MetroWest

Portishead Branch Line (MetroWest Phase 1)

TR040011
Applicant: North Somerset District Council
5.6, Flood Risk Assessment, Part 1 of 17
The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009, regulation 5(2)(e)
Planning Act 2008

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Date: November 2019

The original submission version of this document can be found in Appendix 17.1 of the ES. The document contained within the ES will not be updated. However, this standalone version of this document may be updated and the latest version will be the final document for the purposes of the Order.

Notice

Document history

Project	Portishead Branch Line (MetroWest Phase 1) Development Consent Order Scheme
Planning Inspectorate Scheme Reference	TR040011
Part and Application Document Reference	5, 5.6
Document title	Flood Risk Assessment, Part 1 of 17
Regulation Number	Regulation 5(2)(e)
Applicant	North Somerset District Council
Lead Author	RB at CH2M

Version	Date	Status of Version
Rev: 01	12/11/19	Application Issue

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Acronyms and Abbreviations

1D	One Dimensional
2D	Two Dimensional
AIMS	The Environment Agency's Asset Information Management System
AVTMBRT	Ashton Vale to Temple Meads Bus Rapid Transit
B&NES	Bath and North East Somerset District Council
BCC	Bristol City Council
CAFRA	Central Area Flood Risk Assessment
CFMP	Catchment Flood Management Plan
DCO	Development Consent Order
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
EIA	Environmental Impacts Assessment
ES	Environmental Statement
FRA	Flood Risk Assessment
FRMS	Flood Risk Management Strategy
FZ	Flood Zone
GPDO	General Permitted Development Order
GRIP	Governance for Railway Investment Projects
IUD	Integrated Urban Drainage
LFRMS	Local Flood Risk Management Strategy
NPPF	National Planning Policy Framework
NPPG	National Planning Policy Guidance
NRIL	Network Rail Infrastructure Limited
NSC	North Somerset Council (now North Somerset District Council)
NSDC	North Somerset District Council
NSIP	Nationally Significant Infrastructure Project
NSLIDB	North Somerset Levels Internal Drainage Board
PINS	Planning Inspectorate
SAB	SuDS Approval Body
SAC	Special Area of Conservation
SFRA	Strategic Flood Risk Assessment
SGC	South Gloucestershire Council
SMP2	Shoreline Management Plan 2
SuDS	Sustainable Drainage Systems
uFMSWF	updated Flood Map for Surface Water Flooding

SECTION 1

Introduction

1.1 DCO Scheme Scope and Purpose

1.1.1 The DCO Scheme scope and purpose are detailed in the Environmental Statement ("ES") Chapter 1, DCO Document Reference 6.4.

1.2 The Need for a Flood Risk Assessment

1.2.1 The National Policy Statement for National Networks ("NPSNN") sets out the need for, and Government's policies to deliver, development of nationally significant infrastructure projects ("NSIP") on national road and rail networks in England. Essential transport infrastructure that has to cross areas at risk, is permissible in areas of high flood risk subject to meeting the requirements of the Exception Test set out in the National Planning Policy Framework ("NPPF").

1.2.2 NPS NN paragraph 5.92 advises that applications for projects in Flood Zones 2 and 3 (medium and high probability of river and sea flooding) should be accompanied by a Flood Risk Assessment ("FRA") to identify and assess the risk of all forms of flooding to and from the project and demonstrate how these flood risks will be managed, taking climate change into account.

1.2.3 The DCO Scheme crosses some areas of land that are in Flood Zones 2, 3a and 3b and so a FRA is required to accompany the application for the scheme.

1.2.4 This FRA has been prepared to support a Development Consent Order ("DCO") application made by North Somerset District Council ("NSDC") to the Secretary of State under the Planning Act 2008 to construct the Portishead Branch Line DCO Scheme (MetroWest Phase 1) ("the DCO Scheme"). Government policy on flood risk together with the information required to be provided in the FRA is set out in Section 2.4.

1.2.5 The main sources of potential flood risk are:

- Flooding from rivers due to overbanking (fluvial flooding) on its own and combined with tidal flooding
- Flooding from overtopping of coastal flood defences
- Flooding from stormwater (pluvial flooding)
- Flooding due to the surcharging (overflowing) of sewers
- Flooding due to rising groundwater
- Flooding from reservoirs and canals

1.2.6 The design life of the DCO Scheme is 60 years, relative to a 2015 base year (section 5.1.2). Projected future climate change and sea level rise impacts are therefore assessed for the 2075 future year, as well as for the future 2115 year as a sensitivity test.

1.3 Available Information

1.3.1 The key information considered in the preparation of this flood risk assessment is listed below and full references are provided at the end of this report.

- National Planning Policy Framework, March 2012 ("NPPF") and Guidance (2014)
- Agreed notes of consultation meetings with the Environment Agency ("EA") and NSDC, and EA consultation responses
- Consultation response from the North Somerset Levels Internal Drainage Board
- EA Flood Risk Assessment Product 4 for the study area. This includes: EA Flood Zones map (Flood Map for Planning), EA actual flood risk map (National Flood Risk Assessment modelled flood extents), EA historic flooding map, EA modelled flood levels, and details of flood defences
- Information on local flood risk provided by NSDC and BCC
- North Somerset Council, 2012. *Flood Investigations*.
- North Somerset Council and Bristol City Council planning policy documents
- North Somerset Council and Bristol City Council Local Flood Risk Management Strategies and Plans
- Bristol City Council Strategic Flood Risk Assessment Level 1 (2009)
- North Somerset Council Strategic Flood Risk Assessment Level 1 (2008)
- North Somerset Council Strategic Flood Risk Assessment Level 2 (2009)
- Bristol City Council Central Area Flood Risk Assessment (2012)
- Draft Severn Estuary Shoreline Management Plan Review ("SMP2"), Atkins (2010)
- Draft Severn Estuary Flood Risk Management Strategy, EA (2013)
- North Somerset Council Local Flood Risk Management Strategy (draft), North Somerset Council (2013)
- Project design drawings
- Topographic survey undertaken for this scheme
- Results of hydraulic modelling undertaken for this FRA
- EA Somerset North Coast Flood Warning Improvements Final Model Development Report (2012)
- EA Somerset North Coast Flood Warning Improvements hydraulic model and results (updated 2015)
- Bristol City Council Central Area Flood Risk Assessment updated hydraulic model and results (2015)
- Flood Risk Assessment for South Bristol Link full planning application (2013)
- Flood Risk Assessment and Addendum for Ashton Vale to Bristol City Centre rapid transit scheme (2013)

1.4 Report Structure

1.4.1 This FRA has been structured as follows:

- Chapter 2 – Background information including development location and description, overview and naming convention for water features in the vicinity of the DCO Scheme, overview of other flood risk management plans, strategies and assessments.
- Chapter 3 – Identifies sources of flood risk and existing flood defences.
- Chapter 4 – Reports the probability of flooding informed by an interpretation of EA flood maps and hydraulic modelling undertaken for this study, for the base case and the post-development case.
- Chapter 5 – Details of projected climate change and sea level rise assumed when assessing the future scenario.
- Chapter 6 – Summary of consultations meetings held with the EA and North Somerset Levels Internal Drainage Board.
- Chapter 7 – Details of the DCO Scheme proposals, NPPF vulnerability classification and compatibility with Flood Zones and NPPF Sequential Test.
- Chapter 8 – Impacts of the development on flood risk and how flood risk will be managed post-development.
- Chapter 9 – Assessment of off-site impacts post-development.
- Chapter 10 – Summary of proposed measures to mitigate potential impacts on flood risk.
- Chapter 11 – Summary of residual risks and how they are to be managed.
- Chapter 12 – Conclusions.
- Chapter 13 – References.

1.4.2 Supporting information is provided in Appendices A to T, DCO Document Reference 5.6.

SECTION 2

Background

2.1 Development location and description

2.1.1 Figure 2.1 shows the location of the DCO Application Area. The DCO Scheme extends from the centre of Portishead to Ashton Junction, located approximately 700 m down line from Parson Street Junction in the outer suburbs of Bristol. Portishead town has undergone considerable redevelopment and expansion over the last decade with several thousand new homes built at The Vale, the Village Quarter and Port Marine. The whole area was formerly dominated by heavy industry, including two coal fired power stations and a phosphorous works, but these activities had all ceased by the late 1980s. Development since has been typically high density housing with a modern urban design layout and appearance.

2.1.2 Pill is an historic village, with Easton-in-Gordano to the south west and Ham Green to the east. The three villages effectively form one urban settlement and are surrounded by Green Belt land. The disused Pill station is located in the heart of the historic centre of the village.

2.1.3 Bristol is the largest city in the West of England and across the wider south west region, with a population of about 428,100 (Census, 2011), which is projected to reach 500,000 by mid-2027 (Bristol City Council, 2016). The city developed on the River Avon, with close links with the sea and international trade.

2.1.4 The terrain between Portishead and Pill is generally low-lying coastal plain crossed by a number of land drains and small rivers and at risk from tidal flooding. The terrain around Portishead and Bristol is characterised by alternating ridges and broad valleys. The River Avon passes through a pronounced gorge, separating much of Bristol to the east from the wooded slopes and valleys to the west. Much of the countryside lies in the designated green belt. The agriculture on the coastal plains is based on pasture for livestock, with arable farmland above the scarps. There are also patches of woodland throughout the study area.

2.1.5 Towards the southern end of the Portbury Freight Line, the railway passes through the urban areas of Ashton Gate and Ashton Vale, before joining the south west main line between Bristol and Exeter at Parson Street Junction.

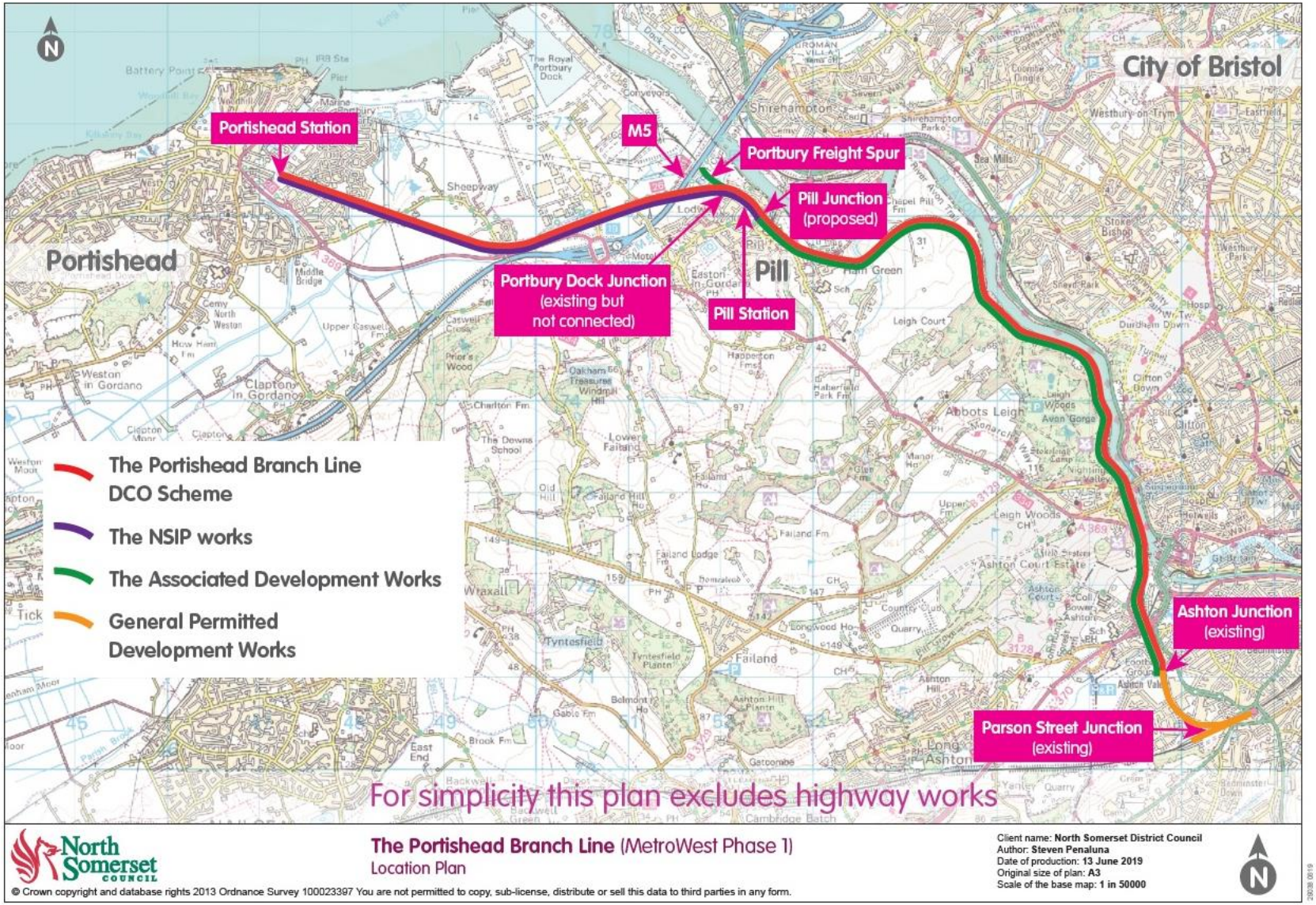

Figure 2.1: Location plan

2.2 Regional overview of water features

2.2.1 MetroWest Phase 1 lies partly within the catchment of the River Avon, a tributary of the River Severn. The River Avon has a large catchment area of approximately 2,220 km^2 encompassing the major cities of Bristol and Bath. The primary river flows from its source upstream of Malmesbury south then west for approximately 134 km through gentle rural landscapes and towns such as Bradford-on-Avon, Bath, and Bristol, before flowing through the Avon Gorge to Avonmouth, and into the Severn Estuary.

2.2.2 The DCO Scheme extends along the coastal plain of North Somerset and the left[1] (south and west) bank of the River Avon.

2.3 Surface Water Features and Drainage

2.3.1 The main features of the surface water environment for the DCO Scheme comprise the River Avon, which is tidal throughout the study area, and several watercourses and drains which form tributaries of the river. There is an extensive network of small drains and ditches, with a number of culverts under the existing railway track, particularly through the disused section between Portishead and Pill. From on-site observations, the culverts, mostly brick lined, are in moderate to poor condition, with flow restricted by siltation. Further inspections will be undertaken to determine the structural integrity of the culverts. Many of the ditches in this area are also heavily overgrown and with the flat topography, the direction of the drainage may be unclear. The project culvert survey report (*Track Culvert Survey* in Appendix O, DCO Document Reference 5.6) identifies that the majority of culverts under the Portishead to Pill disused railway require replacement and most culverts under the Portbury freight line (operational railway) with potential to be affected by the proposed works require further survey and/or information to assess appropriate actions.

2.3.2 A lot of the watercourses and ponds are un-named and for the purposes of assessment have been assigned a unique number or name. The surface water features within the study area are presented, from west to east, in Appendix 17.3 of the Environmental Statement, DCO Document Reference 6.25, and are shown on Figure 17.1 (Sheets 1 to 5) of the Environmental Statement Book of Figures, DCO Document Reference 6.24.

2.4 Other flood risk management plans, strategies and assessments

Strategic Flood Risk Assessments

Bristol City Council Strategic Flood Risk Assessment Level 1

2.4.1 Bristol City Council Strategic Flood Risk Assessment Level 1 (2009) is a study/interpretation of flood risk information up to 2009. The following Information is relevant to this FRA.

[1] The left and right hand banks of a river assume the respondent is facing in the downstream direction.

- River Avon tidal flooding is a significant source of flood risk in central Bristol, including at Ashton Gate. This is consistent with the EA's historical Flood Map (Appendix B, DCO Document Reference 5.6).
- The report includes the EA Flood Zones current at the time of publishing (2009). These are superseded by the current EA Flood Zones, included in Appendix B, DCO Document Reference 5.6.
- The EA records of historical groundwater flood events do not include any groundwater flooding within Bristol City Council.
- The historical flood map shows instances of tidal flooding in the vicinity of Bower Ashton and surface water and sewer flooding in the vicinity of Ashton Gate. This is consistent with the relatively low local ground levels.
- The potential for flood risk associated with the failure of Barrow Reservoirs is noted. More recently the EA has developed and published reservoir inundation maps on its website (Section 3.1.19).

North Somerset Council Strategic Flood Risk Assessment Level 1

2.4.2 North Somerset Council Strategic Flood Risk Assessment Level 1 (2008) is a study/interpretation of existing (in 2008) flood risk information. The following information is relevant to this FRA.

- Based on the EA Flood Map, tidal flooding is a significant source of flood risk in North Somerset. Areas identified to be at risk of tidal flooding include Portishead, Pill and Easton-in-Gordano. Tidal flood risk is expected to increase in the future due to projected future sea level rise.
- There is limited evidence for flood risk due to reservoir failure. More recently the EA has developed and published reservoir inundation maps on its website (Section 3.1.19).
- The use of sustainable drainage systems ("SuDS") in new developments is promoted to manage local flood risk.

North Somerset Council Strategic Flood Risk Assessment Level 2

2.4.3 North Somerset Council Strategic Flood Risk Assessment Level 2 (2009) reports the results of hydraulic modelling undertaken to assess flood risk at five areas including potential development sites where flood risk may be significant. These areas are shown in Figure 2.2 and those areas where results may be relevant for the DCO Scheme are summarised below.

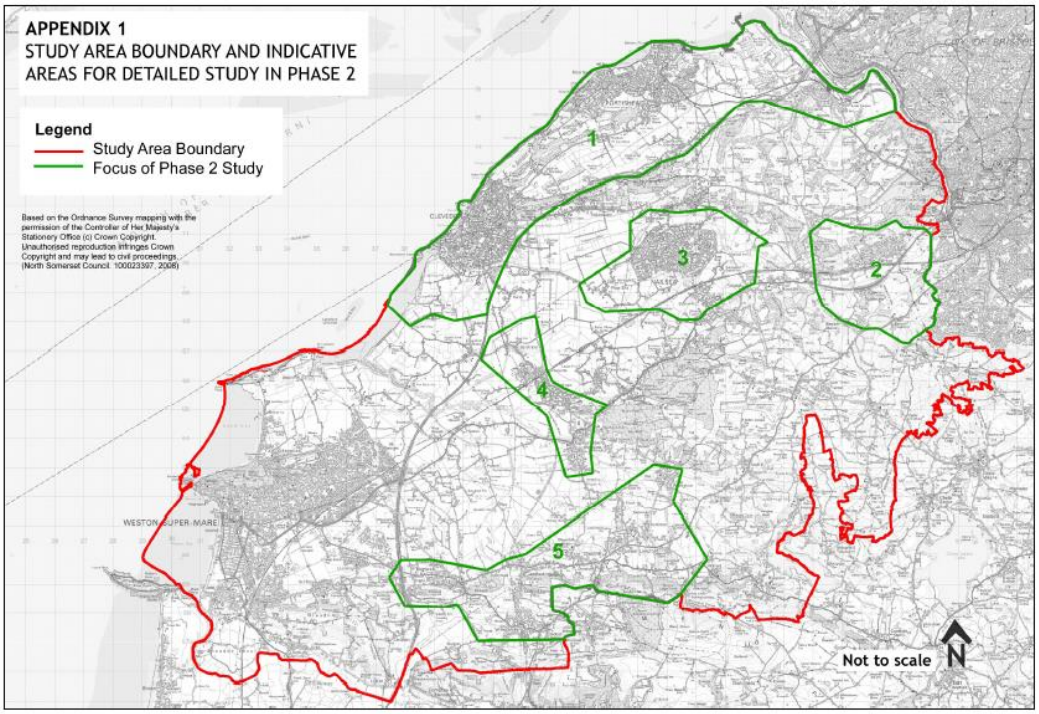

Figure 2.2: NSC SFRA Level 2 study areas (reproduced from NSC 2009)

- Area 1: Coastal strip from south of Clevedon to Ham Green near Pill close to the River Avon. Area 1 includes the coastal floodplain between Portishead and Avonmouth and the confluence of the River Avon with the Severn Estuary. Coastal inundation modelling was undertaken accounting for the cases with and without existing (in 2009) coastal flood defences. The EA has more recently (2012) undertaken coastal flood modelling between Portishead and Avonmouth, which has been developed further for this FRA (Sections 4.2.1 to 4.2.4).
- Area 2: Urban extension area south-west of Bristol (*this urban extension is no longer proposed*). For Area 2, fluvial hydraulic modelling of Longmoor Brook and Colliter's Brook, which pass through Area 2, was undertaken. However, Area 2 is upstream of the Portbury freight Line crossing of Longmoor Brook and Colliter's Brook and the North Somerset Council SFRA Level 2 model results do not extend downstream to Portbury freight Line (which is approximately 600 m further downstream).

2.4.4 Results of the North Somerset Council SFRA Level 2 coastal modelling undertaken for Area 1 are considered to be consistent with, but superseded by, the more recent EA coastal modelling and its further development for this FRA (Sections 4.2.1 to 4.2.4).

2.4.5 The North Somerset Council SFRA Level 2 interprets the modelling undertaken and considers that:

- Failure of coastal flood defences is a significant flood risk for Area 1.
- Development proposals in Area 1 should assess the standard of protection for the development and consider appropriate flood warning mechanisms.

- The impacts of projected future sea level rise are likely to be significant for Area 1, for example longer duration of tide locked surface water drainage and more frequent overtopping of coastal defences.
- There is potential for tide locking of Longmoor Brook and Colliter's Brook during high River Avon tide conditions.

2.4.6 The North Somerset Council SFRA Level 2 (in Section 2.5) also notes the requirement to assess the impact of any land raising on flood risk elsewhere and that "*developments which include flood risk areas need to provide appropriate flood warning and emergency plans so that users and residents are safe should a flood occur*". The SFRA Level 2 promotes the use of SuDS in new development.

Catchment Flood Management Plans

2.4.7 The Bristol Avon Catchment Flood Management Plan ("CFMP") and North and Mid Somerset Catchment Flood Management Plan summary reports are included in Appendix C, DCO Document Reference 5.6. Table 2.1 lists the CFMP policy units in which the DCO Scheme lies, as well as the CFMP policies.

2.4.8 Table 2.1 indicates that, except for the Portishead to Pill (disused section) within the North and Mid Somerset CFMP Levels and Moors Policy Unit, CFMP policies along the DCO Scheme alignment are either Policy P4 (take action to maintain current level of flood risk into the future) or Policy P5 (take action to further reduce flood risk). The Levels and Moors Policy Unit (CFMP Policy P3) includes Drove Rhyne and Portbury Ditch. Flood risk associated with these watercourses for the present day scenario (2015) and future scenarios (2075 and 2115) is considered in Sections 4.2 and 8.1.

Table 2.1: CFMP Policy Units and Policies

CFMP Policy Unit	CFMP policy	CFMP summary of flood risk	Elements of the DCO Scheme within Policy Unit
North and Mid Somerset CFMP			
Portbury	P4 – take action to maintain current level of flood risk into the future	Tidal flooding through overtopping or breach of coastal defences Surface water flooding due to tide locking	Railway: Portishead to Pill (disused section)
Levels and Moors	P3 – continue current level of flood risk management activities	Surface water flooding and tidally influenced fluvial flooding	Railway: Portishead to Pill (disused section)
Coastal Towns	P4 – take action to maintain current level of flood risk into the future	Tidal flooding through overtopping or breach of coastal defences Surface water flooding due to tide locking	Railway: Portishead to Pill (disused section) Portishead Station

Table 2.1: CFMP Policy Units and Policies

CFMP Policy Unit	CFMP policy	CFMP summary of flood risk	Elements of the DCO Scheme within Policy Unit
Bristol Avon CFMP			
Bristol	P5 – take further action to reduce flood risk	Tidal/fluvial flooding	Portbury Freight Line between Ham Green and Parson Street Junction
Markham Brook and Avonmouth	P4 – take action to maintain current level of flood risk into the future	Tidal flood risk (tidal river Avon) Surface water flooding due to tide locking	Railway: Portishead to Pill (disused section) and Portbury Freight Line Pill station

Local Flood Risk Management Strategies

North Somerset Council Local Flood Risk Management Strategy (2013)

2.4.9 The North Somerset Council Local Flood Risk Management Strategy ("LFRMS") reviews existing information on flood risk within North Somerset and identifies flood risk management measures to reduce flood risk within North Somerset Council.

2.4.10 Key elements of the LFRMS relevant to the DCO Scheme are as follows.

- The LFRMS identifies the top 15 communities within North Somerset Council's jurisdiction considered to have significant local flood risk (from surface water, ordinary watercourses or groundwater flooding) and includes action plans to manage local flood risk over the next ten years for the 15 communities identified. These identified communities including Pill, for which there is a risk of surface water flooding due to, for example, blockage of gullies or tide locking of urban drainage. Actions identified for Pill include assessing the operation of a surface water pumping station conveying surface water into the River Avon during high tides, investigating the highway drainage network and evaluate any required improvements to the maintenance regime, assessing the condition and capacity of the culvert conveying an ordinary watercourse that is culverted from Brookside, Pill and joins the culverted Markham Brook in Pill.
- The LFRMS identifies the potential for surface water flooding in Portishead and groundwater flooding north of the M5 motorway junction 19 and in Portishead east of the A369 Portbury Hundred road (this assessment of groundwater flooding was based on the EA's susceptibility to groundwater flood map, Appendix D, DCO Document Reference 5.6).

- The LFRMS identifies the potential for flood risk to increase with future projected climate change and sea level rise. In particular, this includes an increase in surface water flood risk due to increased tide locking of urban drainage (e.g. in Portishead and Pill).
- The LFRMS promotes use of SuDS in new development, maintaining/enhancing overland flow routes and replacing culverted watercourses with open channels where possible.
- The LFRMS encourages the uptake of EA flood warnings and development of emergency plans where appropriate.

Bristol City Council Local Flood Risk Management Plan (2014)

2.4.11 The Bristol City Council Local Flood Risk Management Strategy (BCCLFRMS) reviews existing information on flood risk within North Somerset and identifies flood risk management measures to reduce flood risk within Bristol City Council.

