Hydrological Summary

for the United Kingdom

September 2022

General

Although bookended by unsettled conditions, some crisp temperatures and heavy rainfall, September rainfall was only slightly above average at the national scale, and did little to alleviate long-term rainfall and river flow deficits that have been developing over much of the last year. Reflecting this, September mean river flows were generally in the normal range to notably low, even in regions which had plentiful rainfall. A handful of catchments registered exceptionally low flows, with two new September minima recorded in southern England. Although soils started to wet up through September, for the most part they remained drier than normal at month-end. Groundwater levels continued to recede across the country. Below normal levels were observed in two thirds of index sites, with some exceptionally low levels on the south coasts of England and Wales. Several more regions of Wales were moved into drought, meaning all of Wales and all but three regions of England were in official drought status by month-end. Reservoir stocks for England & Wales were almost 25% below average. Stocks in many impoundments fell relative to average, Roadford substantially so by 24%, and some set new September minimum stocks (e.g. Elan Valley, Stithians and Wimbleball, in series of at least 35 years). The Outlook for the coming three months suggests that late autumn/early winter rainfall is unlikely to be significantly above average in areas of the south and east where this period is critical for replenishing water resources. Given this delayed start to the recharge season, it is very likely that the current drought situation will persist into 2023.

Rainfall

A month of three parts, September started and ended with unsettled cyclonic conditions, whilst mid-month was more settled with few appreciable rainfall totals. Low pressure systems moved in from the Atlantic in the first week bringing localised showers with some notable rainfall totals across the UK, including 41mm on the 3rd at Plymouth (Devon) and 76mm on the 5th at Balmoral (Aberdeenshire). Surface water flooding over this period resulted in transport disruption across central and eastern Scotland, County Tyrone and Surrey, in addition to a mudslide and associated road closure and flooding in Taunton (Somerset) on the 5th. The final week was similarly unsettled as frontal systems again moved across the UK, in particular on the 30th, when a slow-moving system brought heavy rainfall to much of the UK. The heaviest rainfall was in the north and west, e.g. 100mm at Seathwaite and 94mm at Honister (both Cumbria), causing flooding and a mudslide in the north-west Highlands, and transport disruption and livestock losses in Cumbria. At the national scale, the UK received 111% of average rainfall, but there were marked spatial variations. More than 170% of average rainfall was registered in much of north-east Britain, parts of Northern Ireland and southern England, and almost 160% of average for Northern Ireland and Southern at the regional scale. In contrast, less than 90% of average was received in western Scotland, west Wales, and across much of the East Midlands and East Anglia – with localised parts of Scotland and eastern England receiving less than 70%; at the regional scale only Highland, Severn-Trent and Anglian regions registered below average rainfall. It was the second driest summer-half year (April-September) for Anglian region, and in the 12 months from October, all regions received below average rainfall – some such as Anglian, Thames, Southern, Wessex with less than 75% of average.

River flows

River flows across the country responded to the wet weather at the start of the month, with the exception of groundwater dominated catchments where recessions continued with little to no response to rainfall – the Coln, for example, set new daily flow minima every day in September (in a series from 1964). At month end, flows responded to heavy rainfall in responsive northern and western catchments on the 30th/31st, although flows in many catchments remained below average. September mean monthly flows were generally in the normal range or below across the UK despite the wet weather, except for a couple of catchments with above normal flows in north-east Scotland. The Coln and Waveney recorded new minimum September mean flows, which were also period of record minima of any month in these catchments (both in series from 1964). Exceptionally low flows were also recorded on the Aire, the Yscir (both the second lowest September in series from 1972 and 1959, respectively, the latter just 14% of average) and the Wye, which was the fourth lowest September in a long record from 1936. Over the summer half year mean flows were below average in almost all catchments, with those away from the far north-west below normal to exceptionally low. New minimum flows were registered for this period in a number of catchments across Great Britain, focussed around south-western parts of England and Wales. April-September average outflows for England & Wales were the third lowest on record (in a series from 1961) behind 1976 and 1990. Over the last 12 months, mean flows were more generally in the normal range, but most were below average, with some less than two-thirds of average.

Groundwater

Soils began to wet up during September but remained dry across much southern and eastern England, and in south Wales. Month-end soil moisture deficits were low or zero across most of north-west England, Northern Ireland and Scotland, with the exception of the east coast of Scotland. Groundwater levels were below normal in three quarters of Chalk index sites, with exceptionally low levels recorded along the south coast at Ashton Farm, Compton House and Chilgrove House. Levels rose at Killyglen: having been exceptionally low in August, they ended September in the normal range. At Chipstead, Houndean and Westdean No.3, levels moved towards the normal range. In the Jurassic limestones and Magnesian Limestone, groundwater levels fell and were below normal or notably low, except at Brick House Farm where they were above normal. Levels were below normal across the Carboniferous Limestone, with a fourth successive record low (in a 27 year record) recorded at Pant y Lladron. Groundwater levels receded and were in the normal range at the majority of Permo-Triassic sandstone sites. At Skirwith the level rose slightly and became above normal. Levels fell or plateaued in the Upper Greensand and Devonian/Carboniferous sandstones, and were normal in the former and normal to notably low in the latter. Notably low levels at Easter Lathrisk were the third lowest September level in a 26 year record.

