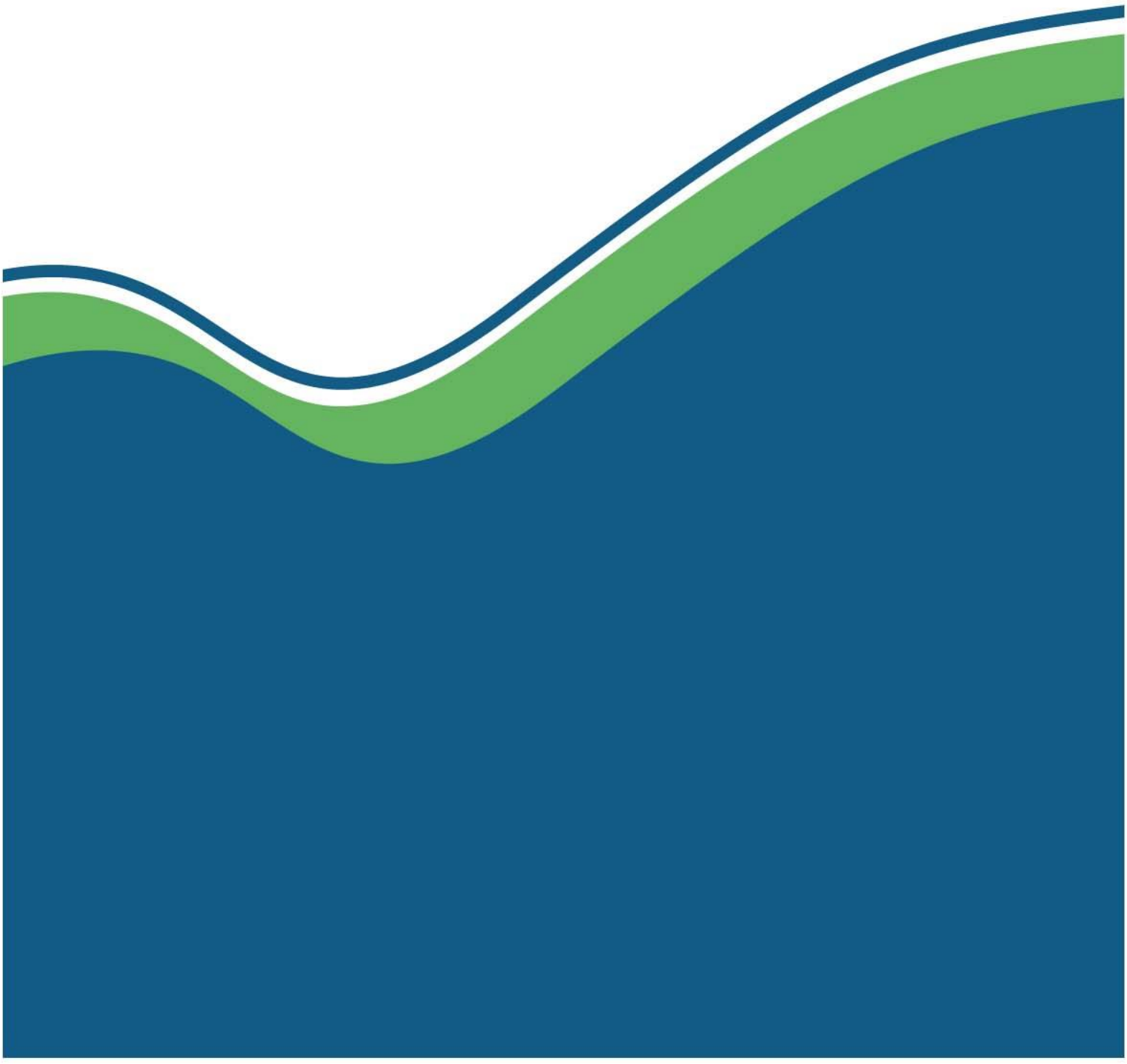
SEPA
Scottish Environment Protection Agency

Climate change allowances for flood risk assessment in land use planning



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Climate change allowances for flood risk assessment in land use planning		

Update Summary

Version	*Description*
Version 1	Not applicable

Notes

This document provides SEPA guidance on land use planning and flood risk. It is based on SEPA's interpretation of national planning policy and duties and requirements under relevant legislation.

This document is uncontrolled if printed. Always refer to the online document for accurate and up-to-date information.

