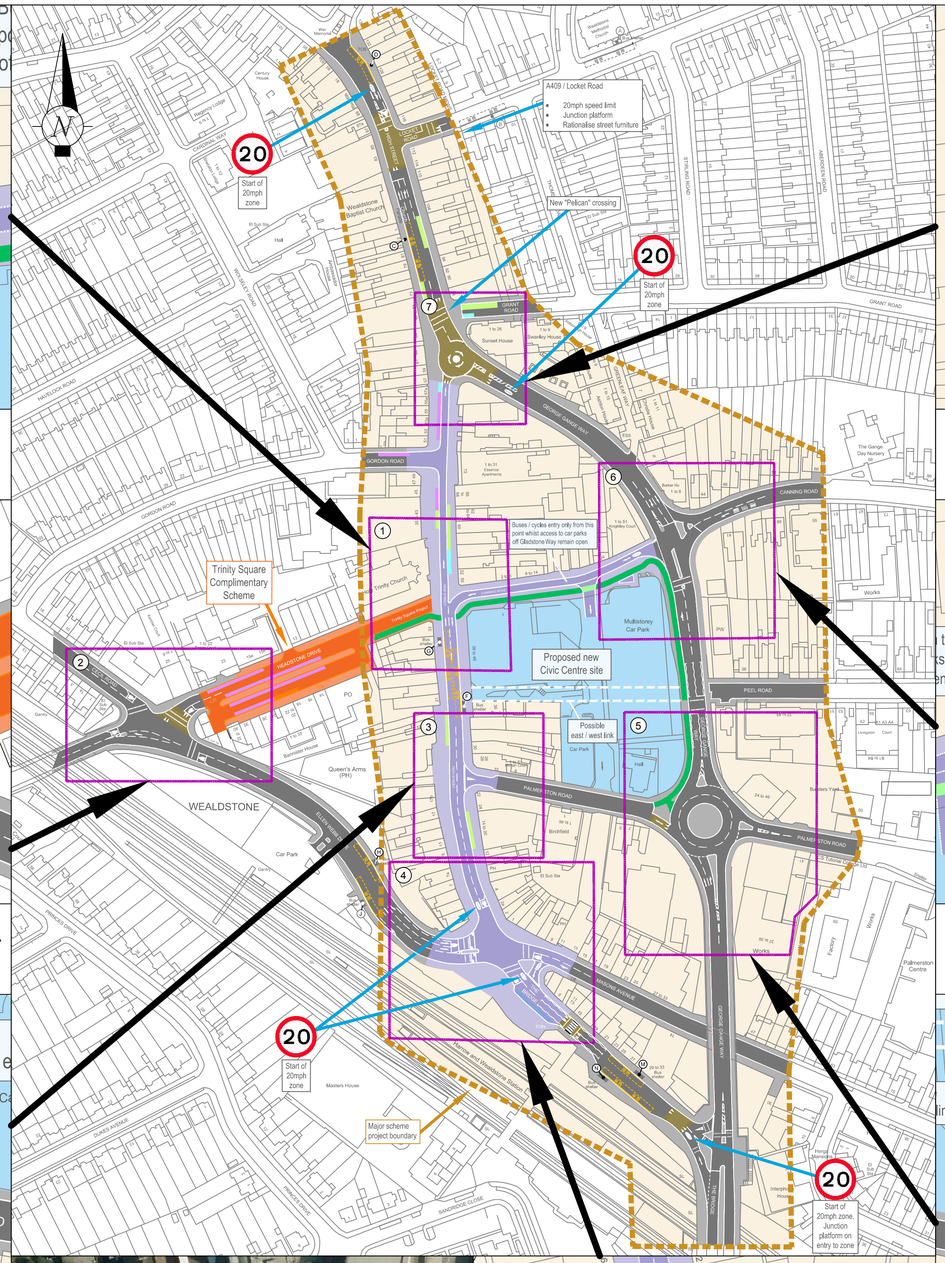
- Remove signals at junction (Palmerston Road is one-way from roundabout to High Street).
- Realign carriageway / footways - High Street has wide footways, minimum width carriageways, low kerbs and minimal street furniture.
- 20 mph speed limit.
- Introduce priority junction.
- Review inset loading / parking areas.

