Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

For the future of our environment

Climate change allowances for flood risk assessment in land use planning

Version 6

Issued date: 25 February 2025

Update Summary

Version	Description
Version 2	Update to peak flow and peak rainfall allowances
Version 3	Updates to reflect NPF4 adoption
Version 4	Update to Appendix 2: Question 11 re. November 2023 update to coastal flood maps in Outer Hebrides
Version 5	Update to sentence in Appendix 2, FAQ 9, to ensure the correct report is referenced.
Version 6	Update to Appendix 2: Question 11 re: future surface water flood maps Update to Section 2 paragraph 2 on climate, Table 3 header description, and Section 5.2.2 to reflect information in Appendix 4 Question 2. Update formatting style.

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

Contents

1. Purpose of the guidance

This guidance sets out required allowances for climate change that must be used for flood risk assessment following the adoption of National Planning Framework 4 in February 2023. It allows planning authorities in Scotland to 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: Technical background paper), which sets out the climate science and modelling assumptions that underpin the required allowances.

The allowances are available to view in mapped form in the webmap.

2. Delivering climate-resilient places

If Scotland is to be a successful country where our communities and businesses 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 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 last decade (2014-2023) was 1.02°C warmer than the 1961 - 1990 average, and annual average rainfall for the same period was 10% higher than the 1961-1990 average[1]. Sea level rise is also likely to be an important risk for Scotland, with the mean sea level around the UK having risen by approximately 1.4 mm/year from the start of the 20th century[2].

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[1] Climate change projections for Scotland - Summary, based on Met Office analysis (updated March 2024): Climate change trends and projections - Adaptation Scotland.

[2] Climate Projections for Scotland – Summary, 2021, based on Met Office analysis: Climate change trends and projections - Adaptation Scotland

Considering climate change adaptation in land use planning is essential and an early understanding of potential future impacts reduces the risk associated with long term investment decisions. Policy 22 in NPF4 aims to ensure that places are resilient to current and future flood risk. This guidance supports planning authorities and other stakeholders involved in the assessment of flood risk in achieving this outcome.

3. Policy context

National Planning Framework 4 (February 2023) updates the Scottish Planning Policy (2014) definition of 'functional floodplain', or 'area at risk of flooding' to the following:

"For planning purposes, at risk of flooding or in a flood risk area means land or built form with an annual probability of being flooded of greater than 0.5% which must include an appropriate allowance for future climate change. This risk of flooding is indicated on SEPA's future flood maps or may need to be assessed in a flood risk assessment. An appropriate allowance for climate change should be taken from the latest available guidance and evidence available for application in Scotland. The calculated risk of flooding can take account of any existing, formal flood protection schemes in determining the risk to the site".

SEPA's Future Flood Maps are indicative and provide a useful screening tool (along with any other information available on flooding) to understand where a proposed development may be at flood risk. Where a potential flood risk is identified any subsequent planning applications must be supported by a flood risk assessment which uses the climate change allowances within this guidance to calculate the area "at risk of flooding or in a flood risk area". Information on the key differences between the Future Flood Maps and the climate change allowances included in this guidance can be found in response to Question 11 of the Technical Background Paper.

