



Cowley Bridge Jn – Demountable Flood Defence

Mark Dennis Howells FdEng MPWI MIAM

Senior Asset Engineer (Drainage & Lineside)

South & West Wales PWI Section Meeting – 12th April 2021



The Issue...



Copyright – Phil Mingo/Pinnacle – 2012 flooding

Background:

Cowley Bridge Junction is located on the Great Western main railway line from London Paddington to Plymouth, situated approximately 2.5km north of Exeter City centre.

The railway junction forms the connection to the Barnstaple branch line and is named after the road bridge that carries Cowley Hill road (A377) over the railway at this location.

Flooding occurs at Cowley Bridge when the two culverts passing beneath the railway corridor, just north of the junction, become overwhelmed with floodwater (from the Exe Backwater and the River Exe). This causes flooding to the railway corridor, leading to washout of track ballast and damage to railway infrastructure assets; ultimately contributing to delays to, or the suspension of, all train services through this area.

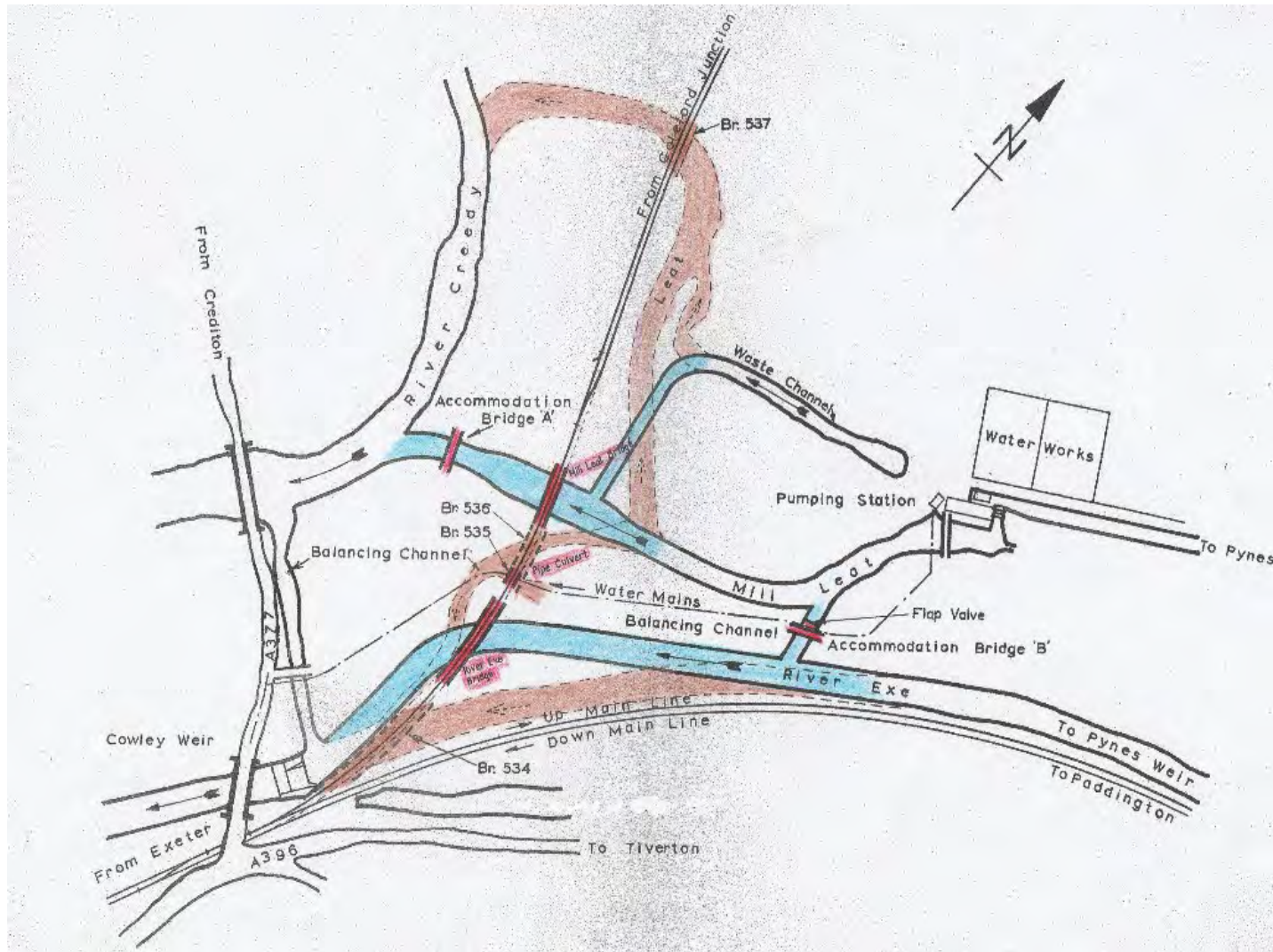
This project has seen the installation of a demountable flood defence at Cowley Bridge Jn.

Flooding and flood relief schemes aren't new...



October 1960 – Picture courtesy of Dick Watts

Flood Relief schemes aren't new...



Exeter Flood Relief Scheme – 1966, plan courtesy of Dick Watts

Flood Relief culverts aren't new, 1896... (125 years)

[-3.5476910,50.7476339] -> DAC-173M+1163.6 [-3.5475426,50.7476107] 10.8
21 Oct 2020 at 13:35:16



Background:

The demountable defence forms an integral part of the Exeter City Flood Defence Scheme (FDS) which is a £15 Million project being delivered by the Environment Agency and partners including Devon County Council and Exeter City Council.

A phased approach was taken, phase 1 which is focused on the area by Exwick Weir and the Quays area was commenced in 2014 and now completed with phase 2 currently ongoing.

As part of phase 2, the flood modelling completed highlighted a significant hole in the proposed defences and an undesirable exceedance flow path during events above the 1 in 50 Annual Estimated Probability (AEP) threshold.

The hole is located immediately downstream of Cowley Weir on the River Exe and permits the Exeter to Bristol and Barnstaple branch to pass beneath the A377 highway on the final approach to Exeter St. David's station.

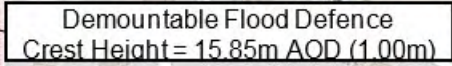
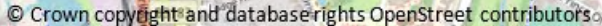
Background Video – Exeter FDS:

<https://www.gov.uk/government/publications/exeter-flood-defence-scheme/exeter-flood-defence-scheme>

Background:

Flood Risk Assessment:	AECOM
Demountable Defence Design:	Crouch Waterfall
Track Design:	Balfour Beatty Rail
Statutory Authority:	Environment Agency
Demountable Defence Supply:	Flood Control International
Principal Contractor:	Balfour Beatty Rail
Sub Contractors:	MMP Total Rail Solutions Protech Rail Engineering
Client:	Network Rail
Sponsor:	Route Asset Management Team (Mark Howells)
Project Duration:	12 months (May 2019 to May 2020).
Project Budget:	£0.5M
Project Spend:	£0.48M

All images by the author unless stated otherwise



Copyright – Crown Copyright/AECOM - 2020

Background:

Through detailed flood modelling the defence height has been set at 15.580 MAOD.