Contents

1. What is the purpose of this guidance?

This guidance sets out recommended allowances for climate change that can be applied to Flood Risk Assessments submitted in support of planning applications and Strategic Flood Risk Assessments to inform the spatial strategy of development plans. It supersedes our previous advice on climate change allowances for flood risk assessment in land use planning.

This guidance represents a big step forward in ensuring that planning authorities in Scotland underpin their land use planning decisions with the best evidence available. It will be updated to take on board feedback from users and as the evidence on climate science evolves.

The information in this guidance is supported by a Technical Background Paper (Appendix 2), which sets out the climate science and modelling assumptions that underpin the recommended allowances.

The allowances are available to view in mapped form here.

2. Delivering climate resilient places

If Scotland is to be a successful country where our communities and businesses can flourish we need to ensure that we create places that are well adapted to climate change so they can stand the test of time. It is widely accepted that climate change is now affecting every country on Earth through changing weather patterns, sea level rise and more extreme weather events. It is vital that we understand the potential implications of these changes in Scotland for flood risk if we are to ensure the resilience and wellbeing of our communities and businesses for the future. This guidance provides decision makers with information on the most likely implications of future climate change on flood risk across Scotland based upon the best science available.

There is evidence that climate change is already affecting Scotland. The average temperature in the 2000s was 0.9°C warmer than the 1961 - 1990 average, and warmer than any other decade since records began in 1910, and annual rainfall has increased by around 11% over the past century. As demonstrated during the winter of 2015-2016, extreme weather and flooding are immediate and major climate risks and in the longer term, sea level rise is also likely to be an important risk for Scotland[1].

Considering climate change adaptation in land use planning is essential: an early understanding of potential future impacts reduces risk associated with long term investment decisions. This guidance should therefore be of particular interest to planning authorities in

[1] Scotland's Climate Change Plan, Scottish Government, February 2018

considering the implications of flood risk in planning decisions. Scottish Planning Policy 2014 (SPP) recognises that climate change will increase the risk of flooding in some parts of the country, and that the planning system should promote a precautionary approach to flood risk, taking account of the predicted effects of climate change. This guidance helps planning authorities and others involved in the assessment of flood risk implement this approach.

3. Policy Context

The Climate Change (Scotland) Act 2009 places duties on public bodies to contribute to climate change mitigation, climate change adaptation, and to act sustainably. Within the context of land use planning, climate change adaptation is defined in SPP as "the adjustment in economic, social or natural systems in response to actual or expected climatic change, to limit harmful consequences and exploit beneficial opportunities"[2].

SPP recognises that climate change will increase the risk of flooding in some parts of the country, and that the planning system should promote a precautionary approach to flood risk, taking account of the predicted effects of climate change. Scottish Government guidance on Delivering Sustainable Flood Risk Management identifies land use planning decisions as one of the most powerful tools available to manage flood risk.

The following sections provide guidance on recommended climate change allowances for river, coastal and surface water flooding based upon the current evidence base.

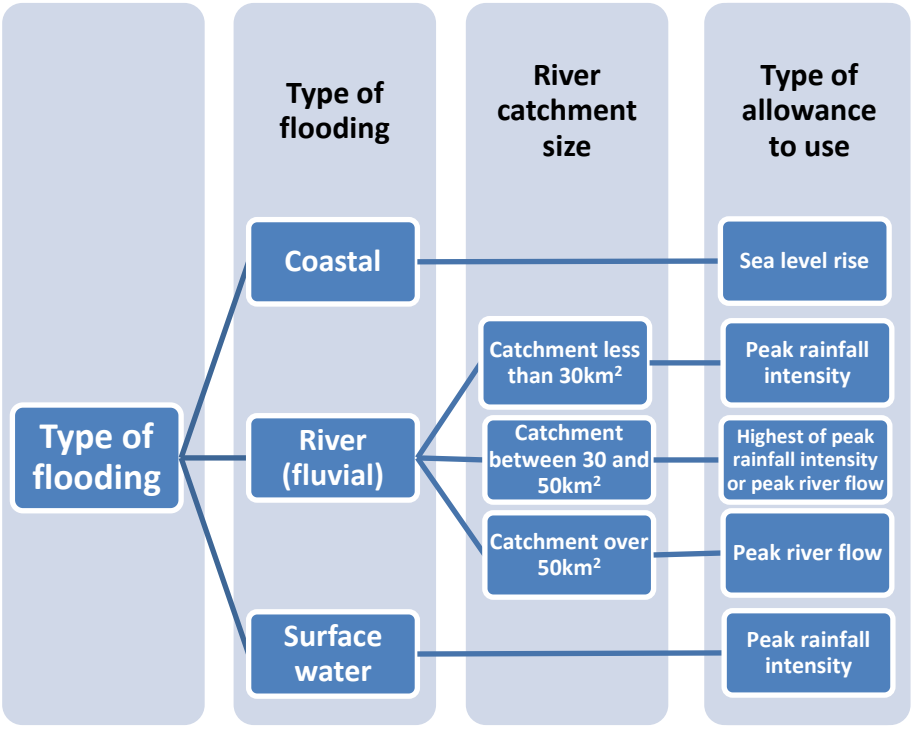
[2] SPP, Scottish Government, 2014 (Glossary, p71)

