Sotera
Risk Solutions

Risk Assessment for Croxton AHB Level Crossing

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REVISIONS

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Issue 00	Chris Chapman	David Harris	-	Working draft
Issue 01	Chris Chapman	David Harris	03/05/19	Issued to Network Rail for review
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APPROVAL

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	Date:

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 Croxton Level Crossing	Sky High-Count on Us 8801 Task 4 Site 56 – March 2013
5.	Croxton AHB Level Crossing, Traffic & Pedestrian Nine-Day Census Report	RSK Business Solutions, BS316/012/D320.1, July 2022
6.	Level Crossing Guidance Document: Applying Risk Reduction Bednefits in ALCRM When Modelling Safety Enhancements	LCG 14 March 2016
7.	Signalling Design: Module X10 – Level Crossings: Automatic Half Barriers	NR/L2/SIG/11201/ Mod X10
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.	Croxton and Brettenham & Kilverstone Joint Neighbourhood Plan	Nov 2018
11.	Cambridge Local Plan	Adopted October 2018
12.	AHB+ HAZID Report	AES/1739/R03, Issue 2, 09/07/19
13.	AHB+ System Definition	AES/1739/R01, Issue 1, 29/03/19
14.	AHB+ Option 2 Feasibility Analysis Extract	
15.	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 of an up to date (2022) usage census.

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 Croxton 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 assessments of the crossing type options using the ALCRM 2.0.
- Developed a risk model for the prediction of risk at AHB^+ type level crossings (see *Section 4.1*).
- 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

Croxton is an AHB crossing with two half-width barriers and four LED type RTLs. It is monitored by Cambridge signal box.

The maximum line speed is 90mph on the Up approach and 65mph on the Down approach although it should be noted that there is currently a speed restriction in place for the level crossing. The line is not electrified.

Figure 1 shows the configuration of the crossing, viewed from the west. *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

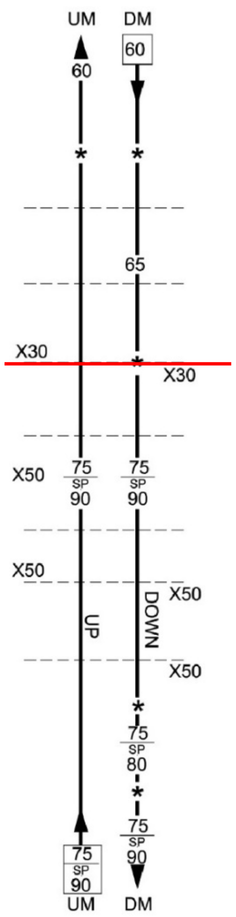
Level crossing name	Croxton
Level crossing type	AHB
ELR and mileage	ETN 96m 44ch
Status	Public Road
Number of running lines	2
Permissible speed over crossing (Up)	90mph
Permissible speed over crossing (Down)	65mph
OS grid reference	TL902867
Postcode	IP242RQ
Road name and type	A1075
Local Authority	Norfolk County Council
Supervising signal box	Cambridge PSB
Electrification and type	None

Figure 2 Extract from the sectional appendix

LOR	Seq.	Line of Route Description	ELR	Route	Last Updated
EA1580	005	Ely North Jn to Trowse Jn	ETN	Anglia	03/10/2016

Location	Mileage M	Mileage Ch		
	94	20	*	
Gooderham's No.41 LC (UWC)	94	70		T
Gooderham's No.42 LC (UWC)	95	28		T
Croxton LC (AHBC-X)	96	44	*	
Shadwell LC (UWC)	98	50		T
Drove Road LC (FPK)	99	51		
Hockham Road LC (R/G-X) (UWC)	99	67		T
Roudham Hall Road LC (UWC)	100	17		T
	100	27	*	
	100	47	*	

Running lines & speed restrictions



Signalling & Remarks

GSM-R

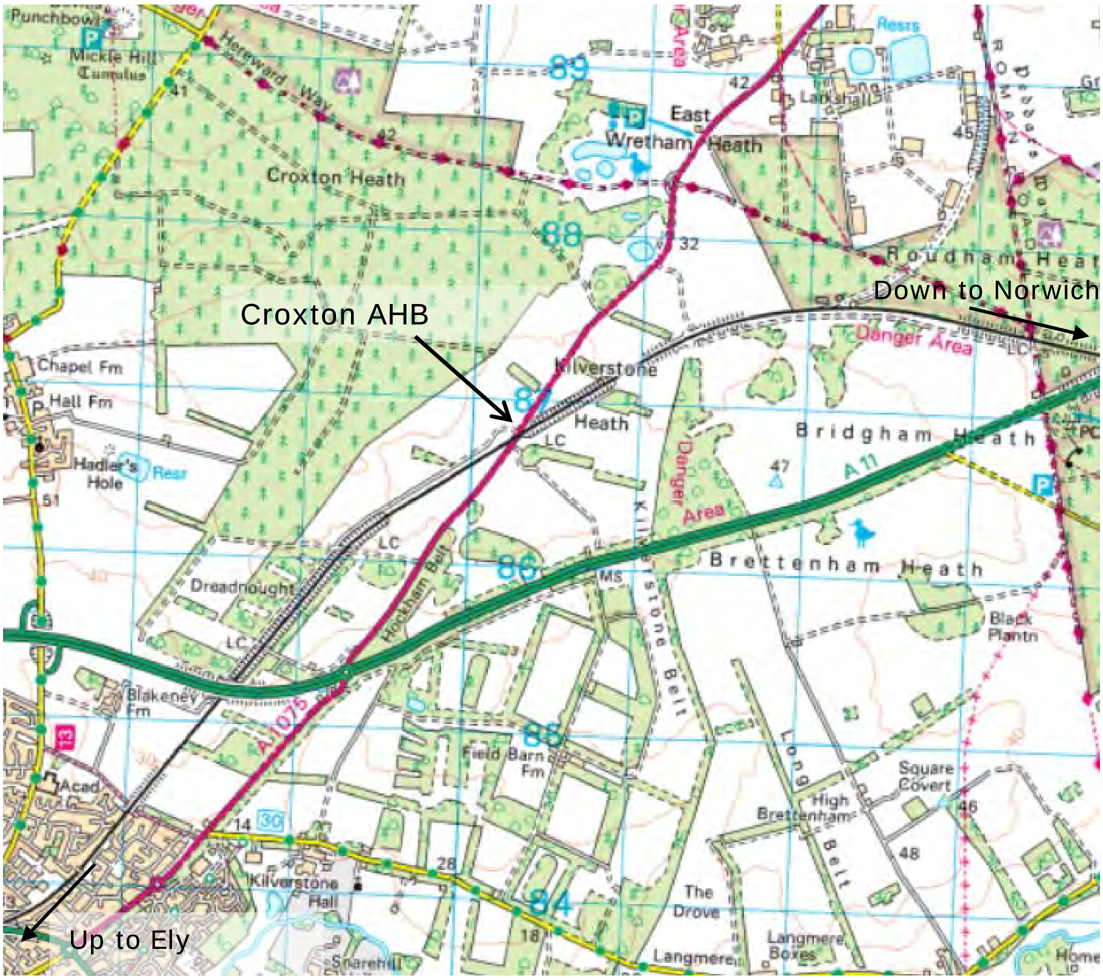
TCB	Cambridge SB (EN)

UM - Up Main
DM - Down Main

2.2 Environment

The crossing is located on the A1075 north-east of Thetford and provides access towards Watton and Dereham as shown in *Figure 3*..

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

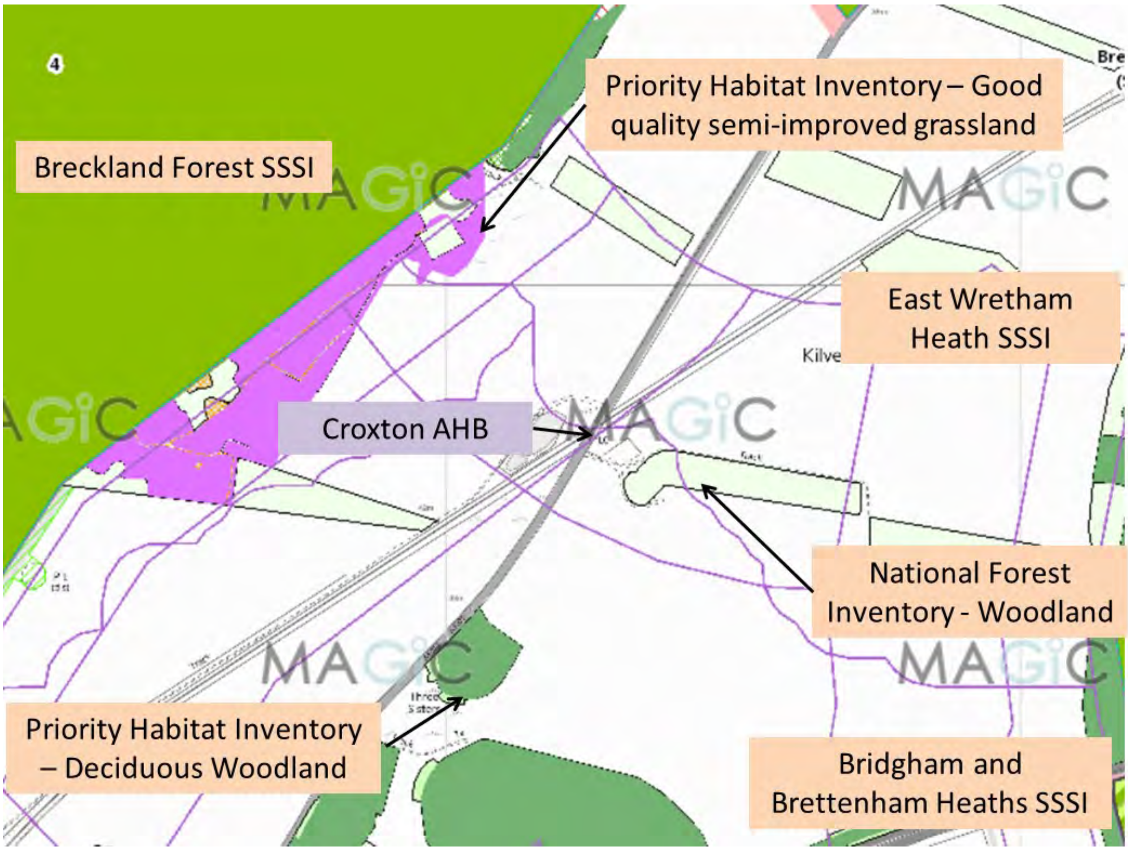


A satellite view of the location is shown in *Figure 4*.