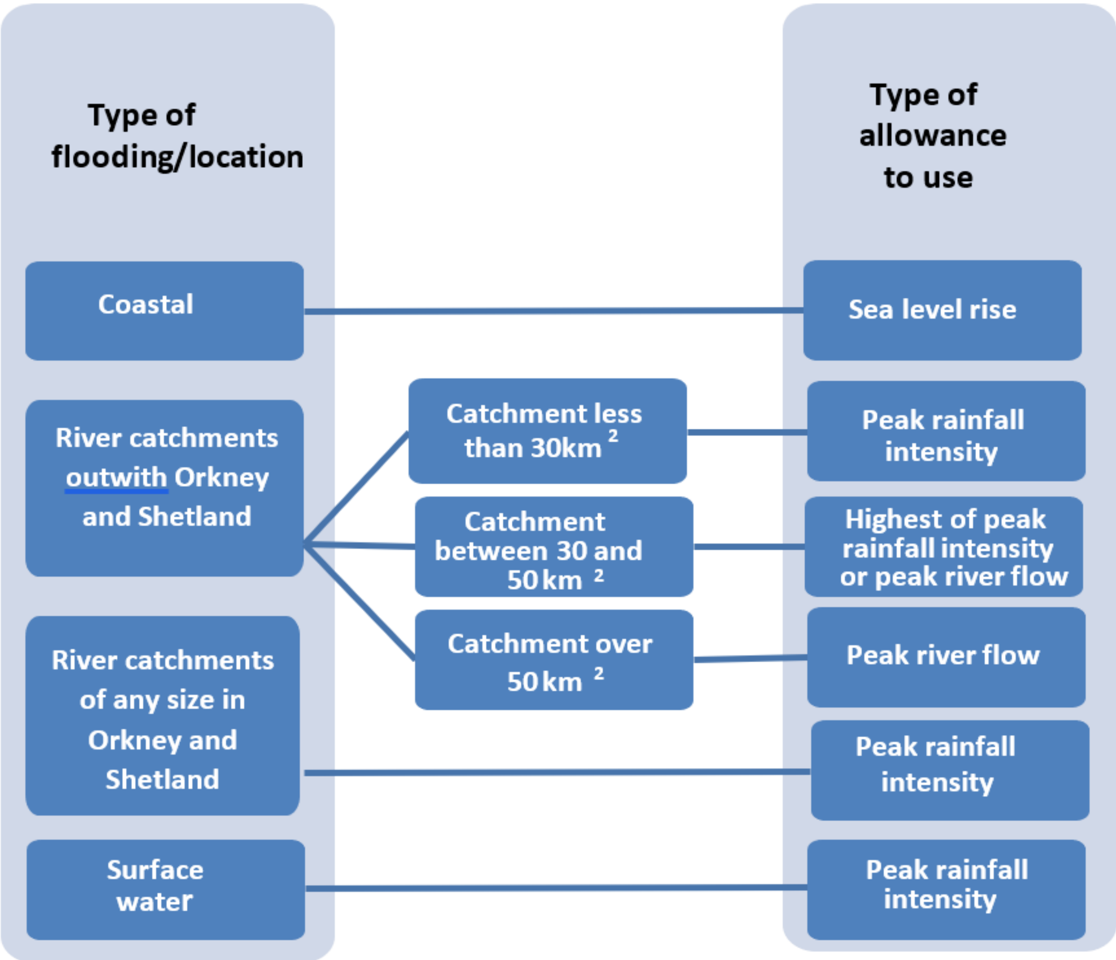
The Climate Change (Scotland) Act 2009 places duties on public bodies to contribute to climate change mitigation, climate change adaptation, and to act sustainably. Scottish Government guidance on Delivering Sustainable Flood Risk Management identifies land use planning decisions as one of the most powerful tools available to manage flood risk. The following sections provide guidance on required climate change allowances for river, coastal and surface water flooding based upon the current evidence base.

4. Climate change allowances and when they should be used

A climate change allowance is a prediction of anticipated change in peak river flow, peak rainfall intensity or 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 or location. A summary is provided below with links to the relevant sections of this guidance.

Figure 1 identifies the appropriate type of climate change allowance to use in a flood risk assessment.

Figure 1: Type of climate change allowance to use in a 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 excluding catchments in Orkney and Shetland.
- River catchments (excluding those in Orkney and Shetland) between 30km^2 and 50km^2 where the peak river flow uplift is greater than the flow increase resulting from using the peak rainfall intensity uplift.

5.1.1 Background

A 2020 study commissioned by the Environment Agency (and contributed to by SEPA to ensure outputs covered Scotland) was carried out by the UK Centre for Ecology and Hydrology to assess the impact of climate change on fluvial flood peaks (this study is referred to as 'CEH 2020 study[3]' henceforth). The CEH 2020 study was itself based upon the UK Climate Projections 2018 (UKCP18).

The figures presented in Table 1 reflect both the regional differences identified within the UKCP18 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** overleaf. Alternatively, you can use the webmap to identify the applicable allowance.

For river catchments between 30km^2 and 50km^2 a comparison of the peak flow and peak rainfall intensity uplift is required to determine which is the greater. Where required, this can