2.4.12 Key elements of the BCCLFRMS relevant to the DCO Scheme are as follows.

- Ashton (which includes Ashton Vale and Bower Ashton) is identified to have a high surface water flood risk, tidal flood risk (tidal River Avon) and susceptibility to groundwater flooding (although there are no records of groundwater flooding). There is potential for tide locking of surface water drainage during high River Avon levels.
- Tidal flood risk is considered the most significant flood risk to Bristol.
- The most significant impact of future projected climate change on flood risk will be an increase in tidal (River Avon) flood risk due to projected sea level rise. Impacts will also include increased surface water flood risk and a modest increase in fluvial flood risk due to the increased intensity of rainfall.
- Actions identified in the BCCLFRMS include assessing the business case for a strategic approach to manage future River Avon tidal flood risk in Bristol. A strategic approach is likely to involve either a River Avon tidal barrier or flood defence walls.
- Actions include development of an integrated flood risk study for Ashton (BCC in partnership with the EA and Wessex Water) to improve understanding of flood risk. The BCCLFRMS identifies an ‘overarching driver’ for new development in Ashton to reduce drainage discharge rates (compared to existing rates).
- The BCCLFRMS promotes use of SuDS to ensure new development contributes to reducing local flood risk.

Bristol City Council Surface Water Management Plan (2012)

2.4.13 The Bristol City Council Surface Water Management Plan (2012) applies Integrated Urban Drainage (“IUD”) modelling to identify areas within BCC with the highest potential for surface water flood risk. The IUD modelling represents routing of intense rainfall over the surface topography as well as through the drainage system (with drainage pipes greater than 450 mm represented in the modelling). The modelling does not include watercourse channels and hydraulic structures (e.g. weirs and culverts through roads and railways).

2.4.14 The modelling identifies Ashton as an area with potential for significant surface water flood risk. Model results show accumulation of surface water upstream of the Portbury freight line (operational railway) near Bower Ashton for simulated intense rainfall events (at Bower Ashton the results of the Bristol City Council Surface Water Management Plan are the same as the EA updated Flood Map for Surface Water Flooding, available on the internet at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map). However, the surface water catchment area upstream of this location is drained by the local watercourse running from Bower Ashton and culverted from the west of Clanage Road with a culvert outfall to the River Avon. As the Bristol City Council Surface Water Management Plan modelling does not represent this drainage mechanism, the results are likely to overestimate surface water flood risk at this location. However, there is potential for tide locking of this watercourse and so surface water may accumulate upstream of Clanage Road and/or the Portbury freight line (operational railway) near Bower Ashton during simultaneous intense rainfall and high tide conditions in the River Avon.

North Somerset Council 2012 Flood Investigations

2.4.15 North Somerset Council's report Flood Investigations (NSC, 2012) reports locations within North Somerset Council's boundary that experienced internal or external flooding of properties during 2012, when rainfall depths were exceptionally high and the main cause of flooding. The locations identified near the DCO Scheme and the main causes of flooding are listed below:

- Pill and Easton-in-Gordano – primarily highway and surface water runoff;
- Portishead (west of the DCO Scheme western extent) – primarily highway runoff also runoff from saturated fields; and
- Portbury (including Sheepway) – surface water runoff from land.

2.4.16 Appendix F, DCO Document Reference 5.6 includes maps showing the locations of these properties, which were provided by North Somerset Council.

Bristol City Council Central Area Flood Risk Assessment

2.4.17 The Bristol City Council Central Area Flood Risk Assessment ("CAFRA"), 2013, presents the results of hydraulic modelling to assess fluvial and tidal flood risk in the River Avon and its tributaries. The CAFRA report indicates that flood risk from the River Avon is dominated by tidal flood risk in the vicinity of the DCO Scheme. The CAFRA modelling has been developed further to meet the requirements of this FRA (Section 4.2).

Severn Estuary Shoreline Management Plan 2

2.4.18 The Severn Estuary Shoreline Management Plan 2 ("SMP2") (EA, 2010) sets out policies for shoreline management in the River Severn estuary for the next 100 years. Appendix G, DCO Document Reference 5.6 shows the locations of SMP2 Policy Units relevant to the DCO Scheme. Policy choices relevant to the DCO Scheme are either *Hold the Line* (for Policy Units Bris5 and Bris6) or *No Active Intervention* (for Policy Units Port 1, where natural ground levels are high enough for tidal flood defences not to be required). The Severn Estuary SMP2 notes (in the Executive Summary) that the *Hold*

the Line SMP2 policy choice recognises the need "*to provide some level of coastal defence, keeping the position of the defence approximately where it is now. This does not automatically mean that defences will be improved to counteract climate change – i.e.: how well the shore is protected from coastal flooding is not considered by the SMP2. This will be considered in more detail by Flood Risk Management Strategies and individual defence schemes."* The relevant Flood Risk Management Strategy considering future management of coastal flood defences protecting the DCO Scheme is The Severn Estuary Flood Risk Management Strategy (Section 2.4.19).

Severn Estuary Flood Risk Management Strategy

2.4.19 The Severn Estuary Flood Risk Management Strategy ("FRMS") (EA, 2013) was developed in parallel with the SMP2, developing the Severn Estuary SMP2 policies into practical management shoreline options.

2.4.20 The Severn Estuary FRMS summary of management options for the coast between Portbury and Clevedon is included in Appendix H, DCO Document Reference 5.6. Management options relevant to the DCO Scheme are as follows.

- The Sea Commissioner's Bank coastal flood defence between Portishead and Portbury Docks (flood defence 46 in Appendix J, DCO Document Reference 5.6) will not be maintained into the future as the inland defence at Portishead (Ashlands defence) provides a more effective and higher defence standard.
- At Portishead, the EA intends to maintain the defences into the medium to long term future (as funds allow). After 2030, the defences or ground levels could be raised to keep pace with climate change.

National planning policy advice on flood risk

2.4.21 NPS NN advises on flood risk considerations for NSIPs at paragraphs 5.90 – 5.115, together with National Planning Policy Framework Section 14 Meeting the challenge of climate change, flooding and coastal change, at paragraphs 155 – 165, and Planning Practice Guidance on Flood Risk paragraphs 029 - 042.

2.4.22 Paragraph 5.98 of the NPS NN states that "*Where flood risk is a factor in determining an application for development consent, the Secretary of State should be satisfied that, where relevant:*

the application is supported by an appropriate FRA;

the Sequential Test (see the National Planning Policy Framework) has been applied as part of site selection and, if required, the Exception Test (see the National Planning Policy Framework)".

2.4.23 NPS NN paragraph 5.99 advises that when determining an application the Secretary of State should be satisfied that flood risk will not be increased elsewhere and only consider development appropriate in areas at risk of flooding where (informed by a flood risk assessment, following the Sequential Test and, if required, the Exception Test), it can be demonstrated that:

- within the site, the most vulnerable development is located in areas of lowest flood risk unless there are overriding reasons to prefer a different location; and

- development is appropriately flood resilient and resistant, including safe access and escape routes where required, and that any residual risk can be safely managed, including by emergency planning; and priority is given to the use of sustainable drainage systems.

2.4.24 The NPS NN recognises that the nature of linear infrastructure means that areas of flood risk are unavoidable in some cases, including where upgrades are made to existing infrastructure in an area at risk of flooding; infrastructure in a flood risk area is being replaced; infrastructure is being provided to serve a flood risk area; and infrastructure is being provided to connect two points that are not in flood risk areas, but where the most viable route between the two passes through such an area.

2.4.25 Where linear infrastructure can reduce the risk of flooding for the surrounding area the Secretary of State should take account of any positive benefit to placing linear infrastructure in a flood-risk area.

2.4.26 Paragraph 5.104 advises that reasonable mitigation measures should be made where linear infrastructure has been proposed in a flood risk area, to ensure that the infrastructure remains functional in the event of predicted flooding.

2.4.27 NPS NN refers to the advice on flood risk in the National Planning Policy Framework ("NPPF"), as expanded on Planning Practice Guidance on flood risk. The NPPF was revised in July 2018 and this FRA refers to the provisions set out in the revised NPPF.

2.4.28 The Flood Zone classifications used in the Sequential Test are set out in Table 1 of the Planning Practice Guidance on Flood Risk:

Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)
Zone 2 Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding. (Land shown in light blue on the Flood Map)
Zone 3a High Probability	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding.(Land shown in dark blue on the Flood Map)
Zone 3b The Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map)

2.4.29 As advised by NPS NN paragraph 5.105 and NPPF the flood zones through which the DCO Scheme passes have been identified. Seven areas of works lie within undefended Flood Zones 3a and 3b. These works are set out in Table 4.6 of this FRA. All other works are located in flood zones 1, 2 and defended Flood Zones 2 and 3.

2.4.30 The Sequential Test provides that preference should be given to locating projects in Flood Zone 1. If there is no reasonably available site in Flood Zone 1, then projects can be located in Flood Zone 2. If there is no reasonably available site in Flood Zones 1 or 2, then national networks infrastructure projects can be located in Flood Zone 3, subject to the Exception Test. The Environmental Statement Chapter 3 Scheme Development and Alternatives Considered, DCO Document Reference 6.6, explains that the route of the DCO Scheme is the only feasible option. There are no reasonably available sites in areas with a lower probability of flooding that are appropriate for the DCO Scheme. The Sequential Test is considered to be met.

2.4.31 Table 3 of the Planning Practice Guidance specifies appropriate development types for the different EA Flood Zones in terms of flood risk vulnerability classes. This is reproduced as Table 2.2 below.

Table 2.2: Planning Practice Guidance Table 3 – Flood risk vulnerability and flood zone 'compatibility'

Flood Zones	**Flood risk vulnerability classification**				
	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test required	✓	✓	✓
Zone 3a †	Exception Test required †	✗	Exception Test required	✓	✓
Zone 3b *	Exception Test required *	✗	✗	✗	✓*

Key:

✓ Development is appropriate

✗ Development should not be permitted

Notes to table:

- This table does not show the application of the Sequential Test which should be applied first to guide development to Flood Zone 1, then Zone 2, and then Zone 3; nor does it reflect the need to avoid flood risk from sources other than rivers and the sea;
- The Sequential and Exception Tests do not need to be applied to minor developments and changes of use, except for a change of use to a caravan, camping or chalet site, or to a mobile home or park home site;
- Some developments may contain different elements of vulnerability and the highest vulnerability category should be used, unless the development is considered in its component parts.

† In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

* In Flood Zone 3b (functional floodplain) essential infrastructure that has to be there and has passed the Exception Test, and water-compatible uses, should be designed and constructed to:

- remain operational and safe for users in times of flood;
- result in no net loss of floodplain storage;
- not impede water flows and not increase flood risk elsewhere.

2.4.32 Applying the flood risk vulnerability classification set out in Planning Practice Guidance, the DCO Scheme is essential transport infrastructure that has to cross the area at risk. Therefore, the Exception Test must be applied. For the Exception Test to be passed:

- it must be demonstrated that the project provides wider sustainability benefits to the community that outweigh flood risk; and
- the FRA must demonstrate that the project will be safe for its lifetime, without increasing flood risk elsewhere and, where possible, will reduce flood risk overall.

2.4.33 In addition, any project that is classified as 'essential infrastructure' and proposed to be located in Flood Zone 3a or 3b should be designed and constructed to remain operational and safe for users in times of flood; and any project in Zone 3b should result in no net loss of floodplain storage and not impede water flows.

2.4.34 It is considered that the DCO Scheme provides wider sustainability benefits to the community that outweigh flood risk. These are set out in the Environmental Statement Chapters 1 Introduction, 3 Scheme Development and Alternatives Considered and 15 Socio-economics and Regeneration, the Planning Statement and Appendix 9.12 Habitats Regulations Assessment, , DCO Document References 6.4, 6.6, 6.18, 8.11 and 6.25 respectively. The focus of this FRA is on demonstrating that the project will be safe for its lifetime, without increasing flood risk elsewhere, and that where possible it will reduce flood risk.

2.4.35 As advised in NPS NN paragraph 5.94, this FRA:

- considers the risk of all forms of flooding arising from the project, in addition to the risk of flooding to the project, demonstrates how these risks will be managed and, where relevant, mitigated, so that the development remains safe throughout its lifetime;
- takes the impacts of climate change into account, using the DCO Scheme lifetime over which the assessment has been made of 60 years from a baseline 2015;
- considers the vulnerability of those using the infrastructure including arrangements for safe access and exit;
- includes the assessment of the remaining (known as 'residual') risk after risk reduction measures have been taken into account and demonstrates that this is acceptable for the particular project;
- considers if there is a need to remain operational during a worst case flood event over the development's lifetime; and

- provides the evidence for the Secretary of State to apply the Sequential Test and the Exception Test.

Local planning framework

2.4.36 The local planning framework is considered in more detail in Chapter 6 of the Environmental Statement, DCO Document Reference 6.9. Policies relating to flood risk and key aspects of these policies relevant to the DCO Scheme are listed below.

North Somerset Council

North Somerset Council Core Strategy (2017)

CS3: Environmental impacts and flood risk assessment

2.4.37 The policy states a requirement for development in Flood Zones 2 and 3 to satisfy the NPPF Sequential Test and, if appropriate, the Exception Test unless it is:

- of a category for which the NPPF and its technical guidance makes specific alternative provision;
- or development for the same or similar character and scale for which the site is allocated subject to demonstrating the development will be safe from flooding and not increase flood risk elsewhere, and, where possible, reduce overall flood risk.

2.4.38 If development is considered inappropriate under the NPPF for the flood zone within which the site is located then permission would normally be refused.

Sites and Policies Management Plan Part 1: Development Management Policies (2016)

DM1: Flooding and drainage

2.4.39 This policy requires compliance with the NPPF and technical guidance (https://www.gov.uk/government/collections/planning-practice-guidance).

2.4.40 SuDS are expected for all major developments; alternatives will only be permitted where SuDS are impractical or would compromise the viability of the scheme and the alternative does not conflict with national planning policy.

Bristol City Council

Bristol Core Strategy (2011)

BCS16: Flood Risk and Water Management

2.4.41 Development in Bristol will follow a sequential approach, giving priority to development of sites with the lowest risk of flooding.

2.4.42 Development in areas at risk of flooding will be expected to be resilient through design and layout and/or incorporate mitigation measures to ensure that the development remains safe from flooding over its lifetime. Mitigation works may take the form of on-site works or a contribution or commitment to undertake off-site works required to minimise the vulnerability of the site to flooding.

2.4.43 All development will be expected to incorporate measures to reduce surface water runoff and ensure it does not increase flood risk elsewhere. This should include the use of SuDS.

Other Flood Risk Assessments

South Bristol Link Full Planning Application (2013)

2.4.44 The South Bristol Link project is a new transport link between Long Ashton and Hengrove in south west Bristol. The route crosses Colliter's Brook and Longmoor/Ashton Brook approximately 800 m upstream of the Portishead Branch Line crossing of Colliter's Brook and Longmoor/Ashton Brook.

2.4.45 The South Bristol Link Flood Risk Assessment developed hydraulic modelling of Colliter's Brook and Longmoor/Ashton Brook to assess flood risk to the proposed new route and the impact of the proposed new route on flood risk elsewhere. The hydraulic model downstream extent is approximately 130 m upstream of the Portishead Branch Line crossing of Colliter's Brook and Longmoor/Ashton Brook. Results of the hydraulic modelling undertaken for the South Bristol Link Flood Risk Assessment indicate that flood levels at the downstream model extent are relatively insensitive to the proposed works (simulated change in peak flood level at the downstream model extent of +0.1 m for the 100 year return period flood and -0.02 m for the 100 year flood with climate change allowance). The use of CAFRA model results (Sections 4.2.5 to 4.2.10) in the DCO Scheme flood risk assessment is therefore considered reasonable as the impact of the proposed South Bristol Link on flood levels downstream is minor.

2.4.46 The DCO Scheme will not significantly alter Colliter's Brook and Longmoor/Ashton Brook flood levels or flood flow conveyance/storage (Section 8.1.19) and so would not impact the South Bristol Link.

Metrobus m2 Scheme

2.4.47 The metrobus m2 (formerly known as the Ashton Vale to Temple Meads and Bristol City Centre Rapid Bus Transit Scheme or AVTM MetroBus) is a new metrobus route between Ashton Vale and Temple Meads train station in Bristol, and a circular city centre bus route. Elements of the proposed works relevant to m2 include:

- Crossing of Longmoor Brook approximately 800 m southwest (i.e. upstream) of the DCO Scheme;
- Crossing of Colliter's Brook approximately 500 m upstream of the DCO Scheme and crossing of culverted Colliter's Brook directly upstream of the DCO Scheme, with the bus route parallel to Colliter's Brook between these crossings (and in Flood Zone 1); and
- The proposed bus route includes a bridge crossing the DCO Scheme between Colliter's Brook and Longmoor Brook (in Flood Zone 1).

2.4.48 The AVTM Metrobus FRA interpreted results of Bristol City Council's CAFRA hydraulic model (2010 version) to assess flood risk. All crossings of Colliter's Brook and Longmoor Brook channels are designed to have soffit levels above the 1000-year modelled flood level with climate change allowance and compensation storage is included for all works within Flood Zone 3.

2.4.49 The impacts of the AVTM Metrobus Scheme on the DCO Scheme are therefore considered to be negligible, and so the AVTM Metrobus Scheme does not invalidate use of the CAFRA modelling (updated in 2015) to assess flood risk associated with Colliter's Brook, Longmoor Brook and the River Avon in this FRA.

SECTION 3

Definition of flood hazard

3.1 Sources of flooding and existing flood defences

Fluvial and tidal flooding

Portishead to Pill (disused section)

3.1.1 The EA Flood Map (Appendix B, DCO Document Reference 5.6) indicates that parts of the Portishead to Pill (disused section) are at risk of fluvial/tidal flooding. However, the EA Flood Zones do not account for the presence of flood defences.

3.1.2 The Portishead to Pill (disused section) between Portishead and the M5 motorway Junction 19 is shown to be partly in defended Flood Zone 3. Comparison of the EA Flood Map and results of the EA undefended tidal flooding model (Appendix B, DCO Document Reference 5.6) indicate that the defended Flood Zone 3 and Flood Zone 2 shown in the EA Flood Map between Portishead and the M5 motorway Junction 19 is due to tidal flood risk (including the defended Flood Zone 3 shown adjacent to Drove Rhyne).

3.1.3 The EA Flood Map shows the Portishead to Pill (disused section) crosses Flood Zones 2 and 3 at Easton-in-Gordano Stream. Here the EA Flood Map estimates tidal flood risk by projecting simulated River Avon tidal flood levels up the Easton-in-Gordano Stream. (Modelling undertaken for this FRA provides a more detailed assessment of Easton-in-Gordano Stream tidal flood risk due to tidal River Avon levels, see Sections 4.2.23 to 4.2.27).

3.1.4 There is also the potential for fluvial flooding where the Portishead to Pill (disused section) crosses significant watercourses i.e. Portbury Ditch, The Cut, Drove Rhyne and Easton-in-Gordano Stream. Flood risk from these watercourses is considered in Section 4.

3.1.5 The EA Historic Flood Map (Appendix B, DCO Document Reference 5.6) shows flooding in Portishead in 1981 caused by overtopping of coastal flood defences and the tabulated historical flood data notes exceedance of Portbury Ditch channel capacity in 1990 leading to flooding of properties in Victoria Square, Portishead (approximately 450 m southwest of the DCO Scheme western extent).

3.1.6 The Portishead to Pill (disused section) crosses the North Somerset Levels Internal Drainage Board (“IDB”) area (Appendix F, DCO Document Reference 5.6) where watercourse gradients are flat. Watercourses crossed within the IDB area include Portbury Ditch, The Cut, Drove Rhyne and other minor drainage channels.

Portbury Freight Line (operational railway)

3.1.7 The EA Flood Map indicates that the primary source of fluvial/tidal flood risk along the Portbury Freight Line (operational railway) between Pill and Parson Street Junction is the River Avon. Here the River Avon is tidally dominated and so flood risk from the River Avon is dominated by tidal flood risk.

3.1.8 Through the Avon Gorge the Portbury Freight Line lies adjacent to the River Avon but at a significantly higher elevation than River Avon flood levels. Consequently, the operational railway is not considered to be at risk of flooding from the River Avon.

3.1.9 The elevation of the operational railway descends near Bower Ashton. From where the operational railway is closest to the A369 to approximately 500 m further south the EA Flood Map shows the Portbury Freight Line (operational railway) to be within Flood Zone 3, due to tidal River Avon flood risk.

3.1.10 The Portbury Freight Line (operational railway) crosses the culverted Colliter's Brook, immediately downstream of where the Colliter's Brook enters a culvert at Ashton Vale, and is adjacent to Colliter's Brook Flood Zone 2. The alignments of the Colliter's Brook and Ashton Brook/Longmoor Brook culverts are shown in Figure 17.1 in the Environmental Statement Book of Figures, DCO Document Reference 6.24.

3.1.11 Between Pill and Bower Ashton the Portbury Freight Line (operational railway) crosses Markham Brook which is culverted through Pill, Chapel Pill and the small watercourse WC1. At these locations the Portbury Freight Line (operational railway) is significantly higher (by several metres) than the watercourses it crosses and hence potential fluvial flood risk is discounted at these locations.

3.1.12 The EA Historic Flood Map (Appendix B, DCO Document Reference 5.6) shows flooding in Pill adjacent to the River Avon caused by overtopping of River Avon flood defences in 1989 and 1990.

Combined fluvial/tidal flooding

3.1.13 There is the potential for tide locking of watercourses within the study area, namely for the Portbury Ditch, The Cut, Drove Rhyne, Easton-in-Gordano Stream and Colliter's Brook, Longmoor Brook and Ashton Brook, which all drain either into the tidal River Avon or North Somerset coast. This occurs when high water levels in these watercourses coincide with high tides.

Pluvial (surface water) flooding

3.1.14 Pluvial (surface water) flooding is flooding that may occur due to intense rainfall due to exceedance of the local drainage system capacity or localised ponding of runoff. The EA surface water flood map indicates that there may be relatively small and localised areas in the vicinity of the DCO Scheme that could be vulnerable to surface water flooding during rainstorms (https://flood-warning-information.service.gov.uk/long-term-flood-risk/map).

3.1.15 NSDC has provided maps showing properties recorded to have experienced surface water flooding in the vicinity of the DCO Scheme (Appendix F, DCO Document Reference 5.6). These maps show there are properties in Pill that have experienced internal flooding, properties in Portbury that have experienced internal and/or external flooding, a property near Sheepway that has experienced external flooding and a property in Leigh Woods that has experienced internal flooding.

3.1.16 NSDC's broad scale modelling indicates that there may be an existing surface water flooding problem at Monmouth Road in Pill, which lies to the north of the railway and between the station and the location of the proposed new Pill station car park. However, as there was no flooding reported at Monmouth Road during the 2012 surface water flooding event, it

is likely that local drainage infrastructure, which is not represented in the broad scale modelling, drains Monmouth Road effectively.

Sewer flooding

3.1.17 The proposed new stations at Portishead and Pill will connect to existing sewerage systems.

Groundwater flooding

3.1.18 The EA Susceptibility to Groundwater Flooding map is shown in Appendix B, DCO Document Reference 5.6. The Susceptibility to Groundwater Flooding map was developed to provide a strategic indication of areas where there may be potential for groundwater flooding based on geology, ground levels and an estimation of high groundwater levels (and is not intended to provide a definition of local groundwater flood risk). The Susceptibility to Groundwater Flooding map shows there may be potential for groundwater flood risk between Portishead and Pill and in the vicinity of Ashton Gate/Ashton Vale. However, during consultation the EA has indicated there are no specific groundwater flooding problems along the DCO Scheme alignment (Section 6.2.2).

Flooding from reservoirs and canals

3.1.19 The EA Risk of Flooding from Reservoirs map (https://flood-warning-information.service.gov.uk/long-term-flood-risk/map) indicates that the Portbury Freight Line (operational railway) is at risk of flooding from a breach of the Barrow Nos. 1, 2 and 3 reservoirs, located to the south west of Bristol and owned by Bristol Water Plc, shown in Figure 3.1. Figure 3.1 shows the simulated reservoir breach flood extent for these reservoirs, and notes that "*since this* [the simulated breach] *is a worst case scenario, it's unlikely that actual flooding would be this large"*. The EA website notes that: "*Reservoir flooding is extremely unlikely to happen. There has been no loss of life in the UK from reservoir flooding since 1925. All large reservoirs must be inspected and supervised by reservoir panel engineers. As the enforcement authority for the Reservoirs Act 1975 in England, we ensure that reservoirs are inspected regularly and essential safety work is carried out."*

3.1.20 The Canals and Rivers Trust website map of canals (https://canalrivertrust.org.uk/enjoy-the-waterways/canal-and-river-network) indicates there are no canals for which a breach would result in flooding in the vicinity of the DCO Scheme.