Environmentally significant sites are shown in *Figure 5*. While the Breckland Forrest SSSI is located to the north-west of the crossing, there are no environmental features that would preclude a close to in-situ bridge 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 east side (*Figure 6*) is about 0.8m wide and there is mud and vegetation in the footway. The footway on the west side (*Figure 7*) is about 0.85m wide and there is again vegetation at the ends of the footway.

The barrier to barrier length is 31m due to the skew of the crossing.

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 Croxton, based upon a 9-day census, is 4. 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 1 and a weekly average of 1.

The footways are, therefore, not quite in compliance with the minimum width of 1.0m specified in ORR guidance for a pedestrian category C crossing with fewer than 25 pedestrians per day although it should be noted that very few pedestrians use the level crossing.

There are no pavements with which to meet up and 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 – east side

Figure 7 Footway – west side

2.4 Road approaches

Road approach to the crossing from the south

The key features of the approach are:

1. The view from the advance warning signage on the A1075 is shown in *Figure 9*. It can be seen that the road is curved, it is not possible to see the crossing at the advance signage and there are no count down markers to the crossing. The road is level and has no posted speed limit and so the national speed limit of 60mph applies. The 85th percentile road approach speed is 65.1 mph indicating that this is a very high road approach speed. At this road approach speed, ORR guidance is that it is desirable to be able to sight RTLs at a distance of 300m.

2. Advance signage is located at about 300m and shortly after this point (at about 250m from the crossing), one of the RTLs becomes visible. Where desirable sighting distances cannot be achieved, advance warning signage such as vehicle activated signs (VASs) or count down markers should be considered.

3. It can be seen that there is a turning into a pig farm on the right hand side in *Figure 12*. This is a left hand turn for vehicles that have traversed the crossing and so is unlikely to cause blocking back unless a large vehicle takes time to complete the turn; the entrance is quite wide so this is unlikely. No blocking back was noted during the traffic census.

4. The road approach is orientated south west to north east at the crossing and there is a low horizon indicating that low sun may be an issue at some times of the year particularly given the high approach speed.

5. The level crossing signage had good conspicuity at the time of the site visit.

The distant, intermediate and closer road approaches from the south are shown in *Figure 9* to *Figure 13*.

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 southern approach to the crossing

Figure 9 Road approach to crossing at distant signage (south approach)

Figure 10 Road approach to crossing (south approach)

Figure 11 Intermediate View of Crossing (south approach)

Figure 12 Entrance into Pig farm

Figure 13 Near view from Crossing of road approach (south approach)

Road approach to the crossing from the north

The key features of the approach are:

1. The approach to the crossing from the north is shown in *Figure 15*. The road is straight on this approach and it is possible to see the RTLs from the distant signage well in excess of 300m. The road has a speed limit of 60mph and the 85^{th} percentile road approach is 58.4 mph indicating that this is a high-speed road approach. There are also no turnings or intersections near to the crossing and the motorist will be used to travelling at this speed without impedance. As for the approach from the south, there were no count down markers.

2. It can be seen that there is a turning into an agricultural facility on the right hand side in *Figure 18* and *Figure 19*. This is a left hand turn for vehicles that have traversed the crossing and so is unlikely to cause blocking back unless a large vehicle takes time to complete the turn; the entrance is quite wide so this is unlikely. No blocking back was noted during the traffic census.

3. The RTLs are visible from over 400m on the approach.

4. The level crossing signage had good conspicuity at the time of the site visit.

5. The crossing has a skew of 30^{0}.

The distant, intermediate and close road approaches from the north are shown in *Figure 15* to *Figure 17*.

A plan of the key features is shown in *Figure 14;* the numbers in the figure refer to the above numbered list of features.

Figure 14 Key features on the northern approach to the crossing

Figure 15 Distant View of Crossing (north approach)

Figure 16 Intermediate View of Crossing (north approach)

Figure 17 Near View of Crossing (north approach)

Figure 18 Turning for agricultural facility

Figure 19 Large vehicle turning into agricultural facility

2.5 Impact of low sun on the crossing

Croxton level crossing is a northeast-southwest facing crossing (for the road), 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. The shortest and longest day are shown in *Figure 20*.

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).

Northbound approach

There is one potential issue with low sun when approaching the crossing northbound:

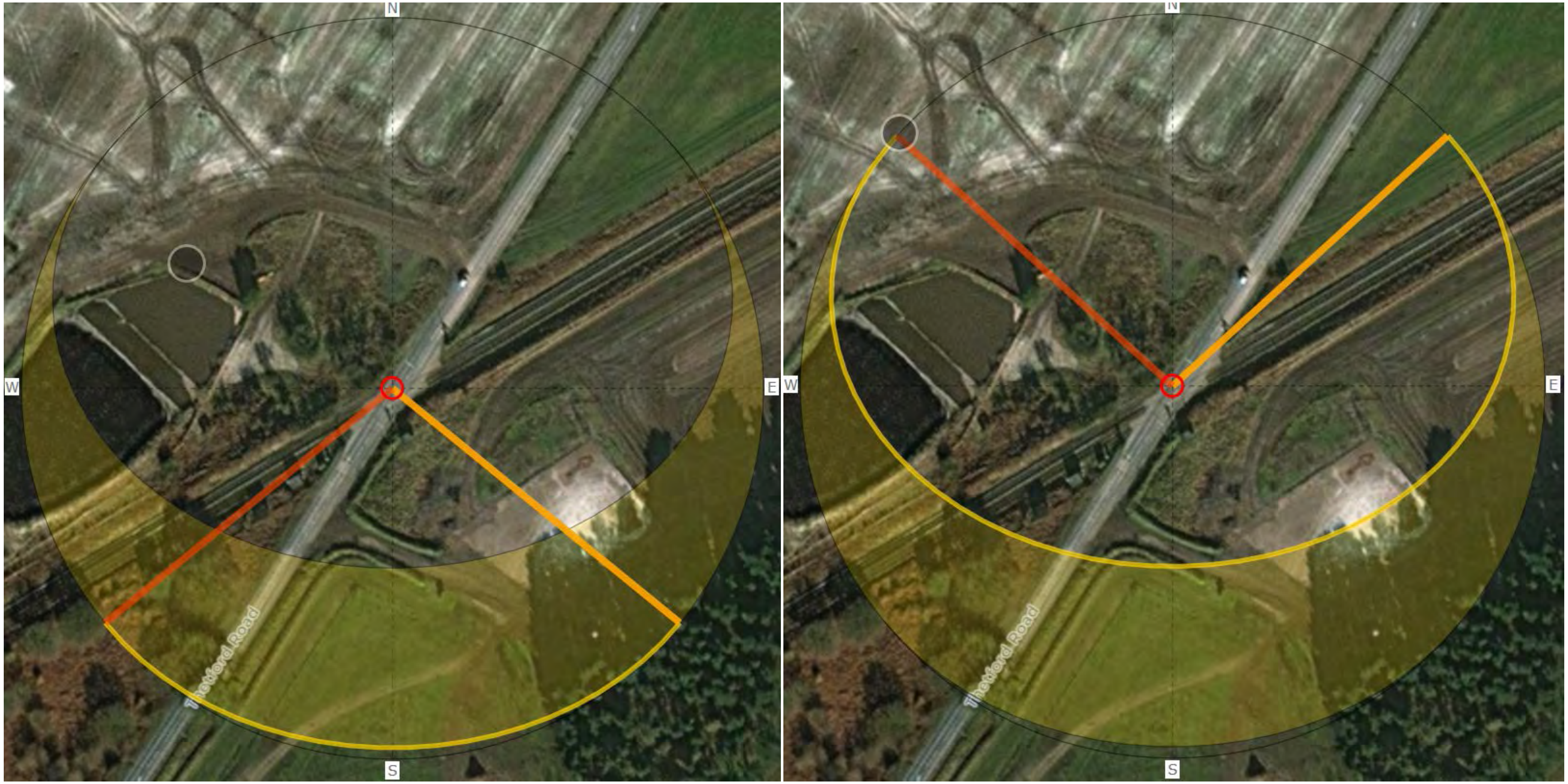
1. In the winter, the low afternoon sun would shine towards the RTLs, potentially washing them out. This is mitigated by the use of LED RTLs.

Southbound approach

There is one potential issue with low sun when approaching the crossing southbound:

1. In the winter, the low afternoon sun would be straight behind the crossing, potentially causing glare. The vehicle approach speed is high and although the horizon is above the crossing the low sun effects may be quite significant.

Figure 20 Suncalc diagrams



Shortest Day Longest Day

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 Update to Level crossing census

Overview

A nine-day, 24-hour traffic census by continuous recording was carried out at the crossing between 21st and 29th May 2022 (5). This is an update to the previous census carried out in March 2013 (4), which served as the previous basis of the risk assessment. The camera locations and usage flows are shown in *Figure 21* to *Figure 23*.

