Llywodraeth Cymru
Welsh Government

Adapting to Climate Change:

Guidance for Flood and Coastal Erosion Risk Management Authorities in Wales

August 2022

This guidance has been prepared by Natural Resources Wales on behalf of the Welsh Government. Its purpose is to assist Risk Management Authorities in Wales consider the impacts of climate change when planning and developing flood and coastal erosion risk management projects and strategies.

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Contents

1 Introduction

This guidance is provided as supplementary information to the Welsh Government's Flood and Coastal Erosion Risk Management (FCERM) Business Case Guidance, published June 2019. It supports the National Strategy for Flood and Coastal Erosion Risk Management (2020) and should be used to consider the impact of climate change within the development of all FCERM projects or strategies.

This document replaces the 2017 version of 'Adapting to Climate Change: Guidance for Flood & Coastal Erosion Risk Management Authorities in Wales'.

Sea level rise projections have been updated to reflect the revised projections published in November 2018 by UK Climate Projections (UKCP18). Further information on how the projections were developed can be found on the UKCP18 website.

Sea level rise allowances have been updated to reflect the higher central allowance (70th percentile) and upper end allowance (95th percentile) of Representative Concentration Pathway (RCP) 8.5, which reflects an increase in global mean surface temperature of around 4.3^{0}C) by 2100.

There has been **no change** in the guidance for peak river flows, extreme rainfall or storm surge data, which is based on an assessment of UKCP09 data undertaken by the Environment Agency between 2013 and 2015. There has also been **no change** to wave climate projections. An update to these allowances will be made following analysis on the impacts of revised UKCP18 climate projections.

Given the long lifetime and high cost of the built environment and many FCERM measures, it is imperative that plans and investment projects consider, in an appropriate way, the changing risks over the coming century. This includes accommodating adaptation to a changing climate where appropriate.

There are two approaches for managing climate change:

- Managed Adaptive – where appraisals consider the flood risk management measures that are not necessary now but may be in the future.
- Precautionary Approach – where measures are designed to fully account for estimated climate change.

Guidance on how to apply these approaches can be found in the Welsh Government's FCERM Business Case Guidance (2019).

Please note: The climate change allowances presented in this guidance align with those provided by the Welsh Government for use in Flood Consequence Assessments to support planning applications and inform development plan allocations[1]

[1] https://gov.wales/climate-change-allowances-and-flood-consequence-assessments

1.1 Schemes requiring Flood and Coastal Erosion Risk Management Grant Funding

The purpose of this guidance is to ensure that economically credible business cases, which are consistent in their application of the uncertainties associated with climate change, can be made to support Welsh Government investment decisions. This will ensure sustainable investment decisions which align with the aspirations of the Wellbeing of Future Generations Act.

This advice is specifically intended for projects or strategies seeking Welsh Government FCERM Grant Funding. However, Risk Management Authorities (RMA) in Wales may also find this information useful in developing plans and making FCERM investment decisions even if there is no intention of applying for central government funding.

A RMA may decide to recommend an investment decision that is not based on the climate change allowances presented in this guidance. However, where a FCERM Grant Funding contribution is being sought the supporting investment business case must develop at least one option based on the recommended climate change allowances. This is required to demonstrate the implications of using alternative climate change allowances which may influence the outcome of the application. Such an approach also ensures that the implications of alternative approaches to risk assessment and management can be more consistently compared and communicated.

It is recommended that RMAs making FCERM investment decisions which do not attract grant funding also follow this approach.

2 Transitional arrangements

This advice should be applied to all new business cases from 1 April 2021.

For business cases, which are already in development **Table 1** below explains how and when to apply the revised allowances provided in this guidance. This is required to ensure the revised figures would not lead to different decisions.

Any queries regarding the application of this guidance during the transitional period should be directed to Welsh Government Flood and Coastal Risk Branch.

Scheme Development Stage		Assumption	Action
Five Case Model	**Previous Appraisal Guidance***		
• New Business Case • SOC/OBC in development	• New PAR • PAR in development	Hydraulic Modelling/Economic Appraisal work not yet commenced.	Appraise scheme using the revised allowances within this guidance document.
• OBC Completed • Detailed Design in Development	• PAR Completed • Detailed Design in Development	Economic Appraisal completed in OBC using climate change allowances from 2017 guidance.	Assess preferred option against revised allowances within this guidance to ensure that results would not lead to significantly different decisions at Detailed Design stage. Undertake Detailed Design using revised allowances if work not too far progressed to allow this.
• Detailed Design Complete • Scheme Construction Ready	• Detailed Design Complete • Scheme Construction Ready	Detailed Design completed using allowances from 2017 guidance.	Consider the implications of using the revised allowances within this guidance and report any significant findings to the relevant funding authority.
• Existing approved plans and strategies	• Existing approved plans and strategies	Plans or Strategies are subject to ongoing review process.	At next review, appraise plan or strategy using the revised allowances within this guidance document.