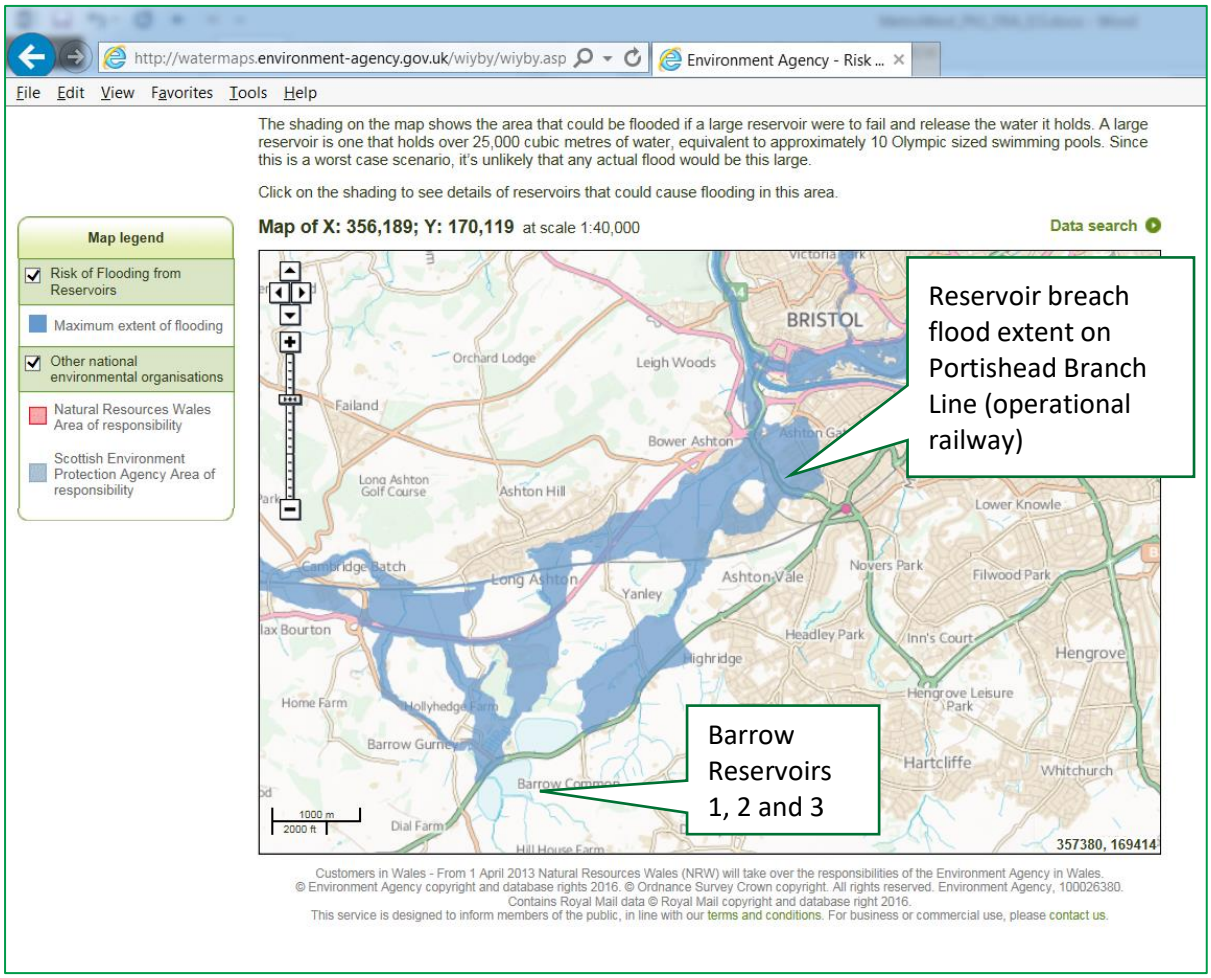

Figure 3.1: Simulated reservoir breach flood extent
Source: EA website 2016

Existing flood defences

3.1.22 The EA has provided details of existing flood defences in the vicinity of the DCO Scheme, which are listed in Table 3.1 below and presented in Appendix J, DCO Document Reference 5.6.

Table 3.1: Details of existing flood defence data provided by the EA

EA data request reference	Date data created	Coverage
SW/6775	6/6/14	Area between the DCO Scheme and North Somerset coast west of Portishead
SW/8936	2/2/14	Portbury Ditch in Portishead and River Avon between Pill and Ashton Vale (detail near Ashton Gate was not included in the map as there are no built defences at this location)
WX/0411	2/3/15	Colliter's Brook and Longmoor/Ashton Brook in the Ashton Vale/Ashton Gate area. Also includes River Avon 'high ground' defence line.

3.1.23 The data provided are described below.

EA data reference SW/6775

3.1.24 There are existing tidal flood defences protecting the coastal floodplain to the north of the Portishead Branch Line (disused section). These are shown in the EA map of current flood defences and described in the accompanying EA Asset Information Management System (AIMS) information table (Appendix J, DCO Document Reference 5.6). There is a defence line protecting the Portishead Branch Line (disused section) from coastal flooding running between high ground south of Portbury Dock to high ground at Portishead. This includes the 'Sea Commissioner's Bank' (defence No. 46 in the EA map of flood defences) with a crest level of 5.48 mAOD and, further east, a mix of walls and embankments with crest levels between 8.0 mAOD (defence No. 5) and ranging from 9.76 mAOD to 10.37 mAOD (from west to east defence Nos. 42, 40, 43, 41, 39, 36, 35, 34, and 33).

3.1.25 Inland from the Sea Commissioner's Bank there is a defence line with higher crest levels, which joins two areas with high ground levels (defence Nos. 24 and 31), comprising a wall with a crest level of 9.31 mAOD defence No. 30) and an embankment with crest level 9.70 mAOD (defence No. 23).

3.1.26 The condition of all the defences described above is described in AIMS as "fair" (Appendix J, DCO Document Reference 5.6). The EA has recently agreed with a private developer actions required to resolve a structural issue with defence No. 30. After these remedial works have been undertaken, the EA will adopt the defence for maintenance.

3.1.27 There are no built defences along Drove Rhyne.

EA data reference SW/8936

3.1.28 There are no built defences along Portbury Ditch.

3.1.29 Markham Brook is culverted through Pill, including under the operational railway which is elevated on Pill Viaduct at that location.

3.1.30 Downstream (north-west) of the Markham Brook confluence with the River Avon, there are built flood defences protecting Pill from tidal River Avon flooding. These vary in level between approximately 8.19 mAOD and 10.05 mAOD.

3.1.31 Upstream (south-east) of the Markham Brook confluence with the River Avon, no built defences are shown to protect Pill, but there are high ground levels adjacent to the River Avon shown to be between 6.28 mAOD and 6.97 mAOD. The DCO application area within Pill is at a significantly higher elevation than River Avon flood levels (Section 8.5.5).

3.1.32 There are no built defences on the River Avon between Pill and Ashton Gate.

EA data reference WX/0411

3.1.33 The locations of culverted sections of Colliter's Brook (culverts 42 and 33) and Longmoor Brook/Ashton Brook (culvert 31) are shown in Appendix J, DCO Document Reference 5.6. The Portbury Freight Line (operational railway) crosses Colliter's Brook culvert 42 and Longmoor Brook/Ashton Brook culvert 31 and runs adjacent to culvert 31 for approximately 300 m.

3.1.34 There are no built defences on the River Avon in the vicinity of Ashton Gate.

3.2 Structures that may influence local hydraulics

3.2.1 The Portishead Branch Line (disused section) crosses several watercourses which are culverted through the railway embankment. These include Portbury Ditch, The Cut, Drove Rhyne, Easton-in-Gordano Stream and other minor channels/ditches. The North Somerset Levels Internal Drainage Board ("NSLIDB)" has advised that for watercourses within the NSLIDB area, i.e. all watercourses crossed by the Portishead Branch Line (disused section) west of Marsh Lane, any proposed increase in culvert size would be viewed positively (Section 6.3).

3.2.2 Drove Rhyne and Easton-in-Gordano Stream have flapped orifice outfalls to the North Somerset coast and tidal River Avon respectively. These prevent high tide levels propagating up the watercourses but also restrict outflow from the watercourses during high tide levels, resulting in storage of fluvial flows within the channels.

3.2.3 Modelling undertaken for this FRA (Appendix K, DCO Document Reference 5.6) indicates that the farm access underpass (under the railway embankment) directly west of the M5 overbridge named as Cattle Creep underbridge is an important bypass flow route for Easton-in-Gordano stream flood flows as the railway culvert cannot adequately convey flood flows. Reducing or closing this opening would increase flood levels upstream.

3.2.4 Between Pill and north of Bower Ashton, the Portishead Freight Line (operational railway) lies at a higher level than River Avon flood levels and hence has no influence on the River Avon hydraulics. Existing railway bridges and drainage culverts through the railway embankment may influence hydraulics of local drainage/minor watercourses.

3.2.5 The Portishead Freight Line (operational railway) adjacent to the River Avon at Bower Ashton is at a lower elevation than it is further north and is within the River Avon tidal floodplain. At this location, for flood levels exceeding the railway elevation, the railway would act as a hydraulic control on River Avon out of bank flood water crossing the railway westwards.

3.2.6 Whilst the Portishead Freight Line (operational railway) lies in Flood Zone 1 south of Bower Ashton, it crosses culverts on Colliter's Brook and Longmoor Brook/Ashton Brook and runs adjacent to the Longmoor Brook/Ashton Brook culvert for approximately 300 m.

3.3 Consequences of flooding on the site

3.3.1 Flooding above the railway level would result in disruption to the railway service, with associated inconvenience to passengers and economic impacts to the service provider. Recovery of the railway service after flooding is expected to be relatively quick. NRIL has advised that following the winter 2013/14 Somerset Levels railway closures due to flooding (for approximately 3 weeks), lines were operational within approximately one day of flood levels subsiding (remedial works were not required) and that depth of flooding is not usually an issue but flowing water is more problematic.

SECTION 4

Probability of flooding

4.1 Environment Agency flood maps

Environment Agency Flood Zones

4.1.1 The EA Flood Map covering the DCO Scheme is provided in Appendix B, DCO Document Reference 5.6. This shows the DCO Scheme to be in Flood Zone 1 except for:

- Flood Zone 3 at the crossing of Portbury ditch
- Partly in Flood Zone 2 and defended Flood Zone 3 between Portbury Ditch and Royal Portbury Dock Road.
- Mostly in Flood Zones 2 and 3 between Royal Portbury Dock Road and the M5 Motorway crossing
- Flood Zone 3 at the crossing of Markham Brook in Pill, although the railway is elevated on Pill Viaduct and Markham Brook is culverted through Pill
- Flood Zone 3 at the crossing of Chapel Pill watercourse
- Flood Zone 3 near Paradise Bottom
- Flood Zone 3 near Bower Ashton
- Adjacent to Flood Zone 2 at Colliter's Brook culvert entrance adjacent to the Portbury Freight Line.

4.1.2 The EA Flood Zones in the vicinity of the DCO Scheme were derived by the EA using the following models:

- EA coastal model (Somerset North Coast Flood Warning Improvements, 2012) for assessing the coastal flood risk between Portishead and Avonmouth
- Bristol City Council Central Area Flood Risk Assessment ("CAFRA") River Avon and tributaries model for the River Avon, Colliter's Brook and Longmoor/Ashton Brook.
- EA broad scale fluvial modelling (Jflow) for other channels e.g. Drove Rhyne, Easton-in-Gordano Stream, Markham Brook, and Chapel Pill watercourse.

4.1.3 Hydraulic modelling undertaken for the DCO Scheme has provided a more detailed assessment of flood risk than the modelling undertaken for the EA Flood Zones, as follows:

- Reviewed and refined the EA coastal model at the DCO Scheme location to refine the assessment of coastal flood risk in the vicinity of the DCO Scheme between Portishead and Avonmouth.
- Further development of the Bristol City Council CAFRA model and interpretation of results.

- Developed hydraulic models representing Drove Rhyne and Easton-in-Gordano Stream to refine the assessment of fluvial flood risk from these watercourses and assess the tidal flood risk from Easton-in-Gordano Stream which discharges to the Avon. The tidal flood risk in the vicinity of Drove Rhyne is represented in the coastal modelling and the Drove Rhyne discharges to the Severn Estuary.

4.1.4 A review of Flood Zones informed by results of the hydraulic modelling undertaken for this FRA is presented in Section 4.2.30 and Appendix L, DCO Document Reference 5.6.

Historical flood map

4.1.5 The EA Historic Flood Map, and corresponding tabulated flood descriptions, included in Appendix B, DCO Document Reference 5.6, report the following historical floods in the vicinity of the DCO Scheme:

- Flooding in/near Pill due to overtopping of River Avon flood defences in 1960, 1989 and 1990. For all these events, flooding did not extend to the Portishead to Pill (disused section) except for under the Pill Viaduct, where the railway is elevated on a viaduct and was not affected by flooding in the valley below.
- River Avon 'just' out of bank flooding for much of its length between Avonmouth and Ashton Gate in 1960.
- Ashton Vale/Ashton Gate – Colliter's Brook channel capacity was exceeded in 1954, 1958, 1960, 1965, 1968, 1971 and 1974. There has been significant change to Colliter's Brook since these floods e.g. Colliter's Brook culverting and flood flow diversion upstream of the DCO Scheme (implemented in the 1970s) and so historical flooding may not be representative of current flood risk in this area.
- Ashton Vale/Ashton Gate: River Avon channel capacity was exceeded in 1703 and 1896 (no raised defences).

4.1.6 The Historic Flood maps indicate potential for River Avon and Colliter's Brook flooding in the Ashton Vale/Ashton Gate area as well as localised flooding in the vicinity of Pill. This is consistent with the EA Flood Map (Appendix B, DCO Document Reference 5.6) and results of the hydraulic modelling undertaken for this FRA (Section 4.2), noting changes to Colliter's Brook flood routing (culverting) since the reported flooding between 1954 and 1974.

4.1.7 The historic flood map and associated descriptions may not provide a complete record of historical flooding, particularly for older periods of record.

Surface water flood risk

4.1.8 The EA Updated Flood Map for Surface Water Flooding (uFMSWF) is shown at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map

4.1.9 A mapped summary of the suitability classification of the underlying modelling undertaken to provide the mapping is in Appendix E, DCO Document Reference 5.6. The uFMSWF is shown to have a suitability classification of *County to Town* for most of the area shown within North Somerset Council and *Town to Street* within the Bristol City Council area.

This higher confidence for results in the Bristol City Council area reflects that model results within the North Somerset Council area were derived from the national scale modelling undertaken for the uFMSWF whilst the Bristol City Council area mapping is derived by more detailed modelling undertaken by Bristol City Council to support its Surface Water Management Plan (2012).

4.1.10 The Bristol City Council modelling includes a representation of the sewer network within Bristol City whereas the national broad scale modelling does not represent sewers. However, both modelling approaches do not include details of surface water channels and structures and results are therefore considered indicative only.

4.1.11 The uFMSWF indicates there is potential for localised surface water flooding at low spots along the DCO Scheme alignment and shows surface water accumulation at Bower Ashton, directly west of the DCO Scheme alignment. However, the modelling does not represent, for example, local surface water drainage systems and channels/culverts and so the mapping is considered to give an indication of potential surface water flood risk rather than actual surface water flood risk.

4.1.12 During consultation NSDC has indicated there has been historical surface water flooding in Pill.

Groundwater flooding

4.1.13 The EA has indicated there are no specific groundwater flooding problems along the DCO Scheme alignment (section 3.1.18).

4.2 Hydraulic modelling results

Development of Environment Agency coastal model

4.2.1 The EA coastal model (North Somerset Coast Flood Warning Improvements, 2012) was developed further for the DCO Scheme by improving model detail relevant to this FRA as follows:

- Use of topographic survey levels along railway alignment;
- Extended tidal boundary along River Avon upstream as far as the M5 motorway crossing of the River Avon (where high ground levels are above the tidal design levels);
- Represented flow path towards Easton-in-Gordano Stream in model 2D domain (culvert and spill level over culvert added). Dimensions were taken from the Easton-in-Gordano Stream model (Section 4.2.23);
- Reviewed and added significant openings through railway alignment where missing in the model; and
- Use of design levels along the railway alignment for the model representing the post-development situation.

4.2.2 In addition, model boundary conditions were developed to represent projected climate change and sea level rise scenarios.

4.2.3 Simulated flood extents derived by the coastal modelling are shown in Appendix M, DCO Document Reference 5.6 for the present day (2015) for the 1000 year return period (flooding does not reach the railway for the 1000

year event and so less extreme events are not simulated), for the future (2075) scenario for return periods 200, 1000 year (same results pre and post development in 2075 as flood levels do not overtop the railway) and for the future (2115) scenario for return periods 25, 50, 75, 100, 200 and 1000 years, for the pre-development and post-development cases (the post-development case is discussed further in Section 7).

4.2.4 The results of coastal modelling indicate:

- The Portishead to Pill (disused section) would not be flooded (by coastal flooding) for the pre-development and post-development cases for the present day scenario (2015) for all return periods simulated (up to 1000 year). For these simulations the Portishead to Pill (disused section) is defended from coastal flooding by the existing coastal flood defences: Sea Commissioner's bank and the Ashlands inland bund defence (flood defences 46 and 23 in Appendix J, DCO Document Reference 5.6).
- The future scenarios (2075 and 2115) allow for projected sea level rise and climate change. The projected sea level rise of 0.59 m between 1990 and 2075, and 1.14 m between 1990 and 2115 (Section 5), results in an increase in frequency of overtopping of the inland bund coastal flood. For the future scenario (2075) model results indicate the 200 year flood extent would not reach the railway, and the 1000 year flood extent would just reach the railway between Portishead and Sheepway, but peak flood levels would be lower than the railway levels. For the future scenario (2115) model results indicate the lowest simulated return period with flooding of the railway alignment is reduced to approximately 200 to 1000 years (this does not allow for the likely implementation of strategic mitigation for sea level rise in the future).

Bristol City Council Central Area Flood Risk Assessment hydraulic model

4.2.5 The Bristol City Council Central Area Flood Risk Assessment CAFRA hydraulic model was provided by BCC for use in this FRA. The CAFRA model covers the River Avon, through Bristol to the North Somerset coast, and its tributaries. Flood risk from the River Avon is tidally dominated at the DCO Scheme location.

4.2.6 The CAFRA model was reviewed and developed for this FRA further as follows:

- Topographic survey data along the Portbury Freight Line railway alignment near Bower Ashton was used to refine model levels in this area.
- Model boundary conditions derived for the future (2115) scenario applying projected climate change and sea level rise.
- Buildings in the floodplain were represented using the "stubby buildings" approach (Appendix N, DCO Document Reference 5.6).
- Representation of post-development situation (the post-development situation is described in Section 7)

Tidal River Avon

Simulations and results

4.2.7 Simulated tidal River Avon flood extents derived by the updated CAFRA modelling are shown in Appendix N, DCO Document Reference 5.6 for the present day (2015) and future (2075 and 2115) scenarios for the base tide (between Mean High Water Spring and Highest Astronomical Tide) and return periods 1 (for 2075 and 2115 only), 2, 5, 10, 20, 75, 200 and 1000 years, for the pre-development and post-development cases (the post-development case is discussed further in Section 7).

4.2.8 Simulated maximum flood levels along the railway alignment during River Avon tidal flood events, at railway chainages within the simulated flood extents, are tabulated in Appendix N, DCO Document Reference 5.6 (in spreadsheet with filename "*5.6 Flood Risk Assessment Appendix N CAFRA Rlw Results 2019 Tidal.xlsx*"). The railway chainage locations are shown in Appendix N, DCO Document Reference 5.6. Table 4.1 lists modelled maximum flood depth relative to lowest rail level of the Portbury Freight Line (operational railway) near Bower Ashton for the present day (2015) and future (2115) scenarios.

Table 4.1: Modelled maximum River Avon tidal flood depth relative to the lowest rail level of the DCO Scheme near Bower Ashton

Maximum flood depth relative to lowest rail level (m)						
	Present day (2015)		***Future year (2075)***		***Future scenario (2115)***	
Return period (years)	Pre-development	Post-development	Pre-development	Post-development	Pre-development	Post-development
Base (Tidal): With peak level midway between Mean High Water Spring and Highest Astronomical Tide	No flooding	No flooding	No flooding	No flooding	No flooding	No flooding
1 (Tidal)	Not simulated	Not simulated	0.44	0.44	1.02	1.02
2 (Tidal)	No flooding	No flooding	0.64	0.64	1.09	1.09
5 (Tidal)	No flooding	No flooding	0.80	0.80	1.20	1.20
10 (Tidal)	0.15	0.15	0.90	0.90	1.29	1.29
20 (Tidal)	0.53	0.53	0.98	0.98	1.36	1.36
75 (Tidal)	0.74	0.74	1.11	1.11	1.52	1.52
200 (Tidal)	0.97	0.97	1.33	1.33	1.93	1.93
1000 (Tidal)	1.20	1.20	1.75	1.75	2.27	2.27

Flood risk to railway at Bower Ashton

4.2.9 The model results show that, for the present day (2015) scenario, the railway is simulated to flood at Bower Ashton for events with a return period between 5 and 10 years for the pre- and post-development scenarios. For the future (2075 and 2115) scenarios simulated flooding occurs with a higher frequency (during the 1-year return period) due to the influence of significant projected sea level rise. Table 4.1 shows the maximum flood depths simulated along this section of the railway relative to the lowest rail level. Simulated flood risk to the railway during the 1 year return period tidal event in 2075 is discussed further in Sections 4.2.20 to 4.2.24.

4.2.10 Appendix N, DCO Document Reference 5.6 includes flood maps for the simulated events. These flood maps show the proposed Clanage Road compound to be within the 20-year tidal River Avon flood extent, and outside of the tidal River Avon 10-year flood extent i.e. within simulated Flood Zone 3b.

4.2.11 However, a further consideration of model results in the Bower Ashton area, in the context of available flood history and information relating to CAFRA model uncertainty, indicates the CAFRA model results in the Bower Ashton area are likely to overestimate flood risk, and assigning Flood Zone 3b rather than Flood Zone 3a to the Clanage Road compound is therefore considered precautionary. This is discussed below in Sections 4.2.12 to 4.2.19.

Consideration of available flood history information

4.2.12 Whilst the latest MetroWest model results show the compound to be in FZ3b (i.e. within the 20 year flood extent), this does not appear to be consistent with available flood history information.

- Bristol Local Flood Risk Management Strategy identifies significant historic River Avon tidal flood events as 1607 (reported to be a Tsunami), 1896, 1981 and 2014.
- The only events in the EA historic flood maps provided that show the compound area to be flooded are 1703 and 1896.
- Internet searches of e.g. “flood Bower Ashton”, “flood police Bower Ashton”, “flood Clanage Road”, “flood Bristol” do not reveal any evidence of historic flooding to the Clanage Road compound site.
- A search of the British Hydrological Society Chronology of British Hydrological Events (http://cbhe.hydrology.org.uk/) does not identify additional flood events.

4.2.13 The recording of historic flood records is likely to be most reliable within the last 50 years or so. The above consideration of historic flood information suggests the Clanage Road compound has not flooded due to River Avon tide levels in the last 50 years (and possibly longer). If the compound were within the 20 year flood extent, the most likely number of instances of flooding to the site within the last 50 years would be 2 events with 26% probability, and the probability of no floods in a 20 year period would be only 7.7% (Table 4.2 below).

Table 4.2: Probabilities for number of flood events occurring in a 50 year period – assuming flooding occur once every 20 years on average

Number of flood events	Probability (%)
0	7.7
1	20.2
2	26.1
3	22.0
4	13.6
5	6.6

4.2.14 If the compound flooded once every 50 years on average, then the probability of no floods occurring in a 50 year record would be significantly higher at 36% (Table 4.3).

Table 4.3: Probabilities for number of flood events occurring in a 50 year period – assuming flooding occur once every 50 years on average

Number of flood events	Probability (%)
0	36.4
1	37.2
2	18.6
3	6.1
4	1.5
5	0.3

4.2.15 This suggests the compound is likely to flood less frequently than once every 20 years on average, i.e. the compound is likely to be outside of Flood Zone 3b, and a flood frequency of approximately once every 50 years on average is plausible. Estimating a higher return period for flooding of the Clanage Road site is also consistent with understood uncertainty in the MetroWest CAFRA model derived results, as follows in Sections 4.2.16 to 4.2.18.

Uncertainty in CAFRA model results

Updated Coastal Flood Boundary Dataset (2018)

4.2.16 An update to the Defra Coastal Flood Boundary ("CFB") dataset has recently been released.

4.2.17 The CFB 2018 Extreme Water Levels ("EWL") at Avonmouth are compared in Table 4.4 below with those of the CFB 2011 dataset (applied in the CAFRA modelling). This comparison shows the revised CFB2018 EWLs are lower than equivalent CFB2011 EWLs, by 0.09 m for the 20 year return period EWL. This indicates that the CAFRA (and hence MetroWest) modelling overstates tidal flood risk. The CFB2018 20 year EWL

(8.61 mAOD) is similar to the CFB2011 10 year EWL (8.58 mAOD), for which the current MetroWest modelling shows no simulated flooding within the Clanage Road compound. This is consistent with the Clanage Road compound being in Flood Zone 3a (no flooding for the 20 year return period event).

Table 4.4: Comparison of CFB 2018 and CFB 2011 EWLs, for 2017 (the CFB 2018 base year)

Return period (years)	CFB 2018 EWLs (base year 2017) (mAOD)	CFB2011 EWLs adjusted from 2008 base year to 2017 (by +3.5 mm/yr) (mAOD)	Difference (m)
1	8.11	8.19	0.08
2	8.22	8.30	0.08
5	8.37	8.46	0.09
10	8.49	8.58	0.09
20	8.61	8.70	0.09
25	8.65	8.75	0.10
50	8.79	8.88	0.09
75	8.86	8.95	0.09
100	8.92	9.01	0.09
200	9.07	9.14	0.07

CAFRA model calibration uncertainty

4.2.18 There is additional uncertainty associated with model representation and model calibration. The CAFRA model made use of limited calibration data. The nearest calibration gauge to Bower Ashton is Netham Weir (approximately 6 km upstream of the Clanage Road compound). Here, peak levels are generally overpredicted for the calibration events (by +0.098 m, +0.231 m and +0.024 m for the three tidal calibration events, and +0.116 m for the verification event). This suggests the CAFRA model may have a tendency to overestimate tide levels in the River Avon.

Interpretation of modelling uncertainty and flood history information

Clanage Road compound Flood Zone

4.2.19 In the context of CAFRA model uncertainty, the revised Coastal Flood Boundary dataset 2018 Extreme Water Levels, and available flood history at Bower Ashton, it is considered reasonable to conclude that the Clanage Road compound would not be flooded during the 20 year River Avon tidal flood. Assigning Flood Zone 3b rather than 3a to the Clanage Road compound based on the model simulations undertaken is therefore considered precautionary.

