



River Wall and Chocolate Path – Section B

BD79/13 Management Report

Document No. R002 | A

11/07/18

Client: Bristol City Council



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Document history and status

Revision	Date	Description	By	Review	Approved
A	10/07/18	First Issue	Rafael Ramirez Romero	Liz Rivers	John McElhinney

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1. Introduction

The Chocolate Path is a pedestrian and cycling path (National Cycle Route 33) running along the northern bank of the River Avon New Cut channel. The Chocolate Path is approximately 1km long, starting from the western end of Cumberland Road (where it joins Avon Crescent) going eastwards towards Cumberland Road Rail Bridge, where the railway and path turn under the road and into the Bristol Floating Harbour. The path is supported by a masonry river wall on its south side. The Bristol Harbour Railway and Cumberland Road are located adjacently to the path on the north side. Cumberland Road is a wide highway with parking bays either side raised above the railway by a masonry retaining wall. Section B is situated at grid reference 357434, 172110.

The designer of the Chocolate Path River Wall structure and date of construction are unknown, but it is believed the wall was constructed between 1896 and 1900 as part of the Bristol Harbour Railway.

Section B is a 217m long stone retaining wall starting at approximately Chainage 81m (buttress 1) and ending at approximately chainage 298m (buttress 37). Section B incorporates a mass gravity wall which is braced by 37 buttresses. The retained height varies from 2.1m to 5.2m. The structure has no expansion joints.

The pedestrian and cycling path is currently closed to public.



Figure 1-1: Site Location Plan

2. Summary

The river wall at Section B is 217m long and incorporates a mass gravity wall which is braced by 37 buttresses. The retained height varies from 2.1m to 5.2m. Both, the River Wall structure and the Chocolate Path are in very poor condition at present.

Two rows of survey pins were installed in the path in February 2016 to monitor the movement. Monitoring was undertaken on monthly intervals from February 2016. Monitoring and inspections undertaken in December 2017 and May 2018 identified a number of defects throughout an approximately 70m long section of the structure (between Ch. 140m and Ch. 210m). The defects observed and the signs of distress exhibited in the river wall and the Chocolate Path include: tilting; major settlement; undulations of the path; rotation; seepage between some of the buttresses; areas of missing mortar; significant displacement of stonework; areas of bulging and multiple random cracks to the river wall.

Load mitigation measures consisting of closure of the Chocolate Path and the bus parking bays on Cumberland Road in the area adjacent to the Harbour Railway were adopted in December 2017. The monitoring frequency was also increased to fortnightly from April 2018. These measures, together with the proposed fortnightly inspections, are considered adequate to warn of the progression and development of the failure process.

The most likely failure process would be one or a combination of sliding or bearing capacity failure of the River Wall foundations, internal erosion of backfill materials forming voids which collapse to the rear of the wall or a deep-seated slip through the weak clay soils behind and beneath the river retaining wall. The risk of failure will progressively increase as the wall deformation continues to the point where the structure collapses.

The river wall is considered to be an "Immediate Risk Structure". There is a possibility that movement will progress to the extent that the stability of Cumberland Road is affected. The river wall can be considered to have failed and movement will be ongoing and continuous until stabilisation is undertaken.

Partial or complete collapse of the wall at Section B could happen at any time, but it is anticipated that the rate of movement would increase with further visible signs of distress apparent before an event of this kind.

It is recommended that BCC develop a transport plan for any immediate road or lane closure at Cumberland Road. This would require implementation should any of the trigger levels listed in Appendix H be reached. This plan should include for maintained provision of access for businesses and local residents.

3. Assessment Status of Structure

There are no records of any assessments being carried out for Chocolate Path River Wall and Cumberland Road Retaining Wall structures. It is expected that Section B of the Chocolate Path River Wall would fail a Level 1 assessment if undertaken due to its poor condition at present.

4. Proposed Action

It is recommended that the structure be prioritised for stabilisation including full reinstatement of the Chocolate Path River Wall and adjacent railway. It is also recommended to undertake ground investigations, surveys, and ground and wall monitoring to identify and adequately define the failure process, wall geometry and ground model for stability calculations.

In the interim, the load mitigation measures consisting of closure of the Chocolate Path and the bus parking bays on Cumberland Road in the area adjacent to the Harbour Railway should remain in place. The fortnightly monitoring of the survey pins on Chocolate path should continue whilst a new survey grid and monitoring system is established. Additionally, fortnightly inspections of the wall should be carried out to detect signs of further movement and provide warning of any collapse.

5. Interim Measures

The existing load mitigation measures consisting of closure of the Chocolate Path and the bus parking bays on Cumberland Road in area adjacent to the Harbour Railway remain appropriate.

The fortnightly monitoring of the pins on Chocolate Path should continue until a new survey grid and monitoring system is established. Details of the new survey points and monitoring are enclosed within Appendix H of this report.

It is proposed that a Geotechnical Engineer undertake a fortnightly site inspection for any observable increase in movement of the wall, path, railway and Cumberland road. The aim being to increase the possibility of early identification of impact on the adjacent highway should the area of movement spread.

It is proposed that a Drainage Engineer review any options for temporary improvements of drainage, after the upcoming drainage survey undertaken. The aim being to minimise any increase in pressure on the wall that may occur from ground water and surface water build up.

6. Risk Assessment

No Quantitative or Probabilistic Risk Assessment has been carried out at this stage. The structure is considered to be an “Immediate Risk Structure” representing an immediate and unacceptable safety risk to the public. Our understanding is that the river wall can be considered to have failed and movement will be ongoing and continuous until stabilisation is undertaken.

Partial or complete collapse of the wall at Section B could happen at any time, but it is anticipated that the rate of movement would increase with further visible signs of distress apparent before an event of this kind.

It should be noted that this risk is greater at times of wet weather and high tides. Some mitigation may be achieved through temporary drainage improvements but consideration should also be given to increased inspection frequencies during these periods.

A consideration of risks posed by the River Wall in current state is enclosed within Appendix C of this report.

Appendix A. Management Process

APPENDIX A MANAGEMENT PROCESSES

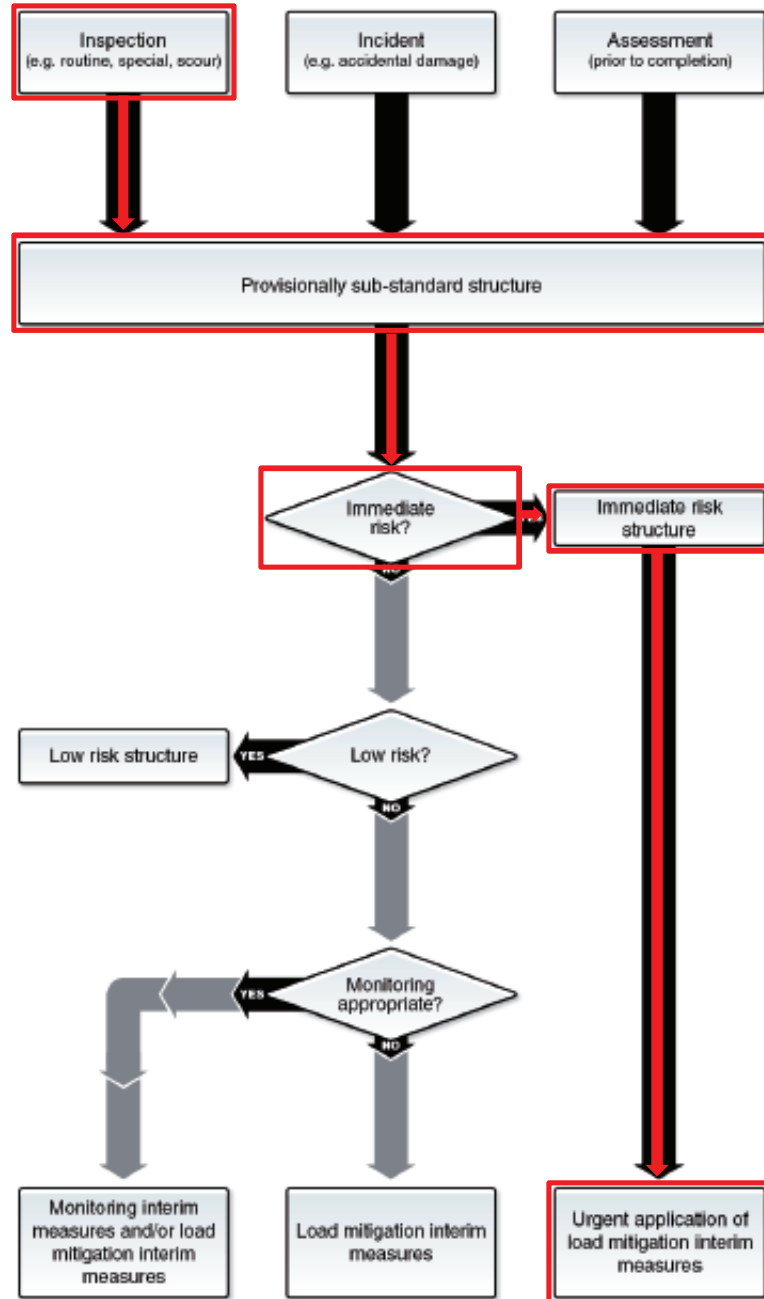


Figure A.1 – Management Processes Flowchart – Phase 1 Provisionally Sub-standard Structures

