



A450 Corridor Enhancement Report

Worcestershire County Council

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A450 Corridor Enhancements

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2. Introduction

- 2.1.1 Jacobs has been commissioned by Worcestershire County Council (WCC) to prepare an 'Options Report' that considers schemes to resolve existing and future congestion at several key junctions along the A450 corridor to the south of Kidderminster.
- 2.1.2 The purpose of this report is to assess the capacity performance of the proposed options using forecast 2036 model flows obtained from the Wyre Forest Transport Model (WFTM), and to determine whether any of the schemes will ensure that the A450 corridor is operating effectively in the future.
- 2.1.3 The outcome of this work will be used to define any infrastructure requirements as part of the evidence base to support proposals contained in the Wyre Forest District Infrastructure Delivery Plan (WFIDP),
- 2.1.4 In addition, the report looks to identify the schemes that are directly required by the proposed development in the Wyre Forest Local Plan and therefore the schemes 'along A450' which need to be included in the Wyre Forest Infrastructure Delivery Plan (WFIDP).

Background

- 2.1.5 This report builds on base information collected by Jacobs, which outlined the existing conditions and identified any key issues in the operational performance of junctions on the A450 corridor.
- 2.1.6 The A450 corridor experiences marked weekday peak period congestion now, which can only be expected to worsen with increased traffic demand arising from development proposals in the emerging Wyre Forest Local Plan, this report provides an evidence base for the need of intervention.
- 2.1.7 Analysis provided by WCC show that the A450 has the second highest rate of casualty accidents on 'A' roads in Worcestershire, with different causation factors recorded along the route. The schemes identified should help reduce accidents because the options would improve capacity, causations factors indicate that junctions with poor accident records occur where motorists are tempted to make turns through smaller gaps in congested conditions.

2.2 Scope of Study Area

- 2.2.1 Base information collected by Jacobs considered the existing operating conditions along the A450 in Wyre Forest. The length of the corridor considered extends from the A449/A450 Black Bridge traffic signals to the A456/ B4187 junction, and some additional junctions on the A449 and A456 that interact with the A450 were included. The junctions considered are shown on Figure 1 – 2 and are as follows:
 - A449 Worcester Rd / A450 Worcester Rd 'Black Bridge Junction', a 3-arm signalised junction;
 - A449 Worcester Rd / A442 Droitwich Rd, also a 3-arm signalised junction;
 - A450 Worcester Rd / A442 Droitwich Rd, a 4-arm roundabout;
 - A450 Worcester Rd / A448 Bromsgrove Rd 'Mustow Green Roundabout', a 4-arm roundabout;
 - A450 Stourbridge Rd / B4188 Hackmans Gate Lane, a 4-arm signalised crossroads;
 - A450 Worcester Rd / A456 Kidderminster Rd South, a 3-arm signalised junction; and

- A456 Kidderminster Rd / B4187 Worcester Rd, a 5-arm signalised junction.

Figure 1: A450 Corridor and Emerging Local Plan Development sites

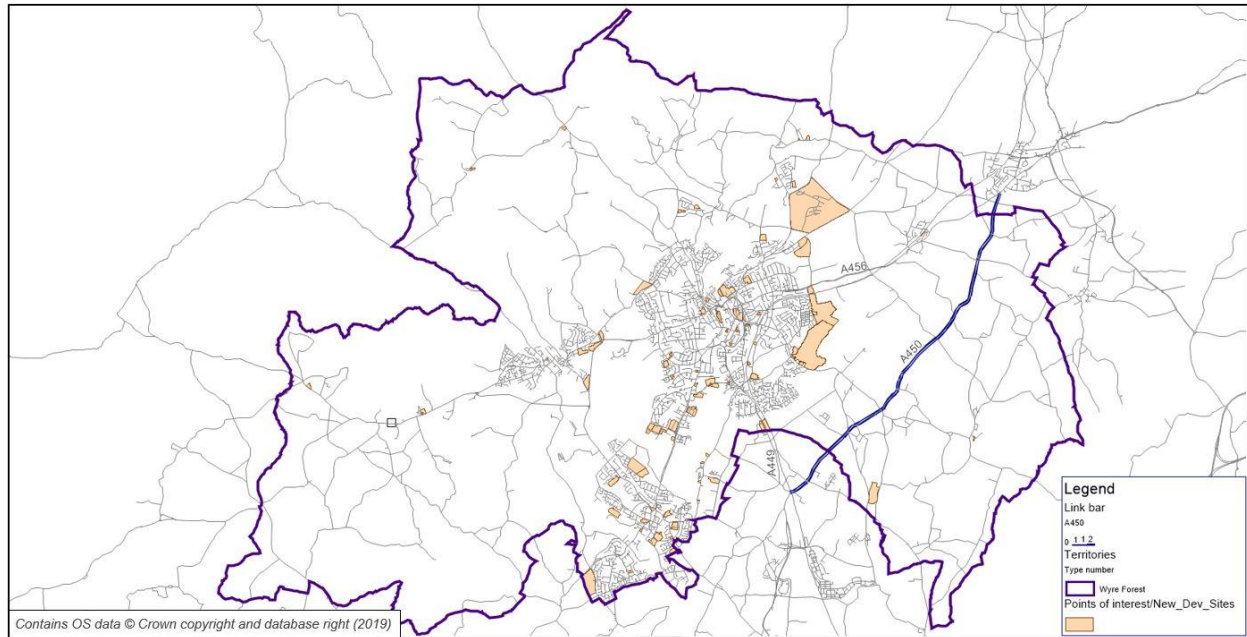
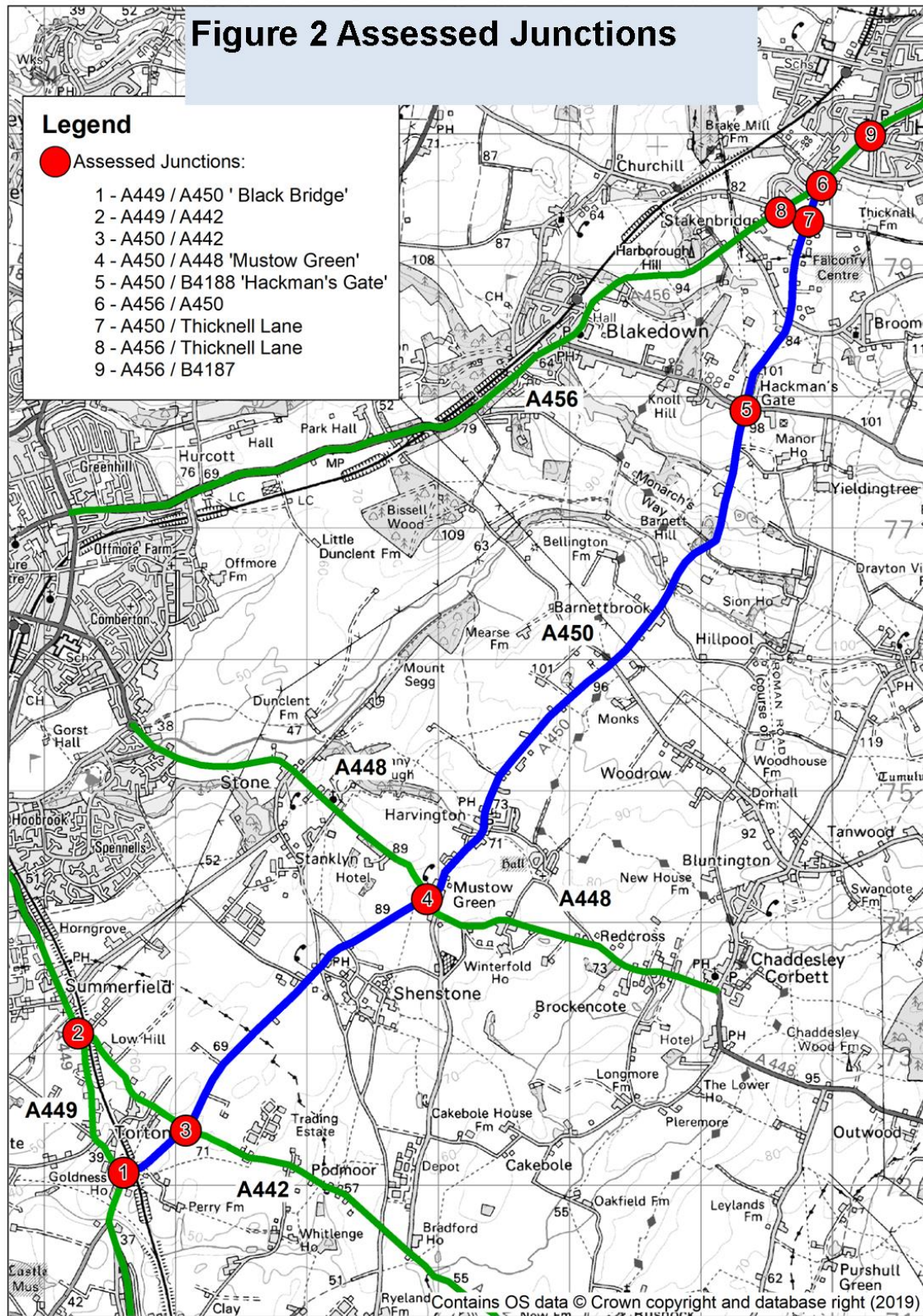


Figure 2 Assessed Junctions



2.3 Report Structure

2.3.1 This report is presented in the following chapters:

- **Chapter 2** – Transport Solutions;
- **Chapter 3** – Capacity Assessment;
- **Chapter 4** – Route Impact Analysis;
- **Chapter 5** – Scheme Costs;
- **Chapter 6** – Option Evaluation;
- **Chapter 7** – Wyre Forest Traffic Model;
- **Chapter 8** - Preferred Option Capacity Assessment; and
- **Chapter 9** - Summary and Conclusions.

3. Transport Solutions

3.1 Introduction

- 3.1.1 This section identifies the options to be taken forward for capacity modelling. At this stage of the study no scheme drawings have been prepared and further analysis will be required to determine the design feasibility. The development of the options will incorporate casualty reduction into the design to help reduce accidents and will be supported by Road Safety Audits (RSA) before technical approval and implementation.

3.2 Description of Options

- 3.2.1 The options at each of the key junctions are described in the table below with diagrams of all the options shown in appendix 1 and identified on Figure 2 above.

Table 1: List of Options

Location	Option
A449/A450 Black Bridge & A449/A442 & A450/A442	Reconfigure A449 to one-way northbound from A450 to A442 (Option 1)
	Introduce Gyratory to encompass three junctions (Option 2)
	Ban A450 right turn out, and widen and lengthen A449 right turn flare (Option 3)
A450/A448 Mustow Green	Reposition junction and increase size of the roundabout (Option 1)
	Reposition junction and replace roundabout with signals (Option 2)
A450/ B4188 Hackmans Gate	Minor signal adjustments (Option 1)
A456/A450	Ban movements and provide two-lane exit merge eastbound (Option 1)
	Introduce A450 one-way southbound (Option 2)
	Introduce Gyratory (Option 3)
A450/ B4187	Introduce a longer left turn taper to B4187 from the A456 and improve pedestrian safety (Option 1)
	WCC Option – Widen A456 to 2 lanes eastbound from A450 to B4187 (Option 2)

3.3 Combined A449/A450 Black Bridge, A449/A442 and A450/A442 junctions

3.3.1 Option 1 - Reconfigure A449 to one-way northbound

3.3.2 The improvements include the following features:

- Convert A449 northbound only from 'Black Bridge' junction to the A449/A442 junction, any A449 traffic wishing to travel southbound will be required to travel onto the A442 and A450, to re-join the A449 at the A449 / A450 'Black Bridge' junction, provision will be made to allow bus only access on the A449 southbound;
- Right turn out from A450 to the A449 called on demand;

- Layout at A449 / A450 'Black Bridge' junction modified to allow bus only access on the A449 North (southbound approach). The signal staging and timings will be amended to provide optimum performance; and
- Increase the size of the A450 / A442 roundabout to an inscribed circle diameter (ICD) of 43 m (the existing ICD is 33 m), larger roundabout needed to accommodate the re-assigned A449 southbound traffic.