Frequency of flooding of railway at Bower Ashton in 2075

4.2.20 Simulations undertaken based on the CAFRA modelling show the railway to be flooded at Bower Ashton during the 1 year return period tidal River Avon flood in 2075. Simulated flooding of the railway begins when River Avon flood levels exceed 8.75 mAOD (the threshold at which flood water spills across the railway into the floodplain) adjacent to the railway at Bower Ashton.

4.2.21 Figure 4.1 shows simulated River Avon levels for the 1 year tidal event in 2075. Figure 1 also shows the 8.75 mAOD spill threshold level and lowest rail level (8.35 mAOD) in the Bower Ashton area. For this event, simulated River Avon levels exceed the 8.75 mAOD spill threshold for approximately 45 minutes, with a peak level of 8.93 mAOD. River levels drop below the lowest rail level approximately 1 hour after the spill threshold is first exceeded.

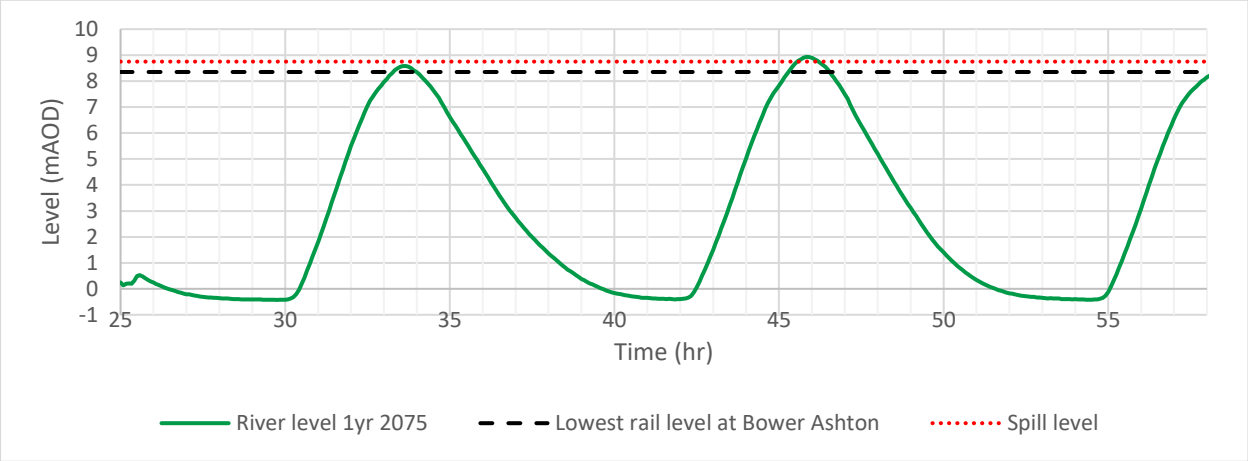

Figure 4.1: Simulated River Avon levels for the 1 year tidal event in 2075

4.2.22 Table 4.1 indicates a maximum flood depth along the railway of 0.44 m above the lowest rail level at railway chainage 121 mi 68 ch (6180 m)[2]. However, flood water spills from the River Avon onto the railway at chainage 121 mi 72 ch (6250 m). The modelling assumes flood water flows down (along) the railway towards railway chainage 6180 m, without any loss of flood water through the railway ballast/drainage and into the adjacent floodplain. The simulated maximum depth of 0.44 m at chainage 6180 m is therefore considered an overestimate. At railway chainage 6250 m the maximum simulated flood depth above lowest rail level is lower at 0.26 m.

4.2.23 In addition, further contributions to the likely overestimation of the future (2075) 1 year return period peak flood depth and duration of flooding on the railway at Bower Ashton are:

- As described in Sections 4.2.16 to 4.2.18, the CAFRA model is considered likely to overestimate flood levels at Bower Ashton
- The FRA sea level rise allowances are precautionary (rather than central estimates) and so are likely to be an overestimation.

4.2.24 In summary, whilst the simulations undertaken show the railway to be flooded at Bower Ashton during the 1 year return period River Avon tidal event in 2075, the modelling includes a combination of several conservative modelling assumptions, and so the simulation results are likely to be overestimates. The 1 year tidal flood in 2075 is therefore considered likely to have only a relatively minor impact on railway operation (short duration with

[2] The Network Rail chainage is based on miles and chains. The railway design uses both the Network Rail chainage and a project-specific metric chainage where the chainage datum is 4000 m at the 120 mi 40 ch mile post on the Portishead Line. Both forms of chainage are shown on the General Arrangement Plans (DCO Document Reference 2.4) and the Minor Civils Plans for the NSIP (DCO Document 2.7).

River Avon levels reducing below the lowest rail level approximately 1 hour after overtopping of the railway, allowing drainage back into the river, and shallow depth above lowest rail level) and hence only minimal disruption to the railway service.

Longmoor and Colliter's Brooks

4.2.25 Simulated Longmoor and Colliter's Brooks fluvial flood extents derived by the updated CAFRA modelling are shown in Appendix N, DCO Document Reference 5.6 for the present day (2015) and future (2075 and 2115) scenarios for return periods 50, 75, 100, and 1000 years, for the pre-development and post-development cases (the post-development case is discussed further in Section 7). For the present day (2015) scenario, results are only shown for the 100 and 1000 year return periods, as there is no simulated flooding at the railway for events with return period 100 years and below.

4.2.26 For the present day (2015) scenario only the 1000 year return period flood results in flooding of the railway and in the Ashton Gate area. For the 100 year return period there is no flooding on the railway. The water just reaches the railway at Ashton Vale without flooding.

4.2.27 For the future (2075 and 2115) scenarios flooding of the railway is simulated for the 75 year return period event and above.

4.2.28 Simulated maximum flood levels along the railway alignment during River Avon fluvial flood events, at railway chainages within the simulated flood extents, are tabulated in Appendix N, DCO Document Reference 5.6 (in spreadsheet with filename "*5.6 Flood Risk Assessment Appendix N CAFRA Rlw Results 2019 Fluvial.xlsx"*). The railway chainage locations are shown in Appendix N, DCO Document Reference 5.6.

4.2.29 Table 4.5 lists modelled maximum flood depth relative to lowest rail level of the Portbury Freight Line (operational railway) near Bower Ashton and at the railway crossing of Longmoor and Colliter's Brooks, for the present day (2015) and future (2075 and 2115) scenarios. These results indicate that, at the crossing of Longmoor and Colliter's Brooks, the Portbury Freight Line currently (pre-and post- development cases in 2015) floods approximately once every 100 to 1000 years on average, and for the future scenario (pre- and post- development cases in 2075 and 2115), this frequency of flooding will increase to approximately once every 50 to 75 years on average.

4.2.30 The flooding at Bower Ashton for the present day (2015) and future (2075 and 2115) events during the simulated fluvial events listed in Table 4.5 is a result of the simulated tidal condition in the joint events specified according to an assessment of joint fluvial/tidal event probabilities in the CAFRA modelling (e.g. 10 year tidal event for the simulated 1000 year fluvial event in 2015 and 2 year tide condition for the simulated 75 year fluvial event in 2075 and 2115 – further details are in the CAFRA modelling technical note in Appendix N, DCO Document Reference 5.6).

4.2.31 Extreme fluvial event simulations assume a design tidal condition based on the CAFRA model combined fluvial/tidal event joint probability assessment. This design tidal condition may result in simulated tidal River Avon flooding at Bower Ashton, and so tidal flooding results at Bower Ashton have been included for completeness.

Table 4.5: Modelled maximum River Avon flood depths relative to the lowest rail level at crossing of Longmoor and Colliter's Brooks (fluvial events)

Maximum flood depth relative to lowest rail level (m)						
	Present day (2015)		*Future year (2075)*		*Future scenario (2115)*	
Return period (years)	***Pre-development***	***Post-development***	***Pre-development***	***Post-development***	***Pre-development***	***Post-development***
At Longmoor / Colliter's Brooks (fluvial River Avon)						
50 (Fluvial)	No flooding	No flooding	No flooding	No flooding	No flooding	No flooding
75 (Fluvial)	No flooding	No flooding	0.07	0.07	0.39	0.39
100 (Fluvial)	No flooding	No flooding	0.20	0.20	0.49	0.49
1000 (Fluvial)	0.61	0.61	0.81	0.81	0.86	0.86
At Bower Ashton (tidal River Avon)						
50 (Fluvial)	No flooding	No flooding	No flooding	No flooding	No flooding	No flooding
75 (Fluvial)	No flooding	No flooding	0.62	0.62	1.09	1.09
100 (Fluvial)	No flooding	No flooding	0.62	0.62	1.10	1.10
1000 (Fluvial)	0.32	0.32	0.97	0.97	1.52	1.52

Drove Rhyne hydraulic model

4.2.32 A hydraulic model has been developed for this FRA to assess fluvial flood risk to the DCO Scheme from Drove Rhyne and the potential for the DCO Scheme to impact on Drove Rhyne fluvial flood risk.

4.2.33 The Drove Rhyne hydraulic modelling undertaken is reported in Appendix K, DCO Document Reference 5.6. Key features of the modelling include:

- Topographic survey of channels and structures was commissioned in August 2015 to support the modelling
- The hydraulic model includes a 1D-2D representation of the Drove Rhyne channel and catchment north (downstream) of the M5 Motorway
- The hydraulic model extends to the Drove Rhyne downstream tidal limit (flapped outfall structure)
- Model inflows were developed using standard approaches (Flood Estimation Handbook upstream of the M5 motorway and direct rainfall applied to the 2D domain downstream of the M5 motorway)
- The downstream tidal boundaries are consistent with CAFRA model tidal boundaries.

4.2.34 The Drove Rhyne model has been used to simulate the present day (2015) and future (2115) scenarios. Simulations for the 2075 design year were not undertaken as results for the more extreme future (2115) scenario do not show flood risk to the DCO scheme or offsite impacts due to the DCO scheme. Key results of the Drove Rhyne modelling are presented in Table 4.6 for the three Drove Rhyne tributary channels that are culverted through the railway embankment, and for Drove Rhyne downstream of the DCO Scheme. Figure 4.2 shows the locations of the model nodes in Table 4.6. A post-development model is not required for Drove Rhyne as the design does not change existing culvert dimensions and the impact of raising the railway alignment by up to approximately 200 mm is considered insignificant away from the railway alignment (confirmed by modelling sensitivity test, see Appendix K, DCO Document Reference 5.6) as the influence of the railway level on model results is insignificant at this location (the railway remains largely dry even for the future (2115) scenario 1000-year return period simulation and does not act as a significant hydraulic control of floodplain flows). Pre-development and post-development model results are therefore considered to be essentially the same away from the railway alignment.

4.2.35 The results in Table 4.6 indicate that at the culvert locations modelled flows in Drove Rhyne and its tributaries remain in-bank up to the 100 year return period for the present day (2015), and are in bank for the 30 year return period flood for the simulated future scenario (2115). For the events with out of bank flood levels, modelled out of bank flooding is localised to Drove Rhyne and its tributaries.

4.2.36 The DCO Scheme railway embankment level is above the modelled 1000-year return period Drove Rhyne flood level for the present day (2015) and future (2115) scenarios, and so not considered to be at risk of flooding from Drove Rhyne.

4.2.37 Sensitivity of model results at the DCO Scheme to increased flood locking of Drove Rhyne (i.e. during tidal flood events) has been tested by simulating the 100-year return period fluvial event with a 2-year return period tidal event. This gives an increase in peak flood levels of approximately 0.02 m to 0.03 m at the DCO Scheme culverts, indicating that the impact at the DCO Scheme of increased tide locking of Drove Rhyne due to joint fluvial and tidal flood events is minor.

4.2.38 The hydraulic modelling was developed to assess fluvial flood risk and so does not explicitly represent surface water drainage processes. However, results indicate that there is the potential for surface water flooding at low points along the railway alignment e.g. where the railway passes underneath road bridges (Appendix K, DCO Document Reference 5.6). Surface water drainage is considered in more detail in the drainage strategy and design (Appendix O, DCO Document Reference 5.6).

Table 4.6: Modelled flood levels in Drove Rhyne and its tributary channels that are culverted through the railway embankment

		Maximum flood level (mAOD)						
		culvert node 3.004		***culvert node 4.004***		***culvert node 5.004***		***Drove Rhyne***
	Return period (years)	Up-stream	Down-stream	Up-stream	Down-stream	Up-stream	Down-stream	Model node 1.024
Present (2015) scenario	30	5.992	5.965	5.665	5.665	5.830	5.730	5.646
	100	6.155	6.143	5.947	5.945	6.140	5.979	5.902
	1000	6.381	6.355	6.472	6.663	6.670	6.430	6.318
Future (2115) scenario	30	6.169	6.160	6.029	6.027	6.141	6.024	5.974
	100	6.338	6.310	6.411	6.522	6.496	6.308	6.229
	1000	6.598	6.551	6.597	6.541	6.852	6.689	6.631
	Railway level above culvert	7.15		7.03		7.38		n/a
	Culvert soffit level	6.03	6.03	5.54	5.54	5.84	5.84	n/a
	Channel bank top level	6.66	6.95	6.68	6.52	7.27	6.87	6.03

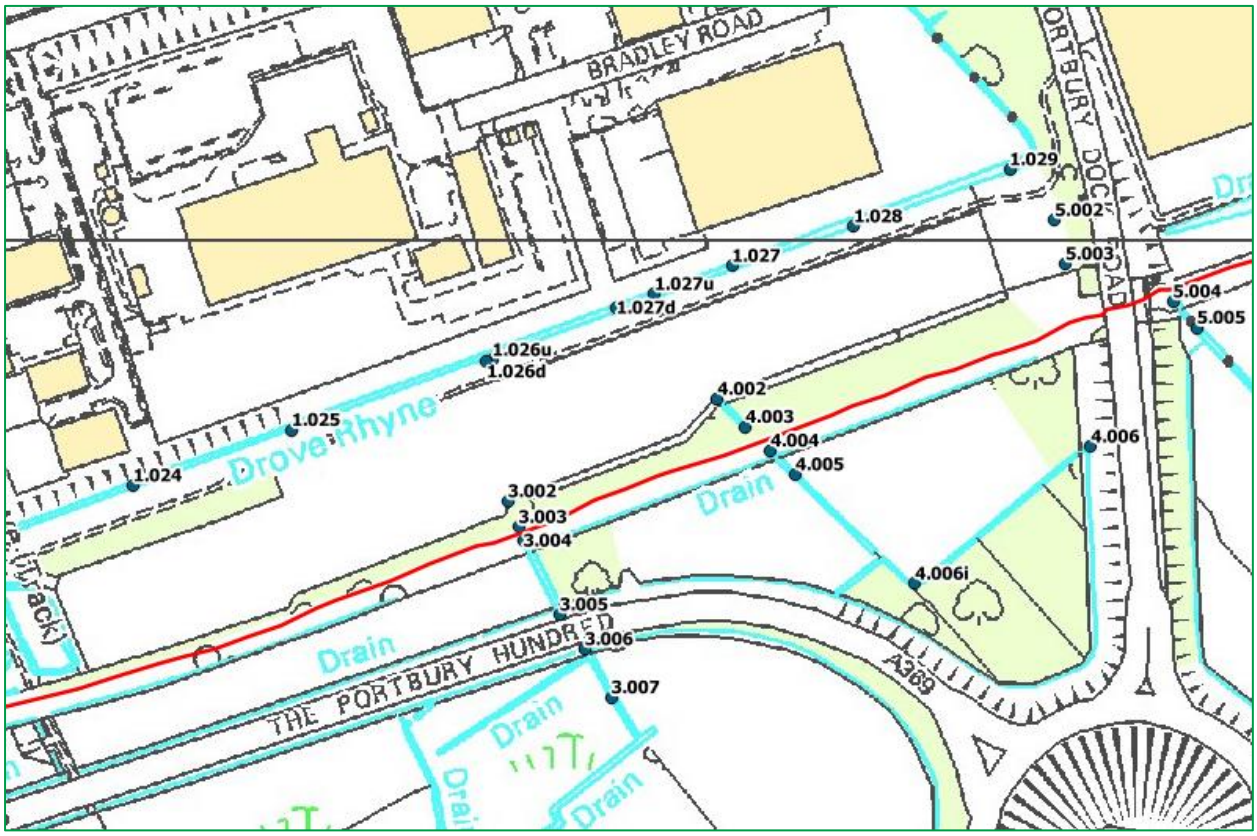

Figure 4.2: Locations of Drove Rhyne model nodes

Easton-in-Gordano Stream hydraulic model

4.2.39 A hydraulic model has been developed for this FRA to assess fluvial and tidal flood risk to the DCO Scheme from Easton-in-Gordano Stream and the potential for the DCO Scheme to impact on Easton-in-Gordano Stream fluvial and tidal flood risk.

4.2.40 The Easton-in-Gordano Stream hydraulic modelling undertaken is reported in Appendix K, DCO Document Reference 5.6. Key features of the modelling are:

- Topographic survey of channels and structures was commissioned in August 2015 to support the modelling
- The hydraulic model includes a 1D-2D representation of the Easton-in-Gordano Stream channel and catchment north (downstream) of the M5 Motorway
- The hydraulic model extends to the Easton-in-Gordano Stream downstream tidal limit (flapped outfall structure)
- Model inflows were developed using standard approaches (Flood Estimation Handbook upstream of the M5 motorway and direct rainfall applied to the 2D domain downstream of the M5 motorway)
- The downstream tidal boundaries are consistent with CAFRA model tidal boundaries.

4.2.41 The DCO Scheme proposed works in the vicinity of Easton-in-Gordano Stream including:

- Increase in elevation of railway embankment. Its lowest level increases from 8.65 mAOD to 9 mAOD for the post-development case.
- A slight increase in railway embankment footprint within the Easton-in-Gordano Stream floodplain, between the M5 Motorway crossing and Marsh Lane, by approximately 3 m on average along the southern edge of the DCO Scheme. This change is too small to represent accurately in the hydraulic model grid.

4.2.42 As the proposed changes in railway elevation are above modelled flood levels, and the slight increase in embankment footprint is too small to be represented in the hydraulic model, no post development model is required. The impact of the increase in railway embankment on floodplain storage is considered in Section 8.1.9.

4.2.43 Key results of the Easton-in-Gordano Stream modelling are presented in Tables 4.7 and 4.8 and in Appendix K, DCO Document Reference 5.6.

Table 4.7: Modelled fluvial flood levels in Easton-in-Gordano Stream

		Peak flood levels (mAOD)	
		Upstream of Railway	**Downstream of Railway**
Minimum Railway Level		Pre-development 8.65 Post-development 9.00	
Present day (2015) events	30 yr	8.09	6.62
	100 yr	8.19	6.76
	200 yr	8.24	6.90
	1000 yr	8.36	7.31
Future (2075) events	30 yr	8.16	6.72
	100 yr	8.25	6.95
	200 yr	8.30	7.13
	1000 yr	8.40	7.58
Future (2115) events	30 yr	8.17	6.78
	100 yr	8.26	7.09
	200 yr	8.31	7.30
	1000 yr	8.42	7.75

Table 4.8: Modelled tidal flood levels in Easton-in-Gordano Stream

		Peak flood levels (mAOD)	
		Upstream of Railway	**Downstream of Railway**
Minimum Railway Level		Pre-development 8.65 Post-development 9.00	
Present day (2015) events	20 yr	7.07	7.05
	50 yr	7.36	7.39
	200 yr	7.47	7.74
	1000 yr	7.59	8.01
Future (2075) events	20 yr	7.40	7.47
	50 yr	7.47	7.69
	200 yr	7.72	8.11
	1000 yr	7.74	8.13
Future (2115) events	20 yr	7.80	8.16
	50 yr	7.93	8.22
	200 yr	8.20	8.32
	1000 yr	8.45	8.46

4.2.44 At the crossing of Easton-in-Gordano Stream the existing disused railway top of embankment level is 8.65 mAOD and the proposed embankment level is 9.00 mAOD. Tables 4.7 and 4.8 show that modelled flood levels are below the disused railway embankment top level for the 1000-year return period fluvial and tidal events, for the present day (2015) and future (2075 and 2115) scenarios.

4.2.45 The figures in Appendix K, DCO Document Reference 5.6 show that the farm access track under the railway between Easton-in-Gordano Stream and the M5 motorway conveys flood flows (e.g. fluvial 30-year event, tidal 50-year event for the present day scenario). This provides a significant flood relief route as the farm access track flow path is approximately 2.75 m wide, compared to the Easton-in-Gordano Stream culvert through the railway embankment which has a diameter of approximately 0.5 m. The DCO Scheme will not change this arrangement (the farm access bridge will be strengthened in-situ, with same flood flow path dimensions).

Review of Flood Zones

4.2.46 A review of Flood Zones based on model results (and topography of Portbury Ditch floodplain) is detailed in Appendix L, DCO Document Reference 5.6. This assessment indicates the whole of the DCO Scheme is in Flood Zones 1, 2 and defended Flood Zones 2 and 3 except for the locations in undefended Flood Zones 3a and 3b, listed in Table 4.9.

Table 4.9: Review of Flood Zones – DCO Scheme proposed works within undefended Flood Zones 3a and 3b

Proposed DCO Scheme Works No.	Description	Permanent or Temporary	Reviewed Flood Zone	Justification	Implication for proposed works
1	A railway of 2,264 metres in length shown on sheets 1, 1A, 2, and 3 of the works plans, DCO Document Reference 2.3, commencing at a point 96 metres north of the junction of Quays Avenue and Galingale Way, Portishead, using the track bed of the disused Portishead Branch Line railway, and terminating at a point 57 metres to the east of the bridge carrying Station Road (Portbury) over the disused Portishead Branch Line railway;	Permanent			
1A	A railway of 2,498 metres in length shown on sheets 3, 4, 5 and 6 of the works plans, DCO Document Reference 2.3, commencing at a junction with the termination of Work No. 1 at a point 57 metres to the east of the bridge carrying Station Road (Portbury) over the disused Portishead Branch Line railway, using the track bed of the disused Portishead Branch Line railway and terminating at a point 49 metres to the west of the bridge carrying the Parson Street to Royal Portbury Dock railway over public footpath LA8/5/40 between Avon Road and Lodway Close, Pill;	Permanent	**Between Royal Portbury Dock Road and the M5 motorway** Partly within FZ3b **Pill viaduct crossing of Markham Brook** FZ3a (but works are actually above FZ2 and FZ3 flood levels)	Between Royal Portbury Dock Road and the M5 motorway Partly within Easton-in-Gordano stream modelled fluvial 30 year flood extents. Pill viaduct crossing of Markham Brook Proposed works are at a level several metres higher than Markham Brook at this location, and so outside of Flood Zone 3b.	Between Royal Portbury Dock Road and the M5 motorway. Consider potential impacts of displaced floodplain storage (detailed in Section 8.1.2). Pill viaduct crossing of Markham Brook will not result in displacement of floodplain storage. No requirement for floodplain compensation storage.
1B	A railway of 796 metres in length shown on sheets 6 and 7 of the works plans, DCO Document Reference 2.3, commencing at a junction with the termination of Work No. 1A at a point 49 metres west of the bridge carrying the Parson Street to Royal Portbury Dock railway over public footpath LA8/5/40 between Avon Road and Lodway Close, Pill and terminating at a junction with Work No. 1C, at a point 86 metres to the north of the junction of the highways of Ham Green and Westward Drive, Pill; and	Permanent			

Table 4.9: Review of Flood Zones – DCO Scheme proposed works within undefended Flood Zones 3a and 3b

Proposed DCO Scheme Works No.	Description	Permanent or Temporary	Reviewed Flood Zone	Justification	Implication for proposed works
1C	A railway of 1003 metres in length being a realignment of the Parson Street to Royal Portbury Dock railway shown on sheets 6 and 7 of the works plans, DCO Document Reference 2.3, commencing at a point 262 metres north west of the bridge carrying that railway over public footpath LA8/5/40 between Avon Road and Lodway Close, Pill then terminating at a new junction with the Parson Street to Royal Portbury Dock railway, at a point 86 metres to the north of the junction of the highways of Ham Green and Westward Drive, Pill.	Permanent			
3	A foot and cycle track, of 63 metres in length, shown on sheet 1 of the works plans, DCO Document Reference 2.3, commencing at a junction with Work No. 4 east of the watercourse known as the Portbury Ditch, to a point west of Portbury Ditch, together with associated landscaping, signage, fencing, lighting, cables, ducts, troughs, telecommunication apparatus, conduits and apparatus for utilities;	Permanent	Defended FZ3, except FZ3a over existing culvert structure on Portbury Ditch.	All proposed works over Portbury Ditch are at the top level of the existing crossing (approx. 7.5 mAOD) and above anticipated flood levels as there is significant lower lying Portbury Ditch floodplain storage.	Will not result in displacement of floodplain storage. No requirement for floodplain compensation storage.
16B	Pond and associated ecological works, shown on sheet 5 of the works plans, DCO Document Reference 2.3, to the south of the disused Portishead Branch Line railway and west of the M5 Special Road, Easton in Gordano;	Permanent	FZ3b	Hydraulic modelling of Easton-in-Gordano Stream undertaken for the DCO Scheme indicates the proposed pond is partly within the Easton-in-Gordano Stream tidal 200-year and 1000-year flood extents, (Figures K111 and K.112 in Appendix K, DCO Document Reference 5.6) and within the fluvial 30-year flood extent (Figures K101 in Appendix K, DCO Document Reference 5.6).	The proposed pond design will lower levels and will not result in displacement of floodplain storage. No requirement for floodplain compensation storage.
16D	Flood mitigation area of 4078 square metres in area, shown on sheet 5 of the works plans, DCO Document Reference 2.3, to the south of the disused Portishead Branch Line railway and west of the M5 Special Road, Easton in Gordano;	Permanent	FZ3b, FZ3a and FZ2	Hydraulic modelling of Easton-in-Gordano Stream undertaken for The Project indicates the proposed floodplain compensation area is partly within the Easton-in-Gordano Stream fluvial 30-year, 100-year and 1000-year flood extents (Figures K101, K102 and K.104 in Appendix K, DCO Document Reference 5.6).	The proposed floodplain compensation area will create additional floodplain storage. No requirement for floodplain compensation storage.