Figure 21 Camera locations and traffic flows

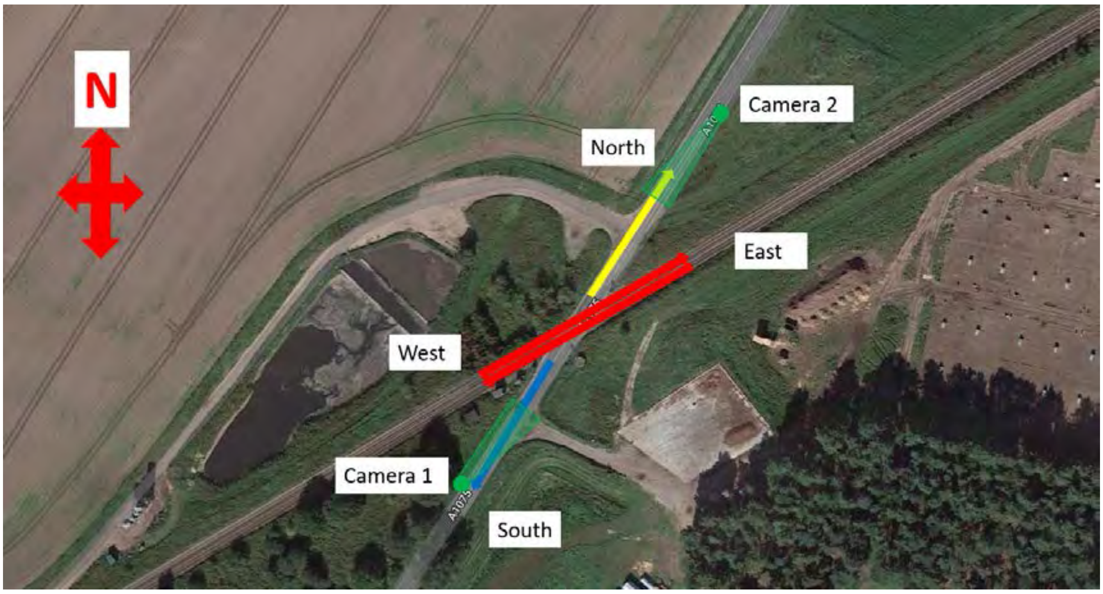


Figure 22 View from Camera 1

Figure 23 View from Camera 2

The following provides a summary of the results obtained of this census including a comparison with the 2013 census. It can be seen that rail traffic has increased marginally (20% increase on Sundays) but road traffic has increased considerably (36% increase in weekday usage). The road approach remains extremely fast. The observed train, vehicle and pedestrian usage is presented in *Table 2*.

Parameter		2013	2022	Change
Train frequency	Weekday	60	61.5	3%
	Saturday	63	60	-5%
	Sunday	40	48	20%
Road closure (min:secs)	Average	N/A	01:04	
	Maximum	N/A	02:09	
Road vehicle frequency	Busiest day	5,560	7,219	30%
	Average weekday	4,874	6,630	36%
Blocking Back Observations		None	None	
85th percentile speed (free flowing cars only)	Northbound	65.1	64.1	-2%
	Westbound	58.4	58.2	0%
Pedestrian and cyclist frequency	Busiest day	8	6	-25%
	Average weekday	4	0	-100%
Train Pedestrian Value (TPV)		5	2	-60%
Pedestrian Category		C (with fewer than 25 pedestrians per day)	C (with fewer than 25 pedestrians per day)	

Table 2 Overall Usage at level crossing

Day		Vehicles												Pedestrians													
		Trains	Car	Light Goods Vehicle	Motor Cycles	Pedal Cycles	Heavy Goods Vehicles	Tractor & Trailers	Bus	Horse Riders	Herded Animals & Horses	Large / Slow Vehicles	Total	Adult	Accompanied Child	Unaccompanied Child	Dog Walker (Dog on a lead)	Dog Walker (Dog off lead)	Elderly	Mobility Impaired Person	Encumbered User	Cyclist pushing bike	Wheelchair user	Person with Pushchair/ Pram	Mobility Scooter user	Railway Personnel	*Total excluding Railway personnel*
Saturday	21-May-22	60	4,361	699	105	3	86	25	2	0	0	0	5,281	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	22-May-22	51	3,935	657	171	7	65	28	2	0	0	0	4,865	2	2	2	0	0	0	0	0	0	0	0	0	0	6
Monday	23-May-22	60	4,774	1,462	42	2	471	38	17	0	0	13	6,819	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tuesday	24-May-22	63	4,740	1,333	43	1	518	78	8	0	0	2	6,723	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wednesday	25-May-22	62	4,642	1,322	49	2	451	90	12	0	0	0	6,568	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thursday	26-May-22	61	4,806	1,491	76	2	428	62	11	0	0	1	6,877	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Friday	27-May-22	63	5,275	1,402	92	1	388	44	17	0	0	8	7,227	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saturday	28-May-22	60	4,741	613	115	4	73	39	3	0	0	0	5,588	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	29-May-22	45	4,045	518	48	5	61	32	4	0	0	0	4,713	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total over 9 days		525	41,319	9,497	741	27	2,541	436	76	0	0	24	54,661	2	2	2	0	0	0	0	0	0	0	0	0	0	6
Highest		63	5,275	1,491	171	7	518	90	17	0	0	13	7,227	2	2	2	0	0	0	0	0	0	0	0	0	0	6
7 day average		59.4	4,625	1,095	80	3	299	49	8.8	0.0	0.0	2.9	6,162	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Weekend average		54.0	4,271	622	110	5	71	31	2.8	0.0	0.0	0.0	5,112	0.5	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
Weekday average		61.8	4,847	1,402	60	2	451	62	13.0	0.0	0.0	4.8	6,843	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Vulnerable users

In terms of vulnerable groups, it can be seen in *Table 2* that there was little usage by pedestrians but 2 of the pedestrians appeared to be children.

Train pedestrian value (TPV)

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, based upon a 9-day census, is 2. 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 0 and a weekly average of 0.4 and so a footpath width of 1m would be required to meet ORR guidelines.

Road closure time

The road closure time is summarised in *Table 3*. The seven day average road closure time is 1 minutes and 04 seconds. The longest road closure time was 2 minutes 09 seconds. These are long times compared with typical arrival times at AHB level crossings. A minimum arrival time of 27 seconds is set for level crossings of 15m in length. As Croxton is 34m in length, the minimum arrival time of 33.3 seconds [27+(34-15)/3 is required. Meeting ORR guidance for 50% train arrival in 50 seconds and 95% train arrival in 75 seconds is particularly challenging at locations like Croxton as shown in *Table 4*.

There is considerable misuse in the form of 'red light running' as described below but this is considered to be more related to the very high road approach speeds.

It can be seen in that average road closure time peaks during the week at about 10% of the time (6 minutes in the hour).

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

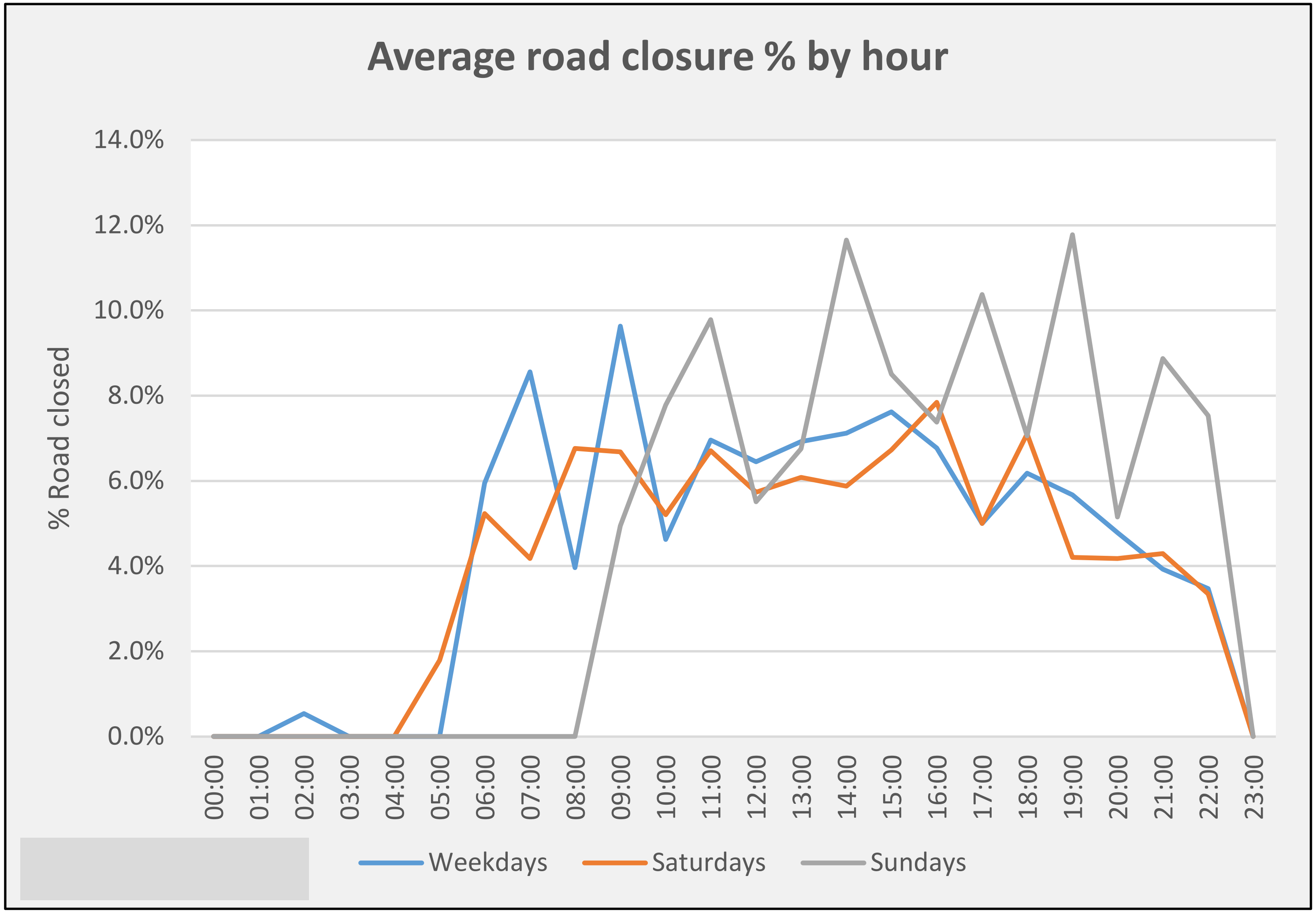
Table 3 Road closure time summary

Road closure time Croxton Level Crossing			Duration per crossing closure			No. closures per day	Road closed %	
Day		No. trains per day	Minimum	Maximum	Average		Maximum	Average
Saturday	21-May-22	60	00:00:53	00:01:32	00:01:03	60	7.2%	5.5%
Sunday	22-May-22	51	00:00:53	00:01:55	00:01:03	51	10.0%	6.3%
Monday	23-May-22	60	00:00:54	00:02:09	00:01:04	60	8.6%	5.8%
Tuesday	24-May-22	63	00:00:51	00:01:21	00:01:03	63	9.0%	6.3%
Wednesday	25-May-22	62	00:00:50	00:02:05	00:01:05	62	10.1%	6.1%
Thursday	26-May-22	61	00:00:53	00:01:19	00:01:03	61	10.6%	6.1%
Friday	27-May-22	63	00:00:54	00:01:59	00:01:05	63	9.9%	6.0%
Saturday	28-May-22	60	00:00:50	00:01:09	00:01:00	60	8.7%	5.3%
Sunday	29-May-22	45	00:00:54	00:01:20	00:01:04	45	1.9%	0.0%
Highest		63		00:02:09		63	10.6%	6.3%
7 day average		60			00:01:04	59.6	8.9%	5.5%
Weekday average		62			00:01:04	61.8	9.7%	6.1%

Table 4 Arrival time assessment

AHB train arrival times Croxton Level Crossing	ORR guidance	Observed	ORR Guidance met
Crossing length (m)		34	
% Train arrival within 50s	≥ 50%	4.8%	No
% Train arrival within 75s	≥ 95%	97.1%	Yes

Figure 24 Average road closure



Breakdown by time of day

Caution should be used when drawing conclusions from the time of day analysis when numbers being considered are small.