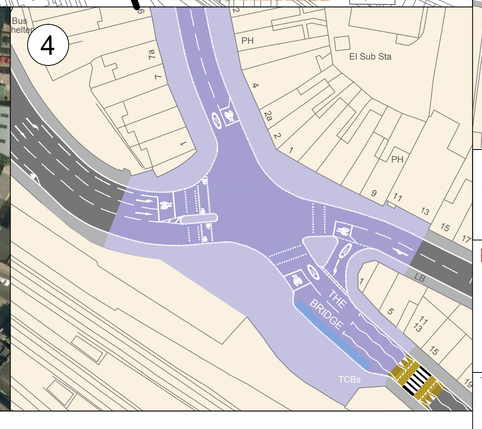
KEY:

- Disabled Bays
- Loading Bays
- P&D Bays
- Cycle Lanes
- Taxi ranks
- Junction / speed platforms
- Footway (reconstruction)
- Carriageway (reconstruction)

Designed by: Nabeel Shahid

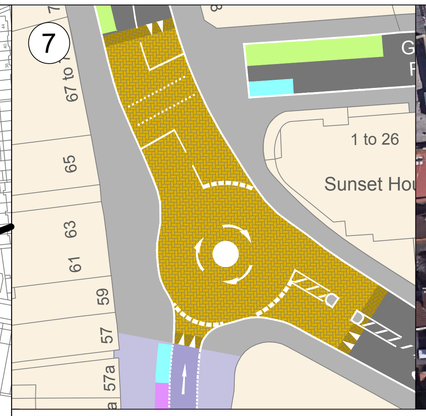
Harrow COUNCIL
LONDON
COMMUNITY & ENVIRONMENT
TRANSPORTATION
P.O. Box 39, Civic Centre,
Harrow, Middlesex. HA1 2XA
Tel: 020 8863 5611
Fax: 020 8420 9611





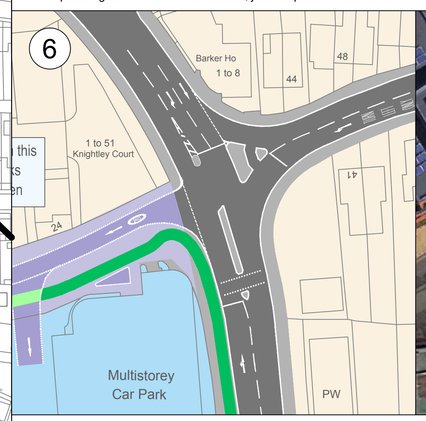
High Street / Ellen Webb Drive / Masons Avenue junction

- Retain traffic signals. Redesign signals to provide controlled crossings on Masons Avenue / Ellen Webb Drive only to maximise performance, entry to high street with realigned carriageways / footways.
- Redesign taxi ranks - to maximise public space.
- Develop public space at station entrance gateway - introduce pedestrian friendly public space in high quality materials, redesign layouts to enhance entry into town from station.
- Introduce speed platform at Zebra Crossing.



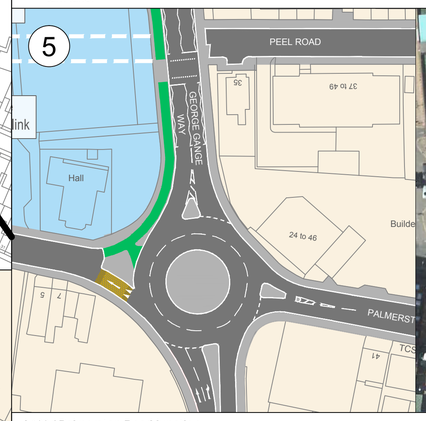
A409 / High Street junction

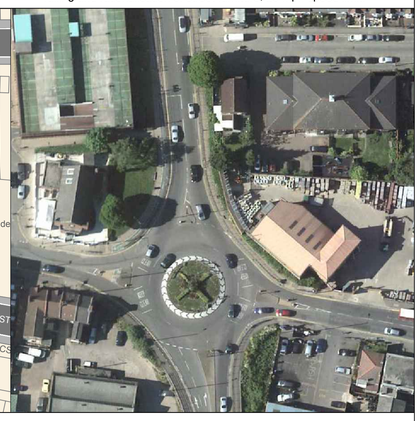
- High Street - Canning Road to George Gange Way has one way operation.
- Exit onto A409 corridor only for all traffic.
- Replace signals with a mini-roundabout, junction platform / islands and "Pelican" pedestrian crossing.
- 20 mph speed limit on A409 and High Street.
- Use of junction platforms at junction to give priority to pedestrians.