Scheme Constraints

3.3.3 Further investigation of the constraints to establish the impact on the development of the design will be required in the feasibility design stage. The possible constraints to the design are outlined below:

- The larger roundabout may encroach on third party land owned by adjacent land owners; and
- The entry arms to the roundabout require widening which may also encroach on third party land.

3.3.4 Option 2 - Introduce a Gyratory

3.3.5 The improvements include the following features:

- One-way gyratory system between all three junctions, converting the A442 Droitwich Road to one-way southbound, A449 northbound and the A450 Worcester Road to one-way westbound; and
- Increase the ICD of the A450 / A442 roundabout to 43m (the existing ICD is 33m). Increase entry width of A450 Worcester Road North and the A442 Droitwich Road East to allow a 2-lane entry to the roundabout.

Scheme Constraints

Further investigation of the constraints to establish the impact on the development of the design will be required in the feasibility design stage. A possible constraint to the design is outlined below:

- The larger roundabout may encroach on third party land owned by adjacent land owners.

3.3.6 Option 3 - Ban A450 right turn & lengthen right turn flare on the A449 and modification to A449/A442 junction

3.3.7 The improvements include the following features:

- Ban right turn out of the A450 which will reduce staging requirement at the traffic signals and will minimise loss of intergreen and improve capacity of the junction;
- Increase the width of the existing A449 right turn flare to a minimum of 3 metres and increase length of flare to 80 metres to ensure the lane can accommodate queuing traffic without impeding ahead movements. The current width is substandard and anecdotal evidence shows that the ahead traffic is impeded creating a lane starvation issue; and
- Provide a 2-vehicle storage ghost island for right turners on the A449, to provide a safe right turn area at the A449/A442 junction.

Scheme Constraints

3.3.8 Further investigation of the constraints to establish the impact on the development of the design will be required in the feasibility design stage. The possible constraints to the design are outlined below:

- Increasing the width and length of the A449 right turn flare may encroach on third-party land owned by adjacent land owners; and
- The provision of the right turn ghost island at A449/A442 junction may encroach on third-party land.

3.4 A450/A448 Mustow Green roundabout

3.4.1 There are two options being considered for the A450 Worcester Road / A448 Bromsgrove Road 'Mustow Green' roundabout.

3.4.2 Option 1 - Re-position junction and increase size of roundabout

The improvements include the following features:

- Reposition the roundabout to the north of existing location and make larger;
- Introduce flared approaches to the new larger roundabout to accommodate turning flows; and
- Introduce a left turn slip from A448 Bromsgrove Road North to A450 Worcester Road East to encourage flow from Kidderminster to Hagley on the A450 instead of the A456.

Scheme Constraints

3.4.3 Further investigation of the constraints to establish the impact on the development of the design will be required in the feasibility design stage. A possible constraint to the design is outlined below:

- Significant land-take is required outside the highway boundary.

3.4.4 Option 2 - Re-position and replace roundabout with traffic signals

The improvements include the following features:

- Reposition and replace roundabout with signals to the north of existing location;
- Provide 2 lane flared approach on all arms to accommodate turning traffic; and
- Introduce a left filter for A448 Bromsgrove Road North to A450 Worcester Road East.

Scheme Constraints

3.4.5 Further investigation of the constraints to establish the impact on the development of the design will be required in the feasibility design stage. A possible constraint to the design is outlined below:

- Significant land-take is required outside the highway boundary

3.5 A450/ B4188 Hackmans Gate

- 3.5.1 One option is being considered for the A450/ B4188 Hackmans Gate traffic signal junction to provide additional green time to the A450. The baseline report showed that this junction operates within capacity using the 2036 forecast flows and therefore there is an opportunity to adjust signal times to provide a benefit to the A450.

3.5.2 Option 1 - Minor signal timings improvements

The improvements include the following feature:

- MOVA amendments to extend signal timings to give priority to A450 traffic.

3.6 A456 / A450 Junction

3.6.1 Option 1 - Ban Movements

The improvements include the following features:

- Ban right turn movement between the A456 Kidderminster Road West and the A450 Worcester Road South; and
- The existing right turn lane on the A456 Kidderminster Road West is modified as a shortened flare lane for the ahead movement. This also requires the A456 exit to be widened into the existing hatching (and will possibly need the left turn lane on the A456 Worcester Road approach to the junction to be moved to accommodate the additional lane) to fit a two-lane merge exit, with enough space to safely merge to a single lane. If constraints are prohibitive reduce scheme to ban right turns only.

Scheme Constraints

- 3.6.2 Further investigation of the constraints to establish the impact on the development of the design will be required in the feasibility design stage. A possible constraint to the design is outlined below:
- The improvements likely to encroach on land outside the highway boundary to accommodate the additional short ahead merge lane; and

3.6.3 Option 2 - Introduce one-way on A450 southbound from A456 to Thicknall Lane

The improvements include the following features:

- A450 Worcester Road from A456 to Thicknall Lane to be modified to one-way towards Kidderminster and A450 traffic towards Birmingham to use Thicknall Lane;
- Thicknall Lane to be widened to accommodate additional traffic; and
- Convert priority junction at Thicknall Lane/ A456/Stakenbridge Lane to traffic signals.

Scheme Constraints

3.6.4 Further investigation of the constraints to establish the impact on the development of the design will be required in the feasibility design stage. A possible constraint to the design is outlined below:

- Land for improvements required to widen Thicknall Lane.

3.6.5 Option 3 - Introduce Gyratory

The improvements include the following features:

- One-way gyratory system between three junctions, A456/A450, A450/ Thicknall Lane and A456/Thicknall Lane/ Stakenbridge Lane; and
- New traffic signals at A450/Thicknall Lane and A456/Thicknall Lane/ Stakenbridge Lane and modified traffic signals at A456/A450.

Scheme Constraints

3.6.6 Further investigation of the constraints to establish the impact on the development of the design will be required in the feasibility design stage. A possible constraint to the design is outlined below:

- Land for improvements required to improve Thicknall Lane.

3.7 A456 / B4187 junction

3.7.1 Option 1 - Extend B4187 left slip and improve pedestrian safety

The improvements include the following feature:

- Introduce a longer left turn taper from the A456 West to the B4187; and
- Introduce a left turn ban out of the B4187 to improve capacity.

Scheme Constraints

3.7.2 Further investigation of the constraints to establish the impact on the development of the design will be required in the feasibility design stage. The following constraint to the design is outlined below:

- Limited land for improvements and therefore any larger scheme is likely to be cost prohibitive.

3.7.3 Option 2 - A456 two lanes eastbound

The improvements include the following feature:

- Provide two lanes eastbound on the A456 from the A450 to B4187.

Scheme Constraints

3.7.4 Further investigation of the constraints to establish the impact on the development of the design will be required in the feasibility design stage. The following constraint to the design is outlined below:

- Limited land for improvements;

- Right turns into residential areas would need to be banned which will cause a reassignment of traffic flows; and
- No traffic data available on side roads along the A456 therefore at this stage the proposed scheme cannot be assessed for capacity.

4. Capacity Assessment

4.1 Introduction

This section of the note assesses the capacity of each of the options using 2036 model flows.

4.2 Combined A449/A450 Black Bridge, A449/A442 and A450/A442 junctions

The 2036 capacity results for options 1,2 and 3 are shown below.

4.2.1 Option 1 - Convert A449 to one-way northbound

Table 4-1: A449 / A450 Black Bridge, 2036 model flows - Option 1 capacity results

Link	Arm	AM Peak			PM Peak		
		DoS	Delay	MMQ	DoS	Delay	MMQ
1/1+1/2	A450 Worcester Rd E	74.8%	4.5	2	74.2%	4.8	2
2/1+2/2	A449 Worcester Rd S	87.1%	12.6	14	82.9%	10.9	12
AM Peak		PRC: 3.3%		Total delay: 3.3		Cycle time: 75s	
PM Peak		PRC: 8.6%		Total delay: 8.6		Cycle time: 70s	

Notes: DoS is the Degree of Saturation, Delay is the average delay per PCU (passenger car unit) in secs, MMQ is the Mean Maximum Queue in PCUs, L denotes left, A ahead and R right movements

Table 4-2: A449 / A442, 2036 model flows - Option 1 capacity results

Link	Arm	AM Peak			PM Peak		
		DoS	Delay	MMQ	DoS	Delay	MMQ
1/1	A449 Worcester Rd N	81.7%	21.4	25	82.2%	25.2	20
2/1	A442 Droitwich Rd E	88.4%	97.6	10	78.5%	57.8	8
3/1+3/2	A449 Worcester Rd S	88.9%	30.6	15	71.8%	14.0	16
AM Peak		PRC: 1.2%		Total delay: 19.66		Cycle time: 110s	
PM Peak		PRC: 9.4%		Total delay: 14.24		Cycle time: 90s	

Table 4-3: A450 / A442, 2036 model flows, Option 1 capacity results

Arm	AM Peak			PM Peak		
	RFC	Delay	Queue	RFC	Delay	Queue
A450 Worcester Rd N	0.67	11.04	2	0.47	5.70	1
A442 Kidderminster Rd E	0.38	7.04	1	0.54	8.12	2
A450 Worcester Rd S	0.45	5.16	1	0.39	4.82	1
A442 Droitwich Rd W	0.93	29.93	11	0.63	6.39	2

- 4.2.2 The 2036 capacity results show that for Option 1 the junctions will operate within capacity, although some further improvements may be required on the Droitwich Road arm of the A450/A442 roundabout to further improve the capacity on that junction.
- 4.2.3 The proposal will introduce longer journeys for some users due to the need for drivers to navigate the alternate southbound route due to the A449 becoming northbound only between the A450 and A442 junctions. The route impact is assessed in chapter 4 of this report.