4. What is a 'climate change allowance' and what type of allowance should be used?

A climate change allowance is a prediction of anticipated change in peak river flow, peak rainfall intensity and sea level rise caused by future climate change. The type of allowance used will depend upon the type of flooding being considered and, for river (fluvial) flooding, the size of catchment. A summary is provided below with links to the relevant sections of this guidance.

Type of allowance	When to apply
Peak river flow	River (fluvial) flooding in larger catchments
Peak rainfall intensity	River (fluvial) flooding in smaller 'flashy' catchments and for surface water flooding
Sea level rise	Coastal flooding

The following diagram helps you identify the appropriate type of climate change allowance to use in your flood risk assessment.



5. Types of allowance

5.1 Peak River Flow

Peak river flow allowances should be used for:

- River catchments greater than 50km^2
- River catchments between 30km^2 and 50km^2 where peak river flow uplift is greater than the peak rainfall intensity uplift

5.1.1 Background

In 2011 we commissioned The Centre for Ecology and Hydrology (CEH) to undertake a study of the regional impacts of climate change on flood flows. The study entitled, "An assessment of the vulnerability of Scotland's river catchments and coasts to the impacts of climate change", (referred to as 'CEH 2011 study' henceforth), was based upon the UK Climate Projections 2009 (UKCP09). The figures presented in Table 1 reflect both the regional differences identified within the UKCP09 projections and how catchments respond to climate change.

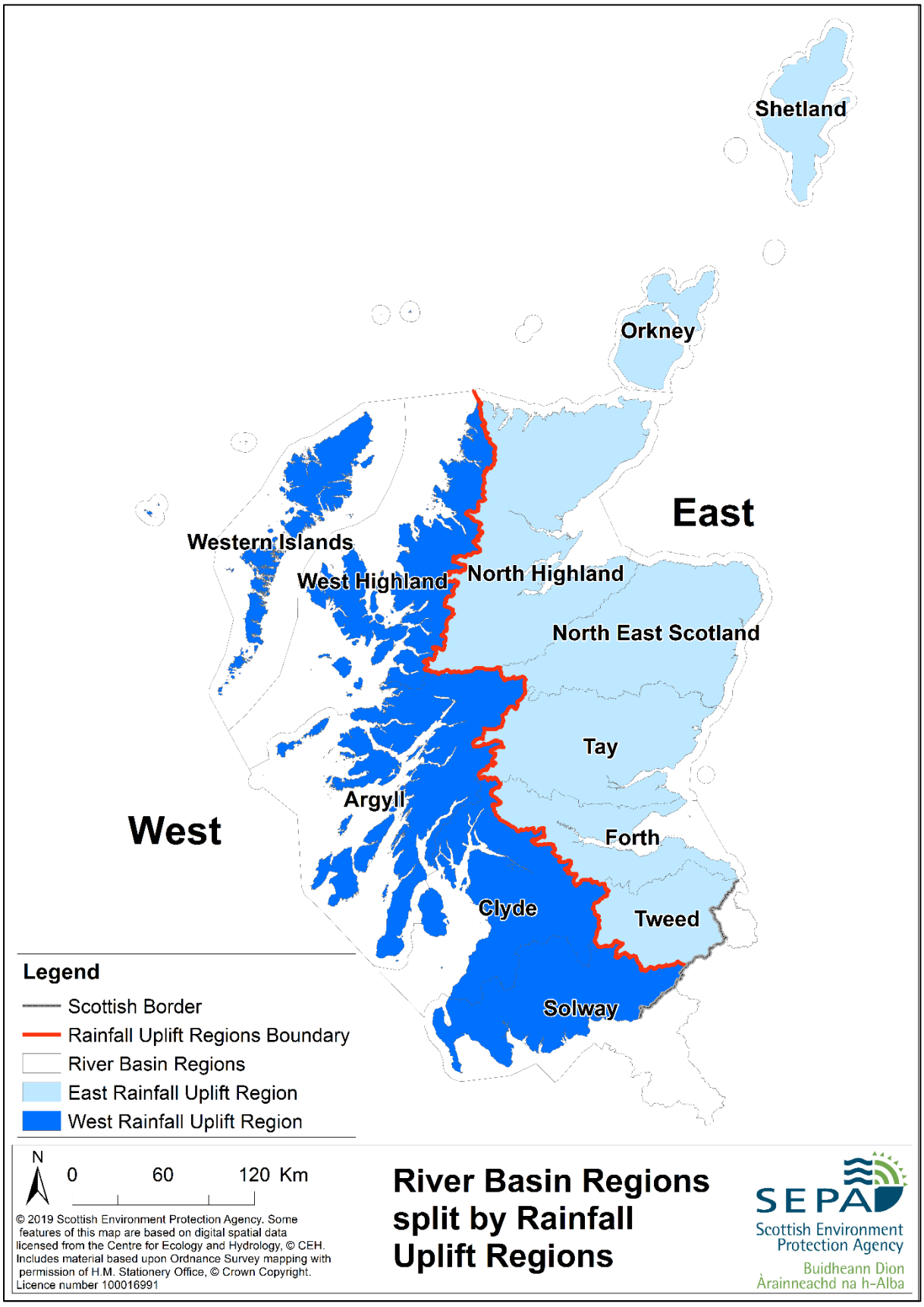
5.1.2 How the allowances should be applied

