

## SUMMARY

River flows in December are likely to be normal to above normal in northern Britain, and normal to below normal in the south. Groundwater levels are likely to be normal to above normal across the country. Over the three month period to February 2022, river flows expected to be normal to above normal in the north and normal in the south. Groundwater levels are most likely to be in the normal range over this period.

### Rainfall:

November saw below normal rainfall across most of the UK, with only the far north of Scotland receiving above normal rainfall. It was particularly dry across southern Britain.

The rainfall outlook (issued by the Met Office on 29.10.2021) suggests that the chance of dry and wet conditions for December is evenly balanced. That there is a higher than normal chance of wet conditions over the period to February.

### River flows:

River flows in November were largely below normal in Wales, southwest England and Northern Ireland and were mostly in the normal range elsewhere, with above normal flows in a few catchments in southern England (note that data are unavailable for Scotland).

The outlook for December is for normal to above normal flows for much of northern Britain, contrasting with normal to below normal flows in the south.

In the three months to February, a similar contrast emerges, but with river flows likely to be normal to above in the north, but normal in the south.

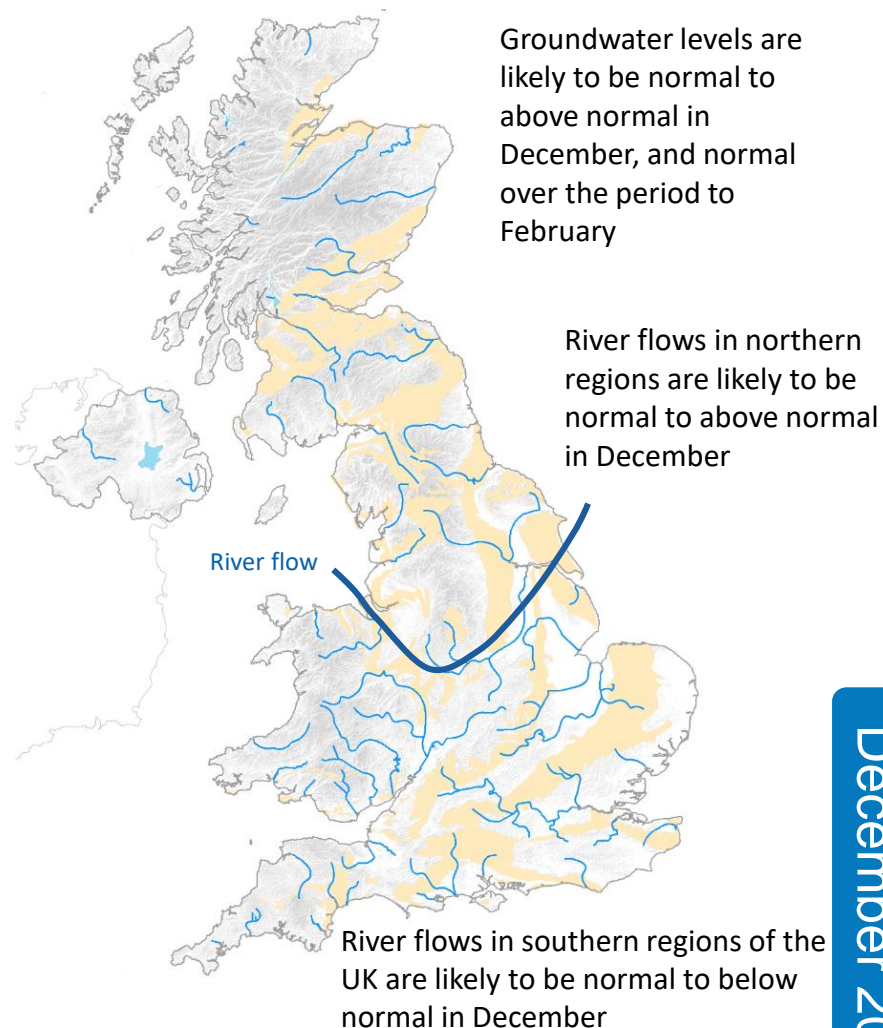
### Groundwater:

Groundwater levels in November were largely in the normal range in aquifers in central and eastern England, and above normal in northern England, with below normal levels in the Carboniferous limestone of south Wales.

During December, normal to above normal levels are likely across the country.

Over the three months to February, groundwater levels are expected to be in the normal range across the country, with below normal levels possible in some boreholes.

The Hydrological Outlook UK provides an outlook for the water situation for the UK over the next three months and beyond. For guidance on how to interpret the outlook, a wider range of information, and a full description of underpinning methods, please visit the website: [www.hydoutuk.net](http://www.hydoutuk.net)



Shaded areas show principal aquifers

## About the Hydrological Outlook:

This document presents an outlook for the UK water situation for the next 1 – 3 months and beyond, using observational datasets, meteorological forecasts and a suite of hydrological modelling tools. The outlook is produced in a collaboration between the UK Centre for Ecology and Hydrology (UKCEH), British Geological Survey (BGS), the Met Office, the Environment Agency (EA), Natural Resources Wales (NRW), the Scottish Environment Protection Agency (SEPA), and for Northern Ireland, the Department for Infrastructure – Rivers (DfIR).

## Data and Models:

The Hydrological Outlook depends on the active cooperation of many data suppliers. This cooperation is gratefully acknowledged. Historic river flow and groundwater data are sourced from the UK National River Flow Archive and the National Groundwater Level Archive. Contemporary data are provided by the EA, SEPA, NRW and DfIR. These data are used to initialise hydrological models, and to provide outlook information based on statistical analysis of historical analogues.

Climate forecasts are produced by the Met Office. Hydrological modelling is undertaken by UKCEH using the Grid-to-Grid, PDM and CLASSIC hydrological models and by the EA using CATCHMOD. Hydrogeological modelling uses the R-groundwater model run by BGS and CATCHMOD run by the EA. Supporting documentation is available from the Outlooks website:

<https://www.hydoutuk.net/about/methods>

## Presentation:

The language used in the summary presented overleaf generally places flows and groundwater levels into just three classes, i.e. below normal, normal, and above normal. However, the underpinning methods use as many as seven classes as defined in the graphic to the right, i.e. the summary uses a simpler classification than some of the methods. On those occasions when it is appropriate to provide greater discrimination at the extremes the terminology and definitions of the seven class scheme will be adopted.

Percentile range of historic values for relevant month

Exceptionally high flow	> 95
Notably high flow	87-95
Above normal	72-87
Normal range	28-72
Below normal	13-28
Notably low flow	5-13
Exceptionally low flow	< 5

## Disclaimer and liability:

The Hydrological Outlook partnership aims to ensure that all Content provided is accurate and consistent with its current scientific understanding. However, the science which underlies hydrological and hydrogeological forecasts and climate projections is constantly evolving. Therefore any element of the Content which involves a forecast or a prediction should not be relied upon as though it were a statement of fact. To the fullest extent permitted by applicable law, the Hydrological Outlook Partnership excludes all warranties or representations (express or implied) in respect of the Content.

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From April 2018 the Hydrological Outlook is supported by the Natural Environment Research Council funded [UK-SCAPE](#) and [Hydro-JULES](#) Programmes.

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## Further information:

For more detailed information about the Hydrological Outlook, and the derivation of the maps, plots and interpretation provided in this outlook, please visit the Hydrological Outlook UK website.

The website features a host of other background information, including a wider range of sources of information which are used in the preparation of this Outlook.

## Contact:

Hydrological Outlooks UK, UK Centre for Ecology & Hydrology, Wallingford, Oxfordshire, OX10 8BB  
t: 01491 692371 e: [enquiries@hydoutuk.net](mailto:enquiries@hydoutuk.net)

## Reference for the Hydrological Outlook:

Hydrological Outlook UK, 2021, December, UK Centre for Ecology and Hydrology, Oxfordshire UK, Online, <https://www.hydoutuk.net/latest-outlook/>

## Other Sources of Information:

The Hydrological Outlook should be used alongside other sources of up-to-date information on the current water resources status and flood risk.

Environment Agency Water Situation Reports: provides summary of water resources status on a monthly and weekly basis for England:

<https://www.gov.uk/government/collections/water-situation-reports-for-england>

Flood warnings are continually updated, and should be consulted for an up-to-date and localised assessment of flood risk:

Environment Agency: <https://flood-warning-information.service.gov.uk/map>

Natural Resources Wales: <https://flood-warning.naturalresources.wales/>

Scottish Environment Protection Agency: <https://www.sepa.org.uk/flooding.aspx>

Hydrological Summary for the UK: provides summary of current water resources status for the UK:

<https://nrfa.ceh.ac.uk/monthly-hydrological-summary-uk>

UK Met Office forecasts for the UK: <https://www.metoffice.gov.uk/#?tab=regionalForecast>

UK Water Resources Portal: monitor the UK hydrological situation in near real-time including rainfall, river flow, groundwater and soil moisture from COSMOS-UK:

