



Delivered in partnership by: UK Centre for Ecology & Hydrology

SUMMARY

In most regions of the UK river flows are likely to be normal to above normal during November, while in south Wales and southern areas of England river flows are likely to be above normal. Groundwater levels are likely to be above normal except in parts of eastern England where normal levels are most likely. Over the three month period to January 2022, river flows expected to be normal to above normal everywhere, while groundwater levels are likely to be normal.

Rainfall:

October rainfall was above average for the majority of the UK, notably so in Cumbria and southern Scotland. Some parts of mid-Wales and central England had less than average rainfall

The rainfall outlook (issued by the Met Office on 25.10.2021) is that the chance of a wet. November is higher than normal, and that there is a higher than normal chance of wet conditions over the period to January.

River flows:

River flows in October were in the normal range in central and north-eastern parts of England, and Northern Ireland and above normal elsewhere (note that data are unavailable for Scotland).

Above normal river flows are likely to persist in southern parts of Wales and England during November. In more northerly parts river flows are likely to be in the normal to above normal range, with normal flows more likely in central England and above normal flows more likely in north Wales, north-west England and eastern Scotland.

In the three months to January, river flows are likely to be in the normal to above normal range throughout the UK.

Groundwater:

Normal groundwater levels were recorded during October in the chalk and limestone aquifers in central England, with levels being generally above normal elsewhere.

During November normal groundwater levels are expected in some parts of eastern England, with above normal levels expected to persist elsewhere.

Over the three months to January, groundwater levels are expected to be in the normal range in all areas.

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











Met Office



River flows in southern regions of the UK are likely to be above normal in November.

Shaded areas show principal aguifers

During November in









UK Centre for Ecology & Hydrology

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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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

Reference for the Hydrological Outlook:

Hydrological Outlook UK, 2021, November, 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/

UK Centre for Ecology & Hydrology

Period: November 2021 – January 2022

Issued on 05.11.2021 using data to the end of October 2021

SUMMARY

The outlook for November is for mainly above normal flows in the south of England, and normal flows elsewhere. The outlook for November to January shows again above normal flows for the south of England, and a mixture of normal and above normal flows elsewhere. Note there are no forecasts available for Scotland.





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

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.

Outlook based on hydrological persistence and analogy

Period: November 2021

UK Centre for Ecology & Hydrology

Site-based: 1 month outlook

Issued on 05.11.2021 using data to the end of October 2021



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November 2021

Period: November 2021 – January 2022

Site-based: 3 month outlook

Issued on 05.11.2021 using data to the end of October 2021



UK Centre for Ecology & Hydrology

15

5

300

Flow [m3/s] 100 200

50

0

12

10

Ś

4

Flow [m3/s] 8 1

Flow [m3/s] 0

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



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Outlook based on modelled flow from historical climate

Overview

Issued on 02.11.2021 using data to the end of October 2021

Period: November 2021 – April 2022

The outlook for November and November-December-January indicates that flows are most likely to be normal to above normal for the majority of the UK, with high flows likely in southern England and Wales, north-western England, and eastern Scotland.



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 bar plot maps show the outlook distribution for 1, 3 and 6month 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 nmonth period. The probabilities fall within five categories, classified as: low, below normal, normal, above normal and high. 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 largescale atmospheric conditions and would therefore be unlikely to occur in the next few months. November 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.

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 largescale atmospheric conditions and would therefore be unlikely to occur in the next few months.





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

Period: October 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.



Flow estimate for each river pixel ranked in terms of historic % flow estimates (1963-2016)

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

November 2021

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Current Daily Simulated Subsurface Water Storage Conditions

Based on subsurface water storage estimated for 31st October 2021

Issue date: 02.11.2021

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 October, subsurface water levels were normal (average) in much of Anglian Region. Elsewhere, subsurface water levels were higher (wetter) than normal.



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Period: November 2021 – April 2022

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. Dec

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





Feb

Apr

SCOTLAND

Highlands Region North East Region

Tay Region

TWR Tweed Region

Forth Region

Clyde Region

Solway Region

Northumbria

Severn Trent Anglian

North West

Yorkshire

Thames

Wessex

Southern

South West

HR

NER

TR

FR

CR

SR

Ν

γ

ST

А

Т

S

W

SW

WALES

WEL Welsh

NW

ENGLAND



currently be used in Northern Ireland

OUTLOOK BASED ON CURRENT CONDITIONS









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



Estimate of Additional Rainfall Required to Overcome Dry Conditions

Based on subsurface water storage estimated for 31st October 2021

Issue date: 02.11.2021

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.

NER

TR

CRTWR

WEL

ST

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
- 0 ST Severn Trent
- 0 A Anglian
- 0 T Thames
- 0 W Wessex
- 0 S Southern
- 0 SW South West
 - WALES
- 0 WEL Welsh





Water storage deficit (anomaly, mm)



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OUTLOOK BASED ON CURRENT CONDITIONS



Period: November 2021 – January 2022

SUMMARY: During November river flows in Anglian are most likely to be in the Normal range or above. Elsewhere, river flows are likely to be Above normal or higher.

Over the next 3 months river flows are likely to be in the Normal range or above.

1-month flow outlook



Issued on 02.11.2021 using data to the end of October

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 1st and 3rd guartiles, actual flows may be more extreme than the flows derived using the highest or lowest rainfall forecasts.