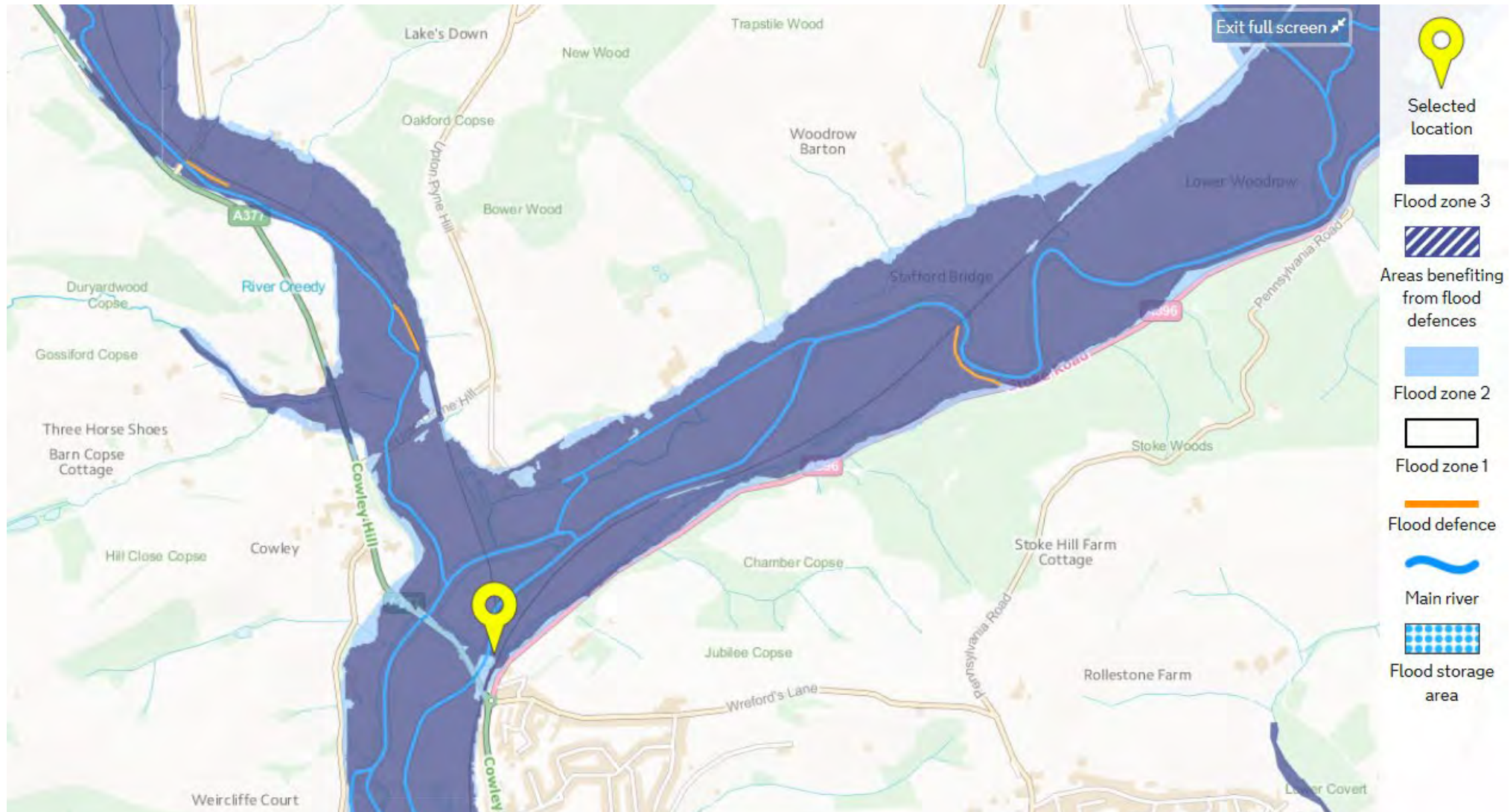
This height is a careful balance between the need to protect the flood cell immediately to the South of the defence in addition to ensuring no additional flood risk is generated for other flood cells or infrastructure.

To ensure resilience there is 275mm of passive provision for a further set of boards to be fitted in the future should it be required. As you can see from the section drawings the columns aren't designed to accept a further board at the present time and new columns would need to be fabricated.

The depth of piles and ground beam has also been designed to accommodate the larger moments imposed by the hydrostatic head of water in the case another row of boards are provided, this is to prevent overturning during operation.

To fit the other board, it would be necessary for a further iteration of the Exeter FDS and the height of the defences raised still further.

Environment Agency Flood Risk Mapping: EA Flood Mapping



Copyright – Environment Agency - 2020

Project History & Facts:

Following initial correspondence with the Environment Agency (EA) via our dedicated liaison officer (Chris Stratton) it was determined that the existing Aqua dams (water filled portable dams) were likely to be inadequate in flood events greater than

A flood risk assessment was produced ahead of a full design in accordance with NR/L2/CIV/003 in addition to a full track design in accordance with NR/L2/TRK/2102 and NR/L2/TRK/2047.

Flood Risk Assessment (FRA)

Produced in accordance with the current National Planning Policy Framework (NPPF) and the associated Planning Practice Guidance (PPG).

Flood Risk Activity Permit (FRAP)

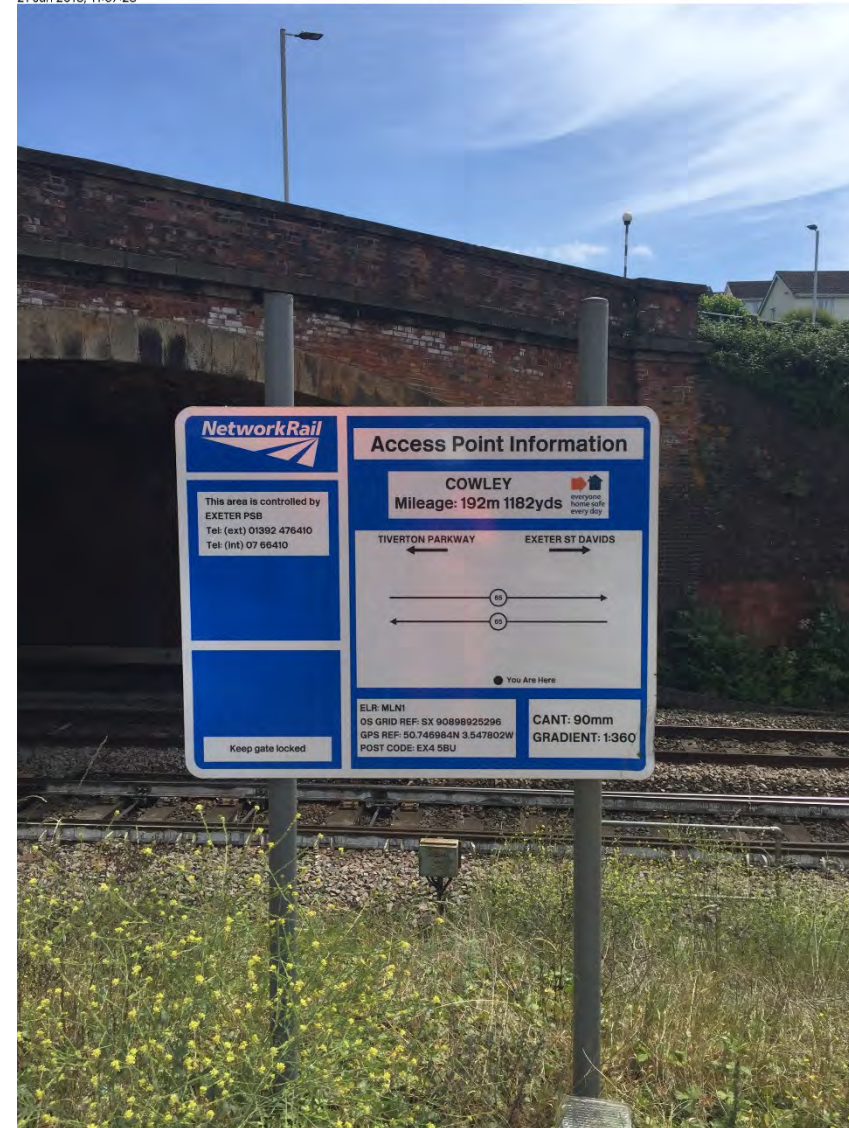
Relied heavily upon the FRA documentation and the design work completed, granted by the EA in March 2020.