4.2.4 Option 2 - Introduce a Gyratory

Table 4-4: A449 / A450 Black Bridge 2036 model flows, Option 2 capacity results

Link	Arm	AM Peak			PM Peak		
		DoS	Delay	MMQ	DoS	Delay	MMQ
1/1	A450 Worcester Rd E (L)	73.0%	3.7	2	73.0%	3.7	2
1/2	A450 Worcester Rd E (R)	47.4%	47.1	3	44.3%	42.6	3
2/1+2/2	A449 Worcester Rd S	72.3%	7.1	8	72.3%	7.3	8
AM Peak		PRC: 23.3%		Total delay: 5.48		Cycle time: 75s	
PM Peak		PRC: 23.4%		Total delay: 5.46		Cycle time: 70s	

Table 4-5: A449 / A442 2036 model flows, Option 2 capacity results

Link	Arm	AM Peak			PM Peak		
		DoS	Delay	MMQ	DoS	Delay	MMQ
1/1	A449 Worcester Rd N	99.4%	72.6	40	77.2%	20.9	18
2/1	A449 Worcester Rd S (A)	51.6%	1.9	1	67.9%	2.9	1
2/2	A449 Worcester Rd S (R)	101.2%	113.1	32	77.8%	44.3	12
AM Peak		PRC: -12.4%		Total delay: 9.96		Cycle time: 90s	
PM Peak		PRC: 15.6%		Total delay: 11.34		Cycle time: 90s	

Table 4-6: A450 / A442 2036 model flows, Option 2 capacity results

Arm	AM Peak			PM Peak		
	RFC	Delay	Queue	RFC	Delay	Queue
A450 Worcester Road N	0.67	10.08	2	0.46	5.35	1
A442 Droitwich Road E	0.39	7.07	1	0.54	8.12	2
A442 Droitwich Road W	0.78	6.58	4	0.73	5.65	3

- 4.2.5 The 2036 capacity results show that for Option 2 the A449/A442 would operate beyond its capacity; this is primarily because of the high right turning flow being reassigned from Black Bridge junction being opposed by a heavy A442 ahead movement. The junction is constrained by adjacent topography and land ownership and therefore additional widening improvements may be cost prohibitive.
- 4.2.6 The proposals will introduce longer journeys to users as they will need to navigate the gyratory one-way network to get to destinations which may be shorter using the existing network. The route impact is assessed in chapter 4 of this report.

4.2.7 Option 3 - Ban A450 right turn out and lengthen the existing A449 flare

Table 4-7: A449 / A450 2036 Black Bridge model flows, Option 3 capacity results

Link	Arm	AM Peak			PM Peak		
		DoS	Delay	MMQ	DoS	Delay	MMQ
1/1	A449 Worcester Rd N	87.2%	32.3	22	83.9%	32.3	19
2/1	A450 Worcester Rd E	78.8%	41.9	12	79.1%	38.1	14
3/1+3/2	A449 Worcester Rd S (AR)	81.6%	14.2	13	72.4%	10.4	10
AM Peak		PRC: 3.2%		Total delay: 18.82		Cycle time: 90s	
PM Peak		PRC: 7.3%		Total delay: 16.29		Cycle time: 90s	

The Option 3 layout of the A449 / A450 'Black Bridge' junction operates within capacity in 2036 in both peaks but is close to capacity in the AM peak.

Table 4-8: A449 / A442 2036 model flows, Option 3 capacity results

Link	Arm	AM Peak			PM Peak		
		DoS	Delay	MMQ	DoS	Delay	MMQ
1/1	A449 Worcester Rd N	72.0%	12.2	16	68.2%	14.6	15
2/1	A442 Droitwich Rd E	85.9%	76.4	9	76.5%	50.9	9
3/1	A449 Worcester Rd S	88.3%	28.3	22	75.9%	17.1	18
AM Peak		PRC: 2.0%		Total delay: 15.66		Cycle time: 90s	
PM Peak		PRC: 17.6%		Total delay: 12.46		Cycle time: 90s	

Table 4-9: A450 / A442 2036 model flows, Option 3 capacity results

Arm	AM Peak			PM Peak		
	RFC	Delay	Queue	RFC	Delay	Queue
A450 Worcester Rd N	0.58	6.68	2	0.42	4.51	1
A442 Droitwich Rd E	0.32	5.21	1	0.50	6.91	1
A450 Worcester Rd S	0.45	5.21	1	0.39	4.87	1
A442 Droitwich Rd W	0.76	20.59	3	0.36	7.69	1

The 2036 capacity results show that Option 3 will operate within capacity with some improvements at Black Bridge and A449/A442 junctions.

4.3 A450/A448 Mustow Green roundabout

The 2036 capacity results for options 1 and 2 are shown below:

4.3.1 Option 1 - Re-position and enlarge roundabout

Table 4-10: A450 / A448 2036 model flows, Option 1 capacity results

Arm	AM Peak			PM Peak		
	RFC	Delay	Queue	RFC	Delay	Queue
A448 Bromsgrove Road N	0.68	9.46	2	0.43	5.34	1
A450 Worcester Road E	0.73	14.00	3	0.57	7.28	2
A448 Bromsgrove Road S	0.73	11.37	3	0.80	14.83	4
A450 Worcester Road W	0.62	8.24	2	0.69	12.01	2

4.3.2 Option 2 - Re-position and replace roundabout with traffic signals

Table 4-11: A450 / A448 2036 model flows, Option 2 capacity results

Link	Arm	AM Peak			PM Peak		
		DoS	Delay	MMQ	DoS	Delay	MMQ
1/1	A448 Bromsgrove Road N	82.3%	30.9	15	48.3%	18.2	7
2/1	A450 Worcester Road E	73.9%	27.6	12	86.0%	40.4	10
3/1	A448 Bromsgrove Road S	81.3%	28.7	17	89.9%	36.2	22
4/1+4/2	A450 Worcester Road W	77.6%	28.8	11	68.9%	26.2	11
AM Peak		PRC: 9.3%		Total delay: 22.38		Cycle time: 80s	
PM Peak		PRC: 0.1%		Total delay: 22.29		Cycle time: 80s	

The capacity results at Mustow Green roundabout show that both the Option 1 (larger roundabout) and Option 2 (new traffic signals) will operate within capacity.

4.4 A450/ B4188 Hackmans Gate

The 2036 capacity results for option 1 are shown below:

4.4.1 Option 1 - Modify signal timings to benefit A450

Table 4-12: A450 / B4188 2036 Option 1 capacity results

Link	Arm	AM Peak			PM Peak		
		DoS	Delay	MMQ	DoS	Delay	MMQ
1/2+1/1	Stourbridge Rd N (LAR)	75.7%	34.1	14	57.4%	30.0	10
3/1	Hackmans Gate (LAR)	77.0%	55.3	8	88.4%	52.9	19
5/1	Stourbridge Road S (LA)	76.7%	36.4	14	86.5%	46.46	19
5/2	Stourbridge Road S (R)	57.8%	56.4	3	13.3%	31.0	1
7/1	Belbroughton Road (LAR)	73.3%	47.9	9	86.1%	113.4	6
AM Peak		PRC: 16.9%		Total delay: 20.88		Cycle time: 90s	
PM Peak		PRC: 1.8%		Total delay: 24.730		Cycle time: 100s	

The capacity results show that the junction operates within capacity.

4.5 A450/ A456 Junction

The 2036 capacity results for option 1 are shown below:

4.5.1 Option 1 - Ban right turn and provide short two exit merge towards Birmingham

Table 4-13: A450 / A456 2036 Option 1 capacity results

Link	Arm	AM Peak			PM Peak		
		DoS	Delay	MMQ	DoS	Delay	MMQ
1/1+1/2	A456 Worcester Rd	83.6%	10.4	22	81.7%	10.8	17
2/1	A450 Worcester Rd	92.4%	73.4	23	89.8%	52.8	17
3/1+3/2	A456 Kidderminster Rd S	93.0%	50.9	33	88.6%	30.8	22
AM Peak		PRC: -3.3%		Total delay: 27.82		Cycle time: 120s	
PM Peak		PRC: 0.2%		Total delay: 20.07		Cycle time: 85s	

4.5.2 The 2036 capacity results show that the proposed improvement at the A450/A456 junction operates beyond capacity in the AM peak and is close to capacity in the PM peak. The feasibility of providing a short two-lane section on the A456 northbound exit by moving lanes possibly into third-party land will need further investigation in the next stage of the study.

4.6 A456/ B4187 Junction

The 2036 capacity results for option 1 are shown below:

4.6.1 Option 1 - Introduce longer left slip to B4187

Table 4-14: A456 / B4187 2036 Option 1 capacity results

Link	Arm	AM Peak			PM Peak		
		DoS	Delay	MMQ	DoS	Delay	MMQ
1/1+1/2	A456 LAR	94.6%	42.4	45	85.9%	29.8	24
3/1	Summervale Rd L	22.7%	3.8	0	9.6%	3.3	0
4/2+4/1	B4187 Worcester Rd LAR	95.0%	107.6	17	86.4%	58.7	12
10/1	A456 Worcester Rd A	74.0%	16.2	21	81.3%	17.9	17
AM Peak		PRC: -5.5%		Total delay: 31.02		Cycle time: 120s	
PM Peak		PRC: 4.2%		Total delay: 20.14		Cycle time: 90s	

The capacity results with the 2036 model flows shows that the junction will operate beyond capacity in the AM Peak but will operate within capacity in the PM Peak.

5. Route Impact Analysis

5.1 Combined A449/A450 Black Bridge, A449/A442 and A450/A442 junctions

The combined A449/A450 Black Bridge, A449/A442 and A450/A442 junctions options 1 and 2 will have an impact on the routes currently made by users of this section of the highway network. This section of the report assesses the impact on local residents, buses and high load vehicles.

5.1.1 Route impact on local residents

Local residents that need access between A449 between Black Bridge junction and the A449/A442 junction would be affected by both options 1 and 2.

- 5.1.2 Option 1, the diversion for local residents would be to use the A442 and then the A450 before travelling back onto the A449 at Black Bridge junction. An alternative diversion could be onto Torton Lane, however this is unlikely due to narrow width of the lane, it provides just enough room for one vehicle and then some passing areas, it is likely to be quicker to use the slightly longer diversion route.

- 5.1.3 Option 2 would require a longer diversion than option 1, A442 traffic would need to divert onto the A450 and then travel onto the A449, therefore option 1 is preferred.

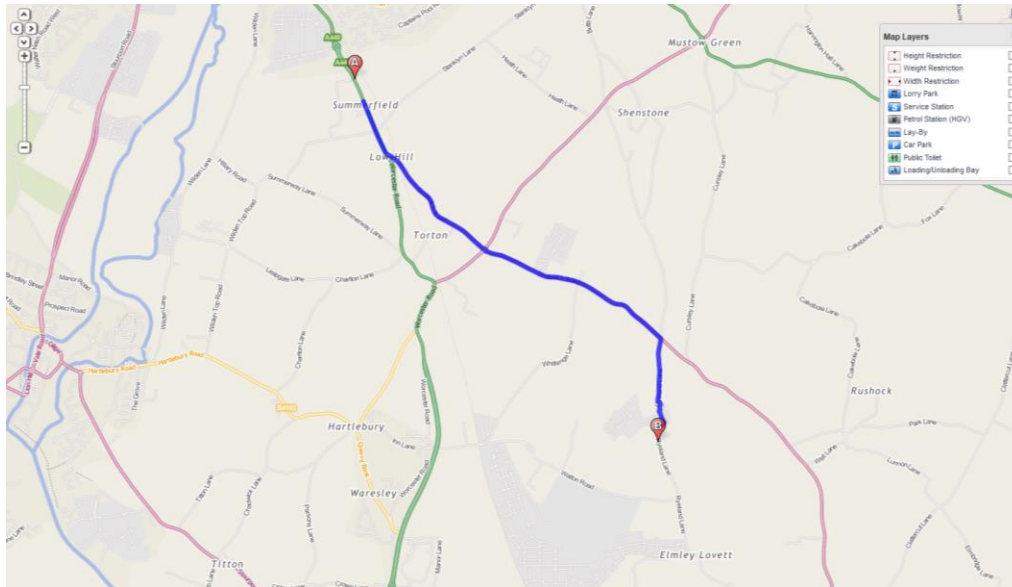
5.1.4 Route impact on buses

Option 1, bus only access could be provided for A449 southbound traffic, so the impact would be neutral, however because the frequency of service is only one bus per hour WCC to consider the benefit of maintain the bus service. Option 2 there would be no provision for A449 southbound traffic so there would be an adverse impact on buses, therefore option 1 is preferred.