Table 4.9: Review of Flood Zones – DCO Scheme proposed works within undefended Flood Zones 3a and 3b

Proposed DCO Scheme Works No.	Description	Permanent or Temporary	Reviewed Flood Zone	Justification	Implication for proposed works
20	Temporary diversion of part of National Cycle Network Route 41 of 83 metres in length shown on sheet 6 of the works plans, DCO Document Reference 2.3, north from its existing alignment on the street north of the Parson Street to Royal Portbury Dock railway, west of Avon Road, Pill to connect with the western turning head of Avon Road, Pill;	Temporary	Mostly FZ1 and partly FZ2 and FZ3	CAFRA model results (2015) at this location confirm the proposed works are mostly FZ1 and partly FZ2 and FZ3.	Will not result in displacement of floodplain storage. No requirement for floodplain compensation storage.
23	Temporary construction compound of 151 square metres in area, as shown on sheet 6 of the works plans, DCO Document Reference 2.3, beneath and to the north of Pill Viaduct, Underbanks, Pill;	Temporary	FZ3a	CAFRA model results at this location indicate ground levels at the compound (approximately 8.6 mAOD) are below adjacent River Avon flood levels for the 20 year tidal flood in 2015 (8.78 mAOD). However, the compound location is protected by flood defences which are above the 20 year flood level but below the 200 year flood level.	Will not result in displacement of floodplain storage. No requirement for floodplain compensation storage.
26	Permanent vehicular access, ramp, flood mitigation works and railway maintenance compound, of 2948 square metres in area shown on sheet 15 of the works plans, DCO Document Reference 2.3, east of the highway of the A369 classified road known as Clanage Road, Ashton, north of the Bedminster Cricket Club;	Permanent	FZ3b	The CAFRA model detail in the vicinity of the Portbury Freight Line/River Avon near Bower Ashton has been updated for this project. The updated CAFRA model results indicate that the permanent vehicular access, ramp and railway maintenance compound, and the temporary construction compound, are mostly within the modelled 20 year flood extents (River Avon tidal event). Simulated tidal River Avon flood maps are shown in Appendix N, DCO Document Reference 5.6. However, a consideration of historic flooding and uncertainty in CAFRA model results (Appendix N, DCO Document Reference 5.6) concludes the modelling is likely to overestimate flooding and assigning FZ3b is precautionary.	Floodplain compensation for the proposed vehicular access and ramp will be provided by lowering ground levels within the compound (details are in Section 8 and Appendix N, DCO Document Reference 5.6).
26A	Temporary construction compound of 3346 square metres in area, shown on sheet 15 of the works plans, DCO Document Reference 2.3, east of the highway of the A369 classified road known as Clanage Road, Ashton, north of the Bedminster Cricket Club,	Temporary	FZ3b		Develop flood management plan to specify constraints on how the construction compound is used and actions/triggers (e.g. in response to EA flood warning service) to manage residual flood risk.

Table 4.9: Review of Flood Zones – DCO Scheme proposed works within undefended Flood Zones 3a and 3b

Proposed DCO Scheme Works No.	Description	Permanent or Temporary	Reviewed Flood Zone	Justification	Implication for proposed works
26B	Permanent vehicular access to the highway of the A369 classified road known as Clanage Road, Ashton from the land to the north of the Bedminster Cricket Club, shown on sheet 15 of the works plans, DCO Document Reference 2.3;	Permanent	Mostly FZ3a, partly FZ3b	The CAFRA model detail in the vicinity of the Portbury Freight Line/River Avon near Bower Ashton has been updated for this project. The updated CAFRA model results indicate that the maintenance road/access point is mostly within the 200 year flood extent, and partly within the 20 year flood extent (River Avon tidal event). Simulated tidal River Avon flood maps are shown in Appendix N, DCO Document Reference 5.6. However, a consideration of historic flooding and uncertainty in CAFRA model results (Section 4.2.12 to 4.2.19) concludes the modelling is likely to overestimate flooding and assigning FZ3b is precautionary.	Floodplain compensation for the proposed vehicular access will be provided by lowering ground levels within the compound (details are in Section 8 and Appendix N, DCO Document Reference 5.6).

Lowest simulated return period with flooding of railway alignment

4.2.47 Table 4.10 lists the lowest simulated return period with flooding on the DCO Scheme railway alignment, for each modelled flood source, for the pre-development and post-development cases and for the present day and future (i.e. with projected climate change and sea level rise) scenarios. Table 4.10 shows that the most significant source of flood risk to the DCO Scheme is currently (present day scenario) the River Avon. Flood risk from the River Avon is tidally dominated adjacent to the DCO Scheme, where flooding of the railway alignment near Bower Ashton from the River Avon is estimated to occur every 5 to 10 years on average.

4.2.48 The modelled future scenarios (2075 and 2115) indicate a significant increase in flood risk due to projected sea level rise, with flooding of the railway alignment near Bower Ashton simulated to occur more than once every year on average in 2075. However, whilst the simulations undertaken show the railway to be flooded at Bower Ashton during the 1 year River Avon tidal event in 2075, the modelling includes a combination of several conservative modelling assumptions, and so the simulation results are likely to be overestimates. The 1 year tidal flood in 2075 is therefore considered likely to have only a relatively minor impact on railway operation (short duration with River Avon levels reducing below the lowest rail level approximately 1 hour after overtopping of the railway, allowing drainage back into the river, and shallow depth above lowest rail level and hence only minimal disruption to the railway service (further details are in Sections 4.2.20 to 4.2.24).

4.2.49 Model results indicate flooding of the railway alignment from coastal flooding between Sheepway (road) and Portishead urban area will less frequently than once every 1000 years on average in 2075 and every 100 to 200 years on average in 2115.

Table 4.10: Lowest simulated return period with flooding of railway alignment

Source of flood risk	Lowest simulated return period with flooding of railway alignment						Location of flooding (for lowest simulated return period for which flooding occurs)
	Pre-development			Post-development			
	Present day (2015)	*Future (2075)	*Future (2115)	Present day (2015)	*Future (2075)	*Future (2115)	
Coastal flooding	>1000 years	> 1000 years	Between 100 and 200 years	>1000 years	> 1000 years	Between 200 and 1000 years	Between Sheepway (road) and Portishead urban area
River Avon: Tidal	Between 5 and 10 years	< 1 year**	< 1 year	Between 5 and 10 years	< 1 year**	< 1 year	Near Bower Ashton and Ashton Vale
Longmoor and Colliter's Brooks: Fluvial	1000 years	Between 50 and 75 years	Between 50 and 75 years	1000 years	Between 50 and 75 years	Between 50 and 75 years	Vicinity of railway crossing of Longmoor Brook
Drove Rhyne: Fluvial	> 1000 years	> 1000 years	> 1000 years	> 1000 years	> 1000 years	> 1000 years	n/a
Easton-in-Gordano Stream: Fluvial	> 1000 years	> 1000 years	> 1000 years	> 1000 years	> 1000 years	> 1000 years	n/a
Tidal River Avon levels propagating up Easton-in-Gordano Stream	>1000 years	> 1000 years	> 1000 years	> 1000 years	> 1000 years	> 1000 years	n/a

* With projected climate change and sea level rise

** Whilst the simulations undertaken show the railway to be flooded at Bower Ashton during the 1yr River Avon tidal event in 2075, the modelling includes a combination of several conservative modelling assumptions, and so the simulation results are likely to be overestimates. The 1 year tidal flood in 2075 is therefore considered likely to have only a relatively minor impact on railway operation (short duration, shallow depth above lowest rail level) and hence only minimal disruption to the railway service (further details are in Sections 4.2.20 to 4.2.24).

4.3 Order, speed, and duration of flooding

Coastal flooding

4.3.1 Model results indicate the DCO Scheme is currently defended from coastal flooding for all present day (2015) periods assessed (up to 1000 years), and for all return periods assessed up to 200 years for the future (2075) scenario. Simulated 1000 year return period flood extents of the future (2075) scenario do reach the railway alignment but flood levels are below the railway level. For the future (2115) scenario flooding, model results indicate the DCO Scheme (post-development) would flood approximately once every 200 to 1000 years on average (Table 4.10). Coastal flooding of the DCO Scheme would require overtopping of the Sea Commissioner's Bank followed by overtopping of the inland Ashlands coastal defence bund (flood defences 46 and 23 in Appendix J, DCO Document Reference 5.6). Model results indicate that for the future (2115) scenario 200 year return period coastal flood (post-development) the Ashlands bund would be overtopped approximately 1 hour after overtopping of the Sea Commissioner's Bank and, approximately 45 minutes after overtopping of the Sea Commissioner's Bank during the next tidal cycle, the DCO Scheme would be inundated between Sheepway road and Portishead urban area. The duration of coastal flooding would be similar to the high tide/surge duration (approximately 6 hours) as at this location the railway is raised and modelled flood levels recede as the tidal levels recede.

Tidal River Avon flooding

4.3.2 During flooding of the Portbury Freight Line (operation railway) at Bower Ashton due to high River Avon tidal flood levels, high River Avon flood levels would result in overtopping of the River Avon banks locally with flood water reaching the railway once water levels are high enough. As the railway is close to the River Avon at this location the duration of flooding would correspond closely to the duration of high tide levels in the River Avon, as drainage of the area would be flood locked until River Avon levels dropped. For the 200-year return period present day (2015) scenario, river levels would reduce enough to enable drainage after approximately 2 hours. For the future (2075 and 2115) scenarios, projected sea level rise would result in a longer duration (in 2075 approximately 2 hours for 200 year return period river levels to drop and enable the area to start to drain, but with flooding occurring for 2 or 3 successive high tidal peaks). The duration would be shorter for less extreme events e.g. approximately 1 hour for the 1 year return period event in 2075.

Fluvial Longmoor and Colliter's Brook flooding

4.3.3 During Longmoor and Colliter's Brook fluvial flooding of the Portbury Freight Line (operation railway) in the vicinity of the Longmoor and Colliter's Brooks, out of bank fluvial flooding would result in flooding of the operational railway.

4.3.4 Model results indicate that fluvial flooding of the railway would occur rapidly (e.g. within approximately 1 hour) following extreme rainfall on the small

upstream catchment with flood depths above the railway of approximately 0.6 m for the 1000 year return period present day (2015) scenario, 0.2 m for the 100 year return period flood for the future (2075) scenario and 0.4 m for the 75 year return period flood for the future (2115) scenario. Flood water would subside as it is drained by the railway drainage system where this exists (in vicinity of Ashton Gate level crossing), or according to local topography.

Surface water flooding

4.3.5 Where the railway is close to surrounding ground levels there is the potential for surface water flooding during intense rainfall events (e.g. at low points where the railway passes under roads). Surface water flooding could occur quickly (e.g. in less than an hour). After an intense storm any surface water flooding of the railway would be drained by the DCO Scheme surface water drainage system (Appendix O, DCO Document Reference 5.6).

SECTION 5

Climate change

5.1.1 The NPPF requires the assessment of flood risk to account for the impacts of projected climate change during the life of proposed development. The design life of the DCO Scheme is 60 years, relative to a 2015 base year. This is considered an appropriate design parameter since:

- A 60 year design life is consistent with the 60 year design life applied for the nearby recent transport schemes South Bristol Link and m2 metrobus (formally known as the AVTM MetroBus), and equal to the minimum required design life for new residential development (https://www.gov.uk/guidance/flood-risk-and-coastal-change#what-is-lifetime-of-development).
- The FRA climate change allowances are precautionary.

5.1.2 Projected future climate change and sea level rise impacts are therefore assessed for the 2075 future year, as well as for the future 2115 year as a sensitivity test.

5.1.3 To account for projected climate change relative to a present day (2015) scenario, modelling undertaken for this FRA includes simulations for future scenarios in 2075 and 2115. To simulate the future (2075 and 2115) scenarios, modelling undertaken for this FRA requires climate change adjustments to extreme rainfall depths, sea level rise, wind speed and wave height.

5.1.4 Projected climate change adjustments have been derived following the NPPF 2013 guidance (which is based on DEFRA 2006 climate change guidance). Noting that there is more recent DEFRA 2011 guidance, the derived climate change adjustments have been compared with those derived by the DEFRA 2011 guidance. The adjustments applied for this FRA (derived following the DEFRA 2006 guidance) are similar to the DEFRA 2011 adjustments for sea level rise and more conservative (i.e. higher) for extreme rainfall. Wind speed and wave height adjustments were applied following the DEFRA 2006 guidance. This approach was agreed to be appropriate with the EA.

5.1.5 The following climate change allowances have been applied in the modelling undertaken for this FRA:

- Extreme rainfall depths: +20% for 2075; +30% for 2115
- Extreme river flows: +20% for 2075 and 2115
- Sea level rise: +0.59 m between 1990 and 2075; +1.14 m between 1990 and 2115
- Extreme wind speed: +10%
- Extreme wave height: +10%.

5.1.6 Table 4.7 shows that the dominant sources of flood risk to the DCO Scheme for the present day (2015) scenario is tidal River Avon flooding, with flooding of the Portbury Freight Line near Bower Ashton simulated to occur

approximately once every 5 to 10 years on average. The projected increase in sea level rise results in simulated flooding at this location more than once every year on average by 2075 (although this simulation result is considered likely to be an overestimate, as discussed in Sections 4.2.20 to 4.2.24).

5.1.7 Flood risk to the DCO Scheme from coastal flooding is currently low (no simulated flooding along the DCO Scheme railway alignment for the 1000-year return period coastal flood event). Model results indicate that for the future (2075) scenario the railway would not be flooded during the 1000 year return period flood event. For the future (2115) scenario coastal flood risk along the DCO Scheme railway alignment (pre-development) would occur approximately every 100 to 200 years on average, due to the projected rise in sea levels (Table 4.7).

5.1.8 Modelling undertaken for this FRA indicates that the impact of projected climate change on fluvial flood risk to the DCO Scheme from Drove Rhyne and Easton-in-Gordano Stream is insignificant, for the present day (2015) and future (2075[3] and 2115) scenarios (Section 4.2).

[3] For Drove Rhyne simulations of the future (2075) design year were not undertaken as results for the more extreme future (2115) scenario do not show flood risk to the DCO scheme or offsite impacts due to the DCO scheme.

SECTION 6

Consultation meetings

6.1.1 During development of this FRA we have attended consultation meetings with the EA, North Somerset Levels Internal Drainage Board and North Somerset Council (as regulator). The meetings aimed to establish flood risk assessment requirements for the DCO Scheme and constraints arising from a consideration of flood risk. Key details of these meetings are summarised below and further information is in Appendices P and Q, DCO Document Reference 5.6.

6.2 Environment Agency meetings

Environment Agency meeting: 2 May 2014

6.2.1 The EA's formal consultation response following the consultation meeting held on 2 May 2014 is included in Appendix P, DCO Document Reference 5.6. Key requirements/constraints noted in the EA consultation response relevant to flood risk are listed below.

- The EA considers the main flood risks to the proposed development to be tidal and fluvial flooding/tide locking of Drove Rhyne.
- The FRA must not rely on the Shoreline Management Plan policy ('hold the line') as mitigation – as future funding to 'hold the line' cannot be guaranteed.
- There are new tidal defences at Portishead (designed to provide a 200-year standard of protection) owned by Persimmons (Ashlands bund) that the EA will adopt (flood defence 23 in Appendix J, DCO Document Reference 5.6). However, these defences currently have structural problems. Until this is resolved, the EA will not provide 'as built' drawings for use in the DCO Scheme.
- The NPPF flood risk vulnerability classification of the restored railway is not clear. This may depend on Network Rail's resilience requirement and resolution will require discussions with all relevant parties (EA, planning authority, Network Rail, and DCO Scheme project team)
- Quantification of tidal flood risk will be required, including future flood risk (for an assumed design life of 160 years4). The EA will not charge for use of its tidal model for the assessment.
- Quantification of fluvial flood risk and tide locking in Drove Rhyne will be required by hydraulic modelling. There is no existing hydraulic model and so channel survey and hydraulic model construction will be required.
- EA access routes to maintain Drove Rhyne are specified (including future access near Sheepway Gate Farm). The proposed design should retain these access arrangements.

[4] A design life of 60 years has since been considered appropriate (Section 5.1.1)

- Attenuation of surface water drainage will be required for the new impermeable areas (car parks and stations) up to the 100-year rainfall event (with climate change allowance). The EA anticipates inclusion of Sustainable Drainage Systems ("SuDS") in the design (for attenuation and water quality). Opportunities to improve local drainage should be sought.
- Network Rail agreed to provide details of its policy on 'resilient design'.

6.2.2 The following additional points were identified during the meeting:

- The Sequential Test for the DCO application should be a formality as the future restoration of the Portishead to Pill passenger railway is identified in NSDC Core Strategy (adopted March 2013) and there are no realistic alternative locations for the railway line.
- The design will follow a sequential approach with vulnerable equipment (e.g. electrical) placed in areas at lowest risk or raised (where feasible).
- Existing culverts under the disused railway on Drove Rhyne (and possibly elsewhere) are in poor condition. Further assessment on which culverts need improvement will be undertaken during detailed design. The drainage design should provide betterment through clearing blockages of existing drainage channels and culverts.
- Drainage of the disused railway track will be improved by the design. The existing ballast (partly blocked with debris) will be replaced with new ballast (with a screening membrane to reduce debris accumulation). The restored railway line will therefore not increase the impermeable area.
- The existing railway ditches (adjacent to and parallel to the disused railway line) will be cleared of debris and vegetation to restore their function, and capacity improved if required.
- The design life of the proposed railway (for future flood risk assessment under projected climate change) may be as long as 160 years[5].
- Access to Pill station during floods could be an issue (to be explored as part of the design).
- North Somerset District Council's ("NSDC") Sustainable drainage advice for developers (April 2014) states: "It is anticipated that Flood and Water Management Act 2010 (Schedule 3) will come into force in October 2014 and will require developers to apply for, and gain approval for sustainable drainage systems through the SuDS approval body (SAB) on new and redevelopment sites." It is therefore likely that the Portishead and Pill stations and car parks drainage designs will require NSDC SAB approval.
- The EA requirements for surface water drainage would be for 'betterment' for a 100-year return period 6-hour duration storm, i.e. no increase in surface water flows and volumes, and no worsening of water quality, compared to the pre-development situation (brownfield or greenfield as appropriate).

[5] A design life of 60 years has since been considered appropriate (Section 5.1.1).

- There are no specific groundwater flooding problems identified in the study area. Infiltration may be poor in some locations due to historical power station ash land fill.

Environment Agency meeting: 10 December 2014

6.2.3 The EA's formal consultation response following the consultation meeting held on 10 December 2014 is included in Appendix P, DCO Document Reference 5.6. Key requirements/constraints noted in the EA consultation response relevant to flood risk are listed below.

- The proposed classification of the DCO Scheme as Less Vulnerable development is not considered to be permissible in Flood Zone 3b (NPPF).
- Careful consideration must be given to the potential impact of climate change, particularly in respect of the possible effects on structural integrity and operational safety. The FRA must be informed by Bristol City Council's CAFRA data, which details the latest flood levels for combined tidal and fluvial scenarios with and without climate change.
- A detailed assessment of the route footprint and crest height will be required to determine potential flood depths/frequency, and inform the process of identifying appropriate mitigation and emergency/contingency measures, where applicable.
- Due to the stated 'Less Vulnerable' development classification, it is understood that the proposed service will not be required to remain operational during a flood event. Full details of the proposed works, including actual flood risk (with an allowance for climate change) confirmation of the development classification, closure trigger levels, mitigation and emergency/contingency measures must be detailed within the FRA.
- As highlighted at our recent meeting, the proposal appears to be reliant on the resolution of existing issues regarding the tidal defences at Portishead. Clarification would be welcomed regarding any contingency proposals in the event of this long-standing issue not being resolved within the DCO Scheme timeframe.
- There are a series of culverts for the old and new Colliter's Brook that are essential for draining the Ashton Vale valley. No additional structural loading must be applied in respect of the culverts, unless it is considered essential in terms of the viability of the proposed works. Under such circumstances, there could be opportunities to improve the culverts, which would necessitate culvert condition surveys.
- EA schemes in the vicinity of the proposed works include the Ashton Vale tunnels (culverts noted above) and outfalls at Avon Chapel.
- The EA would also appreciate additional detail regarding the treatment of the Drove Rhyne culverts.
- Under the provisions of the Water Resources Act 1991 and the Land Drainage Byelaws, the prior written consent of the EA is required for any proposed works or structures in, under, over or within 8 metres of the bank top of the River Avon.

6.2.4 The following additional points were identified during the meeting.

- Works at Drove Rhyne may provide an opportunity to deliver wider benefits.
- North Somerset Council requires SuDS (e.g. surface water drainage of stations and car parks) to meet draft standards.
- Network Rail noted that following the winter of 2013/14 there were railway closures due to flooding in the Somerset Levels. Lines were operational within approximately 1 day of flood levels subsiding (and remedial works were not required). Depth of flooding on railways is not usually an issue, flowing water is more problematic.
- The FRA should understand design changes and impact on flood risk - e.g. electrics/signal boxes to be raised above flood level where possible.
- The only time (Network Rail) recalls closure of the Portbury Freight Line due to flooding is during winter 2013/14 (Bristol Harbourside flooding event).
- The Sequential Test is required but will be notional (as there is only one feasible location for the DCO Scheme).
- Station design will consider surface water management and safe access. The North Somerset Levels Internal Drainage Board should be consulted as appropriate e.g. to ensure access to maintain channels is preserved.
- There has been historical surface water flooding in Pill. The Pill station design should consider the potential for this to impact operability of the new station and safe access.
- Network Rail noted that passenger evacuation of tunnels along the DCO Scheme is unlikely to be a significant risk as the line would be closed before conditions arose resulting in a train being stranded.

Environment Agency meeting: 18 May 2016

6.2.5 Notes of the meeting held on 18 May 2016 are included in Appendix P, DCO Document Reference 5.6. Key meeting outcomes relevant to this flood risk assessment are listed below:

Flood Risk Vulnerability classification

6.2.6 The DCO Scheme will be classified as Essential Infrastructure. As parts of the scheme are within Flood Zones 3a and 3b, there is a need for a flood management plan (or equivalent), which will specify operations during flooding (e.g. triggers and responses).

Floodplain compensation requirements

6.2.7 The DCO Scheme includes elements within Flood Zones 3a and 3b at Bower Ashton. Whilst the DCO Scheme will have a larger footprint in Flood Zone 3a and 3b than the existing arrangement, the proposed works result in a net increase in tidal River Avon floodplain storage at Bower Ashton (see Section 8.1.17). No floodplain compensation is therefore required at Bower Ashton[6].

[6] The scheme design has since changed and floodplain compensation is provided within the Clanage Road compound

6.2.8 As discussed in Section 8.1.11, displaced floodplain storage volumes in Easton-in-Gordano Stream floodplain (FZ3b) are low and the impact on upstream flood levels are insignificant (less than 5 mm). It was agreed that no compensation storage is therefore required to mitigate this insignificant impact, provided affected landowners accept the (insignificant) change in flood risk. There is therefore an obligation on NSC to inform affected landowners.[7]

6.2.9 The Clanage Road compound (near Bower Ashton) will include an access ramp in Flood Zone 3a. No compensation storage will be required for the access ramp if the DCO Scheme results in a net increase in floodplain storage at Bower Ashton. The FRA will need to include justification for the access ramp location.

Ashlands bund

6.2.10 The EA noted that it is currently progressing discussions with the relevant developer to resolve outstanding bund structural issues (Section 6.2).

Environment Agency meeting: 19 October 2016

6.2.11 Notes of the meeting held on 19 October 2016 are included in Appendix P, DCO Document Reference 5.6. The purpose of this meeting was to review the EA's comments (September 2016) on the DCO Scheme draft FRA and hydraulic modelling, and agree requirements to address these comments.

Environment Agency meeting: 27 February 2018

6.2.12 Notes of the meeting held on 27 February 2018 are included in Appendix P, DCO Document Reference 5.6. The purpose of this meeting was to discuss an appropriate design life for the DCO Scheme. Since the meeting, a 100-year design life has been applied in agreement with the EA.

Environment Agency meeting: 30 July 2018

6.2.13 Notes of the meeting held on 30 July 2018 are included in Appendix P, DCO Document Reference 5.6. The purpose of the meeting was to discuss the draft DCO Scheme FRA provided to the EA for review in May 2018. Topics discussed included the following.

- The FRA should provide further details on impacts of the DCO Scheme on flood risk (now included in Sections 8 and 9).
- The EA asked whether the DCO Scheme results in reduced EA maintenance access to main rivers. (This will be addressed by the environmental permitting regime).
- Drainage details including the proposed drainage discharge into Markham Brook.
- Requirement to inform property owners with an increase in flood risk as a result of the DCO Scheme.

[7] The scheme design has since changed and floodplain compensation is provided within the Easton-in-Gordano Stream floodplain

- EA review of hydraulic modelling undertaken as part of the DCO FRA. A formal response was issued after the meeting.
- The FRA should include further explanation of why floodplain compensation is not required at Bower Ashton. Section 8.1.17 now refers to the hydraulic modelling technical note in Appendix N, DCO Document Reference 5.6 for details of flood mechanisms at Bower Ashton.
- Requirement for the FRA to explain why the proposed DCO Scheme (classified as Essential Infrastructure) in Flood Zones 3 and 3b will not be operational during the future (2115) 20 year flood event. This is because the scheme location and design are constrained by the location and elevation of the existing railway line (i.e. there is very little opportunity to change the design with respect to operation during floods).
- Outline Flood Plans have been prepared for the DCO Scheme for the construction and operational phases. The Outline Flood Plan for the construction phase, included in Appendix T, DCO Document Reference 5.6, is concerned with the Clanage Road construction compound, which is the only proposed compound within Flood Zone 3b. The operational phase of the Flood Plan is based on Network Rail's Extreme Weather Plan and is provided in Appendix T, DCO Document Reference 5.6. The contractor will be required to develop the flood plan for the construction phase for works at Clanage Road.