Overview of site – 21st June 2018

[-3.5476767,50.7473213] -> DAC-173M+1127.0 [-3.5476699,50.7473198] 0.5
21 Jun 2018, 10:50:02



[-3.5480032,50.7469143] -> MLN1-192M+1207.8 [-3.5478864,50.7468923] 8.6
21 Jun 2018, 11:57:28

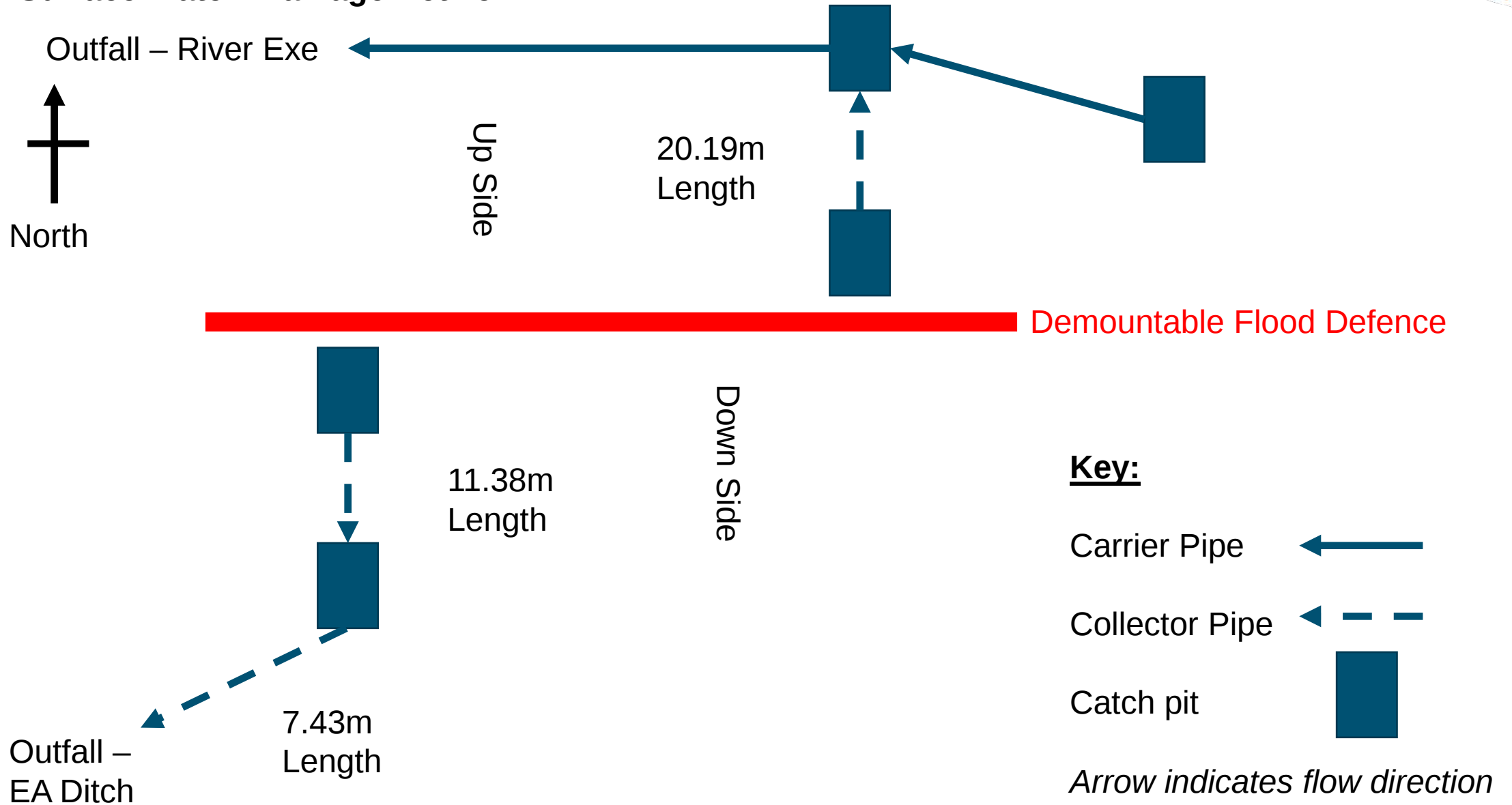


Site Investigation - Drainage

Assessment of existing assets completed including the surface water drainage network to ensure any exceedance flows are able to be conveyed away from the flood defence.



Surface Water Drainage Network



Existing track drainage network – CCTV Surveys, 20th September 2019



Highway Drainage culvert – 600mm stone/brick arch

[-3.5479858,50.7475044] -> DAC-173M+1142.0 [-3.5476141,50.7474382] 272
20 Sep 2019 at 13:29:21



[-3.5476982,50.7475887] -> DAC-173M+1158.2 [-3.5475595,50.7475670] 101
20 Sep 2019 at 13:31:10



Ground Investigation

TOPDRILL				Cowley Bridge				Hole ID BH02		
Project ID: TOP4119				Client: Balfour Beatty		Date: 03/08/2019 - 11/08/2019		Sheet 1 of 1		
Crew: POC, PG				Drilling Method: Windowless Sampling		Co-ordinates: 290901.89E - 95309.93N		Hole Type WS		
Hammer ID: 327				SPT Er (%): 72		Elevation: 14.89m AOD		Scale 1:55		
Logged By WN, CR										
Samples		In Situ Testing		Level mOD	Depth (m)	Legend	Stratum Description	Scale (m)	Water Strike	We
Depth (m)	Type	Depth (m)	Results							
0.70	D				0.60		MADE GROUND: Grey slightly sandy fine to coarse subangular to subrounded GRAVEL of ballast.			
0.90	D				0.80		MADE GROUND: Dark brown slightly clayey very sandy fine to coarse subangular to subrounded GRAVEL of ballast.			
1.20	SPTLS	1.20	N=11 (7,2/3,2,3,3)		1.20		MADE GROUND: Dark brown mottled red brown clayey very sandy fine to coarse subangular to angular GRAVEL of mudstone.	1		
1.30	D						Soft dark brown mottled grey slightly sandy very gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse subangular to angular mudstone, sandstone and quartz.			
1.80	D				2.30		Soft dark grey and brown slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse subrounded to angular quartz and mudstone.	2		
2.00	SPTLS	2.00	N=2 (1,0/1,0,1,0)							
2.40	D				3.00		Very soft brown locally grey slightly sandy gravelly locally organic CLAY with occasional rootlets and rare plant material. Sand is fine to medium, subrounded of mudstone and quartz.	3		
2.80	D									
3.00	SPTLS	3.00	N=0 (1,0/0,0,0,0)							
3.70	D				4.00		Light brown sandy fine to medium subangular GRAVEL of quartz and mudstone. Sand is fine to coarse.	4		
4.00	B	4.00	N=12 (1,2/3,3,3,3)				Becomes slightly organic.			
4.00 - 4.90	SPTLS						Approximately 100mm thick dark grey wood fragment.			
4.95	D				5.00		Dark grey GRAVEL of mudstone	5		
5.00	SPTLS	5.00	N=25 (7,6/6,7,7,5)							
5.80	D				5.70		Very weak dark grey organic MUDSTONE with occasional approximately 2mm white quartz veins interbedded with soft dark grey CLAY.			
6.00	SPTLS	6.00	0 (25,25/0 for 0mm)		6.00		End of Borehole at 6.00m	6		

Water strike 3m below rail level

Competent Mudstone/Clay 6m below rail level

Liner Photographs

Cowley
TOP4119

BH02

0.5-1.0m

1.0-2.0m

2.0-3.0m

3.0-4.0m

4.0-5.0m

5.0-6.0m



Flood Risk Assessment – AECOM



Figure 4-1: Cowley Bridge 2012 Flood Event
Image source: Environment Agency Product 4 Information

Flood Risk Assessment – AECOM

A coupled ESTRY - TUFLOW and Flood Modeller Pro hydraulic model was provided to AECOM by the Environment Agency (EA) in February 2017, which was used to design the Exeter FDS.

