

Risk Assessment for Meldreth Road AHB Level Crossing

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REVISIONS

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APPROVAL

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	Date: 8/4/2020

CONTENTS

ACRONYMS AND ABBREVIATIONS

Acronym	Description	Comments
ABCL	Automatic Barrier Level Crossing, Locally-monitored	
AHB	Automatic Half-Barrier (level crossing)	
ALARP	As Low As Reasonably Practicable	
ALCRM	The All Level Crossing Risk Model	A tool for assessing the risk at particular level crossings.
AOCL	Automatic Open Level Crossing, Locally-monitored	
AOCL+B	Automatic Open Level Crossing, Locally-monitored with retrofitted half barriers	
BAP	Biodiversity Action Plan	
BOAT	Byway Open to All Traffic	
BPM	Barrier Protection Management	A solution for auto-lower crossings that delays barrier lowering should there be a road vehicle underneath a barrier.
CBA	Cost Benefit Analysis	A numerical comparison of the monetised advantages and disadvantages of undertaking a particular course of action.
CCU / LCU	Crossing Control Unit	
COD	Complementary Obstacle Detector	
CCTV	Closed Circuit Television	
DIA	Diversity Impact Assessment	
EA	Equality Act 2010	
ELR	Engineering Line Reference	
ERTMS	European Rail Traffic Management System	A system of train control that allows for automatic train protection and cab based signalling.
ETCS	European Train Control System	
FWI	Fatalities and Weighted Injuries	A measure of safety performance where the predicted rate of fatalities and minor and minor injuries are combined into an overall measure of risk.
HGV	Heavy Goods Vehicle	
LCM	Level Crossing Manager	
LED	Light Emitting Diode	

Acronym	Description	Comments
MCB-CCTV	Manually-Controlled Barrier Level Crossing with CCTV	
MCB-OD	Controlled Barrier Level Crossing with Obstacle Detection	
MCG	Manually-Controlled Gate Level Crossing	
NPV	Net Present Value	
ORCC	Operations Risk Control Coordinator	
ORR	Office of Rail and Road	
PHI	Priority Habitat Inventory	
POD	Primary Obstacle Detector	
PROW	Public Right of Way	
PSB	Power Signal Box	
RAM	Route Asset Manager	
ROC	Regional Operations Centre	
RLSE	Red light static enforcement cameras	
RSSB	Rail Safety and Standards Board	
RTL	Road Traffic Light	
SAC	Special Area of Conservation	
S&SRA	Suitable and Sufficient Risk Assessment	
SEU	Signalling Equivalent Unit	A measure of signalling cost
SLL	Stop, Look and Listen sign	Signage normally used for footpath or user-worked crossings that require pedestrians to check whether a train is approaching before deciding whether it is safe to cross
SMIS	Safety Management Information System	The database used by the UK rail industry for reporting accidents and near misses
SPAD	Signal Passed at Danger	
SRM	Safety Risk Model	The rail risk model managed on behalf of the industry by RSSB
SSSI	Sites of Special Scientific Interest	
TMOB	Trainman Operated Barrier crossing	

Acronym	Description	Comments
TOC	Train Operating Company	
TPV	Train Pedestrian Value	A measure of used based on pedestrian usage and train frequency
TTRO	Temporary Traffic Regulation Order	
TWAO	Transport & Works Act Order	
VAS	Vehicle Activated Sign	A sign that illuminates in the event of blocking back ahead, reminding drivers to keep the crossing clear
VpF	Value of Preventing a Fatality	A value used to express safety risk in financial terms
YN, YO, ZN, ZO	Denotes the corner of the crossing.	Y is closest to the Up line; Z the Down line; N is the nearside (for traffic); O the offside.

REFERENCE DOCUMENTS

The following documents have been used to support the production of this report:

Ref	Document Name	Number
1.	Level Crossings: A guide for managers, designers and operators (ORR)	Railway Safety Publication 7 December 2011
2.	Internal Guidance On Cost Benefit Analysis (CBA) IN Support Of Safety-related Investment Decisions	ORR, April 2015
3.	Network Rail Authority Paper (for LXEU and SEU costs)	V6.15 – 1st July 2015
4.	Census Report for Meldreth Road Level Crossing	Sky High-Count on Us 8801 Task 4 Site 57 – May 2013
5.	South Cambridgeshire Local Plan	Adopted September 2018
6.	Level Crossing Guidance Document: Applying Risk Reduction Bednefits in ALCRM When Modelling Safety Enhancements	LCG 14 March 2016
7.	Transforming Level Crossings: A vision-led long-term strategy to improve safety and level crossings on Great Britain's railways	NR17
8.	Manually Controlled Barriers Obstacle Detection: MCB-OD Selection and Risk Mitigation Guidance	Signalling Design Group NR/IP/SDG York/MCB-OD/02 August 2014 Version 3.1
9.	MCB-OD Pedestrian Risk Tool	AD Little V1
10.	AHB+ HAZID Report	AES/1739/R03, Issue 2, 09/07/19
11.	AHB+ System Definition	AES/1739/R01, Issue 1, 29/03/19
12.	AHB+ Option 2 Feasibility Analysis Extract	
13.	RSSB, Safety Risk Model	V8.5.0.2, March 2018

1 INTRODUCTION

1.1 Background

The renewal of level crossings on the UK network must be supported by appropriate and robust risk assessment. This level crossing risk assessment was originally produced in support of the Cambridge Area Interlocking Renewals (CAIR) project in 2013. The Cambridge – Dullingham – Bury Re-Signalling (CBD) Project started out being called Cambridge Inner Re-Signalling (CIRS) with a smaller geographical scope. A further scope of works Cambridge Outer Re-Control and Life Extension (CORCLE) was added to the CIRS scope partway through GRIP 1 in order to gain efficiencies. An update to this level crossing risk assessment is required in order to take into account the latest project information. As part of this process, Network Rail has tasked Sotera Risk Solutions to update the suitable and sufficient risk assessment of the closure and renewal options for Meldreth Road AHB level crossing.

1.2 Approach to risk assessment

In order to carry out the risk assessments, Sotera has:

- Reviewed available information pertinent to the level crossing (including, SMIS event data, and input data to the All Level Crossings Risk Model (ALCRM)).

- Analysed national level crossing risk information to compare the main level crossing type options.

- Undertaken a site visit to the crossing to assess its current operation, to determine the existing controls, identify local hazards, to measure distances key to the risk assessment and make a photographic record of any issues. If there was no census since 2013, the site visit included a half hour census, which could be used to assess the suitability of the old census.

- Specified and carried assessments of the crossing type options using the ALCRM, where available based upon an up-to-date traffic census otherwise making use of the Department of Transport's TEMPro v7.2 software, which allows users to view the National Trip End Model (NTEM) dataset and can be used to factor up '*old*' censuses to current levels of usage.

- Carried out an initial options assessment which considered the available crossing type options from a safety, cost and feasibility perspective

- Facilitated an options assessment workshop, which reviewed the initial options assessment, supplementing it with additional information and ideas as appropriate.

2 DESCRIPTION OF THE SITE AND THE EXISTING LEVEL CROSSINGS

2.1 Current level crossing detail

Meldreth Road is an AHB crossing, with two half-width barriers and four LED type RTLs. The crossing is monitored from Cambridge signal box.

The maximum linespeed is 90 mph on the Up line and 65mph on the Down line. The line is electrified with overhead lines.

Figure 1 shows the configuration of the crossing, viewed from the south. *Figure 2* provides the relevant extract from the sectional appendix covering the crossing. *Table 1* presents details of the location and operation of the crossing.

Figure 1 **Current crossing equipment**

Table 1 Current Level Crossing Details

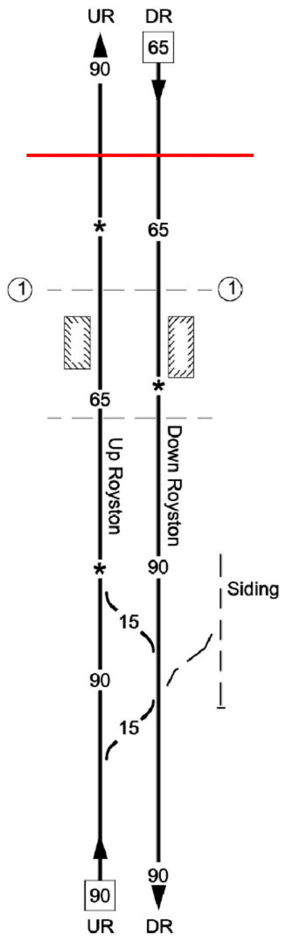
Level crossing name	Meldreth Road
Level crossing type	AHB
ELR and mileage	SBR 49m 37ch
Status	Public Road
Number of running lines	2
Permissible speed over crossing (Up)	90mph
Permissible speed over crossing (Down)	65mph
OS grid reference	TL388477
Postcode	SG8 6XA
Road name and type	Meldreth Road (undesignated)
Local Authority	Cambridgeshire County Council
Supervising signal box	Cambridge PSB
Electrification and type	Overhead Line

Figure 2 Extract from the sectional appendix

LOR	Seq.	Line of Route Description	ELR	Route	Last Updated
EA1230	002	Royston to Shepreth Branch Jn	SBR	Anglia	14/05/2018

Location	Mileage M	Mileage Ch		Signalling & Remarks
				TCB Cambridge SB (CA) RA9 AC: York; GSM-R
Meldreth Road LC (AHBC)	49	37		
	49	40	*	
Shepreth LC (CCTV)	49	63		(1) Supervised from Foxton Gate Box
SHEPRETH	49	67		Up platform - 97m (105yds) Down platform - 171m (187yds)
	50	00	*	
Angel Lane LC (R/G)	50	05		
	50	15	*	

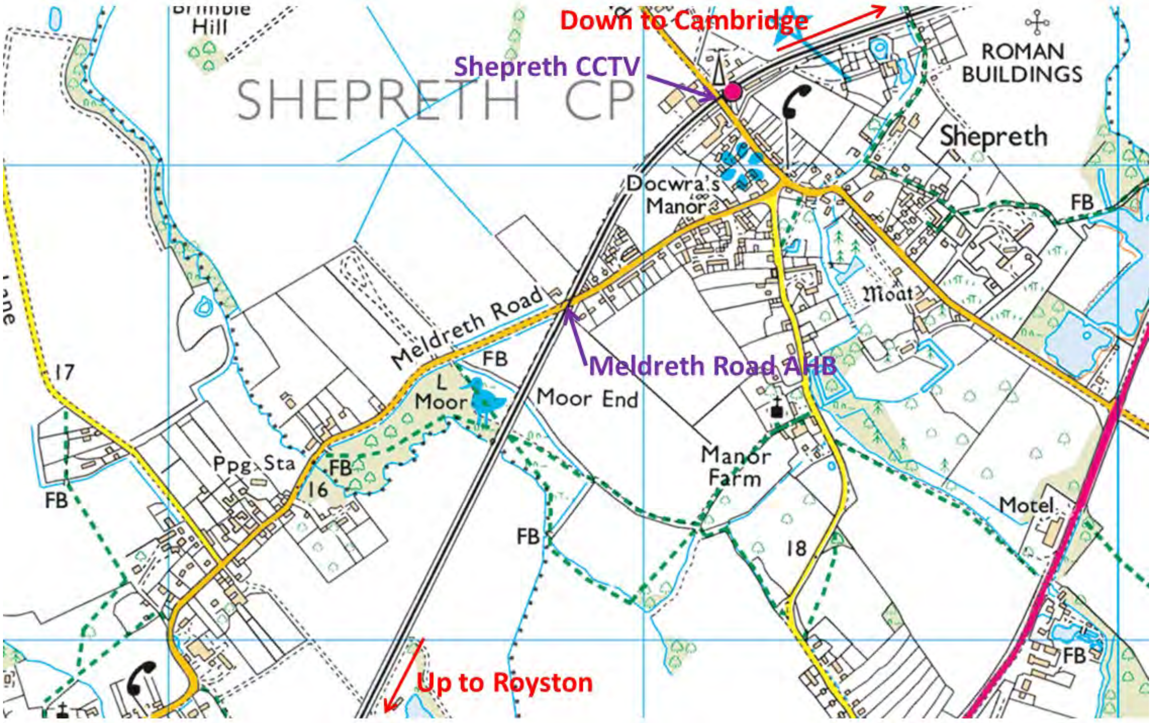
Running lines & speed restrictions



2.2 Environment

The crossing is located on Meldreth Road in the village of Shepreth, in Cambridgeshire as shown in *Figure 3*. The crossing allows access between the villages of Shepreth and Meldreth. The crossing is in a rural village location, with residential properties to the east and mainly farmland to the west.

Figure 3 **Map showing an overview of the location of the crossing**

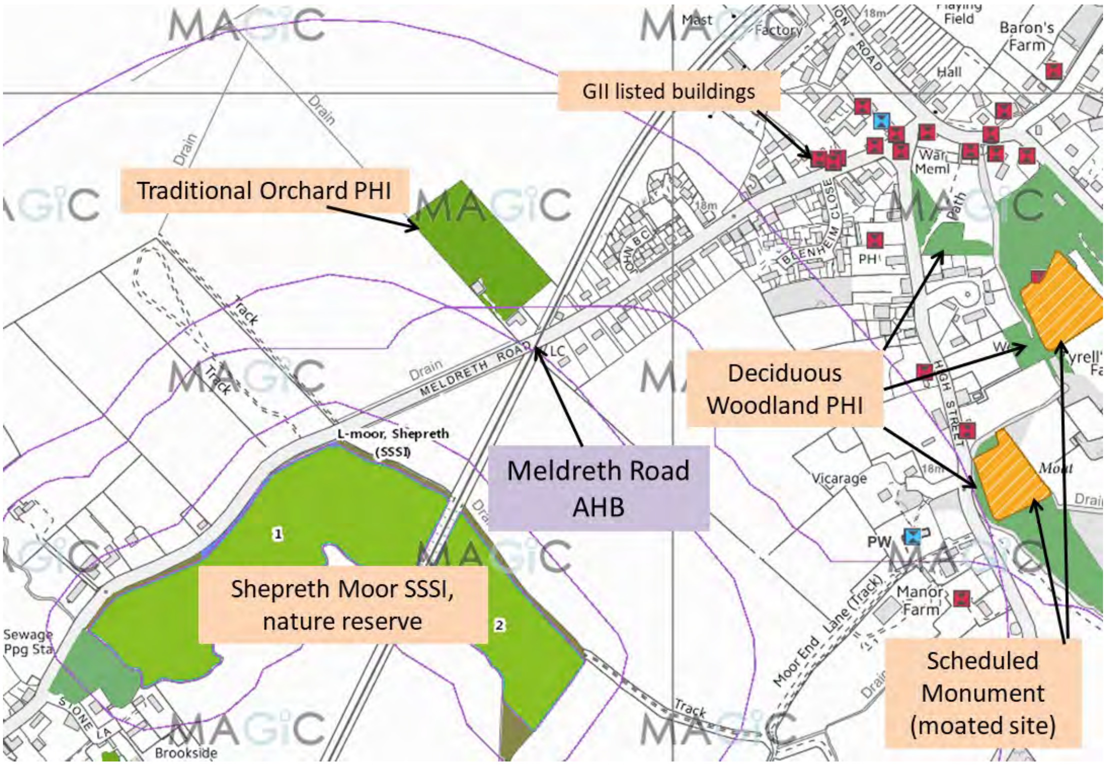


A satellite view of the location is shown in *Figure 4*.