National Hydrological Monitoring Programme
UK Centre for Ecology & Hydrology
BGS British Geological Survey

Rainfall . . . Rainfall . . .

Met Office

Rainfall accumulations and return period estimates

Percentages are from the 1991-2020 average.

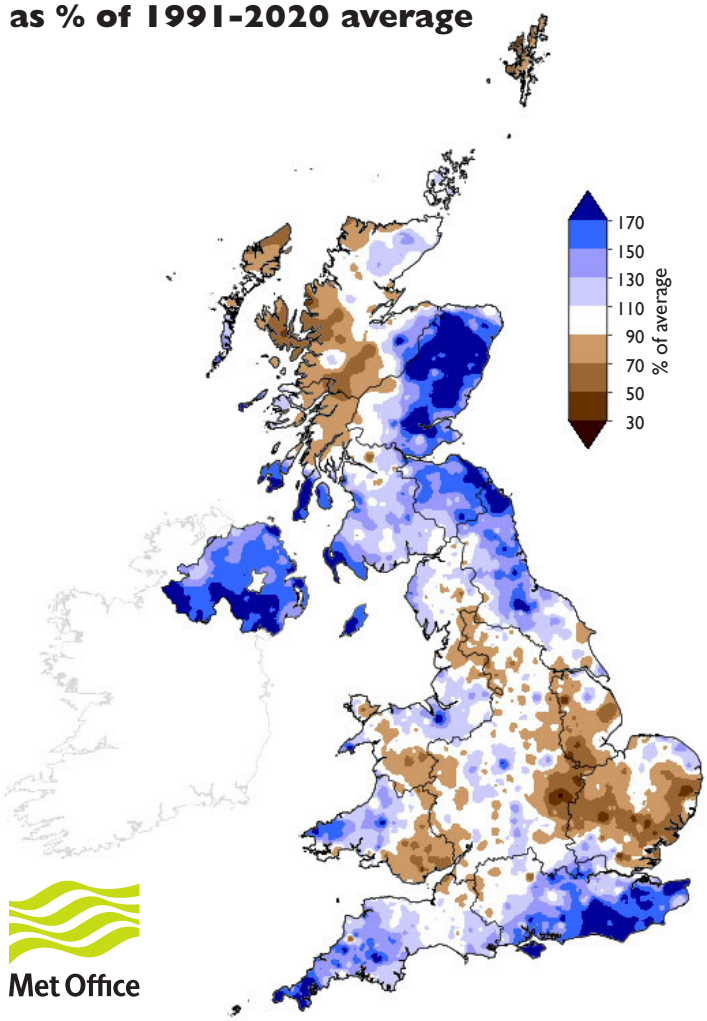
Region	Rainfall	Sep 2022	Aug22 – Sep22	RP	Apr22 – Sep22	RP	Jan22 – Sep22	RP	Oct21 – Sep22	RP
United Kingdom	mm	**101**	152		382		639		1000	
	%	**111**	82	2-5	78	8-12	81	8-12	86	5-10
England	mm	**75**	110		254		424		683	
	%	**110**	77	2-5	65	20-30	71	20-30	79	10-15
Scotland	mm	**135**	216		578		966		1472	
	%	**109**	89	2-5	93	2-5	91	2-5	94	2-5
Wales	mm	**114**	154		387		706		1179	
	%	**102**	69	5-10	66	20-35	73	15-25	81	8-12
Northern Ireland	mm	**139**	183		474		721		1054	
	%	**158**	98	2-5	94	2-5	90	2-5	91	2-5
England & Wales	mm	**80**	116		272		462		750	
	%	**108**	75	2-5	65	20-35	72	20-30	79	10-15
North West	mm	**110**	171		434		727		1178	
	%	**102**	78	2-5	79	5-10	83	5-10	92	2-5
Northumbria	mm	**100**	134		312		480		765	
	%	**139**	87	2-5	74	5-10	76	10-20	84	5-10
Severn-Trent	mm	**60**	89		229		402		627	
	%	**95**	67	5-10	60	30-50	71	15-25	78	10-20
Yorkshire	mm	**73**	102		260		468		708	
	%	**103**	69	2-5	65	15-25	77	8-12	81	5-10
Anglian	mm	**42**	76		169		279		452	
	%	**79**	67	5-10	54	40-60	62	30-50	72	20-30
Thames	mm	**66**	98		203		331		529	
	%	**117**	83	2-5	62	15-25	66	15-25	73	15-25
Southern	mm	**99**	133		237		361		609	
	%	**159**	106	2-5	71	8-12	67	15-25	74	10-15
Wessex	mm	**70**	91		226		388		642	
	%	**105**	66	5-10	60	30-50	64	25-40	71	25-40
South West	mm	**118**	157		330		571		979	
	%	**134**	86	2-5	67	10-20	69	15-25	78	10-15
Welsh	mm	**111**	151		377		678		1130	
	%	**104**	70	5-10	66	20-35	73	15-25	81	8-12
Highland	mm	**125**	217		688		1170		1765	
	%	**85**	78	2-5	98	2-5	93	2-5	95	2-5
North East	mm	**131**	188		442		648		978	
	%	**158**	108	2-5	93	2-5	89	2-5	92	2-5
Tay	mm	**137**	217		509		842		1252	
	%	**135**	104	2-5	91	2-5	89	2-5	90	2-5
Forth	mm	**121**	201		430		727		1102	
	%	**128**	103	2-5	83	2-5	85	2-5	89	2-5
Tweed	mm	**119**	161		353		604		983	
	%	**148**	93	2-5	75	5-10	81	5-10	90	2-5
Solway	mm	**152**	232		538		926		1477	
	%	**127**	94	2-5	84	2-5	87	2-5	94	2-5
Clyde	mm	**163**	252		691		1168		1762	
	%	**109**	85	2-5	94	2-5	91	2-5	93	2-5