It can be seen that on weekdays (*Figure 25)* vehicle usage is reasonably evenly distributed although there are morning and evening peaks.

Usage during the weekend (*Figure 26*) is more evenly spread.

Figure 25 Distribution by time of day (weekday)

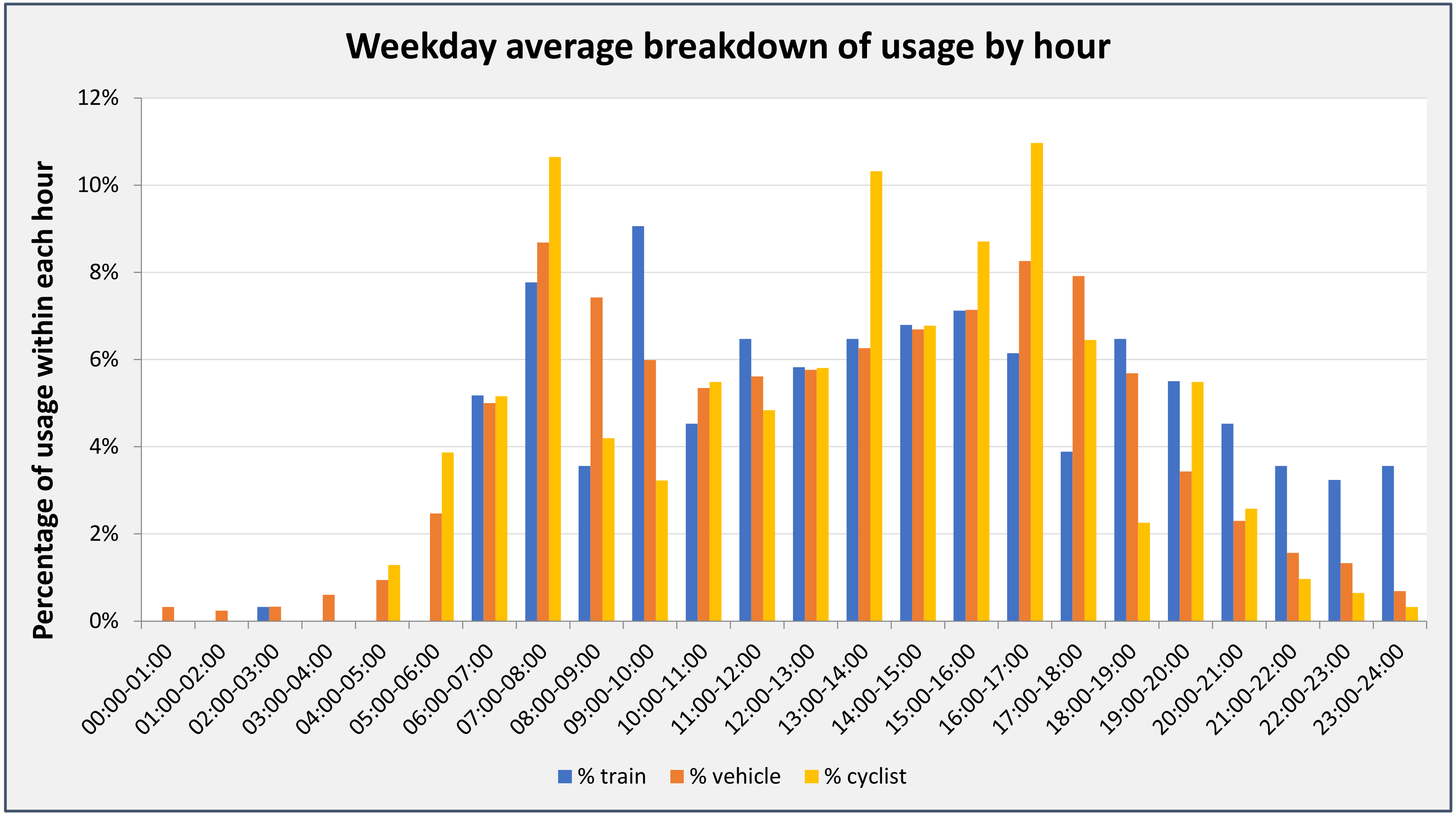
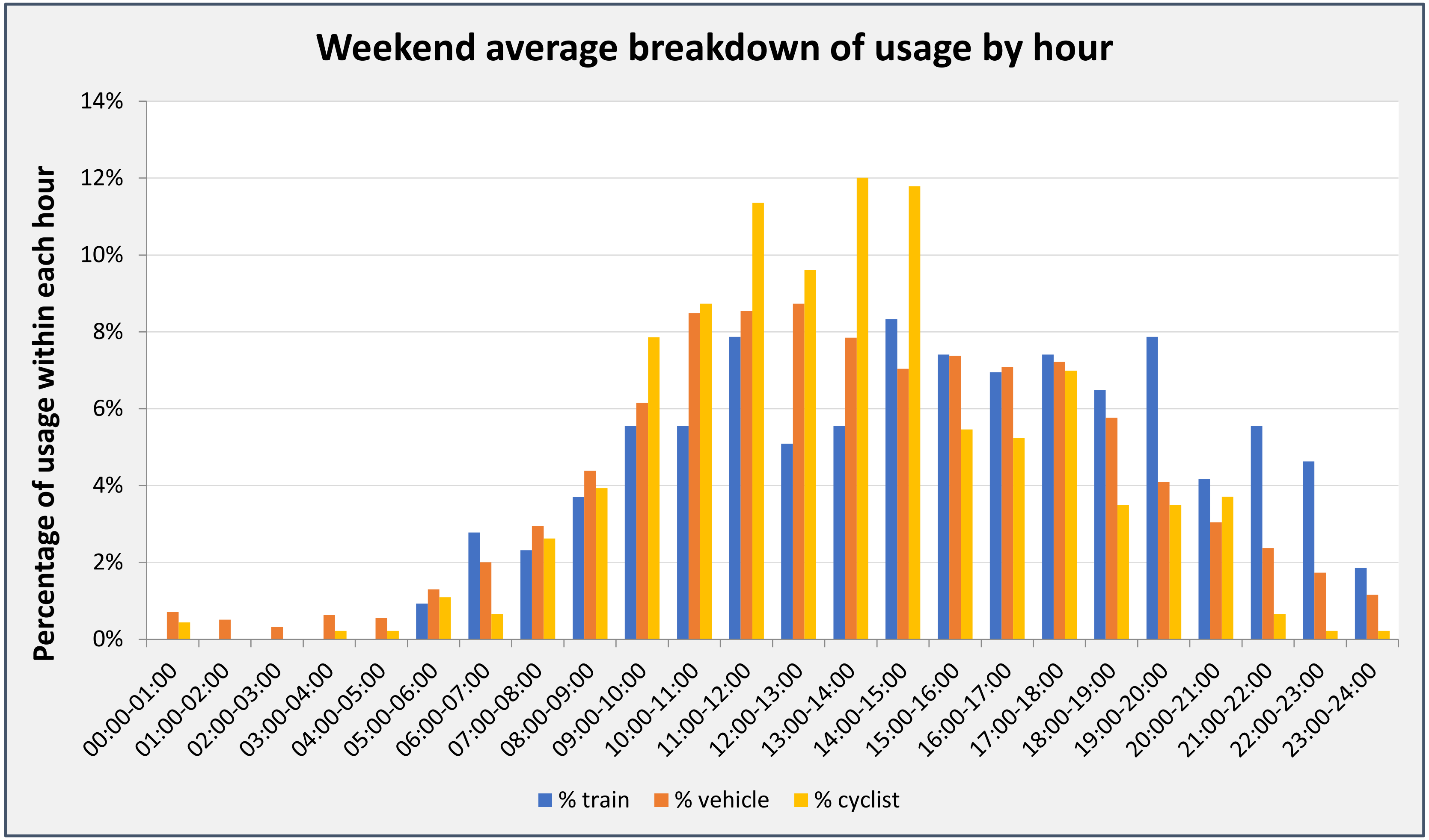


Figure 26 Distribution by time of day (weekend)



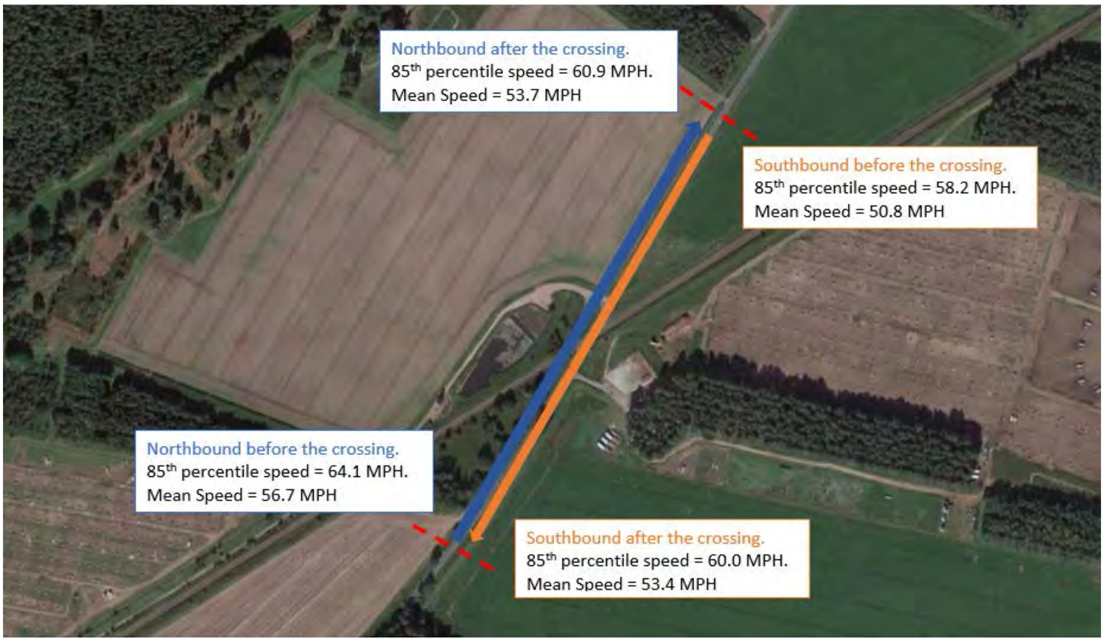
Road approach speed

The Automatic Traffic Count (ATC) speed sensors were located as shown in *Figure 27* and the mean and 85th percentile speeds are shown in *Table 5*.