Environmentally significant sites are shown in *Figure 5*. There is a traditional orchard PHI just to the north of the crossing, which would affect a potential new road joining Meldreth Road to Station Road in order to close the level crossing.

Figure 4 Satellite view showing the location of the crossing

Figure 5 Environmentally significant sites



2.3 Footpath approaches

There are footways on both sides of the crossing as seen in *Figure 1*. The footway on the south side (*Figure 6*) varies between 0.69m and 0.74m wide (the narrowest point is where the fence encroaches in the ZO corner). The footway on the east side (*Figure 7*) varies between 0.6m and 0.91m wide as the footway is narrowed by the fence and vegetation at the YO corner. The panel edges encroaches near to the footway as shown in (*Figure 8*) and there is vegetation growing over footway on north-east side (*Figure 9*).

The south footway is 17.5m long, the north footway is 16m long.

Based upon ORR guidance [(1)], pedestrian footpaths over crossings are categorised into three classes based upon usage by pedestrians and the frequency of rail traffic. From the guidance, the volume of pedestrian and train flow is determined by the train pedestrian value (TPV). The TPV is the product of the maximum number of pedestrians and the number of trains passing over the crossing within a period of 15 minutes. The TPV at Meldreth Road, based upon a 9-day census, is 8. This places the crossing in the lowest usage category – category 'C' (the criteria for class C being a TPV of up to 150). In this class, the ORR recommends that the footpaths are 1.5m wide. The ORR also indicates that the footpath width can be reduced to 1.0m where the daily number of pedestrians is less than 25. The census indicates a weekday average pedestrian frequency of 25 and a weekly average of 27.

The footways are, therefore, not in compliance with the minimum width of 1.5m specified in ORR guidance for a pedestrian category C crossing.

There are pavements in three of the four corners for footways to join but there are no tactile thresholds on the footways.

[1] ORR, Level Crossing: A guide for managers, designers and operators, Railway Safety Publication 7, December 2011.

Figure 6 **Footway – south side**

Figure 7 **Footway – north side**

Figure 8 **Footway marking near edge of deck – south side**

Figure 9 **Vegetation growing over footway – north east side**

2.4 Road approaches

Road approach to the crossing from the east

A 30mph speed limit applies on the road approach from the east. During the 9-day census the 85th percentile speed of approach was 33.1mph.

The key features of the approach are:

1. The road has is straight on the approach.

2. There is a junction with John Breay Close on the right 115m east of the crossing (*Figure 15*). This is a left turn for vehicles that have traversed the level crossing.

3. There is a bus stop on the right, 115m beyond the crossing (*Figure 16*)

4. There are driveways on the right on the approach. The nearest is 45m east of the crossing (*Figure 17*). This is a left turn for vehicles that have traversed the level crossing.

5. There is an area where cars tend to park on the right, 18m east of the crossing (*Figure 18*).

6. There are driveways on the left on the approach. The nearest is 3m east of the crossing (*Figure 19*), which due to its proximity to the crossing could be a cause of blocking back. This is a right turn for vehicles that have traversed the level crossing.

7. The near side RTL is visible from over 150m on the approach, however the off-side RTL is not visible due to a hedge. The off-side RTL becomes visible by 100m.

8. The level crossing warning sign is partially hidden by a hedge on the approach (*Figure 14*).

The distant, intermediate and close road approaches from the east are shown in *Figure 11* to *Figure 13*. It can be seen in *Figure 11* that the crossing is visible from the distant signage.

A plan of the key features is shown in *Figure 10;* the numbers in the figure refer to the above numbered list of features.

Figure 10 **Key features on the eastern approach to the crossing**

Figure 11 **View approaching crossing from the east - distant**

Figure 12 **View approaching crossing from the east - intermediate**

Figure 13 **View approaching crossing from the east - near**

Figure 14 **Level Crossing sign partially hidden by hedge**

Figure 15 **John Breay Close on right**

Figure 16 **Bus stop on right**

Figure 17 **Driveway on right**

Figure 18 **Parking on right**

Figure 19 **Driveway on left**

Road approach to the crossing from the west

A 40mph speed limit applies on the road approach from the west until 12m before the crossing when the speed limit drops to 30mph. During the 9-day census the 85th percentile speed of approach was 45.0mph. The key features of the approach are:

1. The road is straight on the approach.
2. There is field entrance on the left, 7m west of the crossing (*Figure 24*). This is a right turn for vehicles that have traversed the level crossing.
3. There is a driveway on the left by the white line of the crossing (*Figure 25*). This is a right turn for vehicles that have traversed the level crossing. Due to the proximity of this driveway to the crossing, it could very occasionally be a cause of blocking back.
4. The offside RTL is visible from over 170m on the approach; the near side RTL is not, however, visible due to a hedge. The near side RTL becomes visible at 120m from the crossing.
5. The level crossing signage had good conspicuity at the time of the site visit.
6. The crossing has a skew of 45^{0}.

The distant, intermediate and close road approaches from the northwest are shown in *Figure 21* to *Figure 23*.

A plan of the key features is shown in *Figure 20;* the numbers in the figure refer to the above numbered list of features.

Figure 20 **Key features on the western approach to the crossing**

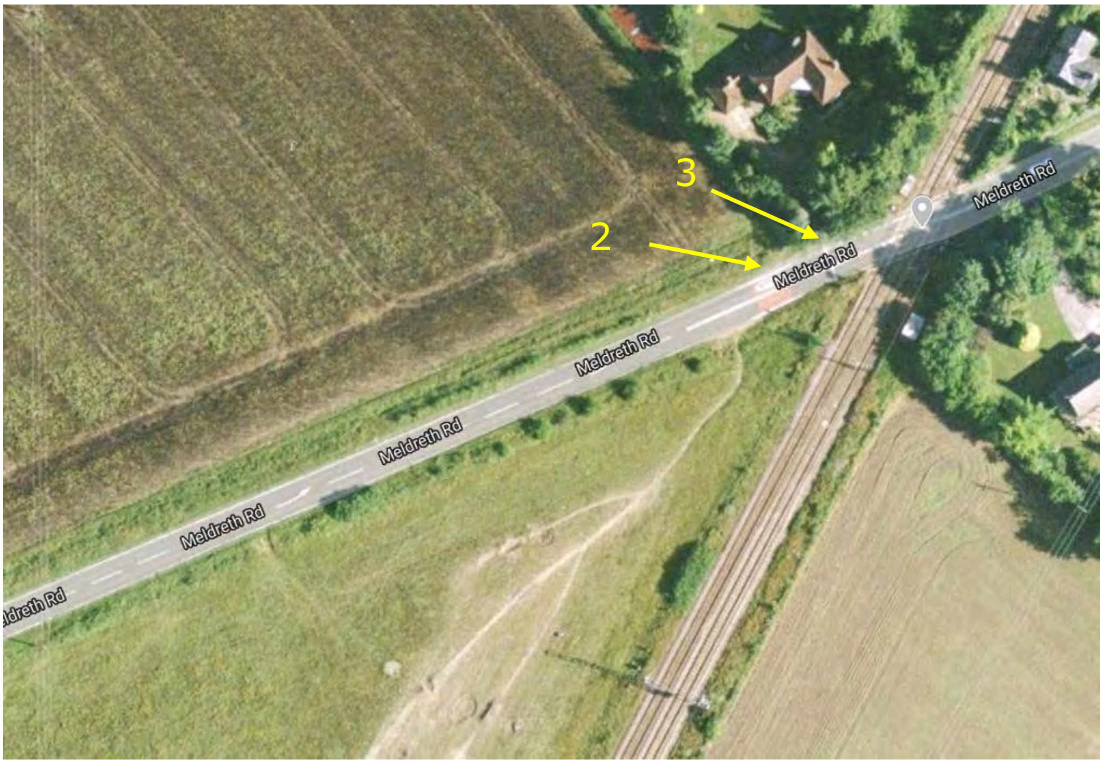


Figure 21 **View approaching crossing from the west - distant**

Figure 22 **View approaching crossing from the west - intermediate**

Figure 23 **View approaching crossing from the west - near**

Figure 24 **Field entrance on left**

Figure 25 **Driveway on left**

Figure 26 **Crossing from driveway on left**

Figure 27 **Crossing surface**

Figure 28 **Crossing skew 45^0**

2.5 Impact of low sun on the crossing

Meldreth Road level crossing is a northeast-southwest facing crossing (for the road), therefore road users are potentially affected by sun glare at certain times of the year.

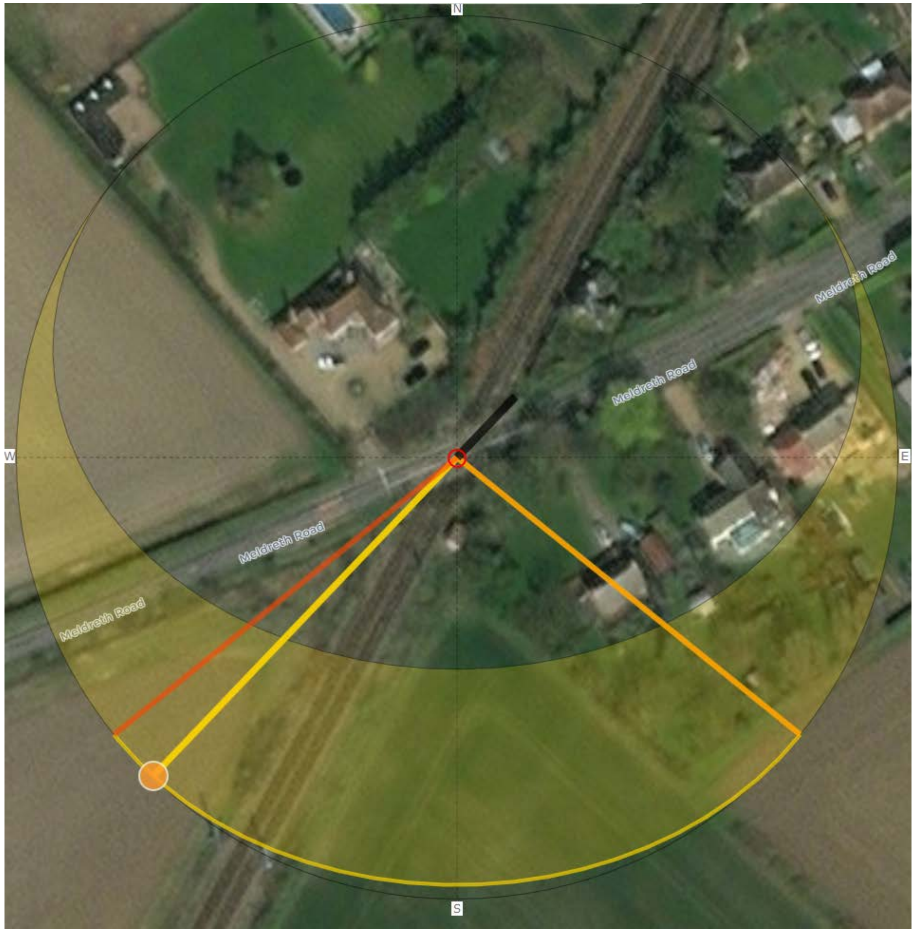
The crossing is currently provided with LED type RTLs to mitigate the impact of any low sun.

Below, is the output from the SunCalc application, which has been used to identify the line of the sun at sunrise and sunset at times of year when low sun would align with the road approaches. The shortest and longest day are shown in *Figure 29*.

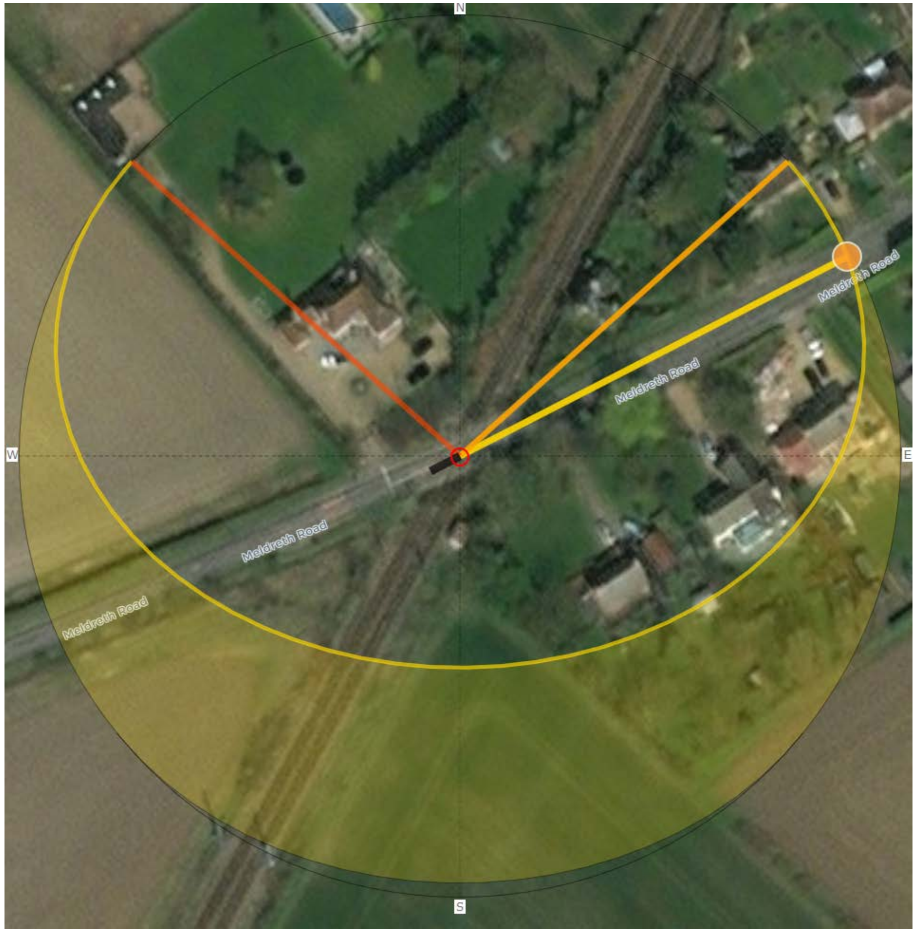
The thin orange curve is the current sun trajectory, and the yellow area around is the variation of sun trajectories during the year. The closer a point is to the centre, the higher is the sun above the horizon.

The yellow line shows the direction of sunrise; the dark orange line the direction of sunset and the mid orange line the direction at a selected time of day (shown by the orange circle above the satellite image).