5.1.5 Route impact on high load vehicles

Option 1, high load vehicles would be affected by the A450 low bridge because the A449 southbound traffic is being diverted onto the A442 and then the A450 before re-joining the A449 at Black Bridge.

Traffic collected in 2011 show that during the period of 0700 to 1900 there are 183 HGV's (3% of traffic using A449) that travel on the A449 southbound at Black Bridge junction, however there is no specific details on the size of the HGV's and therefore it is unclear how many vehicles would be affected by option 1. Nevertheless, there are alternative options that high load vehicles could use which has been established using a website program, freight journey planner, for example a journey made from north of the A449/A442 junction travelling to industrial parks to the south of Black Bridge junction is illustrated in the figure below.

Figure 3 Alternative Route for High Load Vehicles

- 5.1.6 It is likely some HGV's will be adversely affected by the proposals however there are existing advanced warning signs on the diversion route, A442 which would assist high load vehicles make alternative route choice.

Figure 4 Photograph on A442 South with Black Bridge junction to the east

Figure 5 Photograph Facing Whitlence Lane from A442 Kidderminster Road



- 5.1.7 Whilst option 1 will result in a small number of HGV's having to divert to alternative routes, the existing warning sign provision and alternative routes would keep disruption to a minimum.

6. Scheme Costs

6.1 Preferred option scheme costs

- 6.1.1 The schemes have been priced to help select the preferred options, there is no topographical data or geotechnical information and therefore the estimates are considered as 'high level' conceptual estimates. At this stage no cost assumption has been made to account for underground statutory plant, to obtain accurate figures, information from statutory bodies own estimates would be required. A risk allowance of 25% has been applied to the base construction cost developed to cover these high-risk elements. Further, Optimism Bias (OB) at 44% has been added on to the risk-adjusted costs to account for cost uncertainty at this stage of the study.
- 6.1.2 In addition to the above, the scheme costs have been developed taking into account an approximate estimation of certain aspects such as the costs for traffic management, survey and investigation costs, in addition to design, and supervision.
- 6.1.3 Land costs have been provided by WCC through their internal contractors Place Partnerships.

Table 6-1: High Level Costs (2019 prices) of Options

Scheme	Option	Construction and Land Costs	Risk (25%)	Risk adjusted Costs	Optimism Bias (44%)	Total costs
A449/A450 Black Bridge & A449/A442 & A450/A442	1	£943,000	£236,000	£1,179,000	£519,000	£1,698,000
	2	£670,000	£168,000	£838,000	£369,000	£1,207,000
	3	£324,000	£81,000	£405,000	£179,000	£584,000
A450/A448 Mustow Green	1	£982,000	£246,000	£1,228,000	£541,000	£1,769,000
	2	£1,079,000	£270,000	£1,349,000	£594,000	£1,943,000
A450/ B4188 Hackmans Gate	1	-	-	-	-	-
A456/A450	1	£202,000	£51,000	£253,000	£112,000	£365,000
	2	£410,000	£103,000	£513,000	£226,000	£739,000
	3	£-	£-	£-	£-	£-
A450/ B4187	1	£79,000	£20,000	£99,000	£44,000	£143,000
	2	£274,000	£69,000	£343,000	£151,000	£494,000

Note: Costs has been rounded up to the nearest thousand; in general OB is not included for financial estimates, however due to uncertainty of costs at this stage, Optimism Bias has been included to derive the total costs

7. Option Evaluation

7.1 Introduction

7.1.1 The following table has been prepared to help select the preferred options; it provides a summary of the key issues, the impact on capacity and any land-take issues.

Table 6.1 Option Evaluation Table

Black Bridge A449/A442 & A450/A442 Junctions	Option 1 – Convert A449 Northbound from A450 to A442	Option 2 – Gyratory to all three junctions	Option 3 – Ban A450 right turn out and lengthen existing A449 right turn flare
Land take	Some land-take on third-party land for the increased size of roundabout and flared approaches.	Less land-take than Option 1 because flared approach to roundabout not required.	Further investigation required to determine if land-take required on the A449 for widening right turn flare. Some land-take may also be required at the A449/A442 junction to provide a safe right-turn waiting area in the junction intersection.
Capacity	Best performing option with junctions operating within capacity and provides the least queues and delays of all options.	The A449/A442 junction fails to perform within capacity because of a heavy right turn flow being reassigned from Black Bridge junction.	Second best performing option, but the A449/A442 nearing capacity in 2036.
Other	Except for the A450/A442 roundabout, Option 1 could be built largely within highway boundary with minor tweaks to the existing infrastructure. The disadvantage of the scheme is there will be a longer route for A449 southbound traffic, diverting onto the A442 and then the A450. Low bridge on the A450 will restrict high load vehicles using this diversion but numbers are low and there are alternative routes that requires slightly longer diversion.	The one-way system will involve longer diversions for more users than option 1. Low bridge on the A450 will restrict high load vehicles using the gyratory.	Least amount of modification and disruption to motorists, the network largely remains the same.
Price	£1,698,000	£1,207,000	£584,000
	✓✓✓	✓	✓✓
Mustow Green roundabout	Option 1 – Re-position & larger roundabout	Option 2-Re-position & replace roundabout with signals	
Land-take	Significant land-take required outside highway boundary to the north of existing roundabout, however the land required is agriculture and therefore should be easier to acquire.	Significant land-take required outside highway similar requirement to Option 1.	
Capacity	Best performing option with small queues and delays	Second best option operates within capacity but less efficient than Option 1.	
Other	The layout is constrained by adjacent residential properties and therefore requires a significant alteration. Further	Compared with Option 1 the signals would provide increased delays, particularly	

	investigation is required on the feasibility of the scheme.	during off-peak hours.	
Price	£1,769,000	£1,943,000	
	✓✓	✓	
A450/ B4188 Hackmans Gate	Option 1 – Minor signal modifications		
Land-take	Within highway boundary.		
Capacity	The signals operate within capacity, potential for modifications made to MOVA timings to provide priority to queuing on the A450 traffic.		
Other	With increased flow there could be issues with the layout and further investigation may be required.		
Price	-		
	✓		
A450/A456	Option 1 – Ban right turn and provide short exit merge towards Birmingham	Option 2 – Introduce one-way on A450 southbound	
Land-take	Further investigation required the improvement may encroach outside highway boundary.	Land-take on Thicknall Lane	
Capacity	The proposals will provide a betterment to the existing situation	No traffic data to undertake capacity assessments at this stage.	
Other	Constrained network provides less opportunity for more significant improvements. Further investigation/ surveys required to fully understand the implications/cost of this proposal	-	
Price	£365,000	£739,000	
	✓	-	
A456/ B4187	Option 1 –Longer left turn taper to B4187	Option 2 – Extend A456 to two lanes from A450 to B4187	
Land-take	Within Highway boundary	Possible Land-take on of front gardens on the A456.	
Capacity	The capacity results show the junction does not operate within capacity in the AM peak and the proposals result in longer queues on the A456 southbound.	No traffic data to undertake assessment.	
Other	Constrained network provides less opportunity for more significant improvements.	The proposals will impact right turning traffic into residential areas.	
Price	£143,000	£494,000	
	-	-	

Note: ✓ indicates the performance of the layout in comparison with other layouts

8. Wyre Forest Traffic Model

8.1 Introduction

- 8.1.1 The Wyre Forest Transport Model has been used to assess the impact of the emerging local plan development allocations on the network for the year 2036. This model was used to assess the impacts of forecast traffic on the A450 corridor. Model scenarios were developed for 2036 AM and PM peaks Without Scheme (WoS) and with the preferred A450 corridor enhancement options (With Scheme, WS) discussed in preceding sections.
- 8.1.2 Highway network statistics, model flows and journey times along the A450 from both the without and with A450 corridor improvements were extracted and informed the options assessed. Appendix B provides details on the assessments using the WFTM.
- 8.1.3 Additionally, analysis has been undertaken on the forecast flows on the A450 corridor to identify traffic attributed to proposed local plan development sites to help inform schemes that need to be included in the WFIDP. One of the biggest development sites proposed is the Stone Hill North with a capacity for 1100 dwelling units. This development site is to be accessed from the A448 to the east of Kidderminster, not far away from the A450 corridor (A448/A450 roundabout).
- 8.1.4 Analysis of the development site traffic and its distribution to the A450/A448 roundabout is given in Table 8-1 below.

Table 8-1: Traffic from Stone Hill North at A450/A448 roundabout

Model Scenario	Total traffic from Stone Hill North	Traffic using A448/A450 roundabout	%
AM WOS	955	111	12%
AM WS	956	155	16%
PM WOS	711	77	11%
PM WS	704	79	11%

- 8.1.5 The table shows that 12-16% of traffic in the AM and 11% of traffic in the PM from/to the development zone interacts with the A450/A448 roundabout. The development traffic thereafter disperses along different directions from the roundabout.
- 8.1.6 The proportion of traffic from the Stone Hill North development site to the total flow along the junctions assessed on the A450 corridor is summarised in Table 8-2 below.

Table 8-2: Share of Stone Hill North Development traffic to flow at junctions on A450

Junction	2036 AM				2036 PM			
	Total Jn Flow		Development Flow		Total Jn Flow		Development Flow	
	WoS	WS	WoS	WS	WoS	WS	WoS	WS
A456 / B4187 / Western Road / Summervale Road	2433	2595	66	66	2663	2752	45	37
A456 / A450	2322	2405	68	52	2490	2491	45	37
A450 / B4188 Hackmans Gate	1603	1820	61	68	1555	1760	46	35
Mustow Green Roundabout	2664	3252	111	155	2513	2951	77	79
A450 / A442 Roundabout	1890	2729	9	154	1822	2622	5	22
A449 / A450	2542	2659	50	50	2585	2703	26	26
A449 / A442	2159	1748	48	3	1855	1754	26	10
			%				%	
			WoS	WS			WoS	WS
A456 / B4187 / Western Road / Summervale Road			2.7%	2.5%			1.7%	1.3%
A456 / A450			2.9%	2.2%			1.8%	1.5%
A450 / B4188 Hackmans Gate			3.8%	3.7%			3.0%	2.0%
Mustow Green Roundabout			4.2%	4.8%			3.1%	2.7%
A450 / A442 Roundabout			0.5%	5.6%			0.3%	0.8%
A449 / A450			2.0%	1.9%			1.0%	1.0%
A449 / A442			2.2%	0.2%			1.4%	0.6%

- 8.1.7 The table shows that traffic from the development site interacts with all the junctions along the A450 corridor to varying proportions. Depending on the junctions total traffic volume, the proportions vary between 0.2% and 5.6% in the AM peak and between 0.3% and 3.1% in the PM peak.
- 8.1.8 The highest development traffic volumes are at the A450/A448 roundabout; A450/A442 roundabout followed by the A456/B4187 and A450/A456 junctions in the AM peak hour in the With Scheme scenario.
- 8.1.9 The above table demonstrates that improvements to these junctions can be incorporated into the WFIDP and attributed to the emerging local plan development allocations.