<https://eip.ceh.ac.uk/hydrology/water-resources/>

# Monthly mean river flows simulated by the Grid-to-Grid hydrological model

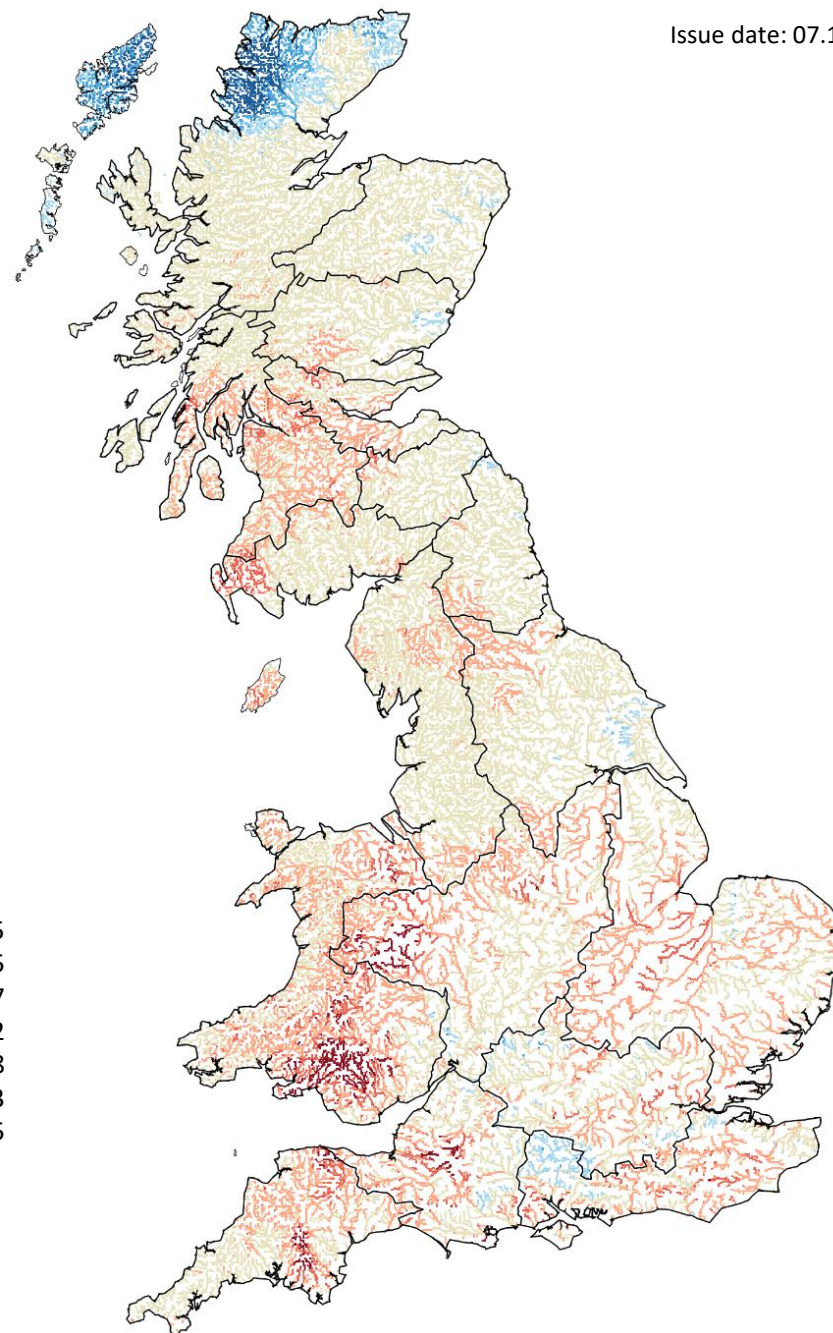
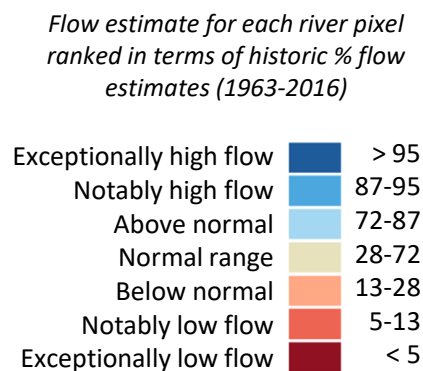
Period: November 2021

Issue date: 07.12.2021

This map shows the simulated monthly mean flow across Great Britain for last month, ranked in terms of 54 years of historical flow estimates (1963 – 2016).

These flows are produced by the 1km resolution Grid-to-Grid (G2G) hydrological model, which is run up to the end of each calendar month using observed rainfall and MORECS potential evaporation as input.

Note that the G2G model provides estimates of natural flows.





# Current Daily Simulated Subsurface Water Storage Conditions

Based on subsurface water storage estimated for 30<sup>th</sup> November 2021

Issue date: 07.12.2021

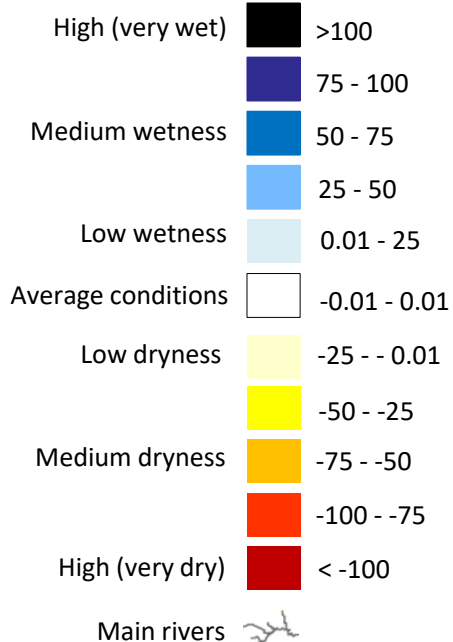
These maps are based on Grid-to-Grid (G2G) hydrological model simulated subsurface water storage, expressed as an anomaly from the historical monthly mean. To highlight areas that are particularly wet or dry, the storage anomaly is presented here using a colour scale highlighting water storage relative to historical extremes. The maps below show the “relative wetness” which combines maps previously shown separately as the “relative wetness” and “relative dryness”.

These maps do not provide a forecast and are not maps of soil moisture. Instead they indicate areas which are particularly wet or dry. Rainfall in areas with high positive relative wetness could result in flooding in the coming days/weeks. Areas of negative relative wetness provide an indication of locations which are particularly dry, and little or no rain in these areas could potentially lead to (or prolong) a drought.

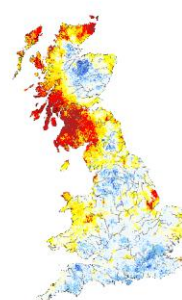
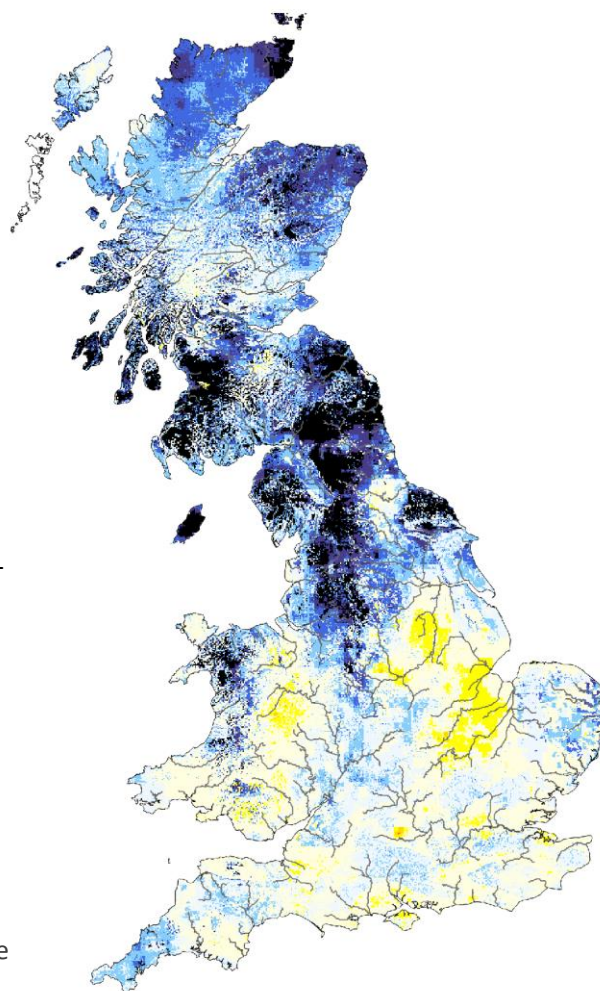
**SUMMARY:** At the end of November, subsurface water levels were higher (wetter) than normal in much of Scotland, northern England and west Wales. Elsewhere, subsurface water levels were lower (drier) than normal.

## Relative wetness

Water storage anomaly as a % of maximum (positive wetness) or minimum (negative wetness) storage anomaly (zero indicates average value)



Labels refer to estimated storage on final day of named month



July



August

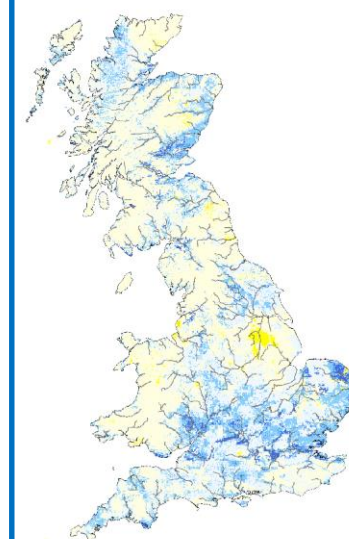


September

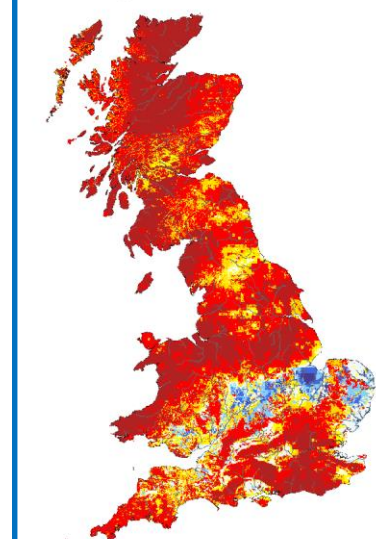


October

November 2020



August 1976\*



\*Example month displaying extreme negative wetness



# Return Period of Rainfall Required to Overcome Dry Conditions

Period: December 2021 – May 2022

Issue date: 07.12.2021

These maps show the **return period** of the rainfall required to overcome dry conditions simulated using the Grid-to-Grid (G2G) hydrological model. The maps are coloured according to the return period of accumulated rainfall required to overcome the estimated current subsurface water storage deficit over the next few months.