Figure 29 **Suncalc diagrams**



Shortest Day



Longest Day

North-eastbound approach

There are two potential issues with low sun when approaching the crossing north-eastbound:

1. In the summer, the rising sun would be straight behind the crossing, potentially causing glare. The impact of this is slightly mitigated by the trees and buildings to the east of the crossing which provide backing for the RTLs.
2. In the winter, the setting sun would shine almost towards the RTLs, potentially washing them out. There are few trees west of the crossing to mitigate this, therefore it is considered likely to be problematic.

South-westbound approach

There are two potential issues with low sun when approaching the crossing south-westbound:

1. In the summer, the rising sun would shine almost towards the RTLs, potentially washing them out. The duration of this would be reduced by the trees and buildings to the east of the crossing which provide screening for the RTLs.
2. In the winter, the setting sun would be straight behind the crossing, potentially causing glare. There are few trees west of the crossing to mitigate this, therefore it is considered likely to be problematic.

The crossing is currently provided with LED type RTLs, which mitigate the impact of the low sun to an extent.

3 CROSSING USAGE

This section of the risk assessment discusses the current usage of the crossing and its history of accidents and incidents. It then considers proposed and potential future changes to the usage and assesses the safety impact.

3.1 Traffic census

A nine-day, 18-hour traffic census by continuous recording was carried out at the crossing between 11th and 19th April 2013. The following provides a summary of the results obtained of this census.

Train frequency	**Weekday**	139
	Saturday	126
	Sunday	97
Road closure (min:secs)	**Average**	00:46
	Maximum	07:21
Road vehicle frequency	**Busiest day**	1,656
	Average weekday	1,559
Blocking Back Observations		None
85th percentile speed (free flowing cars only)	**Northbound**	45.0
	Southbound	33.1
Pedestrian and cyclist frequency	**Busiest day**	249
	Average week day	74
Train Pedestrian Value (TPV)		8
Pedestrian Category		C (with greater than 25 pedestrians per day)

The observed train, vehicle and pedestrian usage is presented in *Table 2;* a comparison to a 30 minute census in 2019 is shown graphically for vehicles in *Figure 30,* and for pedestrians in *Figure 31*. It is concluded from the 30-minute 'quick' census that there has not been a major change in usage since 2013. The notable observations recorded in the report were no observations of blocking back.

Table 2 Traffic survey observed usage 2013

Census Site 57 - Meldreth Level Crossing			Totals per day										
			Vehicles							Non-vehicles			
Day		No. trains per day	Cars	Vans / small lorries	HGVs	Buses	Tractors	Motor cycles	Total	Pedal cycles	Herded animals and horses	Pedestrians	Total
Saturday	11-May-13	127	1,135	58	23	2	0	13	1,231	83	0	22	105
Sunday	12-May-13	96	935	43	1	0	2	16	997	227	0	22	249
Monday	13-May-13	139	1,304	153	35	10	0	15	1,517	35	0	24	59
Tuesday	14-May-13	139	1,337	161	35	7	0	17	1,557	40	0	26	66
Wednesday	15-May-13	137	1,456	139	42	9	0	10	1,656	45	0	21	66
Thursday	16-May-13	139	1,366	137	29	8	0	20	1,560	83	0	35	118
Friday	17-May-13	137	1,299	146	43	10	0	5	1,503	41	0	19	60
Saturday	18-May-13	124	1,123	52	7	1	0	22	1,205	115	0	33	148
Sunday	19-May-13	97	987	57	1	0	0	10	1,055	199	0	28	227
Highest		139	1,456	161	43	10	2	22	1,656	227	0	35	249
7 day average		131	1,267	121	27	6	0	14	1,436	80	0	27	106
Weekday average		139	1,352	147	37	9	0	13	1,559	49	0	25	74

Figure 30 **Comparison to 2019 30-minute census - vehicles**

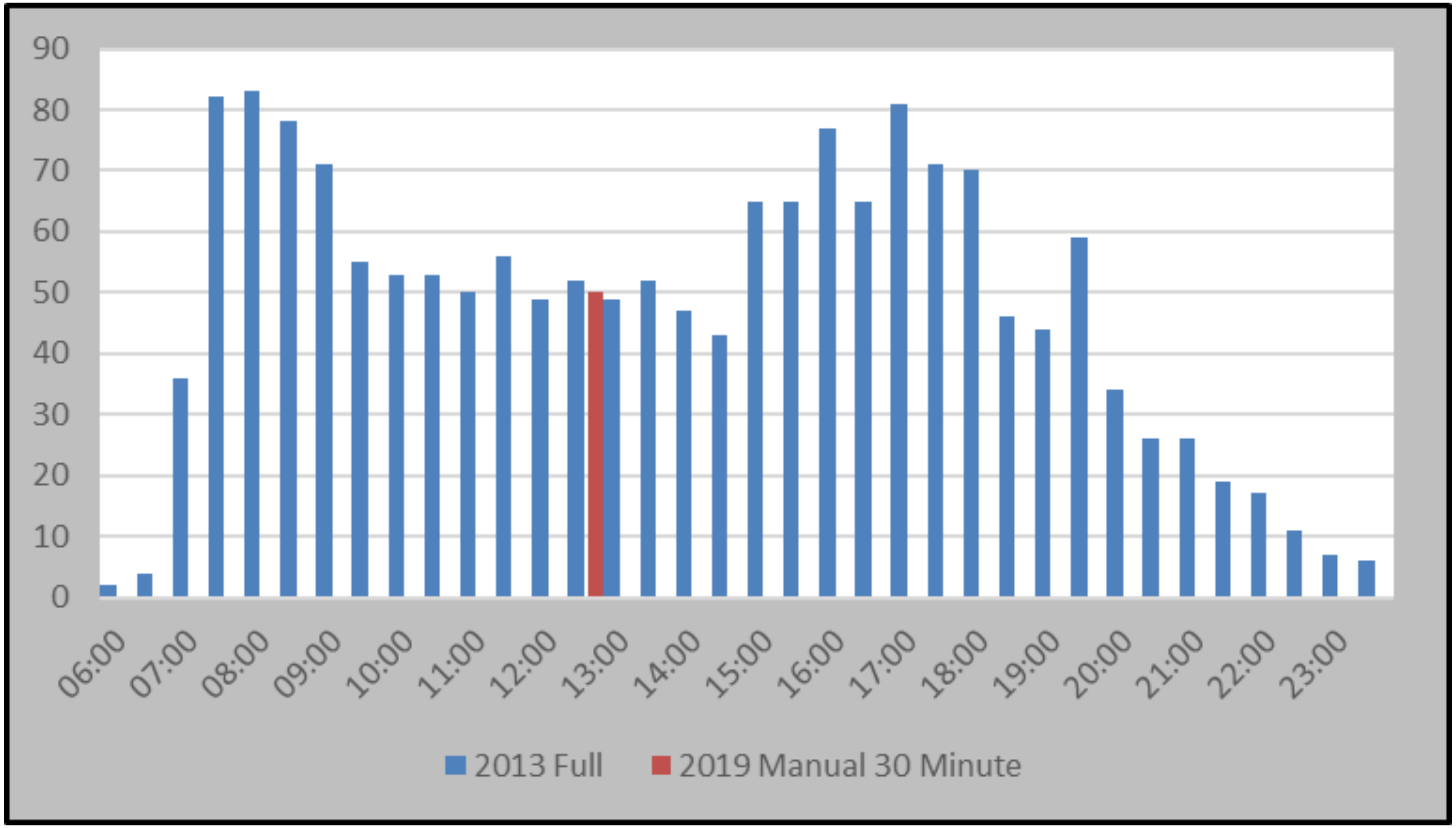
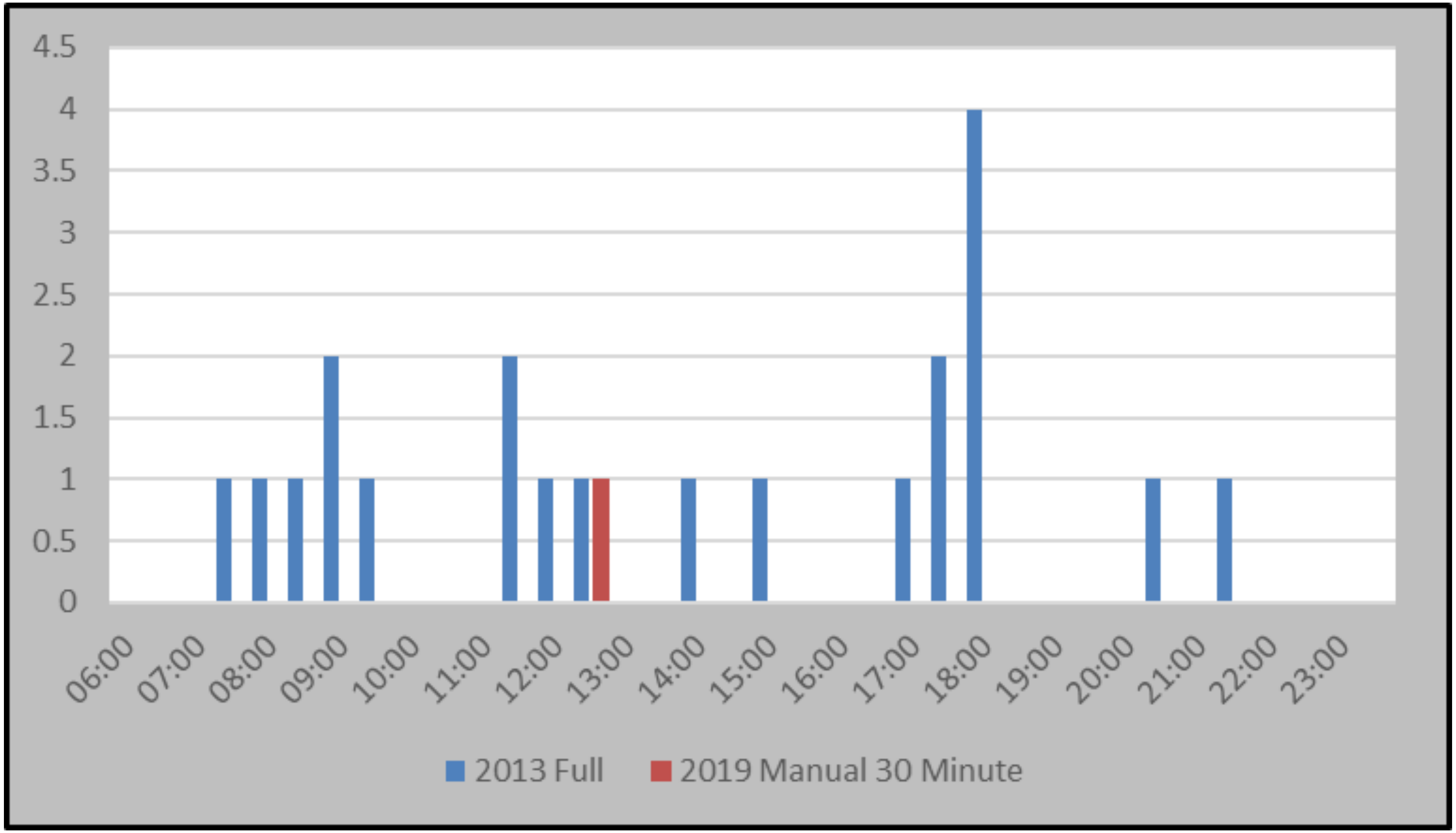


Figure 31 **Comparison to 2019 30-minute census - pedestrians**



3.2 Rail approach and usage

The crossing is located between Royston and Shepreth Branch Junction. There are two tracks at the crossing, and it is electrified with a 25kV overhead line. It is a highly utilised stretch of line with a weekday average of 139 trains per day (approximately 70 passenger trains in each direction).

The rail approach to the crossing from the south

Trains travelling north are travelling in the Down direction towards Cambridge. The view from the crossing looking south is shown in *Figure 32*. The track is straight on this approach.

For trains travelling in the Up direction, in the unlikely event of a derailment following hitting a vehicle on the crossing, the overhead line stanchions may exacerbate the potential derailment consequences.

Figure 32 **View of Down rail approach (looking towards Royston)**

The rail approach to the crossing from the north

Trains travelling south are travelling in the Up direction towards Royston.

The view from the crossing looking north is shown in *Figure 33*. The track has a distant curve on this approach.

For trains travelling in the Down direction, in the unlikely event of a derailment following hitting a vehicle on the crossing, the features that could exacerbate the potential derailment consequences are houses close to the crossing and the overhead line stanchions.

Figure 33 **View of Up rail approach (looking towards Cambridge)**

3.3 Incident/near miss history

Ten years of Incident data have been analysed for the crossing, which was provided by RSSB (the data period ends in August 2016). A summary by incident type is listed in *Table 3*.

The crossing has a lower than average number of near miss/misuse incidents for the crossing type.

It is recognised that not all incidents are reported into RSSB's SMIS database.

Table 3 Summary of Incidents

SMIS classification	Incidents in data set	Average for LC type	Ratio to average for LC type
Train - striking road vehicle or gate at LC	0	0.10	0.00
Train - striking or being struck	0	0.15	0.00
Non-rail vehicles (incl. vehicle on line)	1	1.55	0.65
Person - personal accident	0	0.28	0.00
Level Crossing/LC equipment - misuse/near misses	6	5.36	1.12
Near miss - train with person (not at LC)	0	0.01	0.00
Train - striking animal	0	0.07	0.00
Animals - on the line	0	0.11	0.00
Person - trespass	0	0.12	0.00
Person - vandalism	0	0.25	0.00
Train - signal passed at danger	0	0.05	0.00
Train - running over LC (when unauthorised)	0	0.02	0.00
Irregular working (pre 25/11/2006)	0	0.05	0.00
Irregular Working	0	0.24	0.00
Level crossing - equipment failure	4	9.38	0.43
Signalling system - failure	0	0.11	0.00
Permanent way or works - failure	0	0.03	0.00
All incidents	11	18.10	**0.61**

Note, the data in this table is not normalised, therefore a crossing with high use would generally be expected to have higher ratios.

The following incidents are noteworthy at the crossing:

- Two reported incidents of a '*near miss*' with a pedestrian
- One reported incident of a '*near miss*' with a cyclist
- One reported incident of a road vehicle obstructing the crossing

- Three reported incidents of other misuse by a road vehicle.

More recent SMIS data, for one year to 13th March 2019, shows one reported incident of a road vehicle zig - zagging around the lowered barriers (16/12/2018).

3.4 Future demand and use of the level crossing

Any decision to install a level crossing needs to account for both the current use and any reasonably foreseeable increase in future demand that may affect the risk to passengers and the public.

Key factors that can affect the future use are:

- Planned increases to train services or train speeds;
- Local developments (e.g. opening schools, retail outlets, factories);
- Closure of adjacent level crossings, meaning that the road and pedestrian traffic of any closed crossings now use the one subject to assessment.