The flood risk assessment was required by the EA to demonstrate that there was no increase in flood risk and land drainage in the vicinity.

AECOM were commissioned as they worked closely with the EA on the development of the Exeter FDS scheme.

The existing model for the Exeter FDS was trimmed for the area of interest at Cowley and multiple simulations and model runs completed. An extract of the modelling work completed is provided on slide 19 and 20.

Flood Risk Assessment – AECOM

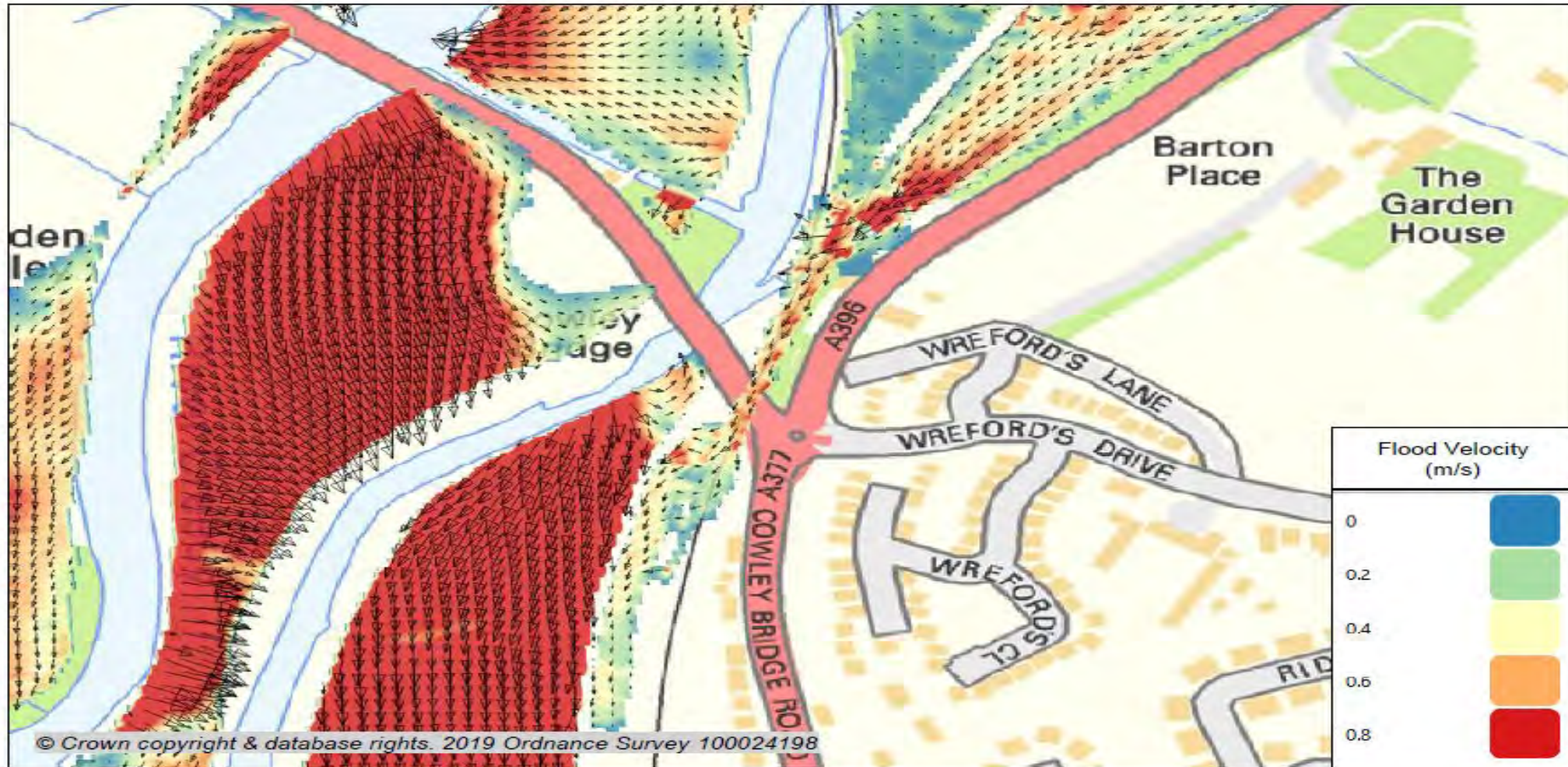
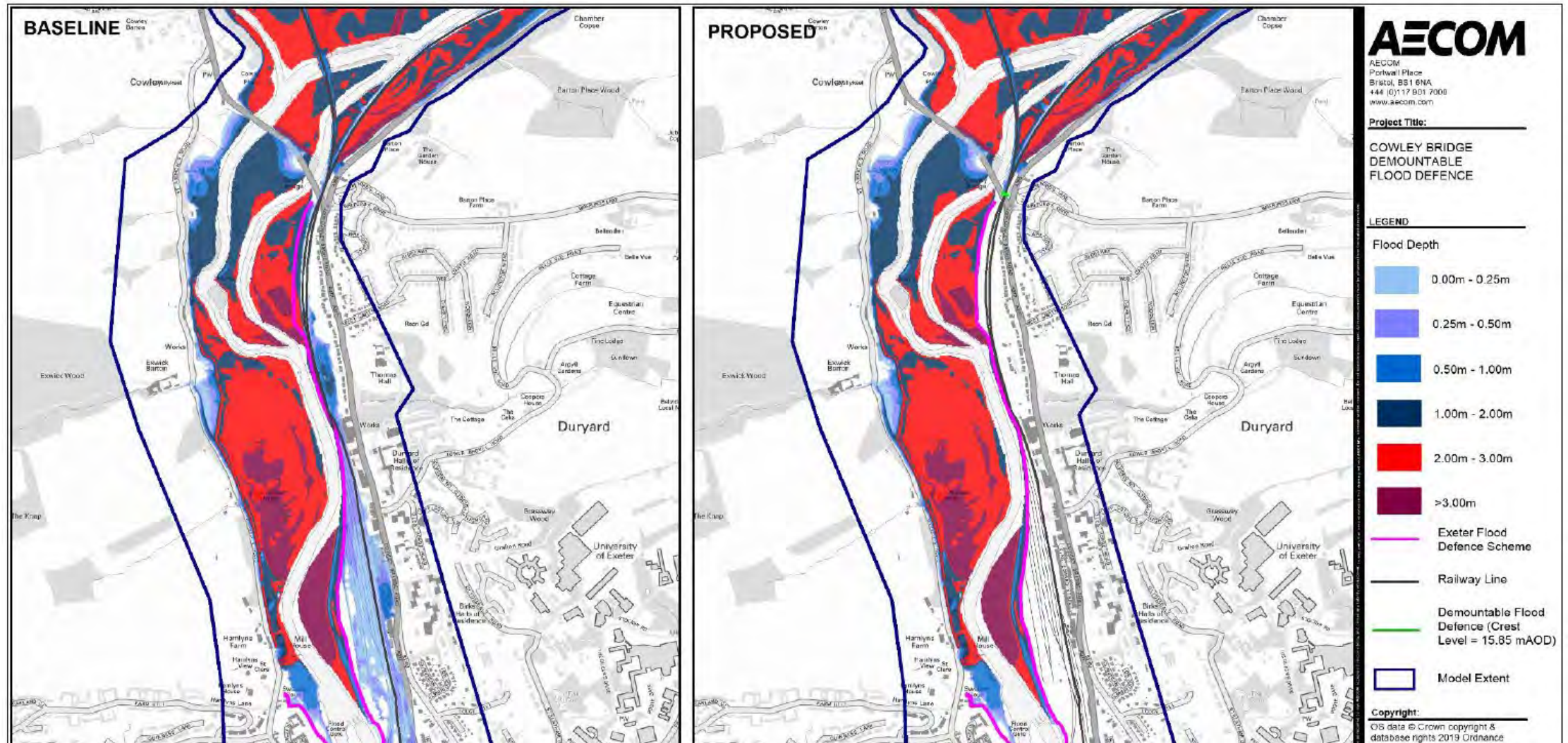