These maps do not provide a drought forecast. Instead they indicate the return period of rainfall required to overcome the dry conditions for the following 6 months based on current conditions.

**SUMMARY:** During December to May, Great Britain will not require particularly unusual rainfall (<5 year return periods) to return to average conditions for the time of year.

Dec



Jan



Feb



Mar










Apr



May



Rainfall amount / Probability		Return period (years)	
Low (this rain is likely to occur)	> 20%		< 5
	< 20%		5 - 10
	< 10%		10 - 25
	< 4%		25 - 50
High (less likely)	< 2%		50 - 100
	< 1%		100 - 200
Extreme (unlikely but still possible)	< 0.5%		> 200

## SCOTLAND

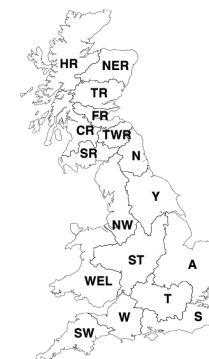
HR Highlands Region  
NER North East Region  
TR Tay Region  
FR Forth Region  
CR Clyde Region  
TWR Tweed Region  
SR Solway Region

## ENGLAND

N Northumbria  
NW North West  
Y Yorkshire  
ST Severn Trent  
A Anglian  
T Thames  
S Southern  
W Wessex  
SW South West

## WALES

WEL Welsh



## NORTHERN IRELAND

This method cannot currently be used in Northern Ireland

# Estimate of Additional Rainfall Required to Overcome Dry Conditions

Based on subsurface water storage estimated for 30<sup>th</sup> November 2021

Issue date: 07.12.2021

These maps show the Grid-to-Grid (G2G) hydrological model simulated subsurface water storage, expressed as an anomaly from the historical monthly mean (1981-2010), presented on a 1km grid and as regional means.

**Subsurface storage deficits**, i.e. where the subsurface water storage anomaly is less than zero, are highlighted by the red/pink colours.

The **subsurface storage deficit (mm)** can be interpreted as an estimate of additional rainfall that would be required in future months to overcome dry conditions (i.e. rainfall in addition to what is expected on average). Regional mean values of additional rainfall required are provided in the table below.

*Regional estimate of additional rainfall required (mm)*

## SCOTLAND

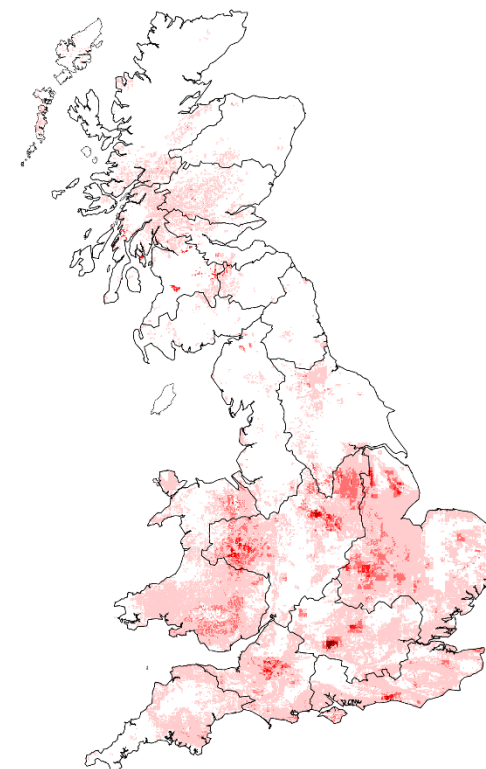
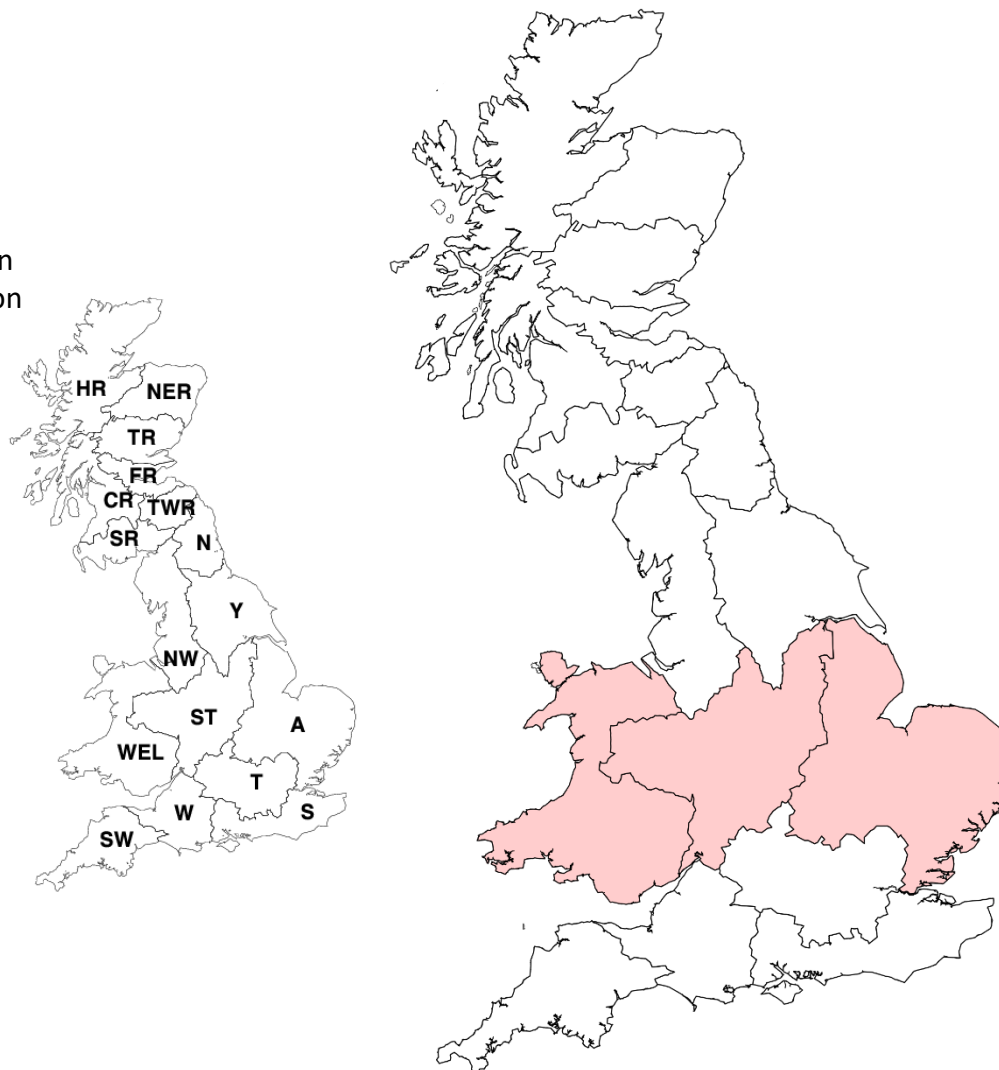
0	HR	Highlands Region
0	NER	North East Region
0	TR	Tay Region
0	FR	Forth Region
0	CR	Clyde Region
0	TWR	Tweed Region
0	SR	Solway Region

## ENGLAND

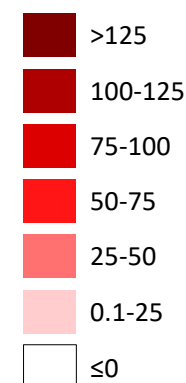
0	N	Northumbria
0	NW	North West
0	Y	Yorkshire
3	ST	Severn Trent
5	A	Anglian
0	T	Thames
0	W	Wessex
0	S	Southern
0	SW	South West

## WALES

2	WEL	Welsh
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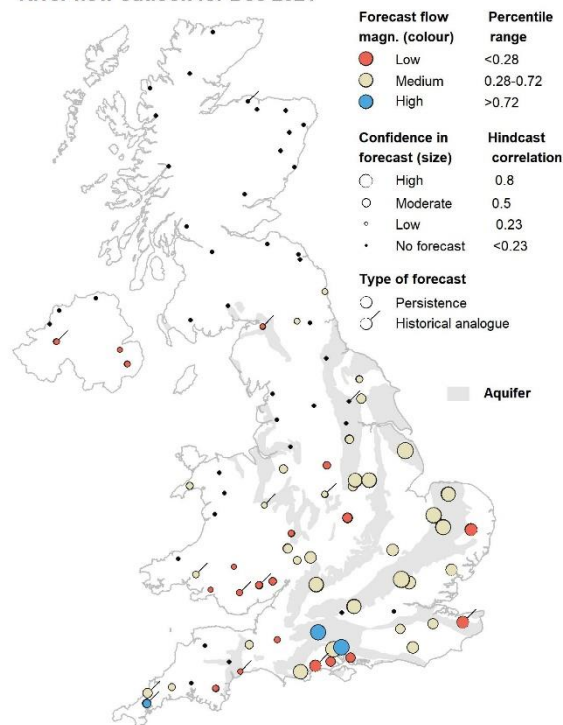
Water storage deficit  
(anomaly, mm)



## SUMMARY

The outlook for December is for mainly normal to below normal flows with some localised exceptions. The outlook for December to February is for mainly normal flows, with some localised exceptions of above and below normal flows. Note there are no forecasts available for Scotland.

