

Great Western Main Line Electrification Project

Environmental Statement Volume 2:
Appendix E – Level 2 Flood Consequences
Assessment (Scoping Study)
Severn Tunnel to Cardiff

Network Rail

February 2013

ATKINS



Plan Design Enable



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Executive summary

Site Name and Address:	Great Western Main Line- Railway sections between the Severn Tunnel (Wales) and Cardiff																																		
Grid Reference:	Severn Tunnel (ST5134987065) to Ninian Park Station, Cardiff (ST1663275975)	Size (hectares):	>1ha																																
Current Use:	<table border="1"> <tr><td>Greenfield</td><td></td></tr> <tr><td>Brownfield (disused)</td><td></td></tr> <tr><td>Industrial</td><td></td></tr> <tr><td>Commercial</td><td></td></tr> <tr><td>Landfill</td><td></td></tr> <tr><td>Rail</td><td>X</td></tr> <tr><td>Residential</td><td></td></tr> <tr><td>Other</td><td></td></tr> </table>	Greenfield		Brownfield (disused)		Industrial		Commercial		Landfill		Rail	X	Residential		Other		Proposed Use:	<table border="1"> <tr><td>Residential</td><td></td></tr> <tr><td>Commercial</td><td></td></tr> <tr><td>Industrial</td><td></td></tr> <tr><td>Hospital</td><td></td></tr> <tr><td>Educational</td><td></td></tr> <tr><td>Rail</td><td>X</td></tr> <tr><td>Landfill</td><td></td></tr> <tr><td>Other</td><td></td></tr> </table>	Residential		Commercial		Industrial		Hospital		Educational		Rail	X	Landfill		Other	
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Rail	X																																		
Landfill																																			
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Comment:	Existing railway	Comment:	Upgrade to install electricity for train power supplies																																
Flood Zone:	Various (depending on location)	Vulnerability:	Essential Infrastructure																																
Justification Test:	Alternative sites not applicable	Acceptability Criteria:	In line with sustainable development and will not lead to increased flood risk																																

Description:

Network Rail is planning to upgrade the existing railway infrastructure along the Great Western Main Line (GWML) from the Severn Tunnel to Cardiff by the addition of overhead line equipment (OLE) consisting of cables and associated electrification systems. This is an extensive project covering nearly 40km of railway route in total.

The main works will predominantly be undertaken within the existing railway footprint and will involve construction of overhead cable supporting gantries, connection of OLE and construction of electricity control / switching stations. There will also be associated storage compounds and small construction sites adjacent to the main railway line. For the cable systems, some sections of existing track may need to be lowered to give sufficient clearance beneath bridge or building structures that cannot otherwise be raised. Where possible, bridge raising (involving demolition and/or rebuilding works) is planned, whilst additions to existing bridges to improve safety (i.e. raising parapet heights) will also be planned.

This FCA covers the railway sections between The Severn Tunnel and Cardiff (just west of Ninian Park Station), involving three local authorities and several Environment Agency Wales and Internal Drainage Board (IDB) river catchments.

The main flood risks are associated with fluvial (river) and coastal systems. However, the construction designs will be of minimal impact on flood storage or flood conveyance routes within the area. Some locations will require track lowering and where these sites are located within Flood Zone 2 or 3 careful

checks will be needed to ensure new flood routes are not created or existing informal flood defence provisions are not adversely affected. Climate change factors for future river and sea levels should be included given the lifetime of the development (as it is permanent infrastructure the maximum of 100 years should be applied). Proposed switching stations and compound areas within floodplains will also need consideration for pollution prevention and flood resilience. Other forms of flood risk such as groundwater flooding are considered a low risk but some locations may be within areas of high water tables and/or superficial groundwater areas and local checks should be made to ensure ground stability is suitable for construction works. Surface water flood risks caused by the scheme are considered low as large impermeable surface areas are not being introduced, other than those within temporary storage or compound areas, but with appropriate site management and application of best practice risks of flooding or pollution from this form of flooding can be avoided. Where work is undertaken within fluvial / coastal flood risk areas, registration with the Environment Agency Flood Warning Service and preparation of a Flood Plan is advised.

The potential for the Scheme to increase any local flood risk issues is considered to be negligible and, provided best practice is applied to design and construction works, the scheme will be compliant with Planning Policy Wales with regard to flood risk.

Consultation with the Environment Agency Wales, the Lead Local Flood Authorities and the Wentlooge and Caldicot IDB is under way and will continue to verify flooding levels at any track lowering locations and to ensure appropriate Flood Defence Consent applications are prepared and obtained in advance of commencement for works in, over or near watercourses.

Glossary

ABD	Area Benefitting From Defence – areas which benefit from formal flood defences for the 1% flood event (rivers) or 0.5% event (coastal) which would otherwise flood
AEP	Annual Exceedance Probability – the probability that a flood event of a specific magnitude could occur in any one year (e.g. the 1 in 100-year event is expressed as the 1% AEP, there is a 1% chance of it occurring within any given year)
AOD	Above Ordnance Datum (in metres)
CDA	Critical Drainage Area – are known to be at risk of flooding in relation to non-fluvial sources of flooding (i.e. artificial drainage, groundwater or overland flows)
DAM	Development Advice Map – flood risk mapping provided by the Welsh Government to inform planning decisions and TAN15 assessments
Defra	Department of the Environment, Food and Rural Affairs
DG5	DG5 Register – register held by water companies on the location of properties at risk of sewerage related (foul/combined/surface water sewer) flooding problems
EAW	Environment Agency Wales
FCA	Flood Consequence Assessment
FRA	Flood Risk Assessment
GWML	Great Western Main Line
HOOB	High Output Operations Base
IDB	Internal Drainage Board
LLFA	Lead Local Flood Authority – unitary authority responsible for Flood Defence Consent and management of non-main watercourses (not under control by the Environment Agency)
OLE	Overhead Line Equipment. A steel structure with two columns, one each side of the track, supporting the overhead electrified lines for (usually) two or more tracks. Example photograph below.
PPW	Planning Policy Wales (Chapter 13: Minimising & Managing Environmental Risks and Pollution)
SFCA	Strategic Flood Consequences Assessment
SoP	Standard of Protection – degree of protection for flood defences in terms of Annual Event Probability
SuDS	Sustainable Drainage Systems – best practice drainage techniques to manage and mitigate for urban runoff with benefits for water quality, peak flow reduction and amenity enhancement
TAN15	Technical Advice Note 15: Development and Flood Risk
WG	Welsh Government

1. Introduction

1.1 Summary

- 1.1.1 Atkins was commissioned by Network Rail to undertake a series of Flood Risk / Consequence Assessments (FRAs or FCAs) for the proposed electrification of the Great Western Main Line railway (GWML) between Maidenhead and Cardiff. This includes sections of the route between Maidenhead and Reading, Reading and Swindon, Swindon to Bristol (via two routes, one passing through Chipping Sodbury and the other via Bath) and from the Severn Tunnel to Cardiff including branch routes between Didcot to Oxford and Reading to Newbury.
- 1.1.2 This FCA aims to review and identify any key flood risk issues that will need further investigation for the Severn Tunnel to Cardiff section, in compliance with Planning Policy Wales (PPW¹) and its accompanying Technical Advice Note 15: Development & Flood Risk (TAN15²).

1.2 Scope of this Report

- 1.2.1 CIRIA C624³ provides guidance on the implementation and good practice in assessing flood risks through the development process. The aim of C624 is to promote developments that are sustainable with regard to flood risk. The document recommends that a FCA should be undertaken in phases so that the type of development corresponds with the detail required. There are three levels of assessment:
- **Level 1 FCA (Screening Study):** To identify if there are any flooding issues related to a development site which may warrant further consideration. The screening study will ascertain whether a Level 2 or Level 3 FCA is required.
 - **Level 2 FCA (Scoping Study):** Undertaken if a Level 1 study indicates that the site may lie within an area which is prone to flooding or that the site may increase flood risk due to increased runoff; and to confirm the possible sources of flooding which may affect the site. The Scoping Study will identify any residual risks that cannot easily be controlled and, if necessary will recommend that a Level 3 FCA is undertaken.
 - **Level 3 FCA (Detailed Study):** Undertaken if the Level 2 study concludes that quantitative analysis is required to assess flood risk issues related to the development site. This may include detailed hydraulic modelling of rivers or drainage systems.
- 1.2.2 Initial site checks using web-based mapping sources has already identified that some sections of the railway potentially lie within fluvial Flood Zones 1, 2 or 3, with numerous crossings over both main rivers and ordinary watercourses. For flood risks to be adequately assessed, it will therefore be necessary that this report forms a **Level 2 FCA (Scoping Study)**. The assessment will review all forms of flood risk and undertake the following:
- Review all available existing information for the site;
 - Undertake liaison with the Environment Agency, Local Planning Authority and Internal Drainage Board;
 - Assessment of fluvial flood risk to the site and determination of whether the development of the site is viable;
 - Assessment of all other forms of flood risk as detailed in PPW (i.e. coastal/tidal/estuarine flooding, groundwater flooding, overland flows, drainage and artificial infrastructure flooding);

¹ Welsh Assembly Government (February 2011) Planning Policy Wales (Edition 4). Chapter 13 – Minimising and Managing Environmental Risk and Pollution.

² Welsh Assembly Government (July 2004) Planning Policy Wales: Technical Advice Note 15: Development & Flood Risk.

³ CIRIA C624 Development and Flood Risk – Guidance for the Construction Industry. London 2004.

- Assessment of the impact of flooding on a site;
- Assessment of how the layout and form of the development can be used to minimise or reduce flood risk;
- Estimates of how climate change could affect the probability and intensity of flood events with details of how the development remains safe without increasing flood risk for its design life;
- Any remaining (residual) risks to or from the site after the construction of any necessary mitigation measures and the means of managing those; and
- Consideration of the proposal relative to any existing Strategic Flood Consequence Assessment carried out by the Local Authority.

1.3 Report Structure

1.3.1 The extent of the route from the Severn Tunnel to Cardiff is covered in this report and the structure is as follows:

- Chapter 2 reviews flood risk policy;
- Chapter 3 provides an outline of the existing environment along the Scheme;
- Chapter 4 reviews the potential flood risks;
- Chapter 5 reviews potential mitigation and residual flood risks; and
- Chapter 6 provides a summary of the main recommendations and general conclusions for flood risk aspects.

1.3.2 Appendix E Figures Volume provides an overview of the areas covered between the Severn Tunnel and Cardiff (west of Ninian Park Station).

2. Policy Context

2.1 Flood Risk and Flood Probability

- 2.1.1 Flooding is a natural process that can present a range of different risks depending on its form. Flood practitioners and professionals define the risks presented by flooding according to an Annual Exceedance Probability (AEP), or as having a 'return period.'
- 2.1.2 Flood risk includes the statistical probability of an event occurring and the scale of the potential consequences. Flood risk is estimated from historical data and expressed in terms of the expected frequency of a flood of a given magnitude. The 10-Year, 50-Year and the 100-Year floods have a 10%, 2% and 1% chance of occurring in any given year, respectively. However, over a longer period the probability of flooding is considerably greater.
- 2.1.3 For example, for the 100-Year return period flood:
1. There is a 1% chance of the 100-Year flood occurring or being exceeded in any single year;
 2. A 26% chance of it occurring or being exceeded at least once in a 30-Year period; and
 3. A 51 % chance of it occurring or being exceeded at least once in a 70-Year period.
- 2.1.4 Table 2.1 below provides a summary of the relevant AEP and corresponding return period events of a particular sensitivity:

Table 2.1 - Definition of AEP and 'Return Period' Flood Events

AEP (%)	Return Period (Years)
100%	1 in 1 Year
10%	1 in 10 Years
2%	1 in 50 Years
1%	1 in 100 Years
0.5%	1 in 200 Years
0.1%	1 in 1000 Years

2.2 Planning Policy Wales (PPW)⁴

- 2.2.1 PPW sets out the Welsh Government's policies with regard to the current policy framework for effective local development and planning. Chapter 13 deals specifically with environmental risks and pollution, which includes considerations for flood risks and climate change. Flood risk, whether inland or from the sea, is a material consideration in land use and development planning. All development within a floodplain, drained via a culvert or on low-lying land near tidal water is at some risk of flooding. For most developments the risk of flooding can be mitigated but it can never be completely eliminated, especially where land is protected by flood defences. The consideration of flooding consequences is therefore also important with regard to the threat to human life and damage to property.
- 2.2.2 PPW highlights the need to reduce flood risk by avoidance of development within high risk areas, as opposed to the previous approach of flood defence and mitigation of the consequences of flooding. The guidance requires Local Planning Authorities to consider the catchment as a whole and take a strategic approach to flood risk.
- 2.2.3 PPW is supplemented by Technical Advice Notes with more specific guidance and advice as part of the planning process.

⁴ Planning Policy Wales (Edition 5, November 2012)

2.3 Technical Advice Note 15 Development and Flood Risk (2004) (TAN15)

- 2.3.1 TAN15 provides guidance to Local Planning Authorities regarding the assessment of flood risk for guiding planning decisions within Local Development Plans. Where development has to be considered within high risk areas, it outlines justification tests in order to guide decisions whether a development may proceed.
- 2.3.2 There are different requirements for site depending on the type of development being proposed and the 'zones' of flood risk into which they fall according to the following criteria⁵:
- **Zone A** – Little or no risk of fluvial or tidal flooding (equivalent of Environment Agency Flood Zone 1). Justification test is not applied;
 - **Zone B** – Areas known to have been flooded in the past evidenced by sedimentary deposits. Precautionary approach to indicate where site levels should be checked against Environment Agency extreme (0.1% annual probability) flood levels. If site levels above extreme flooding, further consideration not required;
 - **Zone C** – Areas where flooding issues should be considered as an integral part of the decision making by the application of the justification test and FCA. Based on Environment Agency extreme flood outline (0.1% annual probability or Flood Zone 2).
 - **Zone C1** – Areas at risk of flooding from fluvial or tidal sources (based on EA extreme flood outline for 0.1% annual probability event), but currently undeveloped and served by significant infrastructure, including flood defences. Development can take place subject to the application of the justification test, including review of acceptability of consequences; and
 - **Zone C2** – Areas at risk of flooding from fluvial or tidal sources (based on EA extreme flood outline for 0.1% annual probability event) and without flood defence infrastructure. Less vulnerable development should only be considered, subject to the justification test and review of acceptability of consequences. Emergency services and highly vulnerable development should not be considered.
- 2.3.3 Section 6 of TAN15 states that new development should be directed away from Zone C and towards suitable land areas within Zone A. Where development is proposed within Zone C it must meet the justification tests and, if it can be justified, must then meet the acceptability criteria detailed in Section 7 and Appendix 1 of TAN15.
- 2.3.4 Where development is within Zone C1 or C2, emergency service and highly vulnerable developments should not be considered appropriate. The area must not flood at the 1% annual (1 in 100-year) event (including climate change), have acceptable consequences of flooding in the extreme 0.1% annual (1 in 1000-year) event and must not cause flooding elsewhere.
- 2.3.5 Where present, flood defences must be shown to be structurally adequate under extreme overtopping conditions and an emergency flood plan (including flood warning system and identified evacuation routes) must be in place.
- 2.3.6 All developments, within any Zone, must give due consideration to the management of surface water, especially if it has the potential to change the natural hydrology of the catchment as a result of increased runoff from impermeable surfaces and built up areas.