Figure 4-5: 1.33% AEP Flood Velocity Map at 21.50 hours into Model Simulation
Floodwater propagating south down the railway line, once water has overtopped from the Exe Backwater

Flood Risk Assessment – AECOM



Environment Agency Flood Risk Activity Permit (FRAP)

Application completed in November 2019 following a year of extensive and detailed pre application work via Chris Stratton, EA/NR Liaison Officer. Permit duly made on Christmas Eve 2019 in readiness for installation in Spring 2020.

Mark Howells
Network Rail Limited
1 Eversholt Street
London
NW1 2DN

Our ref: **EPR/HB3992JP**

Date: **24/12/2019**



Permit with introductory note

The Environmental Permitting (England & Wales) Regulations 2016

Dear Mr Howells

Your new environmental permit

Permit reference: EPR/HB3992JP

Operator: Network Rail Limited

Description of Activity: Construction of the demountable defence.

Site / Location: Cowley Bridge on the River Exe

Our determination of your application for a permit is complete. We're satisfied that you can carry out your activities in accordance with the enclosed permit, without increasing flood risk, or harming land drainage or the environment. Please keep the permit in a safe place.

Network Rail Limited

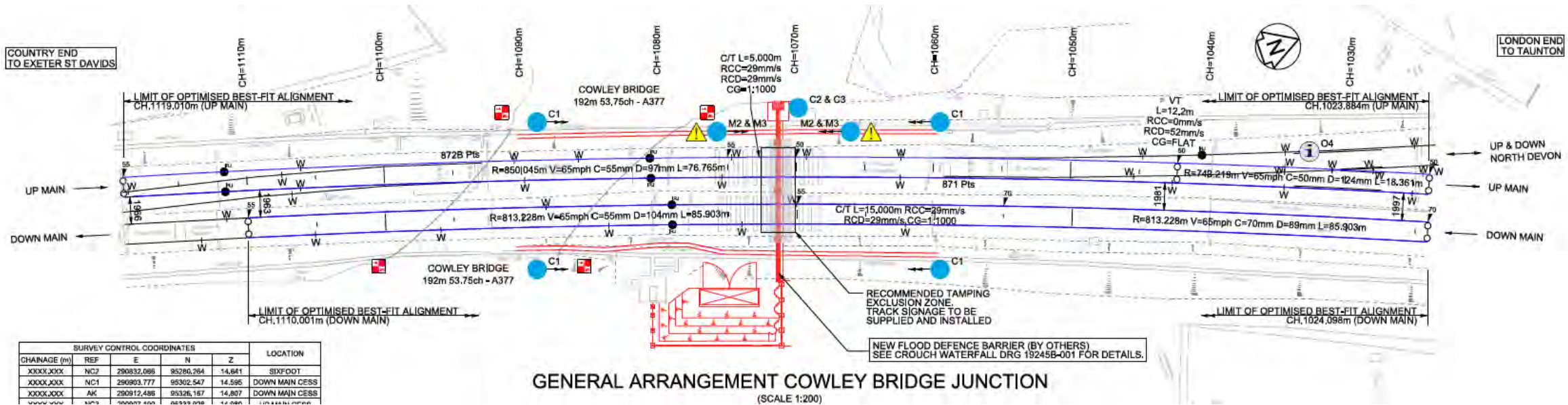
Cowley Bridge Junction, The proposed scheme is a demountable flood defence that will be located perpendicular to the railway track, immediately North of Cowley Bridge O/B (A377)