River flow outlook for Dec 2021



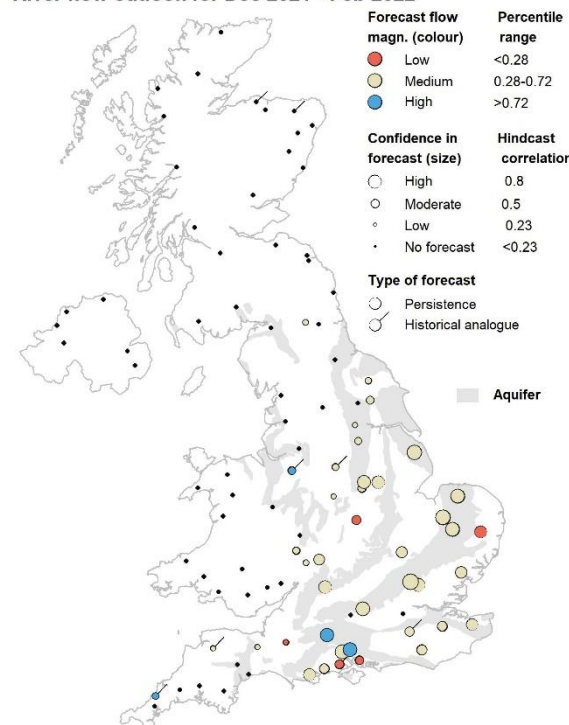
1-month flow outlook

Outlooks from hydrological analogues are based on a comparison of river flow during recent months with flows during the same months in previous years at a set of approximately 90 sites from across the UK. These sites are depicted on the two maps. Years with observed flows that most closely resemble current conditions are identified as the best analogues and the outlook is based on extrapolating from current conditions based on these analogues.

It is, however, often the case that a simpler forecast based on the persistence of river flow provides a better forecast than provided by analogy. This is particularly true for slowly responding catchments associated with aquifer outcrops.

Both methods are considered at each site and the forecast from the method with the higher confidence is presented. A simple classification of flows is used (high, medium and low) as indicated by the colours of the dots, with the confidence

River flow outlook for Dec 2021 - Feb 2022



3-month flow outlook

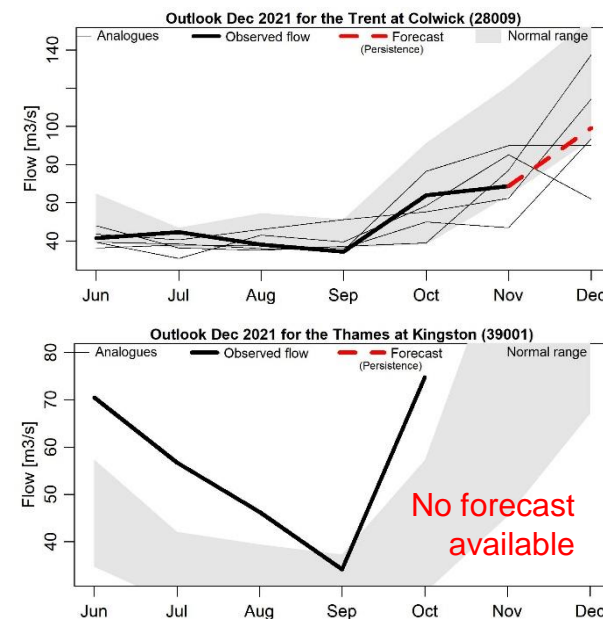
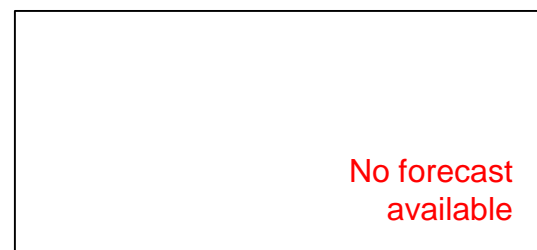
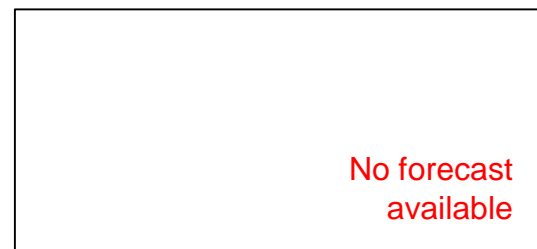
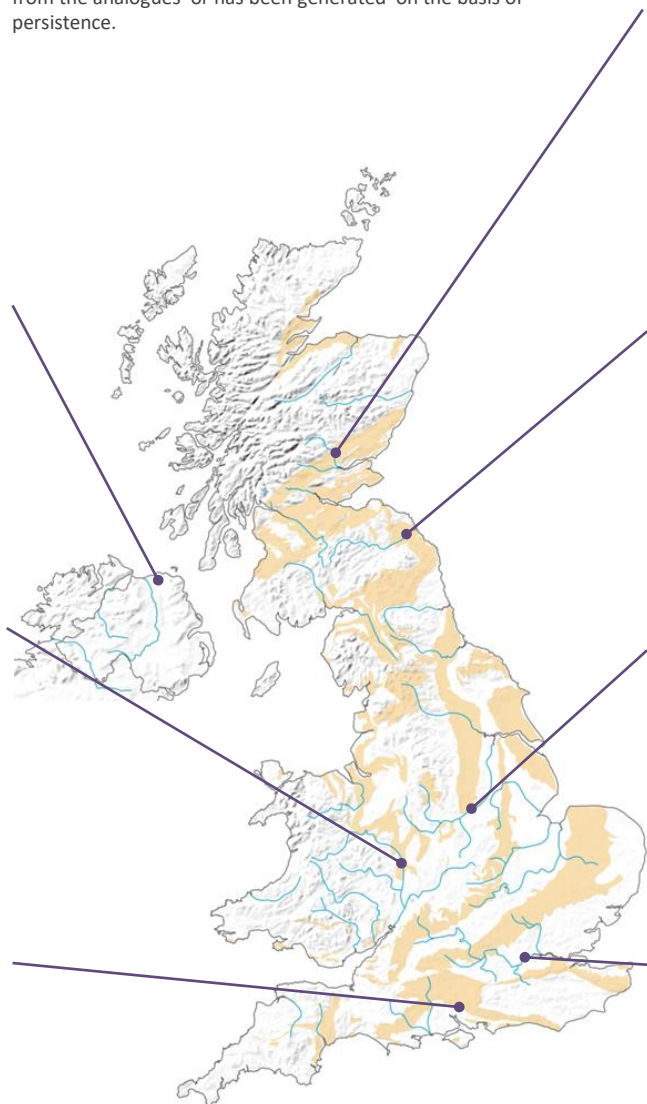
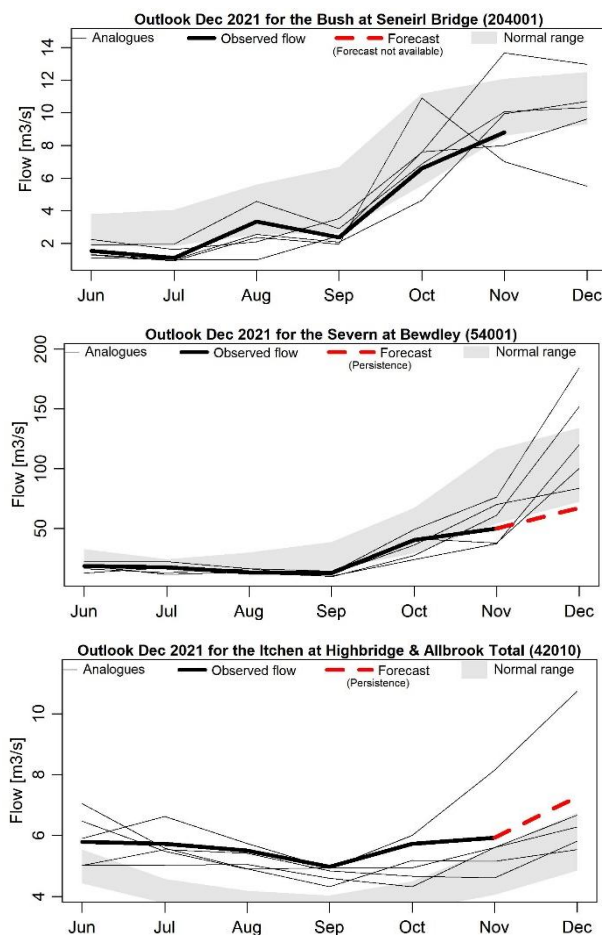
of the forecast being represented by the size of the dot. A tag on the dot indicates which method has been used in each instance.