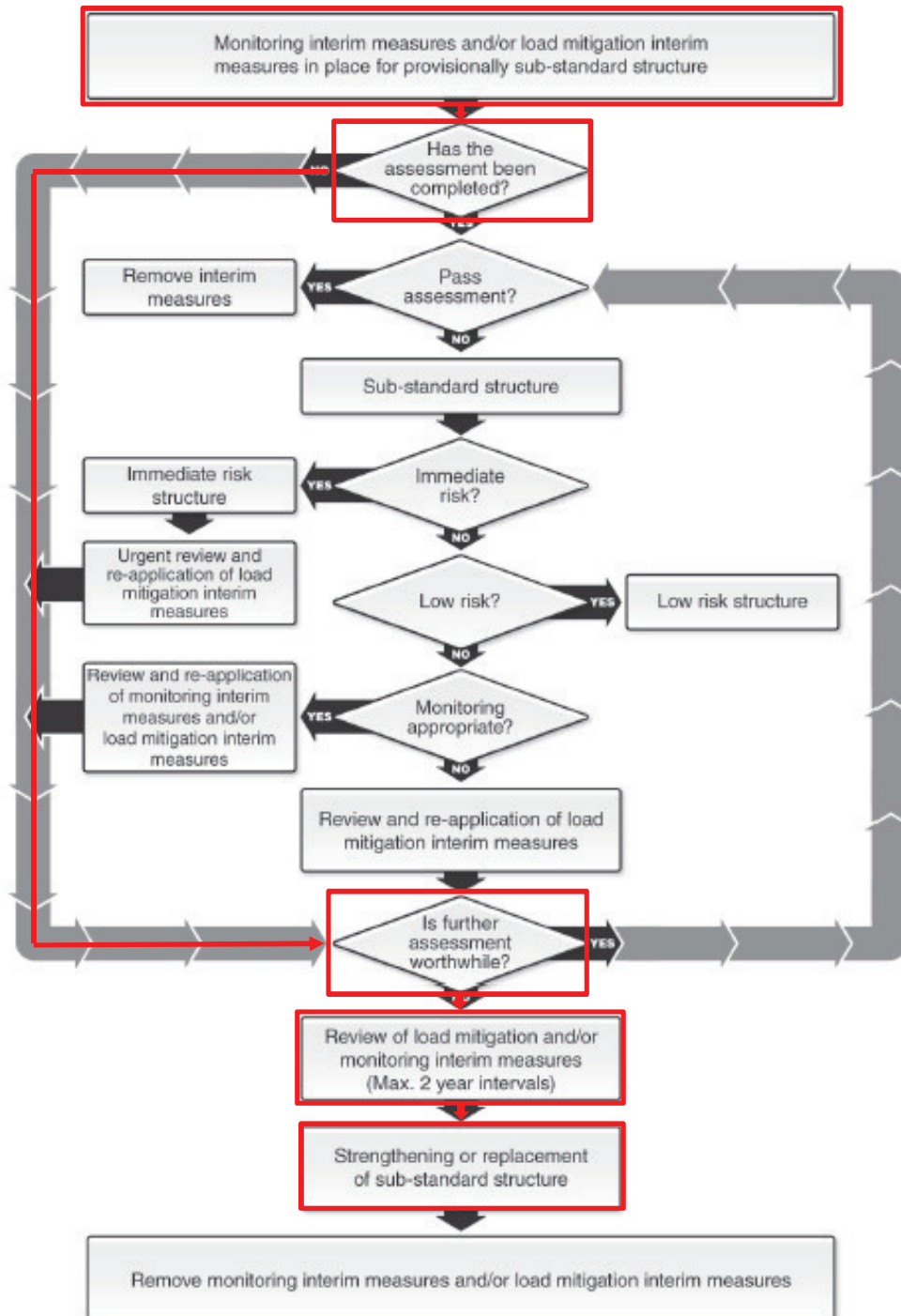


Figure A.2 – Management Processes Flowchart Phase 2 Sub-standard Structures

Appendix B. Retaining Wall General Inspection Form

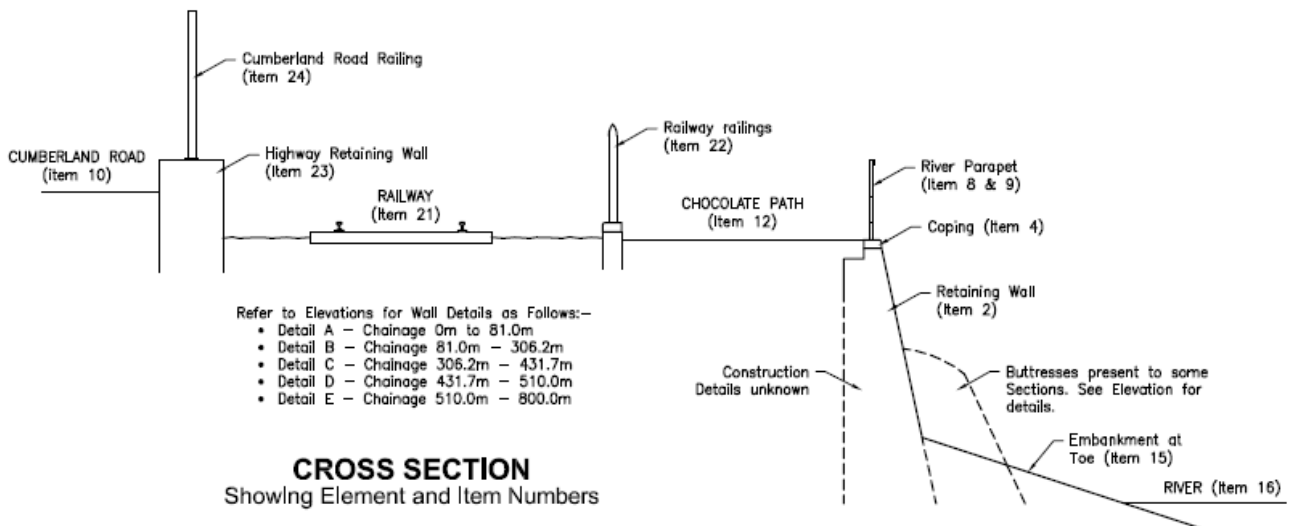
Retaining Wall Inspection Proforma

Version: July 2004

<input type="checkbox"/> Superficial		<input checked="" type="checkbox"/> General		<input type="checkbox"/> Principal		<input type="checkbox"/> Special		Form 1 of 1 for this wall	
Wall Name: Chocolate Path Retaining Wall				Wall Ref. Section B: Ch 81m to 298m			Road Ref/No. Cumberland Road		
District: Bristol			Map Ref. ST57SE		O.S.E: 357434		O.S.N: 172110		
Panel 1 of 1		Retained Height (m)	Max. 5.2m	Ave. 3.2m	Wall/Panel Length (m): 217m		Retaining Wall Code:		
All above ground elements inspected: Y					Photographs? Y		Structural Form Table G.14		R1
Number of construction forms in wall/panel length: 1							Material Table G.15		RC