% = percentage of 1991-2020 average *RP = Return period*

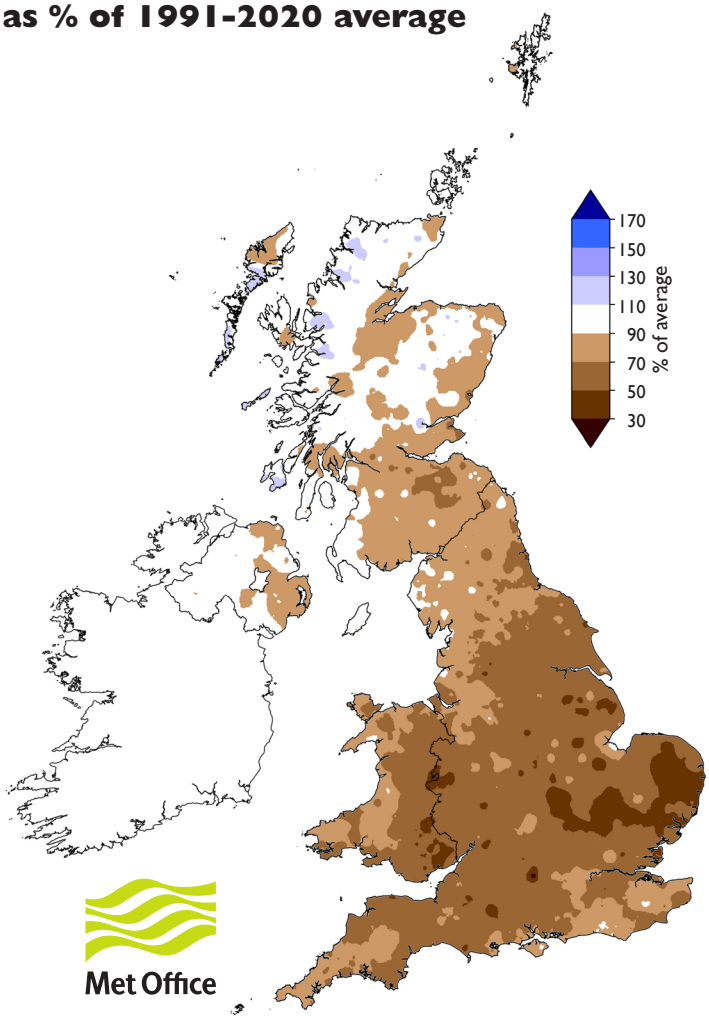
Important note: Figures in the above table may be quoted provided their source is acknowledged. Where appropriate, specific mention must be made of the uncertainties associated with the return period estimates. The RP estimates are based on data provided by the Met Office and reflect climatic variability since 1836; they also assume a stable climate. The quoted RPs relate to the specific timespans only; for the same timespans, but beginning in any month the RPs would be substantially shorter. The timespans featured do not purport to represent the critical periods for any particular water resource management zone. For hydrological or water resources assessments of drought severity, river flows and/or groundwater levels normally provide a better guide than return periods based on regional rainfall totals. Note that precipitation totals in winter months may be underestimated due to snowfall undercatch. All monthly rainfall totals since January 2022 are provisional. Source: Data from HadUK-Grid dataset at 1km resolution v1.1.0.0.

Rainfall . . . Rainfall . . .

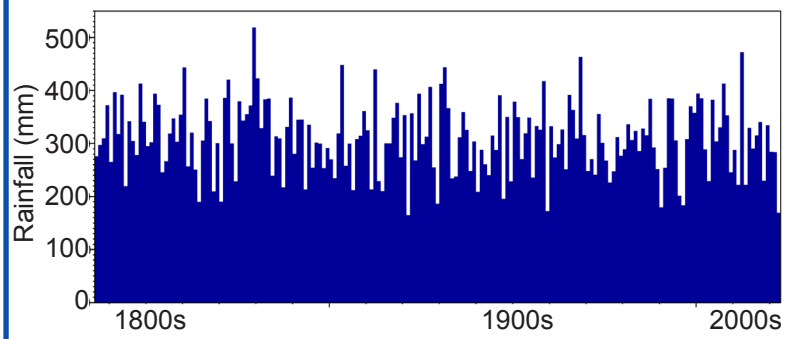
September 2022 rainfall as % of 1991-2020 average