These figures provide insight into the hydrological analogue methodology for a set of sites from across the UK.

In each of the time series graphs the bold black line represents the observed flow during the past six months. The grey band indicates the normal flow range (the normal band includes 44%

of observed flows in each month). The selected analogues are shown as thin lines and the trajectories that flows took in the following month are also shown. The forecast is shown as the dashed red line, and in each plot it states whether this has come from the analogues or has been generated on the basis of persistence.



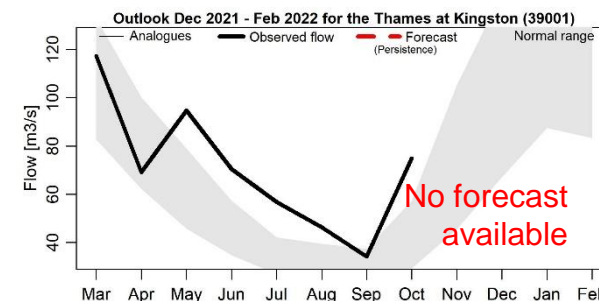
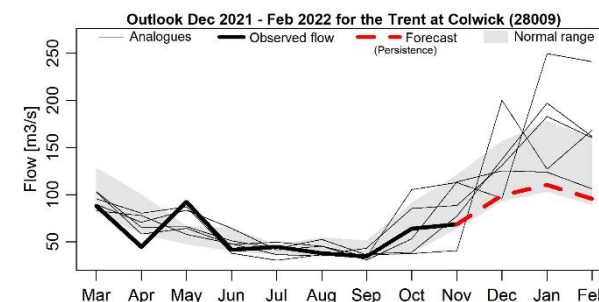
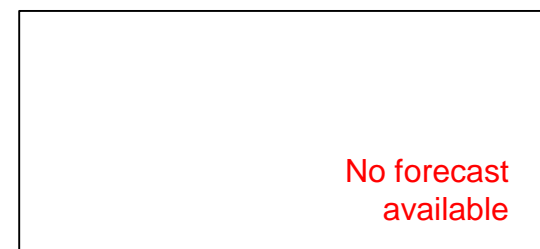
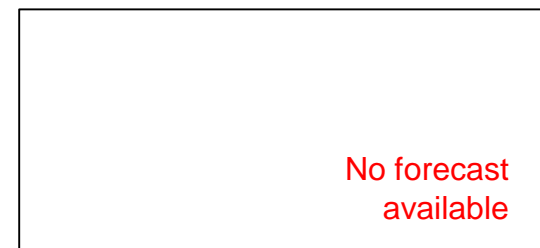
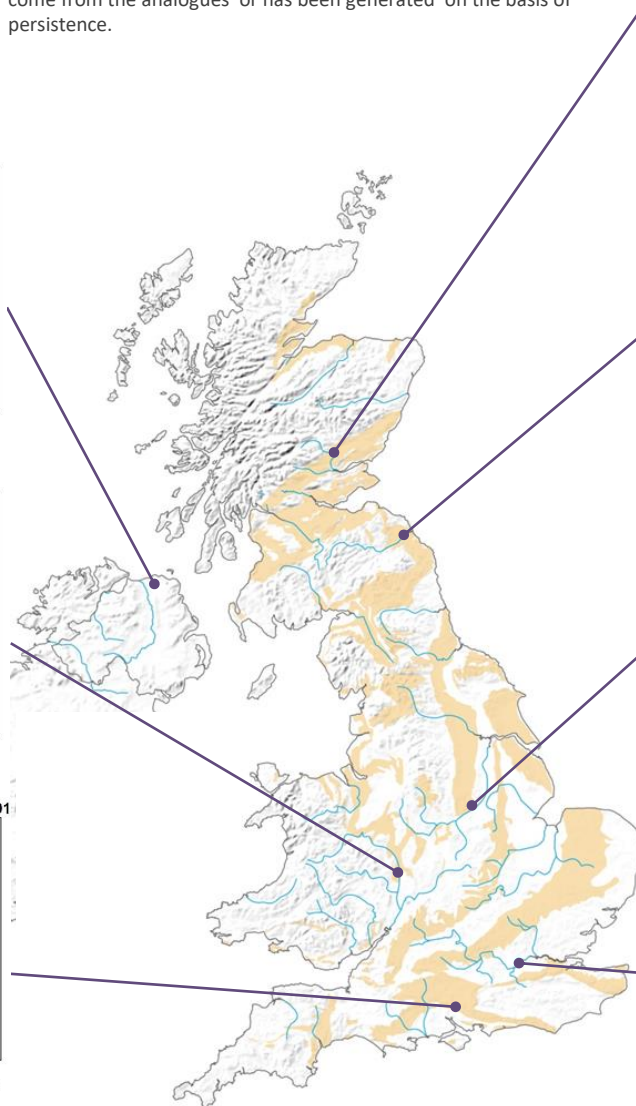
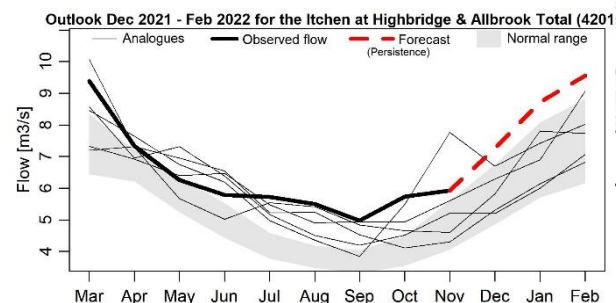
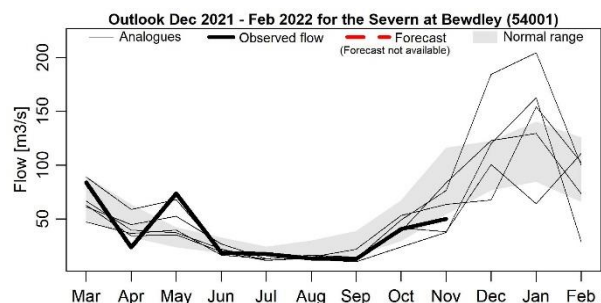
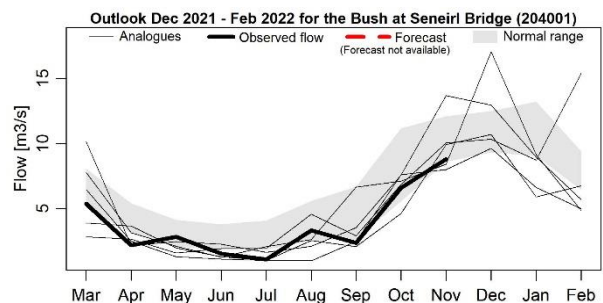
Period: December 2021 – February 2022

Issued on 07.12.2021 using data to the end of November 2021

These figures provide insight into the hydrological analogue methodology for a set of sites from across the UK.

In each of the time series graphs the bold black line represents the observed flow during the past nine months. The grey band indicates the normal flow range (the normal band includes 44%

of observed flows in each month). The selected analogues are shown as thin lines and the trajectories that flows took in the following three months are also shown. The forecast is shown as the dashed red line, and in each plot it states whether this has come from the analogues or has been generated on the basis of persistence.

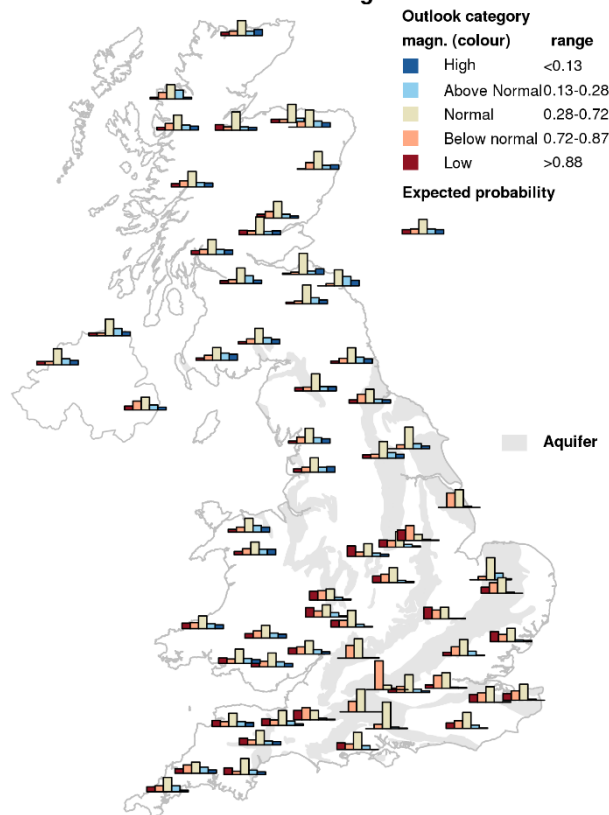


Period: December 2021 – May 2022

Issued on 03.12.2021 using data to the end of November 2021

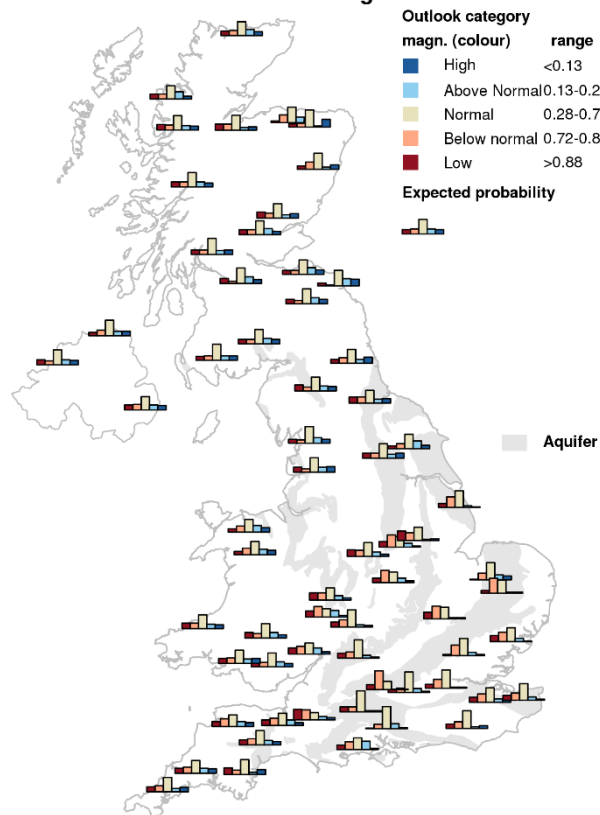
The outlook for December indicates that flows are most likely to be below normal or low for southern and central England, and mostly normal for the rest of the UK. The December-January-February outlook indicates that normal to below normal flows are likely to be dominant across southern England.

