


Risk Assessment for Dimmocks Cote AHB Level Crossing

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REVISIONS

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Issue 01	David Harris	Chris Chapman	01/05/19	Issued to Network Rail for review
Issue 02	David Harris	Chris Chapman	17/06/19	Issued to Network Rail
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APPROVAL

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	Date: 17th April 2020
Accepted By: (RAM Signalling)	Name: Sam Langhurst
	Date: 20/04/2020

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	
EACE	Ely Area Capacity Enhancement (project)	
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	

Acronym	Description	Comments
LED	Light Emitting Diode	
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	

Acronym	Description	Comments
TMOB	Trainman Operated Barrier crossing	
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 Dimmocks Cote Level Crossing	Tracsis 1167-WTR Site 31 – June 2018
5.	East Cambridgeshire Local Plan	Adopted April 2015
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 Dimmocks Cote 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.
- Specified and carried assessments of the crossing type options using the ALCRM based upon an up-to-date traffic census.
- 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

Dimmocks Cote is an AHB crossing, with two half-width barriers and four RTLs. The RTLs are of the LED type.

The crossing is monitored from Cambridge signal box.

The maximum line speed is 75 mph. The line is electrified with overhead lines.

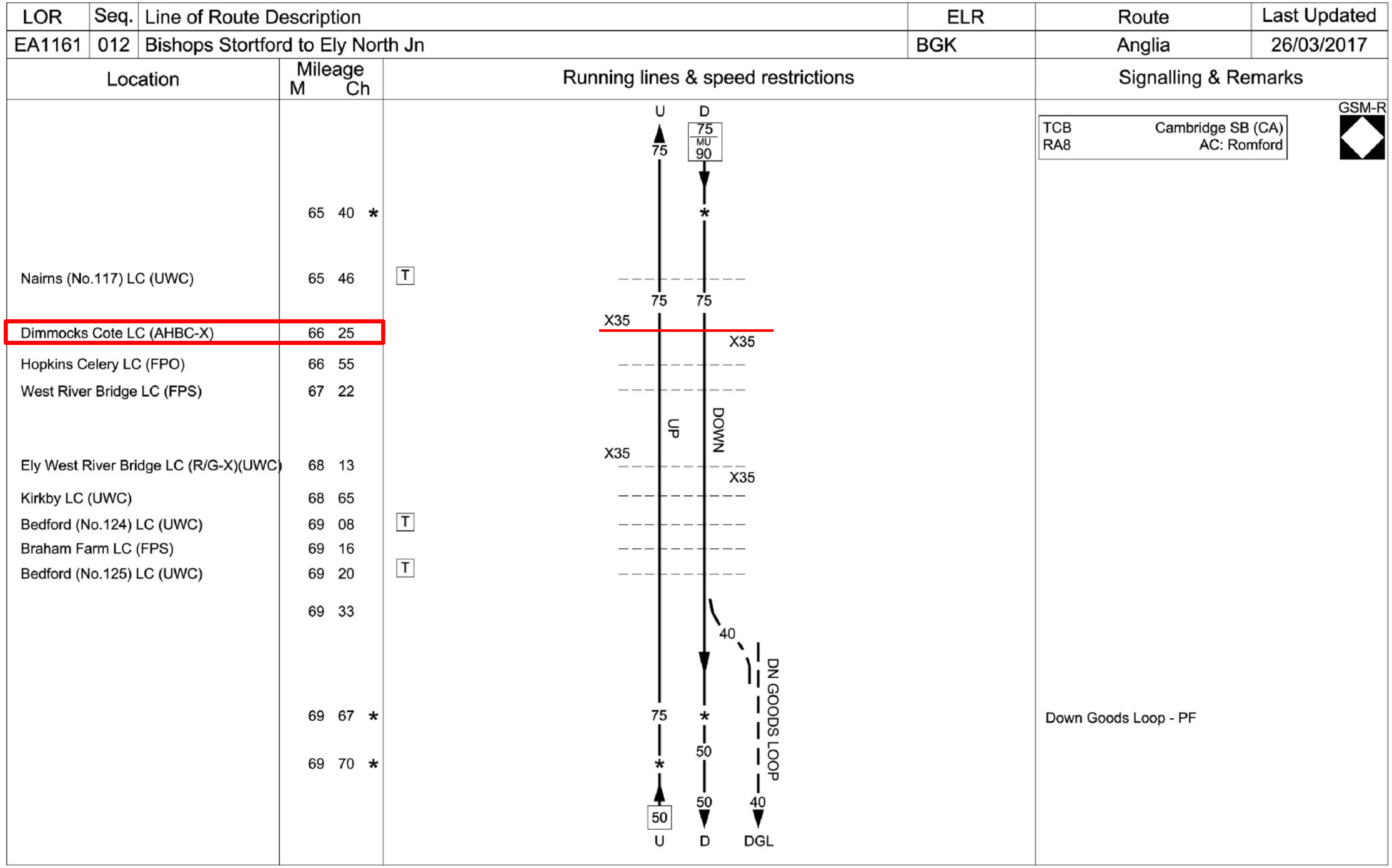
Figure 1 shows the configuration of the crossing, viewed from the east. *Figure 2* provides the relevant extract from the sectional appendix covering the crossing. *Table 1* presents details of the location and operation of the crossing.

Figure 1 Current crossing equipment

Table 1 Current Level Crossing Details

Level crossing name	Dimmocks Cote
Level crossing type	AHB
ELR and mileage	BGK 66m 25ch
Status	Public Road
Number of running lines	2
Permissible speed over crossing (Up)	75mph
Permissible speed over crossing (Down)	75mph
OS grid reference	TL526730
Postcode	CB6 3LG
Road name and type	A1123 Newmarket Road
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
EA1161	012	Bishops Stortford to Ely North Jn	BGK	Anglia	26/03/2017

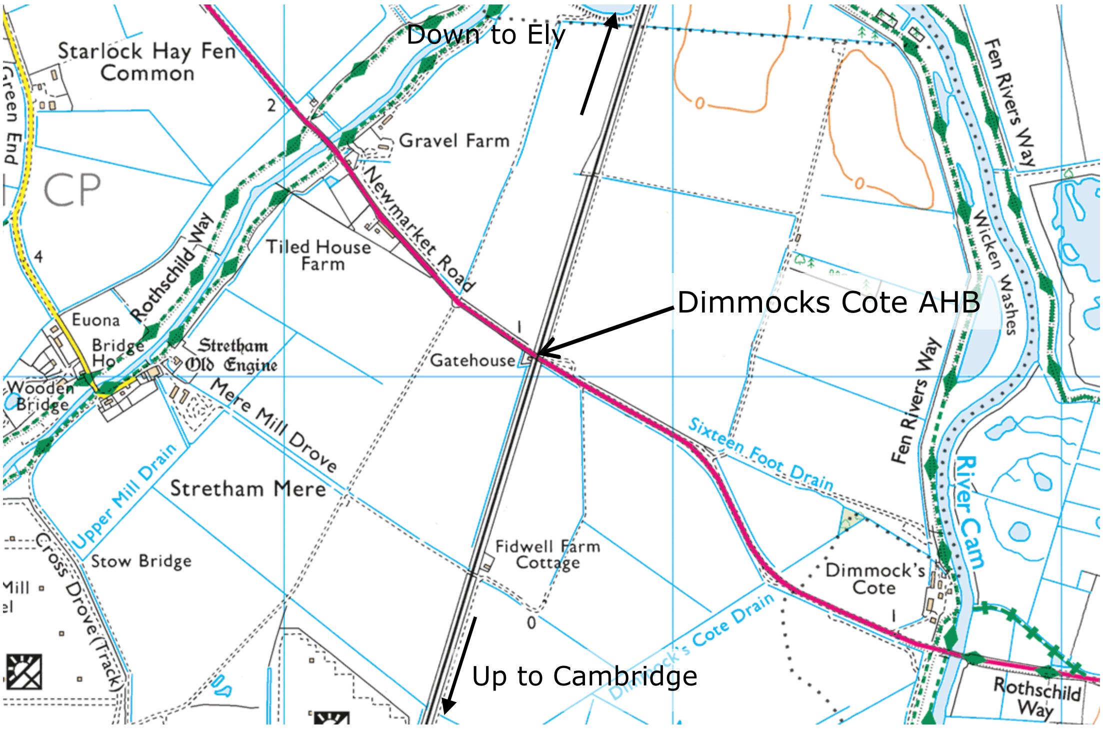
Location	Mileage M	Ch	
	65	40	*
Nairns (No.117) LC (UWC)	65	46	T
Dimmocks Cote LC (AHBC-X)	66	25	
Hopkins Celery LC (FPO)	66	55	
West River Bridge LC (FPS)	67	22	
Ely West River Bridge LC (R/G-X)(UWC)	68	13	
Kirkby LC (UWC)	68	65	
Bedford (No.124) LC (UWC)	69	08	T
Braham Farm LC (FPS)	69	16	
Bedford (No.125) LC (UWC)	69	20	T
	69	33	
	69	67	*
	69	70	*