Environment Agency letter: 18 September 2018

6.2.14 The Environment Agency response to a review of the draft FRA and hydraulic modelling. The letter response is included in Appendix P, DCO Document Reference 5.6. Topics include:

- Model review comments. These have now been addressed (Section 6.2.15).
- Concern regarding frequency of railway closure at Bower Ashton in the future (with projected sea level rise). The Environment Agency requested the line should remain operational for the future 20 year tidal River Avon flood event. However, this cannot be realistically achieved as modelling has demonstrated that raising the railway results in offsite impacts that cannot be mitigated. The flood risk to the railway at Bower Ashton on the DCO Scheme would be managed following Network Rail's Extreme Weather Plan procedures. See Outline Flood Plan (operational phase) in Appendix T, DCO Document Reference 5.6.
- Request for more detailed assessment of third party impacts resulting from raising the railway levels at Bower Ashton. The railway design at Bower Ashton has since been revised such that railway levels will remain as existing. There are therefore no associated offsite impacts.
- Request for more detail in the FRA regarding proposed works (or not) to Main River culverts. See Sections 8.4 and 8.5.
- Request to review consistency between FRA Appendix L, DCO Document Reference 5.6 and Section 4 table listing works in undefended Flood Zone 3. (Since checked).

- Request to provide more information on resistance/resilience measures in FRA. See Outline Flood Plan (operational phase) in Appendix T, DCO Document Reference 5.6.
- Confirm in FRA a 10 m maintenance strip will be maintained adjacent to all Main Rivers. See Section 8.5.
- Request for more information related to floodplain compensation assessments. Floodplain compensation modelling at Bower Ashton, and floodplain compensation calculations at Easton-in-Gordano Stream, have since been undertaken (see Sections 8.1.9 to 8.1.11 and 8.1.16 to 8.1.18, and Appendix N, DCO Document Reference 5.6).
- Request for more information related to works above Portbury Ditch.
- Request for more information on operational flood plan. See Outline Flood Plan (operational phase) in Appendix T, DCO Document Reference 5.6.
- Request for more details of the plan for drainage near to the Markham Brook. Drainage details are in Appendix O, DCO Document Reference 5.6.
- Request for table comparing existing and proposed rail levels against modelled flood levels. Now included in Appendix N, DCO Document Reference 5.6.
- Request for additional Drove Rhyne model sensitivity test (railway +200 mm) to justify not simulating a post development scenario. The test has since been undertaken and the Environment Agency has reviewed and approved the modelling.

Environment Agency letter: 24 April 2019

6.2.15 The Environment Agency response to a review of the revised draft FRA (and other Environmental Statement draft reporting) and hydraulic modelling. The letter response is included in Appendix P, DCO Document Reference 5.6. Topics related to the FRA include the following.

- Confirmation that the Environment Agency has reviewed and approved the hydraulic modelling undertaken for the FRA.
- The Environment Agency notes that the Portishead Branch Line at Bower Ashton will flood more frequently than once every 2 years on average (for a short duration and shallow depth above railway – see Section 4.2.24) in the future (2075 and 2115) scenarios, and the applicant considers it is not possible to reduce this flood risk (without making flood risk worse elsewhere). The Environment Agency considers Network Rail is capable of managing this flood risk by applying its Extreme Weather Plan. (See Outline Flood Plan (operational phase) in Appendix T, DCO Document Reference 5.6). However, as the future frequency of flooding is relatively high, the Environment Agency will raise this matter during the DCO examination period.
- Request for further details related to assessment of options to reduce offsite impacts (due to the proposed increase in railway levels in the Bower Ashton area). The railway design at Bower Ashton has since

been revised such that railway levels will remain as existing. There are therefore no associated offsite impacts.

- Request for more information related to floodplain compensation assessments. Floodplain compensation modelling at Bower Ashton, and floodplain compensation calculations at Easton-in-Gordano Stream, have since been undertaken (see Sections 8.1.9 to 8.1.11, Sections 8.1.16 to 8.1.18 and Appendix N, DCO Document Reference 5.6).
- Request for further details on proposals for Main River culverts, and statement that there will be no additional loading on or additional drainage into any Main River culverts (see Section 8.4.3).
- Confirm in FRA no works are planned within the 10 m maintenance strip adjacent to Main Rivers (see Section 8.5.1).
- Emergency Plan (i.e. Outline Flood Plan (operational phase) in Appendix T, DCO Document Reference 5.6): The Environment Agency is able to assist with use of its flood warning system.

Environment Agency meeting: 17 May 2019

6.2.16 Notes of the meeting held on 17 May 2019, and the Environment Agency's comments on these minutes, are included in Appendix P, DCO Document Reference 5.6. The purpose of the meeting was to discuss the draft DCO Scheme FRA and hydraulic modelling provided to the Environment Agency for review in March 2019. Topics discussed relevant to the FRA included the following.

- Frequency of flooding of the Portishead Branch Line at Bower Ashton in the future (allowing for projected sea level rise during the DCO Scheme design life). The Environment Agency expressed the requirement to protect passengers from flooding and the need for a robust service. These requirements are discussed further in Section 8 and in the Outline Flood Plan (operational phase) in Appendix T, DCO Document Reference 5.6.
- Scheme design life. The DCO Scheme considers 60 years to be appropriate. This is discussed further in Section 5.
- Impacts of the DCO Scheme on offsite flood risk and the requirement to notify third parties with a negative impact on flood risk due to the proposed raising of the railway in the Bower Ashton area. Since the meeting, the railway design at Bower Ashton has been amended to retain existing railway levels and footprint in the Bower Ashton area, and so there are no associated offsite impacts.
- Floodplain compensation requirements. The Environment Agency requested modelling is undertaken to assess floodplain compensation in the Clanage Road area, as compensation cannot be provided on a level-for-level basis. Modelling has since been undertaken to assess compensation options for the proposed Clanage Road vehicular access and ramp. The proposed design fully mitigates for the vehicular access and ramp by providing floodplain compensation within the Clanage Road maintenance compound (see Section 8.1.16 to 8.1.18 and Appendix N, DCO Document Reference 5.6).

- Culverts: The Environment Agency requested the FRA includes a clear statement that the DCO Scheme will not result in additional structural loading of main river culverts (see Section 8.4).
- Works within the Environment Agency's main river 10 m maintenance access strip: The FRA should include a statement that Environment Agency access will not be restricted in the long term by the DCO Scheme, and the Environment Agency will be closely consulted on access restrictions for temporary works (see Section 8.5.1).
- Proposed stations: The Environment Agency requested the FRA provides details relating to the proposed stations and car parks. As these are outside of the present day (2015) and future (2075) modelled flood extents, the FRA therefore focuses on proposed drainage designs for these.
- Emergency Plan (i.e. Outline Flood Plan (operational phase) in Appendix T, DCO Document Reference 5.6): The Environment Agency is able to assist with use of its flood warning system (to be dealt with at permitting stage e.g. when applying for flood risk permits).

Environment Agency meeting: 26 July 2019 (telephone meeting)

6.2.17 Notes of the telephone meeting held on 26 July 2019 are included in Appendix P, DCO Document Reference 5.6. The purpose of the meeting included discussion of modelling work undertaken to assess floodplain compensation options at Bower Ashton, revised design option retaining existing railway levels at Bower Ashton, construction methodology for revised design. Topics discussed included the following.

- Flood mitigation options in the Bower Ashton area: Prior to this meeting, the DCO Scheme team submitted a technical note to the Environment Agency detailing hydraulic modelling undertaken to assess floodplain compensation options to mitigate offsite impacts in the Bower Ashton area. The technical note concluded that realistic floodplain compensation options would not mitigate for raising the railway in the Bower Ashton area. Therefore, the MetroWest design will retain existing railway levels in the Bower Ashton area. The Environment Agency was unable to review the note ahead of the meeting, but considered the avoidance of offsite impacts as positive. Retaining existing railway levels in the Bower Ashton area increases the frequency of flooding to the railway at Bower Ashton (compared to raising the railway). Network Rail is considering the operational aspects.
- Construction methodology for retaining the track at Bower Ashton at its current level: Network Rail is developing a revised track design retaining existing railway levels in the Bower Ashton area. The construction methodology will be developed later (including e.g. moving and storage of ballast).
- Network Rail would propose to agree storage of ballast / other track material this with the Environment Agency prior to commencement of design and methodology works. The DCO Scheme Master Construction Environmental Management Plan is included in the DCO Application, , DCO Document Reference 8.14.

- Floodplain compensation will also be provided in Easton-in-Gordano Stream floodplain. These works are relatively minor (see Section 8.1.9 to 8.1.11).
- The Environment Agency noted that where the project involves working over main river culverts, it will need to be sure not to increase the structural loading over the culverts (see Section 8.4)[8].
- Further to this meeting, the Environment Agency sent an email (on 14 August 2019) responding to the DCO Scheme technical note detailing the assessment of floodplain compensation options. This email response is in Appendix P, DCO Document Reference 5.6 and includes the following text:

  "We [the Environment Agency] will need to complete a review of the modelling, before we are able to accept the findings of the Technical Note. However, as stated during our recent telecon, we are very supportive of the focus on ensuring there is no increase in flood risk to third parties, by maintaining the line at existing levels."

  "We have noted that leaving the railway line at its current level will result in regular flooding, particularly when the predicted impact of climate change is considered. As previously advised, we will continue to highlight the resulting low resilience to flooding, in accordance with our statutory duties."

  "We would reiterate that no material should be stored within the designated floodplain. If this is absolutely necessary/unavoidable, the material should be stored more than 16 metres away from any statutory main river. Any storage of materials within the designated floodplain, which is not deemed to be specifically regulated through the DCO or a Local Planning Authority planning permission, will require a Flood Risk Activity Permit from the Agency."

  "The storage of materials, within the designated floodplain or otherwise, may additionally be subject to the requirements of a formal waste permit from the Agency."

6.3 North Somerset Levels Internal Drainage Board Meetings

8 May 2014

6.3.1 The North Somerset Levels Internal Drainage Board ("NSLIDB") consultation meeting was held on 8 May 2014. Key requirements/constraints identified during the meeting are below.

- NSLIDB considers the enlargement of any culvert under the disused railway to be an improvement and also noted that since the construction of the disused railway line (in approximately 1860) local drainage catchments are likely to have changed due to, for example, the

[8] Where there are proposed works over culverts, the structural performance of these culverts will be assessed in the context of the proposed development, and the culverts will be improved if required to allow for any additional structural loading.

construction of the M5 motorway and the A369 Portbury Hundred road. NSLIDB will be able to advise on local catchment extents. NSLIDB recognises that it may be appropriate to simplify the drainage arrangements, e.g. replacing multiple culverts with a single culvert in some locations. If culverts are enlarged as part of the design, the downstream channel capacity will be reviewed. NSLIDB considers ensuring future maintenance of drainage ditches and culverts to be a significant issue.

- Any engineering works in the NSLIDB area will require land drainage consent (Bye Law).
- NSLIDB would like to review/approve the Portishead Branch Line drainage designs within the NLSIDB area. This could include developing drainage designs in consultation with NSLIDB.
- Drove Rhyne includes a downstream tidal sluice. During tide locking there are only modest variations in water level upstream of the tidal sluice as the storage in Drove Rhyne is significant compared to inflows to Drove Rhyne.
- Following the meeting, NSLIDB provided an annotated map showing local flooding issues and flow directions of drainage within the NSLIDB area. This is included in Appendix Q, DCO Document Reference 5.6.

6.3.2 Since the 8 May 2014 meeting, we have liaised further with NSLIDB when developing the drainage strategy/design. Details are in the appendices of the reports in Appendix O, DCO Document Reference 5.6.

1 June 2018

6.3.3 This meeting consulted NSLIDB on the interface of the proposed DCO Scheme (permanent works and during construction) with NSLIDB's maintenance requirements and any planned works by NSLIDB in the area. The DCO Scheme drainage strategy was presented to NSLIDB.

6.3.4 Meeting minutes are in Appendix Q, DCO Document Reference 5.6.

6.4 NSC, BCC and NSLIDB meeting on 24 October 2017

6.4.1 The NSC, BCC and NSLIDB consultation meeting was held on 24 October 2017. Notes of the meeting are included in Appendix Q, DCO Document Reference 5.6. Key points of the meeting relevant to this FRA are below.

- NSC requires an outline drainage strategy to be submitted with planning applications (i.e. with the DCO application). A Surface Water Drainage Strategy is provided in the DCO application (DCO Document Reference 6.26).
- BCC is updating its surface water flood mapping (due December 2017). Updated results were not yet available in April 2018.
- BCC should be engaged early when detailed drainage designs are available.
- There is uncertainty on whether or not the Portbury Wharf attenuation pond containing bund was built. Associated risk to the railway is

considered insignificant (see technical note in Appendix Q, DCO Document Reference 5.6).

- NSLIDB would prefer a car parking space for maintenance access at Sheepway to be separate to NRIL's space. The car parking area at Sheepway will be doubled under the DCO Scheme which would facilitate NSLIDB's maintenance operations, although separate parking would not be provided.
- The NSLIDB should be consulted regarding discharge to The Cut. The EA will also need to be consulted as The Cut drains into Portbury Ditch. The NSLIDB's maintenance access to The Cut is currently impeded by vegetation growth. The NSLIDB requested maintenance access to The Cut is restored when building the footbridge, and wish to see detailed design drawings for the bridge to ensure the design provides enough space for maintenance equipment to access The Cut.
- NSLIDB should be consulted on the temporary haul road drainage design, and temporary and permanent construction/maintenance compounds. Drainage standards for temporary compounds will be the same as for permanent compounds.
- Drainage designs will need to demonstrate there is sufficient capacity in the highway drainage at Pill to accept additional flows, or upgrade the highway drainage.
- BCC noted that (surface water) flood mitigation will be required at Clanage Road, as there is an existing drainage problem (siltation of culvert under Clanage Road causing flooding in upstream deer park).
- Land drainage consent approval takes approximately 6 weeks (BCC) and 8 weeks (NSC). NSLIDB requires 'construction ready' drawings for consents.
- De-silting of the culvert near Wessex Water pumping station at The Drove would be considered an improvement.
- NSC, BCC and NSLIDB should be re-engaged when the FRA is completed.

6.5 NSDC and NSLIDB meeting on 8 February 2018

6.5.1 The meeting consulted on aspects of the DCO Scheme design relevant to the activities and planned works of the NSDC drainage team and the NSLIDB.

6.5.2 The meeting discussed:

- Consents requirements for permanent works and during construction
- Safeguarding of NSLIDB maintained ditches during construction
- NSLIDB responsibilities post construction, and
- NSLIDB expectations of the DCO application,

6.5.3 Notes of this meeting are in Appendix Q, DCO Document Reference 5.6.

SECTION 7

Development proposals

7.1 The Nationally Significant Infrastructure Project

7.1.1 The works required to commission the Portishead Branch Line comprise the reconstruction of 4,762 metres of disused railway from Quays Avenue in Portishead to the existing operational railway at Portbury Junction, to the east of the M5 Motorway. A further 871 metres of new track will be laid through Pill village, parallel to the existing operational railway line from Portbury Dock which will be slewed across to make room for the new line. A new junction east of Pill Viaduct (Pill Junction) will be constructed, where the new line will connect with the existing operational railway. These works comprise the Nationally Significant Infrastructure Project for which the development consent order is sought.

7.1.2 The disused section of the railway between Portbury Junction and Portishead became heavily over grown, with self-seeded trees, shrubs and scrub. The formation of the original railway between Portishead and Portbury Junction, where the track bed is joined by the track bed for the operational railway, is in a dis-used state, but is largely intact. There is no physical track connection at Portbury Junction and the route from Portbury Junction to Portishead is not part of the national rail network. Repairs are also required to bridges and culverts (see Sections 8.4 and 8.5), as well as new telecommunication and signalling works.

7.2 Associated Development

7.2.1 The new stations and other works such as a new foot and cycle bridge near the Trinity Primary School in Portishead, highway works, temporary haul roads and compounds and minor works in the Avon Gorge are all associated development for the purposes of the 2008 Act.

7.2.2 In Portishead, Quays Avenue will be relocated to the west of its existing position to create space for the new station and car park, with an additional car park along the disused railway corridor between Quays Avenue and Portbury Ditch. There will be a new station and associated parking at Portishead, east of the realigned Quays Avenue.

7.2.3 A new station, forecourt and car park is required in Pill. It is also necessary to modify the signalling equipment along the spur into the Royal Portbury Dock.

7.2.4 Works are also required to enhance the existing operational railway, between Portbury Junction and Ashton Junction, to enable it to be capable of operating an hourly plus passenger train service, as well as maintaining the existing provision for operating freight trains. The existing 30 mph line speed will be maintained, with limited alterations to the track geometry to provide a more comfortable passenger experience. Various other minor railway engineering works along the 9 km alignment involving signalling works, telecommunication works, maintenance works to structures and other railway assets, temporary and permanent compounds, and environmental mitigation.

7.3 DCO Scheme drawings and description

7.3.1 Elements of the DCO Scheme are shown in the DCO Works Plan drawing, DCO Document Reference 5.6. Drawings showing elements of the DCO Scheme are in Part 2 of the DCO application documents. The DCO application document list is included in the DCO application.

7.3.2 Descriptions of all the elements of the DCO Scheme that have been considered in the DCO are in Schedule 1 of the draft DCO, DCO Document Reference 3.1. A more detailed description of the DCO Scheme is provided in the Environmental Statement Chapter 4 Description of the Proposed Works, DCO Document Reference 6.7. The table distinguishes between those works required for the Nationally Significant Infrastructure Project and the Associated Works. These distinctions are explained in the Environmental Statement Chapter 1 Introduction.

7.3.3 Appendix O, DCO Document Reference 5.6 includes details of the drainage design for the DCO Scheme railway, stations (Portishead and Pill) and carparks.

7.4 Flood Zone compatibility and Exception Test

DCO Scheme Project Flood Zone compatibility

7.4.1 As recorded in Section 2.4, the DCO Scheme is considered to be classified as *Essential Infrastructure* for the purposes of National Policy on Flood Risk set out in the NPS NN, NPPF and Planning Practice Guidance. *Essential Infrastructure* development is compatible with all Flood Zones with the Exception Test required for Flood Zones 3a and 3b (Table 2.2). The DCO Scheme is considered to pass the Sequential Test (paragraph 2.4.30) and the first limb of the Exception test (2.4.34).

7.4.2 Elements of the DCO Scheme are shown in the Works Plans, , DCO Document Reference 2.3, and listed in the spreadsheet with filename "*5.6 Flood Risk Assessment Appendix L Flood Zone Review.xlsx"* in Appendix L, DCO Document Reference 5.6. For each element the spreadsheet lists the Flood Zone as shown in the EA Flood Map and a refined estimation of Flood Zone based on more detailed information where available (e.g. modelling undertaken for this FRA).

7.4.3 Elements of the proposed works within undefended Flood Zones 3a and 3b are listed in Table 4.9 together with a summary of implications for flood risk.

Exception Test

7.4.4 In accordance with the Exception Test the DCO Scheme:

- Has been designed and will be constructed to remain operational during normal conditions and in times of flood, provided it is safe for users. As the key flooding risk is from tidal flooding in the opening year and 2075, the flood durations are expected to be relatively short (see Section 4.3.2). Flood risk management is evaluated in Section 8 below. An Outline Flood Plan (operational phase), based on Network Rail's Extreme Weather Plan, has been developed to support the DCO application (included in Appendix T, DCO Document Reference 5.6 and described in Section 8.7). The 1 year return period tidal flood in 2075 is

considered likely to have only a relatively minor impact on railway operation (short duration with River Avon levels reducing below the lowest rail level approximately 1 hour after overtopping of the railway, allowing drainage back into the river, and shallow depth above lowest rail level) and hence only minimal disruption to the railway service (further details are in Sections 4.2.20 to 4.2.24 and 4.3.2).

- Will result in no net loss of floodplain storage within Flood Zone 3b. The proposed works include floodplain compensation to fully mitigate loss of floodplain storage. This is detailed in Sections 8.1.9 to 8.1.11, Sections 8.1.16 to 8.1.18 and Appendix N, DCO Document Reference 5.6.
- Has been designed so as not to impede water flows (Section 4.2 and Appendices K, M and N, DCO Document Reference 5.6) and not increase flood risk elsewhere. Off-site impacts are considered in Section 9.

SECTION 8

Flood risk management

8.1 Fluvial flood risk

Drove Rhyne

Fluvial flood events

8.1.1 The Portishead to Pill (disused section) crosses three watercourses draining northwards into Drove Rhyne (Ditches D10, D11 and D12)[9]. These watercourses are culverted under the Portishead to Pill (disused section). The culverts will be assessed and refurbished or replaced if required with culverts of the same dimensions (i.e. same flow capacity). There will therefore be no increase in flood risk due to Drove Rhyne culvert works.

8.1.2 Hydraulic modelling undertaken for this FRA (Section 4.2 and Appendix K, DCO Document Reference 5.6) indicates that:

- The Portishead to Pill (disused section) embankment top level is above the modelled 1000-year return period flood at all three culvert locations, for the present day (2015) and future (2115[10]) scenarios. Flood risk to the DCO Scheme from Drove Rhyne is therefore considered insignificant.
- Modelled Drove Rhyne 100-year with climate change allowance flood levels are contained within channel in the vicinity of the DCO Scheme and so there is no requirement for displaced floodplain compensation storage.

Tidal flood events

8.1.3 Tidal flood risk management in the vicinity of Drove Rhyne is considered as part of the coastal modelling undertaken for this FRA (Section 4.2 and Appendix M, DCO Document Reference 5.6).

Easton-in-Gordano stream

Flood risk to the DCO Scheme

Fluvial flood events

8.1.4 The Portishead to Pill (disused section) crosses Easton-in-Gordano Stream, which is culverted under the DCO Scheme. The farm access track (cattle creep) under the Portishead to Pill (disused section), between Easton-in-Gordano stream and the M5 Motorway, acts as a flood relief flow path. The scheme design will not change this flood flow path.

[9] The surface water features within the study area are presented, from west to east, in Appendix 17.3 of the Environmental Statement, DCO Document Reference 6.25, and are shown on Figure 17.1 (Sheets 1 to 5) of the Environmental Statement Book of Figures, DCO Document Reference 6.24.

[10] For Drove Rhyne simulations of the future (2075) design year were not undertaken as results for the more extreme future (2115) scenario do not show flood risk to the DCO scheme or offsite impacts due to the DCO scheme.

8.1.5 Hydraulic modelling undertaken for this FRA (Section 4.2 and Appendix K, DCO Document Reference 5.6) indicates that modelled fluvial flood levels are below the disused railway embankment top level for the 1000-year return period, for the present day (2015) and future (2075 and 2115) scenarios. Fluvial flood risk to the DCO Scheme from Easton-in-Gordano stream is therefore considered insignificant.

Tidal flood events

8.1.6 The Easton-in-Gordano Stream drains into the tidal River Avon through a flapped culvert. For River Avon tidal flooding to propagate upstream along the Easton-in-Gordano stream towards the DCO Scheme, tide levels above the flapped orifice structure overtopping level are required.

8.1.7 Results of simulating tidal flooding in Easton-in-Gordano Stream (Section 4.2 and Appendix K, DCO Document Reference 5.6) indicate that the Portishead to Pill (disused section) top of embankment is above the modelled 1000-year return period tidal flood level for the present day (2015) and future (2075 and 2115) scenarios. Tidal flood risk to the DCO Scheme from Easton-in-Gordano stream tidal flood events is therefore considered insignificant.

Impact of the DCO Scheme on flood risk elsewhere

Impact on flood conveyance

8.1.8 The DCO Scheme has no impact on Easton-in-Gordano Stream flood conveyance (i.e. no impact on flood levels elsewhere as a result of changes in flood conveyance) as:

- the proposed increase in railway level at this location level is above modelled flood levels (Tables 4.4 and 4.5), and
- the DCO Scheme does not change flood flow paths through the railway embankment (culvert on Easton-in-Gordano Steam with diameter approximately 0.5 m, and farm access track opening in embankment).

Floodplain compensation requirement

8.1.9 To accommodate a ‘continuous position of safety’ south of the railway, and allow for the existing cycle path north of the railway, the proposed works include an increase in the railway embankment footprint within the Easton-in-Gordano Stream floodplain, between the M5 Motorway crossing and Marsh Lane, by approximately 3 m on average along the southern edge of the DCO Scheme (see drawings in Part 2 of the DCO application documents, DCO Document Reference 2.7). This additional footprint results in additional displacement of potential floodplain storage by the DCO Scheme.

8.1.10 This displacement of floodplain storage has been quantified for future (2075 and 2115) flood levels up to the 200 year return period tidal and 100 year return period fluvial events. Table 8.1 lists the displaced floodplain storage volumes within 0.1 m level ranges, and the compensation volumes provided (peak levels in 2075 and 2115 are from the fluvial events at 8.25 mAOD and 8.27 mAOD respectively i.e. both below 8.3 mAOD).

Table 8.1: Easton-in-Gordano Stream floodplain compensation volumes

Level range (mAOD)			
Lower level (mAOD)	***Upper level (mAOD)***	***Displaced volume in level range (south of the railway) (m3)***	***Compensation provided (south of the railway) by proposed ground level reprofiling (m3)***
7.9	8.0	1.8	10.2
8.0	8.1	11.3	12.6
8.1	8.2	20.2	44.3
8.2	8.3	25.6	55.3

8.1.11 Table 8.1 only includes displaced floodplain storage volumes south of the railway, as north of the railway the proposed railway design results in no displacement of floodplain storage below the design flood levels. Floodplain compensation will therefore be provided by locally lowering ground levels south of the railway. Table 8.1 shows the required compensation volumes are exceeded by the design within each level range, and the design therefore provides local, hydraulically connected floodplain storage to fully mitigate the proposed railway works. The proposed reprofiling of ground levels in the Easton-in-Gordano Stream floodplain south of the railway is shown in Appendix R.