Set	No	Element Description	S	Ex	Def	W	P	Cost	Comments/Remarks
Wall Elements	1	Foundations	4	C	6.6	K	TBC	TBC	1) Settlement and rotation of structure due to assumed slip circle failure. 2) & 4) Poor condition. The retaining wall has undergone significant settlement and rotation between 140m – 210m due to assumed slip circle failure. Multiple defects.
	2	Retaining Wall	4	C	M	K	TBC	TBC	
	3		Secondary						
	4	Parapet Beam/Plinth						Item 2	
Durability Elements	5	Drainage	2	D	8.1	Z	C	£5000	5) Condition unknown – assume some blockages. 6) None present 8) The paint coatings to the river parapet (5D) and railway railings (5E) have failed resulting in surface corrosion throughout.
	6	Movement/Expansion Joints							
	7	Surface finishes: wall							
	8	Surface finishes: handrail/parapet	5	E	4.1	K	C	Item 9	
Safety Elements	9	Handrails/parapets/safety fences	4	C	M	K	C	£43000	9) Corroded fixing to rails. Major deformation due to slip circle. Severe corrosion to several posts. Surface corrosion throughout. 10) Recently resurfaced. Good condition with no apparent defects. 12) Major settlement and undulations between Ch140 – 170m.
	10	Carriageway	1	A	9.1	-	E	-	
	11		Foot of Wall						
	12	Footway/Verge	5	C	9.1				
13	Foot of Wall								
Other Elements	14	Embankments	4	D	11.1	K	C	TBC	14) Tension cracks and significant undulation of footpath indicate a major slip/settlement. 15) There are no obvious signs of deformation or slips within the silt at the toe, but these would tend to be smoothed out by the varying tide.
	15		Foot of Wall	1	A	11.1	-	E	
	16	Invert/river bed	1	A	7.1	-	E	-	
	17	Aprons							
Ancillary Elements	18	Signs							16) No disruption to flow. No scour to the retaining wall. 20) Not inspected. No apparent defects. 21) Major settlement between Ch147 – 195m. Area has been tarmacked over but now has a 50mm wide tension crack with a 100mm vertical step (assumed slip circle).
	19	Lighting							
	20	Services							
	21	Railway	5	D	9.1	K	TBC	TBC	22) Surface corrosion throughout. Significant section loss at the base of some posts. Distortion due to slip circle. 23) Good condition with no signs of distress or settlement. Light vegetation growing on the wall (Ch130 – 200). 24) New railings. RTA damage to 3 panels.
	22	Railway Railings	4	C	M	K	TBC	£32000	
	23	Highway Retaining Wall	2	C	5.1	-	E	-	
	24	Cumberland Road Railings	2	B	13.1	-	E	-	

Defect Sketches:



S – severity, **Ex** – extent, **Def** – defect,
W – work required, **P** – work priority

Inspection Date: 22nd May 2018

Next Insp. (month/yr): TBA

Wall Name: Chocolate Path Retaining Wall	Road Name: Cumberland Road	
Wall Ref/No : Section B: Ch 81m to 298m	Road Ref/No:	
O.S. E 357434	O.S. N 172110	Map Ref: ST57SE

MULTIPLE DEFECTS

Item No.	Defect 1			Defect 2			Defect 3			Comments
	S	Ex	Def	S	Ex	Def	S	Ex	Def	
2	3	C	3.2	4	C	3.1	3	B	3.5	There are significant areas of missing mortar (80m ²), significant displacement of stonework in at least 4 areas, bulging to stonework (2 areas) and multiple cracks ranging from 1mm – 10mm wide.
9	3	B	1.3	4	B	13.1	4	B	1.1	Corroded fixing to rails. Major deformation due to slip circle. Severe corrosion to several posts. Surface corrosion throughout.
22	2	E	1.1	4	B	1.2	4	B	13.1	Surface corrosion throughout. Significant section loss at the base of some posts. Distortion due to slip circle.

INSPECTOR'S COMMENTS

General: The stone retaining wall is 217m long and incorporates a mass gravity wall which is braced by 37 buttresses. The retained height varies from 2.1m to 5.2m.

Foundations: Settlement and rotation of structure due to assumed slip circle failure.

Retaining Wall: Wall was inspected remotely from the south bank using high resolution photographs. The retaining wall has undergone significant settlement and rotation between 140m – 210m due to assumed slip circle failure. There are significant areas of missing mortar (80m²), significant displacement of stonework in at least 4 areas, bulging to stonework (2 areas) and multiple cracks ranging from 1mm – 10mm wide.

Drainage: Condition unknown – assume some blockages.

River Parapets: The paint coatings have failed resulting in surface corrosion throughout. The parapet comprises posts and 3 rails without any infill. The parapet is not compliant with current standards. A small number of intermediate rails are loose due to fixing corrosion. There is severe corrosion to the base of several posts. Major deformation of railings at the centre of the slip circle. Smaller deformation elsewhere. Posts lean towards the river by up to 180mm (11°).

Cumberland Road: Recently resurfaced. Good condition with no apparent defects.

Chocolate Path: Major settlement and undulations between Ch140 – 170m. Minor undulations to the remainder.

Embankment Toe: Tension cracks and significant undulation of footpath indicate a major slip/settlement. A large bank of silt forms the river bank and provides passive resistance to the retaining wall toe. The silt is undulating and presumably changes as the tide rises and falls. There are no obvious signs of deformation or slips, but these would tend to be smoothed out by the varying tide.

River: The River Avon has a very large tidal range. The river is wide with no significant disruptions and no signs of scour to the retaining wall.

Railway: The railway has been tarmacked over between Ch147 – 195m due to significant settlement. The temporary footpath also has a 50mm wide tension crack with a 100mm vertical step due to ground movement (slip circle). The remainder of the railway appears sound.

Railway Railings: The railings are 1.4m high with spiked tops creating a potential impalement risk to cyclists. The paint coatings have failed and there is surface corrosion throughout. There is corrosion and significant section loss at the base of some posts. The railings have been distorted at Ch165m due to ground movement (slip circle).

Highway Retaining Wall: Good condition with no signs of distress or settlement. Light vegetation growing on the wall (Ch130 – 200).

Cumberland Road Railings: New railings installed as part of the AVTM works. Generally in good condition apart from RTA damage to 3 panels.

Name: Steve Whitehead	Signed: <i>S. Whitehead</i>	Date: 25th May 2018
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ENGINEER'S COMMENTS

The Section of Retaining Wall between Ch 81m – 298m is in poor condition with significant defects. A geotechnical investigation is currently underway to determine the cause and propose remedial action.

The river parapet does not comply with current standards and has surface corrosion throughout due to failure of the paint coatings. The railway railings have spiked tops creating a potential impalement risk to cyclists and are also corroded throughout. Consideration should be given to replacing both types of railing once the geotechnical investigation is completed and permanent works to stabilise the Chocolate Path have been completed.

Name: Steve Whitehead	Signed: <i>S. Whitehead</i>	Date: 25th May 2018
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WORK REQUIRED

Ref.No.	Suggested Remedial Work	Priority	Estimated Cost	Action/Work Ordered?
2	Carry out geotechnical investigation to determine cause of failure. Design and implement repairs.	B	TBC	
5	Clean drainage system.	C	£5,000	
9	Replace river parapets (217m).	C	£43,000	
12	Repair undulating paving (160m2) and apply weed killer to footpath. Worse section only.	C	£16k - £100k	
21	Reinstate railway (by others)	C	TBC	
22	Replace railway railings (217m).	C	£32,000	

Name: Steve Whitehead	Signed: <i>S. Whitehead</i>	Date: 6th June 2018
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Wall Name: Chocolate Path Retaining Wall		Road Name: Cumberland Road	
Wall Ref/No : Section B: Ch 81.0m to 298m		Road Ref/No:	
O.S. E 357434	O.S. N 172110	Map Ref: ST57SE	



Photo 01 – Buttress B10 to B14 (Ch135m – 163m)

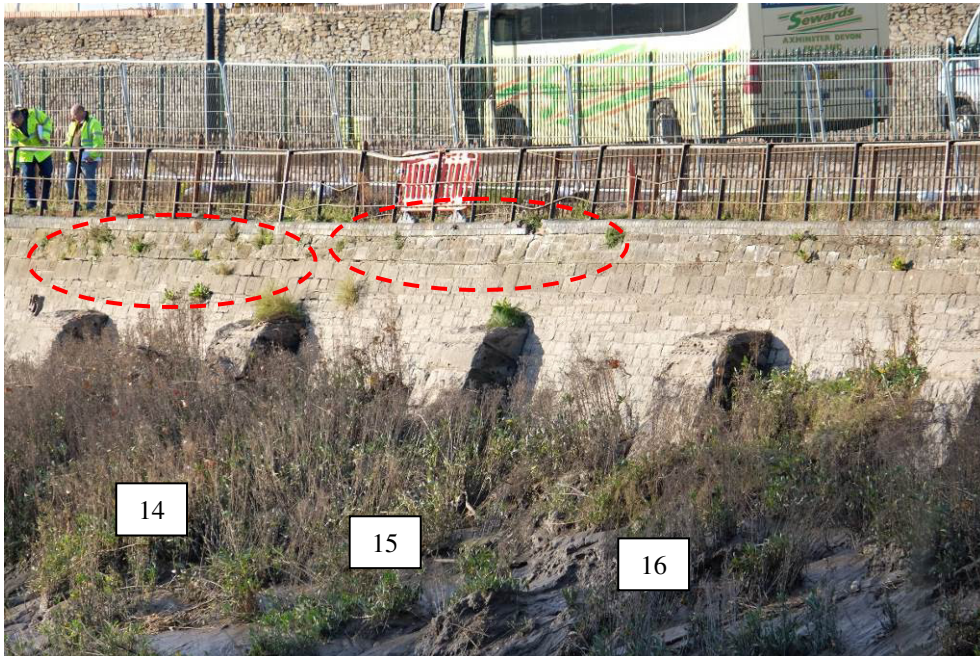


Photo 02 – Buttress B14 to B16 (Ch155m – 180m)