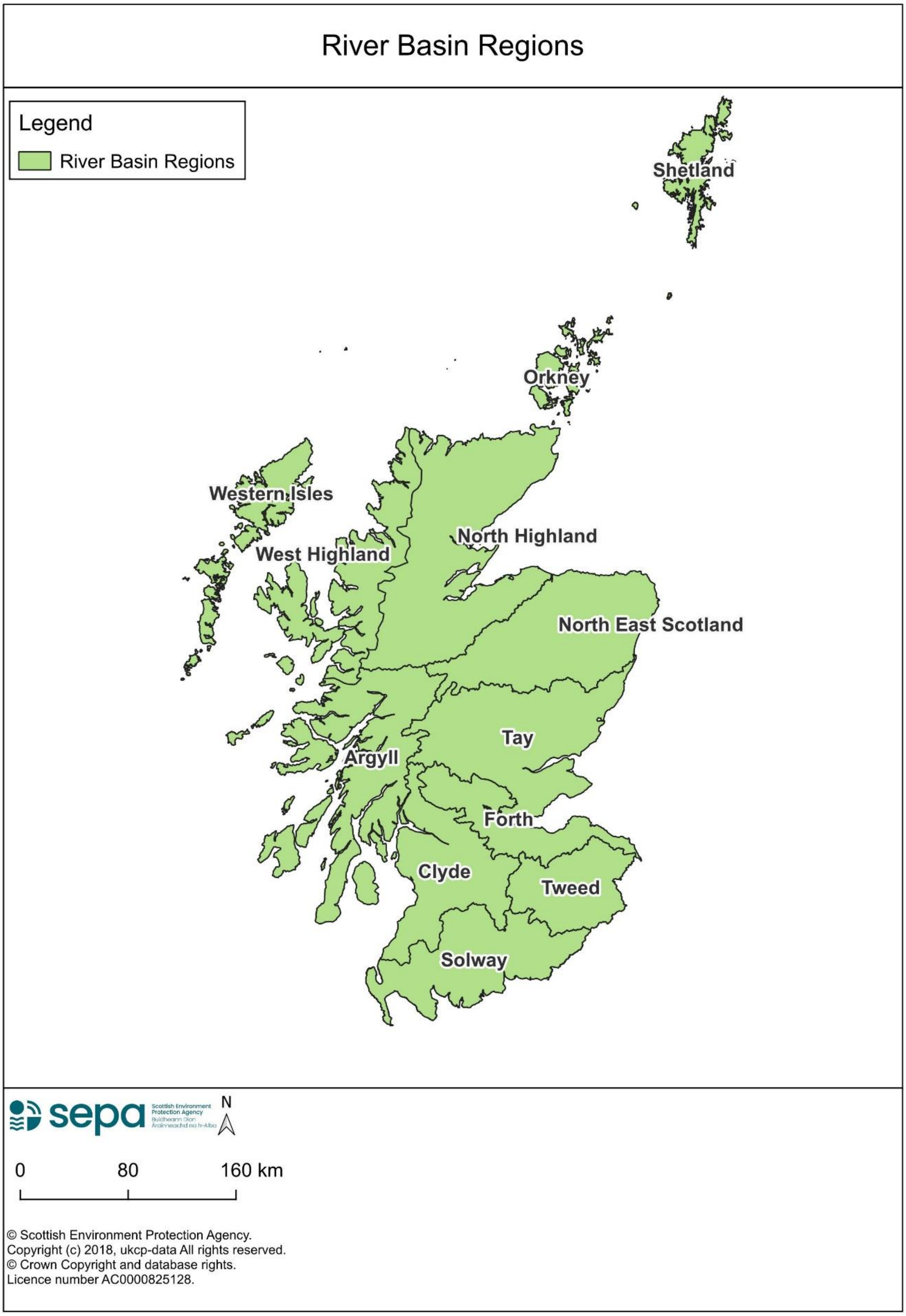
[3] Kay, A.L., Rudd, A.C., Fry, M., Nash, G., Allen, S. 2021. Climate change impacts on peak river flows: combining national-scale hydrological modelling and probabilistic projections. Climate Risk Management 31 (2020).

be done using an appropriate rainfall runoff model (e.g., ReFH2 or FEH R-R) to apply the rainfall intensity uplift, and the resultant increase in flow (compared with the baseline scenario) compared with the peak river flow allowance. Note that this does not in any way inform whether statistical or rainfall runoff methods offer the most suitable flow estimation approach for the catchment; this is only to determine whether the climate change uplift should be taken from the pre-determined flow uplifts (the peak river flows), or from an event-scale determination of the flow uplift from a rainfall runoff model. Either peak flow uplift can then be applied to statistical approaches, where those are most appropriate for the catchment. Further guidance on how this should be done can be found in Question 21 and a worked example can be found in Appendix 1: Worked Examples.

Table 1: Peak river flow allowances by River Basin Region

River Basin Region	Total change to the year 2100 (%)
Argyll	59
Clyde	49
Forth	56
North-East Scotland	34
North Highland	40
Orkney	Use peak rainfall intensity allowance - see Figure 1
Shetland	Use peak rainfall intensity allowance - see Figure 1
Solway	53
Tay	53
Tweed	59
Western Isles	58
West Highland	58

Map 1: River Basin Regions



5.2 Peak rainfall intensity

Peak rainfall intensity allowances should be used for:

- River catchments smaller than $30km^2$.
- River catchments (excluding those in Orkney and Shetland) between $30km^2$ and $50km^2$ where the peak river flow uplift is smaller than the flow increase resulting from using the peak rainfall intensity uplift.
- River catchments of any size in Orkney and Shetland.
- Surface water flooding.

5.2.1 Background

Rainfall allowances can be used to provide a more accurate estimation for surface water (pluvial flooding) and 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.

The 2021 FUTURE-DRAINAGE[4] project provides the most recent analysis of predicted increase in rainfall intensity due to climate change, based upon the UK Climate Projections 2018 (UKCP18).

[4] FUTURE DRAINAGE: Guidance for Water and Sewerage Companies and Flood Risk Management Authorities: Recommended uplifts for applying to design storms, 2021, Prepared by Murray Dale, JBA Consulting

5.2.2 How the allowances should be applied

Use **Map 1** to determine which river basin region is applicable to your assessment, then apply the relevant allowance from **Table 2** overleaf – 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.