2.2 Environment

The crossing is located on the A1123 Newmarket Road, south east of Stretham, in Cambridgeshire as shown in *Figure 3*. The crossing allows access between Stretham and Wicken.

The area is mainly farmland with a few residences, and there is a solar farm 900m southwest of the crossing.

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



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

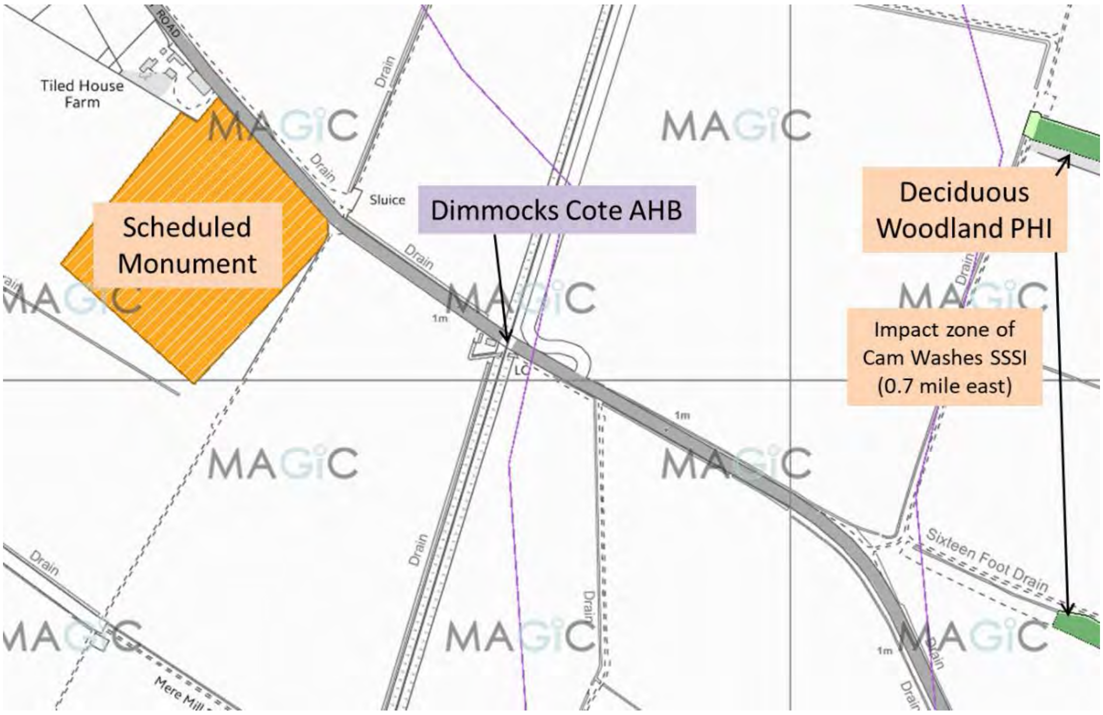
Environmentally significant sites are shown in *Figure 5*.

Cam Washes SSSI is 0.7 miles east of the crossing.

There is a Scheduled Monument (a settlement site) 250m west of the 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 width on the north side (*Figure 6*) varies between 1.53m and 1.10m (the footway is narrowed at the ZN corner). The footway width on the south side (*Figure 7*) varies between 1.47m and 1.38m (the footway is narrowed at the ZO corner).

There is a pole in the middle of the south footway at the east end which forces pedestrians to step into the road to go past it (*Figure 7*). There are small areas of pavement at the ends of both footways, however they are overgrown and present a trip hazard.

There are no pavements along the road for the footways to join.

There are no tactile thresholds on the footway.

The footways are 12.0m 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 Dimmocks Cote, based upon a 9-day census, is 6. 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 an average pedestrian frequency of 1 per day. The footways are therefore in compliance with the minimum width of 1.0m specified in ORR guidance.

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

Figure 6 Footway – North side

Figure 7 Footway – South side

2.4 Road approaches

Road approach to the crossing from the east

The national speed limit applies on the road approach from the east. During the 9-day census the 85th percentile speed of approach was 56.1mph; quite a fast approach.

The key features of the approach are:

1. The road is straight on the approach.
2. There is a gradient up to the crossing.
3. There is a farm track on the left, 118m east of the crossing (*Figure 12*).
4. There is a junction with a road to a marina on the right, 80m east of the crossing (*Figure 13*).
5. There is a field entrance on the left, 52m east of the crossing (*Figure 14*).
6. The RTLs are visible from beyond 400m on the approach.
7. The level crossing signage had good conspicuity at the time of the site visit.

The distant, intermediate and close road approaches from the east are shown in *Figure 9* to *Figure 11*. It can be seen in *Figure 9* that the crossing is visible from the distant signage.

A plan of the key features is shown in *Figure 8;* the numbers in the figure refer to the above numbered list of features.