Table 5 Mean and 85th percentile speeds

Direction	Speed (mph)	
	Mean	85th %tile
Southbound	50.8	58.2
Northbound	56.7	64.1

Figure 27 Location of speed sensors



Blocking back

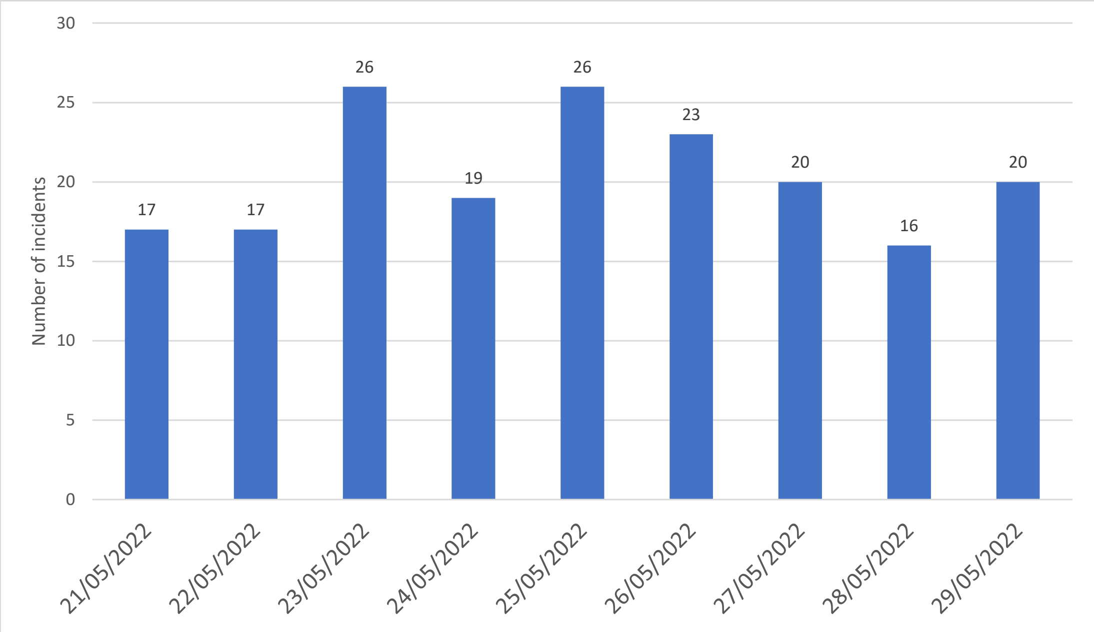
No blocking back was identified.

Incidents/unusual occurrences

The video review personnel classified incidents that might be of interest to Network Rail.

During the nine-day census, a total of 184 incidents of RTL running were identified. There were RTL running incidents recorded on every day of the census, as shown below in *Figure 28*. RTL running is categorised as a vehicle passing the lights after initiation with sufficient warning on approach.

Figure 28 RTL running incidents



3.2 Rail approach and usage

The crossing is located between Ely North Junction and Wymondham South Junction. There are two tracks at the crossing and the line is not electrified. It is a moderately utilised stretch of line with a weekday average of 64 trains per day (approximately 30 passenger trains in each direction). There is limited freight traffic over the line (typically 5-10 trains per day).

Use of the crossing by heavy military vehicles increases the potential for a serious collision with consequences for train passengers. A speed restriction at the crossing helps to mitigate this.

The Down rail approach

The train speeds are limited to 65mph along this stretch of track; there is however a 40mph speed restriction in operation at the crossing. The track is straight in this direction giving the train driver good sighting of the crossing as shown in *Figure 29*.

For trains travelling in the Up direction and derailing after hitting a vehicle on the crossing, there are no structures other than the REB that are likely to exacerbate the potential derailment consequences in the vicinity of the crossing.

Figure 29 View of Down rail approach (looking towards Ely North Junction)

The Up rail approach to the crossing

The train speeds are limited to 90mph along this stretch of track although there is a TSR to 40mph with '*LC sighting*' given as the reason. There is a high incidence of level crossing equipment strikes at the crossing and '*LC sighting*' may refer to the road user. The track is relatively straight in this direction giving the train driver good sighting of the crossing as shown in *Figure 30*.

For trains travelling in the Down direction and derailing after hitting a vehicle on the crossing, there are no structures that are likely to exacerbate the potential derailment consequences in the vicinity of the crossing.

Figure 30 View of Up rail approach (looking towards Wymondham Jn)


T

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 6*.

The crossing has a much 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 6 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)	18	1.55	11.61
Person - personal accident	0	0.28	0.00
Level Crossing/LC equipment - misuse/near misses	41	5.36	7.65
Near miss - train with person (not at LC)	0	0.01	0.00
Train - striking animal	2	0.07	28.52
Animals - on the line	0	0.11	0.00
Person - trespass	1	0.12	8.34
Person - vandalism	3	0.25	12.17
Train - signal passed at danger	1	0.05	22.10
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	13	9.38	1.39
Signalling system - failure	0	0.11	0.00
Permanent way or works - failure	0	0.03	0.00
All incidents	79	18.10	**4.36**

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

There was high incident rate and some of the incidents had very high potential for a catastrophic outcome:

- A SPAD after a barrier failed after being hit by a lorry. The signaller placed T31 signal back to red in front of a train causing a SPAD by one coach length

- 12 cases of equipment failure including one where Holdfast decking installed incorrectly led to a derailment
- Two near misses with vehicles
- Barrier hit a vehicle 21 times
- Six vehicles hit a barrier
- An RTA which caused damage to fencing
- Nine incidents of vehicle misuse
- Two incidents of vandalism including one where syringes were left on hard standing at the crossing
- A case of military personnel with slow moving vehicles failing to call back to report crossing clear
- An incident of trespass
- Two cases of trains striking deer

More recent SMIS data for one year to 13th March 2019 shows there were no further incidents at the crossing.

Due to the high level of misuse there is video surveillance at the crossing as shown in *Figure 31* and the amber warning has been increased from 3 to 5 secs.

Figure 31 Video surveillance to mitigate misuse

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:

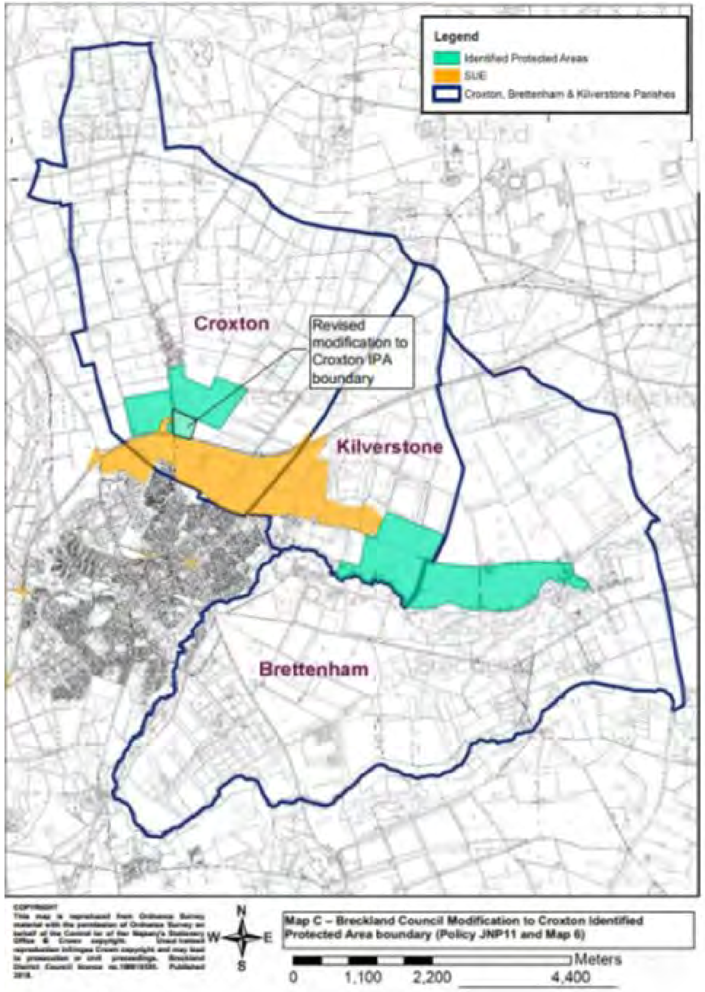
- Planned increases to train services or train speeds;
- Local developments (e.g. opening schools, retail outlets, factories);
- Closure of adjacent level crossings, meaning that the road and pedestrian traffic of any closed crossings now use the one subject to assessment.

Under the Sustainable Urban Extension (SUE) around 3,000 - 3,500 new homes are planned to be built in Croxton Parish under the adopted Thetford area Action Plan (TAAP) (10) as shown in *Figure 32.* Such development would tend to increase the level of usage over Croxton level crossing.

It is understood that there are currently no planned changes to the frequency of the train service although there are longer term plans under the Ely Area Capacity Enhancement (EACE) project to increase the level of train traffic from the current level of about 67 trains per day to about 104 trains per day.

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.