Use Map 1 to determine which River Basin Region is applicable to your assessment, then apply the relevant regional flow allowance from Table 1 below. Alternatively, you can use the web map to identify the applicable allowance.

Table 1: Peak river flow allowances by River Basin Region

River Basin Region	Total change to the year 2100
Argyll	56%
Clyde	44%
Forth	40%
North East	24%
North Highland	37%
Orkney	41%
Shetland	41%
Solway	44%
Tay	35%
Tweed	33%
Western Isles	56%
West Highlands	56%

Map 1


Shetland
Orkney
East
Western Islands
West Highland
North Highland
North East Scotland
Tay
Argyll
West
Forth
Clyde
Tweed
Solway
Legend
Scottish Border
Rainfall Uplift Regions Boundary
River Basin Regions
East Rainfall Uplift Region
West Rainfall Uplift Region
N
0
60
120 Km
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River Basin Regions split by Rainfall Uplift Regions
SEPA
Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

5.2 Peak rainfall intensity

Peak rainfall intensity allowances should be used for:

- River catchments smaller than 30km^2
- River catchments between 30km^2 and 50km^2 where peak rainfall intensity uplift is greater than the peak river flow uplift
- Surface water flooding

5.2.1 Background

Rainfall allowances can be used to provide a more accurate estimation for fluvial uplifts in small 'flashy' catchments. Small watercourses are impacted because of the high volume of runoff relative to their channel capacity. Increases in rainfall intensity due to climate change are likely to result in an increase in the severity and frequency of flooding incidents on small watercourses. Rainfall allowances should also be applied when considering surface water flooding and drainage assessments.

Research undertaken by UK Water Industry Research in 2017[2] (referred to as 'UKWIR 2017 study' henceforth), provides the most recent analysis of predicted increase in rainfall intensity due to climate change.

5.2.2 How the allowances should be applied

Use Map 1 to determine which rainfall uplift region is applicable to your assessment, then apply the relevant allowance from Table 2 below – this should be done by adjusting the design rainfall by the relevant allowance within a rainfall-runoff method (further information can be found in our Technical Flood Risk Guidance for Stakeholders). Alternatively, you can use the web map to identify the applicable allowance.

Please note that the majority of watercourses in the Western Isles, as well as in Shetland and Orkney, will be in small catchments, and the peak rainfall uplift in Table 2 will therefore be applicable rather than the fluvial uplift value in Table 1.

Table 2: Peak rainfall intensity allowance

Region	Total potential change for 2100
East	35%
West	55%

[2] UK Water Industry Research, Report reference number 17/CL/10/17, Rainfall intensity for sewer design – Stage 2, Guidance for water companies, 2017

5.3 Sea level rise

Sea level rise allowances should be used for:

- Coastal flooding

5.3.1 Background

Changes in sea level rise are driven by the thermal expansion of the ocean as well as the addition of water through global ice melt. Within Scotland, these impacts are being partially offset by glacial isostatic rebound - the ongoing rise of land formally depressed by the huge weight of ice sheets during the last glacial period. Isostatic rebound is the key driver for the differences in the rate of cumulative rise shown in Table 3. The allowances set out in Table 3 give the cumulative sea level rise from 2017 to 2100 based on the outputs from UK Climate Projections 2018 (UKCP18). However, given that sea level rise will continue well beyond the end of the 21st century, we recommend that an additional allowance of 0.15m per decade after the year 2100 be applied where the design life of a development is known to extend beyond that date. Further information can be found here.