National Grid Reference: SX9089495352

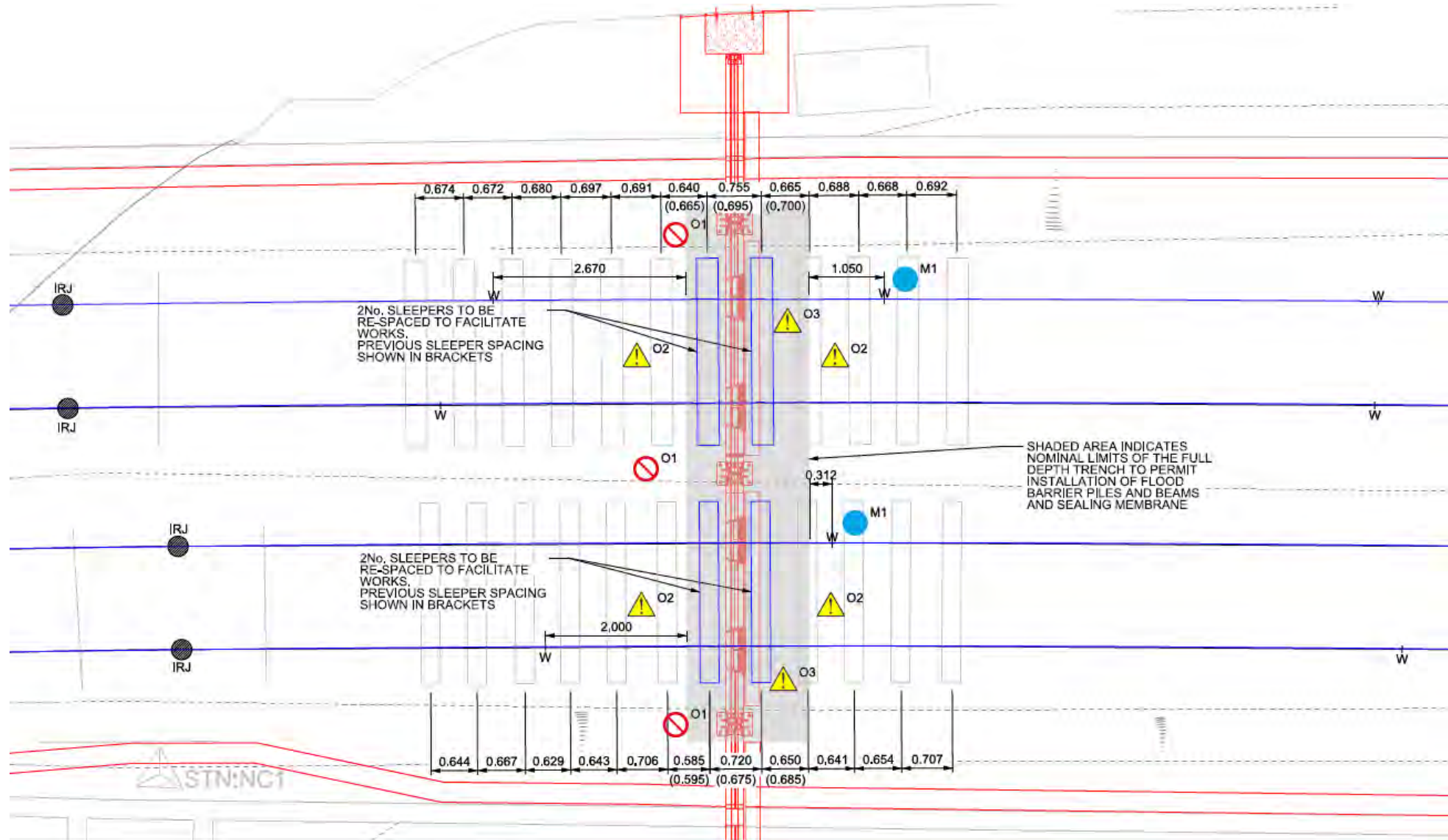
Permit number

EPR/HB3992JP

Extract from the Track Design Form B



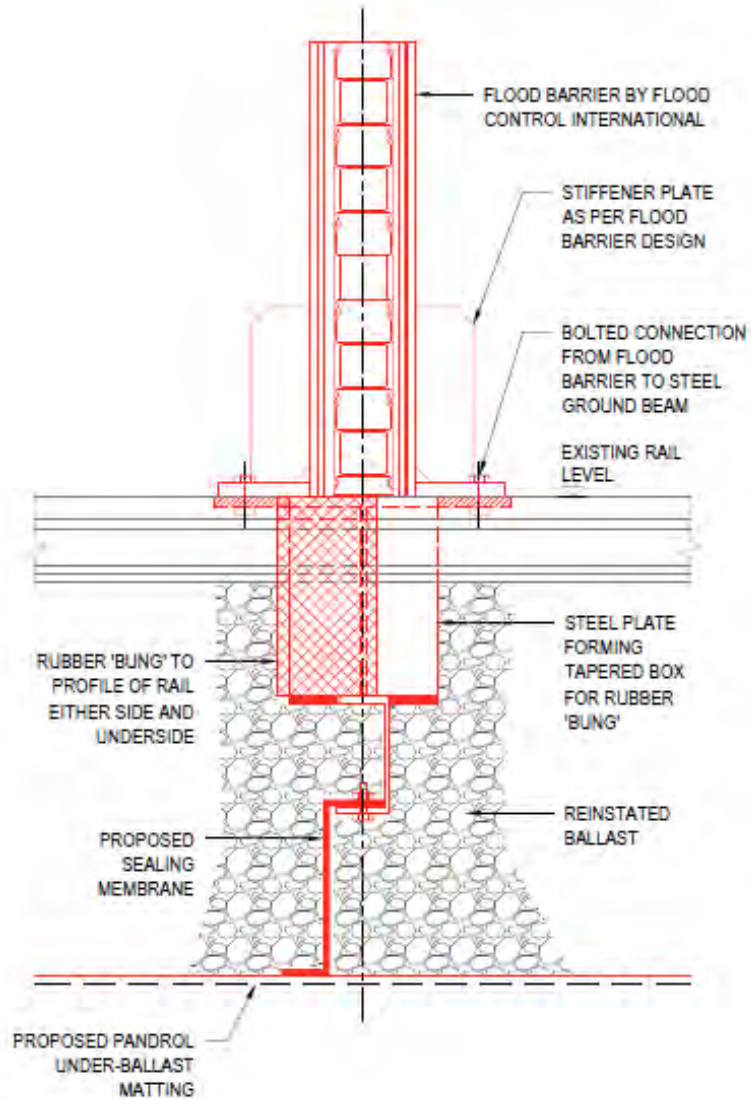
Maximum Line speed: 65mph
 Maximum actual Cant: 55mm
 Cant deficiency: 104mm
 Cant gradient: 1 in 1000
 Minimum radius: 813.228m (Down Main)



INSERT A - SLEEPER SPACING ARRANGEMENT COWLEY BRIDGE JUNCTION

(SCALE 1:50)

Copyright © 2012 Pearson Education, Inc. All rights reserved. Printed in the United States of America. This publication is protected by copyright. Any unauthorized reproduction or distribution of this work in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher is prohibited. All rights reserved.

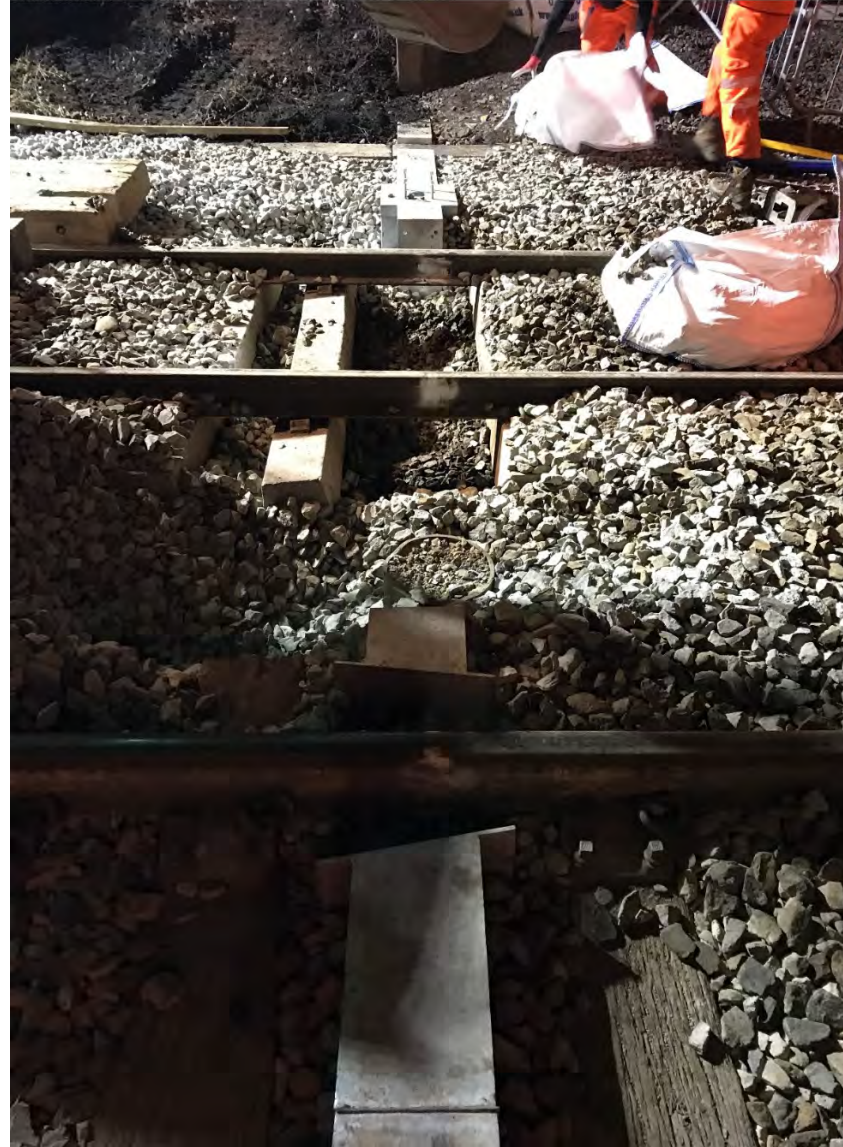


Pile installation

[-3.5477638, 50.7470868] -> MLN1-192M+1182.4 [-3.5477425, 50.7470822] 1.6
5 Apr 2020 at 02:26:37



[-3.5477543, 50.7471463] -> MLN1-192M+1175.3 [-3.5477612, 50.7471477] 0.5
5 Apr 2020 at 01:58:44



Ground Beam Installation

[-3.5477188,50.7471363] -> MLN1-192M+1175.0 [-3.5477144,50.7471353] 0.3
5 Apr 2020 at 04:26:04



[-3.5478124,50.7471528] -> MLN1-192M+1176.0 [-3.5477639,50.7471426] 3.6
5 Apr 2020 at 05:30:45



Frequent checks undertaken using a total station...