Figure 8 Key features on the eastern approach to the crossing

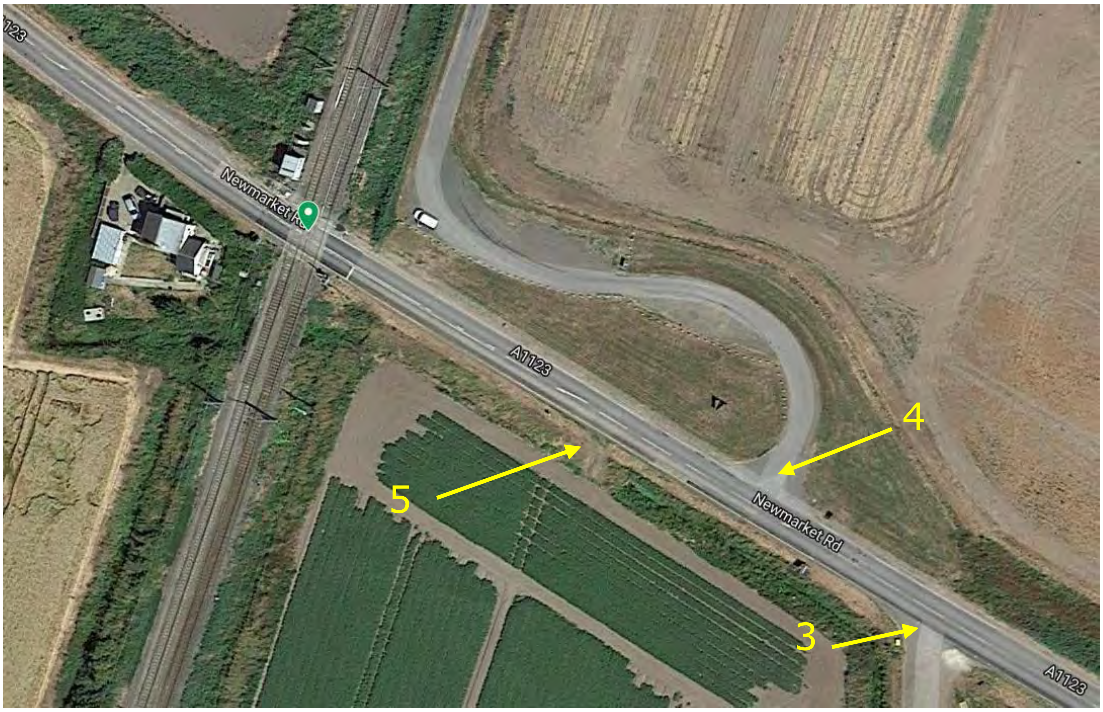


Figure 9 View approaching crossing from the east - distant

Figure 10 View approaching crossing from the east - intermediate

Figure 11 View approaching crossing from the east - near

Figure 12 Farm track on left

Figure 13 Road to marina on right

Figure 14 Field entrance on left

Road approach to the crossing from the west

The National speed limit applies on the road approach from the west. During the 9-day census the 85th percentile speed of approach was 51.6mph, also quite a fast approach. The key features of the approach are:

1. The road is straight on the approach.
2. There is a gradient up to the crossing.
3. There is a driveway on the right, 25m west of the crossing (*Figure 19*).
4. There is a parking area on the left, 1m west of the crossing (*Figure 20*).
5. The RTLs are visible from over 400m on the approach.
6. The level crossing signage had good conspicuity at the time of the site visit.

The distant, intermediate and close road approaches from the northwest are shown in *Figure 16* to *Figure 18*.

A plan of the key features is shown in *Figure 15;* the numbers in the figure refer to the above numbered list of features.

Figure 15 Key features on the western approach to the crossing

Figure 16 View approaching crossing from the west - distant

Figure 17 View approaching crossing from the west - intermediate

Figure 18 View approaching crossing from the west - near

Figure 19 Driveway on right

Figure 20 Parking area on left

Figure 21 Crossing surface

2.5 Impact of low sun on the crossing

Dimmocks Cote level crossing is a northwest-southeast facing crossing (for the road), and there is a gradient up to the crossing on both approaches, therefore road users are potentially affected by sun glare.

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. Days when the sun aligns most closely with the road approaches are shown in *Figure 22*.

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 22 Suncalc diagrams

February & November

May & August

Northwestbound approach

There are two potential issues with low sun when approaching the crossing northwestbound:

1. In the winter the rising sun would shine towards the RTLs, potentially washing them out. The area is very open with few trees to reduce the impact of this. The crossing is currently provided with LED type RTLs and semi-extended hoods to mitigate the impact of this problem.
2. In the summer the setting sun would be straight behind the crossing, potentially causing glare. The area is very open with few trees to mitigate the impact of this, there is a high vehicle approach speed and the approach is uphill. Low sun in drivers' eyes and/or reflecting off a wet road could therefore be a particular problem.

Southeastbound approach

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

1. In the summer the setting sun would shine towards the RTLs, potentially washing them out. The area is very open with few trees to reduce the impact of this. The crossing is currently provided with LED type RTLs and semi-extended hoods to mitigate the impact of this problem
2. In the winter the rising sun would be straight behind the crossing, potentially causing glare. The area is very open with few trees to mitigate the impact of this, there is a high vehicle approach speed and the approach is uphill. Low sun in drivers' eyes and/or reflecting off a wet road could, therefore, be a particular problem.

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, 24-hour traffic census by continuous recording was carried out at the crossing between 2nd and 10th June 2018. The following provides a summary of the results obtained of this census.

Train frequency	**Weekday**	183
	Saturday	141
	Sunday	79
Road closure (min:secs)	**Average**	00:44
	Maximum	01:47
Road vehicle frequency	**Busiest day**	7,876
	Average weekday	7,281
Blocking Back Observations		None
85th percentile speed (free flowing cars only)	**Eastbound**	51.6
	Westbound	56.1
Pedestrian and cyclist frequency	**Busiest day**	75
	Average week day	21
Train Pedestrian Value (TPV)		6
Pedestrian Category		C (with fewer than 25 pedestrians per day)

The observed train, vehicle and pedestrian usage is presented in *Table 2* and *Table 3*; the nine-day average hourly distribution of usage is shown graphically in *Figure 23*.

The notable observations recorded in the report were:

- No incidents of blocking back or red light misuse were observed.