Figure 32 Development in the vicinity of the level crossing under the Local Development Plan



Local Plan:

Under the Sustainable Urban Extension (SUE) around 3,000 - 3,500 new homes are planned to be built in Croxton Parish under the adopted Thetford area Action Plan (TAAP)

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 Croxton, this suggests that the busiest hour road closure time would increase from about 7% for the current level of rail traffic as an AHB without the speed restriction to about 23% as an MCB-OD type crossing. If 100% of the EACE traffic increase occurred, the road closure time would increase to about 35% in the busiest hour as shown in *Figure 33*. The average daytime road closure time is shown in *Figure 34*. The speed restriction at the crossing is likely to increase the current crossing closure time, but that is not accounted for in the above figures.

Figure 33 Road closure time in the busiest hour

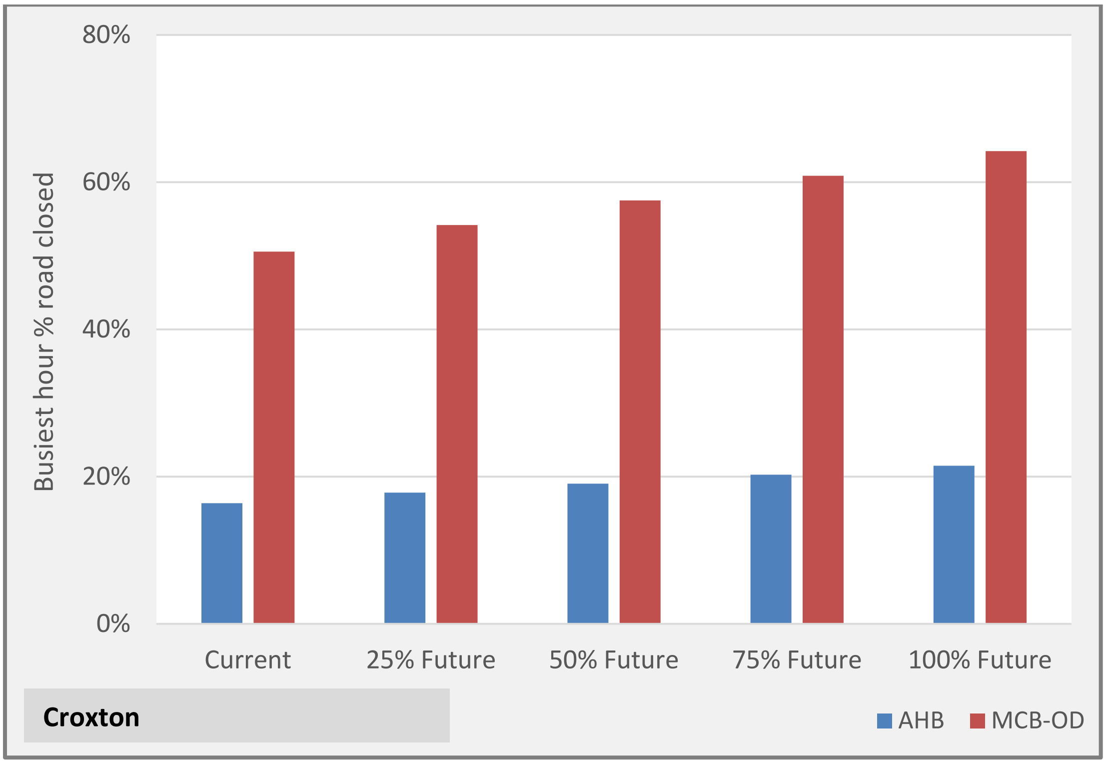
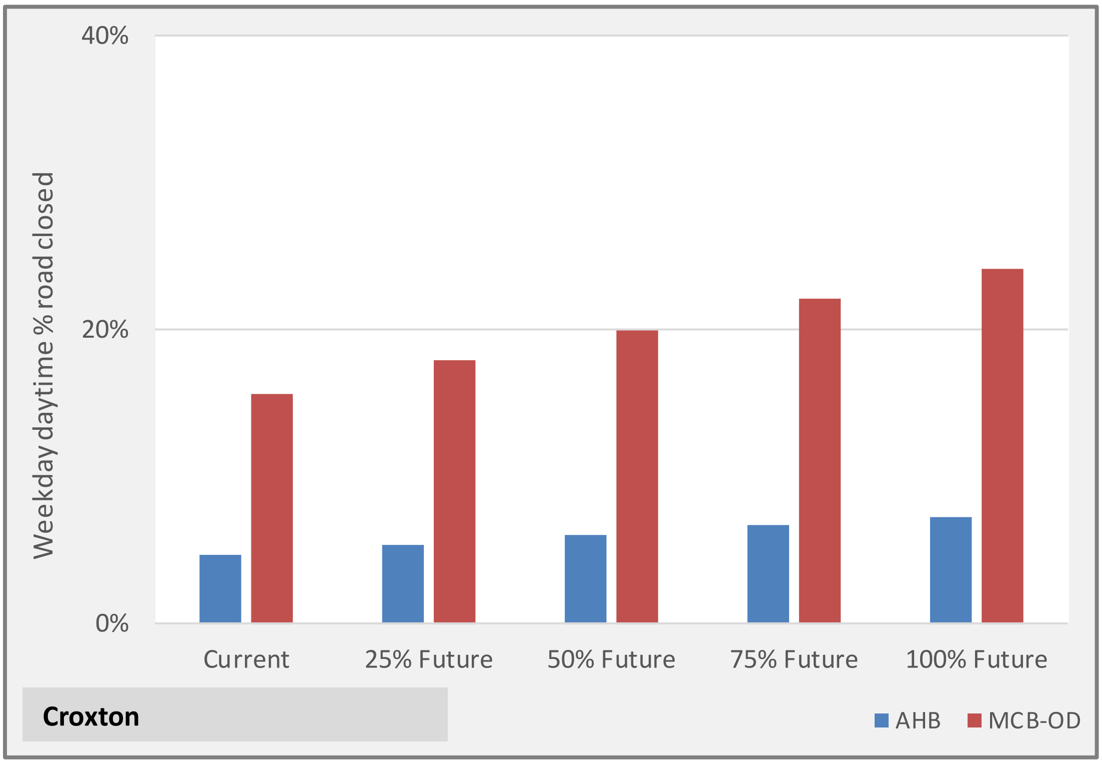


Figure 34 Average daytime road closure time



4 RISK AND OPTIONS ASSESSMENT

4.1 Assessment of Level Crossing Risk using ALCRM

The All Level Crossing Risk Model (ALCRM) has been used to assess the level crossing risk. This update to the assessment takes into account:

1) Update of the ALCRM software to version 2.0 to take into account the latest level crossing data;

2) Update of the census information from 2013 to 2022.

It can be seen that the revised modelling in ALCRM shown in *Table 7* has resulted in a lower predicted level of risk particularly for AHB type crossings. The increase in risk shown in *Table 8* reflects the higher usage level at the level crossing shown in *Table 9*.

Table 7 Change in Risk with revised ALCRM (based on 2013 census)

Type	ALCRM 1 Assessed Risk		ALCRM 2 Assessed Risk		Change between v1 and V2 of ALCRM
	FWI	Score	FWI	Score	
AHB	3.4 E-2	D2	6.2 E-3	G3	-82%
MCB-OD	3.5 E-4	J6	2.8 E-4	K6	-21%

Table 8 Change in Risk with revised census (using ALCRM 2.0)

Type	2013 census		2022 census		Change between 2013 and 2022 census
	FWI	Score	FWI	Score	
AHB	6.2 E-3	G3	8.0 E-3	G3	30%
MCB-OD	2.8 E-4	K6	3.3 E-4	K6	20%

Table 9 Changed usage levels

Census		Totals per day										
		Vehicles						Pedestrians/cyclists				
Day	No. trains per day	Cars	Vans / small lorries	HGVs	Buses	Tractors	Total	Motor cycles	Pedal cycles	Horse Rider	Pedestrians	Total
Croxton												
Old (2013)	67	3,537	512	391	14	13	4,467	11	3	0	1	15
New (2022)	67	4,625	1,095	302	9	49	6,080	80	3	0	0.4	83

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 (15) 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 11*. 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 12*. 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 10*. It can be seen that overall, upgrade to AHB+ is expected to approximately halve the risk compared to an AHB.

Table 10 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 11 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 12 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 13*. The value for each level crossing is the average of the factors for the two approaching directions.

Table 13 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 2013 and 2022 censuses and scaling factors for the Cambridge level crossings are shown in *Table 14*. It can be seen that vehicular usage has increased by 36% while pedestrian and cyclist usage has increased by 463% (mainly an increase in motorcycle usage) affecting those scaling factors. All other factors remain the same.

Table 14 Assessed factors at Croxton

Daily usage	2018	2022	% Change
Vehicles	4466	6080	36%
Pedestrians/ cyclists	15	83	463%
Trains	67	67	0%
Factors	**2018**	**2022**	**% Change**
Vehicles	2.7	3.7	36%
Pedestrians/ cyclists	0.2	0.9	463%
Trains	0.9	0.9	0%
Trains2 (Second train coming)	0.8	0.8	
Station	0.0	0.0	
Road approach speed	10.5	10.5	0%

Level Crossing specific cost benefit analysis

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 15* 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 35*.

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 16. The second to last row 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 16,* it can be seen that Croxton has a benefit to cost ratio less than 1 for upgrade to MCB-OD compared with upgrade to AHB+ due to the need for four additional signals. Croxton is a highly skewed level crossing and it is not clear that AHB+ would be suitable and is only predicted to give a modest decrease in risk relative to an AHB type level crossing.

Only a full barrier crossing with signal protection addresses the main hazards at Croxton level crossing and facilitates the removal of the TSR. Croxton is a skew crossing and so any pedestrians may hold up exit barrier.