[-3.5477670,50.7472118] -> MLN1-192M+1168.1 [-3.5477317,50.7472043] 2.6
5 Apr 2020 at 06:17:27



Site compound and overview of the works location

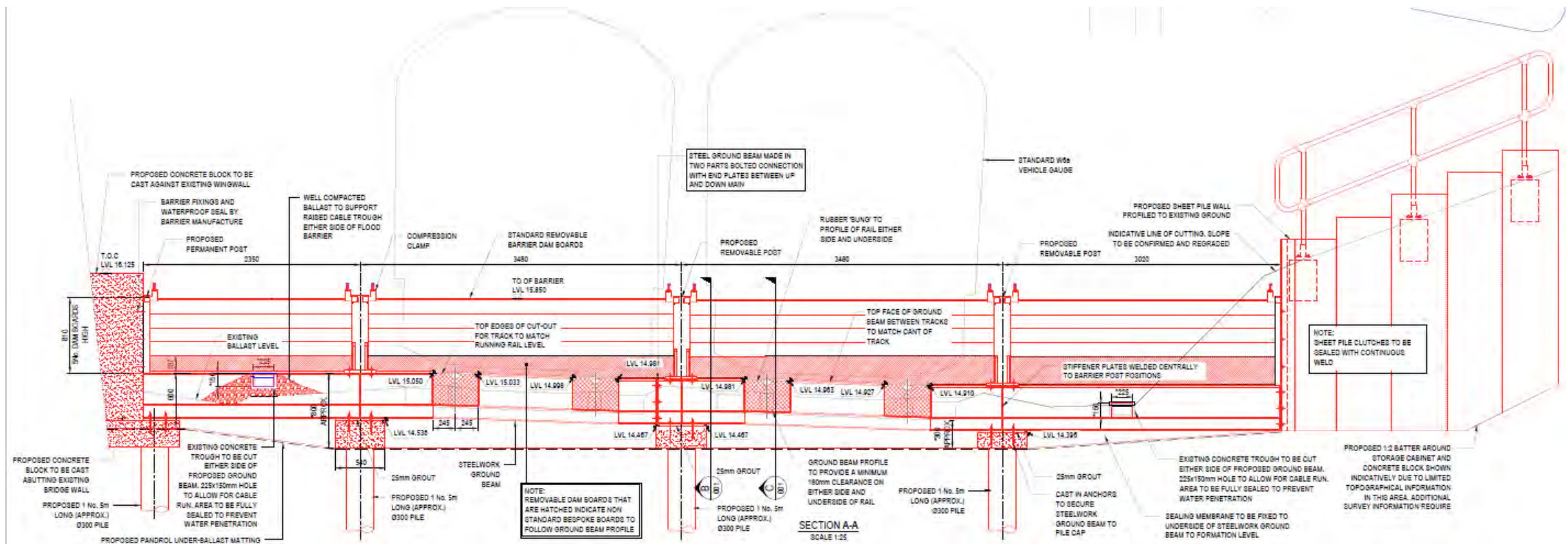
[-3.5474077,50.7473402] -> MLN1-192M+1143.9 [-3.5475792,50.7473809] 12.9
19 Apr 2020 at 04:23:54



Sectional View – Looking North

Up Main

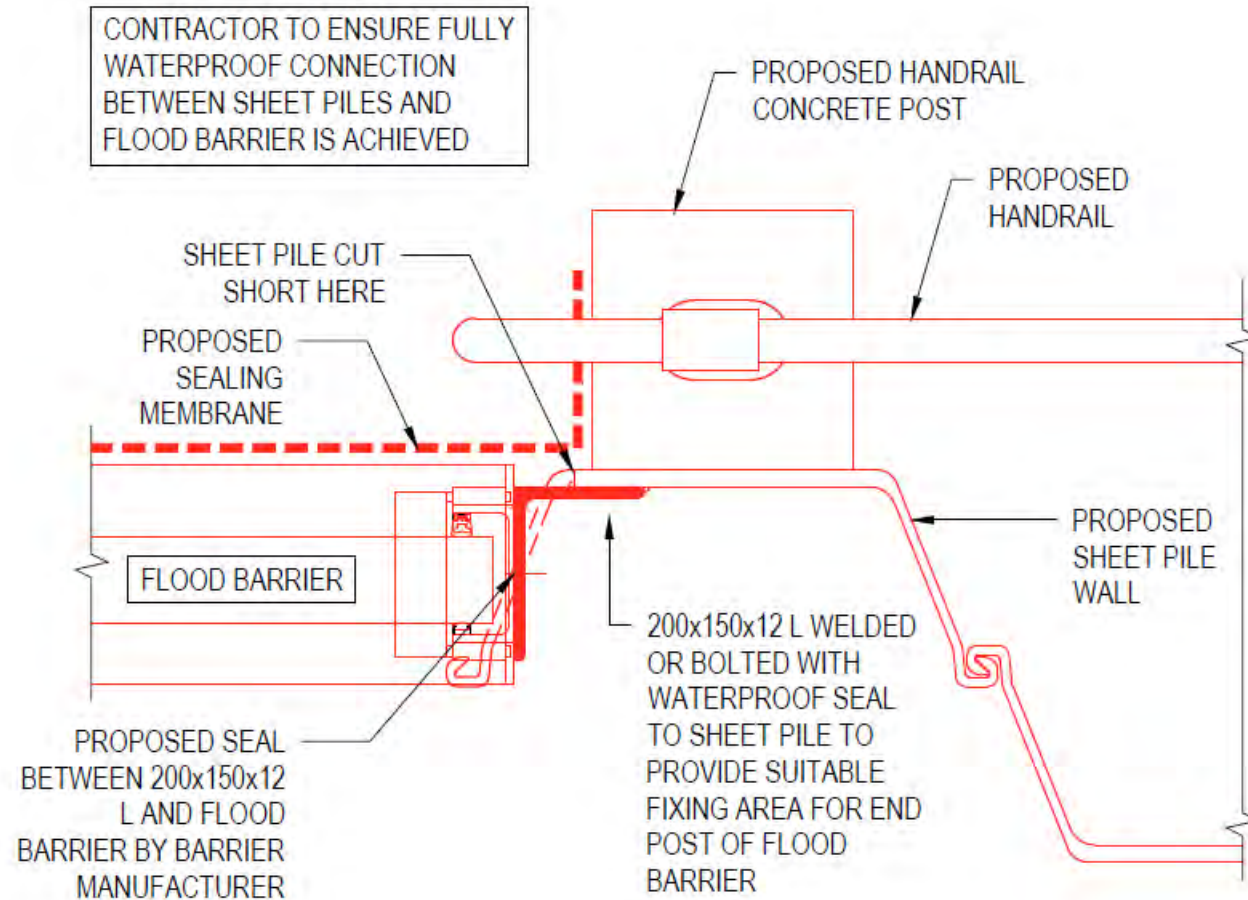
Down Main



Up side reinforced concrete upstand



Waterproofing at the interface between sheet piled section and defence



DETAIL 1
SCALE 1:10

Up side/Down side reinforced concrete/steel upstand – channel detail



Storage container and Junction signage

[-3.5476427,50.7471225] -> MLN1-192M+1175.3 [-3.5477132,50.7471375] 5.3
24 May 2020 at 04:13:09



[-3.5477511,50.7471888] -> MLN1-192M+1170.3 [-3.5477409,50.7471867] 0.8
24 May 2020 at 01:09:59