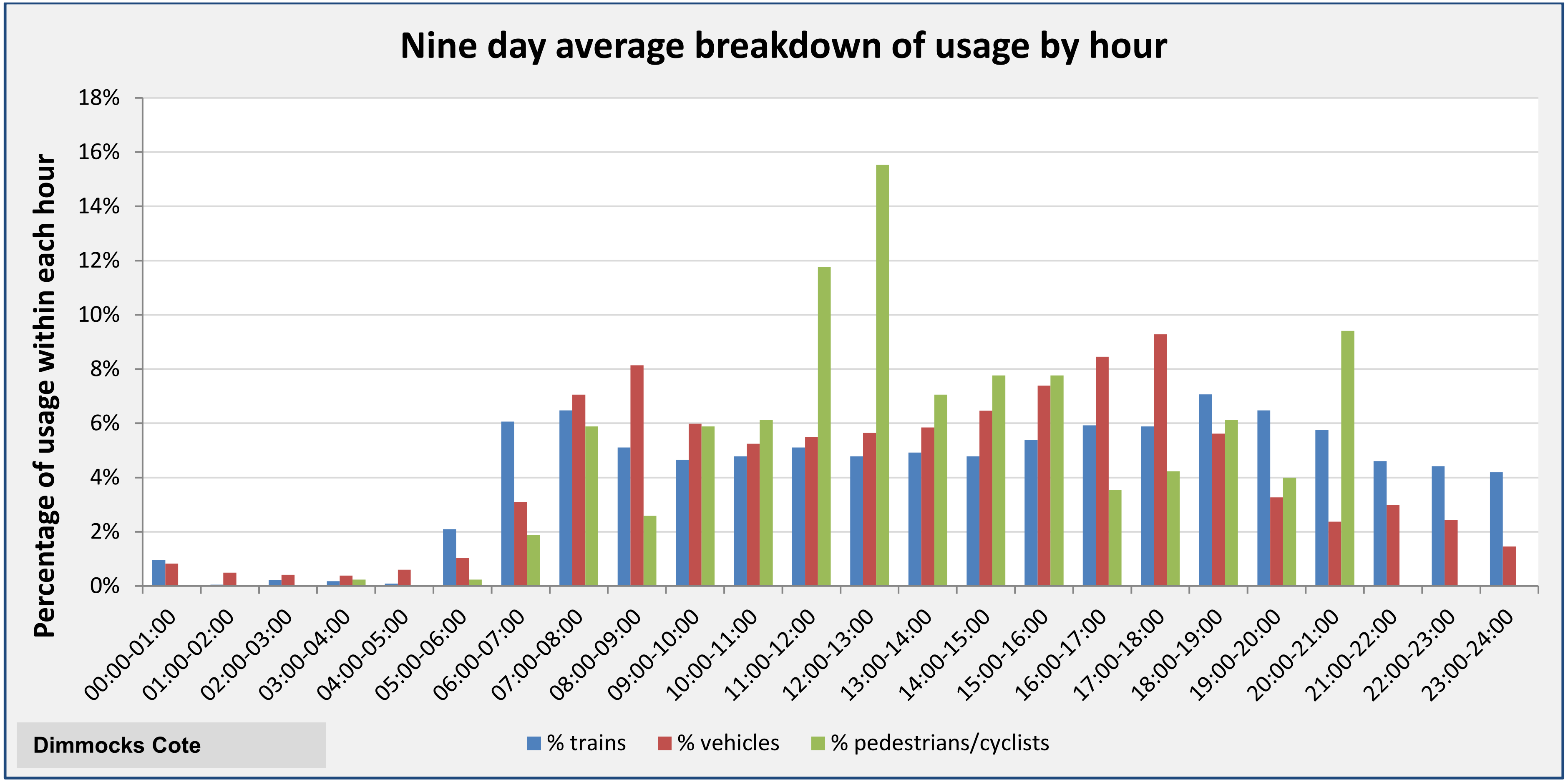
Table 2 Traffic survey observed usage

Census Site 31 - Dimmocks Cote			Totals per day										
			Vehicles							Pedal cyclists and pedestrians			
Day		No. trains per day	Cars	Vans / small lorries	HGVs	Buses	Tractors	Motor cycles	Total	Pedal cycles	Herded animals and horses	Pedestrians	Total
Saturday	02-Jun-18	141	3,547	410	143	4	16	116	4,236	27	0	0	27
Sunday	03-Jun-18	79	3,650	288	54	3	16	175	4,186	46	0	1	47
Monday	04-Jun-18	178	4,797	1038	572	4	39	31	6,481	19	0	1	20
Tuesday	05-Jun-18	183	4,991	1235	712	8	39	101	7,086	31	0	1	32
Wednesday	06-Jun-18	174	5,328	1244	665	9	41	133	7,420	11	0	0	11
Thursday	07-Jun-18	165	5,553	1232	604	11	35	108	7,543	24	0	0	24
Friday	08-Jun-18	178	5,957	1152	616	12	49	90	7,876	13	0	5	18
Saturday	09-Jun-18	139	4,025	456	141	1	36	71	4,730	75	0	0	75
Sunday	10-Jun-18	78	3,611	271	42	2	15	144	4,085	66	0	0	66
Highest		183	5,957	1244	712	12	49	175	7,876	75	0	5	75
7 day average		157	4,863	945	480	7	35	102	6,432	29	0	1	30
Weekday average		176	5,325	1180	634	9	41	93	7,281	20	0	1	21

Table 3 Observed pedestrian usage

Pedestrian census		Totals per day									
Site 31 - Dimmocks Cote											
Day		Adult	Accompanied Child	Unaccompanied Child	Elderly	Impaired	Wheelchair	Pushchair/ Pram	Scooter	Railway Personnel	Total
Saturday	02-Jun-18	0	0	0	0	0	0	0	0	0	0
Sunday	03-Jun-18	1	0	0	0	0	0	0	0	0	1
Monday	04-Jun-18	1	0	0	0	0	0	0	0	0	1
Tuesday	05-Jun-18	1	0	0	0	0	0	0	0	0	1
Wednesday	06-Jun-18	0	0	0	0	0	0	0	0	0	0
Thursday	07-Jun-18	0	0	0	0	0	0	0	0	0	0
Friday	08-Jun-18	1	0	0	0	0	0	0	0	4	5
Saturday	09-Jun-18	0	0	0	0	0	0	0	0	0	0
Sunday	10-Jun-18	0	0	0	0	0	0	0	0	0	0
Highest		1	0	0	0	0	0	0	0	4	5
7 day average		1	0	0	0	0	0	0	0	1	1
Weekday average		1	0	0	0	0	0	0	0	1	1

Figure 23 Nine Day Average Breakdown of Usage by Hour



3.2 Rail approach and usage

The crossing is located between Bishops Stortford and Ely north Junction. There are two tracks at the crossing, and it is electrified by overhead line. It is a moderately utilised stretch of line with a weekday average of 178 trains. There are approximately 176 passenger trains and the remainder are freight trains. The line speed is 75mph along this stretch of track.

The rail approach to the crossing from the south

Trains travelling north are travelling in the Down direction towards Ely. The view from the crossing looking south is shown in *Figure 24*. 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 bridge, the small embankment, and the OHL stanchions may exacerbate the potential derailment consequences.

Figure 24 View of Down rail approach (looking towards Cambridge)

The rail approach to the crossing from the north

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

The view from the crossing looking north is shown in *Figure 25*. The track is straight 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 small embankment and the OHL stanchions may exacerbate the potential derailment consequences.

Figure 25 View of Up rail approach (looking towards Ely)

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 4*.

The crossing has a higher 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 4 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)	0	1.55	0.00
Person - personal accident	0	0.28	0.00
Level Crossing/LC equipment - misuse/near misses	13	5.36	2.42
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
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	1	0.11	9.02
Permanent way or works - failure	0	0.03	0.00
All incidents	18	18.10	**0.99**

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:

- Well above average level of misuse.

- Three reported incidents of vehicles zig-zagging the barriers
- Six reported incidents of vehicles hitting barriers
- One reported incident of a barrier hitting a vehicle
- One reported of pedestrian misuse and lineside trespass

More recent SMIS data, for one year to 13th March 2019, shows no further reported incidents at Dimmocks Cote.

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 East Cambridgeshire Local Plan (5) (Adopted April 2015), 91 new dwellings in are proposed in Stretham and 26 in Wicken, with new housing being built on suitable 'infill' sites within the villages.

There are no significant planning applications current in the area of the 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. Whilst not a resignalling project as such in this area, proposed renewals as full-barrier MCB type crossings will require islands of resignalling to provide appropriate protecting signals and signal spacing.

A separate project, the EACE project, is considering significant enhancement to the train frequency in the long term. If such an increase were to occur it would significantly increase the risk at the crossing, or in the event of renewal as a full-barrier MCB type crossing, would result in much higher road closure times.

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 Dimmocks Cote this suggests that the busiest hour road closure time would increase from about 15% now to about 51%; this would be further increased should any train frequency increases occur as a result of the EACE project as shown in *Figure 26*. The average daytime road closure time is shown in *Figure 27*.