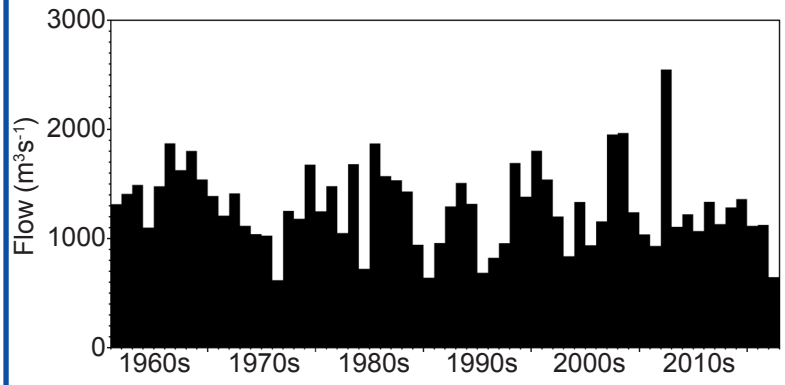
April 2022 - September 2022 rainfall as % of 1991-2020 average



April - September rainfall for Anglian Region



April - September average outflows for England & Wales



UK Hydrological Outlook

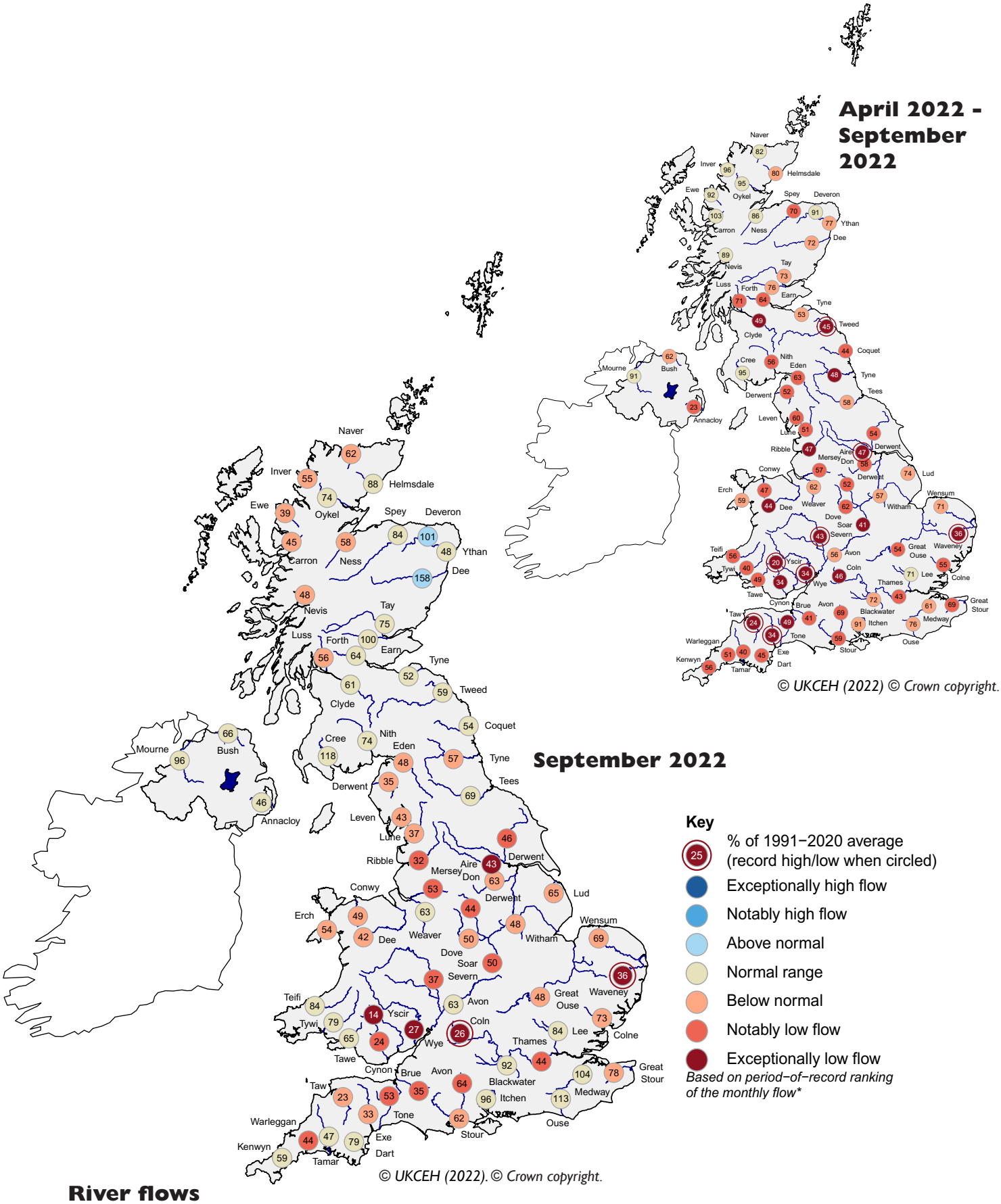
The Hydrological Outlook provides an insight into future hydrological conditions across the UK. Specifically it describes likely trajectories for river flows and groundwater levels on a monthly basis, with particular focus on the next three months.