⁵ Environment Agency fluvial and coastal flood risk mapping is based upon the Flood Zone criteria (Flood Zones 1, 2 or 3a and 3b) specified in Table 1 of the Technical Guidance to the National Planning Policy Framework (Communities & Local Government, March 2012), which differs slightly from the flood risk Zones (A, B or C1 and C2) specified in TAN15 (given above). Both classifications are discussed throughout this FRA as the Welsh Government Development Advice Mapping is based upon a combination of Environment Agency mapping and local information.

2.3.7 Sustainable drainage systems (SuDS) should be encouraged and used to manage surface water runoff wherever possible and there will need to be good justification for drainage systems not using SuDS for developments.

Climate Change

2.3.8 The future implications of climate change are outlined in research carried out by DEFRA. A range of recommendations have been made for precautionary approaches to development design for rainfall, river flows, wind speeds and wave heights that are applicable. This has been summarised below.

Table 2.4- Recommended National and Precautionary Sensitivity Ranges for Peak Rainfall Intensities

Parameter	1990-2025	2025-2055	2055-2085	2085-2115
Peak Rainfall Intensity	+5%	+10%	+20%	+30%
Peak River Flow	+10%	+20%	+20%	+20%
South Wales sea level rise relative to 1990 level (mm/yr)	3.5	8.0	11.5	14.5
Offshore wind speed	+5%	+5%	+10%	+10%
Extreme wave height	+5%	+5%	+10%	+10%

2.3.9 For any development, climate change (for rainfall-runoff calculations and surface water management considerations) will need to be accounted for in accordance with the planned lifetime of the constructed buildings/structures. Short duration rainfall may increase by 30% and flows by 20%, with suggestions that winters could become generally wetter and could lead to an increase in identified flood zones.

2.3.10 Climate change will need to be considered for the GWML within Wales.

2.4 Application of Flood Risk Policy

PPW

2.4.1 Chapter 13 of PPW deals with flood risk and the management of consequences of flooding and is a material consideration in land use planning whether flooding is inland or in coastal areas or whether the risk arises from floodplain areas, watercourses, culverts or low-lying ground. Regardless of any mitigation measures, flooding can never be completely scoped out.

2.4.2 Development sites should not be at risk of flooding from adjacent areas but should also not lead to flooding of these adjacent areas as a result of its construction. Where flood defences are concerned, priorities involve protecting existing developed areas rather than creating new defended areas as sustainability and long term protection is a significant concern with the implications of climate change. In general, development should be avoided in flood hazard areas and, where possible, managed retreat devised to create washlands and restore floodplains.

2.4.3 In areas where the floodplain is currently unobstructed development should be limited to essential transport and utilities infrastructure only and this should be designed to be resilient and remain operational at times of flood, result in no loss of floodplain storage, not impede flood flow routes and not increase flood risk elsewhere.

2.4.4 Development in high flood hazard areas should only be considered where:

- New development can be justified in that location, even though it may be at risk of flooding;
- The development proposal would not result in the intensification of existing development which may itself be at risk;

- New development would not increase the potential adverse impacts of a flood event

2.4.5 Surface water runoff must also be controlled as near to the source as possible, though this is not currently of concern for the GWML electrification scheme as no significant areas of impermeable ground will result from the works and sustainable drainage considerations will be limited to management of compound and storage sites and working areas.

TAN15

2.4.6 The overarching aim of TAN15 is to steer development to the lowest possible flood risk areas and, where this is not possible, the development should be justified in order for it to be located within a flood risk zone. Runoff rates (for surface water management) should be no greater than pre-development rates and developers should seek to utilise SuDS wherever local conditions allow.

2.4.7 It provides a framework within which risks arising from river, coastal flooding and runoff from developments in any location can be assessed. The precautionary framework allows flooding issues to be accorded appropriate consideration whilst recognising that development will continue to be necessary. The Welsh Government has a duty, under section 121 of the Government of Wales Act to promote sustainable development and managing flood is an important part of this and policies are designed to:

- Guide development to locations at little or no risk from river, tidal or coastal flooding or from runoff arising from development;
- Ensure Government resources for flood and coastal defence are directed at reducing risks for existing development and not to provide defences in anticipation of future development;
- Ensure that the consequences of flooding where development can be justified and the consequences are acceptable (with reference to Section 7, Appendix 1 of TAN15);
- Make provision for future changes in flood risk for climate change;
- Consider Catchment Flood Management Plans or Shoreline Management Plans to restore functionality and/or natural heritage benefits of floodplains through removal of inappropriate existing development.

2.4.8 Appendix 1 of TAN15 provides outline guidance for site-specific assessment of flood consequences. Development should be directed, where possible to areas at low risk of flooding. Where development must be within high risk areas (Zone C), only those which can be justified should be approved within such areas (with reference to Sections 6 and 7 of TAN15).

Nature of the Development

2.4.9 Particular development types are appropriate or not appropriate within certain areas, depending on the level of flood risk the development area is subject to. The precautionary framework identifies three categories of vulnerability for various development types to the impacts of flooding: Emergency Services, Highly Vulnerable Development and Less Vulnerable Development.

2.4.10 The GWML falls within the Less Vulnerable Development category which includes general industrial, employment, commercial and retail development; transport and utilities infrastructure; car parks; mineral extraction sites and associated processing facilities (excluding waste disposal sites). Less vulnerable developments are where the occupants can decide on the acceptability of flood risk.

Justification Test

2.4.11 Not all development in Wales has avoided flood risk areas associated with rivers and coastal areas, therefore some development will be vulnerable to flooding and fall within Zone C (or Flood Zones 2/3). Whilst development in flood risk areas cannot always be precluded, it is important to

justify further development to ensure appropriate planning decision and development design can be applied.

2.4.12 New development should be directed away from Zone C, preferentially to land in Zone A or otherwise Zone B where river/coastal flooding is less of a risk. Development within Zone C should not consist of Emergency Services or Highly Vulnerable development types. Development in Zones C1 and C2 should only be determined if the planning authority considers it to be justified in that location. Development, such as transport infrastructure, will only be justified if it can be demonstrated that:

- Its location in Zone C is necessary to assist or be part of a local authority regeneration initiative or a local authority strategy required to sustain an existing settlement; **or**
- Its location in Zone C is necessary to contribute to key employment objectives supported by the local authority, and other key partners to sustain an existing settlement of region;

and

- It concurs with the aims of PPW and meets the definition of previously developed land;
- The potential consequences of a flooding event for the particular type of development have been considered and in terms of the criteria contains in Sections 5 and 7 and Appendix 1, found to be acceptable.

2.4.13 In March 2011, the then Secretary of State for Transport (Philip Hammond) announced there was to be £704m investment in the GWML across England (between Maidenhead, Reading, Newbury, Oxford, Bristol) and Wales (from the Severn Tunnel to Cardiff) to extend the electrification of the system (having confirmed in November 2010 that routes between Reading, Didcot, Newbury and Oxford would be funded) to deliver better, faster and more comfortable services along this route. Electrification of the route from Cardiff to Swansea will be further reviewed for funding at a later date. The scheme will increase train speeds and significantly increase carrying capacity for passengers and is expected to become operational in 2016 to Bristol and 2017 to Cardiff. The scheme is therefore in compliance with Government-led planning objectives and will significantly improve the services for employment and public sectors across the area, whilst providing benefits of reducing the use of diesel powered trains.

2.4.14 As the GWML is already in existence, it can be loosely classified as 'previously developed land' but can also be considered as an upgrade to an existing development. As a Less Vulnerable development type, development is appropriate if resilience is appropriately designed and that the development passes the acceptability criteria assessment.

Acceptability Criteria

2.4.15 If a development proposal in Zones C1, or in C2 if defined as low vulnerability and meets the justification test, the development will need to be planned accordingly as it is possible that the area will flood. The consequences of flooding for that development must be managed to an acceptable level for the development type being proposed, including the effects on existing development.

2.4.16 Where the development is justified, appropriate mitigation measures may need to be used to ensure the development is safe and there is:

- Minimal risk to life;
- Minimal disruption to people living and working in the area;
- Minimal potential damage to property;
- Minimal impact of the proposed development on flood risk generally; and
- Minimal disruption to natural heritage.

2.4.17 Chapters 4 and 5 reviewed the potential flood risks that may affect the proposed scheme and identified if the scheme could lead to increased flood risk to others. The main concerns included

fluvial and coastal flood risk with residual / low risk considerations required for groundwater, overland, artificial drainage, reens, reservoirs and flood defence flood risks.

- 2.4.18 As the majority of the works will be carried out within the existing footprint of the GWML railway corridor, there will be minimal disturbance to adjacent land areas, structures or formal flood defences.
- 2.4.19 Where the railway is set upon raised embankments, these can often form informal flood defences. In some locations where bridge structures cannot be altered to accommodate the cabling works, track lowering will be necessary. It will be important to further review these locations where they lie within Zone B or C (or EA Flood Zones 2/3) when more detail is available about the design of the track lowering works to ensure that local flood protection or flooding routes are not altered from their existing state.
- 2.4.20 Where existing bridge structures can be altered to accommodate the new cabling infrastructure (and thus track lowering avoided), the demolition or alteration processes will, inevitably, lead to some disruption to local sites during the construction works, however, these activities will be carefully planned and appropriate consents and approvals obtained for the works, with consideration applied to sites that lie within areas at risk of fluvial or coastal flooding to ensure alternative routes are safe or can be effectively managed during times of flood. Table 4.2 presents a list of bridge alteration sites.
- 2.4.21 There are associated temporary compound sites and permanent new electricity supply infrastructure systems to be developed as part of the scheme. The location of each of these has been reviewed and further design considerations are required wherever sites are located within EA Flood Zones 2/3 (of Zones B or C) to ensure the consequences of the identified flood risks are managed, the risk of pollution or flood damage is minimised and flood resilience in design ensures that systems can remain operational during times of flood.
- 2.4.22 The electrification infrastructure itself will have a negligible impact on local flood storage or flood conveyance routes wherever the railway runs through Zones B or C as the cabling will be raised above ground level and supported by gantries spaced at between 50 and 70m. The gantry constructions have minimal size and will not significantly impede flows across floodplain areas (see photos of example structures in Appendix E Figures).
- 2.4.23 Much of the GWML runs through potential flood zones that are protected by formal flood defences. The long term management of these structures is mostly the responsibility of the Environment Agency Wales. The Severn Estuary Shoreline Management Plan has identified that the short and long term objectives for these defences is to 'hold the line' which will involve managing the potential future risks of climate change and maintaining the existing level of protection along these sections. The electrification scheme will benefit from the strategy to maintain defences, enhancing the long term sustainability of the project.
- 2.4.24 The heritage aspects of each bridge structure where alterations are necessary have also been checked and will continue to be reviewed. The integrity of adjacent land features and watercourses has been carefully reviewed and appropriate liaison in under way with various authorities such as the Environment Agency Wales, Monmouthshire County Council, Newport City Council and Cardiff City Council and the Caldicot & Wentlooge IDB with regard to the flood risk and consenting aspects that may affect the scheme. This liaison is to be developed further and continued during the detailed design stage of the scheme when more information about site-specific works becomes available.

Assessing Flooding Consequences

- 2.4.25 The first step for assessing development with regard to flood risk is to consult with the Environment Agency Wales. This has already been undertaken as part of the EIA Scoping exercise and as part of the investigations carried out for this FCA.

- 2.4.26 The mechanisms of flooding that may affect the site have been identified in the preceding chapters. There is insufficient detail available at the moment to fully assess individual locations where track lowering, compound sites or electrical infrastructure is to be constructed and the sites identified to be of flood risk concern should be further assessed during the detailed design stage and reviewed with the Environment Agency Wales and any available modelled flooding levels.
- 2.4.27 The consequences of flooding are likely to arise mainly from fluvial and coastal sources. Fluvial sources include main rivers and non-main watercourses including those maintained by the Caldicot & Wentlooge IDB. At most river crossings, the railway is raised on bridge or embankment structures and has a degree of protection from flood waters and, by default, embankments can provide local informal flood defences. Coastal flooding is a major influence on the local landscape, but the majority of the Zone C area is within Zone C1 and benefits from formal flood defences.
- 2.4.28 Previous sections have identified the need for careful consideration and planning where track lowering, siting of compounds and electrical infrastructure could be affected by coastal or fluvial flood risks and this will be key for the next stages of the scheme.
- 2.4.29 Residual risks of flood defence failure remain, in that overtopping, breach or failure can still affect their integrity and, in the event of a breach or failure can lead to rapid inundation of low-lying areas behind the defence. The GWML lies at least 1km away from the edge of the coast for the majority of the section between the Severn Tunnel and Cardiff and generally runs along the outer limits of the identified flooding areas particularly through the Caldicot Levels.
- 2.4.30 The scheme will not lead to significant changes in runoff from the existing site and compound areas will be appropriately managed for runoff and pollutants.
- 2.4.31 Liaison with Dŵr Cymru is under way to identify any buried sewer or water utilities and ensure that piling works do not impact these systems. New connections to sewers will not be necessary for this scheme.
- 2.4.32 Residual fluvial and coastal flood risks can be managed through the use of the Environment Agency's Flood Warning Services which cover the Caldicot and Wentlooge Levels sections and parts of Cardiff that are at risk of flooding. The River Taff has a lead-in warning time of up to 4 hours and coastal warnings can have longer lead-in times (using tide-table information) or shorter warning times during storms.
- 2.4.33 A Flood Plan should also be devised for the scheme to ensure the safety of construction workers and manage the safety of passengers and railway operators post-construction. Materials stored within flood risk areas should be appropriately stored and placed in a safe manner. Appropriate signs and warnings should be provided at sites and appropriate flood awareness provided to all site workers, particularly where flood warning lead-in times may be short and rapid responses or evacuations are required.
- 2.4.34 Management of flood risk for General Infrastructure should aim to manage the consequences of a 1% fluvial and a 0.5% coastal flood event. The general maximum depth of flooding recommended for this form of development would be 600mm with a maximum rate of rise of 0.3m/hour, a maximum speed of inundation of 2 hours and a maximum velocity of 0.3m/s. The speed of flooding from coastal flood defence failure that could affect works along the GWML would depend on sea level height and the location and/or extent of the failure.

2.5 Local Planning Policies

Severn Estuary Shoreline Management Plan (SMP)

- 2.5.1 The Severn Estuary SMP⁶ states that the coastal hinterland supports the cities of Cardiff, Bristol, Newport and Gloucester, with major industries such as ports, chemical works and power stations. Flood risk is more of an issue than coastal erosion, particularly when considering the implications of climate change and predicted resultant sea level rise.
- 2.5.2 The document provides information for the management of the coastal zone over the next 0-20 years, 20-50 years and 50-100 year periods for sustainable coastal defence policy development. Four main policy options are applied to SMP units: hold the line; advance the existing defence line; manage realignment; no active intervention. The policy unit areas for the GWML Wales section include four unit or theme areas: Caldicot Levels, Newport and Usk, Wentlooge, Cardiff.
- 2.5.3 For the majority of coastal sections, the future strategic option is to 'Hold the Line' for short and long term management. Some sections, along the River Usk between St Julian's and Llanhennock (upstream of the railway in Newport) and Portskewett within the Caldicot section (close to the Severn Tunnel section, just north of Sudbrook) will be subject to 'No Active Intervention' with 'Managed Retreat' along the Usk for the 50-100 year timescale.

Catchment Flood Management Plans

- 2.5.4 The Environment Agency has produced a series of Catchment Flood Management Plans (CFMPs) that outline their flood risk management roles to: provide flood mapping; inform strategic planning and development control; manage flood defence assets; maintain permissive powers of main rivers; lead in flood forecasting and incident management; raise and maintain public awareness. Each CFMP identifies key policies for current and future management of flood risk issues. The main catchments through which the Severn Tunnel to Cardiff sections of the GWML runs include: Wye & Usk, Eastern Valleys and the Taff & Ely.
- 2.5.5 Within each catchment, sub-areas are identified according to main river sub-catchments, within which specific flood risk management Policy Options are applied to describe the current flood risk and future actions required within the area.

Wye & Usk

- 2.5.6 The Wye and Usk CFMP covers an area of 5,700km² with 240,000 properties and 1,008km of main rivers⁷. Rivers within the area include the River Wye and its major tributaries the Lugg (including the Frome and Arrow), Monnow, Irfon and Ithon and the River Usk with its main tributaries the Lwyd, Olway Brook and Grwyne. Uplands catchments are steep and mountainous and are highly influential on the lower, flatter reaches of the main river systems.
- 2.5.7 From the Severn Tunnel to Newport, three main CFMP sub-areas cover the GWML route:
- Cwmbran and M4 Corridor (Policy Option 4);
 - The Levels (Policy Option 4);
 - Newport (Policy Option 5).
- 2.5.8 The two main Policy Options within these areas are as follows:
- **Policy Option 4:** Areas of low, moderate or high flood risk where flood risk is effectively managed but where further actions will be needed to keep pace with climate change. Further action to sustain the current level of flood risk will be required in the future. Action will require

⁶ Severn Estuary Coastal Group (December 2010) Severn Estuary Shoreline Management Plan Review. The Shoreline Management Plan: Part B (Main Report) – Policy Statements. Report prepared by Atkins.

⁷ Environment Agency (January 2010) Wye & Usk Catchment Flood Management Plan. Summary Report.

further appraisal for socially and environmentally sustainable and technically viable, economically justifiable options.

- **Policy Option 5:** Areas of moderate to high flood risk where further action can be taken to reduce flood risk. Those areas where the case for further action to reduce flood risk is most compelling. Further appraisal to assess social, environmental, sustainable, technically feasible and economically justifiable options.

Eastern Valleys

- 2.5.9 The Eastern Valleys CFMP area covers 490km² of South Wales, with 175,000 properties and 122km of main river⁸. The catchment is mainly rural with steep upper valleys and 15% of the area urbanised (Caerphilly, Tredegar, Ebbw Vale, Abertillery, Risca, Blackwood and parts of Newport). Rivers include the Rhymney (flowing into the Severn Estuary), Ebbw (flowing into the Usk Estuary), Sirhowy (major tributary of the Ebbw).
- 2.5.10 For the GWML, three sub-areas cover the section between Newport and Cardiff (east):
- Ebbw Corridor (Policy Option 4);
 - Wentlooge Levels (Policy Option 3);
 - Cardiff (Policy Option 5).
- 2.5.11 The three main Policy Options within these areas are as follows:
- **Policy Option 3:** Areas of low to moderate flood risk where the existing flood risk is effectively managed and where the risk of flooding is not expected to increase significantly in the future. Management will be kept under review, improvements identified and responding to information and new challenges as they emerge to ensure the best approach is taken for the long term.
 - **Policy Option 4:** Areas of low, moderate or high flood risk where flood risk is effectively managed but where further actions will be needed to keep pace with climate change. Further action to sustain the current level of flood risk will be required in the future. Action will require further appraisal for socially and environmentally sustainable and technically viable, economically justifiable options.
 - **Policy Option 5:** Areas of moderate to high flood risk where further action can be taken to reduce flood risk. Those areas where the case for further action to reduce flood risk is most compelling. Further appraisal to assess social, environmental, sustainable, technically feasible and economically justifiable options.

Taff & Ely

- 2.5.12 The Taff & Ely CFMP area covers 695km², includes 220,000 properties and 134km of main rivers including the Taff, Ely, Rhondda, Cynon and Clun⁹. For the GWML, this CFMP covers the Cardiff central and western sections within one sub-area, namely Cardiff. Policy Option 4 applies to this area (see text above for definition).
- 2.5.13 Flood risk is considered relatively low but is expected to rise significantly in the future, which presents a severe risk of harm to life and infrastructure. Flood risk management activities will need to increase to sustain the current level of risk into the future.

⁸ Environment Agency (January 2011) Eastern Valleys Catchment Flood Management Plan. Summary Report.

⁹ Environment Agency (January 2011) Taff and Ely Catchment Flood Management Plan. Summary Report.

Strategic Flood Consequences Assessments (SFCAs)

Monmouthshire SFCA

- 2.5.14 Monmouthshire County Council has prepared a Level 1 SFCA¹⁰ and the county area covers 850km² with a number of large urban areas: Monmouth, Chepstow, Abergavenny, Caldicot and Magor and Undy, most of which are at risk from fluvial flooding. The main watercourses that drain land in the east of the area include the River Wye (draining the eastern areas with tributaries including the River Monnow and River Trothy) and the River Usk (draining the west and its main tributary is the Olway Brook). Both these river systems drain into the tidal River Severn. The River Wye lies to the north of the study area and is not considered further, whilst the Usk is within the study area and flows through Newport, forming the boundary between Monmouthshire County and Newport City Councils.
- 2.5.15 The Monmouthshire area has 14km of coastline along the tidal River Severn though the risk of flooding in some areas is reduced through the protection provided by either natural or man-made defences. Some areas have experienced overland flowing and sewer flooding. Groundwater flooding is rare within the area, although the rivers are in close contact with underlying geology and groundwater sources. There are three large reservoirs at St. Pierre near Chepstow, Llandegfedd near Usk and Court Farm near Caerleon as well as smaller watercourses and other smaller water bodies.
- 2.5.16 The main flood risks for the area are linked to fluvial and tidal sources, with a lower risk from overland flows. Groundwater flooding is considered minimal and sewer flooding is restricted to urbanised areas with limited sewer capacity.

Newport SFCA

- 2.5.17 Newport City Council commissioned a Stage 1 SFCA for the district¹¹ to aid the sequential location of potential development sites away from flood risk areas and provide the Council, developers and other interested parties with general guidance of flood risk issues in the area. The main watercourses in the Borough are the River Usk and the River Ebbw.
- 2.5.18 The key flood risks identified within the Borough were fluvial and coastal/tidal flooding. Much of the risk of coastal/tidal flooding has been reduced by natural or man-made flood defences. Flooding has also been attributed to runoff following rainfall events. Groundwater flooding incidents are limited in the area, though the geology influences watercourse flow regimes. Flood risk from groundwater and overland flooding, however, is considered minimal within the area. There have been records of sewer flooding due to insufficient capacity, however, this is not considered to be a significant issue. The Monmouthshire and Brecon Canal flows through the centre of Newport City Council and there are two large reservoirs and potentially other smaller artificial water bodies in the Borough.
- 2.5.19 These flood risks are predicted to increase within the study area with the impacts of climate change.

Cardiff SFCA

- 2.5.20 Cardiff lies within the Ely, Taff and Rhymney River Catchments¹². The main flood risks for the catchment are identified as being from the Rivers Ely and Taff and from direct coastal inundation, along with tidal flooding along the lower River Rhymney in the east of the city.

¹⁰ Monmouthshire County Council (March 2009) Strategic Flood Consequence Assessment. Stage 1. Report prepared by Scott Wilson.

¹¹ URS (Scott Wilson) (August 2011) Stage 1 Strategic Flood Consequence Assessment. 47044571 – Final Report. Newport City Council.

¹² Atkins (2009) Cardiff Strategic Flood Consequences Assessment. Report on Phase 1 (Scoping Study) and Proposed Methodology for Offer of Services for Phase 2 – The Assessment. Report for Cardiff Council. Atkins (2009) Cardiff Strategic Flood Consequences Assessment. Report for Cardiff Council.

- 2.5.21 Flood defences in the Cardiff area include the Cardiff Bay Barrage and flood embankments along the Wentlooge Levels coastline. The latter are at risk of overtopping or breach and coastal erosion of salt marshes that currently protect them. Extreme events still present a residual risk for all areas. The effects of climate change are expected to make the situation worse.
- 2.5.22 Other flood risks include ordinary watercourses, culverted watercourses, sewers and surface water runoff.
- 2.5.23 There are many 'Reen' systems in the Cardiff catchment that perform a dual purpose of draining land areas during wet periods as well as storing water for irrigation during dry periods. They are artificial systems that are often regulated by sluices and are complex.

2.6 Drainage Authorities

- 2.6.1 There are three main organisations responsible for the maintenance and management of watercourses, with whom it is important to liaise with regard to flood risk as part of this scheme.
- 2.6.2 The Environment Agency – For all watercourses designated as Main River (on maps held by Defra and the Environment Agency) works in, above or near Main Rivers will require the consent of the Environment Agency either under their Byelaws or under Section 109 of the Water Resources Act 1991.
- 2.6.3 Internal Drainage Board (IDB) – Drainage dikes and reens are watercourses under direct operational control of the IDB and local maps of watercourses they manage are available from each IDB district. The IDB has permissive (not mandatory) powers to carry out maintenance and improvement works on IDB Reens. For the Severn Tunnel to Cardiff section, two main IDB areas are crossed by the railway:
- Caldicot Levels IDB – from the Severn Tunnel to Newport
 - Wentlooge IDB – from Maes Glas to Cardiff (Rhymney River)
- 2.6.4 Lead Local Flood Authority (LLFA) – For all other rivers, streams and ditches that are 'Non-main Watercourses' and those that are not Main Rivers or under the management of the local IDB, the Local or County Council will be responsible for consenting works that may affect these watercourses.

3. The Proposed Electrification Scheme

- 3.1.1 The proposed Scheme involves the electrification of the Great Western Main Line (GWML) between the Severn Tunnel in the east and Cardiff in the west.
- 3.1.2 The electrification will be undertaken on the existing route of the GWML and will not require the construction of any new railway route. The electrical power for the project from the Severn Tunnel to Cardiff would be provided from the National Grid via a feeder station at Imperial Park, Newport.
- 3.1.3 The Scheme comprises the following rail routes:
- Severn Tunnel to Newport.
- 3.1.4 The intention is that the electrified route will be operational by December 2017.
- 3.1.5 The Scheme can be summarised as including provision of the following main elements:
- OLE system and supports;
 - Bridge Works;
 - Track Works; and
 - Power Supply infrastructure.

OLE System and Supports

- 3.1.6 OLE supports are required to support the overhead electrified lines and therefore are required along the entire length of the electrified scheme. Specific details of the supports location and the techniques for which they will be constructed are not currently defined as such the general works are described as follows.
- 3.1.7 The OLE supports are generally installed approximately 50m to 66m apart; this distance can vary depending on factors such as ground conditions and the location of structures. The contact wire (the lower of the two) is normally 4.7m above track level, supported from the upper suspension wire. The height above the contact wire of the top of the support (at the support) is approximately 1.2m.
- 3.1.8 The foundations or footings for the support masts could be piled, using a range of piling techniques including percussive or drilled, or they could be formed on ground bearing concrete pads. The piled footings can be expected to be 4m to 6m in depth in general, but piling as deep as 10m may be necessary at some points where ground conditions require. The height of the mast would vary depending on the type installed at each location, but will generally be around 7m.

Bridge Works

- 3.1.9 In order to install OLE along the Scheme, there needs to be sufficient clearance above the track to provide a safe installation. This means that a significant proportion of the bridges along the route would need to be altered to achieve the necessary clearance or to overcome any safety risk posed to users of the bridge if OLE was installed without any bridge alteration.
- 3.1.10 The general types of bridge work that would be required across the Scheme are:
- Demolitions and reconstructions, either whole or partial;
 - Jacking to raise the height of a structure to increase clearance;
 - Parapet works – usually increasing the height of the parapet to ensure users of the bridge are a safe distance from live OLE; and
 - OLE attachments, such as attaching OLE supports to the underside of a bridge or tunnel, or attaching supports to a viaduct structure.

Track Works

3.1.11 The track works required would be either:

- Lowering of the track to provide the required headroom where it is considered inappropriate or impractical to change or raise the height of the structure; or
- Slewing (sideways realignment) of the track to pass under a point where the headroom is greater, such as under the centre of an arch.

Power Supply Infrastructure

3.1.12 The power for the Scheme would be provided from the national grid via a new Feeder Station at St Brides, Newport.

3.1.13 The Feeder Station work site would be approximately 71m by 12m at St Brides including access roads, parking and storage areas, and would be located within or adjacent to existing Network Rail infrastructure. The assessment of the environmental effects of the supply cable routes leading to the Feeder Stations would be undertaken by National Grid as part of their consents process and is not included within this assessment.

3.1.14 Further details of the power supply and distribution is provided in Chapter 17 of the relevant Volume 1Bs. Appendix E Figures Volume.2 provides some generic photographic representations of the overhead electrical OLE works that are being proposed.

3.2 The Severn Tunnel to Cardiff

Scope of the Flood Consequence Assessment

3.2.1 The Flood Consequence Assessment for the section of the Scheme between the Severn Tunnel and Cardiff includes the following flood risks:

- History of flooding
- Coastal, tidal and estuarine flood risk
- Fluvial flood risk
- Groundwater flood risk
- Overland and surface water flood risk
- Artificial drainage flood risk
- Infrastructure flood risk (canals, Reens reservoirs and flood defence structures)
- Climate change

3.3 Existing Environment

Site Location

3.3.1 The route from the Severn Tunnel to Newport runs west then south-west to Cardiff, running for a total of just over 41.6km.

3.3.2 The railway passes through several towns and villages including: Portskewett, Cladicot, Rogiet, Llanfihangel near Rogiet, Undy, Magor, Llandevenny, Bishton, Newport, Duffryn, Marshfield, Blacktown, Trowbridge and Cardiff.

3.3.3 Stations along the route include: Severn Tunnel Junction Station, Newport Station, Cardiff Central Station and Ninian Park Station.

3.3.4 Council areas include Monmouthshire County Council, Newport City Council and Cardiff City Council.

- 3.3.5 Drawings for the railway which identify flood zones, inland waterways, any existing structures and labelling where any changes are proposed to structures (i.e. track lowering, bridge alterations) are presented for the whole scheme in Appendix E Figures Volume.

Existing Site Features

Topography

- 3.3.6 The topography of the area is typically low-lying and flat, particularly across the Wentlooge and Caldicot Levels (typically between 6 and 10m AOD), along the coast and areas along the Usk. Steeper slopes lie at Wentwood and Llanvaches and in the upper river catchments. The Rivers Wye and Usk are low-lying channels with steep valley sides.
- 3.3.7 In some sections, the railway is raised above the surrounding ground levels, i.e. through Wentlooge Levels, and as such it may provide an informal flood defence role, though this is dependent upon the number and conveyance through the IDB and other watercourse culverts along the raised railway embankments.

Geology & Groundwater

- 3.3.8 The geology of Monmouthshire is relatively varied in the upper areas, but typically mudstone bedrock along the coastal areas, with a stratum of limestone between Caldicot and Chepstow and older mudstones between Usk, Pontypool and Cwmbiran. Whilst the upper and mid-level areas have little or no superficial deposits, the lowland river valley and coastal areas contain alluvial and river terrace deposits and tidal superficial deposits. The soils of the area are typically deep, well-drained Brown soils, with Gleys located in the coastal zones that are often waterlogged due to fluctuating groundwater levels.
- 3.3.9 The geology of the Newport area is fairly uniform and is dominated by mudstone, siltstone and sandstones, though it is permeable and rainfall can permeate through soil and enter watercourses via groundwater connections. Superficial deposits are dominated by alluvium and glacial till in the south and west. The Usk area supports alluvial and river terrace deposits. In the north-west soils are loamy, clayey soils with slightly impeded drainage, the north-east is more free-draining with slightly acid, loamy soils, whilst the Levels and the Usk floodplain are loamy, clayey soils with naturally high groundwater within alluvial deposits.

Hydrological Features

- 3.3.10 The Newport area is drained by the River Usk (draining land to the north of, and through Newport and draining into the Severn Estuary) and the River Ebbw (draining land to the west and joining the Usk in western Newport). Caldicot Levels lie east of the Usk and the Wentlooge levels lie to the west. The Severn Estuary forms the southern border, forming the Bristol Channel and is a tidally influenced system. The Monmouthshire and Brecon Canal flows through Newport. Other artificial water bodies include Pant-yr-Eos Reservoir and the Ynys-y-fro Reservoir, as well as other smaller water bodies.
- 3.3.11 The Levels are areas of low-lying, intertidal mudflats adjoining the northern bank of the Severn Estuary that have been reclaimed for agriculture. The main rivers include Chapel Reen, Monks Ditch, Flyer Pill Reen, Windmill Reen, Cold Harbour Reen (Caldicot Levels) and Broadway Reen, Sealand Reen, Rhosog Fawr Reen and Torwick Reen (Wentlooge Levels).
- 3.3.12 The Wentlooge Levels are drained by a series of reens and ditches which outfall through coastal defences, protected against tides up to an average standard of 0.5% annual (1 in 200-year) chance flood event (but varying between 2% and 0.1% levels (1 in 50-year to 1 in 1000-year) of protection). Environment Agency flood risk mapping indicates the majority of the area is at risk of flooding but benefits from the flood defences.
- 3.3.13 West Cardiff lies at the lower reaches of the River Taff, which has a catchment area of 510km² upstream of Cardiff Bay and the River Ely further west of Ninian Park Station (the latter is not

within the current study area). A number of ordinary watercourses are also present in the area, many of which are partially culverted within urbanised areas. The lowest section of the River Taff is protected from tidal surges by the Cardiff Bay Barrage which since 1999 has effectively reduced tidal flood risks across Cardiff, meaning much of the city lies within Zone A, maintaining water levels typically around 4.5mAOD.

4. Flood Consequence Assessment

- 4.1.1 Appendix E Figures Volume presents a series of maps for the GWML sections being reviewed for the proposed electrification scheme to indicate locations of flood zones, bridge and other structures and details for any specific alterations to be made to track levels or bridge structures.

History of Flooding

- 4.1.2 The Monmouthshire SFCA identified fluvial flooding associated with the River Usk and its associated tributaries. Areas of fluvial flooding include locations within Usk town, Nedern Brook, some flooding at Portskewett/Sudbrook. Surface water flooding has been recorded at Chepstow, Monmouth, Usk, Caldicot and lower lying areas of the Caldicot and Wentlooge IDB Levels. Sewer flooding was also identified in Caldicot due to undersized sewers. In September 2008, flooding was experienced across Monmouthshire after a 15 hour period of heavy rain which resulted in surface water flows and groundwater flooding that led to landslides in Buckholt and Clumin (near Monmouth) and fluvial flooding by the Rivers Monnow and Wye.
- 4.1.3 The Newport SFCA indicates flooding events associated with fluvial, tidal and surface water events occurred in Decembers 1979, 1981, 1989 and 1999, with the worst affected rivers being the Usk at Caerleon, Crindau (and Malpas Brook) and Corporation Road (docklands).
- 4.1.4 The Cardiff SFCA report identifies the Taff catchment has experienced widespread flooding on a number of occasions over the last 60 years including the 1946/7 major floods (snowmelt), December 1960, December 1979, December 1992 and October 1998 (all from heavy rainfall incidents). Within Cardiff the most notable incidents occurred in 1960 and 1979 where thousands of properties were affected and resulted in the Government spending a considerable amount of money on flood defences.
- 4.1.5 Cardiff Bay Barrage (constructed in 1999) has significantly reduced flooding frequency from tidal sources and reduced the backing up and tidelocking of rivers, though the residual risk of extreme flood events remains. Land areas to the east of the defences (Pengam Moors and Tremforfa) are still at risk of flooding if they are overtopped from the River Rhymney. Flood embankments partially protect the Wentlooge Levels but eroding shorelines and the risk of overtopping or breach could flood low lying land behind.
- 4.1.6 Tidal flooding in 1607 significantly affected land areas when the Wentlooge and Caldicot Levels were extensively flooded and resulted in significant loss of life and property. Subsequent events are thought to have occurred in 1672, 1770 and 1809.

Coastal, Tidal and Estuarine Flood Risk

- 4.1.7 Tidal flooding occurs when sea levels rise above normal tidal ranges, affecting open coast and estuarine areas and systems. These impacts can be increased through combinations of storm or tidal surges, wave action and tidelocking in river and sewer systems that cannot then discharge.
- 4.1.8 The risks of tidal and coastal flooding along this section of the GWML are extensive as the railway lies close to the southern Welsh coastline. Many areas along the route between the Severn Tunnel and Cardiff are protected by sea defences, usually raised earth embankments, but the mouth of the River Taff is protected by the Cardiff Bay Barrage. The Welsh Government flood risk mapping indicates that this section of the GWML is protected by flood defences and lies within Zone C1.
- 4.1.9 Various levels of protection from tidal flooding are provided along the coastline, ranging from none at all, up to the extreme tidal event (or 0.1% annual or 1 in 1000-year event).
- 4.1.10 Areas benefitting from defences (or ABDs) whilst protected at present may be subject to risks of defence breaching or overtopping, which can be catastrophic and can lead to rapid inundation of otherwise protected areas.

4.1.11 Tidal surge levels for the Cardiff Bay area have been estimated as follows (as modelled for the Cardiff SFCA):

Table 4.1 – Surge tidal levels for Cardiff (mAOD)

Date	Annual chance tidal event			
	20% (1 in 5-yr)	5% (1 in 20-yr)	0.5% (1 in 200-yr)	0.1% (1 in 1000-yr)
2010	No overtopping	8.43	8.73	8.99
2060	8.58	8.76	9.06	9.32

4.1.12 Further considerations for this form of flood risk will also need to include the implications of climate change and sea level rise (see the section below on Climate Change).

Fluvial (River) Flood Risk

4.1.13 Fluvial flooding is commonly caused by intense rainfall leading to flash flooding or through prolonged rainfall on saturated ground, which can arise in headwater catchments or across the whole river catchment. Structures, infrastructure failure and blockages can increase the risk of flooding.

4.1.14 Most of the works will simply involve the erection of electric cable support structures (every 50m to 66m) and OLE installation which will be located wholly within land areas owned by Network Rail and which will not be of a nature to cause fluvial flood risk concerns. Any works not within an identified Flood Zone are not considered further. Parapet additions to footbridges for pedestrian safety are not considered to present a flood risk where passage is over the railway.

4.1.15 The main considerations with regard to fluvial flood risk for the scheme will therefore be restricted to works that will involve:

- Structural alterations (i.e. bridge alteration works) or building works (i.e. proposed switching stations or distribution sites) within Flood Zones 2 or 3 that may reduce existing floodplain storage capacity;
- Structural alterations or building works at bridges that may interrupt or alter flood flow routes;
- Alterations to existing track heights for new crossing points or track lowering to allow headroom for overhead cables beneath structures – this is especially important where a rail embankment may provide an informal flood defence role;
- Storage of materials for construction and distribution in floodplain areas; and
- Works in or near a watercourse for Flood Defence Consent (FDC) considerations.

4.1.16 A series of drawings have been produced (see Appendix E Figures Volume) which depict the existing or new structures involved in the scheme, with Environment Agency Wales flood zones and inland watercourses identified. It should be noted that Environment Agency Wales flood risk mapping does not usually include specific details of flood defence structures, whether formal or informal unless more detailed or site-specific modelling has been undertaken.

4.1.17 The table below lists the locations and brief description of works that require consideration regarding fluvial flood risks (works outside such areas have been excluded). This list has also been used to consult with the Environment Agency Wales and the Lead Local Flood Authority (LLFA) including Monmouthshire, Cardiff and Newport Councils and Caldicot & Wentlooge Internal Drainage Board (IDB) in terms of flood risk concerns and to identify works that may require consenting by the Agency as the work progresses into the detailed design stage (Guide to Railway Investment Projects (GRIP) 4/5) and their consenting requirements for each location is included in the table.

4.1.18 For the column detailing EAW/LLFA consenting advice, the following descriptions apply:

- (1) Consult the Environment Agency Wales for any works in, over or under a main river in accordance with Section 109 of the Water Resources Act 1991. Flood defence consent would be required.

- (2) Consult the Environment Agency Wales for permanent or temporary works within 8 metres of the brink of a bank of a main river, or within 4 metres of the toe of a defence, in accordance with the Byelaws made under Section 34 of the Land Drainage Act 1991 [as amended]. Flood defence consent would be required.
- (3) Consult the LLFA for works in the channel of non-main watercourse that impede flow (i.e. culverts, weirs, dam or other obstruction) for works that require Land Drainage Consent from the LLFA in accordance with Section 23 of the Land Drainage Act 1991 [as amended], Floods and Water Management Act 2010. Flood defence consent would be required.
- (4) Consult the Caldicot & Wentlooge IDB for works crossing over reens and drains under their management. Flood defence consent will be required.

Table 4.2 – Severn Tunnel to Cardiff Section: River Crossings, Structures and Proposed Works

Site with potential flood risk identified	Easting Northing	Works proposed*	Watercourse (EAW Flood Zones (FZ) and Welsh Government Development Advice Map (DAM) Zones)	Council	EAW/LLFA Consenting & Comments
Sudbrook Road Level crossing	349996 187561	OLE works	EAW FZ 2/3; DAM Zone C1 Severn Tunnel	Monmouthshire	No track lowering or ground alterations
Culvert	349781 187682	OLE works	Unid. Watercourse (main river) Railway within Severn Tunnel EAW FZ 2/3; DAM Zone C1	Monmouthshire	1 + 2
Culvert	349379 187685	OLE works	Unid. Watercourse (non-main) Railway within Severn Tunnel EAW FZ 2/3; DAM Zone C1	Monmouthshire	3 + 4
Culvert	349903 187450	OLE works	Nedern Brook (main river) Railway within Severn Tunnel	Monmouthshire	1 + 2
Severn Tunnel (western mouth)	348054 187625	Reconstruction and OLE works	Railway opens into cutting EAW FZ 2/3; DAM Zone C1 along railway cutting	Monmouthshire	Works unlikely to impact flooding routes or storage
Station Road / Farm Road overbridge	347500 187603	Reconstruction and OLE works.	Railway in cutting EAW FZ 2/3 ; DAM Zone C1	Monmouthshire	Unlikely to impact flooding routes or storage
Subway (Underbridge)	346573 187556	OLE works	EAW FZ 2/3; DAM Zone C1	Monmouthshire	Unlikely to impact flooding routes or storage
Severn Tunnel Junction Station	346272 187546	OLE works	EAW FZ2/3; DAM Zone C1	Monmouthshire	Unlikely to impact flooding routes or storage
Roggiet Road overbridge	346120 187538	Reconstruction and OLE works	EAW FZ2/3; DAM Zone C1	Monmouthshire	Unlikely to impact flooding routes or storage
Culvert	345030 187496	OLE works	Unid. Non-main watercourse and Vurlong Reen EAW FZ 2/3; DAM Zone C1	Monmouthshire	3 + 4
M4 overbridge	344946 187482	OLE works	EAW FZ 2/3; DAM Zone C1	Monmouthshire	Unlikely to impact flooding routes or storage
Culvert	344141 187219	OLE works	Prat Reen (non-main watercourse) EAW FZ2/3; DAM Zone C1 to south	Monmouthshire	3 + 4
Church Road/Roberts Road overbridge	344021 187159	Track lowering, reconstruction, parapet raising and OLE works	EAW FZ1; DAM Zone A	Monmouthshire	Track lowering site within FZ1/Zone A and not of flood risk concern
Parson's Footbridge overbridge	343764 187043	Reconstruction and OLE works	EAW FZ1; DAM Zone A	Monmouthshire	Unlikely to impact flooding routes or storage
Huggets Road / The Causeway	343504 186933	Reconstruction and OLE works	EAW FZ1; DAM Zone A	Monmouthshire	Railway in cutting – caution for track lowering and opening up new flood route along railway

Site with potential flood risk identified	Easting Northing	Works proposed*	Watercourse (EAW Flood Zones (FZ) and Welsh Government Development Advice Map (DAM) Zones)	Council	EAW/LLFA Consenting & Comments
Undy Halt Footbridge	343348 186892	Reconstruction and OLE works	EAW FZ 2/3; DAM Zone C1	Monmouthshire	Unlikely to impact flooding routes or storage
Culvert	343106 186860	OLE works	Non-main watercourse EAW FZ 2/3; DAM Zone C1	Monmouthshire	3 + 4
Culvert	342910 186860	OLE works	St Bride's Brook / Mill Reen (main river) EAW FZ 2/3; DAM Zone C1	Monmouthshire	1 + 2
Culvert	342843 186865	OLE works	Non-main watercourse EAW FZ 2/3; DAM Zone C1	Monmouthshire	3 + 4
Whitewall Footbridge	342786 186865	Reconstruction and OLE works	EAW FZ 2/3; DAM Zone C1	Monmouthshire	Unlikely to impact flooding routes or storage
Magor Road overbridge	342466 186890	Track lower, parapet raising and OLE works	EAW FZ 2/3; DAM Zone C1	Monmouthshire	Unlikely to impact flooding routes or storage
Underbridge near Blue House Farm (West End)	342025 186927	OLE works	EAW FZ 2/3; DAM Zone C1	Monmouthshire	Unlikely to impact flooding routes or storage
Small pond and culverts	341713 186927	OLE works	Non-main watercourses EAW FZ 2/3; DAM Zone C1	Monmouthshire	3 + 4
B4245 (Magor Road) overbridge	341505 186970	OLE works	Non-main watercourses EAW FZ 2/3; DAM Zone C1	Monmouthshire	3
Landevenny Road overbridge	341124 187002	Reconstruction and OLE works	EAW FZ 2/3; DAM Zone C1 Flooding occurs along railway in cutting	Monmouthshire	Unlikely to impact flooding routes or storage
Steelworks Up line access railway overbridge	340581 187052	OLE works	EAW FZ 2/3; DAM Zone C1	Monmouthshire	Unlikely to impact flooding routes or storage
Various culverts	339509 187138	OLE works	Waundeiland, Wilcrick, Ridings (main river) and Village Reens EAW FZ 2/3; DAM Zone C1	Newport	1 + 2 + 3 + 4
Underbridge and level crossing	339539 187136	OLE works	EAW FZ 2/3; DAM Zone C1	Newport	Unlikely to impact flooding routes or storage
Culvert	339539 187136	OLE works	Non-main watercourse EAW FZ 2/3; DAM Zone C1	Newport	3 + 4
Pipe Llanwern Bridge and culvert	338823 187195	OLE works	EAW FZ 2/3; DAM Zone C1	Newport	Unlikely to impact flooding routes or storage
Culvert	337998 187260	OLE works	Llan Allan Winter Sewer (non-main watercourse) EAW FZ 2/3; DAM Zone C1	Newport	3 + 4
Watercourse along railway with various culvers	336733 187364	OLE works	Oxleaze Reen (non-main watercourse) EAW FZ 2/3; DAM Zone C1	Newport	3 + 4

Site with potential flood risk identified	Easting Northing	Works proposed*	Watercourse (EAW Flood Zones (FZ) and Welsh Government Development Advice Map (DAM) Zones)	Council	EAW/LLFA Consenting & Comments
Culvert	336575 187379	OLE works	Monk's Ditch (main river) EAW FZ 2/3; DAM Zone C1	Newport	1 + 2
Watercourse along railway and various culverts	336553 187384 to 334764 187529	OLE works	Non-main watercourses EAW FZ 2/3; DAM Zone C1	Newport	3 + 4
Culvert	334839 187521	OLE works	Great Spytty Reen (main river) EAW FZ 2/3; DAM Zone C1	Newport	1 + 2
Somerton Marshlands	334075 187644	OLE works	Railway adjacent to wetland area (EAW FZ1; DAM Zone A)	Newport	3
Minor watercourse along railway	333607 187682	OLE works	Non-main watercourse (EAW FZ 1; DAM Zone A)	Newport	3 + 4
Somerton Road underbridge	333362 187746	Reconstruction and OLE works	EAW FZ 1; DAM Zone A	Newport	Unlikely to impact flooding routes or storage
Subway	332582 188063	OLE works	Potential conduit for flooding EAW FZ 2/3; DAM Zone C1	Newport	Unlikely to impact flooding routes or storage
Wharf Road underbridge	332283 188189	OLE works	Potential conduit for flooding EAW FZ 2/3; DAM Zone C1	Newport	Unlikely to impact flooding routes or storage
Chepstow Road underbridge	331864 188459	Modifications and OLE works	Potential conduit for flooding EAW FZ 2/3; DAM Zone C1	Newport	Unlikely to impact flooding routes or storage
Clarence Place underbridge	331628 188566	OLE works	Potential conduit for flooding EAW FZ 2/3; DAM Zone C1	Newport	Unlikely to impact flooding routes or storage
Tregare Street underbridge	331466 188580	OLE works	Potential conduit for flooding EAW FZ 2/3; DAM Zone C1	Newport	Unlikely to impact flooding routes or storage
River Usk Viaduct	331231 188532	OLE works	Town Reach of tidal River Usk (main river) EAW FZ 2/3; DAM Zone C1	Newport	1 + 2
B4591 and A4042 underbridge	331136 188504	OLE works	EAW FZ 2/3; DAM Zone C1	Newport	Unlikely to impact flooding routes or storage
Newport Tunnel	330638 585549 to 330390 187263	OLE works	EAW FZ1; DAM Zone A	Newport	Unlikely to impact flooding routes or storage
Culvert	330280 186279	OLE works	Cefn Adda Reen (Non-main watercourse) EAW FZ1; DAM Zone A/B (unmodelled)	Newport	3 + 4
Culvert	330317	OLE works	Ebbe River (main river, tidal) Railway above EAW FZ 2/3; DAM Zone C2	Newport	1 + 2

Site with potential flood risk identified	Easting Northing	Works proposed*	Watercourse (EAW Flood Zones (FZ) and Welsh Government Development Advice Map (DAM) Zones)	Council	EAW/LLFA Consenting & Comments
Culvert	330315 185202	OLE works	Sea Wall Reen - tributary of Ebbe River (main river) EAW FZ 2/3; DAM Zone C1/2	Newport	1 + 2
Culvert	330267 184964	OLE works	Tributary of Ebbe River (main river) EAW FZ 2/3 (defended); DAM Zone C1	Newport	1 + 2
Culverts	Various locations	OLE works	Ebbe River tributaries (non-main watercourses, various culverts) EAW FZ 2/3 (defended); DAM Zone C1	Newport	3 + 4
Culvert	330190 184674	OLE works	Pont-Y-Cwch Reen - tributary of Ebbe River (main river) EAW FZ 2/3 (defended); DAM Zone C1	Newport	1 + 2
Cuckoo overbridge	330202 184674	Reconstruction and OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Newport	Unlikely to impact flooding routes or storage
Pheasant overbridge	330024 184251	Reconstruction and OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Newport	Unlikely to impact flooding routes or storage
Watercourse along railway, various culverts	Pheasant overbridge to St Brides Brook	Reconstruction and OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Newport	3 + 4
St Brides Brook underbridge	328989 183428	Reconstruction and OLE works	EAW FZ 2/3 (defended); Dam Zone C1	Newport	3 + 4
Maerdy overbridge	328596 183146	Reconstruction and OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Newport	3 + 4
Watercourse along railway with various culverts	St Brides Brook to Hawes Reen	OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Newport	3 + 4
Hawes Reen / Peterstone Road underbridge	327992 182710	Reconstruction and OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Newport	3 + 4
Summerway Reen overbridge	326983 181981	Jacking, parapet raising and OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Newport	3 + 4
Watercourse along railway with various culverts	Hawes Reen to Marshfield Road	OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Newport	3 + 4
Marshfield Road overbridge and adjacent culvert	326626 181721	Parapet raising and OLE works	Broadway Reen (main river) EAW FZ 2/3 (defended); DAM Zone C1	Newport	1 + 2
Blacktown Bridge	326265 181465	Parapet raising and OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Newport	Unlikely to impact flooding routes or storage

Site with potential flood risk identified	Easting Northing	Works proposed*	Watercourse (EAW Flood Zones (FZ) and Welsh Government Development Advice Map (DAM) Zones)	Council	EAW/LLFA Consenting & Comments
Watercourse along railway and various culverts	Marshfield Road to Green Lane	OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Newport	3 + 4
Green Lane overbridge and culvert	325530 180935	Reconstruction and OLE works	Greenlane Reen (non-main watercourse) EAW FZ 2/3 (defended); DAM Zone C1	Cardiff	3 + 4
Watercourse along railway with various culverts	Green Lane to Faendre Reen	OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Cardiff	3 + 4
Culvert and reservoir	324681 180327	OLE works	Faendre Reen / Tarwick Reen (main river) EAW FZ 2/3 (defended); DAM Zone C1	Cardiff	1 + 2
Watercourse along railway and various culverts	Faendre Reen to Trow Road	OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Cardiff	3 + 4
Trowbridge Road overbridge	323411 179404	Reconstruction and OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Cardiff	Unlikely to impact flooding routes or storage
Wentlooge Road / Skew Road overbridge	322884 179113	Demolition	EAW FZ 2/3 (defended); DAM Zone C1	Cardiff	Unlikely to impact flood routes or storage
Culvert	322577 178963	OLE works	Rhosog Fach Reen (main river) EAW FZ 2/3 (defended); DAM Zone C1	Cardiff	1 + 2
Mardy Road (B4239) overbridge	322288 178823	Reconstruction and OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Cardiff	Unlikely to impact channel, storage or flood routes
Watercourse along railway and various culverts	Trow Road to Mardy Road	OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Cardiff	3 + 4
Southern Way / East Moors Viaduct (A4232) overbridge	321379 178376	OLE works	EAW FZ 2/3 (defended); DAM Zone C1	Cardiff	Unlikely to impact flooding routes or storage
Culvert / underbridge	321265 178306	OLE works	River Rymney (main river) EAW FZ 2/3; DAM Zone C1	Cardiff	1 + 2
Culvert	320806 177887	OLE works	Pengam (main river) EAW FZ 2/3; DAM Zone C1/2	Cardiff	1 + 2
Rover Way, Pengam overbridge	320772 177839	OLE works	EAW FZ 2/3 (railway to SW is conduit for FZ 2); DAM Zone C2	Cardiff	Unlikely to impact flooding routes or storage. Consider safety during construction

Site with potential flood risk identified	Easting Northing	Works proposed*	Watercourse (EAW Flood Zones (FZ) and Welsh Government Development Advice Map (DAM) Zones)	Council	EAW/LLFA Consenting & Comments
Beresford Road overbridge	320369 177337	Reconstruction and OLE works	Railway in cutting forms conduit for flood routes. EAW FZ 2; DAM Zone C2	Cardiff	Unlikely to impact flooding routes or storage.
Adamsdown footbridge	319519 176381	Reconstruction and OLE works	EAW FZ 2; DAM Zone C2 (to south)	Cardiff	Unlikely to impact flooding routes or storage
Windsor Road overbridge	319420 176313	Reconstruction and OLE works	Railway within cutting EAW FZ 2; DAM Zone C1/2 (links between C1 and C2 either side of road bridge)	Cardiff	If construction only – no impact
Pellet Street Footbridge	318890 176071	Jacking and OLE works	EAW FZ 2; DAM Zone C1	Cardiff	1 + 2 + 3
Intersection CEJ/SWM2 (Culvert)	318721 176008	Track lower, parapet raising and OLE works	Dock Feeder (canal/non-main watercourse) EAW FZ 2; DAM Zone A	Cardiff	3 + 4
River Taff underbridge	317968 175844	OLE works	River Taff (main river) EAW FZ 2/3; DAM Zone C2	Cardiff	1 + 2
De Croche Place footbridge/Canton Loco	317243 175956	Demolition	Within EAW FZ 2/3 (defended) or DAM Zone C1 of River Taff	Cardiff	Unlikely to impact flooding routes or storage
Severn Tunnel Junction SATS	345311 187548	SATS	EAW FZ 2 & 3 / DAM Zone C1	Monmouthshire	3 + 4
Bishton ATS	339478 187157	ATS	EAW FZ 2 & 3 / DAM Zone C1	Newport	3 + 4
Gaer TSS	330280 186135	TSS	EAW FZ 1 / DAM Zone B	Newport	3 + 4
St Brides ATFS	328998 183462	ATFS	EAW FZ 2 & 3 / DAM Zone C1	Newport	3 + 4
Canton ATFS	316934 175984	ATFS	EAW FZ 2 / DAM Zone C1	Cardiff	1 + 2

* All sections of railway will be subject to OLE construction works.

- 4.1.19 Monmouthshire SFCA identified that the River Monnow and Wye flooded after a heavy rainfall event in September 2008, with surface and groundwater flows resulting in landslides in Buckholt and Clumin (near Monmouth). Tidelocking can affect how effectively watercourses release water into coastal or estuarine systems. Where flows are held back by prolonged high tides or storm conditions river water can back up and flood upstream areas. This problem may increase with climate change and sea level rise. The Wye and Usk and other smaller watercourses across the Caldicot Levels have the potential for this type of flooding to occur, but levels can be managed to some extent by the Environment Agency Wales and/or the IDB. Nedern Brook has been known to flood in the past, affecting local development plans.
- 4.1.20 Within the Newport City area, fluvial (and tidal) flooding is associated with the River Usk and River Ebbw corridors, as well as the Caldicot and Wentlooge Levels (Newport Stage 1 SFCA). Most of the GWML section within the Newport City area is within DAM Flood Zones C1 / EA Flood Zone 3 (defended), with a short section west of Newport in Zone C2 (associated with the lower Ebbw), and short sections within Zones A and B to the north-west of Newport.
- 4.1.21 Fluvial flooding from the River Taff is considered to be a low risk and the Dock Feeder (flowing from an off take from the River Taff at Blackweir) is the only significant ordinary watercourse between the River Taff and the Rhymney River (Cardiff SFCA). The only area at risk of flooding from this is to the north of the railway, where land levels are lowest.
- 4.1.22 Many underbridges or underpasses form flood conduit routes for tidal and fluvial flooding and bridge jacking, reconstruction or other bridge alteration works should ensure the new structures do not adversely affect the through-flow nature beneath the railway line.
- 4.1.23 For overbridges, parapet additions are generally not considered to present an increase to local flood risks. Reconstruction works should also not affect local flood risks if original bridge dimensions are retained. Where the overbridge cannot be altered to allow clearance, track lowering will be proposed. Initial discussions and contact has been made with the Environment Agency, Cardiff, Newport and Monmouthshire Councils (LLFAs) and the Caldicot and Wentlooge IDB.
- 4.1.24 Initial comments received back thus far were that there are generally no significant flood risk concerns about the proposed electrification scheme but that further considerations will be necessary wherever track lowering occurs and where Flood Defence Consents (FDCs) will be required. Any scheme elements that have the potential to increase flood risk, such as track lowering within or adjacent to identified Flood Zones 2 or 3 will require a Level 3 Flood Consequence Assessment to check proposed ground level changes against local modelled flood levels (where available) to ensure new flood routes are not created or existing flood pathways altered (i.e. for the Intersection CEJ/SWM2 culvert – see Table 4.2 above).
- 4.1.25 The Environment Agency Wales will require FDC for any works over or within 8m of the main rivers. Works in, near or over non-main watercourses (under Unitary Authority management) will generally only need consenting if the works result in flow obstruction or channel alterations, which for the proposed scheme would be unlikely. The Caldicot & Wentlooge IDB has also indicated that FDCs will be required for all watercourse crossings over reens and drains within their management and that the scheme should be discussed further to ensure all crossings are identified.
- 4.1.26 The locations of some of the compounds and switching stations (see Table 4.3 below) lie within EAW Flood Zones 2/3² or DAM Zones C1 and further consideration for these sites is required during the detailed design stages to identify ground levels, flooding levels and design temporary or permanent sites with appropriate flood resilience. Sites within areas protected by flood defences may be less important for such considerations but should be further reviewed nonetheless as breach, overtopping or failure cannot be totally ruled out.

Table 4.3 – Severn Tunnel to Cardiff Section: Potential compound sites and distribution sites.

Site	Easting Northing	Area (m ²)	EA Flood Zone / DAM Zone	Council
Potential Compound Sites				
Farm Road Bridge	346327 187579	2161	3 / C1	Monmouthshire
Roberts Road Bridge	344038 187182	173	1 / A	Monmouthshire
Parson's Footbridge	343741 187008	1386	1 / A	Monmouthshire
Hugget's Road	343544 186920	297	1 / A	Monmouthshire
Undyhalt Footbridge	343365 186868	622	1, 2 & 3 / A & C1	Monmouthshire
Whitewall Footbridge	342808 186840	771	3 / C1	Monmouthshire
Llandeenny Road	341192 187017	367	1 & 3 / A & C2	Monmouthshire
Somerton Road Bridge	333300 187735	668	1 & 2 / C1	Newport
Chepstow Road	331663 188648	N/A	1 / A	Newport
Newport Station Footbridge	330890 188339	N/A	1 / A	Newport
Bridge Street	330659 188102	449	1 / A	Newport
Cardiff Road	330302 186691	N/A	1 / A	Newport
Lime Kiln	330332 185905	569	1 / A	Newport
Cwcw (Cuckoo)	330189 184680	N/A	3 / C1	Newport
Pheasant	330068 184299	375	3 (defended) / C1	Newport
Maerdy Road	328648 183159	277	3 (defended) / C1	Newport
Hawse Lane	327999 182685	572	3 (defended) / C1	Newport
Summerway	326699 181816	1353	3 (defended) / C1	Newport
Green Lane	325650 180989	387	3 (defended) / C1	Newport
Trow Road	325385 179366	404	3 (defended) / C1	Newport
Wentlooge Road	322901 179137	583	3 (defended) / C1	Newport
Mardy Road	322257 178778	1387	3 (defended) / C1	Cardiff
Beresford Road	320391 177322	752	1 / & 2 / A & C2 (floods along railway)	Cardiff
Roath Road / Splott Road	319951 176748	683	1 & 2 / A & C2 (floods along railway)	Cardiff
Canton Loco	317231 175988	N/A	3 / C1	Cardiff
Distribution Sites				
Severn Tunnel Junction SATS	345311 187548	N/A	2 & 3 / C1	Monmouthshire
Bishton ATS	339478 187157	N/A	2 & 3 / C1	Newport
Gaer TSS	330280 186135	N/A	1 / B	Newport
St Brides ATFS	328998 183462	N/A	2 & 3 / C1	Newport
Canton	316934 175984	N/A	2 / C1	Cardiff

Groundwater Flood Risk

- 4.1.27 The Severn Tunnel is subject of continuous pumping and regular maintenance activities since its construction in the 1870s, when The Great Spring was discovered which filled the partially constructed tunnel with water up to river level¹³. The spring was sealed off with a giant headwall in 1881 and 50 million litres of water per day is now pumped out and released into the Severn Estuary¹⁴. The failure of the spring headwalls and pumping systems will remain a residual risk for the Severn Tunnel but maintenance is regularly carried out as the tunnel is usually shut on Sundays.
- 4.1.28 Monmouth SFCA identified that the coastal areas are prone to waterlogging caused by groundwater, but across the rest of the county groundwater rise and fall is very slow and confined to localised areas within Monmouth.
- 4.1.29 Groundwater levels within Newport are thought to rise and fall slowly and are not a significant risk within the City. The local geology (mudstone, siltstone and sandstone) is not believed to yield significant quantities of groundwater and this is not considered to be a major risk in the area

¹³ <http://www.severnsideforum.co.uk/severn%20tunnel.htm>

¹⁴ <http://www.greatwestern.org.uk/severn9.htm>

(Newport Stage 1 SFCA). The majority of the bedrock is classified as Secondary B Aquifer, with predominantly low permeability.

- 4.1.30 The Cardiff SFCA indicates that this flood risk is considered low within the Taff and Ely CFMP, though there may be evidence for high groundwater levels at Trowbridge Mawr, north of the railway line but site-specific FCAs should still review this aspect.
- 4.1.31 A small section of the railway through Undy lies above bedrock that forms a Principal Aquifer, bedrock with a high level of water storage that may supply baseflow to rivers or be used for public supplies. The majority of the railway between the Severn Tunnel and Cardiff lies above bedrock that forms a Secondary B aquifer, which is of low permeability and less likely to link to superficial sediment layers and cause groundwater flooding in the area. Bedrock aquifers are less of a flood risk unless deep excavations are being planned.
- 4.1.32 Superficial aquifers can cause localised flooding in shallow excavations and where piling works intercept local flow pathways. The Severn Tunnel to Newport section has patchy Secondary A aquifers at Caldicot, Undy and Magor that may be fluvially linked. From Newport to Cardiff, much of the railway section is underlain by Secondary (undifferentiated) aquifer material and some Secondary A materials mostly made up of alluvial deposits and glacial till, often with clayey content that are poorly draining.
- 4.1.33 The risk of groundwater flooding is considered to be low for the over-ground sections of the GWML and can therefore be scoped out. The residual risk of flooding in the Severn Tunnel, however, remains. Should the scheme require significant excavation works then local assessments of groundwater should be carried out to check for groundwater influences and ensure appropriate piling techniques are used to minimise groundwater seepage impacts on ground stability. Provided appropriate pre-construction assessments are made where groundwater may be impacted by excavation or piling works and appropriate construction methods applied accordingly, the risk of groundwater flooding will be minimised and could be scoped out.

Overland Flow & Surface Water Flood Risk

- 4.1.34 This form of flood risk is governed by factors such as land use, topography, soil type, geology and rainfall amounts. It is typically generated by short duration, intense rainfall events where precipitation exceeds infiltration rates or local drainage systems and water consequently transfers overland and causes local flooding.
- 4.1.35 Within Monmouthshire, overland flooding affects land areas in the steeper upper catchments and urban areas. Identified surface water flooding has affected Chepstow (sewer capacity), Monmouth, Usk, Caldicot (Castle Lea area) and low-lying areas of the Caldicot and Wentlooge IDB areas.
- 4.1.36 Within the Newport City Council area, surface water problems were located in Ringland, Crindau, Rogerstone, Caldicot and Wentlooge Levels (tidelocking) and Lliswerry (Lliswerry Pill and Coronation Park).
- 4.1.37 The route crossing the Wentlooge Levels may be at high risk of surface water flooding at the outflow from Faendre Reen lake and south of Trowbridge and the other sections are at medium or low risk of overland flooding (Cardiff SFCA).
- 4.1.38 Western Cardiff is generally at high risk of overland flows due to its urbanised nature, but insufficient detail was available for an accurate assessment of this form of flood risk across the area and is considered conservative. However, the principles of urban drainage and flood risks apply to the area.
- 4.1.39 The main sections of the GWML at risk of this form of flooding are those sections within cuttings or within underground tunnels. Only two tunnels are present along this section of the GWML: the Severn Tunnel and the Newport Tunnel. Sections in cuttings are located at the mouth ends of the Severn and Newport Tunnels and short sections along the railway at Gwndy/Undy,

Llandeenny, Somerton and Newport. The vast majority of the GWML along this section is at or above ground level, generally raised on ballast materials that would reduce the risk of overland flows affecting the line.

Artificial Drainage Flood Risk

- 4.1.40 Sewer flooding can occur as a result of blockages, insufficient capacity and through structural failures. Most development drainage is designed to manage a 3.33% (or 1 in 30-year) event and rainfall that exceeds this will overload sewer systems. Coupled with increased rainfall intensities predicted for climate change, sewer flooding is a potentially significant future flood risk to consider.
- 4.1.41 Within Monmouthshire, urbanised areas (i.e. Caldicot and Chepstow) have experienced sewer flooding, and such events are expected to increase where increased rainfall in combined or surface water sewers can exceed their carrying capacity, particularly where these systems are already at their limits. Flooding tends to be very localised and is generally not of concern for the GWML. Ground areas between Portskewett and Caldicot lie within the inner catchment of a source protection zone, linked to the limestone bedrock, therefore drainage design within this area should consider pollutant pathways.
- 4.1.42 Newport City has various records of sewer flooding across Newport but it is not considered to be a significant problem in the Borough as they tend to be localised, caused by ponding, blockages or capacity issues, or occasionally through tidelocking (affecting the Caldicot and Wentlooge Levels).
- 4.1.43 Cardiff SFCA identifies that Cardiff has both separate and combined foul and surface water drainage systems, but there is uncertainty about their nature in some locations. The DG5 sewer records were reviewed and screened for hydraulic overloading incidents. A 1 in 60-year rainfall event occurred across Cardiff in July 2001 and led to many combined sewer flooding incidents across many areas of the city due to capacity overloading.
- 4.1.44 It is not intended that the proposed development will create any additional surface water or foul water drainage that will need to go to sewer. Liaison should be undertaken with Welsh Water to ensure that works are not likely to damage existing buried sewer infrastructure or affect co-joined drainage systems linked to the railway drainage facilities. If this is done, this form of flood risk can be removed.

Infrastructure Flood Risk

Canals

- 4.1.45 The Monmouthshire and Brecon Canal flows through Newport City Council area and is managed by the Canal and River Trust (Newport Stage 1 SFCA). It flows in two sections, one flowing north-south from Cwmbran and through Malpas (joining Malpas Brook) and the second from Risca (to the north-west) through Rogerstone and also joins Maplas Brook. It is managed using control gates, sluices and weirs to reduce flooding. The Newport SFCA indicates that there have been no recorded overtopping incidents or breaches along this system, however, the residual risk of failure always remains.
- 4.1.46 At its closest point to the GWML, the canal lies 0.7km to the north, from a point just to the east of Newport Station. The risk of flooding from the canal is considered very low, plus water would be intercepted by Malpas Brook and ground levels are higher than the canal towards the railway hence canal flooding would be unlikely to affect the GWML. Flood risk from the Monmouthshire and Brecon Canal can be scoped out from further assessment at detailed design stage.

Reens

- 4.1.47 Wentlooge Levels are maintained artificially by a system of reens and ditches. There is always a residual risk that there will be flooding due to tidelocking, reduced conveyance, blockages and

extreme rainfall events. A 0.1% (1 in 1000-year) rainfall event and subsequent drainage would lead to flooding levels of 4.71 mAOD, which would lead to flooding across a large proportion of the area on both sides of the railway that lie below this level, whilst the railway itself is generally at ground level or on slightly raised embankments and it may be at risk of local flooding due to drain and re-en flooding incidents.

- 4.1.48 Any track lowering within these areas must be avoided (to prevent an increase in flood risk to the railway or creation of new hydraulic links to adjacent areas) and existing railway levels should be maintained. Should any track raising or alterations to watercourses be necessary it must be discussed with the IDB at design stage to ensure there are no impacts on existing flood routes, flood storage or creation of new flood risks. Any works above or near to IDB-managed watercourses will also require consent and early dialogue is recommended with the IDB to clarify and finalise the exact nature of works.

Reservoirs

- 4.1.49 Reservoirs that are greater than 25,000m³ in volume fall within the Reservoirs Act 1975 and are subject to rigorous inspections and design standards with which owners must comply. The Environment Agency Wales ensures inspections are carried out and have also prepared flood risk mapping related to breach or failure of these systems. There are plans to reduce the regulated volume to 10,000m³ but at present, those with a volume less than 25,000m³ are maintained according to the owners or managers of the site.
- 4.1.50 Within Monmouthshire, the Environment Agency Wales flood risk mapping indicates that the Scheme within the Caldicot area is potentially at risk from flooding by a range of reservoirs located in the very upper reaches of the catchment and lower down the river valleys including:
- St Pierre Lake (ST 513 904) – capacity 26,000m³, impounded
- 4.1.51 Wentwood Reservoir (ST 429 928); Within Newport, Environment Agency Wales flood risk mapping indicates that there are a number of reservoirs which are a potential flood risk to the Scheme and these include:
- Usk Reservoir (283318 228814)
 - Talybont Reservoir (310530 220513)
 - Llandegfedd Reservoir (332538 198537)
 - Gwastad Mawr Flood Storage Area (ST 302 894)
- 4.1.52 Environment Agency Wales flood risk mapping indicates that land to the south-east of Newport is at risk of flooding from Uskmouth Lagoons (Gwent Levels Wetlands Reserve at 333480 183016) and Sloblands Lagoons (333804 184688). The lower Ebbw River is at risk from Tredgar House Lake (329057 185296) and Blaen-y-cwm Reservoir (317349 212735).
- 4.1.53 These pools all lie to the north of the GWML and breached waters are likely to be intercepted by watercourses or would be unable to reach the railway due to topography. The main point of impact would be when they reach the River Usk, however the crossing in Newport is substantially sized and unlikely to be affected by such events.
- 4.1.54 Towards Cardiff, the Faendre Reen feeds into a large lake (at ST246 804) near Pilldu and Llaneanwg (St Mellons) and lies close to the northern side of the GWML, before outflowing into Torwick Reen. Lake levels are artificially maintained by a weir and there is a residual risk of weir failure that could result in damage to the railway crossing immediately downstream.
- 4.1.55 Environment Agency Wales flood risk mapping indicates that areas along the Cardiff section of the GWML are subject to potential flooding by Llanishen Reservoir (318660 181457) and Roath Park Lake (318530 179273), Lisvane Lake (319166 182165), Pontsticill (Taf Fechan) (306094 211756), Beacons Reservoir (298805 218247), Cantref (299686 215358), Llwyn-On Reservoir (301097 211325) and Lluest-Wen Reservoir (295033 201528). Impacts from upstream reservoirs are transferred by the River Taff and Rhydney River.

- 4.1.56 The management and maintenance of these reservoirs are not within the remit of Network Rail, the larger reservoirs are governed by the Reservoirs Act 1975 and the Environment Agency Wales ensure that owners comply with specific inspections and maintenance to prevent and avoid catastrophic failures. Smaller reservoirs may not be so rigorously maintained, however, it is outside the remit of this scheme to address reservoir maintenance issues. This form of flood risk will be retained simply as a residual flood risk to highlight the fact that the main rivers are potential conduits that will intercept reservoir flood water. The main consequences associated with reservoir failure are rapid flow increases. Potential locations affected are at Caldicot (above the Severn Tunnel), central Newport (River Usk), Duffryn (Percoed Reen and associated drains) and Cardiff (River Rhymney and tributaries and the River Taf). . Provided reservoirs are maintained by their owners, this form of flood risk could be considered a low risk and could be scoped out. Design considerations for this scheme, however, would be to ensure that any railway structures, existing or future, are of sufficient robustness and integrity to withstand a catastrophic reservoir failure (in the unlikely event that this should occur) and would be resilient to subsequent high flow conditions. It is therefore important to maintain and provide a good level of structural integrity of railway infrastructure which crosses watercourses that could act as conduit for breached reservoir water as well as being resilient to natural fluvial flooding pressures.

Flood Defence Structures

- 4.1.57 Most flood defences are man-made (walls, embankments) systems adjacent to the coastline or along a river system that protects land behind. Alternatively, land areas have been designed as storage areas to relieve flooding. These systems do not remove the flood risk and there is always a residual risk of overtopping, breach or failure.
- 4.1.58 The Monmouthshire Stage 1 SFCA identified that there are limited inland flood defences in the area, mainly fluvial defences in Monmouth and Usk consisting of man-made raised banks or walls. Protection is typically up to the 1% AEP event and significant areas of Usk, Chepstow and Monmouth are classified as Zone C1. Maintenance is generally the responsibility of the Environment Agency Wales with IDB maintenance works confined to the channels including weed clearance and mowing works. Railways and roads also provide informal flood defences that may not be maintained as such but offer some protection to local areas. Along the coastal areas, there are defences along the majority of the Monmouthshire coastline and in Chepstow which consist primarily of earth embankments and concrete walls. These structures typically provide protection up to the 0.5% AEP event (or 1 in 200 year return period).
- 4.1.59 The Newport Stage 1 SFCA stated that many flood defences are located through Newport to protect the city against both fluvial and tidal flooding from the River Usk. There are also flood defences along the coastal frontage of Caldicot and Wentlooge Levels which are generally constructed of earth embankments. Typical standards of protection are for the 1% annual probability (1 in 100-year) event. Railways and major roads may also provide informal flood defence structures that are not necessarily maintained as flood management infrastructure. Flood storage is also in operation on the Malpas Brook, upstream of the M4 motorway that helps to reduce flood risk within Newport City centre.
- 4.1.60 The Cardiff SFCA indicates the Cardiff Bay Barrage (constructed in 1999) has significantly reduced flooding frequency from tidal sources and reduced the backing up and tidelocking of rivers, though the residual risk of extreme flood events remains. Land areas to the east of the defences (Pengam Moors and Tremforfa) are still at risk of flooding from the River Rhymney.
- 4.1.61 The Wentlooge Levels are partially protected by defence embankments along the coastline and although improvements have been made in recent years, the floodplain remains susceptible to wave and tidal sources. Tidal action along the coast is substantial and is eroding the existing salt marshes that protect the shoreline and overtopping or breaching of the defences could lead to flooding of low lying ground behind. The weakest section is identified adjacent to the outflow of Torwick Reen, near Sluice Farm due to a lower embankment crest level and overtopping/ breaching would currently occur during a 2% (1 in 50-year) event and with climate change the

risk would increase to a 20% (1 in 5-year) event. Flooding both north and south of the railway line close to the Cardiff-Newport Council boundaries is expected during a breach.

- 4.1.62 Defences along the River Rhymney were not designed as formal flood defences and they are not maintained by the Environment Agency Wales, therefore their level of protection cannot be guaranteed. By 2060 it is anticipated that the tidal reaches of the river will be overtopped and that breach failure could occur at Cardiff Flats during an extreme (1% or 1 in 1000-yr event) tidal event but further assessment of topographical levels would be needed to fully assess the consequences. Whilst it does not apply to the current electrification scheme, future planning for the GWML should include reviews of potential future flooding implications in relation to EA-owned and non-EA-owned flood defences to ensure the railway will remain operational when climate change impacts take effect.
- 4.1.63 Informal flood defences are also located along various sections of the railway where it has been built upon raised embankments. The railway embankments were not built to a particular design standard based on modern flood modelling requirements. Although most of the proposed electrification works will not alter existing track levels, any track lowering works should be checked as part of a Level 3 Flood Consequence Assessment for their proximity to Zones B or C / EA Flood Zones 2 or 3, as they may provide some protection to adjacent land. The level of protection will also be limited if there are culverts running through the embankment, which is highly likely through the Wentlooge Levels area.
- 4.1.64 The Welsh Government flood mapping indicates that the GWML along the Severn Tunnel to Cardiff section lies within Zone C2 (see figures below) indicating that the coastal areas are at risk of coastal flooding but that the area is served by significant infrastructure such as flood defences.

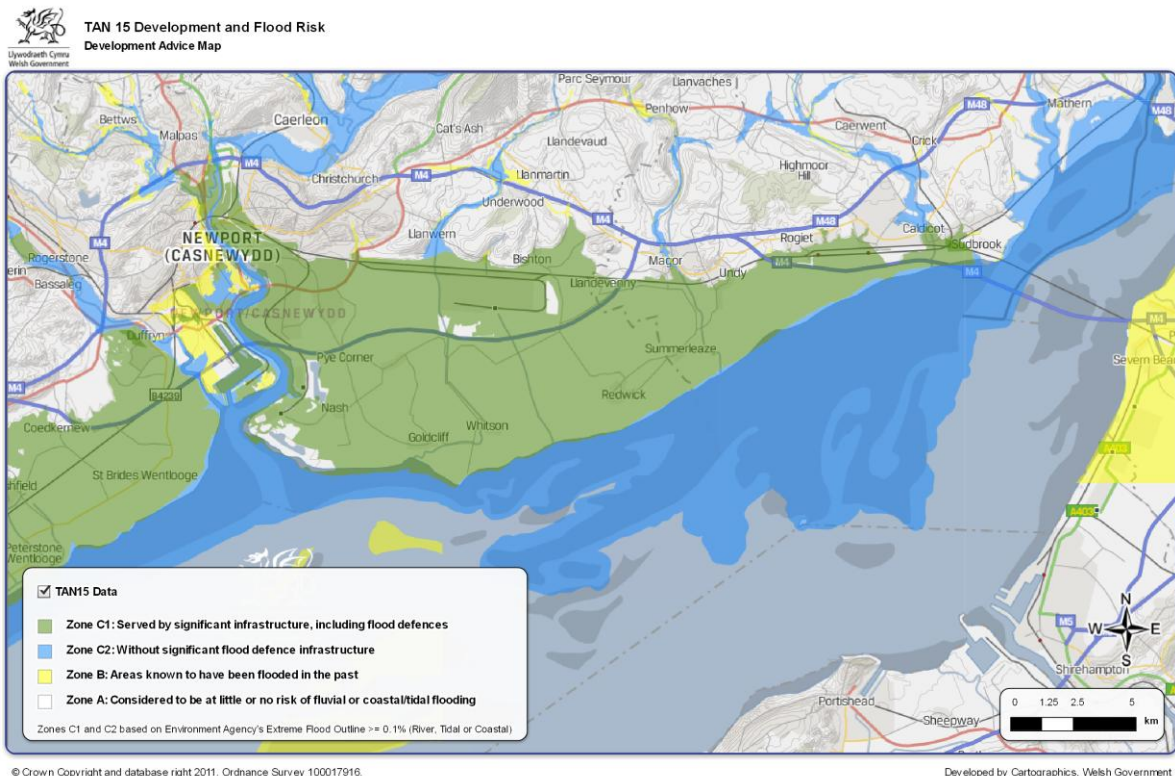


Figure 1. Welsh Government flood risk mapping from the Severn Tunnel (east) to Newport (west)

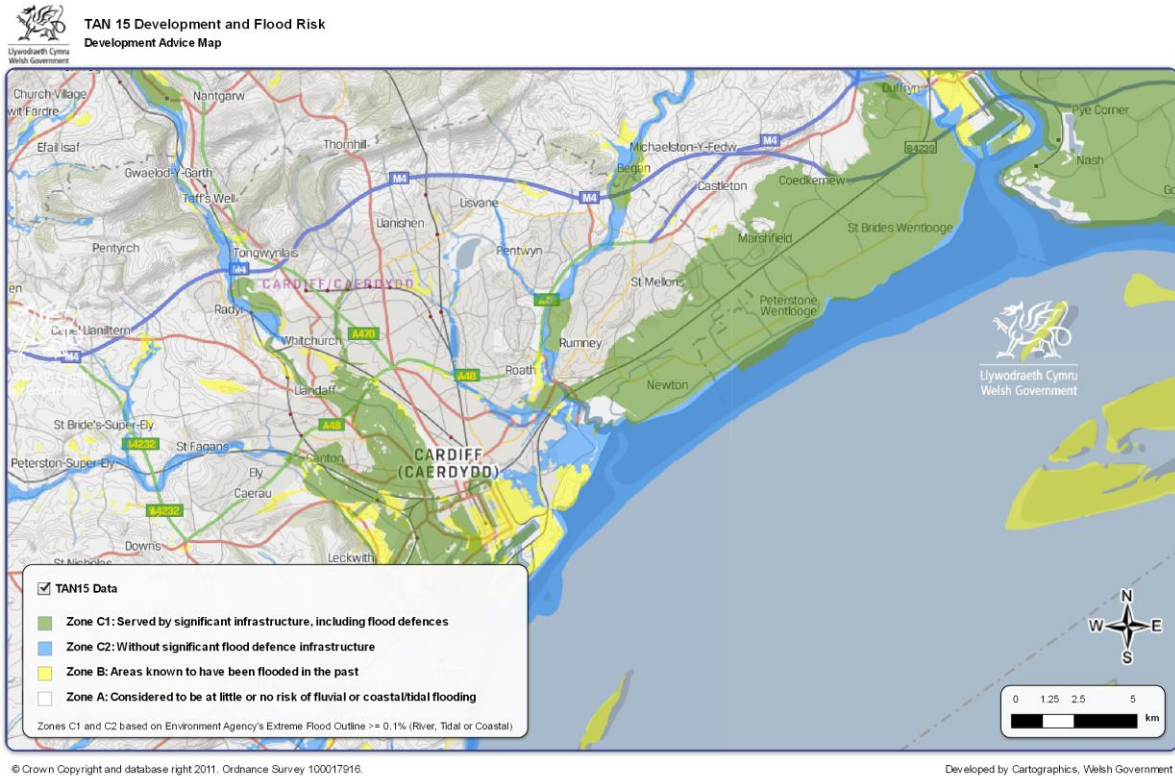


Figure 2. Welsh Government flood risk mapping for the Newport (north-east) to Cardiff (south-west) section

4.1.65 The Severn Shoreline Management Plan indicates that most of the coastal flood defences will be maintained in the near and long term future. Whether informal or formal, the proposed electrification scheme design should consider the potential impacts upon and from flood defences that protect land areas along the route of the railway, especially where track lowering may be proposed. Despite the presence of defences, a residual risk of breaching, overtopping or failure cannot be discounted.

Culverted Watercourses

4.1.66 The majority of watercourses within the area remain in open channel and no particular risks were identified. Residual risks remain that shorter culvert sections could become blocked and lead to backing up and overtopping along upstream reaches. Fly-tipping is noted to be a problem in the catchment and conveyance is dependent upon regular inspections and clearance work where this occurs. Within any urban area, culverted watercourses are common and can lead to localised flooding during heavy rainfall and high river level events.

Climate Change

4.1.67 The future implications of climate change are outlined in research carried out by DEFRA. A range of recommendations have been made for precautionary approaches to development design for rainfall, river flows, wind speeds and wave heights that are applicable. This has been summarised below.

Table 4.4- Recommended National and Precautionary Sensitivity Ranges for Peak Rainfall Intensities

Parameter	1990-2025	2025-2055	2055-2085	2085-2115
Peak Rainfall Intensity	+5%	+10%	+20%	+30%
Peak River Flow	+10%	+20%	+20%	+20%

Parameter	1990-2025	2025-2055	2055-2085	2085-2115
South Wales sea level rise relative to 1990 level (mm/yr)	3.5	8.0	11.5	14.5
Offshore wind speed	+5%	+5%	+10%	+10%
Extreme wave height	+5%	+5%	+10%	+10%

- 4.1.68 For any development, climate change (for rainfall-runoff calculations and surface water management considerations) will need to be accounted for in accordance with the planned lifetime of the constructed buildings/structures. Short duration rainfall may increase by 30% and flows by 20%, with suggestions that winters could become generally wetter and could lead to an increase in identified flood zones.
- 4.1.69 The Monmouthshire SFCA suggests milder wetter winters with long rainfall events will occur, with high intensity, short-duration rainfall and longer drier summers, which will influence fluvial, surface water and sewer systems as well as increasing the likelihood of tidal waters flooding low-lying areas. Peak river flows are expected to increase by 20% over the next 50-100 years and floor levels should be set 600mm above the 1% AEP flood levels plus 150mm freeboard. In locations where flood extent mapping does not include climate change it is advised that Flood Zone 2 should be treated as Flood Zone 3 when considering climate change. For minor catchments (<3km²) where flood modelling is not available, a 20m buffer either side of the channel should be allowed, unless site-specific modelling is required.
- 4.1.70 The Newport SFCA indicates that climate change will bring milder wetter winters with long periods of rainfall and longer, drier summers with short duration, frequent high intensity rainfall events. Following Defra guidance, peak river flows will increase by 20% over the next 50-100 years and that finished floor levels should be 600mm above the 1% flood outline levels, with a further 150mm freeboard, though this should be supplemented by hydraulic modelling where possible. Where Environment Agency mapping is used, it is recommended that Flood Zone 2 should be treated as being Flood Zone 3, unless site-specific modelling is undertaken. Where flood mapping is not available (i.e. non-main watercourses and small catchment tributaries) a 20m buffer either side of the channel should be designated as Flood Zone 3.
- 4.1.71 The Cardiff SFCA indicated that the 2007 report on climate change published by the IPCC emphasizes the certainty for accelerated climate change and the previously stated 5mm/year sea level rise for Wales has now been revised and Defra guidance states that sea level increments apply as shown in Table 4.4 above.
- 4.1.72 The Cardiff Bay Barrage will help to reduce these flood risks but the defences along the Wentlooge Levels (breach risk) and areas to the east of Cardiff (overtopping risk) remain at high risk of tidal flooding though the mechanisms for flooding differ. The combined impacts of tidal and fluvial flooding are also considered significant.

5. Flood Risk Mitigation

5.1.1 The following flood risk mitigation measures are recommended for the current design:

- Design considerations should avoid creating flow linkages that could cause localised groundwater seepage and flooding or routes for contaminants where piling works are proposed.
- The potential flood routes of reservoirs should be considered alongside fluvial flood risk aspects. There are many large reservoirs in the headwater catchments that could impact the Rivers Taff, Usk and Ebbw and various water storage reservoirs and flood storage areas.
- The railway lies within areas identified as Environment Agency Wales Flood Zones 2/3 and WAG flood Zones C1 – therefore the Justification Test and Acceptability Criteria, as outlined in TAN15, should be applied to this scheme (see Chapter 2).
- Any new or existing rail crossing points must maintain ground levels as existing, especially where the site lies within or adjacent to any identified Flood Zones 2/3 or Zone C1/C2 as the railway structure may serve as a local informal flood defence. If changes to embankment or railway levels are necessary, designs should be verified against existing local ground levels and any locally modelled flooding levels to ensure flood protection is retained or mitigated for appropriately, with consideration for climate change implications for river and sea levels.
- Scheme design and construction implementation should consider ground stability where groundwater may be present and identify if there are groundwater flood risks likely to occur along the railway route that may adversely impact the proposed scheme. Excavation or piling works should be designed to minimise environmental impact and avoid the risk of creating new hydraulic linkages or cause contamination to or from groundwater sources.
- Pollution Prevention Guidelines and best practice should be followed for all scheme aspects to reduce the potential impacts of pollutants and construction processes on the environment.
- Those managing the scheme should register with the Environment Agency Flood Warning Service to ensure a 24-hour contact is available to respond to a potential flood incident and ensure the safety of workers and protection of the environment during a flood event. Severe weather forecasts provide warning of potential tidal surges and/or energetic wave climates. Tidal surges are reasonably predictable, combinations of weather and tidal events can increase flood risks. Within the City of Newport flood warnings aim to give a minimum of 2 hours' notice prior to the onset of flooding, but this may not apply to breach situations which can lead to rapid, catastrophic flooding.
- A Flood Plan for the construction phase of the scheme should be prepared and disseminated accordingly to all site workers or visitors.
- Excavation or piling works should be designed to minimise environmental impact and avoid the risk of creating new hydraulic linkages or cause contamination to or from groundwater sources.
- Any piling or foundation works, whilst not considered to cause any increased risk of flooding by storage loss or conveyance alterations, should be designed to be resilient to flooding where they will be located within Flood Zones 2/3 or Zone C1/C2. Further dialogue with the Environment Agency Wales will be required should any piling works be required within Flood Zones 2/3 or Zone C1/C2.
- The impacts of climate change are two-fold for this area in that changes in rainfall patterns will lead to changes in peak river flows and global warming will also lead to local sea level rises. It is generally advised that Flood Zone 2 is used for a potential future level of Flood Zone 3 where local, specific information is not available. The life-span for the works would be permanent and detailed design stages should take account of these impacts for siting and elevation of any ground-based systems (i.e. switching stations, electrical stations), with the application of 600mm above the 1% levels, plus 150mm freeboard wherever possible.

- The location of distribution sites/switching stations and any electrified infrastructure needs to account for local flooding levels and provide appropriate levels of freeboard to elevate water-sensitive equipment above anticipated flood levels or need to be designed with appropriate flood resilience to ensure operation is not adversely affected during flood events. Sites that require further consideration include: Severn Tunnel Junction, Bishton ATS, St Brides ATFS and Canton (see Table 4.3).
- Consideration to flood risk is also needed to any temporary compound and storage areas that lie within Zones C1 or C2 to ensure that in the event of a flood incident polluting substances are not released into the environment and that floating materials are appropriately controlled to prevent damage to property or people in adjacent areas. Table 4.3 indicates which compound sites lay within these areas and whether the site is protected by flood defences or not. Appropriate flood and pollutant management must be considered for each of these sites during their use.

5.1.2 If the Scheme designs change, the following measures should be considered:

- Any changes to the design or location of structures and compounds should be reviewed again for flood risks.
- Any changes in design that result in newly proposed track lowering work should ensure that, if the work is located within Flood Zones 2/3 or Zone C1/C2 that local modelled flood levels are checked and proposed new ground levels compared to ensure that a new flood route is not created for the extreme flood event (equivalent to the level of FZ2). The same applies for any changes to proposed bridge works sites.
- With regards to reens, track lowering must be avoided within these areas, (to prevent an increase in flood risk to the railway or creation of new hydraulic links to adjacent areas) and existing railway levels should be maintained. Should any track raising or alterations to watercourses be necessary it must be discussed with the IDB at design stage to ensure there are no impacts on existing flood routes, flood storage or creation of new flood risks. Any works above or near to IDB-managed watercourses will also require consent.
- Where the railway acts as an informal flood defence, i.e. where the rail runs along raised embankments, caution must be applied to any track lowering or construction activities within the identified flood zone areas. Only a few locations of track lowering are proposed and one or two locations are along railway sections within Flood Zones 2/3 or Welsh Government flood Zone C1. During the detailed design stage, the proposed changes to track levels should be checked against local flooding levels (coastal and/or fluvial) to ensure the existing flood defences or flood zones are not adversely impacted by the changes and that new flood routes are not created.
- Any newly proposed compound areas, material storage areas or changes to designs that arise during forthcoming stages of the scheme should be reviewed for flood risks and appropriate mitigation measures applied, especially if located within Flood Zone 2/3 or Zone C1 or C2 and/or the site area is greater than 1ha in area (as surface water management will be required).

5.2 Further Consultation and Consenting Requirements

5.2.1 The following additional consultation and consenting processes are required:

- Further liaison with the Environment Agency Wales will be needed to identify anticipated flooding levels and suitable design considerations where any ground or embankment level changes are proposed within or adjacent to Flood Zone 2 / 3 or C1 / C2. Further liaison with the Wentlooge and Caldicot IDB will also be required as they are responsible for the maintenance of many watercourses along this section of the GWML.
- The Environment Agency Wales will require Flood Defence Consent for any works within, above or adjacent to (within 8m) of an identified main river. Flood Defence Consent

applications will need to cover both temporary and permanent works aspects where they are required. For non-main watercourses under control of the LLFA, FDC is unlikely to be required unless the scheme will result in structures that could obstruct flows or alter existing channel or culvert forms. For IDB managed watercourses, liaison is under way and further actions are dependent upon their requirements and a formal response is awaited.

- Welsh Water and the Local Councils will require continued consultation to ensure that drainage and sewerage systems are not adversely impacted by the proposed construction works.
- Further consultation with the Environment Agency Wales would be required as the Scheme progresses to identify if piling works could affect culverts or through-pipes that pass under the railway as their function must not be affected by the Scheme.
- Further dialogue with the Environment Agency Wales will be required to identify the best way forward for multiple consenting options and applications made for each Scheme aspect as appropriate.
- Further consultation with the Lead Local Flood Authority Contacts (at Monmouthshire County Council, Newport City Council and Cardiff City Council) as the Scheme progresses.

6. Conclusions & Recommendations

6.1 Recommendations

- 6.1.1 Many underbridges or underpasses form flood conduit routes for tidal and fluvial flooding and bridge jacking. Reconstruction or other bridge alteration works should ensure the new structures do not adversely affect the through-flow nature beneath the railway line.
- 6.1.2 Any scheme elements that have the potential to increase flood risk, such as track lowering within or adjacent to identified Flood Zones 2 or 3 will require a Level 3 Flood Consequence Assessment to check proposed ground level changes against local modelled flood levels (where available) to ensure new flood routes are not created or existing flood pathways altered (i.e. for the Intersection CEJ/SWM2 culvert – see Table 4.2 above).
- 6.1.3 The Environment Agency Wales will require FDC for any works over or within 8m of the main rivers. Works in, near or over non-main watercourses (under Unitary Authority management) will generally only need consenting if the works result in flow obstruction or channel alterations, which for the proposed scheme would be unlikely. The Caldicot & Wentlooge IDB has also indicated that FDCs will be required for all watercourse crossings over reens and drains within their management and that the scheme should be discussed further to ensure all crossings are identified.
- 6.1.4 The locations of some of the compounds and switching stations (see Table 4.3 above) lie within EAW Flood Zones 2/3² or DAM Zones C1 and further consideration for these sites is required during the detailed design stages to identify ground levels, flooding levels and design temporary or permanent sites with appropriate flood resilience.
- 6.1.5 Pre-construction assessments should be made where groundwater may be impacted by excavation or piling works and appropriate construction methods applied accordingly. Local checks should be made to ensure that groundwater does not affect ground stability or construction processes but this is considered a low risk.
- 6.1.6 Liaison should be undertaken with Welsh Water to ensure that works are not likely to damage existing buried sewer infrastructure or affect co-joined drainage systems linked to the railway drainage facilities.
- 6.1.7 Any track lowering within areas influenced by reens must be avoided (to prevent an increase in flood risk to the railway or creation of new hydraulic links to adjacent areas) and existing railway levels should be maintained. Should any track raising or alterations to watercourses be necessary it must be discussed with the IDB at design stage to ensure there are no impacts on existing flood routes, flood storage or creation of new flood risks. Any works above or near to IDB-managed watercourses will also require consent.
- 6.1.8 Although most of the proposed electrification works will not alter existing track levels, any track lowering works should be checked as part of a Level 3 Flood Consequence Assessment for their proximity to Zones B or C / EA Flood Zones 2 or 3, as they may provide some protection to adjacent land. The level of protection will also be limited if there are culverts running through the embankment, which is highly likely through the Wentlooge Levels area.
- 6.1.9 The life-span for the works would be permanent and detailed design stages should take account of these impacts for siting and elevation of any ground-based systems (i.e. distribution sites), with the application of 600mm above the 1% levels, plus 150mm freeboard wherever possible.
- 6.1.10 Consultation is under way with the Environment Agency Wales to further evaluate flood risks and confirm the consenting requirements that will be needed (wherever works are carried out above or near main rivers) to take the scheme forward. Further dialogue with the Environment Agency Wales will be required to identify the best way forward for multiple consenting options and applications made for each scheme aspect as appropriate.

- 6.1.11 Liaison with the Lead Local Flood Authorities (namely Monmouthshire County Council, Newport City Council and Cardiff City Council) is under way to review the scheme and identify if consents will be required. This process will be ongoing as the scheme progresses through detailed design stages.
- 6.1.12 Liaison is also under way with the Caldicot and Wentlooge IDB to ensure the works do not adversely impact any IDB managed watercourses. This will need to be followed up during the detailed design stages.
- 6.1.13 Flood level data will be required to assess sites where track lowering has been proposed within a flood risk location. Provided existing ground levels can be protected wherever they are important as informal flood defence structures, or that checks on local flooding levels indicate that new flood routes will not be created by track or bridge alterations, the fluvial flood risks for this scheme will be minimal.
- 6.1.14 Flood resilience should be designed for any infrastructure located within Zones B or C / Flood Zones 2 or 3. Any changes to the design or location of structures and compounds should be reviewed again for flood risks.
- 6.1.15 Any alterations to track or adjacent drainage, whether within Network Rail land or within adjacent areas, consideration should be given in case other systems are also using the same drainage.
- 6.1.16 With appropriate design and liaison with the appropriate Planning Authorities, Environment Agency Wales, Highways Authority and Welsh Water, the proposed electrification works between the Severn Tunnel and Cardiff will not lead to or be impacted by any flood risks and thus be in compliance with PPW, TAN15 and Environment Agency Standing Advice.

Consenting Arrangements

- 6.1.17 Liaison is under way with both the Environment Agency Wales, LLFA and IDB contacts for each relevant section of the railway to identify Flood Defence Consent requirements and to find an appropriate way forward in dealing with the need for multiple consents along the route of the railway. This process will need to be taken forwards during the detailed design stage for the scheme.

Residual Risk Management

- 6.1.18 Registration with the Environment Agency Flood Warning Service and formulation of a Flood Plan will ensure the safety of people and the environment can be maintained throughout the project where people and/or equipment may be located within areas prone to flooding. The Environment Agency Wales has provided guidance on the considerations and actions that may be necessary to formulate an appropriate Flood Plan and this guidance should be followed for the site. Liaison with the Environment Agency Wales to ensure it is sufficient for the site would also be advised. For information refer to:
- Environment Agency (¹⁵) Flooding – Minimising the Risk. Flood Plan Guidance for Communities and Groups. Practical Advice To Help You Create A Flood Plan.
 - Environment Agency (¹⁶) Flooding – Would Your Business Stay Afloat? A Guide to Preparing Your Business for Flooding.

Reference and Guidance Material

- 6.1.19 The Environment Agency's Pollution Prevention Guidelines should be followed during the construction process to ensure that the risks of pollution to groundwater and/or surface water features is minimised or avoided entirely.

¹⁵ <http://publications.environment-agency.gov.uk/PDF/GEHO0111BTJK-E-E.pdf>

¹⁶ <http://publications.environment-agency.gov.uk/PDF/GEHO0111BTJI-E-E.pdf>

- 6.1.20 Any drainage designs for surface water management of compound or other works areas should be informed by the appropriate guidance, such as
- The SuDS Manual (CIRIA c697); and
 - Site Handbook for the Construction of SuDS (CIRIA c698).

6.2 Conclusions

- 6.2.1 Further liaison will be necessary with the appropriate authority for Flood Defence Consent purposes and to ensure that any flood risk concerns raised by them can be adequately reviewed and mitigated for, particularly where bridge alterations or track lowering is proposed.
- 6.2.2 The general impact of the scheme on existing flood risks will, however, be negligible.

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