Storage container – Operation Details

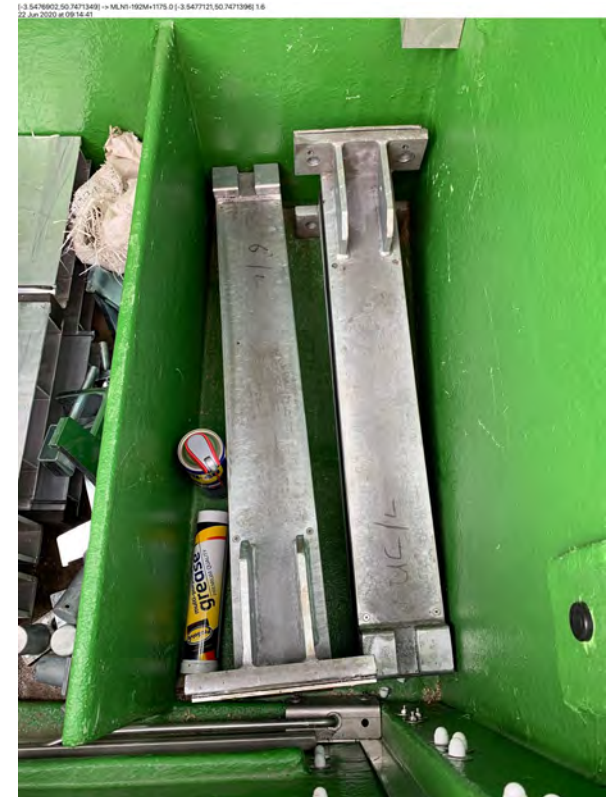
[-3.5477153,50.7470917] -> MLN1-192M+1180.7 [-3.5477352,50.7470959] 1.5
22 Jun 2020 at 09:15:20



Storage container – The contents...

COWLEY BRIDGE FLOOD BARRIER TOOLS INVENTORY.

- 24mm Socket
- $\frac{3}{4}$ Ratchet spanner
- Yard brush
- 2 no 24mm spanners
- Flat head screwdriver
- 8 no 222 padlocks.
- 1 no 6mm Allen keys
- 2 no 8mm Allen key
- 1 tin WD40
- Grease gun c/w 1 tube of grease.
- 2 no Insulated shovels
- Rubber mallet

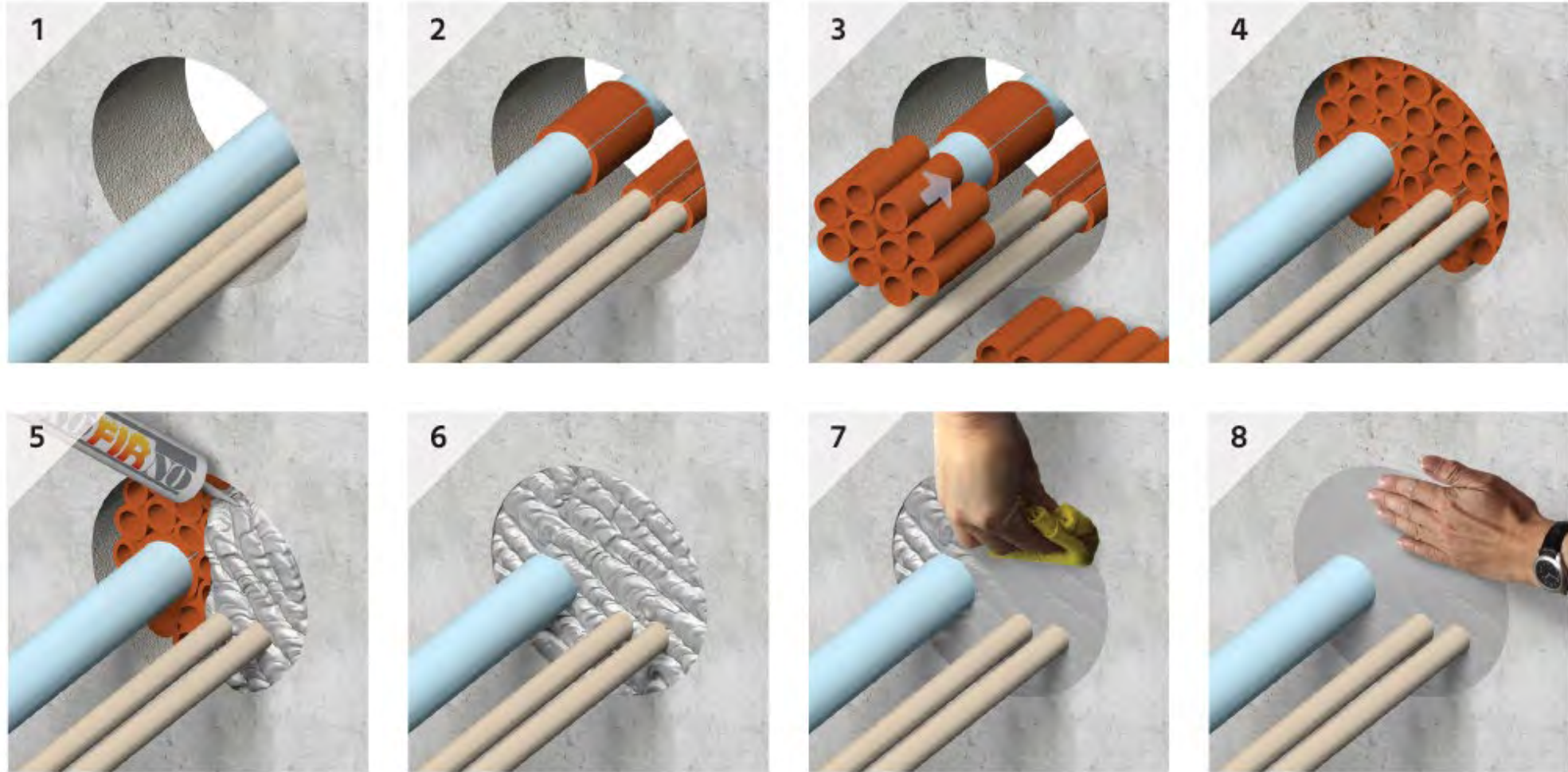


Defence deployed (in a possession and under trial)

[-3.5476720,50.7471587] -> MLN1-192M+1171.8 [-3.5476990,50.7471645] 2.0
24 May 2020 at 03:29:34



NOFIRNO – Troughing Sealant – a watertight seal!



CSD Sealing Systems, source: <https://csdsealingsystems.com/resource-center/document-center/>

NOFIRNO – Troughing Sealant – a watertight seal!



Preventing wrong side track circuit failures



Nylon
insulation

Site Overview from Cowley Bridge O/B (A377) – Looking North

5 Apr 2020 at 07:33:48



Acknowledgments

This project was a truly collaborative effort and below is a summary of all those involved, there were of course others who are owed the same acknowledgement but not named below.

Barry McMahon

Paul Bateman

Chris Stratton

Simon Dart

Tim Lee

Andy Emblin

Vaheesan Maheswaran

Claudia Philps

James Coram

Richard Moore

Zoe Ball

Shaun Merrifield

Bob Barker

Darren Norman

Darren Pauley

Dick Watts

Tom Wellington

Troy Newman

Malcom Short

Steve Pearson

Lyn Townsend

Matt Redstone

Robin Emmons

Chris Neal

Andy Carver

Andy Thomson

Gary Wallace

Sean McNammara

Wayne Batham

Luke Horwill

Tom Doyle

Special thanks to Chris Stratton (EA/NR Liaison Officer) who was a key enabler for all of these works and kept the entire project moving forward during the more difficult times.

Thank you for your attention

Any questions?

Author: Mark Howells FdEng MPWI MIAM, Senior Asset Engineer (Drainage & Lineside)
Network Rail, Western Route

Further Reading:

<https://www.railengineer.co.uk/flood-resilience-schemes-in-southwest-england/>

<https://www.networkrailmediacentre.co.uk/resources/cowley-bridge-flood-defence-being-installed>