Information on offshore wave climate and storm surges is provided in Appendix 2.

We expect sea level rise to increase the rate of coastal erosion. Scotland's National Coastal Change Assessment can be used to identify areas of coastline that are potentially vulnerable to erosion.

5.3.2 How the allowances should be applied

Use Map 1 to determine which River Basin Region is applicable to your assessment and then apply the appropriate sea level rise figure from Table 3 below and add to the baseline coastal flood level[3] for the relevant location. Alternatively, you can use our web map to identify the applicable allowance. Please note that the additional 0.15m allowance per decade beyond 2100 is not displayed on the web map.

[3] Coastal design (or flood) levels are derived from the Coastal Flood Boundary (CFB) dataset.

Table 3: Sea level rise allowance by River Basin Region

River Basin Region	Cumulative rise (in metres) from 2017 to 2100
Argyll	0.86
Clyde	0.85
Forth	0.86
North East	0.87
North Highland	0.89
Orkney	0.93
Shetland	1.02
Solway	0.88
Tay	0.85
Tweed	0.89
Western Isles	0.93
West Highland	0.89

Further assistance

Please contact our Planning team using the contact details at the following link should you require any further clarification as to how to apply this guidance: https://www.sepa.org.uk/media/159226/planning_service_contact_list.pdf

Appendix 1: Worked examples

Example 1: Fluvial – construction of a new industrial park in Ellon adjacent to the functional flood plain of the River Ythan

River Basin Region	Type of allowance	Applicable climate change uplift value
North East	Peak river flow	24%

Comments: Ellon is within a larger river catchment (>50km^2) in the North East River Basin Region. The peak river flow allowance for the North East Region should therefore be applied, which is 24%.

Example 2: Surface Water – construction of a new care home in a part of Glasgow that is subject to surface water flooding

Rainfall Uplift Region	Type of allowance	Applicable climate change uplift value
West	Peak rainfall intensity	55%

Comments: There are only two regional peak rainfall allowances for Scotland that should be applied for surface water flooding. Glasgow is within the West rainfall region. The applicable climate change uplift value is therefore 55%.

Example 3: Coastal – conversion of an industrial dockside building to residential use in Leith

River Basin Region	Type of allowance	Applicable climate change uplift value
Forth	Seal level rise	0.86m

Comments: The site is affected by coastal flooding and therefore the sea level rise allowance should be used. As Leith falls within the Forth River Basin Region, the appropriate allowance is 0.86m to 2100.

Appendix 2: Technical Background Paper

1. *Why is SEPA no longer recommending a universal 20% allowance for climate change?*

For a number of years prior to the publication of this guidance we recommended a 20% allowance for climate change be applied to Flood Risk Assessments and Strategic Flood Risk Assessments. This was based on Department for Environment, Food & Rural Affairs (DEFRA) guidance published in 2006[4]. However, we now have better scientific information at our disposal, necessitating the development of a new approach to ensure that our recommendations are based upon the best and most up-to-date science.

2. *How does the guidance make use of the UK Climate Projections 2018?*

The allowances for sea level rise are based on the outputs from UK Climate Projections 2018 (UKCP18).

However, for peak river flows, further work is required to translate the UKCP18 projections for rainfall and temperature into allowances for this guidance. Together with the Environment Agency we have commissioned The Centre for Ecology and Hydrology (CEH) to produce new projections for flood flows for catchments larger than 100km^2 using UKCP18. Until such time as the new projections are available the allowances in this guidance are based upon the regional uplifts from the CEH 2011 study, which used the UK Climate Projections 2009 (UKCP09).

For peak rainfall intensity, the current outputs from UKCP18 do not provide projections for short duration heavy rainfall that can cause surface water flooding and flooding in flashy catchments. It is anticipated that these will be released by the UKCP18 project in mid-2019, and additional research will be carried out to translate these into a format suitable for use in this guidance. In the meantime, this guidance makes use of the most up-to-date projections for short duration high intensity rainfall from the UKWIR 2017 study.