Wall Name: Chocolate Path Retaining Wall	Road Name: Cumberland Road	
Wall Ref/No : Section B: Ch 81.0m to 298m	Road Ref/No:	
O.S. E 357434	O.S. N 172110	Map Ref: ST57SE



Photo 03 – Buttress B16 to B18 (Ch170m – 190m)



Photo 04 – Retaining Wall (Ch 285m – 298m)

Wall Name: Chocolate Path Retaining Wall	Road Name: Cumberland Road	
Wall Ref/No : Section B: Ch 81.0m to 298m	Road Ref/No:	
O.S. E 357434	O.S. N 172110	Map Ref: ST57SE



Photo 05 - Cracks in Wall Near to Buttress B11 (Ch144m)



Photo 06 – Wall Near to Buttress B11 (Ch145m)

Wall Name: Chocolate Path Retaining Wall	Road Name: Cumberland Road	
Wall Ref/No : Section B: Ch 81.0m to 298m	Road Ref/No:	
O.S. E 357434	O.S. N 172110	Map Ref: ST57SE



Photo 07 – Displaced Stonework Between Buttress B13 and B14 (Ch157m – 160m)



Photo 08 – Displaced Brickwork Above Buttress B15 (Ch168m)

Wall Name: Chocolate Path Retaining Wall	Road Name: Cumberland Road	
Wall Ref/No : Section B: Ch 81.0m to 298m	Road Ref/No:	
O.S. E 357434	O.S. N 172110	Map Ref: ST57SE



Photo 09 – Mortar Deterioration above Buttress B17 (Ch180m)



Photo 10 – Major Distortion of Railings at Centre of Slip (Ch170m)

Wall Name: Chocolate Path Retaining Wall	Road Name: Cumberland Road	
Wall Ref/No : Section B: Ch 81.0m to 298m	Road Ref/No:	
O.S. E 357434	O.S. N 172110	Map Ref: ST57SE



Photo 11 – Major Distortion of Railings at Centre of Slip (Ch170m)



Photo 12 – Localised Severe Corrosion to Base of Parapet Post (Ch140m)

Wall Name: Chocolate Path Retaining Wall	Road Name: Cumberland Road	
Wall Ref/No : Section B: Ch 81.0m to 298m	Road Ref/No:	
O.S. E 357434	O.S. N 172110	Map Ref: ST57SE



Photo 13 – Corroded Fixings to Intermediate Rails (Ch210m)



Photo 14 – Cumberland Road (Ch230m)

Wall Name: Chocolate Path Retaining Wall	Road Name: Cumberland Road	
Wall Ref/No : Section B: Ch 81.0m to 298m	Road Ref/No:	
O.S. E 357434	O.S. N 172110	Map Ref: ST57SE



Photo 15 – Works to Cumberland Road (Ch300m)



Photo 16 – General Condition of Chocolate Path (Ch81m to Ch130m)

Wall Name: Chocolate Path Retaining Wall		Road Name: Cumberland Road	
Wall Ref/No : Section B: Ch 81.0m to 298m		Road Ref/No:	
O.S. E 357434	O.S. N 172110	Map Ref: ST57SE	



Photo 17 – Major Deformation of Chocolate Path (Ch160m)



Photo 18 – Major Deformation of Chocolate Path (Ch150 - 160m)

Wall Name: Chocolate Path Retaining Wall		Road Name: Cumberland Road	
Wall Ref/No : Section B: Ch 81.0m to 298m		Road Ref/No:	
O.S. E 357434	O.S. N 172110	Map Ref: ST57SE	



Photo 19 – General Condition of Chocolate Path (Ch215m to Ch306m)



Photo 20 – Railway to the West of the Slip (Ch81m – 147m)

Wall Name: Chocolate Path Retaining Wall		Road Name: Cumberland Road	
Wall Ref/No : Section B: Ch 81.0m to 298m		Road Ref/No:	
O.S. E 357434	O.S. N 172110	Map Ref: ST57SE	



Photo 21 – Tension Crack in Tarmac over Railway (Ch147m – 195m)



Photo 22 – Railway to the East of the Slip (Ch147m – 306m)

Wall Name: Chocolate Path Retaining Wall		Road Name: Cumberland Road	
Wall Ref/No : Section B: Ch 81.0m to 298m		Road Ref/No:	
O.S. E 357434	O.S. N 172110	Map Ref: ST57SE	

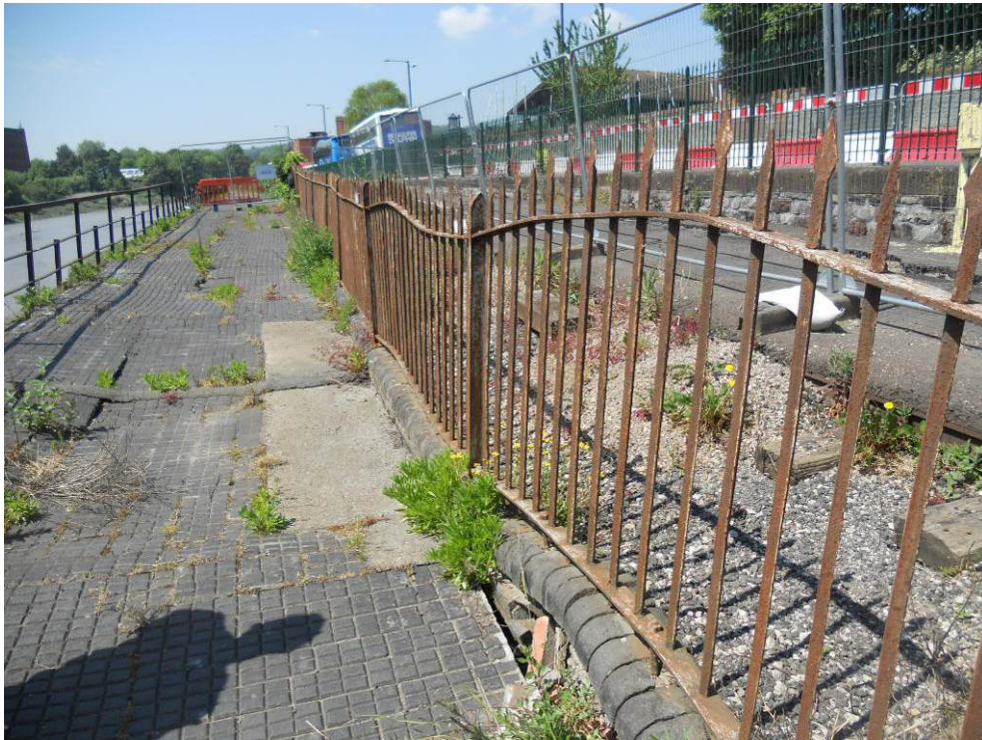


Photo 23 – Major Deformation of Railway Railings Due to Ground Movement (Ch165m)



Photo 24 - Highway Retaining Wall

Wall Name: Chocolate Path Retaining Wall	Road Name: Cumberland Road	
Wall Ref/No : Section B: Ch 81.0m to 298m	Road Ref/No:	
O.S. E 357434	O.S. N 172110	Map Ref: ST57SE



Photo 25 - Cumberland Road Railings – Minor RTA Damage to 3 Panels (Ch220m)