9. Preferred Option Capacity Assessment

9.1 Introduction

9.1.1 To fully assess the proposals the traffic flows from the WFTM with the preferred options coded in (With scheme) were extracted and input into the capacity models to determine the impact on the preferred improvements.

9.1.2 The following options have been tested:

Combined A449/A450 Black Bridge, A449/A442 and A450/A442 junctions

- Option 1 A449 traffic northbound only, southbound on demand for buses only and the right turn from the A450 on demand.

A450/A448 Mustow Green roundabout

- Option 1 the larger roundabout located to the north of the existing layout because it provides the best capacity benefits.

A450/ B4188 Hackmans Gate

- Option 1 modify the existing signals timings to benefit the A450.

A450/A456

- Option 1 ban the right turn from the A456 to the A450 and provide a short two-lane merge exit towards Birmingham, further investigation work is required on constraints for the provision of the merge lane. The network is constrained which provides less opportunity for more significant improvements.

A450/A456

- Option 1 - Introduction of the longer left turn slip on the B4187.

9.2 Combined A449/A450 Black Bridge, A449/A442 and A450/A442 junctions

9.2.1 Option 1 - Convert A449 to one-way northbound

The 2036 capacity results with the revised flows is shown below:

Table 9-1: A449 / A450 Black Bridge, 2036 model flows - Option 1 capacity results

Link	Arm	AM Peak			PM Peak		
		DoS	Delay	MMQ	DoS	Delay	MMQ
1/1+1/2	A450 Worcester Rd E	72.8%	4.0	2	74.7%	4.9	2
2/1+2/2	A449 Worcester Rd S	74.9%	8.1	8	83.5%	11.2	12
AM Peak		PRC: 20.2%		Total delay: 4.47		Cycle time: 70s	
PM Peak		PRC: 7.8%		Total delay: 5.98		Cycle time: 70s	

Notes: A449 southbound buses have not been modelled as the provision is for an hourly service and therefore will have limited impact on the results

Table 9-2: A449 / A442, 2036 model flows - Option 1 capacity results

Link	Arm	AM Peak			PM Peak		
		DoS	Delay	MMQ	DoS	Delay	MMQ
1/1	A449 Worcester Rd N	85.1%	17.2	16	72.2%	12.2	12
2/1	A442 Droitwich Rd E	67.6%	46.9	4	67.7%	43.9	4
3/1+3/2	A449 Worcester Rd S	51.6%	8.2	6	62.4%	10.1	9
AM Peak		PRC: 5.8%		Total delay: 8.77		Cycle time: 60s	
PM Peak		PRC: 24.6%		Total delay: 7.50		Cycle time: 60s	

Table 9-3: A450 / A442, 2036 model flows, Option 1 capacity results

Arm	AM Peak			PM Peak		
	RFC	Delay	Queue	RFC	Delay	Queue
A450 Worcester Rd N	0.66	8.77	2	0.64	10.61	2
A442 Kidderminster Rd E	0.61	11.00	2	0.29	6.39	0
A450 Worcester Rd S	0.58	6.73	2	0.44	4.92	0
A442 Droitwich Rd W	0.66	7.61	2	0.86	15.88	6

The 2036 capacity results show that for Option 1 the junctions will operate within capacity.

9.3 A450/A448 Mustow Green roundabout

9.3.1 Option 1 - Re-position and enlarge roundabout

Table 8-4: A450 / A448 2036 model flows, Option 1 capacity results

Arm	AM Peak			PM Peak		
	RFC	Delay	Queue	RFC	Delay	Queue
A448 Bromsgrove Road N	0.89	27.57	7	0.49	6.37	1
A450 Worcester Road E	0.89	31.15	7	0.64	7.97	2
A448 Bromsgrove Road S	0.81	17.09	4	0.75	12.13	3
A450 Worcester Road W	0.69	9.80	2	0.85	19.27	6

9.3.2 The 2036 capacity results show that Mustow Green begins to near its operational capacity and therefore some further refinements to the geometric parameters should be made during the next stage of the study, to ensure that the junction operates well within capacity.

9.4 A450/ B4188 Hackmans Gate

9.4.1 Option 1 - Modify signal timings to benefit A450

The 2036 capacity results for option 1 is shown below:

Table 8-5: A450 / B4188 2036 Option 1 capacity results

Link	Arm	AM Peak			PM Peak		
		DoS	Delay	MMQ	DoS	Delay	MMQ
1/2+1/1	Stourbridge Rd N (LAR)	87.0%	38.7	20	73.2%	28.1	15
3/1	Hackmans Gate (LAR)	82.3%	60.6	10	74.0%	48.2	9
5/1	Stourbridge Road S (LA)	71.1%	29.6	13	76.8%	30.6	16
5/2	Stourbridge Road S (R)	62.7%	65.9	2	27.5%	34.0	1
7/1	Belbroughton Road (LAR)	82.5%	65.3	9	74.8%	69.6	6
AM Peak		PRC: 3.5%		Total delay: 24.41		Cycle time: 90s	
PM Peak		PRC: 17.1%		Total delay: 17.36		Cycle time: 90s	

The capacity results show that the junction operates within capacity.

9.5 A450/ A456 Junction

9.5.1 Option 1 - Ban right turn and provide short two exit merge towards Birmingham

Table 8-6: A450 / A456 2036 Option 1 capacity results

Link	Arm	AM Peak			PM Peak		
		DoS	Delay	MMQ	DoS	Delay	MMQ
1/1+1/2	A456 Worcester Rd	69.7%	8.4	14	66.6%	8.1	12
2/1	A450 Worcester Rd	83.4%	51.7	20	78.3%	37.2	13
3/1+3/2	A456 Kidderminster Rd S	84.2%	41.3	24	79.7%	26.0	17
AM Peak		PRC: 6.9%		Total delay: 19.58		Cycle time: 120s	
PM Peak		PRC: 12.9%		Total delay: 13.99		Cycle time: 85s	

9.5.2 The 2036 capacity results show that the proposed improvement at the A450/A456 junction operates within capacity. The feasibility of providing a short two-lane section on the A456 northbound exit by moving lanes possibly into third-party land will need further investigation in the next stage of the study.

9.5.3 These results are based on the assumption that there are no exit capacity issues, if there are slow moving exit queues on the A456 this may impact on the capacity of the junction.

9.6 A456/ B4187 Junction

9.6.1 Option 1 - Introduce longer left slip to B4187

Table 8-7: A456 / B4187 2036 Option 1 capacity results

Link	Arm	AM Peak			PM Peak		
		DoS	Delay	MMQ	DoS	Delay	MMQ
1/1	A456 LAR	92.7%	39.0	38	88.3%	31.0	33
3/1	Summervale Rd L	4.7%	3.0	0	5.0%	4.1	2
4/2+4/1	B4187 Worcester Rd LAR	90.4%	89.0	15	89.4%	88.3	14
10/1	A456 Worcester Rd A	76.5%	16.7	23	73.9%	15.7	21
AM Peak		PRC: -3.0%		Total delay: 25.58		Cycle time: 120s	
PM Peak		PRC: 0.7%		Total delay: 22.58		Cycle time: 120s	

9.6.2 The capacity results with the 2036 model flows shows that the junction will operate beyond capacity in the AM Peak but will operate close to capacity in the PM Peak.

10. Summary and Conclusion

10.1 Summary

- 10.1.1 This 'Options Report' has been prepared to establish the preferred improvement options to address congestion and safety issues on the A450 and to identify the schemes that are directly impacted by the proposed development in the Wyre Forest Local Plan and therefore the schemes which need to be included in the Wyre Forest Infrastructure Development Plan (WFIDP).

The following options have been identified as preferred to alleviate capacity issues in 2036, as follows:

Combined A449/A450 Black Bridge, A449/A442 and A450/A442 junctions

- Option 1 A449 traffic northbound only, southbound on demand for buses only and the right turn from the A450 on demand – cost at £1.67 million.

A450/A448 Mustow Green roundabout

- Option 1 the larger roundabout located to the north of the existing layout because it provides the best capacity benefits – cost at £1.77 million.

A450/B4188 Hackmans Gate

- Option 1 modify the existing signals timings to benefit the A450.

A450/A456

- Option 1 ban the right turn from the A456 to the A450 and provide a short two-lane merge exit towards Birmingham, further investigation work is required on constraints for the provision of the merge lane. The network is constrained which provides less opportunity for more significant improvements – cost at £0.36 million.

A450/A456

- Option 1 - Introduction of the longer left turn slip on the B4187 – cost at £0.14 million.

- 10.1.2 The cost of the total package to improve the A450 corridor based on the above options is estimated to be £3.97million.

- 10.1.3 Analysis of the development traffic from the Stone Hill North site identified in the emerging local plan demonstrates direct impact on the junctions along the A450 corridor, with the greatest impact on the A450/A448 roundabout.

10.2 Conclusion

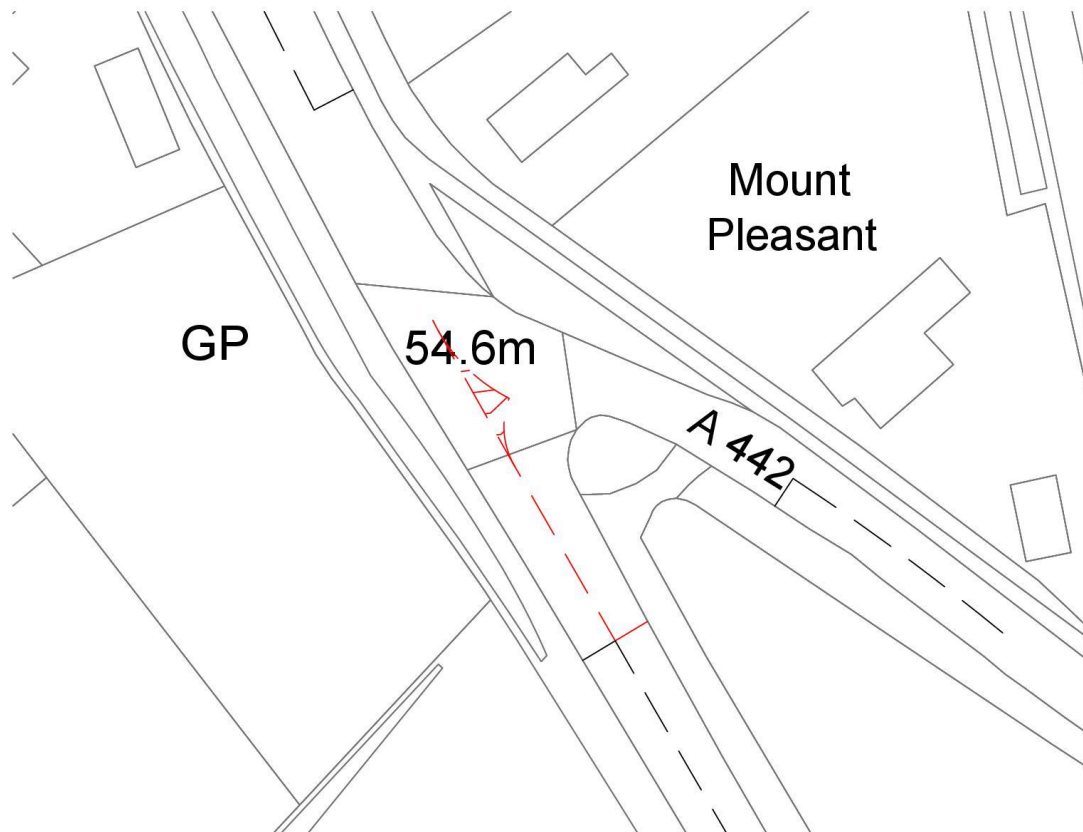
- 10.2.1 The capacity results show that the impact of future year growth, the Wyre Forest local plan developments and without progressing any of the options will result in significant increase in delays on the A450.