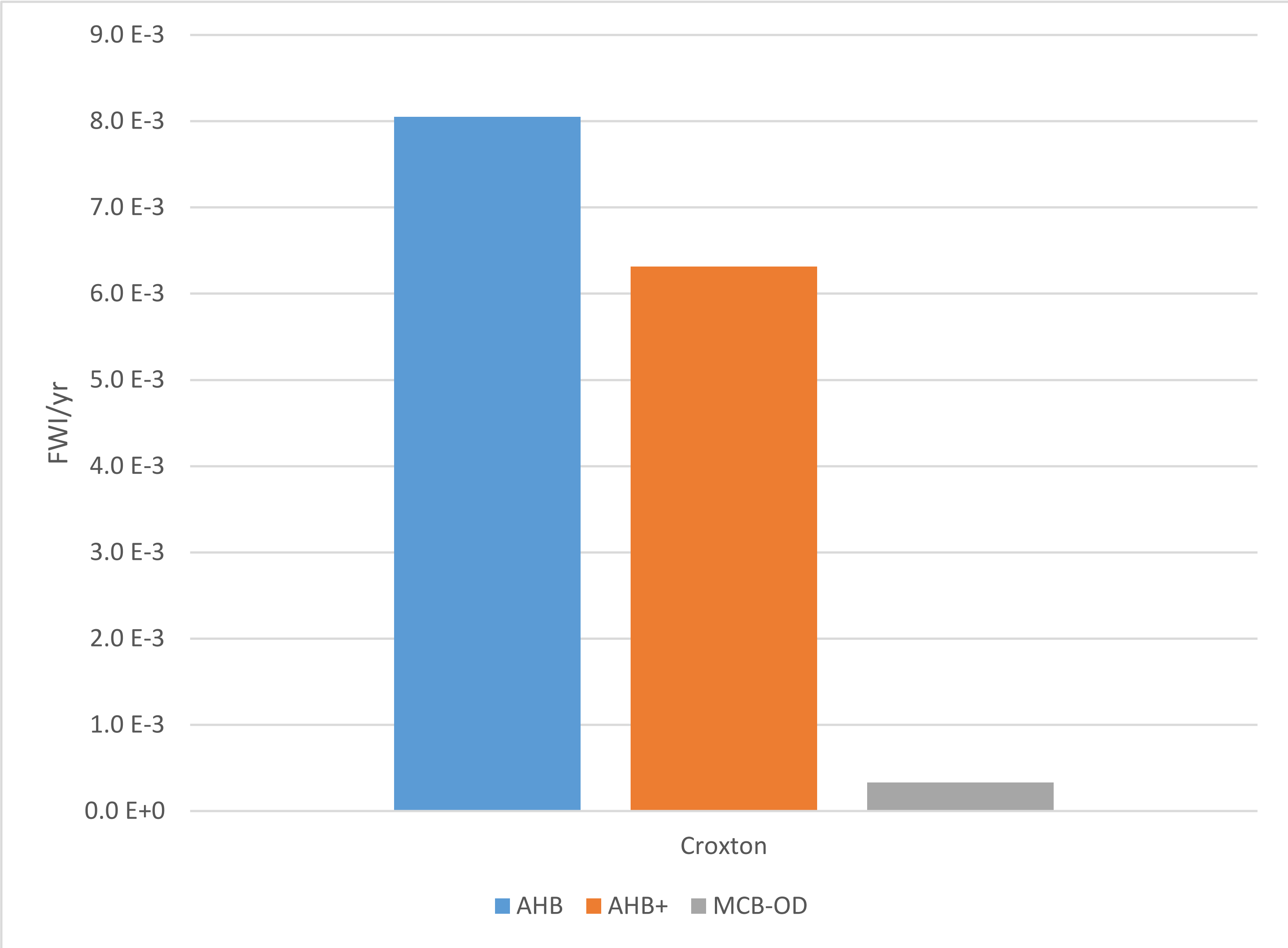
Table 15 Risk benefit and cost benefit analysis for renewing as AHB+ relative to AHB

Level crossing	Croxton
ALCRM Risk as AHB	8.0 E-3
NPV of Safety Risk over 30 years	£411,952
%Risk Benefit for AHB+ from SRM analysis	22%
Comment on benefit of AHB+	Does not address late braking etc.
Risk as AHB+	6.3 E-3
NPV of Safety Risk over 30 years	£323,111
AHB+ Risk Benefit	1.7 E-3
NPV of safety benefit over 30 years (AHB+)	£88,841
Benefit to cost ratio for renewing as AHB+ relative to AHB)	0.16

Table 16 Cost benefit analysis for renewing as AHB+ relative to renewing as MCB-OD

Level crossing	Croxton
Risk as MCB-CCTV or MCB-OD	3.3 E-4
MCB-CCTV or MCB-OD Risk Benefit	7.7 E-3
NPV of safety benefit over 30 years (MCB-OD)	£394,867
%Risk Benefit (AHB to MCB-OD)	96%
Cost of providing MCB-OD or MCB-CCTV	£3,832,532
MCB-OD Cost justification	4 SEUs
Benefit to cost ratio (AHB to MCB-OD)	0.10
Benefit to cost ratio (Difference between upgrading MCB-OD and AHB+)	0.17
Comments	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.

Figure 35 Chart showing risk as AHB, AHB+ and MCB-OD



4.3 Options assessment workshops

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

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 to address consideration of the AHB+ option:

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

A further workshop was then held to consider the implication of the 2022 census and to review the design including the ground plan:

Present	Role
Aaron Barton	ACE Engineer
Nathan Garratt	Project Delivery Engineering Manager
Jehad Mahmoud	LCM
Chris Chapman	Sotera, Workshop Chair
David Harris	Sotera, Scribe
Ben Chipman	Level Crossing Designer
John Prest	Route Level Crossing Manager
Charles Muriu	Senior Asset Engineer
Paul Fletcher	Signaller / Project Operations Interface Specialist
Paige Skinner	Scheme Project Manager
Terry Ngan	Route Level Crossing Manager
Presto Camelo	Portfolio Manager
Peter Fawcett	Portfolio Manager
Dan Fisk	Public and Passenger Safety Manager
Kevin Willoughby	LOM
Mark Crosby	Alstom CRE

4.4 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;
- 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 17 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 2021 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 17 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)	8.0 E-3	G3	£411,952	Feasible. SICA renewal date is 2025, route renewal is 2020. Penguin style barriers due for replacement. A high risk crossing due to high vehicular use (a weekday average of 4,874 vehicles a day), high road speed, high level of misuse and a fairly busy line. The high level of misuse appears from SMIS reporting to have reduced in the past year. 40mph TSR in place since 2012 for the level crossing due to weaving of the barriers - increases road closure time, and potentially misuse, but reduces catastrophic derailment risk Have requested a road speed reduction to 40mph from Highways England but they have not been amenable to this. Used by heavy military vehicles - tank carriers Major housing development on outskirts of Thetford could increase use.	£1,460,010	£16,933	Standard cost, if renewal is required. SICA Renewal date: 2025
Closure	0		£0	On an A-road (A1075) - main road between Thetford and Great Hockham. There is an alternative route via the A11 but this would add approx. 7km onto journeys. Closing an 'A' road is not considered a practical option.			
Closure + pedestrian bridge	0		£0	Main use is road vehicles so would not enable closure.			

Option/ Crossing type	ALCRM 2019 usage			Feasibility	Cost		Justification for cost estimate
	FWI	Score	NPV (30)		Capital	Annual	
Closure + road bridge	0		£0	A bridge would be technically feasible but would require significant investment.	£12m+	£2,746	Significant skew would result in longer bridge. A road bridge is likely high cost
Closure + underpass	0		£0	Typically more expensive that a bridge and very challenging to provide a full height underpass as would be necessary on an' A' road.	£15m+	£2,746	Estimated more than a bridge.
Closure with bypass	0		£0	No other roads in the vicinity to utilise - bypass has no benefit over building a bridge in situ.	N/A		
ABCL	-	-	-	Not a viable option due to the restriction in linespeed that would be necessitated. Would also give a high residual risk.	£1,336,708	£16,933	
AHB+	6.3 E-3		£323,111	Croxton has a benefit to cost ratio less than 1 for upgrade to MCB-OD rather than AHB+ due to the need for four additional signals. Croxton is a highly skewed level crossing and it is not clear that AHB+ would be suitable and is only predicted to give a modest decrease in risk relative to an AHB type level 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	3.3 E-4	K6	£17,085	Feasible. Signals are located at 6857m and 3020m i.e. not near enough to the crossing to act as distant or protecting signals. The crossing may require an extension to the track circuited area - i.e. a minimum of 4 SEUs. The main issue at the crossing is cars impacting the barriers, which would not be solved by making it a 4 barrier crossing, albeit the risk would be mitigated as the longer barrier downtime makes it less likely that a vehicle hits the crossing just before the arrival of a train.	£3,664,316	£54,265	Includes 4 SEUs in the capital costs and CCTV monitoring costs. Cost assessment of signaller in ROC based on 365/24hrs grade 5 signaller with 8 screens
MCB-OD	3.3 E-4	K6	£17,085	Feasible but same issues as MCB-CCTV. Mk.2 MCB-OD frequency closer to military frequencies - do not yet know if any issue with this - needs to be considered as several airfields in the area	£3,832,532	£40k	May need two LIDAR devices due to skew.

4.5 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 a relatively major scheme to build a bridge just off-line (*Figure 36*).

Figure 36 Scheme to close Croxton level crossings

Since this scheme would likely cost in excess of £12m due to the skew of the crossing and the need to provide a bridge suitable for an ‘A’ road; the cost would be grossly disproportionate to the safety benefit compared with the alternative of renewing Croxton as MCB-OD with a cost of about £3.8m.

Although the train frequency is expected to increase from a current level of 67 trains per day to a future level of about 104 trains per day estimated by the EACE project, a road closure time in this maximum case of about 35% in the busiest hour for an MCB-CCTV or MCB-OD type crossing would be sustainable, if undesirable on an ‘A’ Road.

While closure of the crossing could be feasible, crossing renewal as an MCB-OD provides a more viable and cost-effective option providing the predicted road closure times are acceptable to the Highway Authority. Otherwise AHB+ could be considered although the long crossing length would be a challenge for the design. Upgrade to either AHB+ or MCB-OD would be expected to facilitate the removal of the TSR that has been in place since 2012.

Upgrading to an AHB+ type level crossing is an alternative option. Croxton has a benefit to cost ratio less than 1 for upgrade to MCB-OD compared with upgrade to AHB+ due to the need for four additional signals (See *Section 4.1*). Croxton is a highly skewed level crossing and it is not clear that AHB+ would be suitable and is only predicted to give a modest decrease in risk relative to an AHB type level crossing. It is understood that the AHB+ project is in development and there is potential for trial sites. 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. The preferred renewal option is, therefore, upgrade to MCB-CCTV or MCB-OD providing the predicted road closure times are acceptable to the Highway Authority.