CHOCOLATE PATH INSPECTION

Survey Notes – 24th May & 1st June 2018

WALL DETAIL B – 81.0m to 306.2m	
Item 1, 2 & 4 – FOUNDATIONS, RETAINING WALL AND COPING	
General	The wall was inspected remotely from the south bank using high resolution photographs. The following items were recorded in the CAN Structural Report (April 2012). New defects are highlighted in red.
W	<ul style="list-style-type: none"> • Mortar missing or deteriorated to 3 very small areas (Defect W01, W02, W04).
X	<ul style="list-style-type: none"> • Mortar missing, 1200mm x 800mm (Defect X03).
Y	<ul style="list-style-type: none"> • Numerous random cracks <3mm wide, 10000mm x 1000mm (Defect Y02). • Mortar missing, 1500mm x 1000mm (Y03) and 1800mm x 800mm (Y04).
Z	<ul style="list-style-type: none"> • Numerous random cracks <3mm wide, 10000mm x 1000mm (Defect Y02). • Mortar missing, 2600mm x 400mm (Z04), 500mm x 200mm (Z06).
AA	<ul style="list-style-type: none"> • Mortar missing 430mm x 20mm (Defect AA01), 570mm x 30mm (AA02). • Brickwork displaced vertically by 10mm (AA04).
BB	<ul style="list-style-type: none"> • Numerous diagonal stepped cracks in mortar, <3mm wide (BB01). • Flap valve (BB02). DAMAGED. • Area of loose masonry (NEW DEFECT). • Cracks (BB03) are now 10mm wide (NEW DEFECT).
CC	<ul style="list-style-type: none"> • Mortar missing, 350mm x 10mm (CC01), 400mm x 10mm (CC02), 200mm x 30mm (CC05). • Crack in masonry, 400mm x 1mm (CC03). • Masonry missing, 300mm x 30mm x 90mm (CC04), 300mm x 100mm x 70mm (CC06). • Stones displaced outwards by 25-40mm (NEW DEFECT). • Buttress B11 blocks sliding on joints (NEW DEFECT). • Possible area of minor bulging (NEW DEFECT). • Cracks to side face of Buttress B12 (NEW DEFECT).
DD	<ul style="list-style-type: none"> • Mortar surface degraded, 10000mm x 800mm (Defect DD01). • Vertical crack in masonry, 400mm x 3mm (Defect DD02). • Blocks displaced outwards by 25-40mm (NEW DEFECT). • Blocks displaced outwards by 70mm (NEW DEFECT).
EE	<ul style="list-style-type: none"> • Missing mortar, 2000mm x 400mm (Defect EE02). • Area of horizontal cracks in mortar and mortar surface degraded, 1400mm x 300mm (Defect EE03). • Possible area of bulging (NEW DEFECT). • Crack and open bed joints (NEW DEFECT).
FF	<ul style="list-style-type: none"> • Mortar missing (or very loose), 10000mm x 600mm (Defect FF03). • Area of horizontal cracks in mortar, 300mm x 200mm (Defect FF04). • Brickwork missing, 800mm x 200mm (Defect FF04).
GG	<ul style="list-style-type: none"> • Missing mortar, 870mm x 30mm (Defect GG01). • Area of missing mortar and loose blocks, 800mm x 500mm (NEW DEFECT). • Mortar deterioration, 1000mm x 300mm (NEW DEFECT).
HH	<ul style="list-style-type: none"> • Missing mortar, 1500mm x 20mm (Defect HH01). • Area of random cracks in mortar, 700mm x 500mm (Defect HH02). • Loose block (NEW DEFECT). • Flap valve blocked by vegetation (NEW DEFECT). • Possible diagonal stepped crack (NEW DEFECT).
II	<ul style="list-style-type: none"> • Missing mortar, 10000mm x 600mm (Defect II03).
JJ	<ul style="list-style-type: none"> • Mortar missing, 10000mm x 1000mm (Defect JJ02).

KK	<ul style="list-style-type: none"> • Mortar missing, 10000mm x 1000mm (Defect KK01).
LL	<ul style="list-style-type: none"> • Mortar missing, 10000mm x 1000mm (Defect LL01).
MM	<ul style="list-style-type: none"> • Mortar surface degraded (Defect MM02). • Crack 200mm x 2mm (Defect MM03).
NN	<ul style="list-style-type: none"> • Mortar surfaced degraded, 2000mm x 300mm (Defect NN03). • Brickwork missing, 170mm x 100mm x 40mm (Defect NN04). • Area of horizontal cracks in mortar, 2000mm x 300mm (Defect NN05).
OO	<ul style="list-style-type: none"> • Mortar missing, 10000mm x 1000mm (Defect OO01).
PP	<ul style="list-style-type: none"> • Mortar missing, 10000mm x 1000mm (Defect PP01).
QQ	<ul style="list-style-type: none"> • Mortar missing, 3000mm x 30mm (Defect QQ03). • Area of horizontal cracks in mortar, 2000mm x 400mm (Defect QQ04).
Item 8 & 9 – RIVER PARAPET	
General	<p>The paint coatings have partially failed and there is surface corrosion throughout. Railings are 980mm high with intermediate rail at 530mm and bottom rail at 220mm.</p> <p>Main Posts are 60 x 25mm I sections @ 2135mm spacing.</p> <p>Intermediate posts to lower rails are 50 x 30mm I sections. Top rail is 60x60mm angle.</p> <p>Intermediate and bottom rails are 45x15mm angles.</p>
95m	Distortion to intermediate and bottom rails.
113m	Corrosion at base of post.
130m	Leaning towards railway by $5/900\text{mm} = 0.3^\circ$.
140m	Corrosion to base of post.
150m	Leaning towards river by $80/900\text{mm} = 5.1^\circ$.
159m	Corrosion to base of post.
165m	Major deformation to top rail in horizontal and vertical direction. Vertical distortion to intermediate and bottom rails.
168m	Leaning towards railway by $180/900\text{mm} = 11.3^\circ$. Spalling to brick copings due to post movement.
170m	Less deformation to top rail. Intermediate rail deformed.
180m	Deformation to bottom rail. Leaning towards railway by $85/900\text{mm} = 5.4^\circ$.
200m	Leaning towards railway by $40/900\text{mm} = 2.5^\circ$.
209 - 213m	Loose intermediate rails.
220m	Leaning towards railway by $15/900\text{mm} = 1.0^\circ$.
270m	Leaning towards river by $10/900\text{mm} = 0.6^\circ$.
286m	Corrosion to post base.
300m	Leaning towards river by $15/900\text{mm} = 1.0^\circ$.
Item 10 – CUMBERLAND ROAD	
General	Recently resurfaced as part of the AVTM works. No apparent defects.
120 210m	Temporary lane closure in place.
153m	Highway gully.
200m	Highway gully.
250m	Start of footpath.
295m	Gully.

300m	Bus shelter being installed.
Item 12 - CHOCOLATE PATH	
94m	Reinstatement. Weeds and grass growing on footpath from 60m onwards.
117m	Large tarmac reinstatement. Undulations but relatively minor. Gap between pavements and river coping is 30mm horizontally and 70mm vertically.
130m	Gap between pavements and river coping. Tarmac reinstatement.
142m	Major undulations and backfall towards the railway. Vegetation to both channels.
153m	Major steps between pavements. Most extreme at Ch 163m.
155 – 160m	Cracks and steps between pavements.
170m	Path deformation is visible but less than previous section.
200m	Footpath has levelled out again.
210m	Tarmac reinstatement. Footpath is fairly level. Vegetation growth in channels.
257m	Cracking and pavements raised relative to river coping.
Item 21 - RAILWAY	
81m – 130m	Railway alignment appears good. Lots of vegetation growing in ballast. Otherwise, no apparent defects.
130m	Temporary tarmac footpath diversion starts.
147m	End of tension crack.
160m	Tension crack in footpath. Horizontal 40mm. Vertical = 80mm
170m	Tension crack in footpath. Horizontal 50mm. Vertical = 100mm
180m	Tension crack in footpath
183m	Tension crack against highway wall - 50mm wide.
195m	End of tension crack – against highway wall.
215m	Temporary tarmac footpath diversion starts.
306.2m	Railway alignment appears good. No apparent defects.
Item 22 – RAILWAY RAILINGS	
General	The paint coatings have failed and there is surface corrosion throughout. The railings are 1.4m high with spiked top. This is a potential impalement risk especially to cyclists.
140m	Railings start to dip down due to settlement/slip circle between 140m and 200m
162m	Arching of coping and significant deformation of railings.
165m	Leaning towards railway by 90/900mm = 5.7°.
170m	Leaning towards railway by 90/900mm = 5.7°.
172m	Major corrosion to post.
190m	Leaning towards railway by 75/900mm = 4.8°.
198m	Major corrosion to post.
200m	Railings start to dip down due to settlement/slip circle between 140m and 200m
208-213m	Gap in railings due to footpath diversion.
Item 23 – HIGHWAY RETAINING WALL	
81 - 130m	The retaining wall between has been repointed as part of the AVTM works. Good condition with no signs of distress or settlement.

	<ul style="list-style-type: none"> • Ch130m - Height on railway side = 750mm, Height on highway side = 100mm. • Ch150m - Height on railway side = 500mm, Height on highway side = 250mm • Ch160m – Cracked block in slip area but not necessarily structural. • Ch173m – Cracked block in slip area but not necessarily structural.
130 - 200m	Masonry is slightly weathered but there are no signs of distress or settlement. There is some light vegetation growing on the wall.
200 - 306m	<p>Good condition with no signs of distress or settlement.</p> <ul style="list-style-type: none"> • Ch200m- Height on railway side = 450mm, Height on highway side = 200mm. • Ch250m - Height on railway side = 880mm, Height on highway side = 250mm.
Item 24 – CUMBERLAND ROAD RAILINGS	
General	New railings installed as part of the AVTM works. Generally in good condition.
220m	RTA damage to 3 of the new panels.