3. *Which emissions scenarios are used in the guidance?*

All of the allowances used in this guidance are based on scenarios assuming limited efforts to mitigate climate change, so that greenhouse gas levels in the atmosphere will continue to increase. For allowances based on UKCP18, the scenario used is Representative Concentration Pathway 8.5 (RCP 8.5), which is used in the Intergovernmental Panel on Climate Change's 5th Assessment report (IPCC AR5). Allowances based on UKCP09 use the UKCP09 High Emissions Scenario, which is based on the Special Report on Emissions Scenarios

[4] Flood and Coastal Defence Appraisal Guidance, FCDPAG3 Economic Appraisal, Supplementary Note to Operating Authorities – Climate Change Impacts, Department for Environment, Food and Rural Affairs, 2006

A1FI scenario used in the Intergovernmental Panel on Climate Change's 4th Assessment report (IPCC AR4), and is the most similar to RCP8.5 in terms of global temperature rise. In RCP8.5 the best estimate global average temperature rise is 4.3°C above pre-industrial levels by 2100. Further information on the emissions scenarios used in the UK Climate Projections are available through the UKCP18 website.

In basing the guidance upon these scenarios, we acknowledge that the 2015 Paris Agreement commits 137 countries to limiting their carbon emissions with the aim of holding global temperature rise to well below 2°C above pre-industrial levels, and pursuing efforts to limit the rise to below 1.5°C. The Scottish Government is fully committed to meeting the Paris Agreement and introduced a new Climate Change Bill to Parliament on 23 May 2018. The Bill amends the Climate Change (Scotland) Act 2009, and will immediately increase the 2050 emission reduction target from 80% to 90% by 2050. However, we have opted to base the guidance on these scenarios given that the intended nationally determined contributions of those countries signed up to the Paris Agreement suggest that we are currently on a higher emissions pathway than 2°C[5]. We consider this to be an appropriately precautionary approach for this guidance given that it will help to inform significant and long lasting land use planning decisions.

4. ***UK climate projections, and the studies undertaken by CEH and UKWIR provide a range of allowances. How have the single allowances in the guidance been selected?***

Please note, the climate change projections relevant for different sources of flooding have been calculated in different ways, and are not directly comparable.

The peak river flow allowances are based on UKCP09 land projections for temperature and precipitation. These projections are probabilistic and simulate a wide range of possible climate outcomes for each emissions scenario. The CEH 2011 study used these projections to produce probabilistic estimates for change in flood flows for 30-year epochs. The peak river flow allowances are based on the 67th percentile for the 2080s epoch (2070-2099). This percentile is considered unlikely to be exceeded – it is the point at which 67% of the possible scenarios fall below it and 33% fall above it.

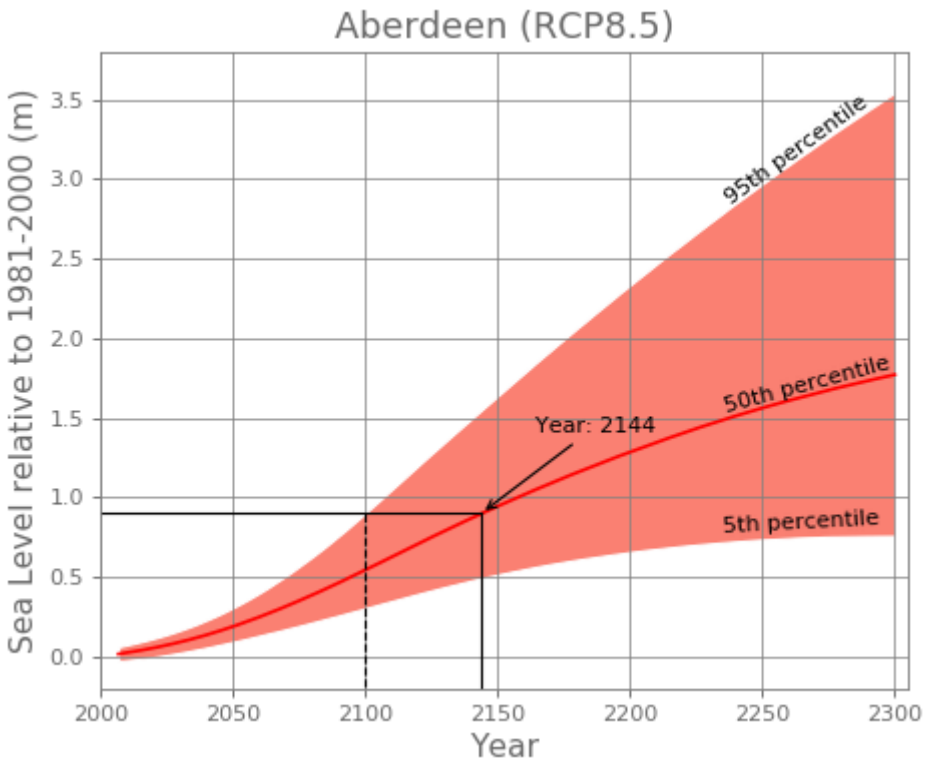
Sea level rise allowances for each River Basin Region have been calculated from the 95th percentiles for sea level rise for 2100 from UKCP18. The 95th percentile is considered very unlikely to be exceeded – it is the point at which 95% of the possible scenarios fall below it and 5% fall above it. These use a simpler approach to quantifying uncertainty than the land projections. However, there is additional uncertainty associated with ice sheet dynamics that