The complete version of the Hydrological Outlook UK can be found at: www.hydoutuk.net/latest-outlook/

Period: **from October 2022**
Issued: **10.10.2022**
using data to the end of September 2022

The outlook for October and for the October–December period is for below normal river flows in central, eastern and southern England. Elsewhere, river flows are likely to be in the normal range. Groundwater levels for October are likely to be normal to below across the country, and exceptionally low in southern England. Over the three-month period, levels are expected to return to the normal range.

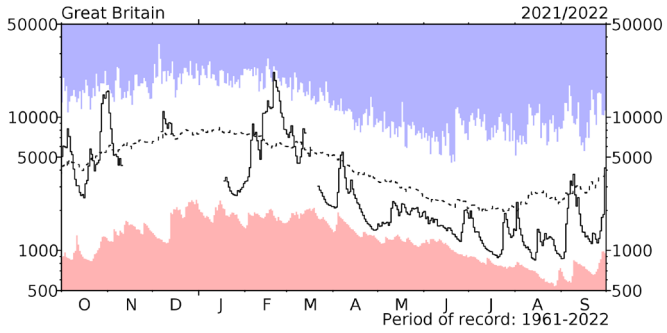
River flow . . . River flow . . .

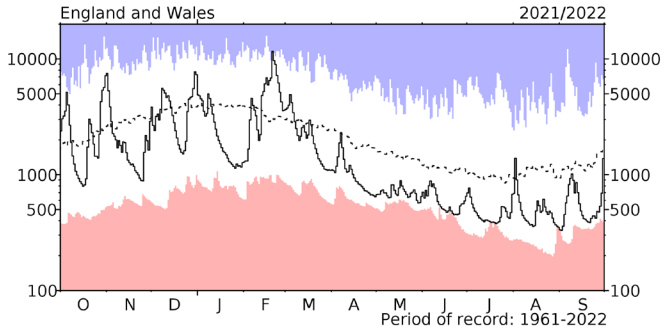


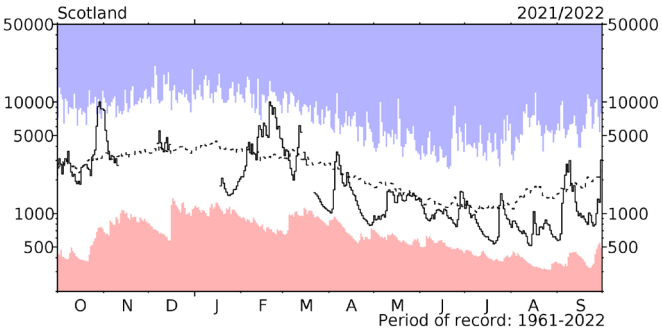
River flows

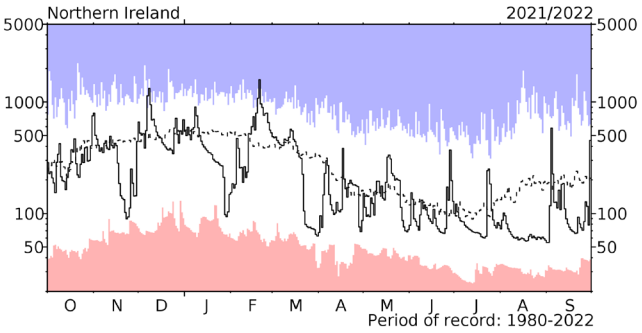
*Comparisons based on percentage flows alone can be misleading. A given percentage flow can represent extreme drought conditions in permeable catchments where flow patterns are relatively stable but be well within the normal range in impermeable catchments where the natural variation in flows is much greater. The categories of the spots are based on the full period-of-record data whereas the percentages are based on the 1991-2020 averaging period for consistency between rainfall and river flows. Percentages may be omitted where flows are under review.

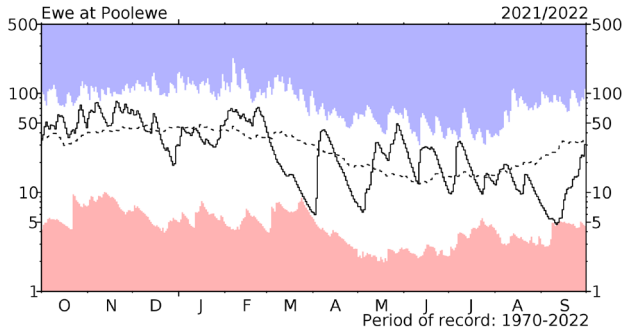
River flow . . . River flow . . .