SCOTLAND

HR **Highlands Region** NER North East Region TR **Tay Region** FR Forth Region CR Clyde Region TWR **Tweed Region** SR Solway Region ENGLAND Ν Northumbria NW North West Υ Yorkshire ST Severn Trent А Anglian Thames S Southern W Wessex SW South West

RIVER FLOW FROM RAINFALL FORECASTS

Т NORTHERN IRELAND This method cannot WALES currently be used in WFI Welsh Northern Ireland 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

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Outlook Based on Modelled Flow from Rainfall Forecasts

1- and 3-month variability

Highlands Region

North East Region

Tay Region

Forth Region

Clvde Region

Tweed Region Solway Region

Northumbria

North West

SCOTLAND

HR NER

TR

FR

CR

SR

Ν

NW

TWR

ENGLAND

Period: November 2021 – January 2022

Issue date: 02.11.2021

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 November river flows in Anglian are most likely to be in the *Normal range* or above. Elsewhere, river flows are likely to be *Above normal* or higher.

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Ecology & Hydrology

Over the next 3 months river flows are likely to be in the *Normal range* or above.

expected

100

0



RIVER FLOW FROM RAINFALL FORECASTS

NORTHERN IRELAND This method cannot

currently be used in Northern Ireland

Percentile range of historic values for relevant month

xceptionally 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

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Outlook Based on Modelled Flow from Rainfall Forecasts

1- and 3-month variability

HR

TR

FR

CR

SR

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Υ

ST

А

Т

S

W

SW

WALES

WEL Welsh

NW

TWR

NER

Period: November 2021 – January 2022

Issue date: 02.11.2021

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 November river flows in Anglian are most likely to be in the Normal range or above. Elsewhere, river flows are likely to be Above normal or higher.

Over the next 3 months river flows are likely to be in the Normal range or above.

1-month ahead	А	NW	Ν	ST	sw	s	т	Welsh	w	Y	CR	FR	HR	NER	SR	TR	TWR
Exceptionally high flow	2	2	2	10	10	2	2	12	2	2	2	2	12	7	10	5	2
Notably high flow	10	31	2	14	21	7	14	17	29	7	17	14	19	33	21	24	24
Above normal	24	26	57	52	45	62	57	48	45	50	29	40	21	36	29	45	48
Normal range	60	33	31	17	19	29	26	17	24	33	40	38	36	24	33	21	26
Below normal	5	5	7	7	5	0	0	7	0	7	5	5	10	0	7	5	0
Notably low flow	0	2	0	0	0	0	0	0	0	0	7	0	2	0	0	0	0
Exceptionally low flow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3-months ahead	Α	NW	N	ST	SW	S	т	Welsh	w	Y	CR	FR	HR	NER	SR	TR	TWR
Exceptionally high flow	0	14	2	5	7	0	0	5	0	2	2	7	5	2	5	10	19
Notably high flow	5	5	17	14	14	19	21	14	26	17	2	12	14	17	14	10	0
Above normal	21	24	29	29	26	31	24	21	31	31	36	26	14	26	26	29	14
Neuroslasses																	
Normal range	67	48	45	50	48	50	55	52	43	45	52	50	62	48	48	48	60
Below normal	67 7	48 10	45 5	50 2	48 5	50 0	55 0	52 7	43 0	45 5	52 7	50 5	62 5	48 7	48 7	48 5	60 7
Below normal Notably low flow	67 7 0	48 10 0	45 5 2	50 2 0	48 5 0	50 0 0	55 0 0	52 7 0	43 0 0	45 5 0	52 7 0	50 5 0	62 5 0	48 7 0	48 7 0	48 5 0	60 7 0



This method cannot currently be used in Northern Ireland

RIVER FLOW FROM RAINFALL FORECASTS

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Outlook based on modelled groundwater level & climate forecast

Period: November 2021 – January 2021

Above normal groundwater levels are forecast across much of England and Wales over the next month, with levels becoming more normal in the three month forecast. In the Chalk of the south-east of England and Yorkshire, levels generally remain in the normal range throughout the one and three month forecasts. Some exceptions are noted, including notably low levels predicted at Hucklow South in the next month. 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.



Issued on 08.11.2021 using data to the end of October

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.

y		Percentile range of historic observed values for relevant month
	Exceptionally high levels	> 95
	Notably high levels	87-95
	Above normal	72-87
	Normal	28-72
	Below normal	12-28
	Notably low levels	5-13
	Exceptionally low levels	< 5



3-month outlook

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GROUNDWATER FROM CLIMATE FORECASTS



UK Centre for

Outlook based on modelled groundwater from historical climate

Period: November 2021 – October 2021

Issued on 08.11.2021 using data to the end of October

In the Chalk sites at Rockley, Washpit Farm and Little Bucket Farm the groundwater levels are predicted to be normal to above normal for the next 3-4 months, returning to more normal levels after then. At Dalton Holme, normal to below normal levels are predicted in the next 10 months, then normal levels are likely to prevail between 10-12 months. In the Permo-Triassic sandstone at Skirwith levels are predicted to remain above normal throughout the 12-month period.



This outlook is based on monthly ensembles of historical sequences of observed climate (rainfall and potential evpotranspiration) 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.

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