For river catchments between 30km^2 and 50km^2 a comparison of the peak flow and peak rainfall intensity uplift is required to determine which is the greater. Where required, this can be done using an appropriate rainfall runoff model (e.g., ReFH2 or FEH R-R) to apply the rainfall intensity uplift, and the resultant increase in flow (compared with the baseline scenario) compared with the peak river flow allowance. Note that this does not in any way inform whether statistical or rainfall runoff methods offer the most suitable flow estimation approach for the catchment; this is only to determine whether the climate change uplift should be taken from the pre-determined flow uplifts (the peak river flows), or from an event-scale determination of the flow uplift from a rainfall runoff model. Either peak flow uplift can then be applied to statistical approaches, where those are most appropriate for the catchment. Further guidance on how this should be done can be found in Question 21 and a worked example can be found in Appendix 1: Worked Examples.

Note that these allowances can also be used in the design of surface water management infrastructure.

The allowances in Table 2 can be used for development with a lifetime up until 2100.

Table 2: Peak rainfall intensity allowances by River Basin Region

River Basin Region	Total change to the year 2080 (%)
Argyll	46
Clyde	41
Forth	39
North-East Scotland	37
North Highland	42
Orkney	40
Shetland	Use Orkney peak rainfall allowance
Solway	38
Tay	39
Tweed	35
Western Isles	48
West Highland	48

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 require 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 in Appendix 2 Question 8.

Information on offshore wave climate and storm surges is provided in Question 7.

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[5] 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.

[5] 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

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 Scotland	Peak river flow	34%

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 34%.

Example 2: Fluvial - redevelopment of a site in Dornoch for a new craft distillery, next to the bank of a burn

River Basin Region	Type of allowance	Applicable climate change uplift value
North Highland	Peak rainfall intensity	42%

Comments: The catchment area of the burn is 8km^2, which sits within the North Highland River Basin Region. The peak rainfall allowance should therefore be applied, as the catchment is smaller than 30km^2.

Example 3: Fluvial – bridge replacement near Maud, Aberdeenshire, on the South Ugie Water

River Basin Region	Type of allowance	Applicable climate change uplift value
North East Scotland	Peak rainfall intensity	37% (47% - see comments below)

Comments: The catchment of the South Ugie Water at the site is 48km^2, which sits within the Northeast Scotland River Basin Region. As this is a catchment between 30km^2 and 50km^2, both the peak river flow (34%) and the peak rainfall intensity allowance (37%) will need to be considered. A rainfall runoff model should be used to apply the rainfall allowance to a baseline scenario, to calculate the resultant percentage increase in flow. Once a percentage increase in flow is calculated using a rainfall runoff model, if it is greater than the peak flow uplift for the area, that should be used instead. The resultant percentage increase in flow can be applied directly to either rainfall runoff or statistical methods of flow estimation in place of the peak flow uplift, based on whichever methods are most appropriate for the catchment – the method for determining the best climate change allowance does not in any way determine the best approach to flow estimation for the catchment. In this case, applying the 37% rainfall uplift in the ReFH2 model results in a 47% increase in peak flow. As this is higher than the peak river flow uplift (34%), the percentage increase in flow from the rainfall runoff model (47%) should be used, applied to whichever method is best for the catchment hydrology approach.

Example 4: Surface Water – construction of a new care home in a part of Glasgow that is subject to surface water flooding

River Basin Region	Type of allowance	Applicable climate change uplift value
Clyde	Peak rainfall intensity	41%

Comments: Glasgow is within the Clyde River Basin Region. The applicable climate change uplift value is therefore 41%.

Example 5: Coastal – conversion of an industrial dockside building to residential use in Leith

River Basin Region	Type of allowance	Applicable climate change uplift value
Forth	Sea 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 does SEPA no longer recommend a universal 20% allowance for climate change?

For several years prior to the publication of Version 1 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[6]. Improved scientific information has become available over the past few years which means that planning decisions can be underpinned by the most up-to-date science reflected in this guidance.

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

All three allowances make use of the UK Climate Projections 2018 (UKCP18), in different ways.

The allowances for sea level rise use the direct outputs from the projections.

For peak river flows, further work was required to translate the UKCP18 projections for rainfall and temperature into allowances for this guidance. The peak river flow allowances are therefore based upon the CEH 2020[7] study, commissioned by the Environment Agency (and contributed to by SEPA to ensure the outputs covered Scotland), and carried out by the UK Centre for Ecology and Hydrology (CEH). The study examined the impact of climate change on fluvial flood peaks for catchments larger than 100km^2 using the UKCP18 projections. It builds on a number of former research projects, including the earlier CEH 2011 study[8] that was used as the basis for the peak river flow allowances in Version 1 of this guidance. The CEH 2020 study applied a sensitivity framework approach with a national-scale grid-based hydrological model (Grid-to-Grid). Modelled flood response surfaces were produced for every point on a 1km grid with a catchment area ≥100km^2. The study overlaid regional rainfall projections from UKCP18 onto the modelled flood response surfaces to produce probabilistic impacts on flood peaks for any of the

[6] 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
[7] Kay, A.L., Rudd, A.C., Fry, M., Nash, G., Allen, S. 2021. Climate change impacts on peak river flows: combining national-scale hydrological modelling and probabilistic projections. Climate Risk Management 31 (2021).
[8] Kay, A.L., Crooks, S.M., Davies, H.N. and Reynard, N.S. An assessment of the vulnerability of Scotland's River catchments and coasts to the impacts of climate change (2011).