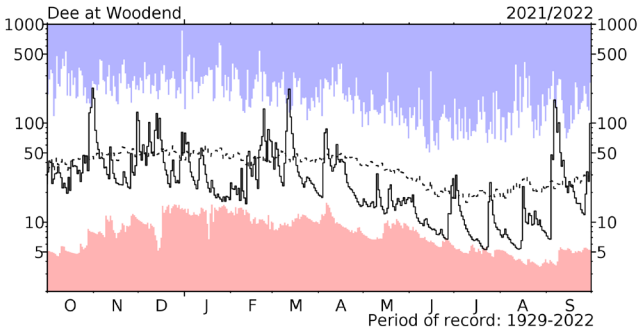


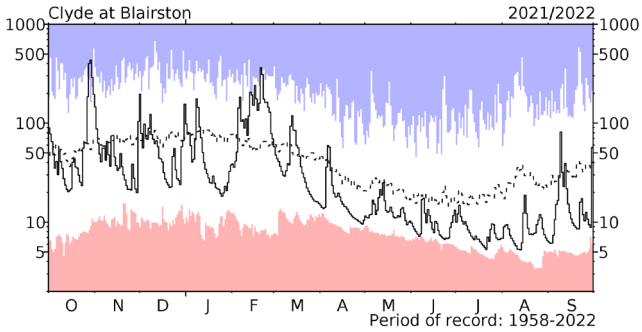


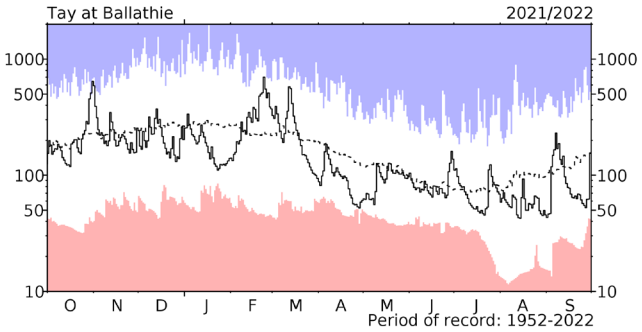


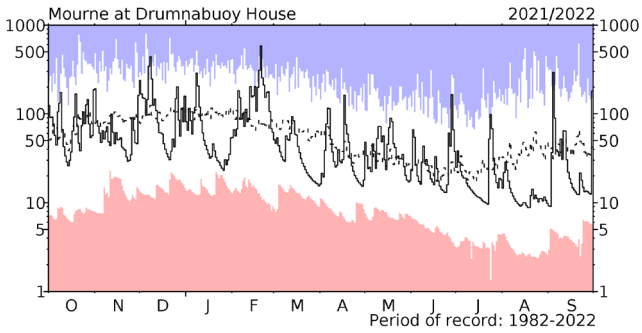


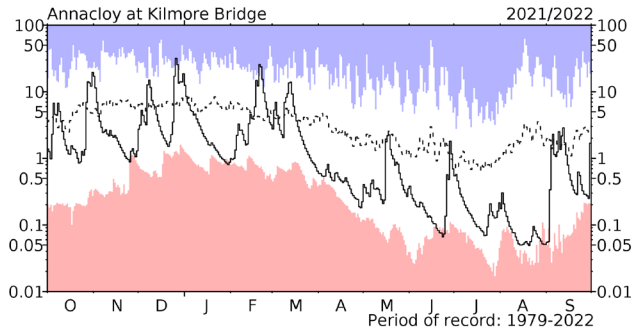








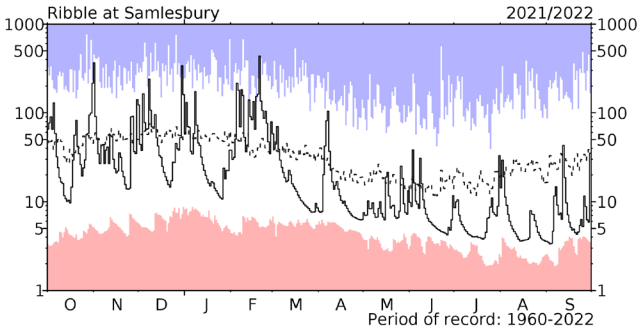


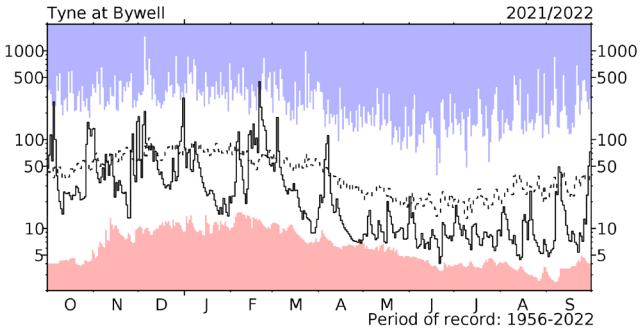


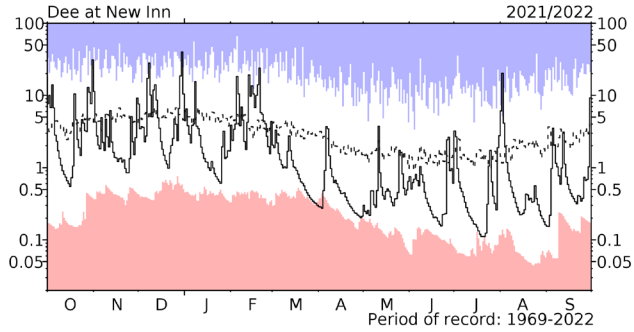
River flow hydrographs

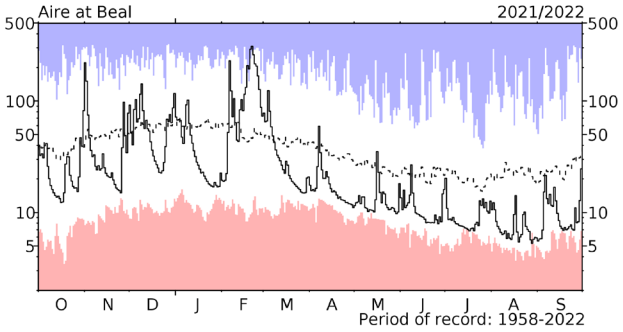
*The river flow hydrographs show the daily mean flows (measured in m^3s^{-1}) together with the maximum and minimum daily flows prior to October 2021 (shown by the shaded areas). Daily flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas. The dashed line represents the period-of-record average daily flow.

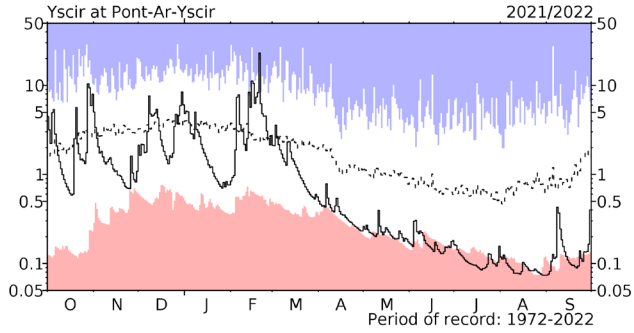
River flow . . . River flow . . .