- 10.2.2 As such it is recommended that the preferred options should be taken forward to the next stage of the study and discussions are held between WCC and stakeholders on the benefits of the schemes.

10.3 Appendix 1

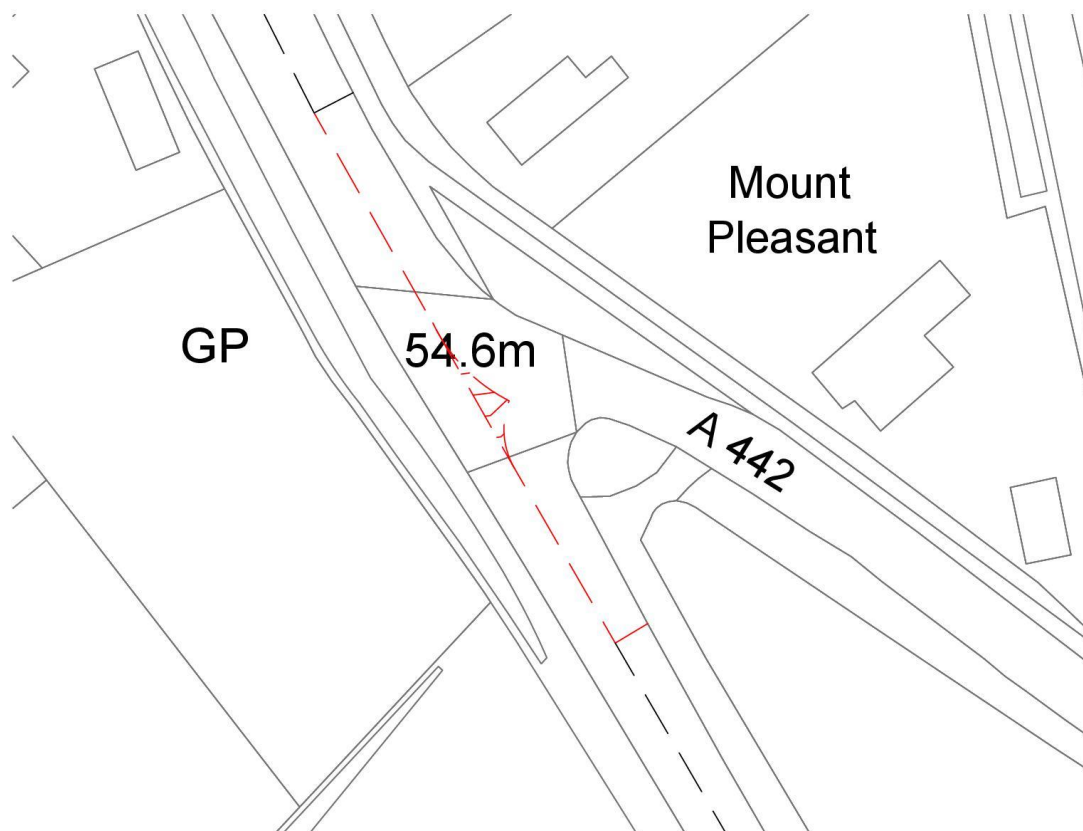
10.3.1 All designs subject to change and refinement. Multiple options for each identified project exist.

Figure 6 A449 and A442 Option 1



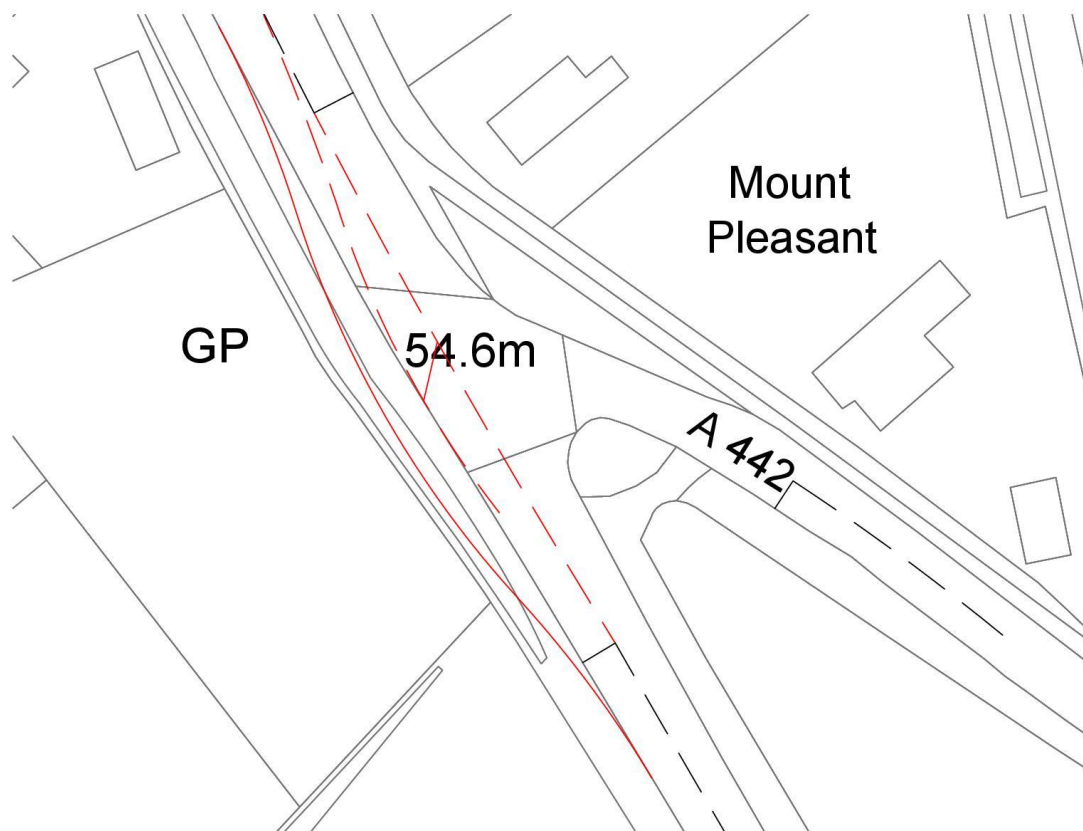
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Figure 7 A449 and A442 Option 2



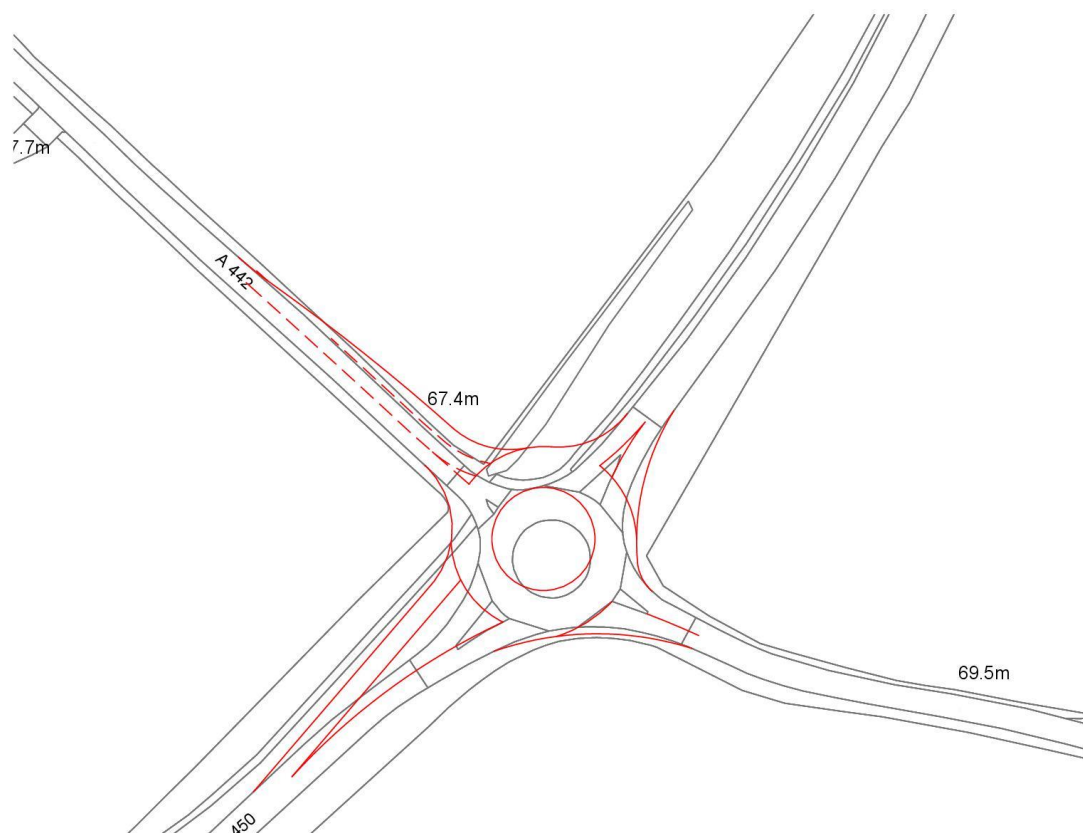
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Figure 8 A449 and A442 Option 3



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Figure 9 A450 and A442 Option 1