Under the South Cambridgeshire Local Plan[5] (Adopted Sept 2018), Shepreth is identified as an '*Infill Village*'. Residential development and redevelopment within the development frameworks of these villages will be restricted to scheme sizes of not more than 2 dwellings. In very exceptional circumstances, a slightly larger development (not more than about 8 dwellings) may be permitted where this would lead to the sustainable recycling of a brownfield site bringing positive overall benefit to the village.

Current approved planning applications in the vicinity of the crossing include:

S/3052/16/FL - Land to the east of Collins Close - Near, Meldreth Road. Erection of 25 dwellings including 40% affordable along with access, car and cycle parking and associated landscaping. Approved. (*Figure 34*)

S/0545/18/FL - Land Rear of 80, Meldreth Road. New house adjacent to Brymble House. Approved. (*Figure 35*)

Figure 34 Twenty-five dwellings east of Collins Close

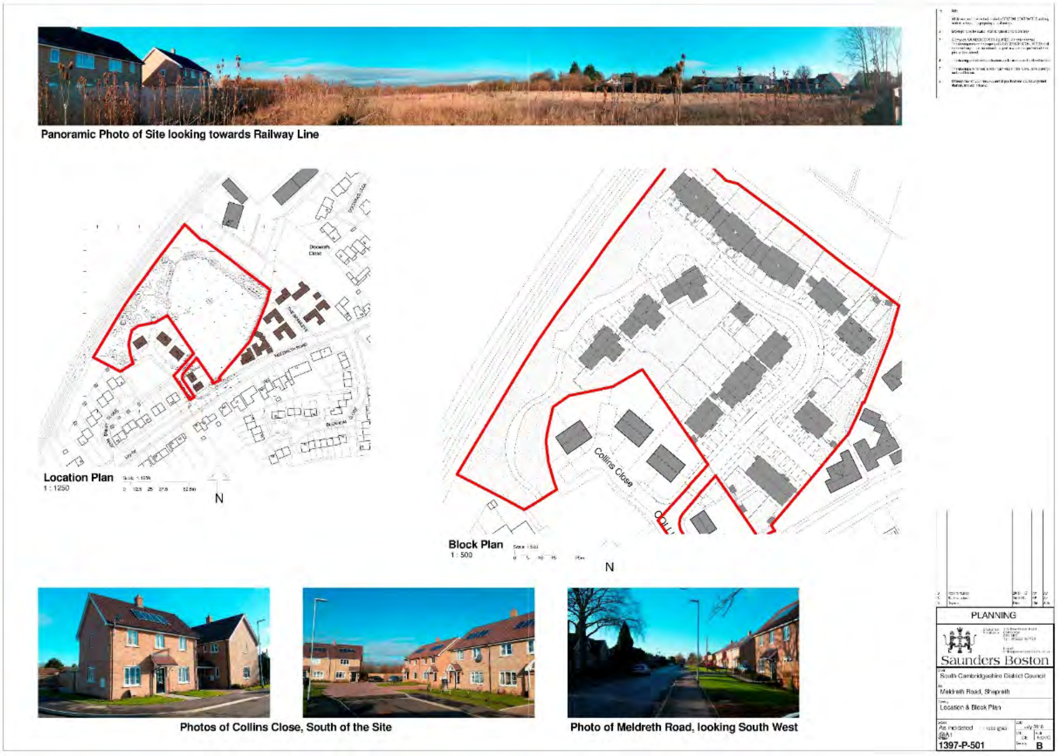
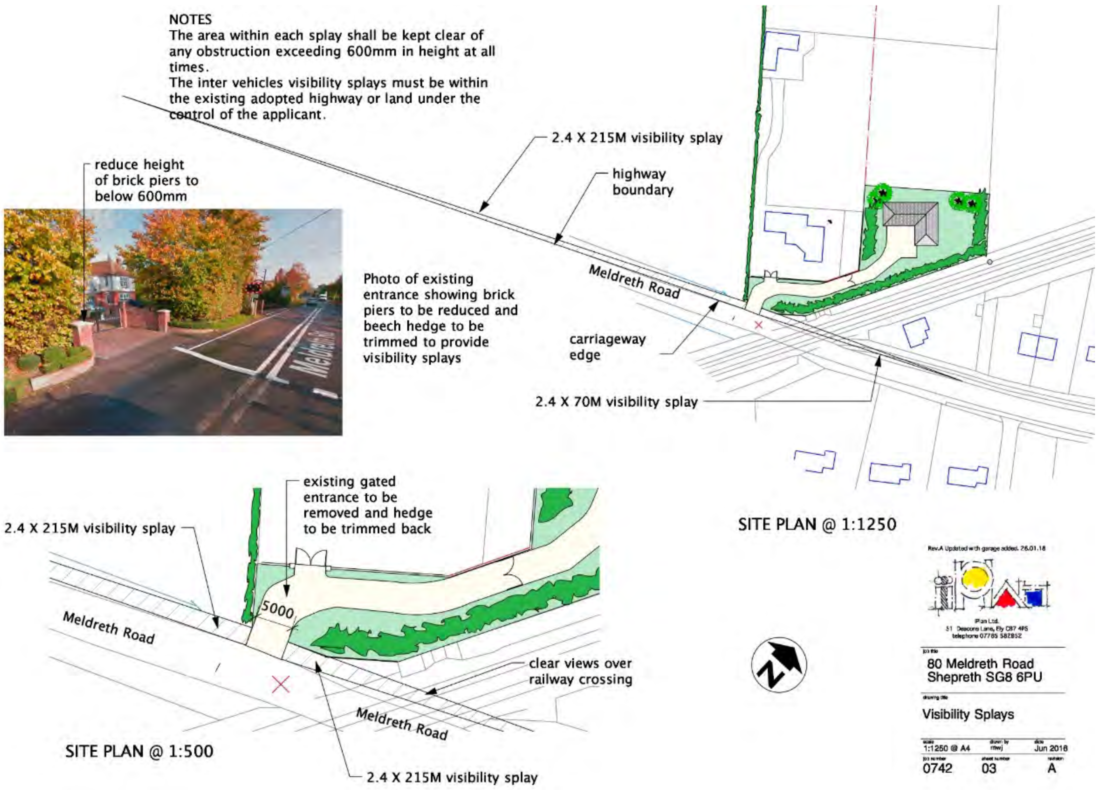


Figure 35 New house north-west side of crossing



It is important, as for all level crossings, that Network Rail ensures it is consulted about any change of use for the businesses and area adjoining the crossing and seeks compensation for further upgrade should anything be proposed which would significantly increase the usage of the crossing.

There are no proposals for increasing the line speed or providing new signalling infrastructure apart from that required to support any level crossing renewals. Train frequency increases are not currently planned.

Road closure time predictions

Road closure time is an important parameter that impacts level crossing risk as well as utility. This is because a high road closure time can cause aggravation and frustration for users which can lead to increased misuse.

Sotera has used a fairly simple model to estimate the potential impact of any upgrade to an MCB-type fall barrier crossing (MCB-OD or MCB-CCTV). For Meldreth Road, this suggests that the busiest hour road closure time would increase from about 18% currently as an AHB level crossing to about 71% as shown in *Figure 36*. The average daytime road closure time is shown in *Figure 37*.

Figure 36 Road closure time in the busiest hour

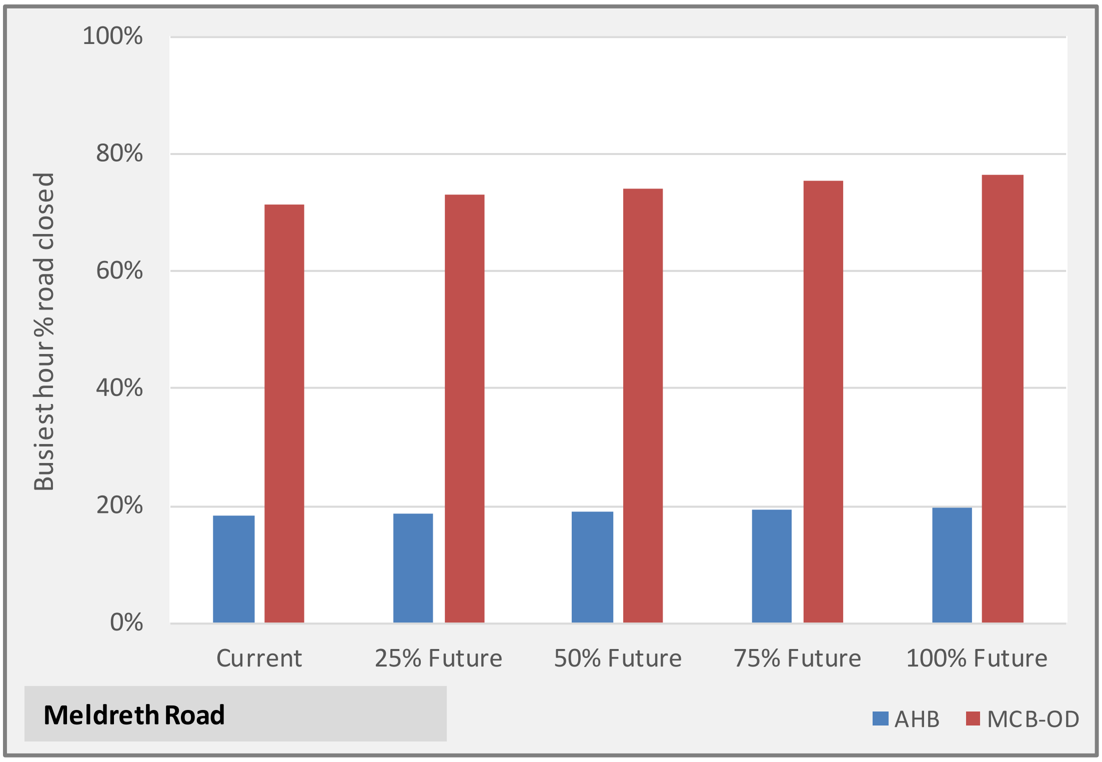
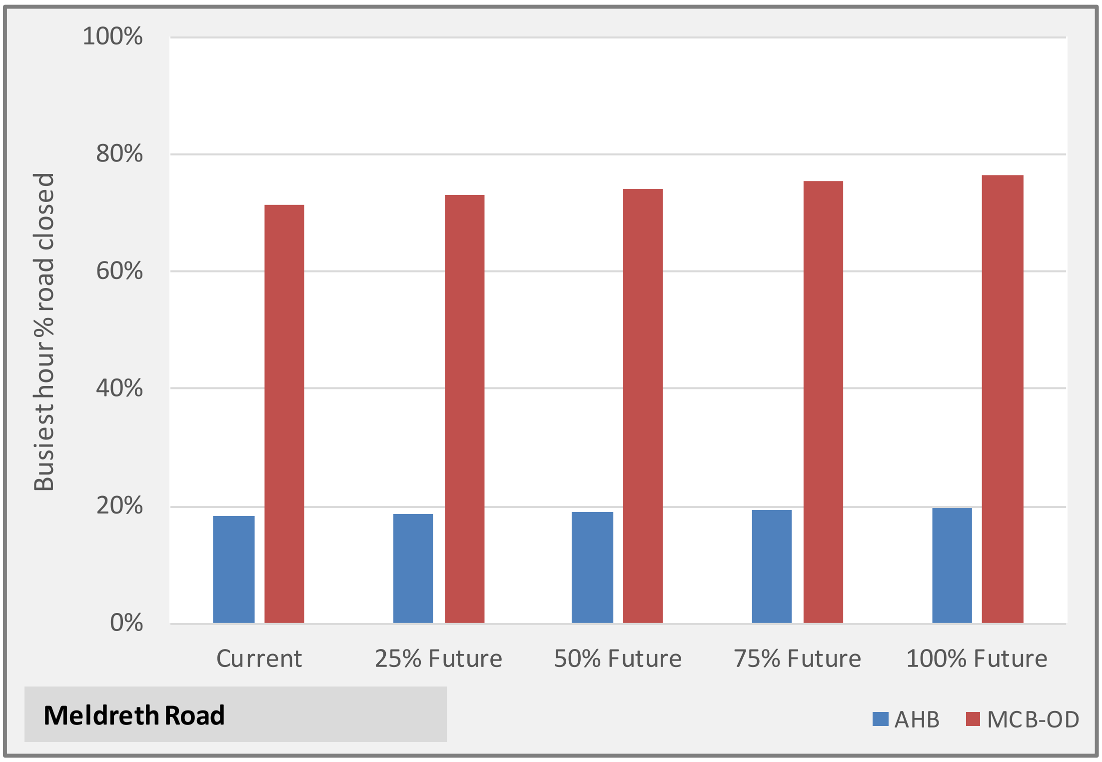


Figure 37 **Average daytime road closure time**



4 OPTIONS ASSESSMENT

Sotera carried out an initial assessment of options for the crossing, which was then reviewed and updated in a workshop with Network Rail staff. The results of the assessment are described in this section.

4.1 Options assessment workshops

The attendees of the initial workshop at One Stratford Place on 4th April 2019 were as follows.

Present	Role
John Prest	Route Level Crossing Manager
Ray Spence	Senior Delivery Manager
Charles Muriu	Asset Engineer
Nathan Garratt	DPE
Brendan Lister	LCM
Huma Hameed	Scheme Project Manager
Paul Joy	Project Engineer Telecoms
Chris Chapman	Sotera, Workshop Chair
Peter Dray	Sotera, Workshop Secretary

Following this initial workshop, The Safety Review Panel commented that a more robust consideration should be made of a new type of full barrier level crossing (AHB+), which is being developed by Network Rail. The basic premise of this type of level crossing is envisaged to be an adaptation of the existing AHB crossing type, adding exit barriers whilst retaining the AHB's train approach initiated method of operation. Road closure times would be comparable with those of existing AHB level crossings. The lowering function of the exit barriers would be controlled by obstacle detection technology.

As such two further workshops were held:

i) To understand better the functionality of AHB+ level crossings and the progress of the AHB+ development project;

ii) To assess the potential benefits of AHB+ at crossings at the specific crossings that were proposed for upgrade as part of the Cambridge resignalling and recontrol project.