Figure 26 Road closure time in the busiest hour

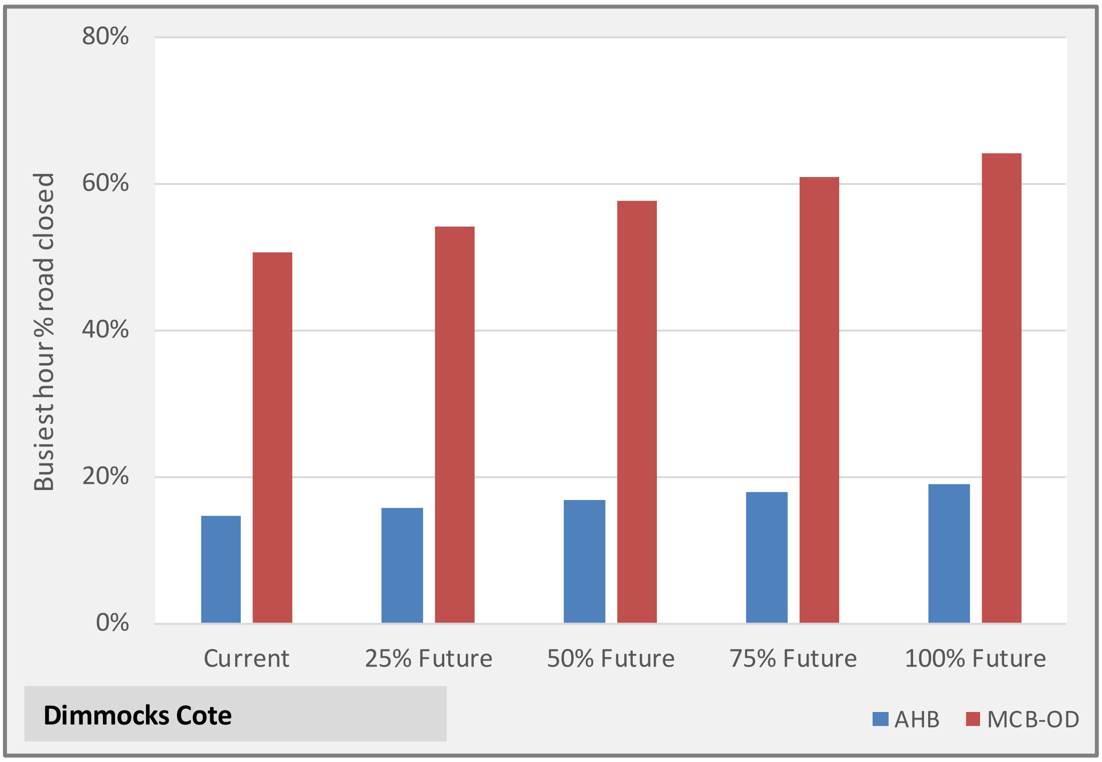
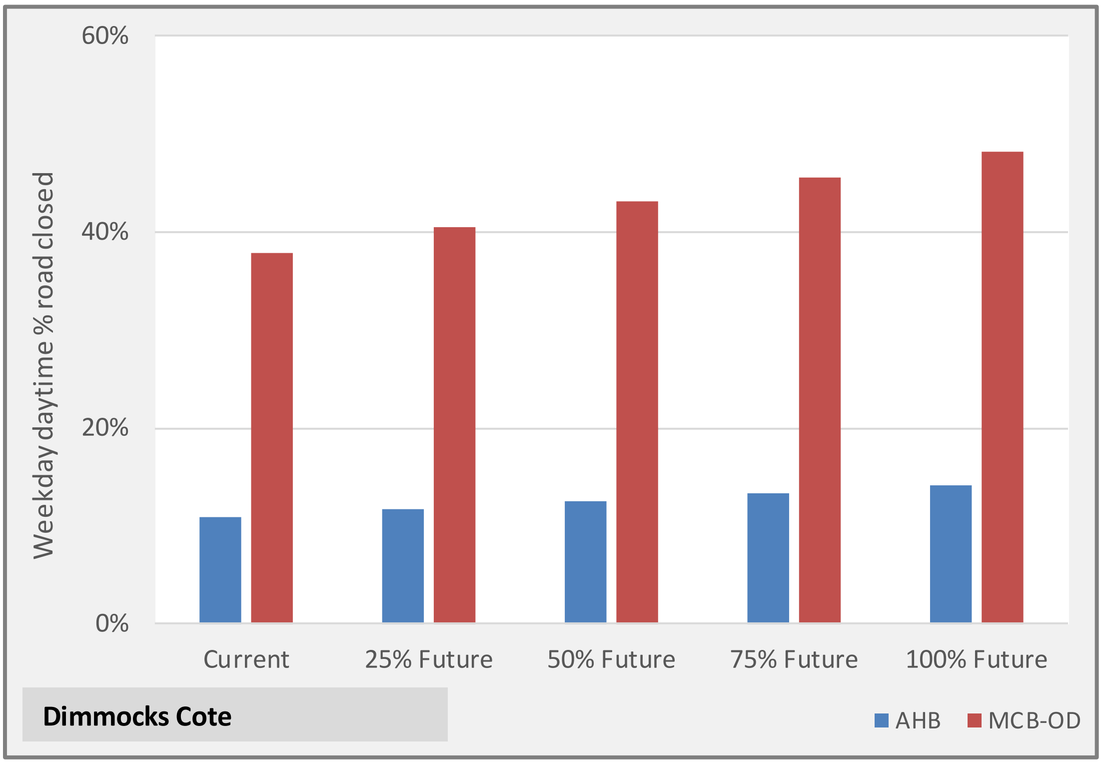


Figure 27 Average daytime road closure time



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 3rd April 2019 were as follows.

Present	Role
David Swift	Project Engineer Signalling
Bode Asabi	Project Manager
Ray Spence	Senior Delivery Manager
John Prest	Route Level Crossing Manager
Sam Longhurst	Senior Asset Engineer, Signalling
Nathan Garratt	DPE
Brendan Lister	LCM
James Taylor	Programme Manager, Level Crossing Development Team
Chris Chapman	Sotera, Workshop Chair
David Harris	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

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 6*. 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 7*. 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 5*. It can be seen that overall, upgrade to AHB+ is expected to approximately halve the risk compared to an AHB.

Table 5 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 6 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 7 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 8*. The value for each level crossing is the average of the factors for the two approaching directions.

Table 8 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 9*. 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 10* 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 28*.

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 11*. 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 11,* it can be seen that the very high levels of risk at Dimmocks Cote mean that the upgrade to MCB-OD is justified despite the costs of the additional signalling. The other issue is the road closure time. Dimmocks Cote is on an A-Road and, as such, a significantly increased road closure time may be an issue for the Highway Authority.

Table 9 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

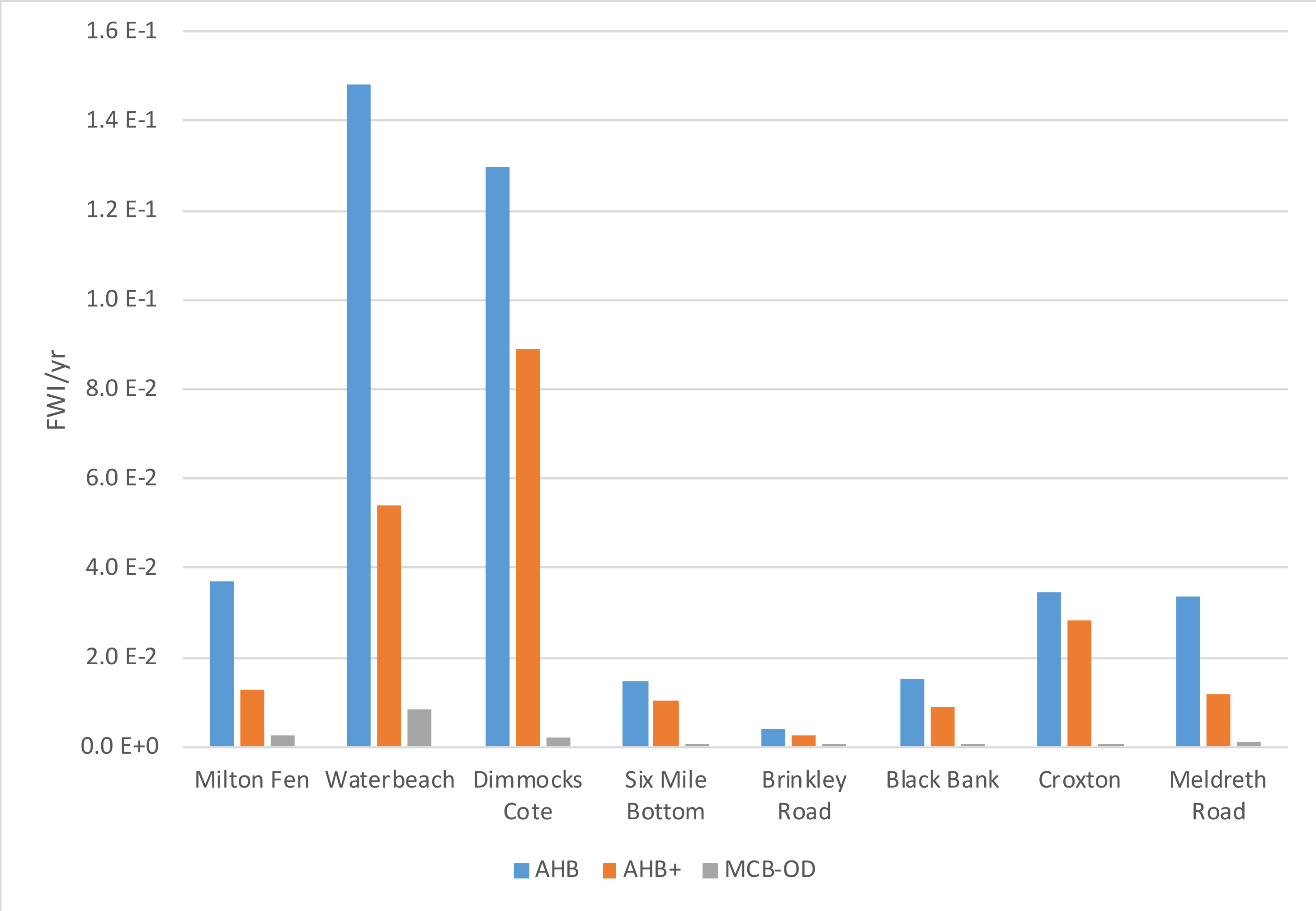
Table 10 Risk benefit and cost benefit analysis for renewing as AHB+ relative to AHB