1km river grid cells, for a range of future emissions scenarios, time periods, and return periods (10, 20, 50yr).

For peak rainfall intensity, the allowances are based on the analysis of the UKCP18 local projections published in 2021 by the FUTURE-DRAINAGE project[9]. This project analysed how rainfall depths during the heaviest rainfall events in the climate model simulations changed between the present-day period 1981-2000 and the future period 2061-2080, to develop a set of rainfall uplifts, which can be applied to a present-day depth duration frequency (DDF) model based on observed data.

3. Which emissions scenarios are used in the guidance?

All the allowances in this guidance are based upon UKCP18 data, using Representative Concentration Pathway 8.5 (RCP 8.5), which assumes limited efforts to mitigate climate change, so that greenhouse gas levels in the atmosphere will continue to increase. This scenario is used in the Intergovernmental Panel on Climate Change's 5 Assessment report (IPCC AR5). 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 this scenario, 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 committed to meeting the Paris Agreement through the amended Climate Change (Scotland) Act 2009, which sets a net zero greenhouse gas emissions target for 2045. However, we have opted to base the guidance on this scenario 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. 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.

[9] FUTURE DRAINAGE: Guidance for Water and Sewerage Companies and Flood Risk Management Authorities: Recommended uplifts for applying to design storms, 2021, Prepared by Murray Dale, JBA Consulting

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

The allowances in this guidance distil large and complex datasets on how climate change may affect flooding into single value allowances that can easily be applied by land use planners without a background in climate science. Please note that although all allowances are based on a precautionary approach, the climate change projections relevant for different sources of flooding have been calculated in different ways, and so are not directly comparable.

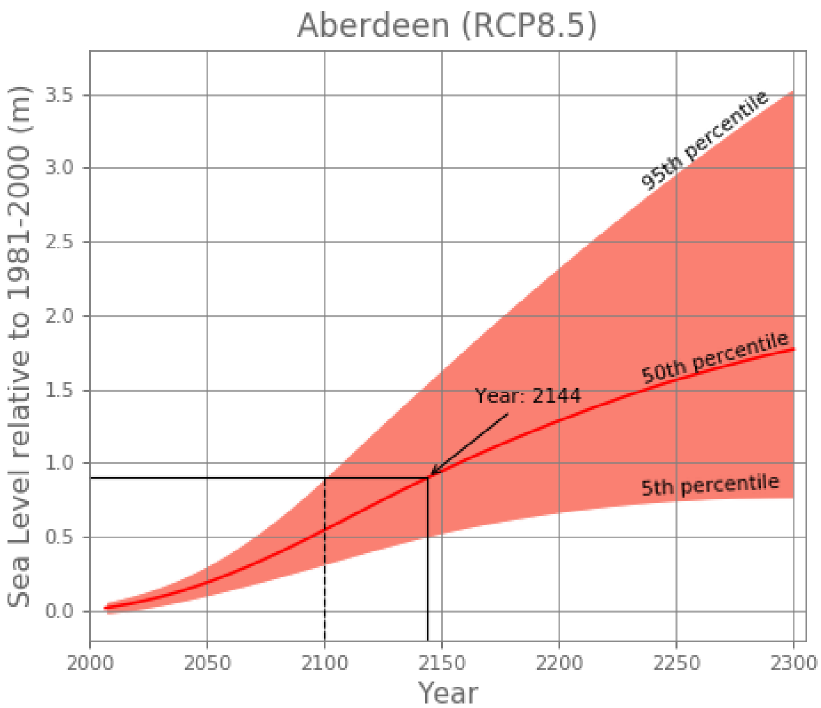
The peak river flow allowances are based on UKCP18 projections. These projections are probabilistic and simulate a wide range of possible climate outcomes for each emissions scenario. The CEH 2020[10] study produced information on the potential range of change in peak flows for several different flood return periods, future time-slices, and Representative Concentration Pathways, with outputs produced at 1km grid cell resolution. The peak river flow allowances are based on the 67th percentile. Following analysis of the study outputs, we determined it was not advisable to use the grid cell data because the climate projections used to derive the flow projections are averaged over river basin regions, so variations in response across a river basin region due to variation in rainfall projections is not captured. Furthermore, the study outputs are based on application of the Grid2Grid hydrological model, which generally performs very well for Scottish catchments, however there is still uncertainty associated with Grid2 Grid. Different hydrological models were compared as a sensitivity test in the CEH study, and in river basin regions where there tended to be more variation in response between neighbouring catchments, there also tends to be a greater sensitivity in the uplifts to the hydrological model used. Taking a river basin average therefore reduces the risk of using grid cell data, which may be either anomalously high or low due to differences in how well the hydrological model is able to predict the actual response for neighbouring catchments, rather than underlying differences between neighbouring catchments. Further information on when we would suggest the grid cell data could be used can be found in Question 20.