### 1-month river flow outlook starting Dec 2021



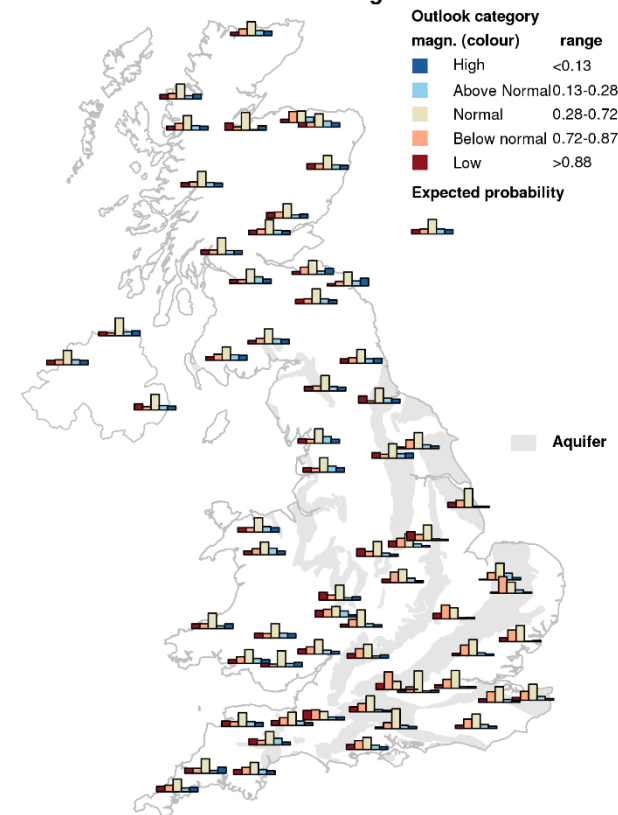
This outlook is based on monthly ensembles of historical sequences of observed climate (rainfall and potential evapotranspiration) that form input to a hydrological model. The outputs are probabilistic simulations of the average river flow over the forecast period (1 to 12 months ahead), at each location. The simulations are generated by the GR4J conceptual rainfall-runoff model from IRSTEA (France) calibrated on observed or naturalised flows.

### 3-month river flow outlook starting Dec 2021



The bar plot maps show the outlook distribution for 1, 3 and 6-month period for 64 catchments across England and Wales. Each bar plot represents the probabilistic distribution of the simulated river flow compared to the historical river flow, for the same n-month period. The probabilities fall within five categories, classified as: low, below normal, normal, above normal and high.

### 6-month river flow outlook starting Dec 2021



This outlook is based entirely on historical sequences and therefore does not contain any knowledge of the state of the atmosphere and ocean. It is hence possible that some of the historical sequences used might be inconsistent with current large-scale atmospheric conditions and would therefore be unlikely to occur in the next few months.





This outlook is based on monthly ensembles of historical sequences of observed climate (rainfall and potential evapotranspiration) that form input to a hydrological model. The outputs are probabilistic simulations of the average river flow over the forecast period (1 to 12 months ahead), at each location. The simulations are generated by the GR4J conceptual rainfall-runoff model from IRSTEA (France) calibrated on observed or naturalised flows.

The stack diagrams show the variation over time of the outlook distribution for a number of individual catchments. Each graph represents variation over time of the number of simulated river flows, in each month ensemble, that fall within each of seven categories: exceptionally low, notably low, below normal, normal, above normal, notably high and exceptionally high. The categories represent cumulative flow conditions, e.g. For 3-month, the simulated total 3-month flow compared to the historical 3-month flow distribution. The monthly variations can be compared to the long-term average distribution of river flows (shown as columns

on the right of each timeline graph).

This outlook is based entirely on historical sequences and therefore does not contain any knowledge of the state of the atmosphere and ocean. It is hence possible that some of the historical sequences used might be inconsistent with current large-scale atmospheric conditions and would therefore be unlikely to occur in the next few months.

Period: December 2021 – February 2022

Issued on 07.12.2021 using data to the end of November

**SUMMARY:** During December, river flows in the south east of England and in Tay Region are likely to be in the *Normal range*. Elsewhere, river flows are likely to be in the *Normal range* or *Above normal*.

**Over the next 3 months** river flows are likely to continue to be in the *Normal range* in the south east of England. Elsewhere, river flows are likely to be in the *Normal range* or above.

These forecasts are produced by using five members of the Met Office rainfall forecast ensemble as input to a water balance hydrological model to provide the five estimates of river flows shown on the left for one month and three months ahead.

Regional forecast monthly-mean river flows are derived from the average of 1km river flow estimates within each region and ranked in terms of 54 years of historical flow estimates (1963 – 2016).

The five maps illustrate the wide range of possible flows and while there is a 50% chance of flows between the 1<sup>st</sup> and 3<sup>rd</sup> quartiles, actual flows may be more extreme than the flows derived using the highest or lowest rainfall forecasts.

### 1-month flow outlook

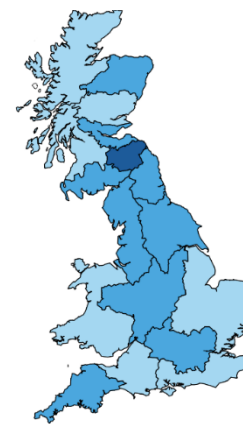
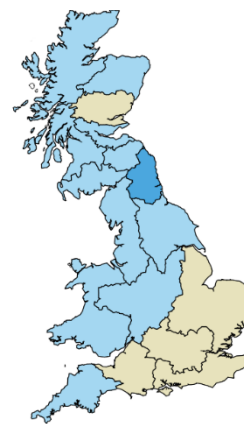
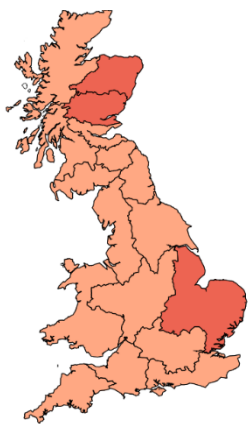
Lowest rainfall forecast

1<sup>st</sup> quartile

Median

3<sup>rd</sup> quartile

Highest rainfall forecast



#### Key

Exceptionally high flow  
Notably high flow  
Above normal  
Normal range  
Below normal  
Notably low flow  
Exceptionally low flow

Percentile range of historic values for relevant month

> 95  
87-95  
72-87  
28-72  
13-28  
5-13  
< 5

### 3-month flow outlook

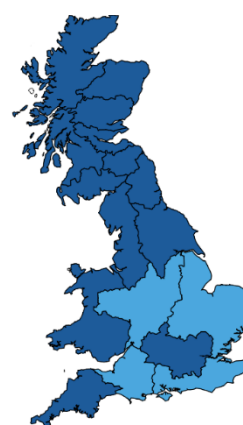
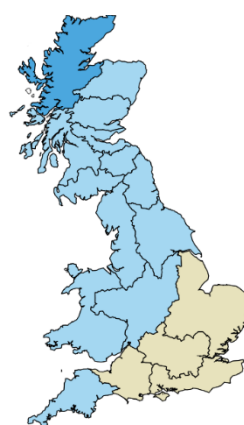
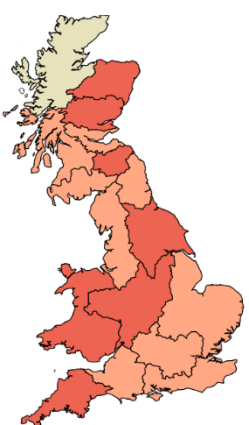
Lowest rainfall forecast

1<sup>st</sup> quartile

Median

3<sup>rd</sup> quartile

Highest rainfall forecast



#### SCOTLAND

HR Highlands Region  
NER North East Region  
TR Tay Region  
FR Forth Region  
CR Clyde Region  
TWR Tweed Region  
SR Solway Region

#### ENGLAND

N Northumbria  
NW North West  
Y Yorkshire  
ST Severn Trent  
A Anglian  
T Thames  
S Southern  
W Wessex  
SW South West