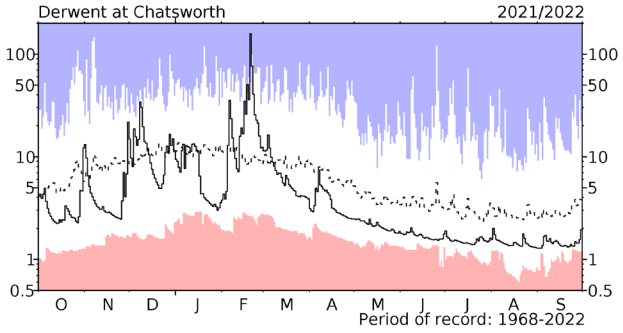


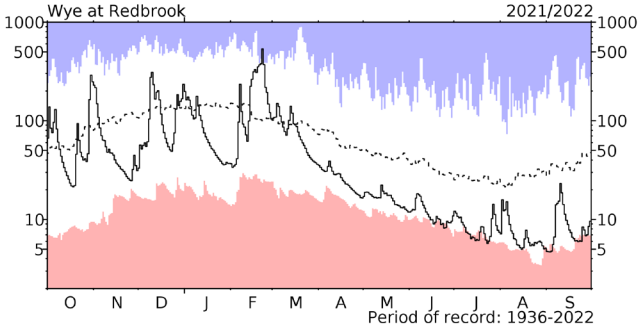


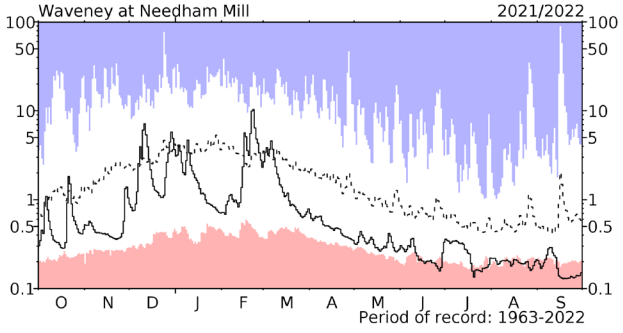


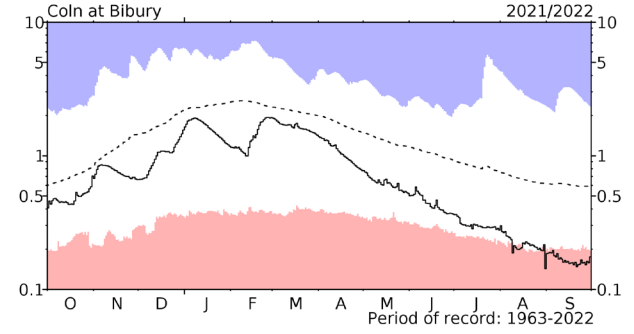


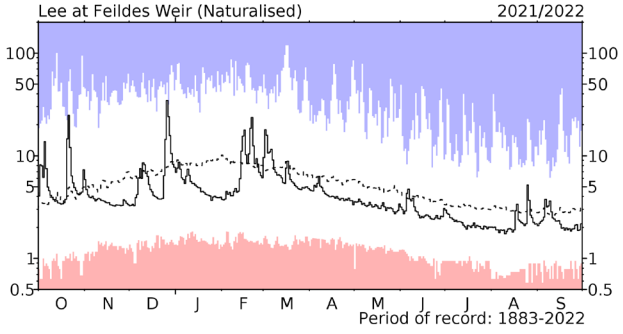


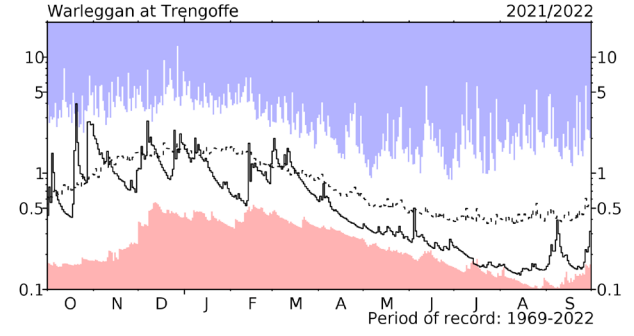