The attendees at the first AHB+ workshop on 9th September 2019 were:

Present	Role
Bode Asabi	Project Manager
Nathan Garratt	DPE
Brendan Lister	LCM
Chris Chapman	Sotera, Workshop Chair
Ben Chipman	Level Crossing Designer
Gavin Scott	RAM Signals Anglia
Sam Rose	Graduate
Paul Fletcher	Signaller / Project Operations Interface Specialist
Paige Skinner	Scheme Project Manager
Darren Witts	STE Principal Engineer
Will Cavill	Principal Designer

The attendees at the second AHB+ workshop on 25th October 2019 were:

Present	Role
Bode Asabi	Project Manager
Nathan Garratt	DPE
Brendan Lister	LCM
Chris Chapman	Sotera, Workshop Chair
Ben Chipman	Level Crossing Designer
Gavin Scott	RAM Signals Anglia
Sam Rose	Graduate Engineer
Paul Fletcher	Signaller / Project Operations Interface Specialist
Paige Skinner	Scheme Project Manager
Darren Witts	STE Principal Engineer
John Prest	Route Level Crossing Manager
Charles Muriu	Asset Engineer
Gabrielle Hodlaun	Delivery Manager
Harry Newgas	Graduate Engineer
Isaac Dozen-Anane	Assistant Project Engineer
Rebecca Wiecigroch	Asset Engineer - Signalling

4.2 Assessment of AHB+

Overall risk benefit

Currently the All Level Crossing Risk Model (ALCRM) does not include an assessment of AHB+ and does not include a breakdown of AHB hazards to enable such an assessment to be made. In order to make an assessment of potential benefits of AHB+, RSSB's Safety Risk Model (SRM) v8.5.0.2 (13) can be used. The risk at an AHB level crossing is broken down into 66 contributory events in *Table B1* of the SRM. The most significant contributors to risk at an AHB crossing are shown in *Table 5*. It can be seen that not all risk contributors are expected to be affected by fitment of AHB+ e.g. '*RV struck by train - on AHB - RV stranded/failed on LC*' is not expected to be affected by the fitment of the additional barrier as there are no protecting signals with which to stop a train. One of the highest contributors to risk at an AHB level crossing is, however, '*MOP (non-trespasser) pedestrian or cyclist struck/crushed by train on AHB - ignores lights/barriers*' and it is reasonable to assume that an AHB+ type crossing, which would have an offside barrier lowering as the same time as the entrance barrier, would provide a greater deterrent to level crossing users who might use the open off side to traverse the railway with the lights on and barriers down. In this instance, a 75% reduction in risk from this source is estimated.

Of the 66 AHB contributors identified in the SRM, the following change in risk was estimated for AHB+:

- 10 were considered to be reduce
- 3 were considered to increase (additional barriers likely to result in more strikes on people)
- 53 were considered to be similar (no change in risk estimated).

The risk contributors for which change is predicted is shown in *Table 6*. It was noted in the first workshop that if the off-side barrier was not fully lowered, the train driver would report it as a '*failure*'. As such, it is expected that AHB+ level crossings will only be installed in locations where the off-side OD controlled barriers very rarely fail to lower i.e. AHB+ will only be fitted to crossings that do not have high peak pedestrian/cyclist use, not at a busy station or where there is pedestrians are not going to be able to traverse the crossing in time due to a long traverse distance or slow/vulnerable users. As such, the benefits of AHB+ is assessed on this basis.

Generally, the following factors are taken into account:

- The '*second train coming*' benefits are taken to be greater than for first train as the likelihood that the off-side barriers have lowered is greater;
- Whilst an AHB+ is not considered suitable for a busy station environment, the benefits at a station would be considered lower

as there is an incentive to cross to catch a train on the opposite platform;

- Road vehicles generally get a higher level of benefit than pedestrians/cyclists as it will be more of a violation to drive through a barrier than to duck under or climb the barrier;
- A minor benefit is taken for users that have failed to observe the level crossing, which is likely to be associated with those that approach from the off side; and
- A disbenefit is predicted for users being potentially struck by barriers.

It should be noted that existing AHB precursors from the SRM have been modified; there may be new error mechanisms such as users going onto the crossing while the barriers are held up incorrectly believing that the crossing is safe. Such potential precursors have not been assessed.

Taking these benefits into consideration, the risk at all current AHB level crossings and total benefit if all these crossings were upgraded to AHB+ is shown in *Table 4*. It can be seen that overall, upgrade to AHB+ is expected to approximately halve the risk compared to an AHB.

Table 4 Overall risk benefit if all AHB level crossings were upgraded to AHB+.

Parameter	SRMv8.5 Risk (FWI/yr)
AHB	1.62
AHB+	0.84
AHB+ Benefit	0.78
% AHB+ Benefit	48%

Table 5 Most significant contributors to risk at an AHB level crossing

Hazardous Event Code	Precursor code	Cause precursor description	Risk cont. (FWI/year)	% of Total	Assessment of AHB reduction in risk	Comment
HEM-27E	KAHB-WALKH	MOP (non-trespasser) pedestrian or cyclist struck/crushed by train on AHB - ignores lights/barriers	0.627	39%	75%	AHB+ barriers will be down in vast majority of instances such that a pedestrian would have to climb over or under barrier, rather than walk around the barrier.
HET-10E	VAHB-DELTH	RV struck by train - on AHB - zigzags barriers	0.245	15%	85%	AHB+ barriers would be lowered in vast majority of instances to prevent a zig zagging car being struck by the approaching train. There may be some unreliability of OD and small objects may prevent barrier lowering. Note that there is no 'fail safe' for OD system – if there is an OD system failure, the exit barrier will not lower.
HET-10E	VAHB-STRTE	RV struck by train - on AHB - RV stranded/failed on LC	0.090	6%		
HET-10E	VAHB-EBLTE	RV struck by train - on AHB - RV incorrectly on LC due to environmental factors/driver error: user brakes too late	0.068	4%		
HEM-27E	KAHB-2TRAH	MOP (non-trespasser) pedestrian or cyclist struck/crushed by train on AHB - second train coming	0.063	4%	85%	AHB+ barrier will be down in vast majority of instances by the time a second train arrives so pedestrian would have to climb over or under a barrier.
HET-10E	VAHB-ASETH	RV struck by train - on AHB - fails to observe level crossing	0.050	3%	2%	Additional barrier would give a small increase in visibility if approaching from the off-side
HET-10E	VAHB-VANTE	RV struck by train - on AHB - RV deliberately placed on level crossing	0.043	3%		
HET-10E	VAHB-ESNTE	RV struck by train - on AHB - RV incorrectly on LC due to environmental factors: sunlight obscures crossing/lights	0.043	3%		
HET-10E	VAHBRTA-TE	RV struck by train - on AHB - RV incorrectly on LC due to RTA	0.036	2%		
HEM-27E	KAHB-SLOWH	MOP (non-trespasser) pedestrian or cyclist struck/crushed by train on AHB - slow moving/short warning	0.035	2%		

Table 6 Changes in Risk with AHB +

Hazardous Event Code	Precursor code	Cause precursor description	Risk cont. (FWI/year)	% of Total	Assessment of AHB+ reduction in risk	Comment
HET-10E	VAHB-ASTTH	RV struck by passenger train - on AHB - second train coming	1.15E-03	0.1%	90%	AHB+ barrier will be down in vast majority of instances by the time a second train arrives so vehicle would have to drive through barrier. There may be some unreliability of OD and small objects may prevent barrier lowering.
HET-11E	VAHB-ASTTH	RV struck by freight train - on AHB - second train coming	1.36E-04	0.0%	90%	AHB+ barrier will be down in vast majority of instances by the time a second train arrives so vehicle would have to drive through barrier. There may be some unreliability of OD and small objects may prevent barrier lowering.
HEM-27E	KAHB-2TRAH	MOP (non-trespasser) pedestrian or cyclist struck/crushed by train on AHB - second train coming	0.063	3.9%	85%	AHB+ barrier will be down in vast majority of instances by the time a second train arrives so pedestrian would have to climb over or under a barrier.
HET-10E	VAHB-DELTH	RV struck by passenger train - on AHB - zigzags barriers	0.245	15.1%	85%	AHB+ barrier will be down in vast majority of instances by the time a zig zagging car that would be hit by a train arrives. Unreliability of OD and small object being detected. There may be some unreliability of OD and small objects may prevent barrier lowering. Note that there is no 'fail safe' for OD system – if there is an OD system failure, the exit barrier will not lower.
HET-11E	VAHB-DELTH	RV struck by freight train - on AHB - zigzags barriers	0.029	1.8%	85%	AHB+ barriers would be lowered in vast majority of instances to prevent a zig zagging car being struck by the approaching train.
HEM-11E	PAHB-2TRAH	Passenger struck/crushed by train on AHB adjacent to station - second train coming	0.030	1.9%	75%	AHB+ barrier will be down in vast majority of instances by the time a second train arrives so pedestrian would have to climb over or under a barrier. There is an Incentive to cross at a station to join the arriving train.

Hazardous Event Code	Precursor code	Cause precursor description	Risk cont. (FWI/year)	% of Total	Assessment of AHB+ reduction in risk	Comment
HEM-27E	KAHB-WALKH	MOP (non-trespasser) pedestrian or cyclist struck/crushed by train on AHB - ignores lights/barriers	0.627	38.7%	75%	AHB+ barriers will be down in vast majority of instances such that a pedestrian would have to climb over or under barrier, rather than walk around the barrier.
HEM-11E	PAHB-WALKH	Passenger struck/crushed by train on AHB adjacent to station - ignores lights/barriers	5.41E-03	0.3%	50%	AHB+ barriers will be down in vast majority of instances such that a pedestrian would have to climb over or under barrier, rather than walk around the barrier. There is an incentive to cross at a station as the passenger may attempt to join the arriving train.
HET-10E	VAHB-ASETH	RV struck by train - on AHB - fails to observe level crossing	0.050	3.1%	2%	Additional barrier would give a small increase in visibility if approaching from the off side
HET-11E	VAHB-ASETH	RV struck by train - on AHB - fails to observe level crossing	5.90E-03	0.4%	2%	Additional barrier would give a small increase in visibility if approaching from the off side
HEN-44E	KEQUAHB-1H	MOP (non-trespasser) pedestrian or cyclist/motorcyclist struck/trapped by level crossing equipment on AHB - user error	9.38E-04	0.1%	-50%	Assumed that near side barriers are a threat to those entering of leaving the crossing while the off side barriers are a threat only to those entering the crossing
HEN-44E	KEQUAHB-3H	MOP (non-trespasser) pedestrian or cyclist/motorcyclist struck/trapped by level crossing equipment on AHB - other	9.38E-04	0.1%	-50%	
HEN-44E	KEQUAHB-2H	MOP (non-trespasser) pedestrian or cyclist/motorcyclist struck/trapped by level crossing equipment on AHB - incorrect use	4.69E-04	0.0%	-50%	

Level crossing specific risk benefit

The risk reduction at a particular crossing will be dependent at the risk contributors at that crossing. The following scaling factors were taken to apply:

Pedestrian/cyclist hazards were taken to scale with:

- The number of pedestrian/cyclists relative to the average at AHB level crossings;
- The number of trains relative to the average at AHB level crossings.

Vehicular hazards were taken to scale with:

- The number of pedestrian/cyclists relative to the average at AHB level crossings;
- The number of trains relative to the average at AHB level crossings.

Second train coming hazards were taken to scale with the square of the number of trains relative to the average at AHB level crossings unless there was a single track, in which case, the factor was set to zero.

Road approach speed was used to generate the scaling factors for the *brakes too late* hazard. The methodology used is summarised in *Table 7*. The value for each level crossing is the average of the factors for the two approaching directions.

Table 7 Road approach speed factor

85% tile Speed (mph)	Road approach speed factor
<20	0.1
20-30	0.2
30-40	0.5
40-50	2
50-60	6
>60	10
>60 long straight	15

The level crossing usage from the 2018 census and scaling factors for the Cambridge level crossings are shown in *Table 8*. The risk benefit from upgrading to AHB+ can then be calculated and the benefit to cost ratio for renewing as an AHB+ level crossing as compared with renewing as an AHB can also be calculated assuming the renewal costs are as follows:

- AHB renewal cost		£1.46m
- AHB+ renewal cost		£2.007m

These costs are based on the CP6 unit rates for level crossings and, in particular, the AHB+ cost was based on the cost of an MCB-OD level crossing without lower LIDAR.

A benefit to cost ratio greater than 1 in *Table 9* does not indicate that AHB+ is the preferred upgrade. Indeed, at very high risk level crossings, it is likely that the preference will be to upgrade to a protected full barrier crossing (MCB-OD or MCB-CCTV), as this will give a higher level of safety benefit. The risk for each crossing as an AHB, AHB+ and as an MCB-OD is shown in *Figure 38*.

The cost benefit analysis for upgrading to an MCB-OD type crossing relative to upgrading to an AHB+ type level crossing is shown in *Table 10*. The second to last column in this table compares the safety benefits and costs for upgrading to an MCB-OD type with upgrading to AHB+. A higher value indicates that and MCB-OD type crossing is justified from a safety perspective and a value less than 1 indicates that investing in and MCB-OD is disproportionate to the safety benefit. However, whether cost is grossly disproportionate also needs to be considered, and as such, other factors such as a road closure time and modifying signal locations are likely to be factors.

From *Table 10,* it can be seen that Meldreth Road level crossing has a very high benefit to cost ratio as the costs of a MCB-OD or AHB+ are similar (there are no additional signals for the MCB-OD) and there is a higher safety benefit for the MCB-OD type. The only other considerations are road closure time and the proximity of Meldreth Road to Shepreth Station CCTV level crossing. Having different modes of operation for two crossings in close proximity introduces additional hazards when in degraded working. This reinforces the case to upgrade Meldreth Road as an MCB-OD type crossing.