#### WALES

WEL Welsh



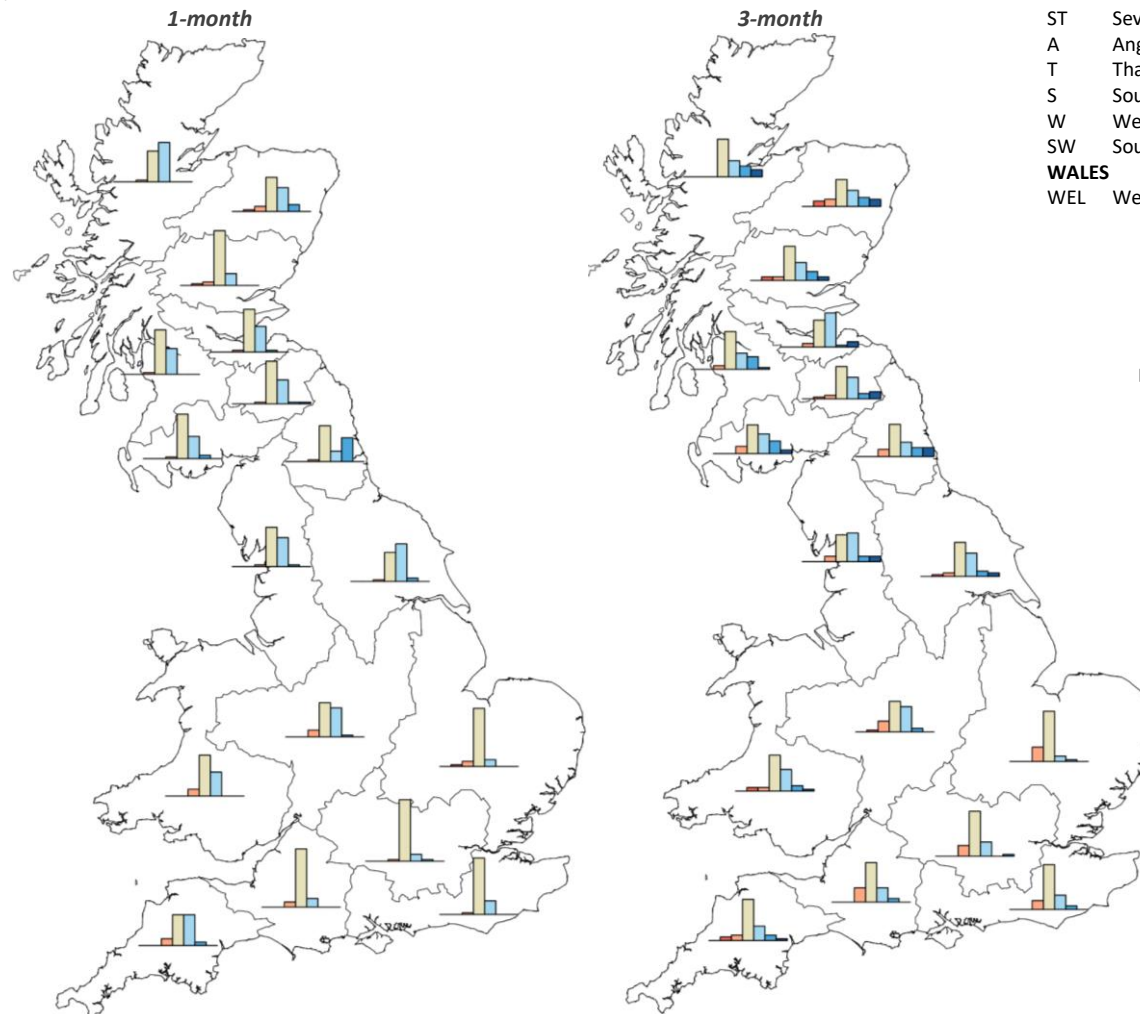
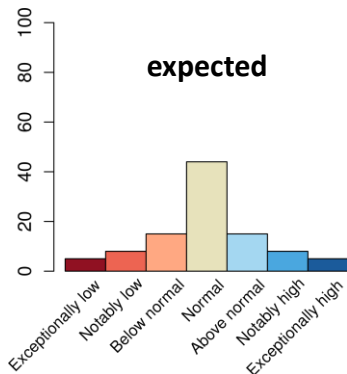
**NORTHERN IRELAND**  
This method cannot currently be used in Northern Ireland

The regional maps illustrating the regional river flows for five members of the Met Office ensemble of rainfall forecasts give some indication of the range of possible river flows in the coming months. As noted previously, the actual flows could be more extreme than the flows generated by either the lowest or highest members of the rainfall ensemble.

The bar charts (below) give further insight into the range of river flow forecasts by considering all members of the forecast rainfall ensemble. The regional bar charts show the percentage of ensemble forecasts falling in each of the flow categories as generated by the monthly-resolution water-balance model. As before results are averaged by region then ranked in terms of 54 years of historical regional flow estimates (1963 – 2016).

**SUMMARY:** During December, river flows in the south east of England and in Tay Region are likely to be in the *Normal range*. Elsewhere, river flows are likely to be in the *Normal range* or *Above normal*.

**Over the next 3 months** river flows are likely to continue to be in the *Normal range* in the south east of England. Elsewhere, river flows are likely to be in the *Normal range* or above.



### SCOTLAND

HR Highlands Region  
NER North East Region  
TR Tay Region  
FR Forth Region  
CR Clyde Region  
TWR Tweed Region  
SR Solway Region

### ENGLAND

N Northumbria  
NW North West  
Y Yorkshire  
ST Severn Trent  
A Anglian  
T Thames  
S Southern  
W Wessex  
SW South West

### WALES

WEL Welsh



### NORTHERN IRELAND

This method cannot currently be used in Northern Ireland



Period: December 2021 – February 2022

Issue date: 07.12.2021

The maps illustrating the regional river flows for five members of the Met Office ensemble of rainfall forecasts give some indication of the range of possible river flows in the coming months. As noted previously, the actual flows could be more extreme than the flows generated by either the lowest or highest members of the rainfall ensemble.

The tables below give further insight into the range of river flow forecasts by considering all members of the forecast rainfall ensemble. The numbers in the tables are the percentage of ensemble forecasts falling in each of the flow categories as generated by the monthly-resolution water-balance model. As before results are averaged by region then ranked in terms of 54 years of historical regional flow estimates (1963 – 2016).

**SUMMARY:** During December, river flows in the south east of England and in Tay Region are likely to be in the *Normal range*. Elsewhere, river flows are likely to be in the *Normal range* or *Above normal*.

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1-month ahead	A	NW	N	ST	SW	S	T	Welsh	W	Y	CR	FR	HR	NER	SR	TR	TWR
Exceptionally high flow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Notably high flow	0	2	33	2	5	0	2	0	0	5	0	2	0	10	5	0	2
Above normal	10	40	14	40	43	19	10	33	12	52	36	36	55	33	31	17	33
Normal range	81	55	50	48	43	79	86	57	81	40	62	60	43	48	62	76	60
Below normal	7	2	2	10	10	2	2	10	7	2	2	2	2	7	2	5	2
Notably low flow	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0
Exceptionally low flow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

3-months ahead	A	NW	N	ST	SW	S	T	Welsh	W	Y	CR	FR	HR	NER	SR	TR	TWR
Exceptionally high flow	0	8	13	0	3	0	3	3	0	5	3	8	10	10	5	5	10
Notably high flow	3	8	13	5	8	5	0	8	5	8	18	3	15	13	18	13	8
Above normal	8	40	20	35	20	20	20	30	20	33	23	48	23	23	28	25	30
Normal range	70	38	45	43	58	63	63	50	55	48	52	38	52	38	40	48	45
Below normal	20	8	10	15	8	13	15	5	20	5	5	5	0	10	10	5	5
Notably low flow	0	0	0	3	5	0	0	5	0	3	0	0	0	8	0	5	3
Exceptionally low flow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