Appendix C. Consideration of Risks of Structure in Current State

Section B of the River Retaining Wall and Chocolate Path is in poor condition at present. Settlement of the path and rotation of the wall structure were noted in a 70m long section, between chainages 140m and 210m approximately. Based on the data available at present from historical information, monitoring and site inspections, it is thought that settlement, rotation and lateral movement of the River Wall, Chocolate Path and the Heritage Railway has occurred since 2012, and more likely since 2014.

The settlement resulted in a broken and uneven surface and tilted railings that make the path unsuitable for use. In December 2016, the settlement area of Chocolate Path was closed with pedestrians and cyclists being diverted through a tarmac diversion path over the Harbour Railway Line. In December 2017, tension cracking was observed in the diversion route tarmac path resulting in closure of the diversion route, which meant closure of the Chocolate Path and users being diverted onto Cumberland Road between Vauxhall Bridge and Avon Crescent.

Other defects observed comprise tilting of the path, seepage between some of the buttresses, displacement of stonework and cracking to the River Wall, bulging, bed failure and mortar degradation to the upper part of the wall and the buttresses.

The limited information available to date suggests that the most likely failure process that have occurred / is occurring is one or a combination of:

- Sliding or bearing capacity failure of the River Wall founded on weak clay soils.
- Internal erosion of backfill materials forming voids which collapse to the rear of the wall.
- A deep-seated slip through the weak clay soils behind and beneath the river retaining wall.

From preliminary assessments, it is thought that the most probable cause of all three types of failure is increased hydrostatic pressure behind the river wall, due to flood water over topping of the wall at high tide and percolating through the railway ballast into the backfill material. Also contributing to increased pressures are non-functioning drainage and non-functioning tidal flap valves. Due to defective or inadequate back of wall drainage, the level of water in the New Cut falls more quickly than the water level in the retained soil resulting in a large imbalance between the water pressure behind and in front of the river retaining wall. This additional hydrostatic pressure increases the destabilising forces acting on the retaining wall and is likely to be the cause of the movement. Due to the number of uncertainties regarding the retaining wall and foundation construction, the nature of movement on the front face of the wall, and geology at the site, the cause of movement is inconclusive and other mechanisms cannot be ruled out at this stage to settlement of the masonry river wall, path and railway.

The current risks posed by Section B of the River Wall and Chocolate Path at present are as follows:

- Further Deformation of Structure

Forward movement of the wall could cause further settlement to the rear and the opening of tension cracks due to loss of support. Surface water run-off and drainage water could collect in the area of settlement, potentially raising ground water pressures and placing additional loads on the wall. This may result in the wall being weakened, cracks increased and masonry joints opened.

Monitoring data indicates that settlement and lateral movement of the wall will continue, so the likelihood of further deformation of Section B of the River Wall and Chocolate Path is certain.

The wall movement and deformation could continue to the point of partial collapse leading to lane closures in Cumberland Road and / or to a complete failure / collapse scenario. See 2 and 3 below.

- Partial Collapse leading to lane closure in Cumberland Road

Further movement increases the likelihood that larger areas of the wall will be affected, and increases the risk of partial collapse of Section B of the River Wall and Chocolate Path. Partial collapse of the wall could lead to the undermining of the Cumberland Rd retaining wall which in turn threatens the stability of Cumberland Road.

Movement may eventually result in a collapse of the wall, or may continue slowly until reaching a state of equilibrium. However, even if a state of equilibrium is reached any future increases in loads or changes to site conditions may reactivate movement causing failure to the river wall.

There is no evidence of cracks on Cumberland Rd surfacing and no distress to the Cumberland Road retaining wall has been noted, but given the geometry of the movement observed, future ground movement to Cumberland Rd cannot be ruled out. Therefore, the likelihood of partial collapse leading to a lane closure in Cumberland Road is high and the consequences of partial collapse cannot be considered to be low.

- Collapse of Structure

Different factors can lead to the retaining wall failure / collapse, including changes in geometry or loading acting on the path and wall, water pressure or material degradation.

Collapse of structure could occur in case of increase in vertical live loading due to heavy traffic and parked vehicles on the South side of Cumberland Road (it should be noted that there is no evidence that loads have increased), or changes in horizontal loading due to increased earth pressure or reduced passive resistance due to loss of support at the toe due to scour.

The River Wall may become unstable due to an accumulation of water pressure. This could be due to several factors;

- The flap valves in the wall not functioning properly.
- Blocked drainage for the Harbour Railway and/or Cumberland Road, causing an increase in groundwater pressure.
- Increased flow of water into the area of instability and backfill materials due to settlement, presence of tension cracks, and voids in the backfill (in case of internal erosion).
- High spring tides over topping the wall and draining into the backfill via the railway ballast.
- Water may reach a slip plane (if present) reducing the shear strength along the plane.

Deterioration of masonry units or mortar could also be contributing to instability of the wall and leading to failure or collapse of structure. Causes of deterioration include:

- Freeze/thaw action.
- Vegetation growth.
- Wash out due to seepage through the wall or scour action.
- Deterioration of the foundation structure which is currently of unknown construction.
- Wash out of fines from the backfill material due to increased groundwater pressures causing voids.

C.1 Risk

The structure is considered to be an “Immediate Risk Structure” representing an immediate and unacceptable safety risk to the public. Our understanding is that the river wall can be considered to have failed and movement will be ongoing and continuous until stabilisation is undertaken.

Partial or complete collapse of the wall at Section B could happen at any time, but it is anticipated that the rate of movement would increase with further visible signs of distress apparent before an event of this kind.

Collapse of the River wall would have significant consequences that may include: serious injury or death to users; loss of heritage structure; damage to Cumberland Road; need for diversion to the AVTM bus route and unplanned traffic disruption.

It should be noted that this risk is greater at times of wet weather and high tides. Some mitigation may be achieved through temporary drainage improvements but consideration should also be given to increased inspection frequencies during these periods.

Appendix D. Sub-standard Structure Summary

The form set out below provides a model for recording the progress of the assessment process in accordance with Clause 2.12. The form should be used to record any changes in the status of the Sub-standard Structure.

Structure Name: River Wall and Chocolate Path – Section B

Structure Ref. No.: Not known.

Assessment/ Review	Stage:	First Review				
	Date:	June 2018				
	Report Reference:	R002				
	Assessed capacity:	N/A				
	Sub-standard status:	Sub-standard				
Interim Measures Feasibility Assessment	Date:	June 2018				
	Is the structure an Immediate Risk Structure or a Low Risk Provisionally Sub-standard Structure?	Immediate risk				
	Is the structure monitoring- appropriate?	No				
Interim Measures Proposal	Date:	June 2018				
	Recommendations:	Continued closure of path, adjacent railway and parking bays increased monitoring.				
Interim Measures Approval	Date:					
	Approval/Rejection:					
Actions	Implementation date:					
	Details/ref:					
	Provisional finish date for monitoring:					
	Removal date:					
Documentation Date	Form used:					
Additional Notes						

Appendix F. Interim Measures Feasibility Assessment for Retaining Walls

Report Ref: 673846.CV.73.01/R002/A

Prepared by: Rafael Ramirez Romero

1. GENERAL DETAILS

1.1. Structure Name: **River Wall and Chocolate Path – Section B**

Assessment reference: **Not assessed.**

Structure Ref. No.: **Not known.**

1.2. Location, route and county/area: The Chocolate Path runs along the northern bank of the River Avon New Cut channel in Bristol. The Chocolate Path is approximately 1km long, starting from the western end of Cumberland Road (where it joins Avon Crescent) going eastwards towards Cumberland Road Rail Bridge, where the railway and path turn under the road and into the Bristol Floating Harbour. The Bristol Harbour Railway and Cumberland Road are located adjacently to the path on the north side. Cumberland Road is a wide highway with parking bays either side raised above the railway by a masonry retaining wall. Section B is a 217m long section starting at approximately Chainage 81m (buttress 1) and ending at approximately chainage 298m (buttress 37), and situated at grid reference 357434, 172110.

1.3. Assessing Organisation: n/a

Assessed by: n/a

Checked by: n/a

Assessment date: n/a

1.4. Estimated cost of permanent strengthening/replacement works: Estimated costs for strengthening or replacement works cannot be provided until further information is available and a detailed study on stabilisation options has been completed.