[5] https://climateactiontracker.org/global/temperatures/

is not fully taken account of in the projections – for further details please see the UKCP18 Marine Report.

Under all emissions scenarios, sea level rise continues beyond the end of the 21st century, so that the 95th percentile for 2100 is lower than the 50th percentile (best guess) estimate of sea level rise by 2150 across Scotland. This is demonstrated in Figure 1 below, which shows sea level rise projections to 2300 for Aberdeen (North East River Basin Region): 2144 is the year at which the 95th percentile for 2100 becomes a less conservative estimate than the 50th percentile best guess estimate. It is for this reason that we have provided the 95th percentile allowances for sea level rise in the guidance.

Figure 1: UKCP18 sea level rise projections to 2300 for Aberdeen - the black lines show where the 95th percentile for 2100 becomes lower than the 50th percentile of best guess in the future.



The peak rainfall intensity allowances are based upon the central estimate for the 2080s epoch from the UKWIR 2017 study. These are based on more limited information than the peak river flow and sea level rise allowances, and the upper allowance in the UKWIR 2017 study is provided for sensitivity testing only.

5. ***How did you select the catchment size thresholds used for the peak river flow and rainfall intensity allowances?***

The CEH 2011 study used for the peak river flow allowances is based on running hydrological models for a number of catchments with good gauge records to determine their sensitivity to climate change. The smallest catchment modelled in the CEH 2011 study is 30km^2 and there are only 10 catchments included in the study with an area <100km^2, so the study does not represent small catchments well. In addition, use of the UKCP09 daily data means that changes in short duration rainfall, which can cause flooding in rapidly responding catchments, are not well represented by the study. We have therefore suggested that for catchments smaller than 30km^2, peak rainfall intensity allowance should be used instead of peak river flow. Catchments smaller than 50km^2 are also not well represented in the study, and therefore the guidance suggests sensitivity testing for catchments between 30km^2 and 50km^2 in order to determine whether peak river flow or peak rainfall intensity allowances should be used.

6. ***How can I confirm the size of the catchment for the site or area I am interested in?***

Catchment size information can be obtained by registering with The Centre for Ecology & Hydrology's Flood Estimation Handbook Web Service.

7. ***Why have allowances not been provided for the offshore wave climate or storm surges?***

Changes in the offshore wave climate or the size and number of storm surges affecting Scotland are uncertain, but are expected to have a much smaller effect on coastal flood risk than sea level rise. The UKCP18 Marine Report estimates that changes in extreme sea levels due to changes in storm surge will be an order of magnitude smaller than changes in extreme sea levels due to changes in mean sea level.

The size of waves at the coast is often limited by water depth, so for many sites sensitive to wave overtopping, the increase in mean sea level will have a greater impact on overtopping rates than any change in offshore wave climate. For sites where wave overtopping is expected to be sensitive to changes in the offshore wave climate, a sensitivity test to a 10-20% increase in extreme offshore wave heights is recommended based on the range of changes in offshore wave climate reported in the UKCP18 Marine Report.

8. ***The allowances cover the time period until 2100 - how should the allowances be applied to developments with a shorter or longer predicted design life?***

We have provided allowances until 2100, approximately 80 years from now. We consider it reasonable to assume that most development built now should be designed to last for *at least*

80 years. However, allowances for other timeframes are available where there is certainty that a particular development has a shorter, fixed design life.

For peak river flow, allowances for the period 2040-2069 can be found in Appendix C of the summary report of the CEH 2011 study. Only projections for the medium emissions scenario are available for this time period, however differences in rainfall and temperature projections between the medium and high emissions scenarios are relatively small until the middle of the 21st century. For consistency with the allowances out to 2100 provided in this guidance, it is recommended that the 67th percentile is used.