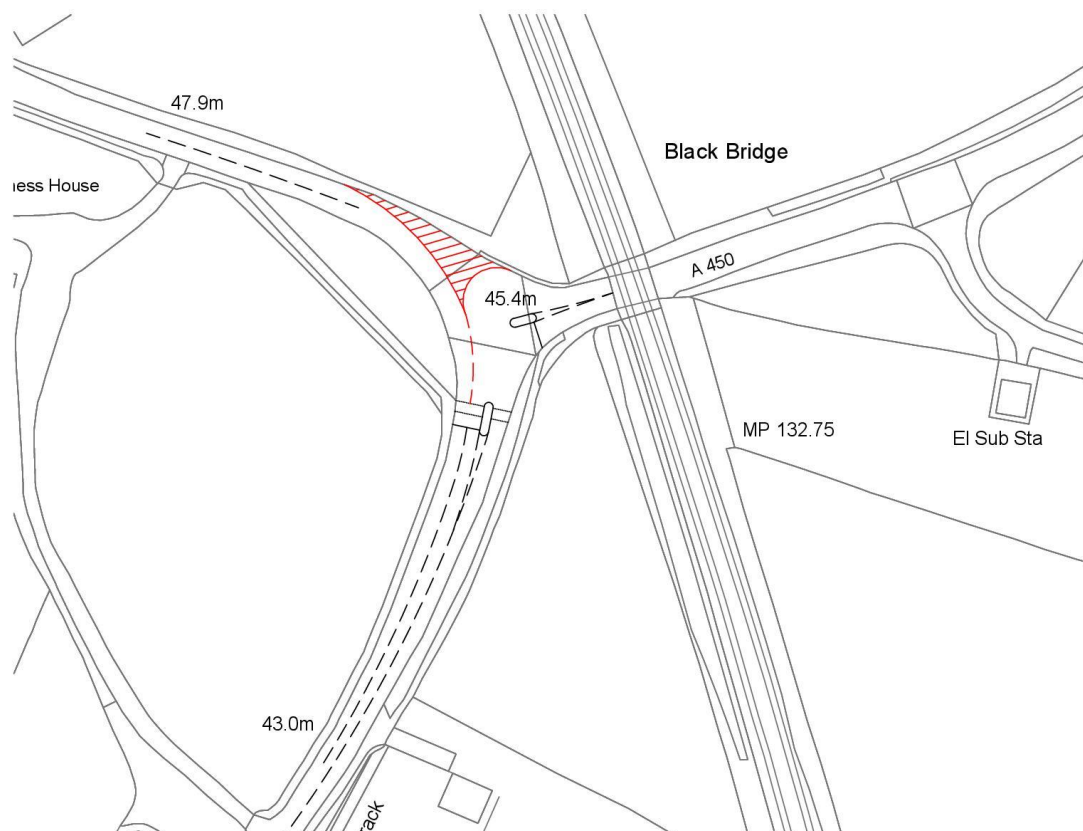


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Figure 10 A450 and A442 Option 2

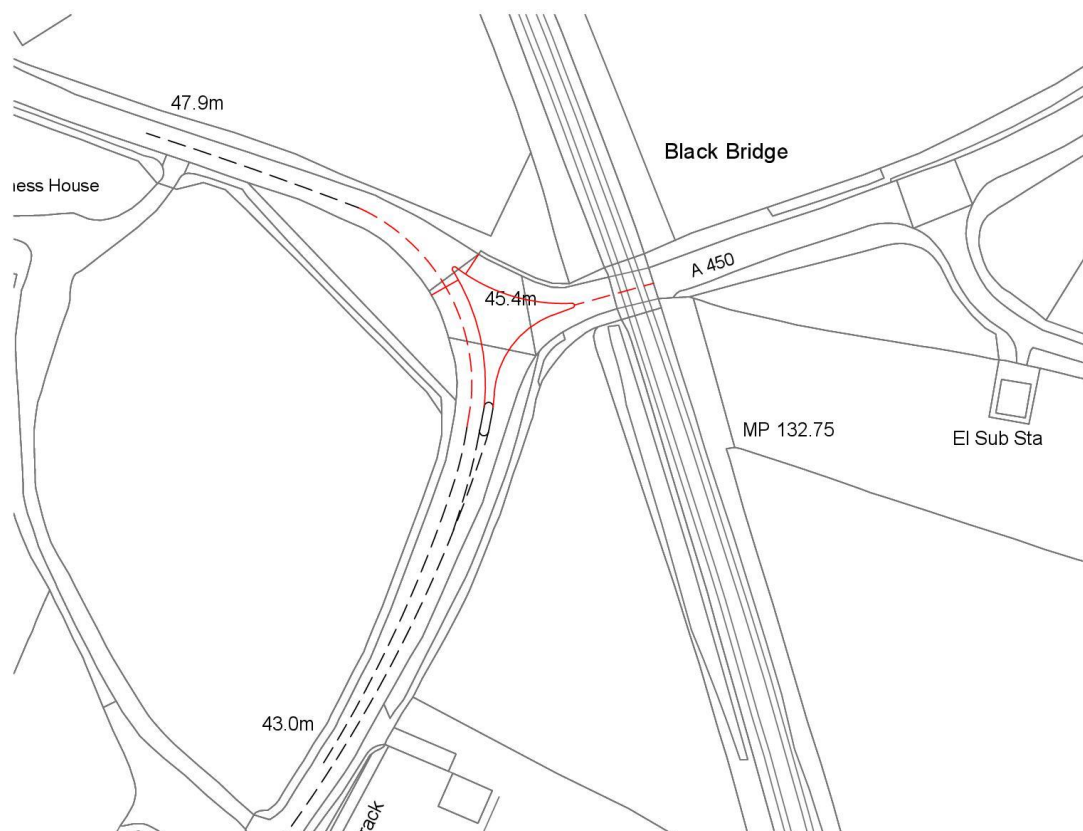


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Figure 11 Black Bridge Option 1

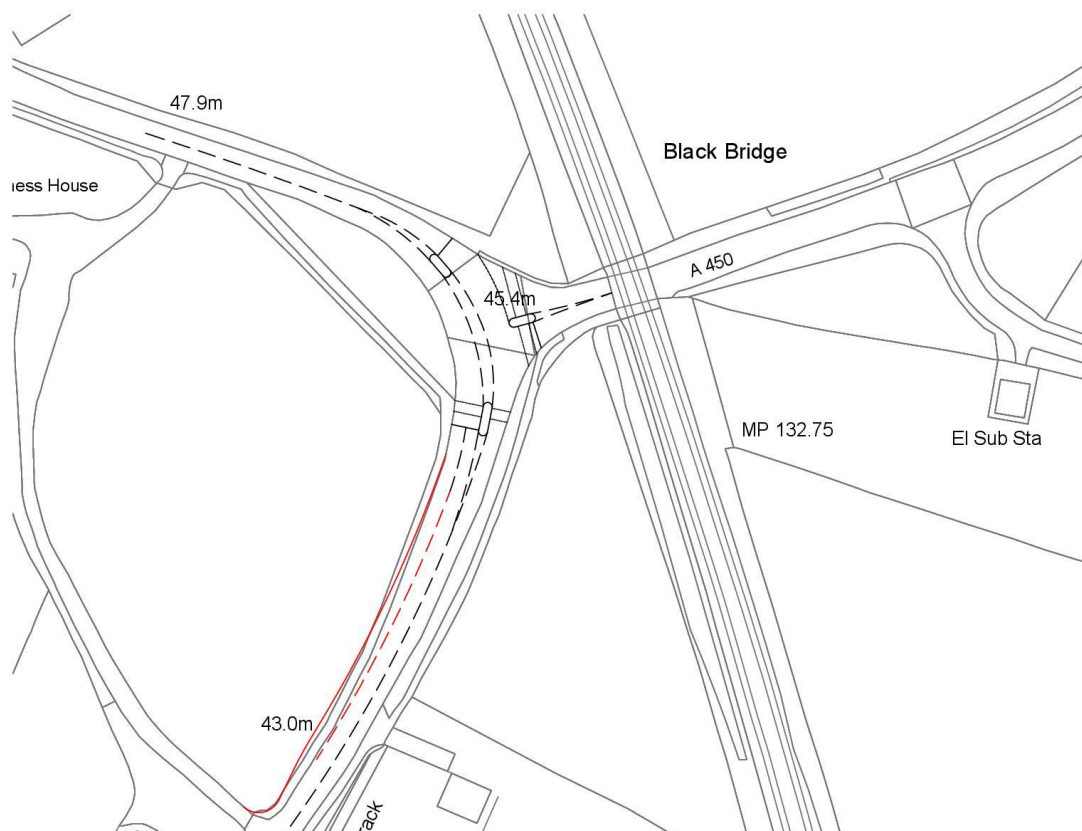
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Figure 12 Black Bridge Option 2



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Figure 13 Black Bridge Option 3



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Figure 14 Mustow Green Option 1



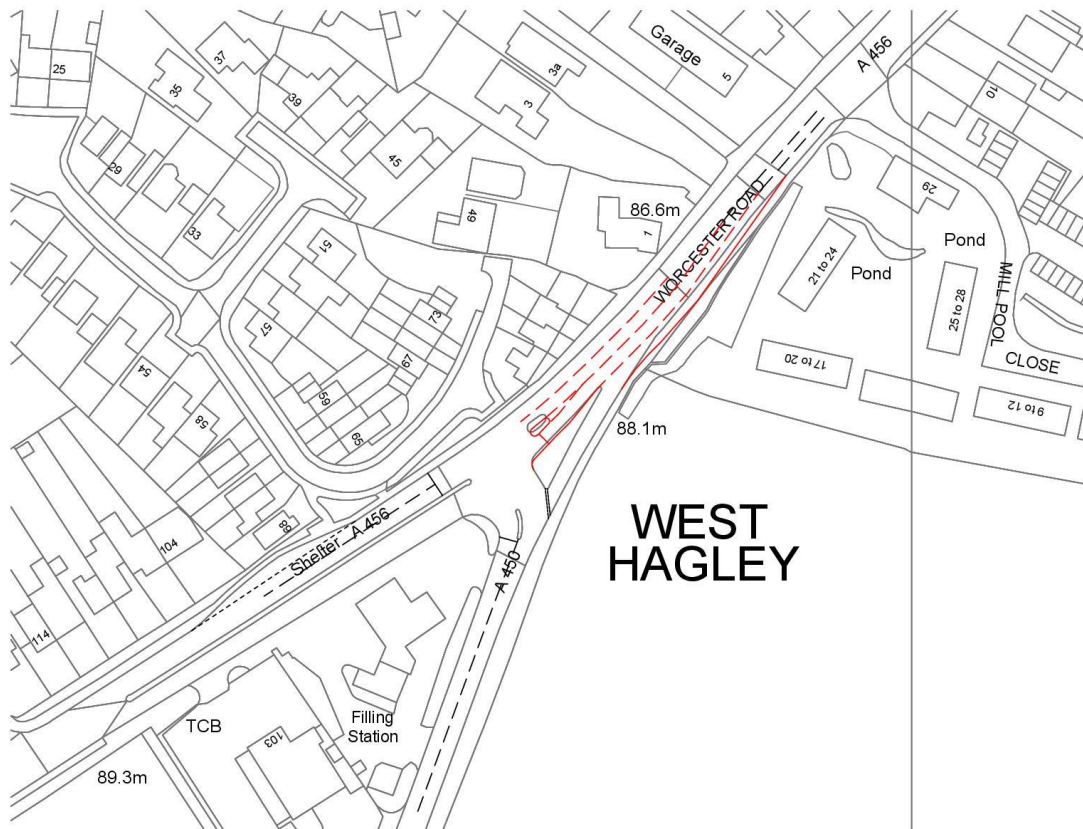
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Figure 15 Mustow Green Option 2