Table 1 - Use of revised climate change allowances at each stage of the 5BCM

SOC – Strategic Outline Case
OBC – Outline Business Case
PAR – Project Appraisal Report
* FCDPAG – Flood and Coastal Defence Project Appraisal Guidance – 2001
* FCERM-AG – Flood and Coastal Erosion Risk Management Appraisal Guidance 2010

3 Provision of climate change allowances

This guidance aims to inform the design and resilience of flood and coastal risk management schemes, which should consider credible and reasonable climate change impacts. It is recommended that the long-term sustainability and resilience of flood risk management options are assessed against the relevant climate change allowances for the whole of the decision lifetime.

Recommended climate change allowances for river flood flows, extreme rainfall and wave climate are provided in Annex 1. Estimates of future sea level rise based on UKCP18 projections is also provided.

3.1 Scheme Design

FCERM schemes should be designed in accordance with Welsh Government's FCERM Business Case guidance (2019). This notes that the impacts of climate change need to be considered within the economic assessment to support a scheme appraisal.

For river flood flows, extreme rainfall and storm surge, this guidance provides the central (50th percentile) and upper (90th percentile) climate change allowances based on the assessment of UKCP09 data. For wave climate, national precautionary sensitivity ranges for offshore wind speed and wave height up to 2120 are provided. These allowances provide the current national representation of how climate change is likely to influence flood risk from these sources.

It is recommended risk management schemes designed to mitigate risk from rivers are assessed against the central allowance presented in **Table 2** (Annex 1).

Revised sea level rise allowances based on UKCP18 Climate Change projections are presented as regionalised data, with the impact of climate change dependent on location. This guidance has been updated to indicate projected increases in sea level rise for each local authority administrative area[1]. Regional allowances replace the single allowance for Wales previously provided and should be used in FCERM scheme design.

Table 4 (Annex 1) provides indicative projected sea level rise around the Welsh coastline by 2100 and 2120. These allowances are based on UKCP18, RCP8.5, 70th and 95th percentiles. The allowances presented give an estimate of future sea level rise for the relevant local authority administrative area. Location specific allowances, projections for different timescales and projections beyond 2100 can be obtained from the UK Climate Projections (Met Office) user interface. Coastal

[1] Based on UK Met Office dataset: Assessment of climate change up to 2100

risk management schemes should be assessed using the higher central allowance of climate change, RCP8.5, 70th percentile.

The UKCP18 dataset projects to 2100. To calculate epochs up to 2125, use the average incremental increase from the last 5 years of the dataset (2094 to 2099) from RCP8.5. Should you wish to perform an extra assessment for the lifetime of the scheme after 2125, the 2300 sea level rise projections dataset from UKCP18 (to 2300) for RCP 8.5 should be used.

3.2 Sensitivity Testing

The Welsh Government recommend that a full appreciation of climate uncertainty is considered when planning and designing FCERM schemes. Appropriate sensitivity testing against potential future climate change impacts will help RMAs to determine and plan for appropriate mitigation measures within the scheme design (e.g. through a strategy for managed adaptation) – thereby encouraging the use of managed adaptation.

For river risk management schemes, sensitivity testing should be undertaken against the upper allowance (90th percentile) presented in **Table 2** (Annex 1) to consider longer term sensitivity to future climate change impacts.

For coastal risk management schemes, sensitivity testing should be undertaken against the RCP8.5 95th percentile (sea level rise projections). This can be obtained either from **Table 4** (Annex 1) or the UK Climate Projections (Met Office) user interface.

Annex 2 of this guidance provides examples of river and coastal flood risk management proposals to guide RMAs through the process of considering climate change impacts. This should help RMAs make full use of the information from Annex 1.

H++ Scenario

There is no current requirement to undertake sensitivity testing against the High ++ (H++) scenario for fluvial risk management schemes in Wales and additional sensitivity testing is not normally required for sea level rise.

It is envisaged that only where the consequences of flooding or erosion could be extreme would the H++ scenario need to be considered within assessments for sensitivity purposes covering the period to 2120. Further information on H++ can be obtained from the Met Office.