2. DEFORMATION DESCRIPTION:

2.1. Bulging: Present (areas of bulging to the River Wall)

2.2. Tilting: Present (the Chocolate Path is tilting northwards)

2.3. Sliding: Present (possible sliding of some stone blocks on the wall and possible sliding failure mechanism of the wall)

3. EXTENT OF DEFORMATION:

- 3.1. Height and width of deformation: Multiple areas of deformation noted with variable height and width along the full length of Section B.
- 3.2. Maximum retaining height of wall: 5.2m
- 3.3. Average retained height of wall: 3.65m
- 3.4. Deviation from line vertical: Unable to determine deviation of the river wall, however river parapet posts lean towards the river by up to 180mm (11°).

4. HISTORY:

4.1. General Inspection or Principle Inspection references to deformation: The January 2018 “Chocolate Path River Wall Stability – Preliminary Assessment of Deformation” report records a number of defects noted in Section B of the river wall and the Chocolate Path. The main defects are: settlement of the Chocolate Path resulting in a back fall towards the railway, settlement and outward displacement of the retaining wall, distortion and buckling of the river parapet railings, multiple random cracks in the river wall, possible bed failure and sliding of two blocks forming the top of Buttress No. 11, areas of outward displacement of stonework to the river wall, blocked or broken flap valves to drainage, exposed footing to Buttress No. 22 and 23, and mortar deterioration and open bed joints to the upper part of the wall.

The May 2018 Section B General Inspection forms record new defects observed including areas of mortar missing and deterioration, areas of bulging, appearance of new vertical cracks, displacement of stone blocks and loose blocks in the river wall.

5. CONSIDERATION OF RISK POSED BY STRUCTURE IN CURRENT STATE

5.1. Discussion

The likelihood of partial or complete collapse of Section B of the River Wall and Chocolate Path is considered to be high. The expected failure mode would be one or a combination of a deep-seated slip through the weak clay soils behind and beneath the river retaining wall, sliding or bearing capacity failure of the River Wall foundations, and internal erosion of backfill materials forming voids which collapse to the rear of the wall. Consideration of Risks enclosed within Appendix C of this report considers the River Wall to be an “Immediate Risk Structure”.

5.2. Is the structure an Immediate Risk Structure? Yes, Section B of the River Wall and Chocolate Path is considered to represent an immediate and unacceptable safety risk to the public.

5.3. Is the structure a Low Risk Provisionally Sub-standard Structure? No, the structure is not a Low Risk Provisionally sub-standard.

6. APPROPRIATENESS OF MONITORING

6.1. Discussion

The River Wall is displaying evident signs of distress and the early signs of failure are already present. When following the flowchart of the BD79 process (refer to Appendix A), the wall is deemed to be an immediate risk.

At present there are cracks on the Chocolate Path and the tarmacked diversion path over the Harbour Railway, and signs of distress in the river wall that indicate some structural movement. Therefore, under Clause 5.3 of BD79/13, fortnightly inspections (including survey of existing and proposed monitoring pins) of the Chocolate Path and River Wall are to be carried out while stabilisation solutions are designed and implemented.

An Emergency Response and Communication Plan should be developed immediately to accompany the monitoring and any interim measures that are chosen.

6.2. Is the structure monitoring-appropriate? Yes, if proposed measures are implemented. However stabilisation will be required.

7. OPTIONS FOR LOAD MITIGATION INTERIM MEASURES

The following options have been considered

7.1. Option 1 -Current measures implemented

The path has been closed for the full length, heritage railway line has been closed and parking bays on Cumberland Road adjacent to the affected area have been closed.

operational and cost implications; Pedestrians and cyclists haven diverted to Cumberland Road.

other implications; Ongoing issues with trespassing onto the closed Chocolate path and associated risks.

7.2. Option 2 – Load Restrictions / Lane Closures on Cumberland Road

Additional measures may be considered to further reduce the load on the wall. However, live traffic is located approx. 10m from the wall face – it is considered that current movement is primarily occurring under permanent loading. Traffic Management measures may be considered to mitigate safety risks for road users, but may not impact on risk of wall collapse.

operational and cost implications; Cumberland Road is a busy route for access to city centre. Diversion of traffic would potentially cause traffic delays / congestion and require signage on the diversion route.

Cumberland Road is used for buses and will be used by the Metrobus. Lane / road closures would impact on these services.

8. OPTIONS FOR MONITORING INTERIM MEASURES

The affected area is already undergoing monitoring with regular surveys to observe settlement. Inclined meters have been placed in boreholes around the area to observe lateral movement. Additional intrusive geotechnical investigation is planned.

The options for monitoring cover additional measures to be implemented prior to and during the geotechnical works. These may also be carried forward after site investigation.

8.1. Option 1 – Continue with current Class 2 monitoring regime

Regular surveys. Fortnightly site visits by BCC / CH2M staff.

Operational and cost implications; Cost of staff time and surveyor visits. Operational risk for Cumberland Road should area of movement spread.

8.2. Option 2 - Continue with Class 2 current monitoring regime, with additional fortnightly site inspection by Geotechnical Engineer.

It is proposed that a Geotechnical Engineer undertake a fortnightly site inspection for any observable increase in movement of the wall, path, railway and Cumberland road. The aim being to increase the possibility of early identification of impact on the adjacent highway should the area of movement spread.

It is proposed that a Drainage Engineer review options for temporary improvements of drainage, after the upcoming drainage survey undertaken. The aim being to minimise any increase in pressure on the wall that may occur from ground water and surface water build up.

Operational and cost implications; Cost of staff time and surveyor visits. Operational risk for Cumberland Road should area of movement spread.

9. RECOMMENDED OPTIONS FOR INTERIM MEASURES

7.1. Recommended Load Mitigation Interim Measures:

It is not recommended to impose any additional load mitigation measures other than those in place.

7.2. Recommended Monitoring Interim Measures:

Monitoring Interim Measures Option 2 (Class 2 monitoring) is recommended. Additional monitoring requirements will be considered after the upcoming site investigation.

Appendix G. Proposal for Interim Measures

1. GENERAL DETAILS

1.1. Structure Name: River Wall and Chocolate Path – Section B

Assessment reference: Not assessed.

Structure Ref. No.: Not known.

1.2. Location, route and county/area: The Chocolate Path runs along the northern bank of the River Avon New Cut channel in Bristol. The Chocolate Path is approximately 1km long, starting from the western end of Cumberland Road (where it joins Avon Crescent) going eastwards towards Cumberland Road Rail Bridge, where the railway and path turn under the road and into the Bristol Floating Harbour. The Bristol Harbour Railway and Cumberland Road are located adjacently to the path on the north side. Cumberland Road is a wide highway with parking bays either side raised above the railway by a masonry retaining wall. Section B is a 217m long section starting at approximately Chainage 81m (buttress 1) and ending at approximately chainage 298m (buttress 37), and situated at grid reference 357434, 172110.

1.3. Assessing Organisation: n/a

Assessed by: n/a

Checked by: n/a

Assessment date: n/a

1.4. Estimated cost of permanent strengthening/replacement works: Estimated costs for strengthening or replacement works cannot be provided until further information is available and a detailed study on stabilisation options has been completed.

2. PROPOSED INTERIM MEASURES

2.1. Summary of assessment progress.

No assessment has been undertaken to date. Due to safety concerns, it is unclear if access is possible for the intrusive investigation that would be required to confirm depth and thickness of wall to allow an assessment.

2.2. Summary of feasibility of options for Interim Measures (details attached as an appendix).

Class 2 monitoring with fortnightly inspection. Refer to Appendix F.

It is recommended that BCC develop a transport plan for any immediate road or lane closure at Cumberland Road, including provision of access for businesses and local residents.

2.3. Summary of Recommended Load Mitigation Interim Measures (details attached as an appendix, if appropriate) including maximum duration and date for formal review.

Continued implementation of path closure, railway closure and closure of adjacent parking bays.

2.4. Summary of Recommended Monitoring Interim Measures, if appropriate (refer to Monitoring Specification, attached as an appendix) including maximum duration and date for formal review.

Refer to Appendix F, monitoring measures to be reviewed after upcoming site investigation.

2.5. Proposal made by:

.....10/07/18.....

Date:

..... 

Assessment Team Leader

.....11/7/18.....

Date:

..... 