A409 / Canning Road junction

- One way operation in Canning Road (Westbound) - Entry from A409 corridor to access High Street for buses / cycles only.
- Introduce signals with a pedestrian crossing phase and delineated right turn lane.
- Left in / left out arrangement at Canning Road east side remains.
- Existing cycle route remains.
- George Gange Way de-cluttering - removal of central island / guard railing and rationalisation of street furniture, 20 mph speed limit.





A409 / Palmerston Road junction

- Close off Palmerston Road, exit onto roundabout and make road one-way from the roundabout to High Street - main access for vehicles from A409.
- Existing toucan crossing north of roundabout to remain.
- Aspiration for more direct pedestrian / cycle link along Peel Road and through development site to High Street (existing route is not straight).
- Possible future relocation of toucan crossing onto desire line for new link in future.

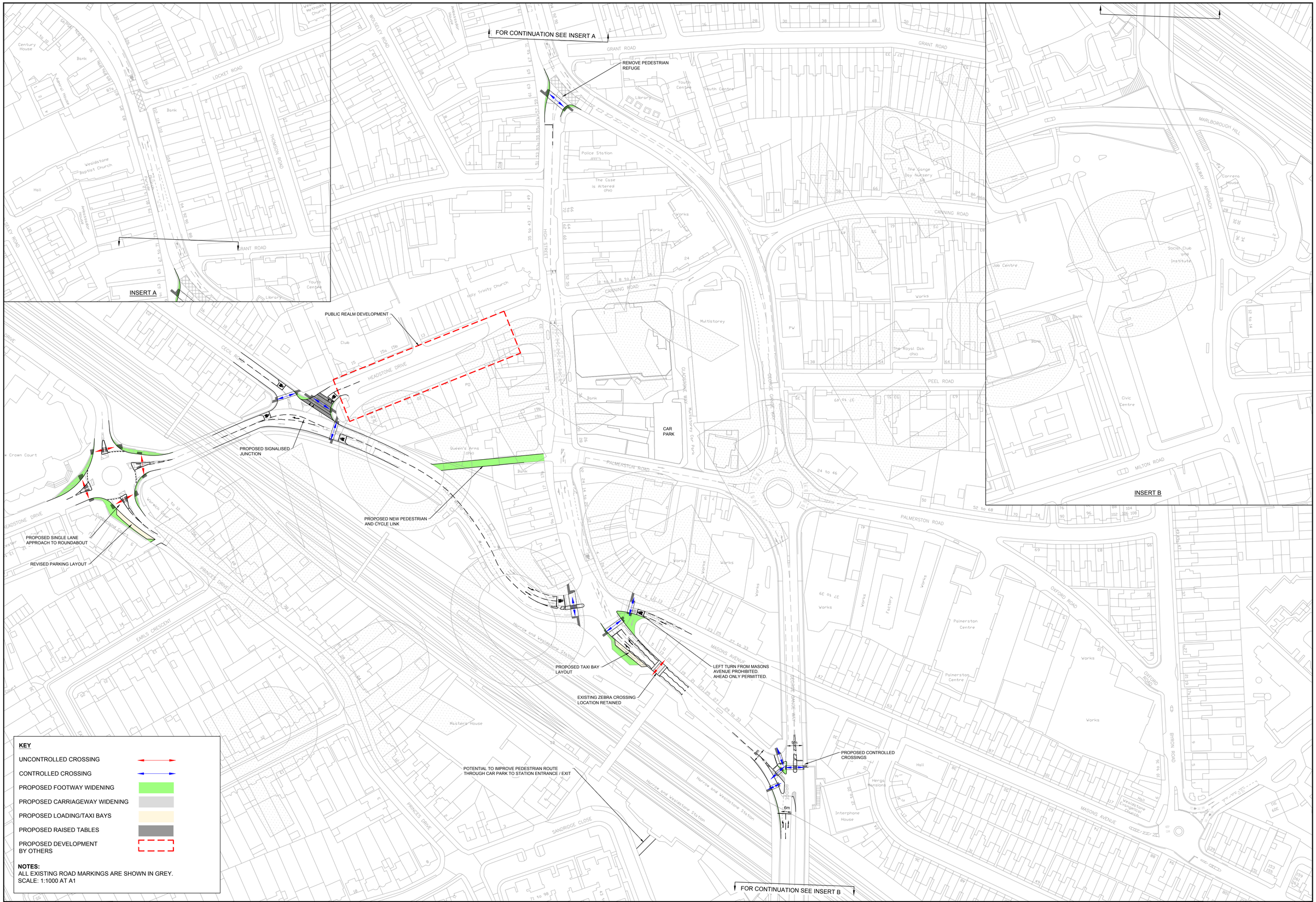
Project

HIGH STREET, WEALDSTONE IMPROVEMENT SCHEME

Title

PROPOSED MAJOR SCHEME

Appendix K. Option Drawings



ATKINS™

OPTION 1 - DO MINIMUM

FIGURE 1

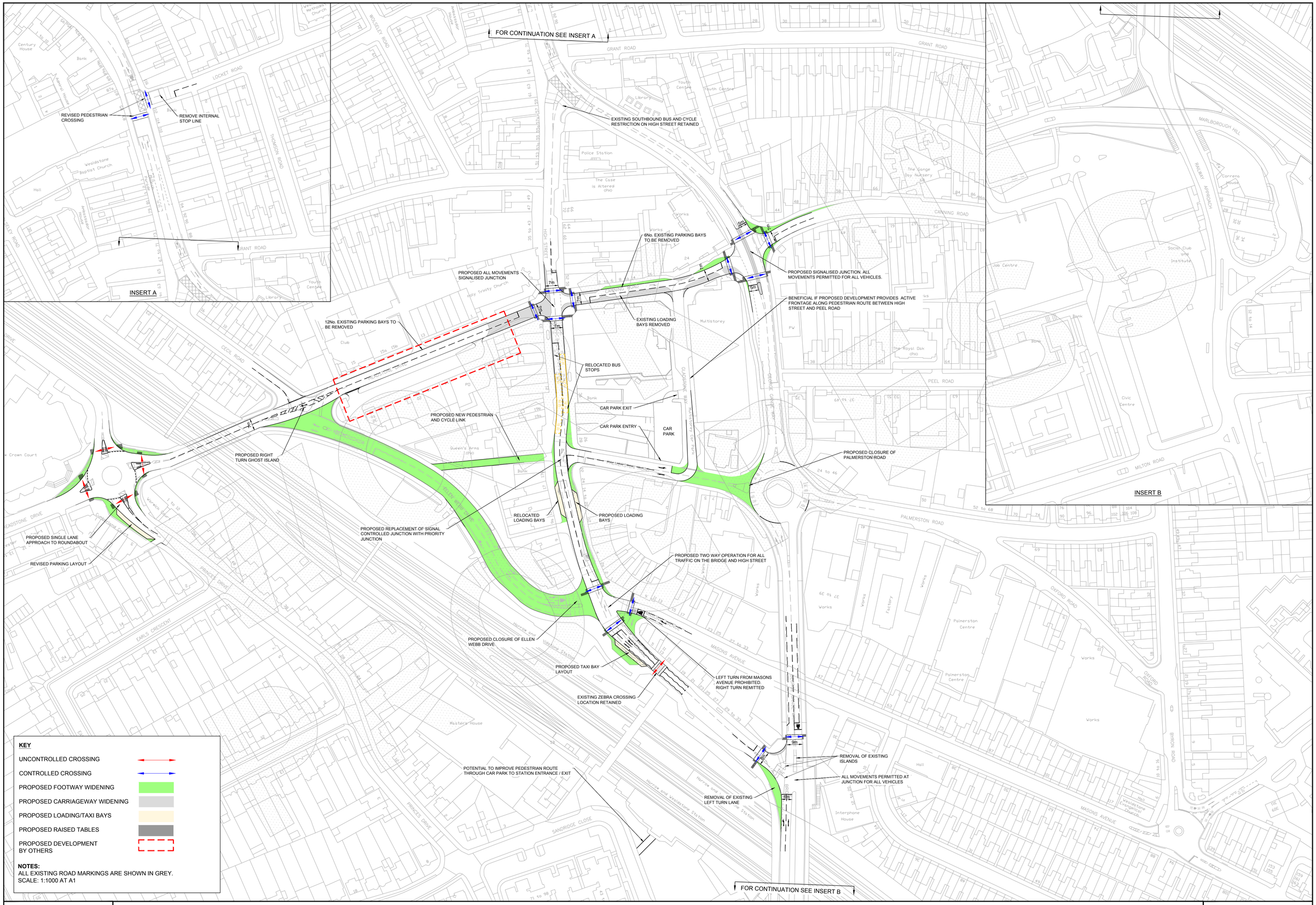
P:\GBEMB\TP\HB\PROJECTS\5147962 - Wealdstone TC - MALY9417\20_CAD\01-WIP\D\DR\HCWTC-ATK-HGN-XX-DR-D-0001.dwg

ATKINS™

OPTION 2 - HIGH STREET TWO-WAY AND PALMERSTON ROAD CLOSED

FIGURE 2

P:\GBEMB\TP\HB\PROJECTS\5147962 - Wealdstone TC - MALY9417\20_CAD\01-WIP\D\DR\HCWTC-ATK-HGN-XX-DR-D-0002.dwg



ATKINS™

OPTION 3 - HEADSTONE DRIVE TWO-WAY

FIGURE 3

P:\GBEMB\TP\HB\PROJECTS\5147962 - Wealdstone TC - MALY9417\20_CAD\01-WIP\D\DR\HCWTC-ATK-HGN-XX-DR-D-0003.dwg

PROPOSED SINGLE LANE APPROACH TO ROUNDABOUT

REVISED PARKING LAYOUT

PROPOSED SIGNALISED JUNCTION

PUBLIC REALM DEVELOPMENT

PROPOSED NEW PEDESTRIAN AND CYCLE LINK

PROPOSED LOADING BAY

PROPOSED TAXI BAY LAYOUT

EXISTING ZEBRA CROSSING LOCATION RETAINED

POTENTIAL TO IMPROVE PEDESTRIAN ROUTE THROUGH CAR PARK TO STATION ENTRANCE / EXIT

RELOCATED BUS STOP

CAR PARK

REMOVE PEDESTRIAN REFUGE

PINICH POINT IN LANE WIDTHS

PROPOSED SOUTHBOUND BUS LANE

REMOVAL OF EXISTING CENTRAL RESERVATION

PROPOSED RIGHT TURN FOR BUSES ONLY

PROPOSED SIGNALISED JUNCTION

CIVIC CENTRE DEVELOPMENT

KEY

- UNCONTROLLED CROSSING
- CONTROLLED CROSSING
- PROPOSED FOOTWAY WIDENING
- EXISTING CYCLE LANE
- PROPOSED BUS LANE
- PROPOSED CARRIAGEWAY
- PROPOSED LOADING/TAXI BAYS
- PROPOSED RAISED TABLES
- PROPOSED DEVELOPMENT BY OTHERS