4 Limitations and Managing Exceptions

The climate change allowances provided in this guidance have been derived from national scale research. There may be cases where local evidence supports the use of other local change factors. For example, the impact of climate change on peak river flow may vary within a river basin district. In such cases decision makers may use alternative change factors where robust science supports this. Where national grant funding is being sought, the Welsh Government will need to be satisfied that the science is indeed sufficiently robust to support such an exception.

It will be up to the RMA to consider the most appropriate local evidence and justify exceptions on a case-by-case basis. The rationale for using other data and the implications should be transparent and recorded within the plan or investment decision documentation.

Annex 1
Climate Change Allowances

1. Changes to river flood flows by river basin district

The information provided in **Table 2** is derived for change to river flow likelihood of a 1 in 50 (2%) chance of occurring in any year for each river basin district in Wales. For extrapolation of these projections to other events, the research suggested that the regional allowances are likely to remain relatively constant with increasing return periods.

The climate change allowances provided correspond to the central estimate of change from the research. The projections are percentage changes to a 1961-1990 baseline.

	Total potential change anticipated for the 2020s (2015 to 2039)	**Total potential change anticipated for the 2050s** (2040 to 2069)	**Total potential change anticipated for the 2080s** (2070 to 2115)
Severn			
Upper (90th)	25%	40%	70%
Central (50th)	10%	20%	25%
West Wales			
Upper (90th)	25%	40%	75%
Central (50th)	15%	25%	30%
Dee			
Upper (90th)	20%	30%	45%
Central (50th)	10%	15%	20%

Table 2: Changes to river flood flows by river basin district (use 1961-90 baseline)

The illustration provided in **Figure 1**, shows how the projections for changes in river flow may be plotted and used in typical assessments.

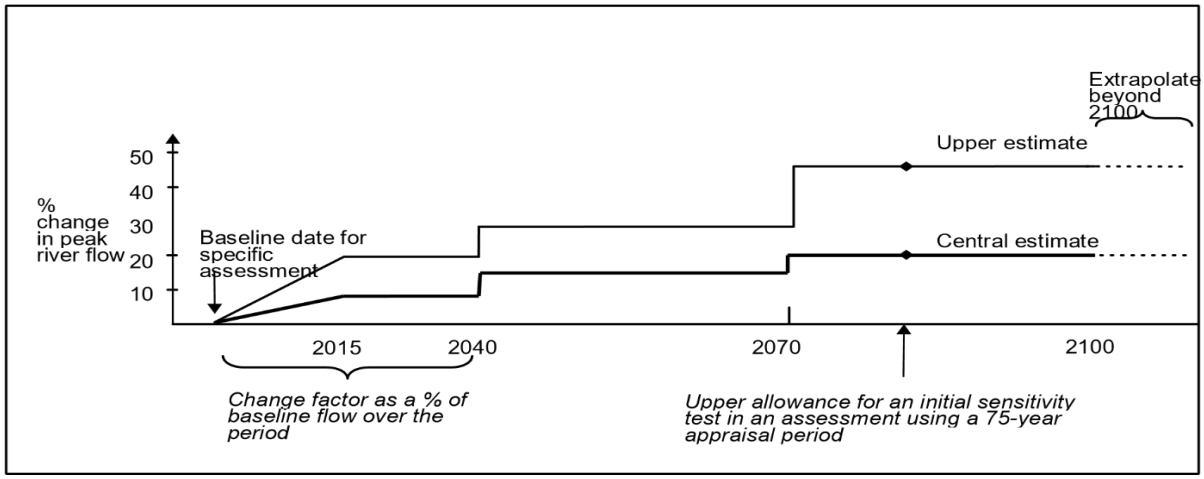

Figure 1 - Changes in river flows for the Dee river basin district and their application in assessments

2. Change to extreme rainfall

Increases in rainfall intensity due to climate change is likely to effect river levels, particularly within smaller catchments (less than 5km^2) and on land and urban drainage systems.

There is still considerable uncertainty regarding the magnitude of changes locally. Typically, for flood management purposes the concern is less frequent (but greater impact) events such as those that have a 1 in 20 annual chance of occurring or rarer.