Table 8 Scaling factors for individual AHB level crossings

Level crossing	Daily usage 2018			Factors 2018					
	Vehicles	Pedestrians/ cyclists	Trains	Vehicles	Pedestrians/ cyclists	Trains	Trains[2] (Second train coming)	Station	Road approach speed
Milton Fen	77	366	178	0.05	4.0	2.4	5.5	0	0.1
Waterbeach	4,880	889	178	3.0	9.7	2.4	5.5	Yes	0.4
Dimmocks Cote	6,330	133	178	3.8	1.4	2.4	5.5	0	6.0
Six Mile Bottom	7,826	99	35	4.7	1.1	0.5	0.0	0	3.3
Brinkley Road	1,626	60	35	1.0	0.6	0.5	0.0	0	4.0
Black Bank	1,378	59	127	0.8	0.6	1.7	2.8	0	4.0
Croxton	4,466	15	67	2.7	0.2	0.9	0.8	0	10.5
Meldreth Road	1,455	124	194	0.9	1.4	2.6	6.6	0	1.3

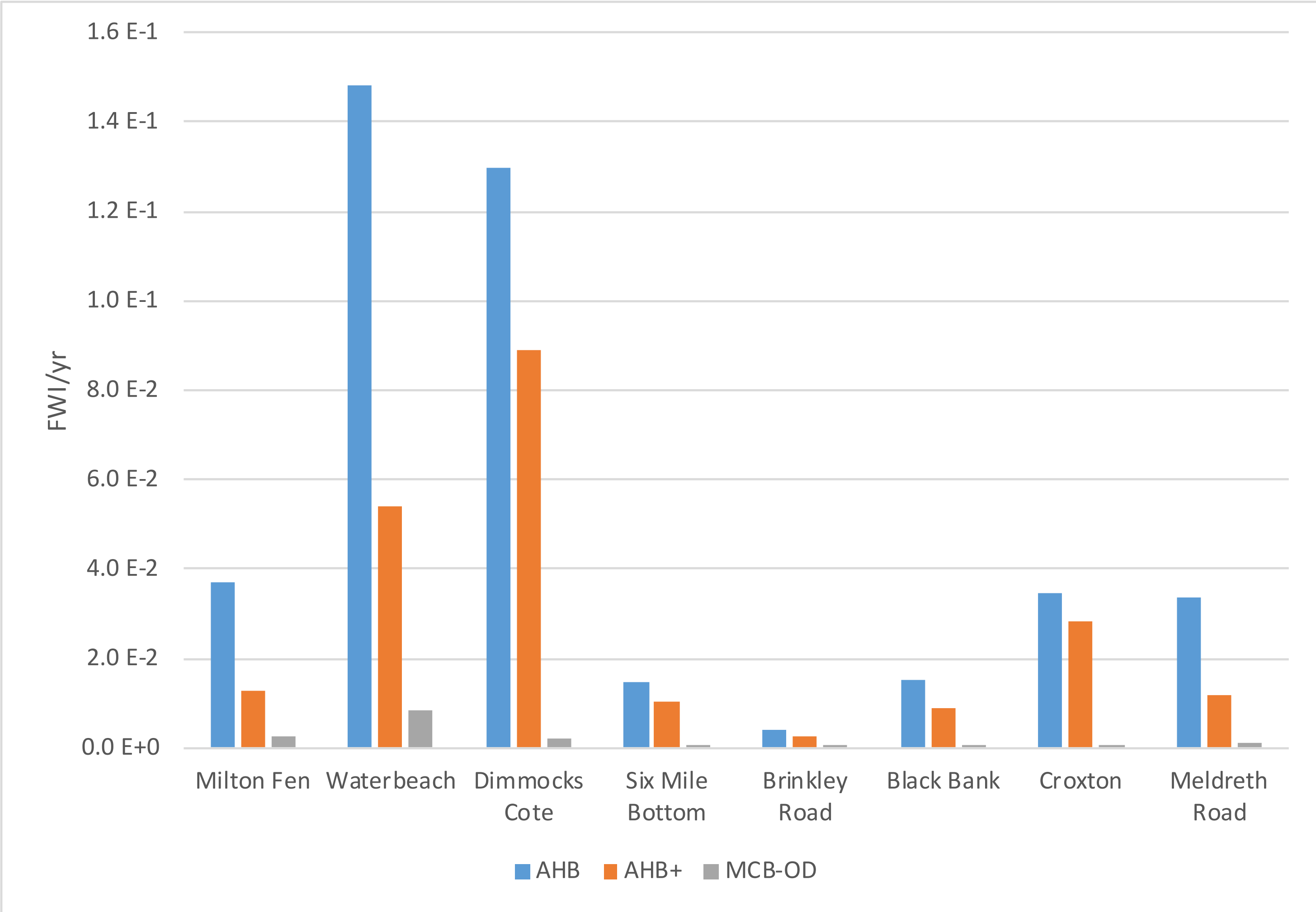
Table 9 Risk benefit and cost benefit analysis for renewing as AHB+ relative to AHB

Level crossing	ALCRM Risk as AHB	%Risk Benefit for AHB+ from SRM	Comments	Risk as AHB+	AHB+ Risk Benefit	NPV of safety benefit over 30 years (AHB+)	Benefit to cost ratio for renewing as AHB+ relative to AHB)
Milton Fen	3.7 E-2	65%	High pedestrian and rail use	1.3 E-2	2.4 E-2	£1,145,935	2.09
Waterbeach	1.5 E-1	64%	High level of benefit for AHB+ but currently at a station and so probably would not be suitable for fitment as AHB+	5.4 E-2	9.4 E-2	£4,466,196	8.16
Dimmocks Cote	1.3 E-1	31%	Does not address late braking	8.9 E-2	4.1 E-2	£1,929,555	3.53
Six Mile Bottom	1.5 E-2	31%	No second train coming benefit (single track)	1.0 E-2	4.6 E-3	£217,390	0.40
Brinkley Road	4.0 E-3	36%	No second train coming benefit (single track)	2.6 E-3	1.5 E-3	£68,963	0.13
Black Bank	1.5 E-2	40%	Does not address late braking e.g. southwest bound traffic. Vehicles do slow down for crossing.	9.0 E-3	6.1 E-3	£288,859	0.53
Croxton	3.4 E-2	17%	Does not address late braking etc.	2.8 E-2	6.0 E-3	£285,008	0.52
Meldreth Road	3.4 E-2	65%	Addresses second train coming; relatively high pedestrian use	1.2 E-2	2.2 E-2	£1,047,676	1.91

Table 10 Cost benefit analysis for renewing as AHB+ relative to renewing as MCB-OD

Level crossing	NPV of safety benefit over 30 years (MCB-OD)	%Risk Benefit (AHB to MCB-OD)	Cost of providing MCB-OD or MCB-CCTV	MCB-OD Cost justification	Benefit to cost ratio (AHB to MCB-OD)	Benefit to cost ratio (Difference between upgrading MCB-OD and AHB+)	Comments
Milton Fen	£1,627,290	93%	£2,482,532	1 SEU	0.66	1.01	Some concern about vulnerable users with AHB+ (4 uses by wheelchair user and 1 scooter in 9 days)
Waterbeach	£6,610,690	94%	£2,932,532	2 SEUs	2.25	2.32	AHB + at a station not likely to be preferred. May be suitable if station is moved
Dimmocks Cote	£6,059,183	98%	£4,732,532	Six additional signals 6 SEUs	1.28	1.52	Much higher benefit for full barrier level crossing
Six Mile Bottom	£691,693	98%	£3,832,532	4 SEUs	0.18	0.26	To be considered in conjunction with Brinkley Road
Brinkley Road	£184,971	97%	£2,032,532	0SEUs - assume signals already in place for Six Mile Bottom	0.09	4.58	Brinkley Road would not cost significantly more to renew as MCB-OD if the signals have already been put in place for Six Mile Bottom. Mix of crossing types for protecting signal if not upgraded.
Black Bank	£694,912	97%	£3,157,532	2 new signals and 2 signal re-heads (2.5 SEUs)	0.22	0.35	If signals installed at Black Bank, a train stopped at the signal would stand over adjacent AHB level crossings introducing a new hazard at those AHB level crossings
Croxton	£1,617,385	99%	£3,832,532	4 SEUs	0.42	0.73	Only a full barrier crossing with signal protection addresses the main hazards at Croxton level crossing and facilitates the removal of the TSR. Skew crossing and so any pedestrians may hold up exit barrier.
Meldreth Road	£1,543,040	96%	£2,032,532	0SEUs	0.76	19.54	The only benefit of AHB+ relative to a full barrier crossing is the shorter road closure time

Figure 38 **Chart showing risk as AHB, AHB+ and MCB-OD**



4.3 Options for closure or alternate level crossing designs

Options Assessment

The following options were considered:

- Crossing closure (via diversions);
- Crossing closure with a pedestrian bridge only provided;
- Crossing closure with an underpass for road vehicles and pedestrians;
- Crossing closure with a full road bridge provided;
- Crossing closure with a diversion to Barrington Road so that users can divert over Shepreth CCTV level crossing;
- Retain '*As-Is*' as AHB type;
- Renew as ABCL;
- Renew as an automatic full barrier (AHB+);
- Upgrade to an MCB-CCTV or MCB-OD, which provide the highest level of protection as a level crossing.

Table 11 provides a summary of the results of the workshop. The main arguments are then discussed below.

In the table the residual safety risk of each option has been converted into monetised safety cost in Net Present Value (NPV) terms over the life of the crossing. This is based on the VpF for 2018 published by RSSB and a safety discount rate of 1.5%. It represents the total financial value of safety for accidents at the crossing over a life of 30 years should that option be pursued. It includes minor (injury) accidents such as slips, trips and falls as well as more serious accidents involving vehicles or pedestrians being struck by trains.

Table 11 Closure / level crossing type assessment

Option/ Crossing type	ALCRM 2019 usage			Feasibility	Cost		Justification for cost estimate
	FWI	Score	NPV (30)		Capital	Annual	
Current crossing type (AHB)	3.4 E-2	D2	£1,600,909	As a high risk crossing, renewal as AHB would be contrary to Network Rail strategy.	£1,460,010	£16,933	Standard cost, if renewal is required. SICA Renewal date: 2029 Route renewal date: 2023
Closure		0	£0	The crossing is on the main road between Meldreth and Shepreth. There is an alternative route along the busy and congested A10 and may involve a detour of up to 8km. Given the usage of the crossing (1,500 vehicles, 100 pedestrians and cyclists per day) this is not a viable closure option.			
Closure + pedestrian bridge		0	£0	Main use is road vehicles so would not enable closure as above.			
Closure + road bridge		0	£0	A road bridge or underpass at this location is not likely to be feasible without purchasing significant land and houses as there are houses on either side of the crossing and any potential route for an off-line bridge has been eliminated by recent house building on Collins Close.			

Option/ Crossing type	ALCRM 2019 usage			Feasibility	Cost		Justification for cost estimate
	FWI	Score	NPV (30)		Capital	Annual	
Closure + underpass	0		£0	A road bridge or underpass at this location is not likely to be feasible without purchasing significant land and houses as there are houses on either side of the crossing and any potential route for an off-line bridge has been eliminated by recent house building on Collins Close			
Closure with bypass	1.2 E-3		£57,870	Could divert the road to Barrington Road and cross the railway at Shepreth station. There would be the need to build about 800m of new undesignated road. There would also need to be an additional ramped footbridge at Meldreth Road. Significant local objections are likely. Road would divert additional vehicles to Shepreth Station CCTV crossing so would not eliminate the risk. Would reduce the road closure time issue at Shepreth somewhat.	£4.5m		800m of new road (approx £2.4m). Land purchase costs would also be a consideration. £2.1M for an EA footbridge if required.
ABCL	-	-	-	Not a viable option due to the restriction in linespeed that would be necessitated.	£1,336,708	£16,933	
AHB+	1.2 E-2	-	£553,233	Meldreth Road level crossing has a very high benefit to cost ratio for MCB-OD rather than AHB+ as the costs of a MCB-OD or AHB+ are similar (there are no additional signals for the MCB-OD) and there is a higher safety benefit for the MCB-OD type. The only other considerations are road closure time and the proximity of Meldreth Road to Shepreth Station CCTV level crossing. Having different modes of operation for two crossings in close proximity introduces additional hazards when in degraded working. This reinforces the case to upgrade Meldreth Road as an MCB-OD type crossing.	£2,007,185	£20,154	CP6 standard renewal costs for MCB-OD without lower LIDAR and no signalling costs

Option/ Crossing type	ALCRM 2019 usage			Feasibility	Cost		Justification for cost estimate
	FWI	Score	NPV (30)		Capital	Annual	
MCB-CCTV	1.2 E-3	G4	£57,870	Feasible. Would share the protecting signals with Shepreth (on Shepreth station platform) which would increase the road closure time. The other signal is about 200 metres from the crossing. Future busiest hour road closure time of Shepreth station and Meldreth Road may not be sustainable.	£1,864,316	£54,265	CP6 standard renewal costs. No SEUs
MCB-OD	1.2 E-3	G4	£57,870	May be feasible but is within the exclusion zone of the Merlin radar telescope (just within inner 6.5km exclusion zone). Mk 2 radar are understood to be less problematic in this regard and are proposed for this project. Would share the protecting signals with Shepreth (on Shepreth station platform) which would increase the road closure time. The other signal is about 200 metres from the crossing. Future busiest hour road closure times of Shepreth station and Meldreth Road may not be sustainable.	£2,032,532	£40k	CP6 standard renewal costs. No SEUs

4.4 Conclusions regarding closure of the crossing

The first priority should be to close the crossing where possible. The only option identified would be to divert Meldreth Road to Barrington Road via a new link road (*Figure 39*) and users can utilise Shepreth level crossing. This has the disadvantage of increasing the usage over an already busy level crossing. Need to build about 800m of new road. There would need to be an additional ramped footbridge at Meldreth Road and significant local objections are likely and so such a scheme may not be deliverable. The link road would divert additional vehicles to Shepreth Station CCTV crossing so would not eliminate the risk.

Figure 39 **Scheme to close Meldreth Road crossing**

Since this scheme would likely cost an estimated £4.5m, the short-term capital cost is higher than the alternative of renewing Meldreth Road as MCB-OD with a cost of about £2m and a similar residual risk.

A road closure time of about 71% in the busiest hour for an MCB-CCTV or MCB-OD type crossing is very long but might be mitigated somewhat by stopping/non-stopping controls. Meldreth Road would share the Up protecting signals with Shepreth (on Shepreth station platform) which would increase the road closure time. It is, therefore, concluded that whilst closure of the crossing could be feasible, crossing renewal provides a more viable and cost-effective option.

4.5 Conclusion about crossing type

Retaining an AHB crossing would not be the preferred option as it presents a high level of 3.4×10^{-2} FWI per year. It is also exposed to hazards associated with a relatively fast road approach from the south and the opportunity to weave as it is a skew level crossing. Renewal of a crossing with an ALCRM score of D2 as an AHB would also be contrary to Network Rail's strategy of upgrading high risk AHB crossings when renewal is required.