For sea level rise, allowances for time periods up to 2100 can be taken directly from the UKCP18 user interface for the time period of interest. For the time period beyond 2100, we have recommended an additional allowance of 0.15m per decade in section 5.3 of the guidance, to be applied in addition to the appropriate cumulative rise allowance for 2017 to 2100; for consistency, this was derived from the 95th percentile estimate for RCP8.5. However, given the uncertainty inherent in this estimate, you may consider it more appropriate to use lower percentiles for the time period beyond 2100, dependent upon the adaptability of the proposed development.

For peak rainfall intensity, allowances for the period 2040-2069 can be taken directly from the UKWIR 2017 study. For consistency with the allowances out to 2100 provided in this guidance, it is recommended that the central estimate is used.

However, for most development we consider it unlikely that a precise and fixed design life will be known from the outset, and therefore that the 2100 allowances provide a suitably precautionary approach.

9. How should the allowances be applied to developments that are likely to be particularly vulnerable to climate change?

For developments that are likely to be particularly vulnerable to climate change, we recommend that additional sensitivity testing be carried out as follows:

- for peak river flows, sensitivity testing is carried out to the 90th percentile flow uplift for 2100 for the high emissions scenario from the CEH 2011 study.
- for peak rainfall intensity, sensitivity testing is carried out to the high estimate for 2100 from the UKWIR 2017 study.
- for sea level rise, sensitivity testing is carried out to the H++ sea level rise estimate from UKCP09[6]. Beyond 2100, the higher estimate of the 95th percentile from the UKCP18 exploratory projections for RCP8.5 and the UKCP09 H++ estimate should be used.

[6] UK Climate Projections science report: Marine and coastal projections, Met Office Hadley Centre, Exeter, UK Lowe et al., 2009.

10. When will the guidance be updated?

The guidance will be updated based upon feedback from users and as new evidence on climate science evolves. When the guidance is updated we will inform key stakeholders including flood risk consultants and planning authorities.

11. Are the allowances in the guidance available in mapped form?

The allowances are available to view in mapped form here. The allowances are not reflected in the indicative outline of our Flood Maps at present, but we plan to make such indicative map outlines available in the near future. We will let key stakeholders know when this information is available and how to access it.

12. How does the guidance link to SEPA's Technical Flood Risk Guidance for Stakeholders?

We have updated this guidance to make reference to our new climate change guidance.

13. How does the guidance relate to the climate change allowance required in SEPA's Planning Guidance on Development Protected by Flood Protection Schemes?

Our planning guidance sets out our position on development protected by flood protection schemes. For certain types of development we require an allowance for climate change to be included in the standard of protection offered by a scheme. Until now, our requirement has been for a 20% allowance for climate change, based on DEFRA guidance as explained in Question 1 of this Technical Background Paper. In the short to medium term, we consider it pragmatic to continue to require a 20% allowance as a minimum, with the allowances set out in this guidance that are greater than 20% being recommendations only. In the longer term, we will review how well the new allowances are being understood and utilised by stakeholders, and in consultation with key partners, consider revisiting our approach.

In the meantime, planning authorities should carefully consider the implications of applying the 'minimum 20%' climate change allowance to development protected by flood protection schemes. In particular, planning authorities should consider the intended design life of the proposed development if known, whether the flood protection scheme can be adapted to increase its standard of protection at a later date, and the magnitude of the variation between the 'minimum 20%' and the new recommended allowance (for example the peak river flow allowance for the River Clyde is 44%, considerably higher than 20%).

14. Does the guidance apply to modelling climate change allowances for new flood risk management measures?

Due to the uncertainties in projecting future levels of flood risk, the Scottish Government Options Appraisal Guidance for Flood Risk Management recommends that flood protection measures are designed, wherever possible, so that they can be adapted in future (this is known as the managed adaptive approach). Potential flood risk management measures are therefore likely to require assessment against a number of different future scenarios and timescales – so although use of the same climate change projections that have been used to develop this guidance is also recommended for flood schemes, it is not recommended that flood protection measures are solely tested against a single climate change allowance.

We are currently developing separate advice on the application of climate change allowances for flood risk management measures. In the meantime, measures should be tested against a range of emissions scenarios, probability levels and timeframes from the following sources:

- Fluvial: CEH 2011 study
- Pluvial: UKWIR 2017 study
- Sea Level Rise: UKCP18