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 11 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 reheads (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 28 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 an underpass for road vehicles and pedestrians;
- Crossing closure with a full road bridge provided (in-situ);
- Crossing closure with a full road bridge provided (off-line);
- Crossing closure with a pedestrian bridge only provided;
- 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 12 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 12 Closure / level crossing type assessment

Option/ Crossing type	ALCRM			Feasibility	Cost		Justification for cost estimate
	2019 usage						
	FWI	Score	NPV (30)		Capital	Annual	
Current crossing type (AHB)	1.30E-01	C1	£6,160,226	High level of risk such that renewal as AHB would not be a viable option (renewal scheduled 2022) Fast straight approach - consider countdown markers Significant misuse - consider red light enforcement cameras	£1,460,010	£16,933	Standard cost, if renewal is required. SICA Renewal date: 2023
Closure	0		£0	High level of use on fast busy road (A1123). The only alternative route is via Ely an 18 mile diversion, this would create a substantial deviation as well as further congestion at Ely.			
Closure + pedestrian bridge	0		£0	Main use is road vehicles so would not enable closure.			
Closure + road bridge (in-situ)	0		£0	Not feasible in-situ due to a house close to the crossing in the southwest corner which would be tricky to maintain access to therefore property purchase may be required.	£7,000,000		Assumed
Closure + underpass	0		£0	Water courses nearby. Risk of flooding.			
Closure with off-line bridge	0		£0	Likely to be feasible off-line to the north, but need to retain marina access Bridge may be more expensive than £7m as an 'A' road	£10,500,000		Assume: Road bridge £7m but an 'A' road so assume £9m Link road 500m at £3k per m assumed Plus land purchase
ABCL	-	-	-	Not a viable option due to the restriction in linespeed that would be necessitated	£1,336,708	£16,933	

Option/ Crossing type	ALCRM 2019 usage			Feasibility	Cost		Justification for cost estimate
	FWI	Score	NPV (30)		Capital	Annual	
AHB+	8.9 E-2		£4,230,672	The very high levels of risk at Dimmocks Cote mean that the upgrade to MCB-OD is justified despite the costs of the additional signalling. The other issue is the road closure time. Dimmocks Cote is on an A-Road and, as such, a significantly increased road closure time may be an issue for the Highway Authority. It is understood that the AHB+ project is in development with a trial site expected to be installed in 2020. It is understood that there is potential for further trial sites. The project risk of utilising a number of trial sites on this project due to the uncertainty of when AHB+ will be available to install as a renewal is a significant concern.	£2,007,185	£20,154	CP6 standard renewal costs for MCB-OD without lower LIDAR and no signalling costs
MCB-CCTV	2.13E-03	H4	£101,044	Feasible but potential for significant road delays in the future with traffic growth Signals do not look to be in suitable locations.	£2,764,316	£54,265	CP6 standard renewal costs, 2 x SEUs assumed (signals currently at 1234m and 1436m).
MCB-OD	2.13E-03	H4	£101,044	Feasible but potential for significant road delays in the future with traffic growth Signals do not look to be in suitable locations. Within 20km Cambridge radio telescope planning zone. Could trigger vehicle misuse	£2,932,532	£20,154	CP6 standard renewal costs, 2 x SEUs assumed (signals currently at 1234m and 1436m).

4.4 Conclusions regarding closure of the crossing

The first priority should be to close the crossing where possible. The only option identified that could be feasible is closure via a bridge and new link roads to the north of the crossing. Moving the bridge off-line would make a bridge feasible; however, access to the marina would need to be retained. Whilst this scheme would likely also cost £10m or more, it would deliver the maximum safety benefit without the high road closure time implications of an MCB-CCTV or MCB-OD type crossing. Should the train frequency increases under consideration by the EACE project occur then a future road closure time of about 64% in the busiest hour would be hard to sustain on such a busy road and misuse could become prevalent.

Depending on the cost of the bridge, the whole life cost may be less than a level crossing solution given a nominal bridge life of 100 years.

It is, therefore, concluded that closure of the crossing could be feasible and should be explored with the EACE project which is considering the feasibility of this in more detail.

4.5 Conclusion about crossing type

Like-for-like renewal as an AHB crossing would not be the preferred option as it presents a very high level of risk of 0.13 FWI per year. It also is exposed to hazards associated with high vehicle approach speeds and a high level of misuse. Renewal of a crossing with an ALCRM score of C1 as an AHB would also be contrary to Network Rail's strategy of upgrading higher risk AHB level crossings.

The very high levels of risk at Dimmocks Cote mean that the upgrade to MCB-OD is justified despite the costs of the additional signalling; the risk as high with the crossing in its current form and with an upgrade to AHB+ the risk would remain quite high. The other issue is the road closure time. Dimmocks Cote is on an A-Road and, as such, a significantly increased road closure time may be an issue for the Highway Authority and it may also result in increased vehicle misuse at the crossing. The AHB+ project is in development with a trial site expected to be installed in 2020 and there may be potential for further trial sites; conceptually that could include sites within the Cambridge area. The much lower road closure time of AHB+ would be beneficial at Dimmocks Cote, but the project risk of utilising a number of trial sites on this project due to the uncertainty of when AHB+ will be available to install as a renewal is a significant concern, in particular for Dimmocks Cote where the safety risk is so high.

The preferred renewal option is, therefore, MCB-CCTV or MCB-OD providing the predicted road closure times are acceptable to the Highway Authority; both of these crossing types would offer significant risk reduction compared with AHB from 0.13 to 2.13×10^{-3} FWI per year.

Normally MCB-OD would be preferred over MCB-CCTV for workload reasons. The crossing is within the 20km Cambridge MERLIN radio telescope planning zone so precautions against interfering with this would need to be taken should MCB-OD Mk1 be provided; it is understood, however, that the project intends to use Mk2 radar and so proximity to the MERLIN telescope should not be an issue.

Both MCB-CCTV and MCB-OD types would lead to similarly high road closure times which would be problematic on such a busy road, particularly should train frequency increases occur in the future. Liaison with the Highways England about the likely build-up of traffic, once a full barrier crossing has been provided, is recommended.

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

4.6 Options for additional controls

The key level crossing hazards at the crossing have been considered to determine what additional controls should be provided upon renewal (see *Table 13*).

The additional controls identified for consideration include:

- RLSE cameras to help mitigate the risk from misuse, especially by road vehicles. The crossing has a relatively high level of misuse and this might be increased by renewal to an MCB-CCTV or MCB-OD due to the road closure time.
- Low sun is potentially an issue for road approach sighting, particularly around dawn in February and November and sunset in May and August; there are no trees on either side of the crossing to mitigate this, and the crossing is on hump. The crossing already has LED RTLs and semi-extended hoods to mitigate this hazard. Additional controls to consider include large backboards and an anti-reflective and anti-slip road surface.
- The road approaches to the crossing are fast and straight, giving an elevated risk of misuse, late braking and barrier strikes. Additional controls to consider include an anti-reflective and anti-slip road surface, count down markers (likely has limited effectiveness), traffic slowing measures (the Highway Authority is unlikely to be agreeable) and VASs.
- There is a post in the middle of the approach to the footway just before barrier (at the YN corner). There is also a patch of pavement under the barrier, which presents a trip hazard. These should be removed upon renewal.