[10] Kay, A.L., Rudd, A.C., Fry, M., Nash, G., Allen, S. 2021. Climate change impacts on peak river flows: combining national-scale hydrological modelling and probabilistic projections. Climate Risk Management 31 (2021).

For the peak rainfall allowances, direct use of the FUTURE-DRAINAGE project outputs in this guidance was not feasible as the dataset is too complex to be applied by non-climate specialists. The project provided a total 60 sets of uplifts, consisting of 3 return periods (50% (2 year), 3.3% (30 year) and 1% (100 year)), 5 storm durations (1, 3, 6, 12 and 24 hours), 2 future time horizons (2050s and 2070s) and 1 emissions scenario RCP8.5 (see Question 3 above). The uplifts vary spatially and are provided for 5% contour intervals on a 5km grid across the UK (with the exception of Shetland, which is not covered by the UKCP18 2.2km projections). Guidance provided by the project authors recommends that rather than using results from individual grid cells, users instead take results from a region (considering the range of values across the region). SEPA therefore analysed the grid-based uplifts on a river basin region basis (to avoid having different spatial units for peak rainfall, flow, and sea level allowances). Our analysis found that using the river basin region averages rather than the grid-based uplifts would result in only small differences in rainfall depths (less than 5%), therefore assessing other options for regionalising the uplifts was not considered necessary. As per Version 1 of this guidance, the peak rainfall allowances are applicable to assessing the impact of climate change on flooding from watercourses in catchments <30km^2, with sensitivity testing applied to the applicability of rainfall or flow allowances for catchments 30-50km^2. Our analysis showed that in catchments <50 km^2, the critical storm duration is likely to be 3 hours or shorter. This shows that rainfall uplifts are unlikely to be applied to catchments where the 12 or 24-hour uplift is closest to the critical storm duration, hence only the 1-, 3- and 6-hour durations need to be considered in the allowances. The analysis also showed that use of a single allowance using the 3-hour duration would be most consistent with taking a precautionary approach. The allowances are based on the 50th percentile for the 2070s-time horizon. SEPA's view is that the allowances are appropriate for use up until 2100 because the RCP8.5 emissions scenario is suitably precautionary.

Sea level rise allowances for each River Basin Region have been calculated from the 95th percentiles for sea level rise for 2100 from UKCP18. A percentile describes the proportion of possible scenarios that fall below an allowance level. 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 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 2 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 2: 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.



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

Projections from the CEH 2020 study are only available for catchments with an area greater than 100km^2. As the driving precipitation data had a daily temporal resolution, it was considered that results would not be reliable for smaller catchments[11]. There is a knowledge gap around the projected changes in flood risk for small catchments. Further research will help to resolve this, but for now the catchment size thresholds of 30km^2 and 50km^2 from Version 1 of the guidance have been retained to inform decisions regarding which allowances to use for catchment sizes smaller than 100km^2.

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.

[11] Kay, A.L., Rudd, A.C., Fry, M., Nash, G., Allen, S. 2021. Climate change impacts on peak river flows: combining national-scale hydrological modelling and probabilistic projections. Climate Risk Management 31 (2020).

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 for between 60 and 80 years from now. We consider it reasonable to assume that most development built now should be designed to last for at least that long. However, allowances for other timeframes are available where there is certainty that a particular development has a shorter, fixed design life.

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 required 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, we recommend sensitivity testing to a higher allowance for developments with a longer design life as set out in Question 9. For the 2050s, allowances are provided below from the FUTURE-DRAINAGE project. For consistency with the allowances provided in section 5.2 of this guidance, it is recommended that the central estimate is used, as follows in **Table 4**:

Table 4: Peak rainfall intensity allowances for the 2050s, by River Basin Region

River Basin Region	For peak rainfall intensity: Total change (%) to the 2050s (using the 50th percentile)
Argyll	33
Clyde	30
Forth	29
North-East Scotland	29
North Highland	30
Orkney	30
Shetland	Use Orkney peak rainfall allowance
Solway	29
Tay	30
Tweed	26
Western Isles	35
West Highland	35

For peak river flows, we have been unable to carry out the analysis required to provide allowances for nearer time periods due to the impact of the 2020 cyber-attack on our organisation. We will update the guidance when we recover the data needed to carry out this analysis. For developments with a longer design-life we require sensitivity testing to a higher allowance as in Question 9.

However, for most development we consider it unlikely that a precise and fixed design life will be known from the outset, and therefore the required 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 require 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 the 2080s (2070-2099) for RCP 8.5 from the CEH 2020 study. However, please note that we have been unable to carry out the analysis required to provide these allowances due to the impact of the 2020 cyber-attack on our organisation. We will update the guidance when we recover the data needed to carry out this analysis.