4.6 Conclusion about crossing type

Retaining an AHB crossing would not be the preferred option as it presents a high level of risk at 8.0 x 10^{-3} FWI per year. It is also exposed to hazards associated with a fast road approach and has a history of barrier strikes and misuse to such an extent that there has been a TSR in place since 2012. 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.

An automatic full barrier (AHB+) type crossing is not likely to be a viable option at this location due to the high vehicle approach speed and high risk. This type of crossing also does not have type approval.

The preferred option is therefore to renew the crossing as MCB-CCTV or MCB-OD; both of these crossing types would offer significant risk reduction compared with AHB from 8.0 x 10^{-3} to 3.3 x 10^{-4} FWI per year.

The choice between MCB-OD and MCB-CCTV is made on the basis of feasibility, signaller workload, road closure time and cost. New distant and protecting signals will be required for this crossing.

4.7 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 18*).

The additional controls identified for consideration include:

- The road approaches to the crossing are fast and straight, giving an elevated risk of misuse, late braking and barrier strikes. Retaining the anti- slip road surface helps to minimise this (but note that maintenance of high friction road surface is responsibility of the highway authority).

- Low sun is potentially an issue for road approach sighting, particularly around sunset in winter, however there are trees, which block the sun and provide background shielding for the RTLs. It is planned to mitigate this with extended hoods, LED RTLs, a reduction in signage clutter and increase in advance signage size and conspicuity.

- The current footway widths are not sufficient to meet ORR guidance although pedestrian use is extremely low. Footways are designed to be 1m widths, intended as a refuge for anyone walking along the road; there are no approach footways to connect with.

Table 18 Assessment of additional controls

Hazard	Comment	Standard/existing controls	Potential additional controls	Feasibility	Cost	Recommend
Road vehicle misuse - weaving around barriers, red light running.		CCTV monitoring	RLSE	Yes	£150k	Not required for renewal as MCB-OD; would use the video cameras in the event that have trouble clearing the crossing
High approach speeds - effectively reducing the warning time of closure		Anti-skid road surface	Count down markers	Yes	£5k	Included. As barriers parallel to rail, and high skew the barriers less visible than it parallel to road so count down markers are included.
			Improved conspicuity of advance signage			Advance signage size increased as was small for the road approach speed, yellow backed signs and '*AHB signage clutter*' removed.
			Reduction in road speed	Would need to be discussed with Highway Authority		Highway Authority not amenable to this in previous discussions

Hazard	Comment	Standard/existing controls	Potential additional controls	Feasibility	Cost	Recommend
			VAS	Feasible but count down markers, increased conspicuity of advanced signage and extended yellow phase already included		Not included
			Increasing amber duration to provide an increased warning time to stop.	Yes, a configuration parameter for MCB-OD	-	Increased from 3s to 5s. See OD-parameter assessment
Narrow footpaths - not to standards	Current footpaths are about 0.8m in width		Widen footways to 1m to be in compliance with ORR guidance	Yes - a ground plan consideration		Designed 1m widths. Intended as a refuge for anyone walking along the road – no approach footways.

Hazard	Comment	Standard/existing controls	Potential additional controls	Feasibility	Cost	Recommend
Low sun	Low sun is potentially an issue for road approach sighting – particularly around sunset in winter, however there are trees which block the sun and provide background shielding for the RTLs. Has extended hoods; does not have LED RTLs.	Extended hoods	LED RTLs	Yes	Low	Yes - Would be provided upon renewal
			Extended hoods	Yes	Low	Provided
Skew	Skew is 30° to the rail.		Velostrail deck	Not approved for this linespeed		Holdfast should not be used on high skew crossings, Strail preferred over Holdfast. No incident history. Concrete and polymer deck provided, which is considered adequate.
			Eliminate skew	Not practical		No
	Slightly elevated turn onto railway risk (no nearby junctions)		Retro-reflective edge markers	Yes	Low	Maybe a risk to cyclists. Not provided

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 19*.

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, a consideration will be the build-up of traffic with longer road closure time and the need to avoid barriers lowering onto tailgating vehicles (entrance barriers). A particular factor here is the use by heavy military vehicles that might accelerate slowly. Barrier Protection Management (BPM) is to be provided to mitigate this.

- *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. The amber phase duration is to be extended to 5s as a mitigation for this.

- *Provide audible warning at all four wig-wags.* The crossing has a large area and providing audible warnings at all four corners allows optimisation of volumes.

- *Standing red man pedestrian* indications are to be provided at 2 offside locations to give pedestrians additional advance warning before entering the large crossing area.

- *Lighting for the degraded mode* when operated by the local control unit is to be considered in detailed design.

Table 19 Review of MCB-OD configuration factors

MCB-OD configuration factor	Hazards	Consideration at level crossing	Recommended
Minimum Road Open time (MROT) Default of 20 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 and therefore MROT does not need adjustment from the default value.	No
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	Blocking back not observed in the traffic census and therefore BPM is not recommended. A consideration due to build up of traffic with longer road closure time in order to avoid barriers lowering onto tailgating vehicles (entrance barriers)	Recommended. Included due to queues of traffic forming during closure so a second train arriving just outside MROT could lead to barrier strikes by road vehicles.
Default time at which time barriers lower (30 secs). Exit barriers at 4 barrier crossing.	Blocking back for extended durations	Blocking back was not observed during the census, therefore not recommended.	No

MCB-OD configuration factor	Hazards	Consideration at level crossing	Recommended
Minimise distance between barriers	Long traverse at skew crossing giving rise to entrapment risk.	There is a long distance between barriers due to the skew. This should be optimised though design. Not likely to get parallel barriers due to 9.1m maximum barrier length. Prefer to use shorter barriers as can get a lot of failures with long barriers and increased wear and tear on barrier machines, particularly in a windy area. Land purchase considerations also.	Crossing area optimised; constrained by maximum barrier length
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	The skew means that the planned barrier to barrier distance is 35m, hence 10 seconds may not provide adequate time for pedestrians to cross. The planned timing is 5s amber, 7s red, nearside barriers lower 6-10s, radar scan and if detects holds exit barriers 10s and then lowers offside. There is then an rescan. If a person is detected, exit barriers are raised and held for 10s. It is considered that this will be sufficient time for someone to get off crossing. Note that pedestrian usage is very low.	No increase on default

MCB-OD configuration factor	Hazards	Consideration at level crossing	Recommended
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	No benefit at this location – very low entrapment risk and have BPM. Have pedestrian stop signals (standing red man closer to crossing at 2 offside locations). RTLs comparatively are a long way out so standing red man indication gives more warning to pedestrians. Tailgating vehicles may be a consideration in the future with a full barrier crossing but this is addressed by BPM.	Not recommended
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.	No
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 are 64.1mph (North) and 58.2mph (South). Hence, extending the sequence to provide road users with adequate warning to stop is recommended.	Amber phase to be extended to 5s.
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.	There is a relatively large area. Due to crossing length providing at all 4 corners and can adjust each volume locally. Becoming more standard fitment as able to tune sound at each corner.	Provide at all 4 RTLs

MCB-OD configuration factor	Hazards	Consideration at level crossing	Recommended
Standing red man indication	High pedestrian use Poorly sited RTLs for pedestrians	Very low pedestrian misuse and a good view of the RTLs. Long crossing distance. RTLs distant from barriers in offside locations.	Standing red man closer to crossing at 2 offside locations
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.	S&T from Thetford so prefer LCU on the Up side Need to consider land purchase to provide a car park for NR staff	Large compound on Up side Note: no emergency floodlights – similar to AHB so would need to take lights in van. Risk is greater for locally checking crossing clear than AHB as trains not cautioned. Standard requires lighting is to same standard as road approaches – no lighting here. *Ben Chipman to consider this post-meeting, but cannot provide permanent lighting as issues with this e.g. bats.*

5 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are made from the analysis:

Strategic options

1. The only feasible closure option identified is to provide an in-situ bridge and new link roads. Since this scheme would likely cost in excess of £12m, the cost would be grossly disproportionate to the safety benefit compared with the alternative of renewing Croxton as MCB-OD at a cost of about £3.8m which would leave a moderate residual 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 (8.0x 10^{-3} FWI per year).

4. Upgrading to an AHB+ type level crossing is a potential option. Croxton has a benefit to cost ratio less than 1 for upgrade to MCB-OD compared with upgrade to AHB+ due to the need for four additional signals (see *Section 4.1*). Croxton is a highly skewed level crossing and it is not clear that AHB+ would be suitable and is only predicted to give a modest decrease in risk relative to an AHB type level crossing. It is understood that the AHB+ project is in development and there is potential for trial sites. 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.

5. The preferred renewal option is, therefore, upgrade to 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. The choice between MCB-OD and MCB-CCTV is made on the basis of feasibility and cost including the operational cost associated with signaller workload.

Consideration of local hazards and MCB-OD configuration parameters

6. The additional controls identified for consideration include:

    - The road approaches to the crossing are fast and straight, giving an elevated risk of misuse, late braking and barrier strikes. Retaining the anti- slip road surface helps to minimise this (but note that maintenance of high friction road surface is responsibility of the highway authority).

- Low sun is potentially an issue for road approach sighting, particularly around sunset in winter, however there are trees, which block the sun and provide background shielding for the RTLs. It is planned to mitigate this with extended hoods, LED RTLs, a reduction in signage clutter and increase in advance signage size and conspicuity.

- The current footway widths are not sufficient to meet ORR guidance although pedestrian use is extremely low. Footways are designed to be 1m widths, intended as a refuge for anyone walking along the road; there are no approach footways to connect with.

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, a consideration will be the build-up of traffic with longer road closure time and the need to avoid barriers lowering onto tailgating vehicles (entrance barriers). A particular factor here is the use by heavy military vehicles that might accelerate slowly. Barrier Protection Management (BPM) is to be provided to mitigate this.

   - *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. The amber phase duration is to be extended to 5s as a mitigation for this.

   - *Provide audible warning at all four wig-wags*. The crossing has a large area and providing audible warnings at all four corners allows optimisation of volumes.

   - *Standing red man* pedestrian lights are to be provided at 2 offside locations to give pedestrians additional advance warning before entering the large crossing area.

   - *Lighting* for the degraded mode when operated by the local control unit is to be considered in detailed design.