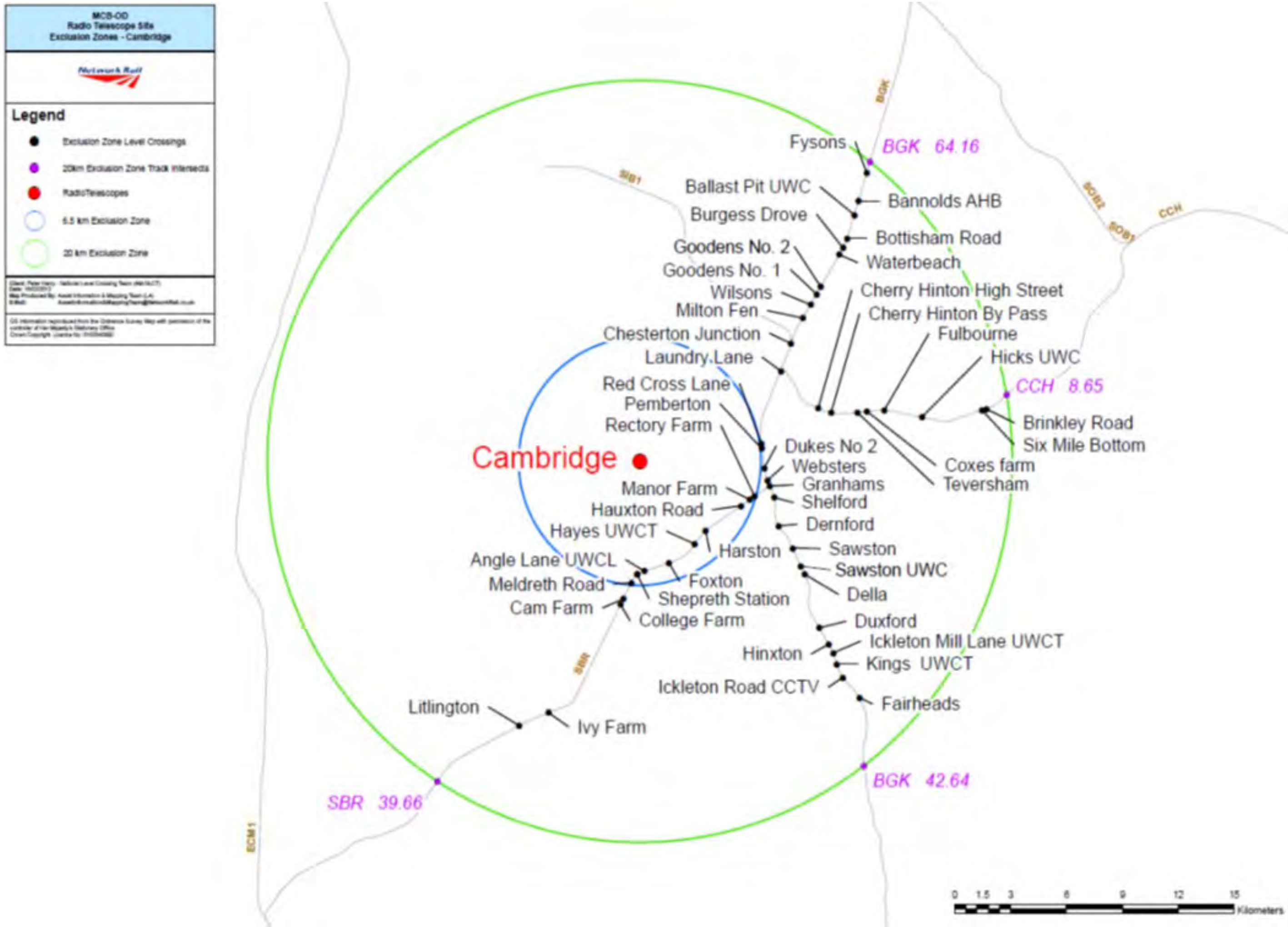
Meldreth Road level crossing has a very high benefit to cost ratio for MCB-OD (or MCB-CCTV) rather than AHB+ as the costs of a MCB-OD and AHB+ are similar (there are no additional signals for the MCB-OD or CCTV) and there is a higher safety benefit for the MCB-OD (or MCB-CCTV) type. The only other considerations are road closure time and the proximity of Meldreth Road to Shepreth Station CCTV level crossing. Having different modes of operation for two crossings in close proximity introduces additional hazards when in degraded working. This reinforces the case to upgrade Meldreth Road as an MCB-OD (or MCB-CCTV) type crossing.

The preferred option is therefore to renew the crossing as MCB-CCTV or MCB-OD. On the Up approach Meldreth Road would share the protecting signals with Shepreth (on Shepreth station platform) which would increase the road closure time. The Down signal is about 200 metres from the crossing, which is in a compliant location.

Either MCB-OD or MCB-CCTV would offer significant risk reduction compared with AHB from 3.4×10^{-2} to 1.2×10^{-3} FWI per year. Normally MCB-OD would be preferred over MCB-CCTV for workload reasons. The crossing is within the 6km Cambridge MERLIN radio telescope exclusion zone (see *Figure 40*) so there are issues with providing MCB-OD Mk. 1; the Mk. 2 MCB-OD units are understood to be less problematic in this respect and are planned for use on this project.

The choice between MCB-OD and MCB-CCTV is therefore likely to be made on the basis of feasibility, signaller workload, road closure time and cost.

Figure 40 **Proximity to Merlin Telescope**



4.6 Options for additional controls

The key level crossing hazards at the crossing have been considered to determine the additional controls that should be provided upon renewal (see *Table 12*).

The additional controls identified for consideration include:

- The crossing is likely to have a long road closure time. Meldreth Road would share the Up protecting signals with Shepreth (on Shepreth station platform) which would increase the road closure time. A road closure time of about 71% in the busiest hour for an MCB-CCTV or MCB-OD type crossing is very long and potential steps including stopping/non-stopping controls should be considered to minimise the road closure time.
- The road approach to the crossing from the south is fast and straight, giving potential for misuse, late braking and barrier strikes although there is not a history of such incidents at Meldreth Road. Additional controls to consider include an anti-reflective and anti-slip road surface (or renewal of the existing anti-slip surface) and VASs (which may be preferred). Such measures were not considered to be necessary from the workshop but should be considered further at detailed design informed by a more recent census.
- Low sun is potentially an issue for road approach sighting, particularly around sunset in winter, however there are trees and buildings which block the sun and provide background shielding for the RTLs. The crossing already has LED RTLs to mitigate this. No other measures were considered to be necessary.
- The crossing is significantly skewed (the road is 45° to the rail) and the census showed significant cyclist use and this may have increased since 2013. Consideration should be given to this when selecting the deck type.
- The current footway widths are not sufficient to meet ORR guidance, especially in areas where they narrow towards the ends. At least one 1.5m footway and ideally two are recommended. Parts of the edge markings are close to the deck edge on the south footway. A wider deck to properly accommodate pedestrian footways is recommended.
- Measures to decrease the likelihood of blocking back such as 'Keep clear' signs at junctions to houses and yellow box markings on the level crossing.

Table 12 Assessment of additional controls

Hazard	Comment	Standard/existing controls	Potential additional controls	Feasibility	Cost (£)	Recommend
High road closure time - misuse by vehicles and pedestrians		Obstacle detection system to ensure crossing is clear	RLSE cameras	Yes	£150k	Mobile camera are recommended for deployment first to see if there is an issue. Would be worth a census after installed to assess misuse and consider if RLSE cameras are a worthwhile investment.
			Stopping/non-stopping controls	Feasible but signaller workload considerations		Recommended
High road speed on straight approach from south-west	40mph zone just west of crossing - likely speed measured some distance from crossing in census Good RTL visibility	Full barriers Obstacle detection system to ensure crossing is clear There is existing anti-slip surface, but has not been maintained for a long duration	Update anti-slip road surface	Yes subject to Highway Authority agreement	Significant maintenance cost to Highways Authority	No - no evidence that this is problematic

Hazard	Comment	Standard/existing controls	Potential additional controls	Feasibility	Cost (£)	Recommend
Blocking back	Nearby driveways give some potential for blocking back, likely of short duration. None was observed in the 2013 census however.	Obstacle detection system to ensure crossing is clear	Yellow box markings on crossing	Standard fitment if upgraded to MCB-OD	N/A	Yes - standard fitment
			BPM	Yes		No - no evidence that this is problematic. Review if new census renewal blocking back.
			Keep clear signs at junctions to houses	Yes		Yes
Crossing warning sign placement	The level crossing warning sign on the Up side is partially obscured by a hedge		Move Up side LC sign so it is unobstructed	Yes	Minimal	Yes - would be moved when crossing is updated.
Skew	Skew is 45° to the rail. Concrete panels and significantly cyclist use.		Velostrail deck	No - maximum speed is 120km/h / 75mph		No
			Eliminate skew	No - nearby houses prevent this		No

Hazard	Comment	Standard/existing controls	Potential additional controls	Feasibility	Cost (£)	Recommend
	Slightly elevated turn onto railway risk	Retro-reflective road edge markers	Retro-reflective road edge markers	Yes	Low	No - only possibility is the residents of the local houses.
Audible warning volume	Set quite low	Audible warnings on two corners	Provide audible warning alarms at all 4 corners	Yes	Low	No
Lighting	The nearest street light is 50m to the east of the crossing. There are none on the west side		Low lux lighting	Yes		Not required as a low pedestrian use crossing and nearby housing.
Narrow footways	Footway widths are not sufficient to meet ORR guidance, especially in areas where they narrow towards the ends. Road width is 6m.		New footways that meet ORR guidance width along entire length (1.5m)	Yes	Low upon renewal	Yes - upon renewal
Footways close to deck edge	Parts of the edge markings are close to the deck edge on the south footway	White lines to denote footway edge	Wider deck to properly accommodate pedestrian footways	Yes	Low upon renewal	Yes
Low sun - Low sun is a potential issue on the southbound approach.		LED RTLs	Extended hoods	Yes		No - no evidence that this is problematic.

Hazard	Comment	Standard/existing controls	Potential additional controls	Feasibility	Cost (£)	Recommend
			Count down markers, eg, rumble strips	Yes		No - no evidence that this is problematic.
			Large backboards	Yes		No - no evidence that this is problematic.
			Anti glare road surface	Yes		No - no evidence that this is problematic.
			Low cost vehicle activated signs	Yes	£10k	No - no evidence that this is problematic.

4.7 Assessment of the costs and benefits of Lower LIDAR

Network Rail has developed an assessment tool [9] to calculate the benefits of the provision of Lower LIDAR at MCB-OD level crossings. The rationale for undertaking the assessment is that the Lower LIDAR, whilst providing some additional safety benefit, reduces the overall reliability of the crossing with a knock-on impact for delaying trains. The system also has associated capital and maintenance costs. The capital cost can be very high for some crossings due to the stringent demands it places on the flatness of the road profile.

The project currently anticipates that it will use the Mk. 2 version of MCB-OD, although this currently does not have type approval. It is expected that the Mk. 2 system will not require LIDAR as the RADAR would be configured to provide equivalent functionality. An assessment of lower LIDAR is however made in case the Mk. 2 system is not available or does not obviate the need for LIDAR.

The Costs of Lower LIDAR

Based upon accepted Network Rail HQ costs and adjustments [8], the costs for providing Lower LIDAR are taken to be as shown in *Table 13*.

Table 13 Assumed Lower LIDAR costs

Type of cost	Costs	
	Low Level LIDAR Child vulnerable user group (175mm beam height)	Low Level LIDAR Adult (elderly) vulnerable user group (280m m beam height)
Materials	£17,141	£17,141
Installation and set up	£8,206	£8,206
Civils work	£site specific, may be zero	£site specific, may be zero
Maintenance costs - attending failure (over 30 year asset life)	£17,987	£17,987
Faulting / local control over (30 years asset life)	£17,987	£8,993
Total cost associated with Lower LIDAR	£61,321 + Civils work	£52,327 + Civils work

No civil engineering or train delay cost estimate for Lower LIDAR is available currently; therefore, in order to provide an onerous assessment case these have been assumed to be zero.

The benefits of Lower LIDAR

The key inputs to and outputs from the numerical assessment are as follows:

Inputs		
Recommended height setting		Child
Train frequency per day		194
Pedestrians per day		27
Cycles per day		83
Motorcycles per day		14
Other road vehicles per day		1,455
Crossing is at a station		N
If at a station, the number of stopping trains per day		N/A
Is line speed at the crossing 20mph or less?		N
Outputs		
Safety benefit	**FWI per year**	1.0 E-3
	NPV_{30}	£41,118
Cost	**NPV_{30}**	£61,321
Safety benefit to cost ratio over 30 years		0.67

From these inputs, the current safety benefit of the Lower LIDAR is 1.0 x 10^{-3} FWI per year. This is equivalent to a monetised benefit over 30 years of £41,118.

Lower LIDAR – comparing costs and benefits

The estimated cost of Lower LIDAR at this crossing is at least £61,321 over the life of the asset. It is considered that the crossing is likely to have some usage by unaccompanied children, so it is assumed to require the lower height setting; the safety benefit is approximately £41,118. The benefit to cost ratio for providing Lower LIDAR is 0.67, subject to there not being significant civils cost, which suggests that the cost of providing Lower LIDAR is not grossly disproportionate to the safety benefit according to the guidance [8] that *"If above 0.5 Lower LIDAR should be considered. Lower LIDAR may be considered if below 0.5 where there are significant hazards unmitigated"*.

Lower LIDAR risk factors

The tool [9] for the assessment of the benefits to pedestrian slip, trip or fall risk from Lower LIDAR identifies a range of potential local hazards related to the causation of users slipping, tripping or falling on the crossing.

This set of hazards has been reviewed and supplemented by Sotera and is considered to represent a fairly comprehensive set of pedestrian slip, trip or fall hazards (some however appear to have only limited relevance to pedestrian slip, trip or fall) but one, relating to equestrian use has been added. Each hazard has been considered in relation to the crossing based upon the site visit and traffic census to determine the potential significance of each hazard based upon the crossing features; it was then discussed in the risk workshop and additional controls considered. Each hazard has been rated as to its significance based upon the tool's three-point rating scale of 'Major', 'Minor' or 'No'.

In assessing whether additional control measures are required, both the rating and the overall level of risk have been considered. Where mitigation is suggested, the post-mitigation risk rating is also provided.

The full list of hazards, ratings and crossing specific comments are presented in *Table 15*. This assumes that the crossing is maintained in good condition over its full life.

The following additional controls are recommended for consideration:

- New level deck;
- Extend the decking panels to properly accommodate pedestrian footways;
- Fit audible alarms to all four RTLs and/or increase volume;
- At least one new footway that meets ORR guidance width along entire length.

Table 14 summarises the number of hazards afforded each rating before and after the proposed additional controls.

Table 14 LIDAR hazard ranking summary

Hazard rating	Number of hazards afforded stated rating	
	Number before additional mitigation	Number after proposed additional mitigation
Major	2	1
Minor	14	9

Conclusion about Lower LIDAR

Lower LIDAR is justified at this crossing as the safety benefit to cost ratio is greater than 0.5 and there is a '*Major*' ranked hazard that cannot be mitigated associated with the skew of the crossing, in particular the potential for cyclists to fall where their tyre is deflected by the rails, that cannot be otherwise effectively mitigated.