The allowances presented in **Table 3** should be used to assess and design FCERM projects, schemes and strategies in:

- small catchments less than 5km^2
- urban locations which are likely to have a lot of impermeable surfaces

Applies across all of Wales	**Total potential change anticipated for 2020s (2015-2039)**	**Total potential change anticipated for 2050s (2040-2069)**	**Total potential change anticipated for 2080s (2070-2115)**
Upper estimate	10%	20%	40%
Central estimate	5%	10%	20%

Table 3 - Change to extreme rainfall intensity compared to a 1961-90 baseline

Both the central and upper end allowances should be assessed to understand the range of impact. As a minimum, proposals should be assessed against the central allowance to inform design levels. As with river flood flows, it is recommended that the 2080s changes are used when considering any time beyond 2115. These ranges should be used in assessments in a similar way to the illustration (**Figure 1**) set out for river flows.

For river catchments over 5km^2, the peak flow ranges in **Table 2** should be used.

3. Change to relative mean sea levels

Indicative projections of sea level rise based on UKCP18 climate projections is presented in **Table 4**. These are provided for each local authority area up to 2100 and 2120 using RCP8.5, 70th and 95th percentiles. Location specific allowances, projections for different epochs and projections beyond 2100 can be obtained from the UK Climate Projections (Met Office) user interface.

The UKCP18 dataset projects to 2100. To calculate epochs beyond 2100, the average incremental increase from the last 5 years of the dataset for the site location should be used (2094 to 2099) from RCP8.5 and multiply by the required number of years after 2100.

The figures presented in **Table 4** for 2120 have been calculated using the average incremental increase for each local authority administrative area, multiplied by 20.

RMAs should use the relevant allowances in their scheme appraisals to help inform their investment decisions.

Local Authority Area	Allowance (percentile)	Mean sea level rise (metres) by 2100 *(UKCP18 baseline 1981-2000)	Mean sea level rise (metres) by 2120 *(UKCP18 baseline 1981-2000)
Flintshire	70th	0.76	0.99
	95th	1.03	1.33
Denbighshire	70th	0.75	0.98
	95th	0.95	1.29
Conwy	70th	0.75	0.98
	95th	1.01	1.35
Anglesey	70th	0.74	0.97
	95th	1.01	1.34
Gwynedd	70th	0.76	1.00
	95th	1.03	1.37
Powys	70th	0.79	1.03
	95th	1.06	1.41
Ceredigion	70th	0.80	1.04
	95th	1.07	1.42
Pembrokeshire	70th	0.83	1.08
	95th	1.10	1.46
Carmarthenshire	70th	0.83	1.08
	95th	1.09	1.45
Swansea	70th	0.84	1.09
	95th	1.11	1.47
Neath Port Talbot	70th	0.84	1.09
	95th	1.11	1.47
Bridgend	70th	0.84	1.09
	95th	1.11	1.47
Vale of Glamorgan	70th	0.85	1.11
	95th	1.11	1.47
Cardiff	70th	0.85	1.11
	95th	1.11	1.47
Newport	70th	0.85	1.11
	95th	1.11	1.47
Monmouthshire	70th	0.85	1.11
	95th	1.11	1.47

Table 4: Estimated mean sea level rise (in metres) expected for relevant local authority areas by 2100 and 2120. Allowances are based on RCP8.5 70th and 95th percentiles.

4. Storm surge

UKCP18 modelling has found no evidence to suggest significant changes in future storm surge.

There is no requirement at this time to incorporate an allowance for increased storm surge when estimating design flood levels for future scenarios.

5. Wave climate

There have been no changes made to wave climate projections within UKCP18. There remain large uncertainties in wave climate, especially with the projected extreme values.

Due to the significant uncertainty of both the future position of storm track over the UK and projections of wave climate, RMAs are advised to employ a sensitivity analysis to understand the impact on flood risk and coastal change. Recommended national precautionary sensitivity ranges for offshore wind speed and wave height up to 2120 are presented in **Table 5.** The allowances for 2085-2120 should be used for schemes beyond 2120.

Parameter	**1990-2025**	**2025-2055**	**2055-2085**	**2085-2120**
Offshore wind speed allowance	+5%		+10%	
Extreme wave height allowance	+5%		+10%	

Table 5 - Recommended national precautionary sensitivity ranges for offshore wind speed and wave height.

Annex 2
Worked Examples

This annex provides worked examples for applying climate change projections in Flood and Coastal Erosion Risk Management

The quantified information provided in Annex 1 sets out the climate change allowances to use when assessing future flood or coastal risks and uncertainty arising from climate change. The following river and coastal examples are provided to support Annex 1 and the wider principles set out within the guidance.

1. River Example

The example below provides guidance on how to apply the climate change allowances set out in Annex 1 for a proposed flood alleviation scheme within the West Wales River Basin District.