NOTES:
ALL EXISTING ROAD MARKINGS ARE SHOWN IN GREY.
SCALE: 1:1000 AT A1

ATKINS™

WEALDSTONE TOWN CENTRE TRANSPORT STUDY - OPTION 11a

FIGURE 1

P:\GBEMB\TP\HB\PROJECTS\5147962 - Wealdstone TC - MALY9417\20_CAD\01-WIP\D\DR\HCWTC-ATK-HGN-XX-DR-D-0010.dwg

PROPOSED SINGLE LANE APPROACH TO ROUNDABOUT

REVISED PARKING LAYOUT

PROPOSED SIGNALISED JUNCTION

PUBLIC REALM DEVELOPMENT

PROPOSED NEW PEDESTRIAN AND CYCLE LINK

PROPOSED LOADING BAY

PROPOSED TAXI BAY LAYOUT

EXISTING ZEBRA CROSSING LOCATION RETAINED

POTENTIAL TO IMPROVE PEDESTRIAN ROUTE THROUGH CAR PARK TO STATION ENTRANCE / EXIT

EXISTING CROSSING RETAINED

REMOVE PEDESTRIAN REFUGE

EXISTING CROSSING RETAINED

BUSES ONLY PAST THIS POINT

CIVIC CENTRE DEVELOPMENT

CAR PARK

4.5m

4.5m

7m

KEY

- UNCONTROLLED CROSSING
- CONTROLLED CROSSING
- PROPOSED FOOTWAY WIDENING
- EXISTING CYCLE LANE
- PROPOSED BUS LANE
- PROPOSED CARRIAGEWAY
- PROPOSED LOADING/TAXI BAYS
- PROPOSED RAISED TABLES
- PROPOSED DEVELOPMENT BY OTHERS

NOTES:
ALL EXISTING ROAD MARKINGS ARE SHOWN IN GREY.
SCALE: 1:1000 AT A1

ATKINS™

WEALDSTONE TOWN CENTRE TRANSPORT STUDY - OPTION 11b

FIGURE 2

P:\GBEMB\TP\HB\PROJECTS\5147962 - Wealdstone TC - MALY9417\20_CAD\01-WIP\D\DR\HCWTC-ATK-HGN-XX-DR-D-0011.dwg

Appendix L. Option Cost Estimates

ATKINS

Wealdstone Town Centre

Option 1 - Do Minimum

Feasibility Design Estimate

Date : July 2017

Job No: 5147962

Rev No: P2

Ref.	Description		(£)	
	Construction Cost			
Series 100	Preliminaries	17.5%	£43,750.00	
Series 101	Traffic management	5.0%	£12,500.00	
Series 200	Site Clearance		£20,000.00	
Series 500	Drainage		£30,000.00	
Series 600	Earthworks		£30,000.00	
Series 700	Pavements		£130,000.00	
Series 1100	Kerbs, Footways and Paved Areas		£40,000.00	
Series 1200	Traffic Signs and Road Markings	5.0%	£12,500.00	
Series 1300	Road Lighting Columns and Brackets, CCTV Masts and Cantilever Masts	5.0%	£12,500.00	
Series 1400	Electrical Work for Road Lighting and Traffic Signs	5.0%	£12,500.00	
Series 3000	Landscape & Horticulture	10.0%	£25,000.00	
		Sub Total	**£370,000.00**	
	Third Party Construction Costs			
	Utilities Diversions Works	15.0%	£55,500.00	
	Signal Installation (£15k per arm)	10	£150,000.00	
		Sub Total	**£205,500.00**	
		Construction Total	**£580,000.00**	
	Risk & Contingency			
	Contingencies	20%	£116,000.00	
	Optimism Bias	20%	£116,000.00	
		Sub Total	**£240,000.00**	
	Scheme Budget (not including VAT)		**£820,000.00**	**£902,000.00**

Notes :

1) All existing footway paving is to be replaced with similar paving.

2) Carriageway is expected to be resurfaced only.

3) Statutory undertakers diversionary costs are an estimate. C2 plans not available at this stage.