Table 15 Lower LIDAR Hazards

Ref:	Topic	Hazards	Site comments	Possible additional controls	Rating pre-mitigation	Rating post-mitigation
Topographic/physical features						
1	Surface	Slippery surface	No specific objects likely to cause slip hazard		No	No
2	Surface	Uneven surface, differential height of slabs, gaps between panels, holes in asphalt, subsided surface	Uneven, especially at the six foot, but no specific raised edges are identified	New level deck	Minor	No
3	Surface - loose material	Mud in rural areas, gravel	Vegetation growth at the ends of the footways, largely OK over decked area	Improved footways over whole crossing length	Minor	No
4	Surface – drainage	Pooling of water following rain	No water pooling on the footways identified (site visit in heavy rain)		No	No
5	Surface - flange gap	Degradation of flange gap - bicycle wheels trapped, trip hazard for pedestrians	To standards		No	No
6	Layout – bend	Level crossing on bend	Crossing is on a straight road		No	No
7	Layout - skew	Direction of users traverse not orthogonal to tracks. Increased traverse time where skew is significant.	Skew is 45° to the rail. Concrete panels and significantly cyclist use.	None - Velostrail not suitable for the line speed	Major	Major
8	Layout / environment / conspicuity	Extraneous light and noise sources, short approach, no audible alarm (or hard to hear), poor conspicuity	Crossing is conspicuous on straight approach. Audible warnings are set to low volume for a fairly large crossing area. No likely distractions.	Fit audible alarms to all four RTLs and/or increase volume	Minor	No
9	Gradient / profile	Crossing on a raised profile (gradient up or down to	Minor hump at the crossing. Uneven profile - lines seem to be at slightly	New level deck	Minor	No

Ref:	Topic	Hazards	Site comments	Possible additional controls	Rating pre-mitigation	Rating post-mitigation
		crossing). Crossing itself on a gradient	different heights			
10	Footpath width and road width	Narrow footpath, or narrow roadway meaning less space for pedestrians	Footway widths are not sufficient to meet ORR guidance, especially in areas where they narrow towards the ends. Road width is 6m.	New footways that meet ORR guidance width along entire length (1.5m)	Major	No
11	Pedestrian walkway - edging	Poor marking of edge of crossing / railway	South footways very close to deck edge	Wider deck to properly accommodate pedestrian footways	Minor	No
12	Pedestrian walkway - obstacles	Posts, fencing, etc protrudes into walkway	No specific obstructions		No	No
13	Lighting	Low levels of lighting in hours of darkness	Street light 50m on east side, none on west side. Pedestrians may be likely to carry torch at night in this rural location.	Low lux lighting	Minor	Minor
Pedestrian vulnerability factors						
14	Vulnerable - elderly	Used by large numbers of elderly people	The demographic of the users is expected to be normal and there are no specific environs that would encourage a particular user group.		Minor	Minor
15	Encumbered – push chairs, luggage / baggage	Used by large numbers of adults with push chairs, and/ or lots of travellers	The demographic of the users is expected to be normal and there are no specific environs that would encourage a particular user group.		Minor	Minor
16	Encumbered - dogs	Used by high proportion of dog walkers	The demographic of the users is expected to be normal and there are no specific environs that would		Minor	Minor

Ref:	Topic	Hazards	Site comments	Possible additional controls	Rating pre-mitigation	Rating post-mitigation
			encourage a particular user group.			
17	Vulnerable – cognitive impairment	Large proportion of users with reduced cognitive capability	The demographic of the users is expected to be normal and there are no specific environs that would encourage a particular user group.		Minor	Minor
18	Vulnerable – other mobility impaired	Large proportion of users with impaired mobility including wheelchair users	The demographic of the users is expected to be normal and there are no specific environs that would encourage a particular user group.		Minor	Minor
19	Vulnerable – unaccompanied children	Used by large numbers of school children who are not accompanied by adults	The 2013 census identified some use by unaccompanied children. There is a small playground to the east.		Minor	Minor
20	Impaired users	Users under the influence of alcohol	The demographic of the users is expected to be normal and there are no specific environs that would encourage a particular user group.		Minor	Minor
N/A	Equestrian use	Person thrown from horse	The census identified no use by this group. There are no specific environs that would encourage a particular user group.		No	No
Operational factors						
21	Event hazard	Local event promotes high temporary use of the crossing	No sources identified and events with high pedestrian use of crossing unlikely in this location		No	No
22	Seasonal hazard	Weather - icy road	Rural location likely subject to occasional icing. On a priority gritting		Minor	Minor

Ref:	Topic	Hazards	Site comments	Possible additional controls	Rating pre-mitigation	Rating post-mitigation
			route.			

4.8 MCB-OD Configuration factors

There are a number of design parameters for the MCB-OD system that can be modified to help manage particular hazards at a crossing. Sotera has considered these and they were further assessed in the workshop. This process is documented in *Table 16*.

No firm recommendations are made as the designer would prefer flexibility to make the design decisions to manage the hazards in the most appropriate way, however key considerations for this crossing are listed as follows:

- *Blocking back.* Whist there is no known issue with blocking back currently, there are features of the road layout that could provide possible sources of blocking back. It should be noted that there will a higher level of congestion at the crossing after the crossing has been upgraded to a full barrier crossing with longer road closure times. BPM was not recommended at the workshop but should be considered further in detailed design with a traffic census that reflects the current rail usage.
- *Lower LIDAR.* See *Section 4.7*. Considered to be justified.
- *Anti-trapping delay in lowering and pausing of the exit barriers.* There is a fairly long traverse distance between the white lines but extending the anti-trapping delay was not considered to be necessary at the workshop but should be considered further in detailed design with a traffic census that reflects the current rail usage.
- *Enhanced OD Control of Barriers Lowering.* This provides an alternative mitigation to increasing the anti-trapping delay. This might particularly be a consideration should BPM also be provided as it utilises the same circuitry, although it can lead to increased misuse. Not recommended at the workshop but should be considered further in detailed design with a traffic census that reflects the current rail usage.
- *Sacrificial RADAR reflectors.* These could be provided to manage the risk of a vehicle turning down the railway which is slightly elevated at this crossing due to the skew. It is likely that they would not be required provided barriers are moved close to the railway, and it is not clear that they would be a design option with the Mk. 2 type MCB-OD.
- *Provide audible warning at all four wig-wags.* The crossing has a fairly large area and the audible warning is currently set quite low; it is, however, a quiet road and were considered unlikely to be necessary providing it is feasible to move barriers in close to the railway.

- *Response time and number of available attendants for CCU operation should it be necessary.* Maintenance response would come from Cambridge on the village side (Up side). The CCU should be located on the Up side and consideration should be given to the provision of a parking space on this side.

Table 16 Review of MCB-OD configuration factors

MCB-OD configuration factor	Hazards	Consideration at level crossing	Recommended
Minimum Road Open time (MROT) Default of 10 seconds from when the barriers are fully raised until the amber light coming on for a new closure	**Lower MROT**: May cause entrapment - large queues of pedestrians not having time to cross, eg, at a station. **Higher MROT**: Increasing closure time, higher chance of second train coming - may lead to frustration and misuse.	Not likely to be used by large groups of pedestrians or vehicles; therefore not recommended	N
Fitting of BPM at exit barriers or at the exit and entrance barriers. Default is fitment but can be removed based on blocking back survey and assessment of likely hazards to the barrier.	**Provision of BPM:** Manages blocking back risk	The local layout, with driveways close to the crossing, suggests there could be some short duration blocking back but this would not be expected to be of significant duration given the road's level of use. Blocking back was not observed in the 2013 traffic census. Therefore BPM is not recommended.	N
Default time at which time barriers lower (30 secs). Exit barriers at 4 barrier crossing.	Blocking back for extended durations	See above - not recommended.	N
Fitting of lower LIDAR. Default is fitment but can be removed based on risk assessment. LIDAR height – adult or child	Person (pedestrian, cyclist, motorcyclist) incapacitated on crossing.	See separate lower LIDAR risk assessment	Y
Minimise distance between barriers	Long traverse at skew crossing giving rise to entrapment risk.	There is a significant skew however the distance between the barriers at the existing AHB crossing has already	Y

MCB-OD configuration factor	Hazards	Consideration at level crossing	Recommended
		been minimised. It is recommended that this principle is retained for the upgraded crossing.	
Anti-trapping delay in lowering and pausing of the exit barriers (default is up to 10 seconds)	Long traverse distance Slow, encumbered or vulnerable users	Fairly long traverse length between white lines, but barrier to barrier distance would be less and within the normal sequence timing.	N
Enhanced OD Control of Barriers Lowering. There is an option to also require the OD system (i.e. POD and COD) to be clear in order to allow the lowering of any barrier pair (similar to BPM).	Long traverse distance (> 39m, or where BPM also provided) Entrapment	There is no specific entrapment risk at this location that is not well managed with the standard configuration.	N
Hurry call systems integrating with highway traffic lights	Traffic congestion caused by nearby highway traffic lights.	Not recommended, there are no nearby highway traffic lights.	N
Lengthen the amber phase. Default is 3 seconds	Amber sequence provides inadequate warning - high road approach speeds, difficulty braking, high use by large vehicles.	The 85th percentile road vehicle speeds northbound was recorded to be 45mph but this was likely measured some distance from the crossing i.e. outside of the 30mph zone. Straight approach with good RTL visibility. Not recommended.	N
Sacrificial RADAR reflectors	Road vehicles accidentally driven down the railway, e.g. high skew or Sat. Nav. errors with nearby junctions.	High skew means that this could be a consideration. Nearest junction is 125m from the crossing. Crossing has retro-reflective edge markers.	N - if barriers are moved in
Provide audible warning at all four wig-wags	Large crossing area, local background noise or high likelihood that would be set to low	Quiet road and area should be reduced	N

MCB-OD configuration factor	Hazards	Consideration at level crossing	Recommended
	volume due to nearby properties meaning that audible warning cannot be heard.		
Standing red man indication	High pedestrian use Poorly sited RTLs for pedestrians	Moderately low pedestrian misuse and a good view of the RTLs, therefore not recommended.	N
Response time and number of available attendants for CCU operation should it be necessary	Crossing spends a long duration in a failed state, delaying trains.	Would come from Cambridge on the village side. Only a short distance from Cambridge. The CCU should be located on the Up side and consideration should be given to the provision of a parking space on this side.	Adequate

Note: Some of the considerations in the above table refer to the Mk.1 MCB-OD, if the new Mk.2 MCB-OD crossing is available and pursued, alternative configuration factors may apply.

5 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are made from the analysis:

Strategic options

1. The only option identified would be to divert Meldreth Road to Barrington Road via a new link road (*Figure 39*) so that users can utilise Shepreth level crossing. This has the disadvantage of increasing the usage over an already busy level crossing with long road closure times. The scheme would require the construction of about 800m of new road and an additional ramped footbridge at Meldreth Road. Significant local objections are likely and so such a scheme may not be deliverable. The link road would divert additional vehicles to Shepreth Station CCTV crossing so would not eliminate the risk.

2. It is, therefore, concluded that whilst closure of the crossing could be feasible, crossing renewal provides a more viable and cost-effective option.

3. Retaining an AHB crossing would not be the preferred option as it presents a high level of risk at 3.4×10^{-2} FWI per year. Renewal of a crossing with an ALCRM score of D2 as an AHB would also be contrary to Network Rail's strategy of upgrading high risk AHB crossings when renewal is required.

4. MCB-OD (or MCB-CCTV) is preferred over AHB+ as the costs of a MCB-OD and AHB+ are similar (there are no additional signals required for the MCB-OD or CCTV) and there is a higher safety benefit for the MCB-OD (or MCB-CCTV) type. The only other considerations are road closure time and the proximity of Meldreth Road to Shepreth Station CCTV level crossing. Having different modes of operation for two crossings in close proximity introduces additional hazards when in degraded working and in terms of interpretation by the general public. This reinforces the case to upgrade Meldreth Road as an MCB-OD (or MCB-CCTV) type crossing.

5. The preferred option is therefore to renew the crossing as MCB-CCTV or MCB-OD. On the Up approach Meldreth Road would share the protecting signals with Shepreth (on Shepreth station platform) which would increase the road closure time. The Down signal is about 200 metres from the crossing, which is in a compliant location. Either MCB-OD or MCB-CCTV would offer significant risk reduction compared with AHB from 3.4×10^{-2} to 1.2×10^{-3} FWI per year. Normally MCB-OD would be preferred over MCB-CCTV for workload reasons but the choice between MCB-OD and MCB-CCTV is therefore likely to be made on the basis of feasibility, signaller workload, road closure time and cost.

Consideration of local hazards and MCB-OD configuration parameters

6. The additional controls identified for consideration include:

- The crossing is likely to have a long road closure time. Meldreth Road would share the Up protecting signals with Shepreth (on Shepreth station platform) which would increase the road closure time. A road closure time of about 71% in the busiest hour for an MCB-CCTV or MCB-OD type crossing is very long and potential steps including stopping/non-stopping controls should be considered to minimise the road closure time.
- The road approach to the crossing from the south is fast and straight, giving potential for misuse, late braking and barrier strikes although there is not a history of such incidents at Meldreth Road. Additional controls to consider include an anti-reflective and anti-slip road surface (or renewal of the existing anti-slip surface) and VASs (which may be preferred). Such measures were not considered to be necessary from the workshop but should be considered further at detailed design informed by a more recent census.
- Low sun is potentially an issue for road approach sighting, particularly around sunset in winter, however there are trees and buildings which block the sun and provide background shielding for the RTLs. The crossing already has LED RTLs to mitigate this. No other measures were considered to be necessary.
- The crossing is significantly skewed (the road is 45° to the rail) and the census showed significant cyclist use and this may have increased since 2013. Consideration should be given to this when selecting the deck type.
- The current footway widths are not sufficient to meet ORR guidance, especially in areas where they narrow towards the ends. At least one 1.5m footway and ideally two are recommended. Parts of the edge markings are close to the deck edge on the south footway. A wider deck to properly accommodate pedestrian footways is recommended.
- Measures to decrease the likelihood of blocking back such as '*Keep clear*' signs at junctions to houses and yellow box markings on the level crossing.

7. Lower LIDAR may not be required for the Mk. 2 MCB-OD units. If lower LIDAR is a consideration, lower LIDAR is considered to be justified at this crossing as the safety benefit to cost ratio is greater than 0.5 and there is a '*Major*' hazard associated with the skew of the crossing, in particular the potential for cyclists to fall where their tyre is deflected by the rails, that cannot be otherwise effectively mitigated.

8. MCB-OD design parameters that should be considered to manage the risk for this crossing are listed as follows:

    - *Blocking back.* Whist there is no known issue with blocking back currently, there are features of the road layout that could provide possible sources of blocking back. It should be noted that there will a higher level of congestion at the crossing after the crossing has been upgraded to a full barrier crossing with longer road closure times. BPM was not recommended at the workshop but should be considered further in detailed design with a traffic census that reflects the current rail usage.

    - *Anti-trapping delay in lowering and pausing of the exit barriers.* There is a fairly long traverse distance between the white lines but extending the anti-trapping delay was not considered to be necessary at the workshop but should be considered further in detailed design with a traffic census that reflects the current rail usage.

    - *Enhanced OD Control of Barriers Lowering.* This provides an alternative mitigation to increasing the anti-trapping delay. This might particularly be a consideration should BPM also be provided as it utilises the same circuitry, although it can lead to increased misuse. Not recommended at the workshop but should be considered further in detailed design with a traffic census that reflects the current rail usage.

    - *Sacrificial RADAR reflectors.* These could be provided to manage the risk of a vehicle turning down the railway which is slightly elevated at this crossing due to the skew. It is likely that they would not be required provided barriers are moved close to the railway, and it is not clear that they would be a design option with the Mk. 2 type MCB-OD.

    - *Provide audible warning at all four wig-wags.* The crossing has a fairly large area and the audible warning is currently set quite low; it is, however, a quiet road and were considered unlikely to be necessary providing it is feasible to move barriers in close to the railway.

    - *Response time and number of available attendants for CCU operation should it be necessary.* Maintenance response would come from Cambridge on the village side (Up side). The CCU should be located on the Up side and consideration should be given to the provision of a parking space on this side.