1. Derive site specific flood hydrology following the latest methods.

2. Apply the appropriate increases based on epochs of interest.

3. Test these against the upper bound increases to understand possible future impacts and scheme sensitivity to acceleration of climate change.

4. Use selected hydraulic model method to create flood extents, depths, etc

Proposed scheme located in the West Wales River basin district (1% AEP flow)					
Possible Managed Adaptive Epochs		Selected Increase for **all** Annual Exceedance Probabilities	Design Flow	Sensitivity or Mitigation testing for upper bound	Design Flow
Study Year	**2017**	**0%**	**185 cumecs**	**0%**	**185 cumecs**
+ 20 years	2037	+15%	213 cumecs	+25%	231 cumecs
+ 50 years	2067	+25%	231 cumecs	+40%	259 cumecs
+ 75 years	2092	+30%	241 cumecs	+75%	324 cumecs
+ 100 years	2117	+30%	241 cumecs	+75%	324 cumecs

Table 6 - Example Cumulative Fluvial Increase Calculation

2. Coastal Example

The example below provides guidance on how to apply the climate change allowances set out in Annex 1 for a coastal design level for a proposed flood alleviation scheme.

1. Determine required return period / standard of protection for defence e.g. 1:200yr.

2. Obtain appropriate tide level estimate for location being assessed from coastal flood boundaries dataset (CFB) e.g. T200 for Mumbles= 6.34m AOD.

Please note: Although the extreme sea levels from the CFB dataset are quoted to 2 decimal places, they are only considered accurate to 1 decimal place.

3. Determine epoch for climate change (i.e. defence life) for example defence life from 2020 to 2100 of 80years

4. Determine relevant regional sea-level rise values from **Table 4**, or obtain site specific values directly from the UKCP18 user interface (using RCP 8.5). It is recommended to use:

    - 70th percentile (higher central) as the **design allowance**. For example, the regional value for sea level rise at Mumbles to 2100 (Swansea) is 0.84m

    - 95th percentile (upper end) allowance in **sensitivity planning** for more severe climate impacts. For example, the regional value for sea level rise at Mumbles to 2100 (Swansea) is 1.11m

5. Add the relevant sea level rise value to the present-day tide level estimate to determine Design Level. For example, T200 (2100) for Mumbles (Swansea) would be:

Tide level estimate from CFB dataset of 6.34m AOD plus the 70th percentile SLR value for 2100 of 0.84m.
This is calculated as 6.34 + 0.84 = 7.18m AOD

The UKCP18 dataset projects to 2100. To calculate epochs from 2100 up to 2125, use the average incremental increase from the last 5 years of the dataset (years 2095 to 2099 from RCP8.5) and add this to the 2100 SLR value. **Table 4** provides regional calculations up to 2120.

For example, (using RCP8.5 70th percentile) sea level rise for Mumbles (Swansea) for 2120 (design life of 100yrs from 2020 to 2120) would be 0.84m (2100 value) + (20 yrs x the average incremental increase of 0.0126) 0.25 = 1.09m. The calculations are presented in Table 7 below.

Met Office 2100 dataset year	Incremental rise – 70th percentile (calculated from raw data)
2094 – 2095	0.012745
2095 – 2096	0.012419
2096 – 2097	0.012521
2097 – 2098	0.012947
2098 – 2099	0.012789
Calculated average annual increase (2095- 2099) in metres	**0.012684**

Calculated **average rise** 2020-2121	average annual rise x 20	0.25368 (0.25m)
2120 SLR allowance	2100 figure plus cumulative rise in metres	**1.09m** (0.84m + 0.25m)

Table 7: Sea Level Rise Calculations for Mumbles (Swansea) for 2120 (RCP8.5, 70th percentile)

Note: the figures in this table are taken directly from the Met Officer user interface (raw data). To present the average rise and final SLR allowance, the figures have been rounded to 2 decimal points.

6. To determine Sea Level Rise beyond 2125, use the "Exploratory Method 2007 – 2300" section of the User Interface. For reference, sea level rise at Mumbles (Swansea) in 2150, based on RCP8.5 70th percentile value is projected to be 1.41m using this dataset.

Please note: The estimates provided from the CFB dataset are known as "still water levels". The impact of any localised wave action at the site being assessed will also need to be considered as part of the coastal engineering design, as well as any allowance for freeboard. *(N.B. With an increase in sea level due to climate change, water depths at the toe of a Sea Defence will increase. In some cases, the effect of "depth-limitation" on wave heights could be reduced, allowing larger waves to impact on the defence).*