Principal for assessing organisation

3. ACCEPTANCE OF INTERIM MEASURES:

3.1. Appraisal of recommended Load Mitigation Interim Measures and Monitoring Interim Measures (if appropriate)

..... Date:

..... TAA and/or Overseeing Organisation ¹

..... Date:

..... Structures Group Manager ²

3.2. Acceptance of Load Mitigation Interim Measures (if required ³)

..... Date:

..... Highway (or Roads) Authority (if different from TAA)

3.3. Instruction to implement Interim Measures

Interim Measures to be implemented ⁴:

..... Date:

..... Overseeing Organisation and/or Structure Owner

[Additional Signatories ⁵]

Notes:

- ¹ TAA and/or Overseeing Organisation to sign to confirm that recommended Load Mitigation Interim Measures and Monitoring Interim Measures have been appraised and their technical efficacy agreed.
- ² Structures Group Manager to countersign for Category 3 structures. (England only).
- ³ Highway (or Roads) Authority acceptance is only necessary where the accepted interim measures affect the traffic on the highway network.
- ⁴ Overseeing Organisation and/or Structure Owner to instruct which option for interim measures is to be implemented and to sign to endorse action to be taken.
- ⁵ Additional signatories may be required to permit additional relevant parties to approve, endorse or instruct action to be taken, for example, where the responsibility for the implementation and/or the cost of interim measures is shared between parties. Such requirements shall be agreed between the relevant parties.

Appendix H. Monitoring Specification

H1.1 The monitoring regime for **River Wall and Chocolate Path – Section B** is as follows:

(1) Background

The relevant information included in the Interim Measures Feasibility Assessment (see Appendices E and F) is as follows:

(i) Assessment Findings. N/A

(ii) Deterioration of Structure. The January 2018 “Chocolate Path River Wall Stability – Preliminary Assessment of Deformation” report records a number of defects noted in Section B of the river wall and the Chocolate Path. The main defects are: settlement of the Chocolate Path resulting in a back fall towards the railway, settlement and outward displacement of the retaining wall, distortion and buckling of the river parapet railings, multiple random cracks in the river wall, possible bed failure and sliding of two blocks forming the top of Buttress No. 11, areas of outward displacement of stonework to the river wall, blocked or broken flap valves to drainage, exposed footing to Buttress No. 22 and 23, and mortar deterioration and open bed joints to the upper part of the wall.

The May 2018 Section B General Inspection forms record new defects observed including areas of mortar missing and deterioration, areas of bulging, appearance of new vertical cracks, displacement of stone blocks and loose blocks in the river wall.

(iii) Service Performance. Path is closed due to concerns over stability

(iv) Anticipated Failure Mode(s). The expected failure mode would be one or a combination of a deep-seated slip through the weak clay soils behind and beneath the river retaining wall, sliding or bearing capacity failure of the River Wall foundations, and internal erosion of backfill materials forming voids which collapse to the rear of the wall.

(2) Monitoring Plan

The planned monitoring regime is as follows:

(i) Visual Observations. Site inspection of Chocolate Path and Cumberland road at fortnightly intervals. Note any signs of visible movement.

(ii) Measurements. Survey of settlement to be undertaken at fortnightly intervals.

(iii) Photographs. Take photographs of any signs of further movement or deformation

(iv) Other Parameters. None

Refer to extract of GI specification for additional details on proposals for survey monument installations.

(3) Monitoring Frequency

The frequency of visual monitoring shall be fortnightly. Surveying fortnightly.

(4) Monitoring Trigger Levels

Triggers or warnings requiring action are:

any cracking or deformation in the carriageway of Cumberland Road;

any tilting or settlement of Cumberland Road retaining wall;

any masonry falling from the bulging section of the river retaining wall;

any signs of new local collapse or tension cracks;

Escalation in rate of rate movement/ settlement.

(5) Monitoring Trigger Actions

Should any trigger level be reached this should be reported immediately following the Emergency response and Communication Plan. A review of the monitoring and traffic management measures should then be carried out immediately and any actions implemented as soon as possible.

(6) Recording and Reporting

The recording and reporting of monitoring activities should be made by the inspector at the time of inspection.

(7) Review of Monitoring Requirements

A review of the monitoring regime will be undertaken after the upcoming intrusive investigation.

(8) Protocol for Monitoring, Reporting and the Escalation of Decision Making

Survey data of monitoring pins shall be provided to BCC Project Manager and CH2M Geotechnical Engineer on a fortnightly basis in current agreed format. CH2M Geotechnical Engineer will provide a brief monitoring report including photographs and basic measurements on a fortnightly basis.

In the event of trigger level being reached, a meeting shall be arranged by the BCC Project Manager – attended by BCC highways and structures managers, CH2M Geotechnical and Structural Engineers.

(9) Emergency Response and Communication Plan

In the event of any significant failure of the wall that threatens the integrity of the carriageway or presents any danger to the public, contact Matthew Ball, Engineer, Bridges & Highway Structures, Bristol City Council, Tel: 07771 941884 (matthew.ball@bristol.gov.uk).

Also Chris Dooley, Structures Manager (chris.dooley@bristol.gov.uk) and Shaun Taylor, Highways Manager (shaun.taylor@bristol.gov.uk), shall be informed.

A lane or road closure shall be arranged immediately and an immediate interim measures review shall be carried out.

H1.2 The monitoring Specification has been developed using the May 2018 General Inspection and the July 2018 Monitoring Review.

H.1 Extract from Ground Investigation Specification

Phase 1a will comprise the following;

- 5 No. shallow trenches, either excavated by hand or by mechanical means to expose the ground which the Harbour Railway infrastructure is founded on and deformation features. The installation of a series of survey monuments shall be placed within the shallow trenches for future monitoring.

Section 'S1.16.10 Settlement Monuments':

A proprietary monitoring system to identify any significant movement within the Chocolate Path is to be established during the works. The type and method of installation of the survey monuments is to be approved by the Investigation Supervisor in advance of the Works commencing.

'Schedule 2: Exploratory holes':

Trench to expose the ground which the Harbour Railway Infrastructure is founded on and deformation features. Survey monument to be constructed within the trench.

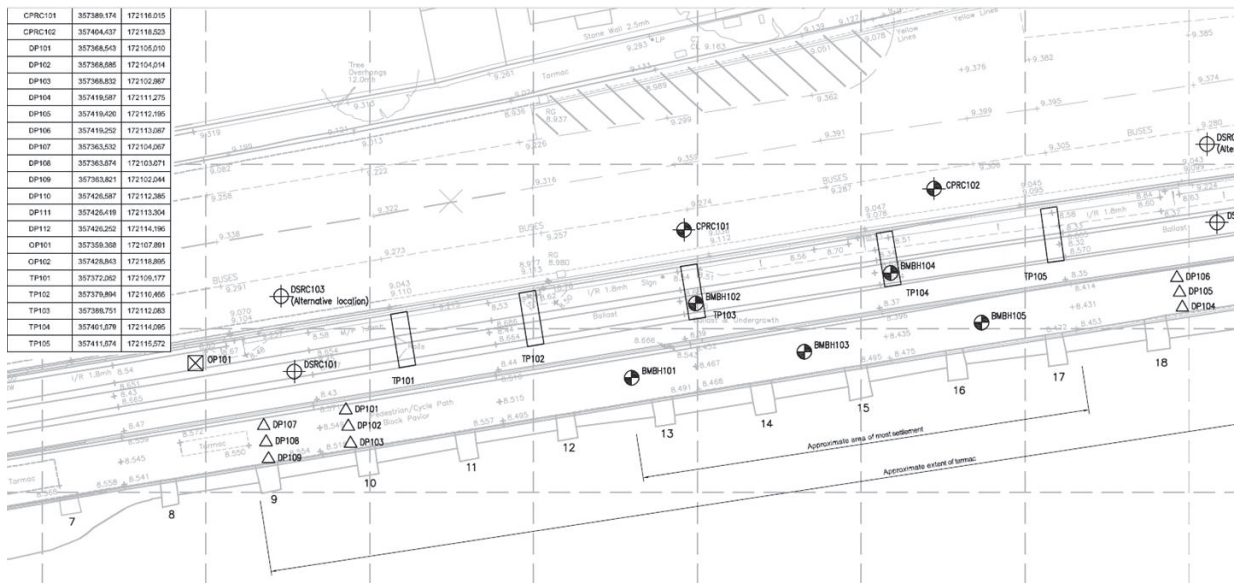


Figure H-1 drawing no. 673846.CV.01-09 showing the location of the slit trenches TP101 to TP105

Appendix J. Immediate Risk Structure: Emergency Action Record of Agreement/Incident Log **(to be used as required)**

Immediate Risk Structure

Proposals for Emergency Action

Record of Agreement/Incident Log

Date:

Structure Name	River Wall and Chocolate Path – Section B
Roads affected	Cumberland Road
Comment on BD 79 procedures	
Brief description of need	
Emergency Action (include timescale for undertaking action)	
Additional comments (include a brief explanation as to why the particular emergency action was chosen)	

The above emergency proposals are agreed by:

Signature:	Signature:
Name:	Name:
Representing:	Representing:
Date:	Date:

Signature:	Signature:
Name:	Name:
Representing:	Representing:
Date:	Date: