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Technical Flood Risk Guidance in relation to Allowances for Climate Change in Northern Ireland

DfI Water & Drainage Policy Division

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Upper Bann, Portadown

Introduction

The EU Floods Directive requires that Climate Change is taken into account in the assessment of flood risk. This Department for Infrastructure (DfI) technical flood risk guidance consolidates and where appropriate, updates existing guidance on allowances for Climate Change and is designed to assist engineers and other professionals in their considerations of flood risk. Appropriate consideration of Climate Change in the design of infrastructure ensures its sustainability and future proofs public assets for the management of flood risk.

The guidance sets out DfI Roads and NI Water's approaches to Climate Change in design of their respective Road Drainage and Storm Drainage systems. These approaches have been reviewed and there has been no change to existing guidance in these areas.

The guidance sets out the DfI Rivers approach to Climate Change in Flood Risk Management. The existing approach has been reviewed and updated. A key change involves the approach to hydrological and hydraulic modelling/design which now requires the allowance for Climate Change to be made separately to any additional allowance for freeboard. Previously guidance recommended 'testing' for Climate Change within the freeboard envelope.

This guidance addresses the issue of a suitable future epoch, or time period, on which to base allowances for Climate Change for Development Planning and Flood Risk Management purposes. The 2080s has been agreed as a suitable epoch.

Any queries on the technical guidance should be directed to waterpolicy@infrastructure-ni.gov.uk and any queries in respect of DfI Rivers advice on flood risk should be directed to riversplanningmailbox@nigov.net or by phone: 028 3839 9118.



Flooding on the A5

Background information on allowances for Climate Change in Flood Risk Management

Historically, a lead was taken from the Environment Agency (EA) in England & Wales in utilising Climate Change projections developed through the UK Climate Impacts Programme (UKCIP) research to set Climate Change allowances for Flood Risk Management in Northern Ireland. This UKCIP research included Climate Change allowances for river and coastal-related impacts e.g. design allowances relating to future peak river flows and sea level rise. The UK Climate Projections (UKCP) site is the authoritative source of Climate Change information for the UK, accessible via the link: ukclimateprojections.metoffice.gov.uk.

Initially, UKCIP02 research (completed in 2002 by the Met Office, funded by DEFRA in England & Wales), formed the basis of UK guidance for river flows and Sea Level Rise. In England & Wales, the EA produced '[FCDPAG3 \(2006\) Supplementary Note to Operating Authorities](#)'. Similarly, brief guidance and allowances were derived for Northern Ireland.

In 2016, the EA in Great Britain and the Scottish Environmental Protection Agency (SEPA) issued updated guidance documents for Flood Risk Assessments which include allowances for Climate Change based on UKCP09 Climate Change projections (completed in 2009). While the intention of these documents is to provide guidance for Development Planning purposes, they also contain updated information on allowances in Great Britain and Scotland relating to Flood Risk Management and Climate Change.

The Republic of Ireland has adopted a scenario-based approach in determining allowances for Climate Change in managing flood risk. The Office of Public Works in its [FRM CC Sectoral Adaptation Plan - Dec 2015](#) outlines two scenarios, Mid-Range (MRFS) and High-End (HEFS) Future Scenarios. The related allowances are similar to those in the UKCP09 in terms of rainfall, river flows and sea level rise.

DfI Water & Drainage Policy Division is updating its guidance on Climate Change allowances for Flood Risk Management in Northern Ireland for the following reasons:-

- The EU Floods Directive requires that Climate Change is taken into account in flood risk management planning;
- The UK Climate Change Risk Assessment ([UKCCRA17](#)) completed in early 2017 to which Northern Ireland contributed data and information, highlights flooding as the most significant climate risk to the UK;
- The formation of DfI in 2016 created an opportunity for a consistent approach to be adopted by DfI Roads and Rivers, and Northern Ireland Water in allowing for Climate Change in managing flood risk.

The 2080s has been agreed as a suitable epoch on which to base allowances for Climate Change for Development Planning and Flood Risk Management purposes. However, flood risk assessment is an ongoing process that will take account of new and updated information. Given that 2080s Climate Change maps provide the most up to date available or readily derivable information on flood risk:

- DfI Rivers will use 2080s Climate Change maps in providing the most up to date flood risk information; and
- Planning Authorities should use 2080s Climate Change maps at development plan preparation stage and for development management purposes, taking account of the best available information on flood risk.

It is emphasised that the following guidance on allowances for Climate Change reflects potential future change relating to rainfall, river flows and sea levels. It does not take account of other potential future changes in physical catchment characteristics which may occur because of Climate Change such as changes in land use (new crops, etc.), soil moisture, level of infiltration / absorption etc. These can lead to changes

in run-off, flows and to the time of response of catchments which may affect how the catchment responds to flooding, flood levels and therefore flood risk. Also, this guidance does not account for any physical changes in catchments which are unrelated to Climate Change e.g. urbanisation. The potential effects of such changes should be considered over and above the advice provided in this guidance.

It should be noted that UKCP09 research, to which this guidance refers, is scheduled to be superseded by a new set of climate projections in 2018 i.e. UKCP18 and information on this is available via the following UKCP link: <http://ukclimateprojections.metoffice.gov.uk/24125>

Transitional Arrangements

This guidance should be applied to all new work. For work already in progress or substantially complete, if the new advice in this guidance can be factored in, or the plan or investment decision tested against it without slowing completion or adding significantly to the cost, then this should be done.



1: DfI Rivers' approach to Climate Change in Flood Risk Management

Unlike England & Wales for which the EA have based Climate Change allowances on River Basin Districts, it is considered that single allowances (e.g. for additional flow or rainfall intensity) are appropriate, covering all of Northern Ireland because of its relative small size, UKCP09 information does not vary significantly across the Province. Scotland has also adopted single allowances. Generally, the allowances for Northern Ireland are based on UKCP09 information, Central estimate (50% probability level) Winter Rainfall for 2080s under the Medium emissions scenario. However, there are circumstances where allowances based on alternative future Climate Change scenarios, probability etc. may be used. For example, where developments of a critical or strategic nature are proposed which, if flooded, could result in loss of life, catastrophic damage to property or infrastructure, or significant economic losses, in such circumstances a higher probability level should be used. An example is Belfast Tidal Study where an upper percentile estimate was used to assess sea level rise in order to provide greater assurance that flood defence levels to the City centre would, over time, continue to meet the necessary standards of protection. In circumstances such as these, it is recommended that further guidance from UKCP should be sought.

Guidance on allowances for Climate Change in undertaking Hydrological and Hydraulic modelling / design - FLUVIAL

It is generally recommended for the fluvial (river) context throughout NI, that a single Climate Change allowance of +20% additional flow is applied to the estimated 'Present Day' **100-year peak flow**. UKCP09 also includes tools to provide alternative future Climate Change scenarios e.g. Low / High Emissions, lower / higher levels of probability; see via the following link - [UK Climate Projections](#). Example scenarios would be where a

strategically important development is being designed or assessed for climate impacts or, where risk to life or major economic losses could occur should design levels be overtopped. In such circumstances it may be more precautionary to use allowances based on a higher probability level. In these circumstances it is therefore recommended that a 'sensitivity test' be undertaken based on a higher 90% probability level to determine whether there are any 'cliff-edge' effects where the flooding consequences may suddenly become extremely severe. If this test yields potentially severe effects, adoption of the higher level of confidence is advised for the proposed development.

The Climate Change allowances are set from a 1961 - 1990 hydrological baseline i.e. Climate Change research used SAAR 1961-90 Annual Average Rainfall as the baseline for determining additional flows through hydrological modelling. The +20% additional flow which this Guidance recommends, is therefore considered against this baseline and is the predicted allowance for the 2080s epoch

For studies and designs of river flood defences, a freeboard allowance is normally added; this is a residual uncertainty allowance commonly of up to 600mm to account, for example, for uncertainty in estimation of design flood levels. Allowance for Climate Change should be made separately from any additional allowance for freeboard / uncertainty in design. This is a change from previous guidance which recommended 'testing' for Climate Change within the freeboard envelope. This change is in line with Principle 2 of Defra's Guidance Report SC1200014, '[Accounting for residual uncertainty; updating the freeboard guide](#)'. It is recognised for practical reasons that an allowance for freeboard / uncertainty may not be fully achievable in all design circumstances.

Guidance on allowances for Climate Change in undertaking Hydrological and Hydraulic modelling / design – COASTAL

The key physical components contributing to coastal flooding are listed as follows:

- Predicted astronomical tide
- Storm surge residual
- Wave / fetch effects
- Local bathymetric and topographic effects

In undertaking any coastal assessment, study or design of coastal defences, the 4 components listed above should be taken into account in determining design sea levels.

For the coastline of NI, work by DfI Rivers and its consultants has led to the production of tidal models and mapping which take account of local coastal effects. This information is readily available within DfI's Geographical Information System (GIS).

Climate Change

Best practice guidance should follow advice provided in UKCP09 for making allowances for changing sea levels due to Climate Change.

Allowances for Climate Change should be made over and above the estimated design sea levels ('Present Day' extreme sea levels) which can be obtained either from the 'coastal point' information available on DfI's GIS (Geographical Information System) or alternatively, determined by using standard design methods which take into account the above 4 physical components.

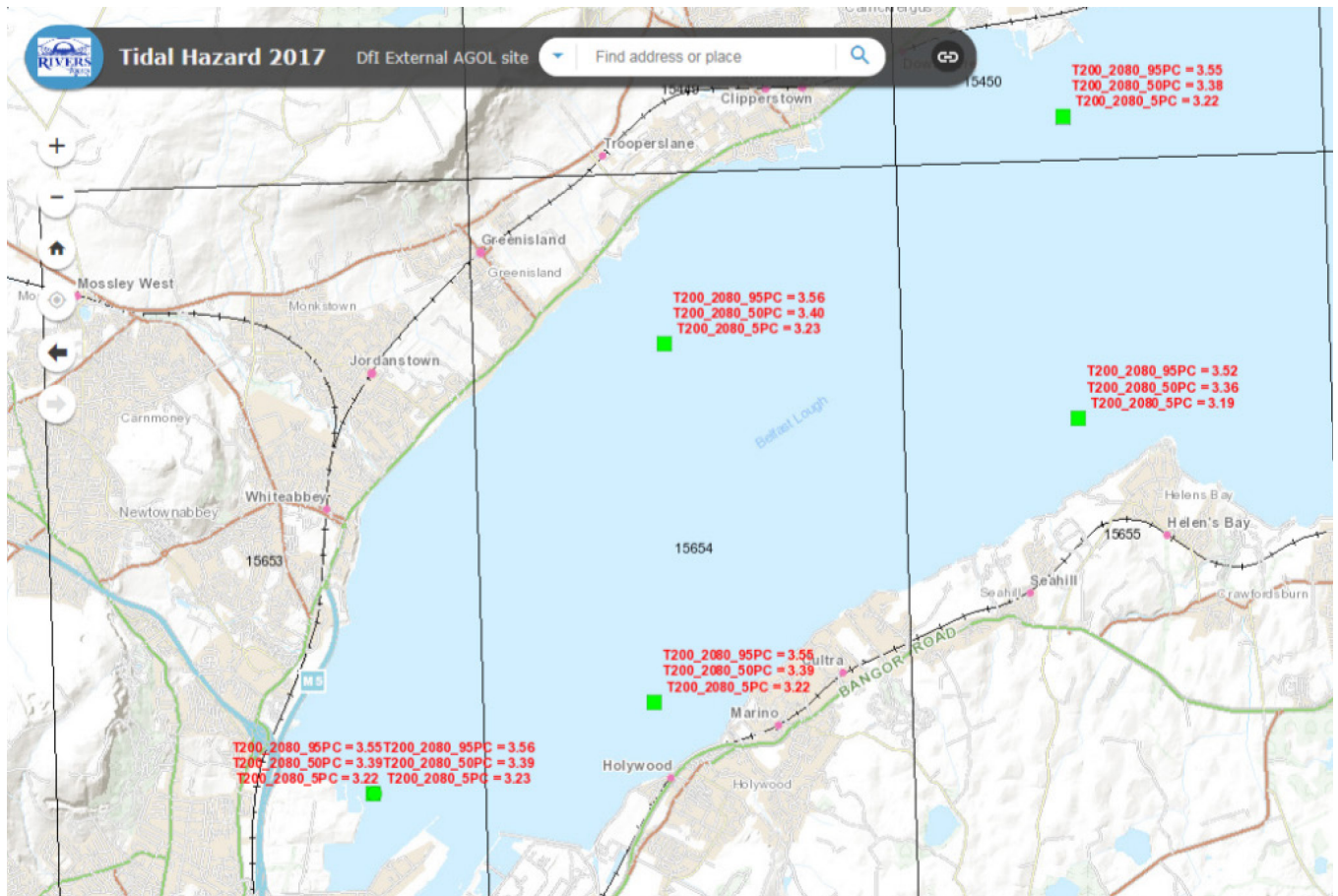
The 'Tidal Hazard' information available on the DfI's GIS provides both 'Present Day' and estimated 'Climate Change' coastal levels for the 2080s epoch (Medium Emissions) for 3 levels of confidence namely 5%, 50% and 95%. It is recommended for normal Flood Risk Assessments that the 50 percentile Relative Sea Level should be used. Where a strategically important development is being designed or assessed for climate impacts

or, where risk to life or major economic losses could occur should design levels be overtopped, it may be more precautionary to use allowances based on a higher percentile. In these circumstances it is therefore recommended that a 'sensitivity test' be undertaken based on a higher 95 percentile Relative Sea Level to determine whether there are any 'cliff-edge' effects where the flooding consequences may suddenly become extremely severe. If this test yields potentially severe effects, adoption of the higher level of confidence is advised for the proposed development. An example is the major redevelopment of Belfast's Titanic Quarter which bounds on Belfast Lough, which is susceptible to tidal surge conditions and comprises important new commercial, domestic and tourism developments.

For studies and designs of coastal flood defences, a freeboard allowance will normally be added; this is an allowance for uncertainty in estimation of design sea levels, commonly of up to 600mm. Allowance for Climate Change should be made separately from any allowance for freeboard.

Projected changes in storm surges

The projected long-term future trends in storm surge in UKCP09 are physically small everywhere around the UK and in many places can be accounted for by natural variability. The surge level expected to be exceeded on average once in 2, 10, 20 or 50 years is not projected to increase by more than 9cm by the year 2100 anywhere around the UK coast (not including the mean sea level change).



Sample GIS screen shot of Tidal Hazard information showing 200 yr extreme sea levels with 2080s Climate Change allowances for 5, 50 and 95% probabilities.

Therefore, in accounting for storm surge in coastal assessments and designs, there are no specific allowances recommended for Climate Change except to ensure that designs / Flood Risk Assessments include a rigorous assessment of the coastal extreme water level(s).

Guidance on allowances for Freeboard

It is important to include a freeboard or uncertainty allowance as part of any coastal flood design or Flood Risk Assessment. This helps to account for uncertainty associated with coastal processes not explicitly taken into account by standard estimation methods; it includes:-

- inherent uncertainty associated with design flood estimation
- uncertainty of wave and spray action
- uncertainty with local bathymetric processes (e.g. reflection and shoaling)

- reduction of design level due to local changes in land e.g. erosion and settlement

Commonly, an allowance of 600mm is added for coastal freeboard. This may be required to be greater or less depending on, confidence in design river (estuarine) or tide levels, local circumstances and /or the availability of specific local information. Also, it is recognised for practical reasons that an allowance for freeboard may not be fully achievable in all design circumstances.

Guidance on allowances for Climate Change in undertaking Hydrological and Hydraulic modelling / Watercourse Storm Drainage design – PLUVIAL

In line with latest technical guidance, it is recommended that Climate Change is considered in modelling and design of Watercourse infrastructure to address pluvial (surface water) flooding and that a +20%

allowance should be applied to ‘Present Day’ peak flows or peak rainfall intensity.

However, similar to the ‘Fluvial’ guidance above, in circumstances where, for example, developments of a critical or strategic nature are proposed which, if flooded, could result in loss of life, catastrophic damage to property or infrastructure, or significant economic losses, it may be more precautionary to use allowances based on a higher, 90% probability level.

Guidance on allowances for Flood Risk Assessments and design of Underground Watercourse conduits (pipes, culverts etc)

It must be noted that under current Planning guidance, new culverting should only be considered in exceptional circumstances.