- for peak rainfall intensity, sensitivity testing is carried out to the 95th percentile for the 2070s from the FUTURE-DRAINAGE project as follows in **Table 5**:

Table 5: Peak rainfall intensity allowances for the 2070s 95th percentile, by River Basin Region

River Basin Region	For peak rainfall intensity: Total change (%) to the year 2080 (using the 95th percentile)
Argyll	65
Clyde	57
Forth	55
North-East Scotland	55
North Highland	62
Orkney	63
Shetland	Use Orkney peak rainfall allowance
Solway	52
Tay	55
Tweed	50
Western Isles	69
West Highland	69

- for sea level rise, sensitivity testing is carried out to the H++ sea level rise estimate from UKCP09[12]. 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.

[12] 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 in the webmap.

SEPA publishes Future Flood Maps (referred to as the maps hereafter), which provide information on how the areas at risk of river, surface water or coastal flooding in a 0.5% Annual Exceedance Probability event may change due to climate change. However, the climate change uplifts used in some of the maps are based upon different projections to those used in this guidance.

For coastal flooding, the maps use allowances that are smaller than those in this guidance, except for in the Outer Hebrides where from November 2023 the maps use allowances that have the same basis as those in this guidance.

For fluvial flooding, for larger catchments the maps were generally consistent with Version 1 of this guidance but are generally smaller than the updated allowances in this guidance. There remain differences in the uplifts for smaller catchments between the river maps and the guidance. These differences exist because both the maps and the guidance are based on UK climate projections, which are frequently refined over time due to improvements in both our understanding of the climate system and to climate modelling. Work required to update the maps in line with the projections is more resource-intensive than that required to update the guidance.

Flooding from watercourses with catchment areas that are less than $10km^2$ is represented in the surface water and small watercourses map. This map additionally includes representation of risk from very small watercourses with catchment areas less than $3km^2$. As the river flood maps also show flooding from watercourses with catchment areas greater than $3km^2$, flooding from watercourses with catchment areas of between 3 and $10km^2$ is represented in both the river and surface water maps.

The surface water and small watercourses map uses uplifts that have the same basis as the allowances in this guidance i.e. rainfall uplifts on a river basin region basis based on the FUTURE-DRAINAGE project, for the 50th percentile for the 2070s time horizon. The allowances in this guidance are based on the 3-hour duration, whilst the uplifts used in the maps varied by storm duration.

For more detail on the differences between the Future Flood Maps and the guidance, see the explanatory note available on SEPA's Guidance and advice notes page.

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

SEPA's Technical Flood Risk Guidance for Stakeholders refers to this guidance.

13. How does this 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. Prior to the publication of Version 1 of this guidance, our requirement was for a 20% allowance for climate change, based on DEFRA guidance as explained in Question 1. 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. This will be undertaken within the new policy context of NPF4.

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 49%, 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 a managed adaptive approach). Adaptation plans allow for the planning and preparation of flood risk management measures, that can adjust efficiently as the future climate change and science progresses and more information on risk becomes available. Such plans can be made up of a series of actions that might be taken at various points in time. Potential flood risk management measures are therefore likely to require assessment against a number of different future scenarios and timescales including a credible worst case.,

It is for local authorities to determine in consultation with local communities what standard of protection is most appropriate for local circumstances considering provision of an appropriate level of risk management alongside place making principles, value for money and the aspirations of the community affected.

Due to the uncertainties in projecting future levels of flood risk, flood risk management measures should not be designed using a single climate change scenario. Rather, a range of possible future scenarios should be tested and set out as part of an adaptation plan

The following sources should be used for these scenarios:

- Fluvial: CEH 2020 study
- Pluvial: FUTURE-DRAINAGE 2021 project[13]
- Sea Level Rise: UKCP18[14]

[13] The FUTURE-DRAINAGE data can be obtained from the CEDA catalogue.
[14] The UKCP18 sea level rise projections can be obtained from the UKCP18 user interface.

15. Why are projected changes derived from less than a 200yr return period recommended for application to the 200yr return period flows?

The CEH 2020 study provides projected changes in peak flows with return periods of 10, 20 and 50 years. Changes in peak flows for larger return periods such as the 200-year could not be calculated directly using the study methodology, however, the change in the 200-year event is expected to be similar to the change in the 50-year event as these are both large flood events that would be expected to have similar flooding mechanisms. As such the projections for the 50-year event are recommended in this guidance for use with the 200-year peak flows.

For the FUTURE-DRAINAGE project, outputs for the 200-year return period could also not be produced directly as the climate model simulations are too short to allow this analysis. However, the project authors have advised that the 100-year return period uplifts can be used as a proxy for the 200-year uplifts. Analysis of the FUTURE-DRAINAGE project uplifts by SEPA found that although uplifts increase with return period the difference between the 30-year and 2-year uplift is much greater than the difference between the 30-year and 100-year uplifts for the 3-hour storm duration used in this guidance, and hence the 200-year uplift is expected to be similar to the 100-year uplift.