4) The range of the final budget estimates is 10%

ATKINS

Wealdstone Town Centre Option 2 - High Street Two-way and Palmerston Road closed Feasibility Design Estimate			Date : July 2017 Job No: 5147962 Rev No: P2	
Ref.	Description		(£)	
	Construction Cost			
Series 100	Preliminaries	17.5%	£100,000.00	
Series 101	Traffic management	5.0%	£28,500.00	
Series 200	Site Clearance		£30,000.00	
Series 500	Drainage		£60,000.00	
Series 600	Earthworks		£70,000.00	
Series 700	Pavements		£330,000.00	
Series 1100	Kerbs, Footways and Paved Areas		£80,000.00	
Series 1200	Traffic Signs and Road Markings	5.0%	£28,500.00	
Series 1300	Road Lighting Columns and Brackets, CCTV Masts and Cantilever Masts	5.0%	£28,500.00	
Series 1400	Electrical Work for Road Lighting and Traffic Signs	5.0%	£28,500.00	
Series 3000	Landscape & Horticulture	10.0%	£57,000.00	
		Sub Total	**£850,000.00**	
	Third Party Construction Costs			
	Utilities Diversions Works	15.0%	£127,500.00	
	Signal Installation (£15k per arm)	10	£150,000.00	
		Sub Total	**£277,500.00**	
		Construction Total	**£1,130,000.00**	
	Risk & Contingency			
	Contingencies	10%	£113,000.00	
	Optimism Bias	20%	£226,000.00	
		Sub Total	**£340,000.00**	
	Scheme Budget Range (not including VAT)		**£1,470,000.00**	**£1,617,000.00**
	Notes : 1) All existing footway paving is to be replaced with similar paving. 2) Carriageway is expected to be resurfaced only. 3) Statutory undertakers diversionary costs are an estimate. C2 plans not available at this stage. 4) The range of the final budget estimates is 10%			

ATKINS

Wealdstone Town Centre Option 3 Headstone Drive Two - way Feasibility Design Estimate			Date : July 2017 Job No: 5147962 Rev No: P2	
Ref.	Description		(£)	
	Construction Cost			
Series 100	Preliminaries	17.5%	£260,750.00	
Series 101	Traffic management	5.0%	£74,500.00	
Series 200	Site Clearance		£80,000.00	
Series 500	Drainage		£120,000.00	
Series 600	Earthworks		£220,000.00	
Series 700	Pavements		£860,000.00	
Series 1100	Kerbs, Footways and Paved Areas		£210,000.00	
Series 1200	Traffic Signs and Road Markings	5.0%	£74,500.00	
Series 1300	Road Lighting Columns and Brackets, CCTV Masts and Cantilever Masts	5.0%	£74,500.00	
Series 1400	Electrical Work for Road Lighting and Traffic Signs	5.0%	£74,500.00	
Series 3000	Landscape & Horticulture	20.0%	£298,000.00	
		Sub Total	**£2,350,000.00**	
	Third Party Construction Costs			
	Utilities Diversions Works	15.0%	£352,500.00	
	Signal Installation (£15k per arm)	14	£210,000.00	
		Sub Total	**£562,500.00**	
		Construction Total	**£2,920,000.00**	
	Risk & Contingency			
	Contingencies	20%	£584,000.00	
	Optimism Bias	20%	£584,000.00	
		Sub Total	**£1,170,000.00**	
	Scheme Budget (not including VAT)		**£4,090,000.00**	**£4,499,000.00**
	Notes : 1) All existing footway paving is to be replaced with similar paving. 2) Carriageway is expected to be resurfaced only. 3) Statutory undertakers diversionary costs are an estimate. C2 plans not available at this stage. 4) The range of the final budget estimates is 10%			

ATKINS

Wealdstone Town Centre Option 10 Feasibility Design Estimate			Date : July 2017 Job No: 5147962 Rev No: P2	
Ref.	Description		(£)	
	Construction Cost			
Series 100	Preliminaries	17.5%	£239,750.00	
Series 101	Traffic management	5.0%	£68,500.00	
Series 200	Site Clearance		£60,000.00	
Series 500	Drainage		£140,000.00	
Series 600	Earthworks		£210,000.00	
Series 700	Pavements		£830,000.00	
Series 1100	Kerbs, Footways and Paved Areas		£130,000.00	
Series 1200	Traffic Signs and Road Markings	5.0%	£68,500.00	
Series 1300	Road Lighting Columns and Brackets, CCTV Masts and Cantilever Masts	5.0%	£68,500.00	
Series 1400	Electrical Work for Road Lighting and Traffic Signs	5.0%	£68,500.00	
Series 3000	Landscape & Horticulture	20.0%	£274,000.00	
		Sub Total	**£2,160,000.00**	
	Third Party Construction Costs			
	Utilities Diversions Works	15.0%	£324,000.00	
	Signal Installation (£15k per arm)	11	£165,000.00	
		Sub Total	**£489,000.00**	
		Construction Total	**£2,650,000.00**	
	Risk & Contingency			
	Contingencies	10%	£265,000.00	
	Optimism Bias	20%	£530,000.00	
		Sub Total	**£800,000.00**	
	Scheme Budget (not including VAT)		**£3,450,000.00**	**£3,795,000.00**
	Notes : 1) All existing footway paving is to be replaced with similar paving. 2) Carriageway is expected to be resurfaced only. 3) Statutory undertakers diversionary costs are an estimate. C2 plans not available at this stage. 4) The range of the final budget estimates is 10%			