Flood Risk Assessments and design processes which involve underground watercourse infrastructure should utilise the allowances for Climate Change contained above in ‘Fluvial’ guidance. Generally, designs of new watercourse conduits should take account of design flows +20% flow. Such structures often come in standardised sizes (e.g. 1,350mm, 1,500mm diameter etc.). Therefore, the culvert size which fully accommodates the ‘Design + Climate Change’ flow, may actually have a greater cross-sectional area than required and so may provide even greater capacity and a higher level of flood protection (until Climate Change may take effect). (Note: Debris and siltation may reduce capacity and this should be considered in designs).

DfI Rivers - General Design Standards for Watercourse Conduits

Location	Design Standard
Sea Defences / Estuarine Rivers	1 in 200 years
Urban Areas, Motorways, Trunk Roads and Critical Infrastructure.	1 in 100 years
Housing and commercial development	1 in 100 years
All other minor public roads,	1 in 50 years
Farms lanes where buildings are accessed or may be at risk of flooding,	1 in 50 years
Access roads to houses.	1 in 50 years
Field crossings where farm building may be at risk of flooding	1 in 50 years
Field crossings where there is no risk to farm buildings	1 in 5 years
Piping of watercourses through farmland	1 in 5 years

2: DfI Roads' approach to Climate Change in Design of Road Drainage

In its design of road drainage systems, DfI Roads utilises the Design Manual for Roads & Bridges (DMRB) Volume 4 (Geotechnics & Drainage), Section 2, Part 3, (HD 33/16), Chapter 7 (referred to as DMRB Chapter 7 in the following text).

Storm Return Period

Design Storm Return Periods shall be determined in accordance with the guidance in DMRB, Chapter 7, paragraphs 7.2 and 7.3 which is as follows:

7.2 Longitudinal sealed carrier drains shall be designed to accommodate a one-year storm in-bore without surcharge. The design shall be checked against a five-year storm intensity to ensure that surcharge levels do not exceed the levels of chamber covers.

Combined surface water and ground water drains shall also be designed to accommodate a **one-year storm** in-bore without surcharge. A design check shall be carried out to establish that a **five-year storm intensity** will not cause chamber surcharge levels to rise above the formation level, or sub-formation level where a capping layer is present. In carrying out this check it should be assumed that pipes are sealed and that back flow from pipes into the filter media does not take place.

7.3 Guidance on the design of surface water channels is given in HA 39 (DMRB 4.2). The principle for the design of channels is that a design storm with a return period of one year must be contained within the channel, and that surcharge consequential to a storm of five-year return period should not encroach into the running lane.

Channels must be designed to accommodate a **1 in 1 year storm** with the flow contained within the channel cross section without surcharging. The allowable surcharge widths must then be checked for **1 in 5 year storm**.

In verges, surcharges under a **1 in 5 year storm** must be limited to a width of 1.5m in the case of hard shoulder and 1.0m in the case of hard strip.

In central reserves, surcharge under a **1 in 5 year storm** must not be permitted to encroach on the carriageway, but flooding within the non-pavement width of the central reserve is permissible providing there is safeguard against flows from the surcharged channel overtopping the central reserve and flowing into the opposing carriageway.

Allowance for Climate Change

Climate Change is referred to in DfI Roads' Sustainability Construction Action Plan, Sustainable Procurement Action Plan and is connected to DfI Roads' Biodiversity Action Plan.

Allowance for Climate Change is addressed by DfI Roads in design of road drainage by applying the guidance contained with DMRB Chapter 7, paragraphs 7.4 and 7.5 which is as follows:

7.4 The rainfall intensities used to calculate the design storms must include an allowance for the effects of Climate Change. Where rainfall data exclude such an allowance, a sensitivity test on the design of the drainage system must be carried out by increasing rainfall intensities of the design storm by 20% and adjustment made to the design should the initial design fail this sensitivity test.

7.5 Application of storms of other return periods shall be influenced by considerations of geography and particular highway geometry. Examples of critical sections of road are quoted in HA 37 (DMRB 4.2) as:

- i.** applications of super-elevation that cause crossfall to be locally zero;
- ii.** sections of road draining to longitudinal sag points where it is important to prevent flooding; and
- iii.** longitudinal sags in cuttings, where it may for example be deemed prudent to design outlet drainage to a design storm return period of say ten years (i.e. having an annual exceedance probability of 10%).