Portbury Ditch

8.1.12 The proposed works include improving the existing pedestrian access over Portbury Ditch. The proposed works retain the existing culvert structure and all works are to the top of the existing crossing. Raised flood levels in Portbury Ditch would be a result of tide locked fluvial flows. Topographic survey undertaken for the DCO Scheme shows the existing crossing has a top level of approximately 7.5 mAOD. There is significant storage in the upstream Portbury Ditch catchment with large flat areas between the M5 motorway and B3124 road, north-east of Clevedon, shown to have levels of approximately 6 m to 7 m in Ordnance Survey mapping. Due to the significant low lying floodplain storage available, it is considered unlikely that flood levels in Portbury Ditch would reach 7.5 mAOD during design fluvial flood events (e.g. 1000 year fluvial flood event in 2075 and 2115). Management of coastal flood risk (i.e. overtopping of coastal flood defences) is considered in Section 8.2.

Tidal River Avon

Flood risk to the DCO Scheme

8.1.13 Simulation of tidal River Avon flooding undertaken for the DCO Scheme (Section 4.2 and Appendix N, DCO Document Reference 5.6) indicates that the DCO Scheme (i.e. post-development) would be flooded during tidal River Avon floods approximately once every 5 to 10 years for the current (2015) scenario and more frequently than once every year (at Bower Ashton) for the future (2075 and 2115) scenarios. Whilst the simulations

undertaken show the railway to be flooded at Bower Ashton during the 1 year River Avon tidal event in 2075, the modelling includes a combination of several conservative modelling assumptions, and so the simulation results are likely to be overestimates. The 1 year tidal flood in 2075 is therefore considered likely to have only a relatively minor impact on railway operation (short duration with River Avon levels reducing below the lowest rail level approximately 1 hour after overtopping of the railway, allowing drainage back into the river, and shallow depth above lowest rail level) and hence only minimal disruption to the railway service (further details are in Sections 4.2.20 to 4.2.24). Areas at risk of tidal River Avon flooding are shown in Appendix N, DCO Document Reference 5.6 to be the Portbury Freight Line (operational railway) between the River Avon and Bower Ashton.

8.1.14 An Outline Flood Plan (operational phase) has been developed by NRIL (refer to Section 8.7 and Appendix T, DCO Document Reference 5.6).

8.1.15 The projected increase in future flood risk to the DCO Scheme at this location due to increased sea levels would also affect urban areas in Bristol. BCC has identified the need for a tidal River Avon flood risk management strategy to address increased flood risk in the future. A tidal River Avon strategic flood risk management option would also reduce future flood risk to the DCO Scheme.

Floodplain compensation requirement

8.1.16 To prevent impacts of the DCO Scheme on flood risk elsewhere (including to properties), the railway design will retain the existing railway elevations and footprint in the River Avon floodplain in the Bower Ashton/Ashton Gate area, including retaining the existing bunds adjacent to the railway. No floodplain compensation will therefore be required to mitigate the proposed DCO Scheme railway works within the River Avon floodplain, as there is no associated change in floodplain storage.

8.1.17 The proposed railway will be replaced at the same level as the existing railway, within standard railway design and construction tolerances (approximately +/-25 mm). There will be no net increase in displaced floodplain storage by the railway (there may minor adjustments to existing alignment to meet railway design standards, but there will be no net increase in displaced floodplain by the railway). The existing earth bunds adjacent to the railway will be retained as these bunds act as a hydraulic control during flooding.

8.1.18 Floodplain compensation will be provided to mitigate the impact of the Clanage Road maintenance compound vehicular access and ramp on flood risk to properties. Floodplain compensation comprises lowering of ground levels, only within the permanent Clanage Road maintenance compound, to 7.4 mAOD relative to the railway topographic survey datum. This option is considered to fully mitigate the impact of the vehicular access and ramp on flood risk elsewhere. Further details are in the floodplain compensation modelling technical note in Appendix N, DCO Document Reference 5.6 (filename "*5.6 Flood Risk Assessment Appendix N FRA Technical Note.pdf*)".

Colliter's and Longmoor/Ashton Brooks

8.1.19 Between Ashton Vale and the A370 road the DCO Scheme crosses culverts conveying Colliter's Brook and Longmoor/Ashton Brook (these culverts are shown in the EA flood defences map in Appendix B, DCO Document

Reference 5.6 as culverts 42 and 31 respectively). The DCO Scheme crosses the upstream end of culvert 42 at Ashton Vale and from approximately 100 m north of the A370 road the DCO Scheme is adjacent to (directly west of) culvert 31 alignment for approximately 300 m after which culvert 31 passes underneath the DCO Scheme and continues north-eastwards to join the River Avon.

8.1.20 The BCC CAFRA modelling developed further for this FRA (Section 4.2 and Appendix N, DCO Document Reference 5.6) indicates:

- For the present day (2015) scenario the DCO Scheme is outside of the Colliter's Brook and Longmoor/Ashton Brook 100-year return period flood extent, and within the 1000-year return period flood extent. The 1000-year return period fluvial design event simulation includes a 10-year return period tide condition (determined as part of the CAFRA fluvial/tidal joint event probability assessment) which acts to impede drainage of Colliter's and Longmoor/Ashton Brooks.
- For the future (2075 and 2115) scenarios the DCO Scheme is shown to be outside of the Colliter's Brook and Longmoor/Ashton Brook 50-year return period flood extent, and within the 75-year return period flood extent. However, the 75-year return period scenario has been simulated with a 2-year return period tide condition (in line with the CAFRA joint probability assessment) whilst the 50-year return period applies a MHWS tide. This difference in results for the different tide conditions (with comparatively similar fluvial inflows) indicates that, as for the present day (2015) scenario, tide locking of fluvial flows leads to flooding in the vicinity of the DCO Scheme, and the frequency of this tide locking will increase in the future due to projected sea level rise.

8.1.21 An Outline Flood Plan (operational phase) has been developed by NRIL (refer to Section 8.7 and Appendix T, DCO Document Reference 5.6).

8.1.22 There is potential for the DCO Scheme to increase the structural loading on culverts 31 and 42. The entrances to Longmoor Brook and Colliter's Brook culverts are approximately 200 m and 30 m away from the proposed works respectively. The structural performance of these culverts will be assessed in the context of the proposed development, and the culverts will be improved if required to allow for any additional structural loading. Any required works (i.e. structural improvements) would be designed in consultation with the Environment Agency.

8.2 Coastal flood risk

8.2.1 Coastal modelling undertaken for this FRA (Section 4.2 and Appendix M, DCO Document Reference 5.6) indicates that for the present day (2015) and future (2075) scenarios the DCO Scheme would not be flooded during the 1000-year return period coastal flood events. For the future (2115) scenario, the DCO Scheme would experience flooding above the level of rail level during coastal flood events approximately once every 200 to 1000 years on average.

8.2.2 Coastal flood risk is not considered to be a significant risk for the present day (2015) and future (2075) scenarios, and only a minor risk in the future (2115) scenario. During extreme tide conditions, the DCO Scheme would be closed due to tidal River Avon flooding at Bower Ashton before coastal

flooding impacted the scheme between Portishead and Pill (Section 8.1.13). An Outline Flood Plan (operational phase) has been developed by NRIL (refer to Section 8.7 and Appendix T, DCO Document Reference 5.6).

8.2.3 The proposed Portishead station and car park are located in defended Flood Zones 2 and 3 (Section 4.2.30 and Appendix L, DCO Document Reference 5.6). For the present day (2015) and future (2075) scenarios, the station and carpark and surrounding areas are defended from coastal flooding for return period above 1000 years. For the simulated future (2115) scenario, projected sea level rise results in overtopping of coastal defences and an increased flood extent in the vicinity of the proposed Portishead station. The modelled future scenario (2115) coastal flood levels in Table 8.4 show the proposed Portishead station and carparks will be above the 200 year return period flood level in 2115. Modelled future scenario (2115) coastal flood depths, velocities and hazard scores for coastal flooding events are shown in Appendix M, DCO Document Reference 5.6.

8.2.4 Proposed rail levels and ground levels in the vicinity of the proposed Pill station and car park, and adjacent roads, are above 17 mAOD which is significantly higher than the modelled future (2115) scenario 1000-year return period River Avon tidal levels (approximately 10.5 mAOD).

8.2.5 As Portishead and Pill proposed stations and car parks are outside of the 200 year return period coastal flood extents for the design life (2075), the assessment of Portishead and Pill proposed stations and car parks in this FRA is focussed on surface water drainage management (Section 8.3).

8.2.6 Impacts of the DCO Scheme on coastal flood risk elsewhere are discussed in Section 9.1.

8.3 Surface water drainage

Railway track drainage

8.3.1 The Track Drainage Design Report is included in Appendix O, DCO Document Reference 5.6. This details the surface water drainage strategy and outline design for the railway track drainage between Parsons Street Junction and Portishead. This has been developed in consultation with the EA, NSDC, BCC and NSLIDB. Key features of the track design, reported in the Drainage Design Report are:

- the track drainage is designed to accommodate a 25-year return period storm with a 20% uplift to allow for projected future climate change
- the drainage pipe gradients will be set to achieve self-cleaning velocities where practicable, and
- the existing track drainage will be improved if required to achieve the design standard (no track drainage works are proposed, except where the drainage system is affected by wider works e.g. Pill station area).

8.3.2 The track drainage design will be finalised during the detailed design stage.

Portishead and Pill stations: Buildings and platforms

Portishead station buildings and platform

8.3.3 Details of the proposed Portishead station buildings and platform drainage are included in Appendix O, DCO Document Reference 5.6, as follows:

- a new drainage system is proposed for Portishead station and platform designed with capacity to drain a 100 year storm with a 30% uplift for climate change, and
- the drainage system will drain into a collector drain, connected to the proposed track drainage, which drains into The Cut watercourse.

Pill station buildings and platform

8.3.4 New drainage is proposed for Pill Station platform and its back wall (a proposed retaining wall). Pill station buildings and platform drainage will drain into a holding tank near Pill car park and then discharged into the highway drainage. The new drainage design life is 60 years, with the design complying with Network Rail design standards.

8.3.5 The track drainage through Pill will also be collected and disposed of to the highway drainage system.

Portishead and Pill stations car parks and associated new highways, haul roads and construction compounds

8.3.6 The Surface Water Drainage Strategy for Portishead and Pill stations car parks and associated new highways, haul roads and compounds, developed in consultation with the EA, NSDC and NSLIDB, is included in Appendix O, DCO Document Reference 5.6. Key features of the Portishead and Pill stations car park drainage strategy and design are as follows.

8.3.7 The design criteria used, detailed in Table 8.3, according with NSDC's requirements for a design life of 60 years for the drainage system in the permanent development sites and for a design life of 1 to 2 years for the temporary development sites.

Table 8.3: Drainage design criteria

	Design return period (years)	Exceedance flows return period (years)	Climate change allowance (uplift to rainfall)
Permanent development sites	30	100	40%
Temporary development sites	30	100	10%

8.3.8 Maximum discharge rates:

- For green-field sites: green-field peak rate or max. of 2.5 l/s
- For pre-developed sites: green-field peak rate or min. of 2.5 l/s if attenuation is possible, otherwise a reduction of 30% for the existing discharge rate.
- For Pill Station and Portishead Station – based on the Concept Drainage, included in Appendix G of the document with filename "*5.6*

Flood Risk Assessment Appendix O Surface Water Drainage Strategy.pdf" in Appendix O, DCO Document Reference 5.6.

8.3.9 Further details are in Appendix O, DCO Document Reference 5.6.

8.4 Culverts and drainage ditches

8.4.1 The structural performance of all culverts along the DCO Scheme alignment will be assessed and the culverts will be refurbished or replaced, if required, with culverts of the same dimensions (i.e. same flow capacity). Where there are proposed works over culverts, the structural performance of these culverts will be assessed in the context of the proposed development, and the culverts will be improved if required to allow for any additional structural loading.

8.4.2 There will therefore be no increase in flood risk due to culvert works. Where culverts are to be replaced, the replacement of a culvert in poor condition with a new culvert (of the same size) represents a reduction in flood risk, as the risk of structure failure (i.e. blockage/collapse) will be reduced. Proposed works to Main River culverts are discussed in Section 8.5.

8.4.3 Where railway drainage ditches are currently overgrown or in poor condition along the DCO Scheme alignment, clearing and refurbishment works will provide an improvement to surface water management.

8.4.4 The DCO Scheme crosses culverts on Colliter's Brook and Ashton/Longmoor Brook. See further information in Section 8.5.6.

8.5 Maintenance access to watercourses and structures

8.5.1 The DCO Scheme design has been developed in consultation with the EA, NSC, BCC and NSLIDB to ensure the DCO Scheme does not compromise required access to maintain watercourses and hydraulic structures. Network Rail will ensure that tender documents for the DCO works include a requirement not to compromise maintenance access requirements. Proposed works within 16 m of the River Avon, which is a tidal Main River, (e.g. tow paths, culverts) will comply with the Environmental Permitting (England and Wales) Regulations 2016 (as amended), and the Applicant will also comply with the Master CEMP requirements around stakeholder engagement in relation to these works.

8.5.2 The DCO Scheme crosses Main Rivers (as shown in the EA Flood Map for Planning) as follows.

8.5.3 **Portbury Ditch:** All proposed works over Portbury Ditch are at the top level of the existing crossing (approximately 7.5 mAOD) and so above the culvert structure, and above anticipated flood levels as there is significant lower lying Portbury Ditch floodplain storage. Maintenance access to Portbury Ditch culvert will therefore not be impacted by the proposed works.

8.5.4 **Drove Rhyne (three culverts under the railway):** All three culverts are to be retained. These are understood to be maintained by the North Somerset Levels Internal Drainage Board ("NSLIDB"). NSLIDB has been consulted during the design process and NSLIDB has not raised concerns with respect to future maintenance of these culverts.

8.5.5 **Markham Brook:** The DCO Scheme crosses Markham Brook on the elevated Pill Viaduct. The Markham Brook culvert is underneath the elevated viaduct. There are no planned works underneath the viaduct. The proposed works therefore have no impact on Markham Brook culvert and its maintenance.

8.5.6 **Longmoor Brook and Colliter's Brook culverts:** The entrances to Longmoor Brook and Colliter's Brook culverts are approximately 200 m and 30 m away from the proposed works respectively. The structural performance of these culverts will be assessed in the context of the proposed development, and the culverts will be improved if required to allow for any additional structural loading. Any required works (i.e. structural improvements) would be designed in consultation with the EA.

8.5.7 The DCO Scheme will therefore have no adverse impact on access required to maintain Main River culverts and Main River watercourses. The design of works in the vicinity of other watercourses (i.e. non Main River), including culvert works, has been developed in consultation with the relevant maintaining authorities (NSC, BCC and NSLIDB).

8.6 Portishead and Pill stations and carparks access and egress

Portishead station

8.6.1 The proposed Portishead station and car park are located in defended Flood Zones 2 and 3 (Section 4.2.30 and Appendix L, DCO Document Reference 5.6). For the present day (2015) and future (2075) scenarios, the station and carpark and surrounding areas, are defended from coastal flooding for return period above 1000 years. The impact of flooding on access/egress is therefore considered insignificant for the present day (2015) and future (2075) scenarios.

8.6.2 For the simulated future (2115) scenario, projected sea level rise results in overtopping of coastal defences and an increased flood extent in the vicinity of the proposed Portishead station. Modelled future scenario (2115) coastal flood levels in the vicinity of Portishead are presented in Table 8.4. Modelled future scenario (2115) coastal flood depths, velocities and hazard scores for coastal flooding events are shown in Appendix M, DCO Document Reference 5.6.

8.6.3 Existing ground levels at the proposed Portishead station location are approximately 7.5 mAOD and the proposed platform level is approximately 9.6 mAOD, and so above the future (2115) 1000-year return period coastal flood level of 8.2 mAOD. The pedestrian crossing of Portbury Ditch has a top level of approximately 7.5 mAOD. Table 8.4 shows that for the future (2115) scenario, Portishead station and car parks, and the pedestrian crossing of Portbury Ditch, will be safe from coastal flooding for return periods up to 200 years.

8.6.4 For the future (2115) scenario, the DCO Scheme would flood at Bower Ashton for lower return period tidal flood events than at Portishead station and car parks, i.e. before the car parks, station and access routes flood (Section 4.2.31), and so the service would cease operation before the car

parks, station and access routes flood. An Outline Flood Plan (operational phase) has been developed by NRIL (refer to Section 8.7 and Appendix T, DCO Document Reference 5.6).

Table 8.4: Modelled coastal flood levels (mAOD) near Portishead station for Future (2115) scenario

	Return period (years)				
Location	**50**	**75**	**100**	**200**	**1000**
Pedestrian crossing of Portbury Ditch	***3.8 (below crossing level)***	***4.3 (below crossing level)***	***4.6 (below crossing level)***	***6.8 (below crossing level)***	***7.9 (above crossing level)***
Proposed Portishead station car parks	No flooding	No flooding	No flooding	No flooding	8.2
Proposed Portishead station at existing Quays Road	No flooding	No flooding	No flooding	No flooding	8.2

Pill station

8.6.5 Proposed rail levels and ground levels in the vicinity of the proposed Pill station and car park, and adjacent roads, are above 17 mAOD which is significantly higher than the modelled future (2075 and 2115) scenarios 1000-year return period River Avon tidal levels (approximately 10.5 mAOD in 2115). Access/egress to Pill station and car park is therefore considered safe from River Avon tidal flooding.

Train stranded during flooding

8.6.6 An Outline Flood Plan (operational phase) has been developed by NRIL (refer to Section 8.7 and Appendix T, DCO Document Reference 5.6).

8.7 Outline Flood Plan (operational phase)

8.7.1 An Outline Flood Plan (operational phase), based on Network Rail's Extreme Weather Plan, has been developed to support the DCO application (included in Appendix T, DCO Document Reference 5.6). It provides an indication of the key issues required for consideration, and the general approach that will be taken, for flooding issues when the DCO Scheme is operational. Network Rail manages flood risk at a route level, producing Extreme Weather Plans (Network Rail Standard Maintenance Procedure NR/L3/TRK/1010) which incorporate flood responses across the route network. Once the DCO Scheme reaches the operational stage any relevant flood response issues pertaining to the line will fall under the auspices of the route-wide plan and any subsequent updates applied to it. Network Rail's route-wide Extreme Weather Plan will identify the likelihood of occurrence of

flooding on the line; will demonstrate how Network Rail will respond to and monitor flooding events; and demonstrate how the DCO Scheme will be returned to operational status following the subsidence of flooding.

8.7.2 The purpose of the route-wide Extreme Weather Plan (including flooding) which will incorporate the operational scheme will be to ensure the safety of rail traffic passengers, personnel and infrastructure where flooding presents a danger. In addition it will advise all concerned of the actions to be taken in the event of a Flood Warning being received from the EA. The Outline Flood Plan (operational phase) in Appendix T, DCO Document Reference 5.6 should be read in conjunction with the Network Rail Standard Maintenance Procedure NR/L3/TRK/1010, Issue 02 August 2008 *Management of responses to extreme weather conditions at structures, earthworks and other key locations* (formally NR/L3/MTC/TK0167). The Outline Flood Plan (operational phase) draws heavily upon the contents of this document to present an illustration of the provisions that will apply as part of Network Rail's strategic approach to flood risk management along the future line of the DCO Scheme once it has reached the operational phases.

SECTION 9

Off-site impacts

9.1 Impact of the DCO Scheme on flood risk elsewhere

Potential impacts

9.1.1 The proposed rail and embankment levels along the DCO Scheme alignment are generally slightly higher (typically by between approximately 0 mm and 300 mm) than existing levels. However, where the railway crosses the tidal River Avon floodplain at Bower Ashton and Longmoor and Colliter's Brooks fluvial floodplain, proposed rail and embankment levels are retained at existing levels. This is to avoid offsite impacts on flood risk which could arise from raising the railway. Earlier designs considered raising the railway slightly at this location, but it was found that associated offsite impacts could not be mitigated. The proposed Clanage Road maintenance compound includes a vehicular access and ramp which have potential to displace tidal River Avon floodplain storage.

9.1.2 Simulated present day (2015) and future (2075) coastal flood extents do not reach the DCO Scheme, and so the proposed changes in railway levels would have no impact in 2015 and 2075. The proposed changes in railway levels have potential to impact on local flood risk between Portishead and Pill for future (2115) scenario coastal flooding.

9.1.3 There are no significant potential impacts on Drove Rhyne fluvial flooding as:

- Modelled flood levels at the railway culvert locations are below the top of the railway embankment levels (and all proposed works) for both the pre-development and post-development cases.
- The minor changes in flood levels outside of the railway corridor shown in Appendix A of the hydraulic modelling technical note in Appendix K, DCO Document Reference 5.6 are a result of slight changes in 2D routing of direct rainfall (and these differences are likely to be overstated as the modelling does not explicitly represent the railway drainage system).

9.1.4 There are no significant potential impacts on Easton-in-Gordano Stream flooding (see Sections 8.1.4 to 8.1.11).

Impact on coastal flooding between Portishead and Pill

9.1.5 The figures in Appendix M, DCO Document Reference 5.6 show peak depth, velocity and hazard score between Portishead and Pill for simulated coastal flood events. These figures show that:

- For the 1000-year return period present day (2015) and future (2075) scenarios simulated flood extents do not reach the DCO Scheme.
- Figures M.16 and M.17 in Appendix M, DCO Document Reference 5.6 show the differences in pre- and post-development modelled peak flood depths for the 100 year and 200 year return period modelled coastal flood events for the (2115) scenario (there is no flooding for the present

day (2015) and future (2075) scenarios and so there are no equivalent 2015 and 2075 difference plots).

- Figure M.16 shows that the proposed railway works have no impact on coastal flood risk for the 100 year return period coastal flood in 2115, as flood levels are below the railway level.
- Figure M.17 shows that, due to a general slight increase in post-development railway levels, for the 200 year return period coastal flood in 2115, coastal flood levels are locally lower south of the DCO Scheme and higher north of the DCO Scheme between Sheepway road and Portishead urban area. The increased flood levels are within the Portbury Wharf flood attenuation area, and do not affect the adjacent urban area. There is an increase in flood levels only for design events higher than those for which the Portbury flood attenuation area was designed, and so the operation of Portbury Wharf Flood attenuation area is not affected.

9.1.6 These changes in flood levels are considered minor (no increase in flood levels for properties) and would only occur for events with flood levels higher than the DCO Scheme railway levels, i.e. coastal flood events larger than the future (2115) scenario 100 year to 200 year return period event. There are no impacts for the future (2075) scenario as flooding would not reach the railway alignment. There is likely to be a strategic response to manage future increased coastal flood risk between Portishead and Pill (Sections 2.4.18 and 2.4.20).

Impact on tidal River Avon flooding

9.1.7 Where the railway crosses the tidal River Avon floodplain at Bower Ashton and Longmoor and Colliter's Brooks fluvial floodplain, proposed rail and embankment levels, and raised bunds adjacent to the railway, are retained at existing levels. This avoids offsite impacts on flood risk which could arise from raising the railway or removing adjacent raised bunds. The proposed Clanage Road maintenance compound includes a vehicular access and ramp in the tidal River Avon floodplain. The proposed lowering of ground levels within the Clanage Road compound fully mitigates the impacts of the vehicular access and ramp (Appendix N, DCO Document Reference 5.6).

9.1.8 Figures N.31 to N.34 in Appendix N, DCO Document Reference 5.6 show differences in pre-development and post-development simulated tidal River Avon peak flood depths for the 10, 20, 75 and 200-year return periods for the present day (2015) and future (2075 and 2115) scenarios. Figures N.35 to N.38 show differences in flood extents for the same events. These figures show the proposed scheme has no negative impact on flood risk outside of the Clanage Road compound. The proposed floodplain compensation does provide some slight benefits directly south of the Clanage Road compound for the 20 year present day (2015) tidal event. The figures also show some apparent changes in flood depths relatively remote from the Clanage Road compound e.g. east of the A3025 Merchants Road for the 10 year and 20 year events in 2075. As the differences in peak depths at surrounding areas are negligible, these differences are considered modelling artefacts due to, for example, the models converging on slightly different solutions within

model convergence tolerances, or slightly different implementation of automatic structure rules in the model. These simulated differences are therefore not considered to be impacts arising from the Clanage Road compound vehicular access and ramp, and so the DCO Scheme is considered to have no negative impact on flood risk elsewhere. Floodplain compensation modelling and results are discussed further in Sections 8.1.16 to 8.1.18 and Appendix N, DCO Document Reference 5.6.

Impact on Colliter's and Longmoor/Ashton Brooks flooding

9.1.9 Figures N.125 and N.126 in Appendix N, DCO Document Reference 5.6 show differences in simulated pre-development and post-development fluvial event peak flood depths and extents respectively in Colliter's and Longmoor/Ashton Brooks, for the 100 year return period, for the present day (2015) and future (2075 and 2115) scenarios.