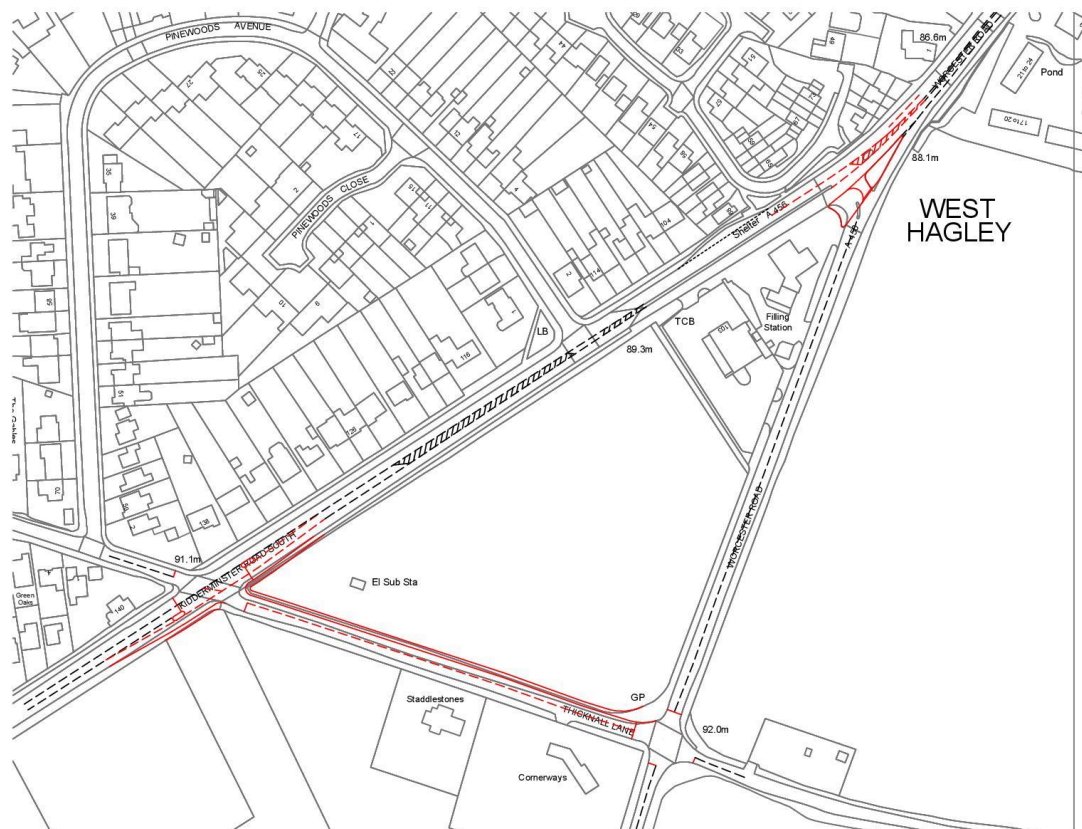


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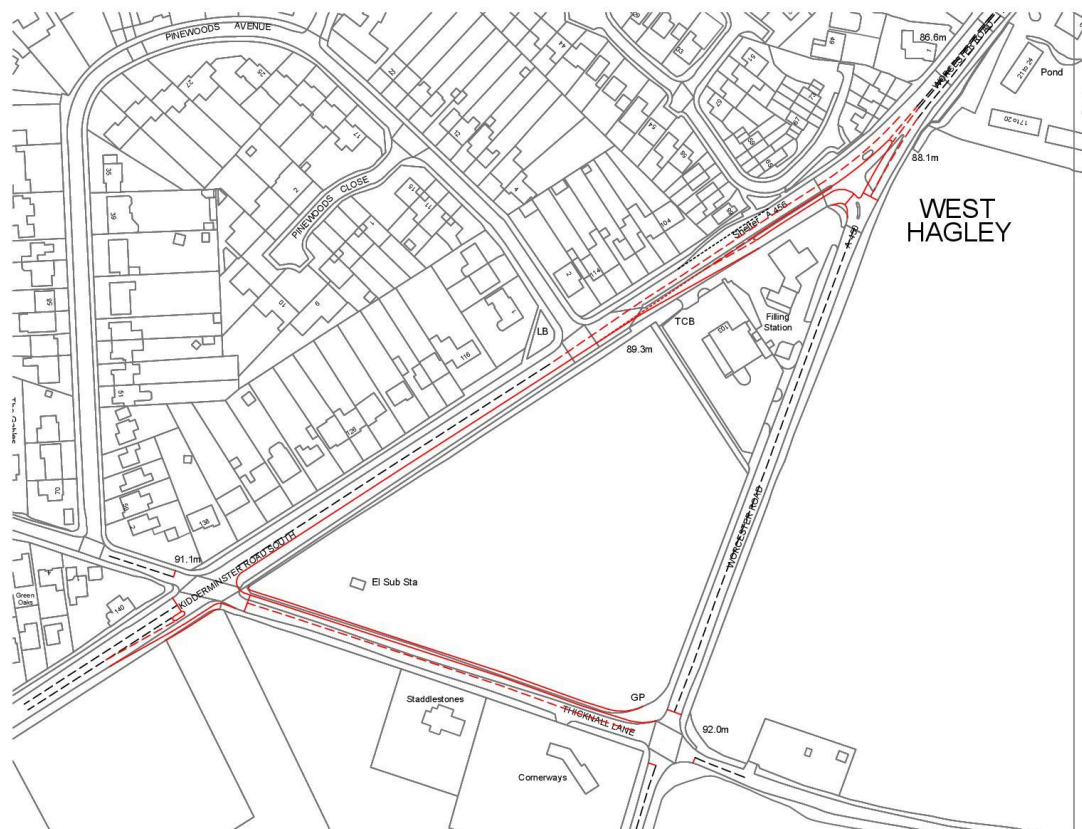
Figure 16 A456 and A450 Option 1



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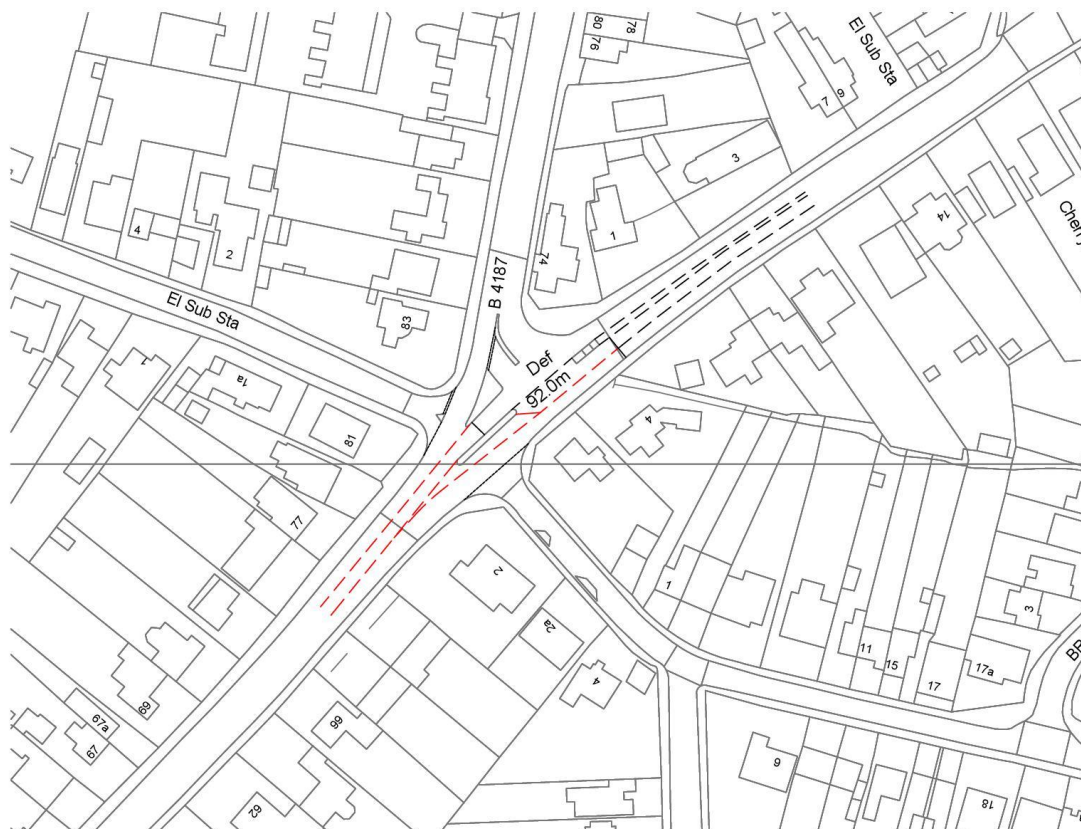
Figure 17 A456 and A450 Option 2

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Figure 18 A456 and A450 Option 3

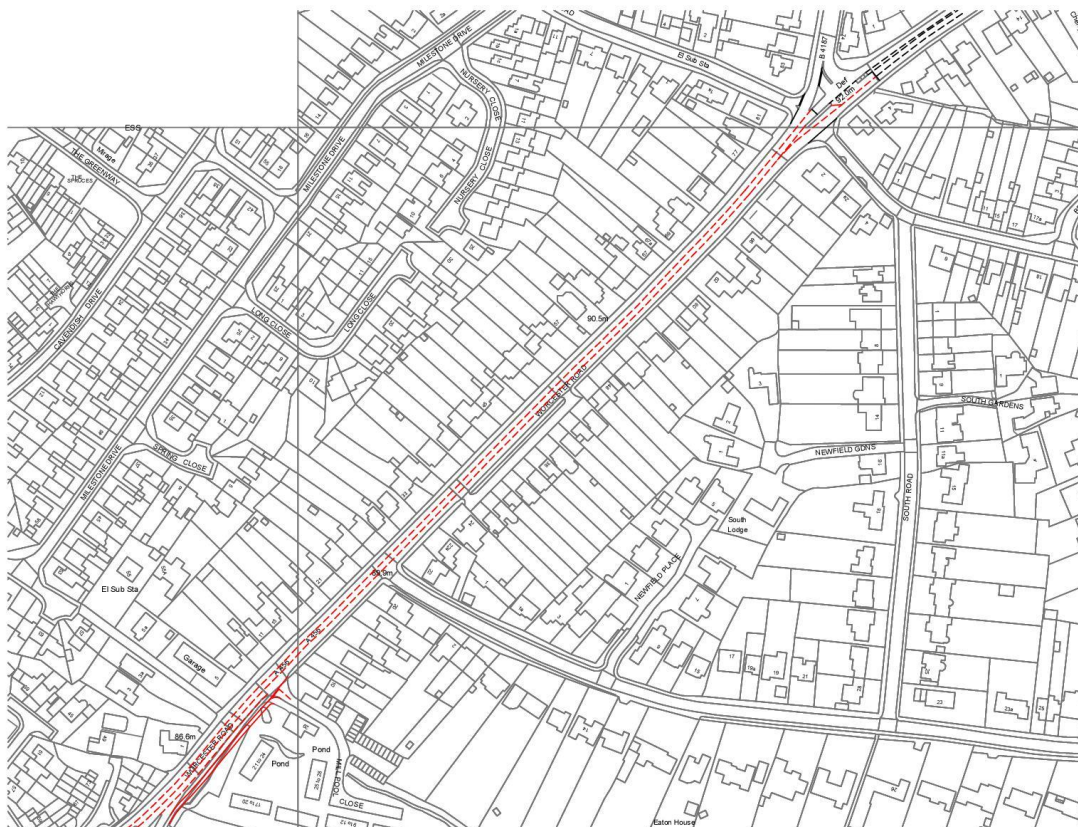
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Figure 19 A456 and B4187 Option 1



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Figure 20 A456 and B4187 Option 2



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