Table 13 Assessment of additional controls

Hazard	Comment	Standard/existing controls	Potential additional controls	Feasibility	Cost (£)	Recommend	Justification for cost estimate
High road closure time - misuse by vehicles and pedestrians	High recorded misuse	Obstacle detection system to ensure crossing is clear	RLSE cameras	Yes	£150k	Consider - misuse may increase with MCB-OD although safety impact of misuse reduced	Typical per site cost (from information provided at EACE workshops)
Low sun impact on RTLs	Low sun is potentially an issue for road approach sighting – particularly around dawn in February and November and sunset in May and August; there are no trees on either side of the crossing to mitigate this, and the crossing is on hump. Has LED RTLs and semi-extended hoods to mitigate this.	LED RTLs Semi-extended hoods	Large backboards	Yes	Minimal	Yes	
			Anti-reflective / anti-slip road surface	Yes subject to Highway Authority agreement	Significant maintenance cost to Highway Authority	Recommend liaise with Highway Authority	
High road speed on straight approaches	Both approaches 85th%ile speed is greater than 50mph (51.6 EB, 56.1 WB). Good RTL visibility SMIS incidents of	Full barriers Obstacle detection system to ensure crossing is clear	Anti-reflective / anti-slip road surface	Yes subject to Highways Authority agreement	Significant maintenance cost to Highway Authority	Recommend liaise with Highway Authority	
			Count down markers	Yes	Low	Consider although	

Hazard	Comment	Standard/existing controls	Potential additional controls	Feasibility	Cost (£)	Recommend	Justification for cost estimate
	vehicles hitting barriers					benefit may be limited	
			Liaison about slowing cars down	Yes however Highway Authority not receptive to this		Liaise with Highway Authority	
			VAS (showing LC fence pictograph)		£8-9k per site	Consider, perhaps in combination with count down markers	
Lighting	No lighting but pedestrian use at night is likely to be negligible		Low lux lighting	Yes		No - risk would be low	
Footway hazards	There is a post in the middle of the approach to the footway just before barrier (YN corner). There is also a patch of pavement under the barrier which presents a trip hazard.		Remove post and pavement from the footway	Yes	Low	Yes	

4.7 Assessment of the costs and benefits of Lower LIDAR

Network Rail has developed an assessment tool to calculate the benefits of the provision of Lower LIDAR at MCB-OD level crossings [(9)]. 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 14*.

Table 14 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		Adult
Train frequency per day		178
Pedestrians per day		1
Cycles per day		29
Motorcycles per day		102
Other road vehicles per day		6,330
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**	0.000352
	NPV_{30}	£14,098
Cost	**NPV_{30}**	£52,327
Safety benefit to cost ratio over 30 years		0.27

From these inputs, the current safety benefit of the Lower LIDAR is 3.5 x 10^{-4} FWI per year. This is equivalent to a monetised benefit over 30 years of £14,098.

Lower LIDAR – comparing costs and benefits

The estimated cost of Lower LIDAR at this crossing is at least £52,327 over the life of the asset. It is considered that the low usage by unaccompanied children (none in the nine-day census) means that it would not require the lower height setting; the safety benefit is approximately £14,098. The benefit to cost ratio for providing Lower LIDAR is 0.27, subject to there not being significant civils cost, which suggests that the cost of providing Lower LIDAR is 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 16*. This assumes that the crossing is maintained in good condition over its full life.

The following additional controls are recommended for consideration:

- Provide new, level deck and footways along entire crossing distance;
- Remove kerbed of footway; and
- Remove post on approach to YN footway.

Table 15 summarises the number of hazards afforded each rating before and after the proposed additional controls.

Table 15 Number of Pedestrian slip, trip or fall hazards

Hazard rating	Number of hazards afforded stated rating	
	Number before additional mitigation	Number after proposed additional mitigation
Major	1	0
Minor	6	5

Conclusion about Lower LIDAR

Lower LIDAR is not required at this crossing as the safety benefit to cost ratio is less than 0.5 and there are no '*Major*' ranked hazards that cannot be mitigated.

Table 16 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, small areas of kerbing create a minor trip hazard	New level deck, remove kerbing	Minor	No
3	Surface - loose material	Mud in rural areas, gravel	Mud and gravel were present at the ends of the footways, largely OK over decked area	Improved footways over whole crossing length	Minor	Minor
4	Surface – drainage	Pooling of water following rain	Crossing slightly humped so major pooling unlikely and no specific issues identified		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.	Road is perpendicular to the rails		No	No
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 of sufficient volume for the small crossing area. No likely distractions.		No	No

Ref:	Topic	Hazards	Site comments	Possible additional controls	Rating pre-mitigation	Rating post-mitigation
9	Gradient / profile	Crossing on a raised profile (gradient up or down to crossing). Crossing itself on a gradient	Minor hump at the crossing		Minor	Minor
10	Footpath width and road width	Narrow footpath, or narrow roadway meaning less space for pedestrians	Footways suitable for the low use and meet ORR guidance. Road width 5.5m with heavy use so minor separation issue.		Minor	Minor
11	Pedestrian walkway - edging	Poor marking of edge of crossing / railway	Footways well marked.		No	No
12	Pedestrian walkway - obstacles	Posts, fencing, etc protrudes into walkway	Post in YN corner in middle of approach to footway just before barrier	Remove post on approach to YN footway	Major	No
13	Lighting	Low levels of lighting in hours of darkness	No light sources nearby, pedestrians may be likely to carry torch at night in this rural location. Very low pedestrian use.		Minor	Minor
Pedestrian vulnerability factors						
14	Vulnerable - elderly	Used by large numbers of elderly people	The census identified no use by this group. There are no specific environs that would encourage a particular user group.		No	No
15	Encumbered – push chairs, luggage / baggage	Used by large numbers of adults with push chairs, and/ or lots of travellers	The census identified no use by this group. There are no specific environs that would encourage a particular user group.		No	No
16	Encumbered -	Used by high proportion of	The census identified no use by this		No	No

Ref:	Topic	Hazards	Site comments	Possible additional controls	Rating pre-mitigation	Rating post-mitigation
	dogs	dog walkers	group. There are no specific environs that would encourage a particular user group.			
17	Vulnerable – cognitive impairment	Large proportion of users with reduced cognitive capability	The census identified no use by this group. There are no specific environs that would encourage a particular user group.		No	No
18	Vulnerable – other mobility impaired	Large proportion of users with impaired mobility including wheelchair users	The census identified no use by this group. There are no specific environs that would encourage a particular user group.		No	No
19	Vulnerable – unaccompanied children	Used by large numbers of school children who are not accompanied by adults	The census identified no use by this group. There are no specific environs that would encourage a particular user group.		No	No
20	Impaired users	Users under the influence of alcohol	The census identified no use by this group. There are no specific environs that would encourage a particular user group.		No	No
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		Minor	Minor

Ref:	Topic	Hazards	Site comments	Possible additional controls	Rating pre-mitigation	Rating post-mitigation
			occasional icing. On a priority gritting 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 17*.

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 and there are few features of the road layout to give any cause for concern, the road will be more congested with MCB-OD due to the higher road closure time. This could lead HGVs and any following traffic to be slow clearing the crossing, giving rise to a risk of barrier strikes on slow vehicles. BPM could, therefore, be a consideration to manage this although the normal BPM criteria are not met. Enhanced OD Control of Barriers Lowering could be utilised as an alternative if BPM is not preferred.