9.1.10 Figures N.125 and N.126 show:

- For the 100 year return period fluvial event in 2015, there are no differences in results for pre and post-development scenarios, as all proposed works are above the simulated Colliter's and Longmoor Brooks peak flood levels, and flood extents do not reach the Clanage road compound.
- For the 100 year return period fluvial event in 2075, there are localised changes in flood depths within the Clanage Road compound due to the proposed vehicular access and ramp and lowering of ground levels in the compound. The floodplain compensation provided within the compound also reduces flood depths directly south of the compound.
- For the 100 year return period fluvial event in 2115, outside of the Clanage Road compound, flood levels are not significantly impacted by the proposed Clanage Road vehicular access and ramp, and lowering of ground levels. Simulated depth differences in the Longmoor and Colliter's Brooks floodplain are within approximately 1 mm except for adjacent to Ashton Vale Road and in Gore's Marsh Recreation Ground, where some grid cells are just wetted for the post development scenario. These simulated differences are considered modelling artefacts, due to the models converging on slightly different solutions within model convergence tolerances as there is no mechanism for the differences to occur. Pre and post development models are identical within the Longmoor and Colliter's Brooks catchments and flood extents here are not connected to River Avon flood extents except for where the watercourses meet the River Avon, where peak levels differ by within 1 mm. In the River Avon floodplain at Bower Ashton, differences are insignificant (within approximately 2 mm) except for within the Clanage Road compound. There are some localised differences of up to approximately 3 mm e.g. south of Hotwells. These differences are considered modelling artefacts due to the models converging on slightly different solutions within model convergence tolerances as nearby differences are smaller. (Note the 100 year fluvial event applies a 2 year tidal boundary, and so the River Avon differences for the 100 year fluvial event are effectively those of the 2 year tidal event.)

Impact on flood risk to properties

Impact on coastal flooding between Portishead and Pill

9.1.11 No properties are impacted by a change in coastal flood risk as a result of the proposed works. Simulated present day (2015) and future (2075) coastal flood extents do not reach the DCO Scheme, and so the proposed changes in railway levels would have no impact in 2015 and 2075. Figure M.17 in Appendix M, DCO Document Reference 5.6 shows a post-development increase in flood depths north of the disused railway and adjacent to housing in eastern Portishead, for the simulated future (2115) 200 year return period coastal flood. However, the simulated post-development flood levels at this location are approximately 7.7 mAOD, compared to a lowest ground level of 7.94 mAOD at the location of adjacent properties on Fennel Road (based on LiDAR level data). This increase in flood depth therefore has no impact on adjacent properties.

Impact on tidal River Avon flooding and Longmoor and Colliter's Brooks fluvial flooding (CAFRA model tidal events and fluvial events)

9.1.12 Appendix N, DCO Document Reference 5.6 includes a technical note (filename "*5.6 Flood Risk Assessment Appendix N FRA Technical Note.pdf*") detailing modelling undertaken to assess floodplain compensation options to mitigate for the proposed Clanage Road compound vehicular access and ramp, and simulated impacts on flood risk to properties. For the proposed compensation option (lowering ground levels within the compound to 7.4 mAOD), for all tidal and fluvial events assessed, the maximum increase in peak flood depths at properties with potential to be impacted by changed flood risk due to the proposed works is 1 mm. This is considered insignificant and within model tolerances. There are therefore no negative impacts on flood risk to properties resulting from the proposed works. Further details are in Appendix N, DCO Document Reference 5.6.

Drove Rhyne

9.1.13 No properties are impacted by a change in Drove Rhyne flood risk as a result of the proposed works (see Appendix K, DCO Document Reference 5.6).

Easton-in-Gordano Stream

9.1.14 No properties are impacted by a change in Easton-in-Gordano Stream flood risk as a result of the proposed works (see Appendix K, DCO Document Reference 5.6).

9.2 Culverts

9.2.1 See Section 8.4.

9.3 Surface water management

9.3.1 The surface water drainage strategy and design for the DCO Scheme has been developed in consultation with the Environment Agency, North Somerset District Council, Bristol City Council and North Somerset Levels Internal Drainage Board. This drainage design ensures the proposed drainage of the DCO Scheme does not increase flood risk elsewhere

including with an allowance for climate change (Section 8.3 and Appendix O, DCO Document Reference 5.6).

9.4 Displaced floodplain storage

9.4.1 There are two locations where the DCO Scheme lies within Flood Zone 3 and occupies a volume that would have been available as floodplain storage. These locations are where the Project crosses Easton-in-Gordano Stream Flood Zone 3 and the tidal River Avon Flood Zone 3 near Bower Ashton (Clanage Road compound vehicular access and ramp). For these locations there is a requirement to consider whether compensation flood storage is required to mitigate for the displaced potential floodplain storage.

9.4.2 Proposed floodplain compensation within Easton-in-Gordano Stream Flood Zone 3 is detailed in Sections 8.1.9 to 8.1.11.

9.4.3 Proposed floodplain compensation within the Clanage Road compound (tidal River Avon Flood Zone 3) is detailed in Section 8.1.18 and in the floodplain compensation modelling technical note in Appendix N, DCO Document Reference 5.6 (filename "*5.6 Flood Risk Assessment Appendix N FRA Technical Note.pdf*").

SECTION 10

Summary of mitigation measures

10.1.1 Table 10.1 summarises the mitigation measures applied in the DCO Scheme design and residual impacts. Residual risk is discussed further in Chapter 11.

Table 10.1. Summary of potential impacts, mitigation and residual impacts of the DCO Scheme on flood risk

Aspect	Impact	Receptors	Mitigation	Residual Impact
Coastal flood risk to the DCO Scheme proposed railway between Portishead and Pill	Flooding of railway line during coastal flooding events. The risk of coastal flooding between Portishead and Pill is insignificant for the present day (2015) and future (2075) scenarios and increases slightly for the future (2115) scenario due to projected future sea level rise. Recovery of service following flooding is expected to be relatively rapid (Network Rail has advised that following the winter 2013/14 Somerset Levels railway closures due to flooding, lines were operational within approximately 1 day of flood levels subsiding).	The DCO Scheme within the coastal floodplain between Portishead and Pill.	An Outline Flood Plan (operational phase) has been developed to support the DCO application (included in Appendix T, DCO Document Reference 5.6). It provides an indication of the key issues required for consideration, and the general approach that will be taken, for flooding issues when the scheme is operational. Network Rail manages flood risk at a route level, producing Extreme Weather Plans (Network Rail Standard Maintenance Procedure NR/L3/TRK/1010) which incorporate flood responses across the route network. Once the DCO Scheme reaches the operational stage any relevant flood response issues pertaining to the line will fall under the auspices of the route-wide plan and any subsequent updates applied to it.	Breach of coastal defences. The impacts of a breach are considered in the modelling technical note in Appendix M, DCO Document Reference 5.6.
Coastal flood risk to proposed Portishead station and car park, and pedestrian	Insignificant for present day (2015) and future (2075) scenarios.	Proposed Portishead station car park and access route	An Outline Flood Plan (operational phase) has been developed to support the DCO application (see first row in this	Breach of coastal defences. The impacts of a breach are considered in the

Table 10.1. Summary of potential impacts, mitigation and residual impacts of the DCO Scheme on flood risk

Aspect	Impact	Receptors	Mitigation	Residual Impact
crossing of Portbury Ditch.	For the future (2115) scenario, Portishead station and car parks, and the pedestrian crossing of Portbury Ditch, will be safe from coastal flooding for return periods up to 200 years.		table and Appendix T, DCO Document Reference 5.6).	modelling technical note in Appendix M, DCO Document Reference 5.6.
Tidal River Avon flood risk to the DCO Scheme proposed railway near Bower Ashton	Tidal River Avon flooding of the DCO Scheme would occur approximately once every 5 to 10 years for the present day (2015) and more frequently in the future due to projected future sea level rise. Recovery of service following flooding is expected to be relatively rapid (Network Rail has advised that following the winter 2013/14 Somerset Levels railway closures due to flooding, lines were operational within approximately 1 day of flood levels subsiding).	The DCO Scheme within the River Avon floodplain near Bower Ashton	An Outline Flood Plan (operational phase) has been developed to support the DCO application (see first row in this table and Appendix T, DCO Document Reference 5.6).	Significant but manageable through well-considered Outline Flood Plan (operational phase). The projected increase in future flood risk is likely to be mitigated by strategic future tidal flood defence solution required for Bristol.

Table 10.1. Summary of potential impacts, mitigation and residual impacts of the DCO Scheme on flood risk

Aspect	Impact	Receptors	Mitigation	Residual Impact
Numerous existing culverts conveying watercourses crossed by the DCO Scheme	Potential increase in flood risk upstream of the DCO Scheme if conveyance is reduced	Areas upstream of watercourses crossed by the DCO Scheme	All existing culverts crossed by the DCO Scheme will be structurally assessed and refurbished or replaced if required with culverts of the same dimensions (i.e. same flow capacity, and so no increase in flood risk). Maintenance of culverts to reduce likelihood of culvert blockage by the EA, NSLIDB, NSDC, NRIL and BCC as appropriate.	Low risk of blockage of culverts (risk reduced through maintenance regime).
Colliter's Brook and Longmoor/Ashton Brook culverts	Overloading of Colliter's Brook and Longmoor/Ashton Brook results in structural failure.	Increased flood risk from Colliter's Brook and Longmoor/Ashton Brook upstream of the DCO Scheme.	The structural performance of these culverts will be assessed in the context of the proposed development, and the culverts will be improved if required to allow for any additional structural loading. Any required works (i.e. structural improvements) would be designed in consultation with the EA.	Insignificant – culverts unlikely to fail structurally after implementation of mitigation measures
Maintain access to EA and NSLIDB maintained watercourses and structures	Potential additional flood risk if maintenance of watercourses and culverts (e.g. clearing culvert blockages, clearing	Areas upstream of watercourses crossed by the DCO Scheme	The DCO Scheme has been designed in consultation with the EA and NSLIDB to ensure required maintenance access is retained.	Insignificant – maintenance access requirements will be retained.

Table 10.1. Summary of potential impacts, mitigation and residual impacts of the DCO Scheme on flood risk

Aspect	Impact	Receptors	Mitigation	Residual Impact
	channels) is not undertaken.			
Surface water management	Potential for surface water runoff rates from the DCO Scheme (railway, stations, car parks) to exceed existing rates and therefore increase surface water flood risk locally.	Areas near the DCO Scheme	The surface water drainage strategy and design for the DCO Scheme has been developed in consultation with the Environment Agency, North Somerset District Council, Bristol City Council and North Somerset Levels Internal Drainage Board, to ensure the proposed drainage of the DCO Scheme does not increase flood risk elsewhere, including with an allowance for climate change. The drainage design includes the implementation of SuDS (and maintenance of them) as appropriate.	Low risk of failure of SuDS to achieve mitigation if they are not maintained or if failure occurs between maintenance inspections.
Surface water management	Potential for change in flow paths for runoff exceeding Portishead and Pill stations and car parks drainage design capacity resulting in increased flood risk elsewhere.	Areas near Portishead and Pill stations and car parks.	Exceedance flows from Portishead and Pill stations car parks will be managed on-site up to the 100 year return period flood with climate change allowance. Portishead station drainage is designed to accept the 100 year return period flood with climate change allowance.	Insignificant – exceedance flows will be managed on-site.

Table 10.1. Summary of potential impacts, mitigation and residual impacts of the DCO Scheme on flood risk

Aspect	Impact	Receptors	Mitigation	Residual Impact
			Pill station drainage will be designed to meet Network rail design standards (Appendix O, DCO Document Reference 5.6).	
Location of maintenance compounds/facilities	Potential for flooding of maintenance compounds resulting in damage to equipment and/or mobilisation of pollutants.	Flood risk to maintenance compounds and equipment. Pollution risk to surface water, groundwater and floodplain.	All permanent maintenance compounds / facilities are outside of the coastal and fluvial floodplain except for the Clanage Road compound, which is within the tidal River Avon floodplain. A new permanent maintenance (vehicular) compound and track access point with hard standing will be required with access off Clanage Road (DCO Document Reference 2.52). This location was selected as being the only suitable site south of the Avon Gorge and close to the operational railway. However, this location lies in the floodplain, so it is not proposed to construct any buildings or use the site for long term storage of any plant or materials at this site, in order to avoid changes to flood conveyance or storage.	Low risk of flooding during temporary storage of plant or materials at the Clanage Road compound. An Outline Flood Plan for the Clanage Road compound during construction has been developed to support the DCO application (see Appendix T, DCO Document Reference 5.6).

Table 10.1. Summary of potential impacts, mitigation and residual impacts of the DCO Scheme on flood risk

Aspect	Impact	Receptors	Mitigation	Residual Impact
			An Outline Flood Plan for the Clanage Road compound during construction has been developed to support the DCO application (see Appendix T, DCO Document Reference 5.6). The Drainage Strategy covers compounds and haul roads.	
Location of temporary construction compounds/facilities	Potential for flooding of temporary construction compounds resulting in damage to equipment and/or mobilisation of pollutants	Flood risk to temporary construction compounds and equipment. Pollution risk to surface water, groundwater and floodplain.	All temporary construction compounds/facilities are outside of the coastal and fluvial floodplain except for the Clanage Road compound, which is within the tidal River Avon floodplain (FZ3b) and the compound beneath and north of Pill viaduct (FZ3a). Mitigation will include appropriate use of Environment Agency flood warning service and development of a Construction Environmental Management Plan. The drainage strategy overs compounds and haul roads.	Low risk of flooding during temporary storage of plant or materials at the Clanage Road and Pill viaduct compounds, and risk of vehicles affected by haul route flooding. These risks will be minimised through appropriate use of Environment Agency flood warning service and development of a Construction Environmental Management Plan.

Table 10.1. Summary of potential impacts, mitigation and residual impacts of the DCO Scheme on flood risk

Aspect	Impact	Receptors	Mitigation	Residual Impact
Electrical equipment: Design minimises flood risk by raising / relocating where possible.	Damage to electrical equipment prolongs service disruption after a flood.	Electrical equipment.	NR generally seeks to locate sensitive assets outside of flood risk zones where possible, and/or constructs them on elevated plinths/platforms/areas of ground to mitigate the risks of localised and/or small scale flooding from a blocked drain etc. This may also mitigate risk in terms of larger scale flooding (fluvial and/or tidal). Additional constraints related to fluvial and/or tidal flood risk will be specified for the GRIP5 design to avoid equipment in flood risk areas wherever reasonable.	Flood levels higher than vulnerable equipment result in damage to electrical equipment and prolonged service disruption after a flood.

SECTION 11

Residual risks

11.1.1 Residual risks are the remaining risks after mitigation. For the DCO Scheme, residual risks and how they will be managed are summarised in Table 11.1.

Table 11.1: Residual risks and how they will be managed

Residual risk	How managed	Future (2075 and 2115) scenarios
Breach of Sea Commissioner's bank coastal flood defence results in flooding of the DCO Scheme.	Model results indicate that a breach of the Sea Commissioner's bank coastal flood defence would not impact the DCO Scheme for the present day (2015) scenario. There is likely to be a strategic response to manage future increased coastal flood risk between Portishead and Pill (Sections 2.4.18 and 2.4.20).	The DCO Scheme is not considered to be at risk of coastal flooding for the present day (2015) scenario. The potential for a breach of coastal flood defences to impact the DCO Scheme will increase in the future due to projected sea level rise. The impacts of a breach of the Sea Commissioner's bank on the DCO Scheme would be relatively minor during the future (2115) scenario 200-year coastal event, and similar to the same event without a breach (Appendix M, DCO Document Reference 5.6).
The inland bund coastal flood defence (flood defence 23 in Appendix J, DCO Document Reference 5.6) has an unresolved structural issue. The EA requires this to be resolved before adopting and maintaining the structure.	The EA has recently agreed with a private developer actions required to resolve the structural issue with the inland flood defence bund. After these remedial works have been undertaken, the EA will adopt the defence for maintenance.	There is likely to be a strategic response to manage future increased coastal flood risk between Portishead and Pill (Sections 2.4.18 and 2.4.20). The inland bund is likely to remain a component of the strategic coastal flood risk management infrastructure in the future.
Culverts become blocked during a flood event or between maintenance inspections, resulting in	Significant culverts under the railway will continue to be managed by the EA,	Fluvial flood risk will increase for the future (2075 and 2115) scenarios due to a

Table 11.1: Residual risks and how they will be managed

Residual risk	How managed	Future (2075 and 2115) scenarios
increased flooding locally during flood event.	NSLIDB, NSDC, NRIL and BCC as appropriate.	projected increase in extreme rainfall intensity. There would be a corresponding increase in impacts (for a given return period) should a blockage occur.
Failure of SuDS between maintenance inspections results in localised surface water flooding.	Maintenance regime will allow for increased seasonal activity when the likelihood of blockage is increased.	Fluvial flood risk will increase for the future (2075 and 2115) scenarios due to a projected increase in extreme rainfall intensity. There would be a corresponding increase in impacts (for a given return period) should a blockage occur.
Risk related to maintenance compounds	All permanent maintenance compounds / facilities are outside of the coastal and fluvial floodplain except for the Clanage Road compound, which is within the tidal River Avon floodplain (Flood Zone 3b). Low risk of flooding during temporary storage of plant or materials at the Clanage Road compound. To minimise this risk, an Outline Flood Plan for Clanage Road compound during the construction phase has been developed to support the DCO application (see Appendix T, DCO Document Reference 5.6). The drainage strategy covers compounds and haul roads.	Tidal flood risk will increase for the future (2075 and 2115) scenarios due to projected sea level rise. The frequency of flooding for a given flood depth will therefore increase in the future.

Table 11.1: Residual risks and how they will be managed

Residual risk	How managed	Future (2075 and 2115) scenarios
Risk related to temporary construction compounds	All temporary construction compounds are outside of the coastal and fluvial floodplain except for the Clanage Road compound, which is within the tidal River Avon floodplain (FZ3b) and the compound beneath and north of Pill viaduct (FZ3a). Low risk of flooding during temporary storage of plant or materials at the Clanage Road and Pill viaduct compounds. This risk will be minimised through appropriate use of Environment Agency flood warning service and development of a Construction Environmental Management Plan. The drainage strategy covers compounds and haul roads.	n/a
Higher flood level than elevation of electrical equipment – results in delay in re-opening of service after flooding due to required repair of damaged electrical equipment	Network Rail's route-wide Extreme Weather Plan will identify the likelihood of occurrence of flooding on the line; will demonstrate how Network Rail will respond to and monitor flooding events; and demonstrate how the scheme will be returned to operational status following the subsidence of flooding.	Network Rail's route-wide Extreme Weather Plan will identify the likelihood of occurrence of flooding on the line; will demonstrate how Network Rail will respond to and monitor flooding events; and demonstrate how the scheme will be returned to operational status following the subsidence of flooding.

SECTION 12

Conclusions

12.1.1 This FRA has assessed flood risk to the DCO Scheme for the present day (2015) and future (2075 and 2115) scenarios. The assessment of flood risk has informed the DCO Scheme design and mitigation measures to ensure that it is safe from flooding during its lifetime (with appropriate mitigation) and does not increase flood risk elsewhere. Key flood risks have been identified and appropriate mitigations proposed. The assessment of flood risk has been informed by available information on flood risk (e.g. EA flood maps) and informed by hydraulic modelling undertaken as part of the FRA.

12.1.2 This FRA has been developed in consultation with the EA, NSLIDB, NSDC and BCC.

12.1.3 The DCO Scheme is considered to pass the NPPF Sequential Test as there are no other feasible locations for the DCO Scheme.

12.1.4 The DCO Scheme is classified as *Essential Infrastructure* for national policy on flood risk. Elements of the scheme are within Flood Zones 3a and 3b. The DCO Scheme passes both limbs of the Exception Test, as required for *Essential Infrastructure* development within Flood Zones 3a and 3b. It has wider sustainability benefits to the community. It will be safe for its lifetime, without increasing flood risk elsewhere and where possible reduce flood risk overall.

12.1.5 The lifetime of the DCO Scheme is assumed to be 60 years (2075 future scenario). Model simulations have also tested sensitivity to a 100 year future scenario (2115). Projected climate change and sea level rise during the life of the DCO Scheme are significant, with projected sea level rise of approximately 0.59 m between 1990 and 2075, and 1.14 m between 1990 and 2115, resulting in the largest impacts.

12.1.6 The DCO Scheme railway levels are generally slightly higher than existing levels, typically by between approximately 0 mm and 300 mm. However, to avoid impacts on flood risk elsewhere, existing railway levels will be retained in the River Avon tidal floodplain in the Bower Ashton area and Longmoor and Colliter's Brooks floodplain.

12.1.7 The most significant flood risk to the DCO Scheme is River Avon tidal flooding near Bower Ashton. For the present day (2015) scenario, modelling undertaken for this FRA indicates the DCO Scheme (i.e. post-development) would be flooded during tidal River Avon floods approximately once every 5 to 10 years for the current (2015) scenario. For the future (2075 and 2115) scenarios simulated flooding occurs with a higher frequency (during the 1-year return period) due to the influence of significant projected sea level rise. Whilst the simulations undertaken show the railway to be flooded at Bower Ashton during the 1 year return period River Avon tidal event in 2075, the modelling includes a combination of several conservative modelling assumptions, and so the simulation results are likely to be overestimates. The 1 year tidal flood in 2075 is therefore considered likely to have only a relatively minor impact on railway operation (short duration with River Avon levels reducing below the lowest rail level approximately 1 hour after overtopping of the railway, allowing drainage back into the river, and shallow

depth above lowest rail level) and hence only minimal disruption to the railway service. Areas at risk of tidal River Avon flooding are shown in Appendix N, DCO Document Reference 5.6 to be the Portbury Freight Line (operational railway) between the River Avon and Bower Ashton.

12.1.8 Coastal flood risk between Portishead and Pill is not significant for the present day (2015) and future (2075) scenarios, as modelling undertaken for this FRA indicates flooding of the DCO Scheme occurs less than once every 1000 years on average. Modelling indicates that for the future (2115) scenario the DCO Scheme will experience coastal flooding once every 200 to 1000 years on average.

12.1.9 Fluvial flood risk from Portbury Ditch, Drove Rhyne and Easton-in-Gordano Stream is not considered to be significant for the present day (2015) and future (2075 and 2115) scenarios.

12.1.10 For the present day (2015) scenario the DCO Scheme is outside of the Colliter's Brook and Longmoor/Ashton Brook 100-year return period flood extent, and within the 1000-year return period flood extent. For the future (2075 and 2115) scenarios the DCO Scheme is shown to be outside of the Colliter's Brook and Longmoor/Ashton Brook 50-year return period flood extent, and within the 75-year return period flood extent.

12.1.11 Portishead station and carpark are in the defended floodplain and so the impact of flooding on access and egress is considered insignificant for the present day (2015 and 2075) scenarios, for which the simulated 1000 year flood does not extend this far. For the future (2115) scenario, Portishead station and car parks, and the pedestrian crossing of Portbury Ditch (providing a pedestrian route from the station to Portishead) will be above the 200-year coastal flood level.

12.1.12 Pill station, car park and adjacent roads are several metres higher than River Avon flood levels and so access/egress is considered safe from River Avon tidal flooding.

12.1.13 The EA surface water flood map (https://flood-warning-information.service.gov.uk/long-term-flood-risk/map) indicates that there may be relatively small and localised areas in the vicinity of the DCO Scheme that could be vulnerable to surface water flooding during intense rainstorms. Surface water drainage of the railway and stations/car parks has been designed in consultation with the EA, NSLIDB, NSDC and BCC, as appropriate, to ensure the DCO Scheme does not increase surface water flood risk elsewhere. The drainage of Portishead and Pill stations and car parks includes SuDS where appropriate.

12.1.14 All loss of floodplain storage by the DCO Scheme will be fully mitigated by providing floodplain compensation storage (Section 8 and Appendix N, DCO Document Reference 5.6). The DCO Scheme design includes floodplain compensation to fully mitigate loss of Easton-in-Gordano Stream fluvial floodplain. The DCO Scheme design includes floodplain compensation within the proposed Clanage Road compound to fully mitigate displacement of floodplain storage by the Clanage Road compound vehicular access and ramp.

12.1.15 A breach of the Sea Commissioner's Bank coastal flood defence during a tidal flood event would not affect the DCO Scheme for the present day

(2015) scenario. The potential for a breach to impact the DCO Scheme increases for the future (2115) scenario, due to projected future sea level rise. The impacts of a breach of the Sea Commissioner's bank on the DCO Scheme would be relatively minor during the future (2115) scenario 200 year coastal event, and similar to the same event without a breach (Appendix M, DCO Document Reference 5.6).

12.1.16 The inland flood bund coastal flood defence (flood defence 23 in Appendix J, DCO Document Reference 5.6) provided as part of a recent residential development has an unresolved structural issue. The EA requires this to be resolved before adopting and maintaining the structure. The EA has recently agreed with a private developer actions required to resolve this structural issue. After these remedial works have been undertaken, the EA will adopt the defence for maintenance. There is likely to be a strategic response to manage future increased coastal flood risk between Portishead and Pill and the inland bund is likely to remain a component of the strategic coastal flood risk management infrastructure in the future.

12.1.17 Significant culverts under the railway will continue to be managed by the EA, NSLIDB, NSDC, NRIL and BCC as appropriate to minimise the risk of blocked culverts resulting in increased flooding locally during a flood event.

12.1.18 The DCO Scheme design has been developed in consultation with the EA, NSC, BCC and NSLIDB to ensure the DCO Scheme does not compromise required access to maintain watercourses and hydraulic structures. Network Rail will ensure that tender documents for the DCO works include a requirement not to compromise maintenance access requirements.

12.1.19 To reduce the risk of failure of SuDS between maintenance inspections, the SuDS maintenance regime will allow for increased seasonal activity when the likelihood of blockage is increased.

12.1.20 The DCO Scheme has been designed to result in no increase in flood risk elsewhere (Section 9).

12.1.21 An Outline Flood Plan (operational phase) has been developed to support the DCO application (included in Appendix T, DCO Document Reference 5.6). It provides an indication of the key issues required for consideration, and the general approach that will be taken, for flooding issues when the scheme is operational. Network Rail manages flood risk at a route level, producing Extreme Weather Plans (Network Rail Standard Maintenance Procedure NR/L3/TRK/1010) which incorporate flood responses across the route network. Once the DCO Scheme reaches the operational stage any relevant flood response issues pertaining to the line will fall under the auspices of the route-wide plan and any subsequent updates applied to it.

SECTION 13

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Divider
Appendix Title

Divider
Appendix Title