ATKINS

Wealdstone Town Centre Option 11a Feasibility Design Estimate			Date : July 2017 Job No: 5147962 Rev No: P2	
Ref.	Description		(£)	
	Construction Cost			
Series 100	Preliminaries	17.5%	£196,000.00	
Series 101	Traffic management	5.0%	£56,000.00	
Series 200	Site Clearance		£70,000.00	
Series 500	Drainage		£90,000.00	
Series 600	Earthworks		£180,000.00	
Series 700	Pavements		£600,000.00	
Series 1100	Kerbs, Footways and Paved Areas		£180,000.00	
Series 1200	Traffic Signs and Road Markings	5.0%	£56,000.00	
Series 1300	Road Lighting Columns and Brackets, CCTV Masts and Cantilever Masts	5.0%	£56,000.00	
Series 1400	Electrical Work for Road Lighting and Traffic Signs	5.0%	£56,000.00	
Series 3000	Landscape & Horticulture	10.0%	£112,000.00	
		Sub Total	**£1,660,000.00**	
	Third Party Construction Costs			
	Utilities Diversions Works	15.0%	£249,000.00	
	Signal Installation (£15k per arm)	11	£165,000.00	
		Sub Total	**£414,000.00**	
		Construction Total	**£2,080,000.00**	
	Risk & Contingency			
	Contingencies	20%	£416,000.00	
	Optimism Bias	20%	£416,000.00	
		Sub Total	**£840,000.00**	
	Scheme Budget Range (not including VAT)		**£2,920,000.00**	**£3,212,000.00**
	Notes : 1) All existing footway paving is to be replaced with similar paving. 2) Carriageway is expected to be resurfaced only. 3) Statutory undertakers diversionary costs are an estimate. C2 plans not available at this stage. 4) The range of the final budget estimates is 10%			

ATKINS

Wealdstone Town Centre Option 11b Feasibility Design Estimate			Date : July 2017 Job No: 5147962 Rev No: P2	
Ref.	Description		(£)	
	Construction Cost			
Series 100	Preliminaries	17.5%	£162,750.00	
Series 101	Traffic management	5.0%	£46,500.00	
Series 200	Site Clearance		£60,000.00	
Series 500	Drainage		£70,000.00	
Series 600	Earthworks		£160,000.00	
Series 700	Pavements		£500,000.00	
Series 1100	Kerbs, Footways and Paved Areas		£140,000.00	
Series 1200	Traffic Signs and Road Markings	5.0%	£46,500.00	
Series 1300	Road Lighting Columns and Brackets, CCTV Masts and Cantilever Masts	5.0%	£46,500.00	
Series 1400	Electrical Work for Road Lighting and Traffic Signs	5.0%	£46,500.00	
Series 3000	Landscape & Horticulture	10.0%	£93,000.00	
		Sub Total	**£1,380,000.00**	
	Third Party Construction Costs			
	Utilities Diversions Works	15.0%	£207,000.00	
	Signal Installation (£15k per arm)	7	£105,000.00	
		Sub Total	**£312,000.00**	
		Construction Total	**£1,700,000.00**	
	Risk & Contingency			
	Contingencies	20%	£340,000.00	
	Optimism Bias	20%	£340,000.00	
		Sub Total	**£680,000.00**	
	Scheme Budget (not including VAT)		**£2,380,000.00**	**£2,618,000.00**
	Notes : 1) All existing footway paving is to be replaced with similar paving. 2) Carriageway is expected to be resurfaced only. 3) Statutory undertakers diversionary costs are an estimate. C2 plans not available at this stage. 4) The range of the final budget estimates is 10%			

Atkins Limited
Woodcote Grove
Ashley Road
Epsom
Surrey
KT18 5BW