- *Amber phase duration.* The crossing is used by a large number of HGVs and the road approach speed by cars is high; both of these factors contribute to an elevated likelihood of vehicles failing to stop sufficiently quickly and consequently of vehicle strikes on barriers. Methods of managing this should be considered and a consideration would be to extend the amber phase of the crossing sequence beyond the default of 3s. The Down side of this would be a slightly increased road closure time and given the high road closure time that would occur at this crossing this mitigation might not be preferred. Other ways of managing this are recommended (see *Section 4.6*).

- *Provide audible warning at all four wig-wags.* The crossing is not likely to have a large area, but the audible warning is currently set quite low and there would sometimes be background noise from farm machinery therefore consideration should be given to providing audible warnings at all four RTLs.

- *Response time and number of available attendants for CCU operation should it be necessary.* A crossing attendant is likely to come from Ely depot. The LCU is currently on the Down side, and as this would normally be the approach side for an attendant this side would be the preferred location upon renewal. If possible, it would be desirable to provide a parking place close to the crossing on the Down side, but this might not be possible at this location.

Table 17 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.	Very low pedestrian use	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	No blocking back currently and layout does not present any specific causes. Road will be more congested with MCB-OD and HGVs may be slow clearing the crossing - consider for this	Consider
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	N
Minimise distance between barriers	Long traverse at skew crossing giving rise to entrapment risk.	No skew and the distance between the barriers at the existing AHB crossing is not high (12m) so no further action needs to be taken.	N

MCB-OD configuration factor	Hazards	Consideration at level crossing	Recommended
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	Not a long traverse length and not a high number of slow, encumbered or vulnerable users recorded in the census so not recommended.	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. Could be considered as an alternative to BPM to cater for the congestion after the crossing reopens and then needs to reclose shortly after the MROT.	Consider
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.	Use by large number of HGVs and the 85th percentile road vehicle speeds are high although there is good RTL visibility. Consider, but due to impact on road closure time might prefer to mitigate with count down markers and VAS instead.	Consider
Sacrificial RADAR reflectors	Road vehicles accidentally driven down the railway, e.g. high skew or Sat. Nav. errors with nearby junctions.	Not a high risk location for vehicles turning down the railway, limited skew, junctions are some distance from the crossing, road is straight so not recommended	N

MCB-OD configuration factor	Hazards	Consideration at level crossing	Recommended
Provide audible warning at all four wig-wags	Large crossing area, local background noise or high likelihood that would be set to low volume due to nearby properties meaning that audible warning cannot be heard.	Low crossing area but audible warning level is set quite low and there is background traffic and potentially farm machinery noise. Considered this in design	Consider
Standing red man indication	High pedestrian use Poorly sited RTLs for pedestrians	Good visibility of RTLs and low pedestrian use	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.	Ely depot LCU on the Down road now, keep same side Parking problematic, would be difficult to provide extra parking at this location	Consider

5 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are made from the analysis:

Strategic options

1. Closure of the crossing via an off-line bridge is considered to be feasible and should be explored with the EACE project and other funding sources that are designed to increase performance and capacity of the railway. Whilst this scheme would likely cost at least £10m, it would deliver the maximum safety benefit without the high road closure time implications of an MCB-CCTV or MCB-OD type crossing. Should the train frequency increases under consideration by the EACE project occur then a future road closure time of about 64% in the busiest hour would be hard to sustain on such a busy road and misuse could become prevalent.

2. Like-for-like renewal as an AHB crossing would not be the preferred option as it presents a very high level of risk of 0.13 FWI per year.

3. The very high levels of risk at Dimmocks Cote mean that the upgrade to MCB-OD or MCB-CCTV is justified over AHB+ despite the costs of the additional signalling. The other issue is, however, the road closure time. Dimmocks Cote is on an A-Road and, as such, a significantly increased road closure time may be an issue for the Highway Authority and it may also result in increased vehicle misuse at the crossing. It is understood that the AHB+ project is in development with a trial site expected to be installed in 2020 and there is potential for further trial sites. The much lower road closure time of AHB+ would be beneficial at Dimmocks Cote, but the risk of utilising a number of trial sites on this project due to the uncertainty of when AHB+ will be available to install as a renewal is a significant concern, in particular for Dimmocks Cote where the safety risk is so high.

4. The preferred renewal option is, therefore, MCB-CCTV or MCB-OD providing the predicted road closure times are acceptable to the Highway Authority; both of these crossing types would offer significant risk reduction compared with AHB from 0.13 to 2.13×10^{-3} FWI per year.

    - Normally MCB-OD would be preferred over MCB-CCTV for workload reasons. The crossing is within the 20km Cambridge MERLIN radio telescope planning zone so precautions against interfering with this would need to be taken should MCB-OD Mk1 be provided; it is understood, however, that the project intends to use Mk2 radar and so proximity to the MERLIN telescope should not be an issue.

- Both MCB-CCTV and MCB-OD types would lead to similarly high road closure times which would be problematic on such a busy road, particularly should train frequency increases occur in the future. The choice between MCB-OD and MCB-CCTV is, therefore, likely to be made on the basis of feasibility, road closure time and cost.

Consideration of local hazards and MCB-OD configuration parameters

5. The additional controls identified for consideration include:

    - RLSE cameras to help mitigate the risk from misuse, especially by road vehicles. The crossing has a relatively high level of misuse and this might be increased by renewal to an MCB-CCTV or MCB-OD due to the road closure time.

    - Low sun is potentially an issue for road approach sighting, particularly around dawn in February and November and sunset in May and August; there are no trees on either side of the crossing to mitigate this, and the crossing is on hump. The crossing already has LED RTLs and semi-extended hoods to mitigate this hazard. Additional controls to consider include large backboards and an anti-reflective and anti-slip road surface.

    - The road approaches to the crossing are fast and straight, giving an elevated risk of misuse, late braking and barrier strikes. Additional controls to consider include an anti-reflective and anti-slip road surface, count down markers (likely to have limited effectiveness), traffic slowing measures (the Highway Authority is unlikely to be agreeable) and VASs.

    - There is a post in the middle of the approach to the footway just before barrier (at the YN corner). There is also a patch of pavement under the barrier, which presents a trip hazard. These should be removed upon renewal.

    - Provide new, level deck and footways along entire crossing distance. This would include removal of the kerbed sections towards the end of the footways.

6. Lower LIDAR is not justified at this crossing as the safety benefit to cost ratio is less than 0.5 and there are no Major ranked hazards that cannot be mitigated. Lower LIDAR may not be required for the Mk. 2 radar units anyway.

7. 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 and there are few features of the road layout to give any cause for concern; the road will be more congested with MCB-OD due to the higher road closure time. This could lead HGVs and any following traffic to be slow clearing the crossing, giving rise to a risk of barrier strikes on slow vehicles if the crossing recloses. BPM could, therefore, be a consideration to manage this although the normal BPM criteria are not met. Enhanced OD Control of Barriers Lowering could be utilised as an alternative if BPM is not preferred.

   - *Amber phase duration*. The crossing is used by a large number of HGVs and the road approach speed by cars is high; both of these factors contribute to an elevated likelihood of vehicles failing to stop sufficiently quickly and consequently of vehicle strikes on barriers. Methods of managing this should be considered and a consideration would be to extend the amber phase of the crossing sequence beyond the default of 3s. The down side of this would be a slightly increased road closure time and given the high road closure time that would occur at this crossing this mitigation might not be preferred. Other ways of managing this are recommended (see *Section 4.6*).

   - Provide audible warning at all four wig-wags. The crossing is not likely to have a large area, but the audible warning is currently set quite low and there would sometimes be background noise from farm machinery therefore consideration should be given to providing audible warnings at all four RTLs.

   - Response time and number of available attendants for CCU operation should it be necessary. A crossing attendant is likely to come from Ely depot. The LCU is currently on the Down side, and as this would normally be the approach side for an attendant this side would be the preferred location upon renewal. If possible, it would be desirable to provide a parking place close to the crossing on the Down side, but this might not be possible at this location.