These are matters for engineering judgement relative to the drainage elements under consideration, and the consequences of surcharge of the system in its unique situation which require a risk assessment to be undertaken and appropriate design alterations made in relation to the findings of such a risk assessment.

While the DMRB is not specific about the intended epoch to which the additional 20% allowance in rainfall intensity pertains, the allowance aligns with the preceding DfI Rivers guidance for Fluvial and Pluvial assessments which relates to a 2080s epoch (Medium Emissions, Central estimate).

Calculation of Runoff Flows

Runoff Flows are calculated in accordance with the DMRB Chapter 7, Paragraphs 7.6 to 7.8, taking into account the preceding advice on Allowance for Climate Change.



Knock dual carriageway, Belfast

3. Northern Ireland Water's (NI Water) approach to Climate Change in Design of Drainage Systems

In its design of sewerage systems, NI Water refers to the document, Sewers for Adoption NI 2nd Edition and its Risk Based Drainage Area Plan Specification.

Surface Water - Hydraulic Design Criteria

For new surface water drainage,

- The system should be designed under pipe full conditions to accept a **1 in 2 year rainfall event** without surcharging above pipe soffit;
- Where consequences of flooding are severe, for example where basements exist or are proposed, sewers should be designed to accept a **1 in 5 year rainfall event** without surcharging.

Surface Water – Flood Protection Criteria

For new surface water drainage,

- The system should be designed to ensure a freeboard of at least 300 mm in a **1 in 30 year rainfall event**, so as not to flood any part of the site;
- The system should be designed to ensure no properties on or off the site are flooded in a **1 in 100 year rainfall event**;
- Design should include 10% uplift in impermeable area to allow for urban creep.

Allowance for Climate Change

Within NI Water, modelling of sewerage network catchments, Drainage Area Planning, includes assessment for Climate Change. NI Water takes a lead from DEFRA guidance (2011) and their allowances for Climate Change are consistent with UKCP09.

NI Water's general guidance to account for Climate Change is for +20% to be added to design rainfall; this is based on the UKCP09 Medium Emissions, Central estimate (50% probability level). However, this should be reviewed and agreed for each individual study because of the uncertainty regarding changes at a local level and for rarer storm events (e.g. 20-Year return period).

In relation to Drainage Area studies, a Risk Based Approach is adopted and catchment risks (hydraulic, environmental etc.) are assessed for two scenarios:

- a) Excluding Climate Change
- b) Including Climate Change

Changes to existing risks due to Climate Change and new risks developing as a consequence of Climate Change, are reviewed as part of the risk assessment phase (employing a 'risk and consequence' analysis).

NI Water's general guidance is therefore that:-

- 10% is added to design rainfall covering the period 2040 – 2069 (i.e. 2050s epoch)
- 20% is added to design rainfall covering the period 2070 – 2099 (i.e. 2080s epoch)

Because of the quantum and scale of data used to generate Time Series Rainfall (TSR) for spill frequencies and volume (this must also cover changes in frequency and duration and not just changes in intensity), there is no universally accepted method for applying Climate Change allowances to TSR storms. An approach for this is still to be defined by NI Water and for the moment is determined on an individual study basis.

4. Sustainability in Design, Flood Storage and Natural Flood Management

The preceding sections of this guidance address allowances for climate change in relation to more conventional engineered approaches to managing flood risk relating to watercourses and drainage systems.

However, DfI recognises it is desirable for watercourse and drainage systems to be designed with necessary regard to the environment and for solutions to be sustainable. Therefore, DfI designs of watercourse, road or storm drainage infrastructure which mimic more natural catchment behaviour may be possible

options or part thereof. These may include flood attenuation solutions either on the line of the watercourse or drainage system or 'off-line', or may include other natural methods of slowing or reducing flows. Such solutions may provide amenity benefits which may be more acceptable to communities for which they are being provided.

In the design of such solutions, Climate Change allowances in accordance with UKCP09 should be taken into account, as well as allowing for uncertainties in design parameters.



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