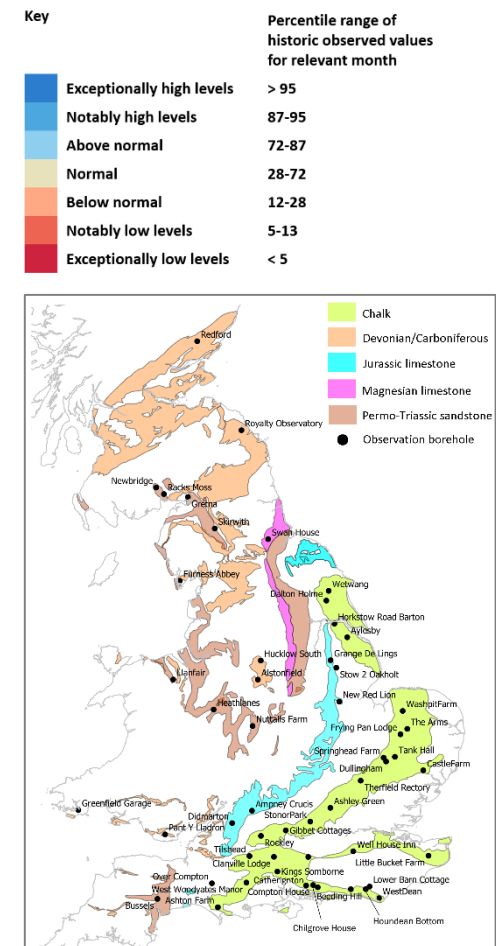
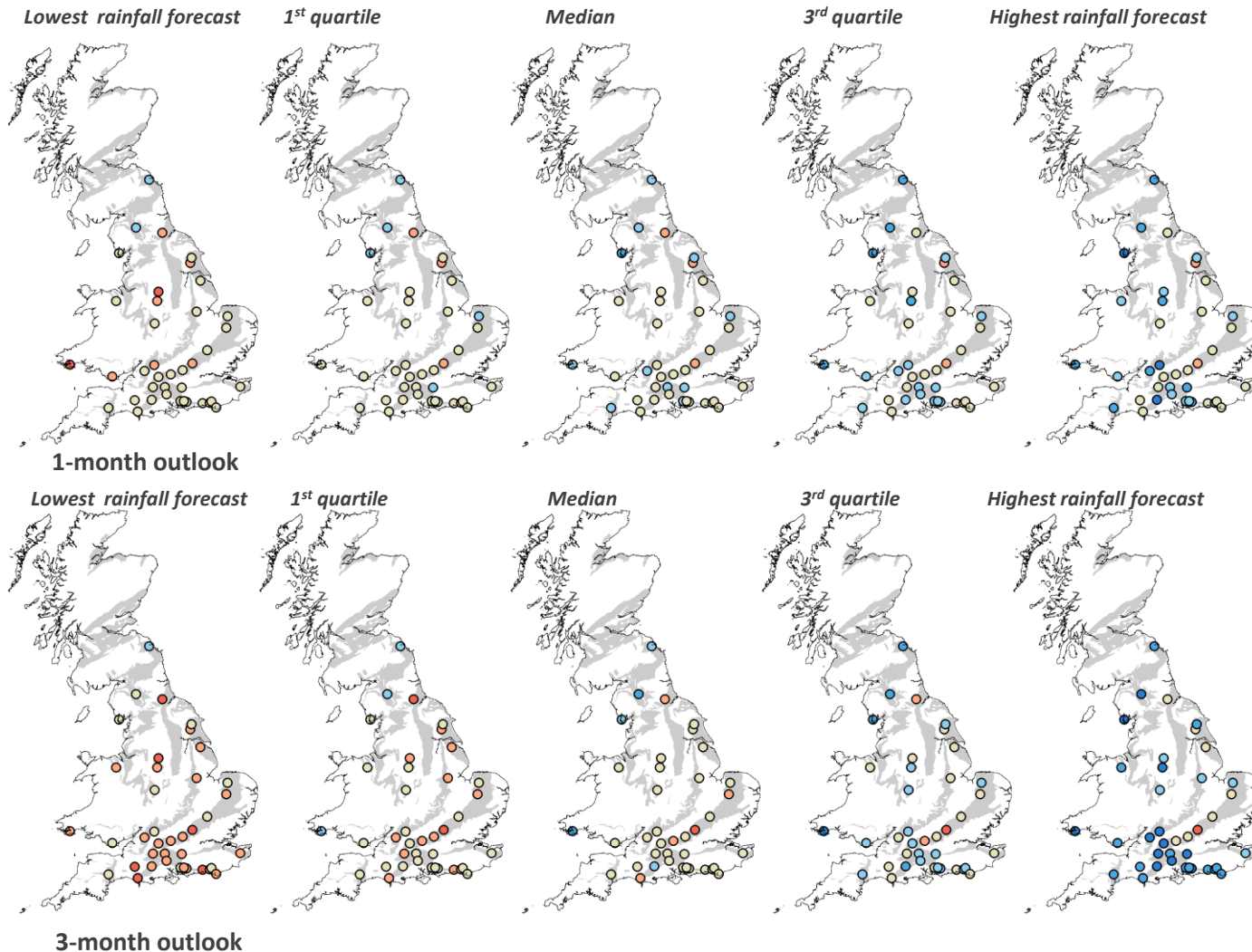
Period: December 2021 – February 2021

Issued on 08.12.2021 using data to the end of November

Over the next month, normal to above normal groundwater levels are forecast across much of England and Wales, with levels tending towards normal to below normal in the three-month forecast. Some exceptions are noted, including notably high levels predicted at Furness Abbey over the next month, and notably low levels at Ashley Green in the next three months. Note there are a reduced number of modelled sites. This is due to Covid-19 restrictions on access to sites in England and IT issues in Scotland.

These forecasts are produced by running five members of the Met Office ensemble climate forecast through groundwater models of observation borehole hydrographs at 42 sites across the country. The sites are distributed across the principal aquifers.

Based on the distribution of observed historical groundwater levels in a given month, seven categories have been derived for each site: very low, low, below normal, normal, above normal, high, and very high. The forecast groundwater level is assigned to one of these seven categories depending on where it falls within the distribution of the historically observed values.

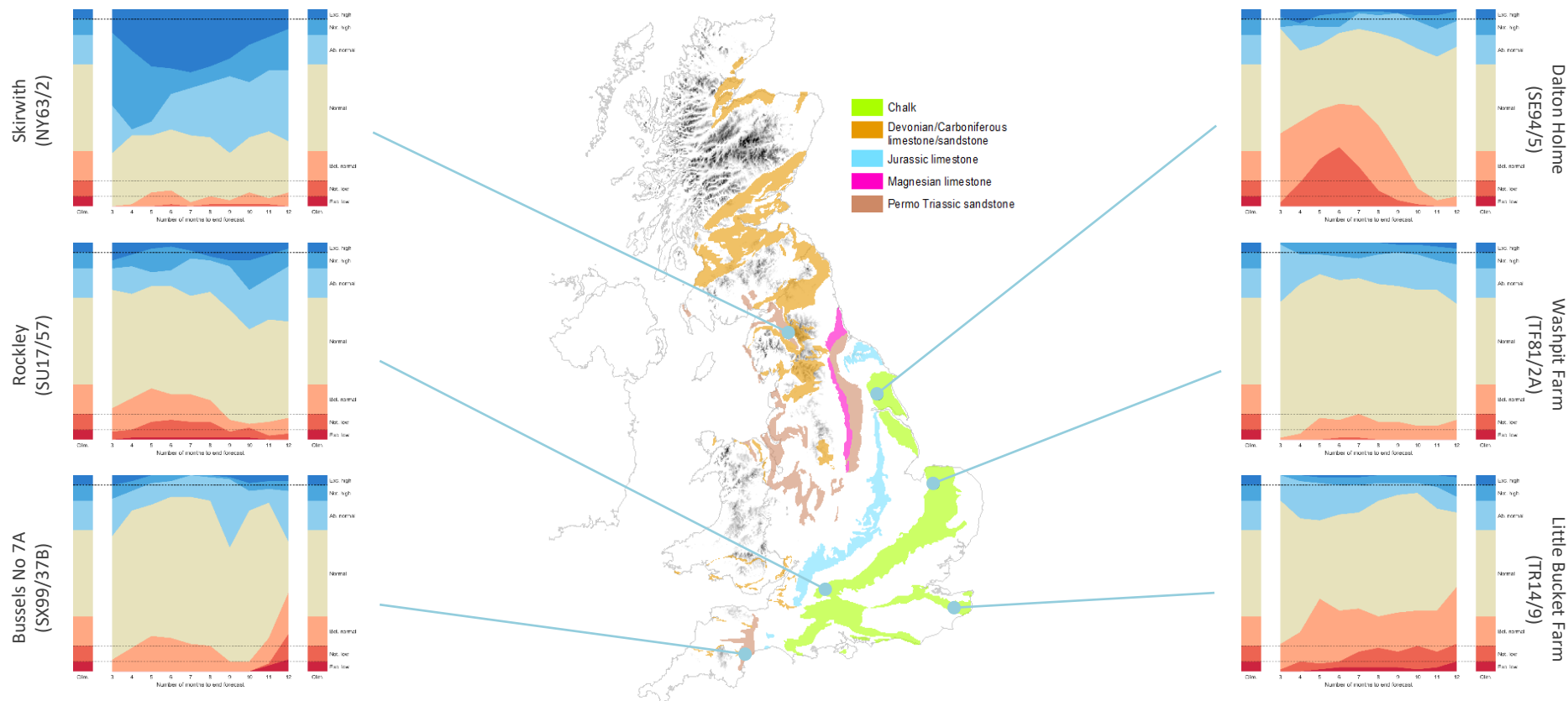


## Outlook based on modelled groundwater from historical climate

Period: December 2021 – November 2021

Issued on 08.12.2021 using data to the end of November

The groundwater levels are predicted to be predominantly normal in the Chalk sites at Rockley, Washpit Farm and Little Bucket Farm over the next 12 months. At Dalton Holme, normal to below normal levels are predicted in the next 9 months, then normal levels are likely to prevail between 9-12 months. In the Permo-Triassic sandstone at Skirwith levels are predicted to remain above normal to notably high throughout the 12-month period.



This outlook is based on monthly ensembles of historical sequences of observed climate (rainfall and potential evapotranspiration) that form input to hydrological models. The outputs are probabilistic simulations of the average groundwater level over the forecast horizon (3 to 12 months ahead), at each location.

The graphs show variation over time of the number of simulated groundwater levels in each monthly ensemble,

that fall within each the seven categories: exceptionally low, notably low, below normal, normal, above normal, notably high and exceptionally high. The monthly variations can be compared to the long-term average distribution of levels, which are shown as columns on the left and right of each graph.

This outlook is based entirely on historical sequences and therefore does not contain any knowledge of the state of

the atmosphere and ocean. It is hence possible that some of the historical sequences used might be inconsistent with current large-scale atmospheric conditions and would therefore be unlikely to occur in the next few months.