16. Why have some areas changed peak river flow allowance river basin region since Version 1 of the guidance?

In Version 1 of the guidance peak river flow allowances were provided for river basin regions consistent with those used in UK Climate Projections 2009 (UKCP09).

Peak river flow allowances are now provided for river basin regions from the more recent UK Climate Projections 2018 (UKCP18). This provides consistency with the spatial unit of the regional rainfall projections from UKCP18 that were used in the CEH 2020 study.

The UKCP18 river basin regions contain a small number of changes to river basin regions relative to the UKCP09 river basin regions.

To work out which river basin region to use, users are recommended to check Map 1 in the guidance or access the web map. Alternatively, the UKCP18 river basin region shapefile is available under an Open Government Licence (see the UKCP Guidance: Data availability, access and formats page 7 for further information).

17. Why are peak river flow allowances not available for Orkney and Shetland? Why are you recommending use of the Orkney peak rainfall allowance for Shetland?

The underlying data from the CEH 2020 study[15], which was used to generate the required allowances in this guidance, was available only for catchments with an area greater than 100km^2. All catchments in Orkney and Shetland are smaller than 100km^2. Peak rainfall allowances should therefore be used for Orkney and Shetland.

The UKCP18 2.2km resolution projections do not cover Shetland as it sits at the edge of the model area, and hence is not covered by the FUTURE-DRAINAGE project. Analysis of the FUTURE-DRAINAGE uplifts shows that uplifts are greater for the north and west of the UK, so that in the absence of other information we are recommending use of the uplift from Orkney as this is the nearest area for which data is available to Shetland. We will update this guidance in future if and when data for Shetland becomes available.

18. Why are you recommending use of the West Highland peak rainfall and flow allowances for the Western Isles?

The Western Isles is within the UKCP West Highland river basin region. The climate projections to derive the flow allowances are averages over UKCP river basin regions, and hence do not support differentiating between the Western Isles and the West Highlands for the flow projections. The FUTURE-DRAINAGE uplifts have been analysed both for the UKCP West Highland river basin region (Western Isles and West Highlands combined), and for the Western Isles and West Highlands as separate regions. The central estimate (50th percentile) 100-year 3-hour storm duration uplift used for the allowances is the same for UKCP West Highland river basin region, the Western Isles and the West Highlands, while the 95th percentile estimate for the Western Isles and West Highlands are both within 3% of that for the whole UKCP West Highland river basin region average. Use of the same rainfall allowance across the entire of the UKCP West Highland River basin region is therefore recommended for consistency with the spatial unit used for the flow uplifts. Separate sea level rise allowances are given for the

[15] Kay, A.L., Rudd, A.C., Fry, M., Nash, G., Allen, S. 2021. Climate change impacts on peak river flows: combining national-scale hydrological modelling and probabilistic projections. Climate Risk Management 31 (2020).

Western Isles as projections for sea level rise are higher for the Western Isles than the West Highlands.

19. Why are different time horizons used for the allowances?

The allowances for all flood sources are based on projected changes for the end of this century. The peak flow allowances use a 30-year epoch covering the period 2070 to 2099 and are therefore described as covering the period to 2100. The peak rainfall allowances use the period 2061-2080 and are so described as covering the period to 2080. The coastal allowances show a cumulative sea level rise in metres from 2017 to 2100.

A shorter time horizon is used for the rainfall allowances as the latest period available in the UKCP18 2.2km resolution projections used to develop the rainfall allowances is the period 2061-2080.

20. Are there instances where use of the grid cell allowances for peak flows would be more appropriate than the recommended regional allowances?

The use of grid cell uplift data may be appropriate to use as an alternative where uncertainty associated with the climate change allowances is greater than uncertainty in the present day flow estimates, i.e. where there is high confidence in present day flood estimates (that is to say, the difference between the climate change uplifts is larger than the uncertainty in the present-day flood frequency estimates), and the modelling analysis is not sensitive to other factors such as roughness, coefficients etc.; AND; there is a clear hydrological reason why the catchment might be expected to respond differently to climate change than the way suggested by the river basin region average, and there is confidence that the underlying grid2grid hydrological model is robust for that catchment (for example, there may be issues with the way in which grid2grid represents snow melt, peat, or flashy catchments). The grid cell uplift data can be found here: https://eip.ceh.ac.uk/hydrology/cc-impacts/.

21. How do I apply the rainfall uplifts to a statistical flood frequency estimate? How do I apply the flow uplifts if I am using a flood frequency estimate from a rainfall runoff model?

If using a rainfall uplift with a statistical flood frequency estimate, the rainfall uplift should be applied within an appropriate rainfall runoff model in order to determine the % change in peak flow for the 200-year event (by comparing the baseline 200-year estimate with the 200-year estimate with the rainfall uplift applied). This flow difference should then be applied to the statistical estimate in the same way as a flow uplift would be.

If using a flow uplift with a flood frequency estimate from a rainfall runoff model, the rainfall input to the rainfall runoff model should be left unchanged and the rainfall runoff model output hydrograph should be scaled by the flow uplift.

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