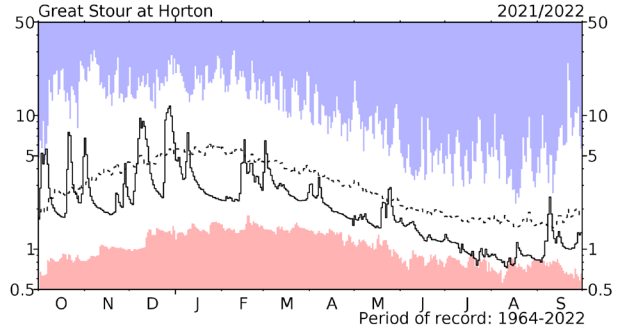




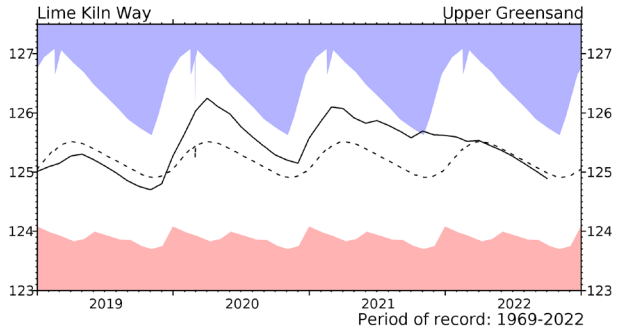


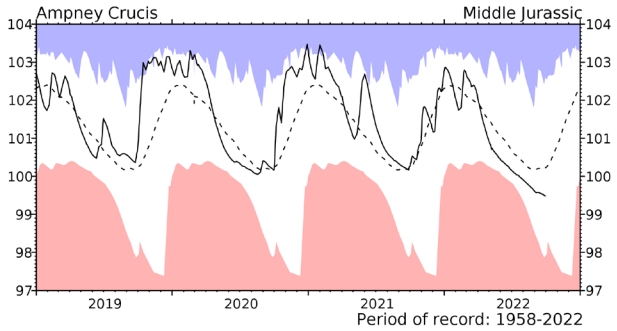


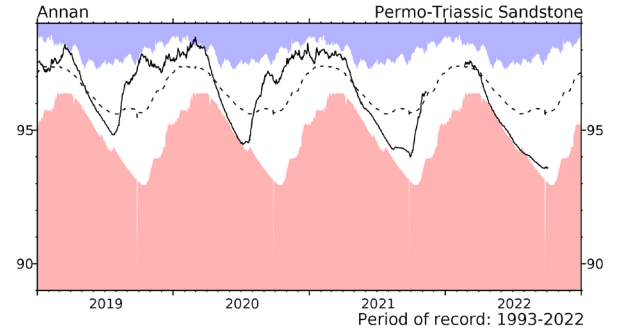


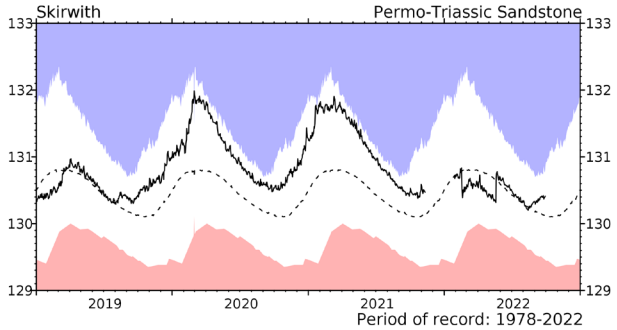


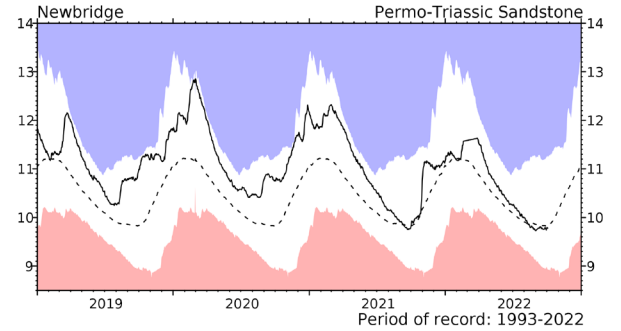
Groundwater… Groundwater

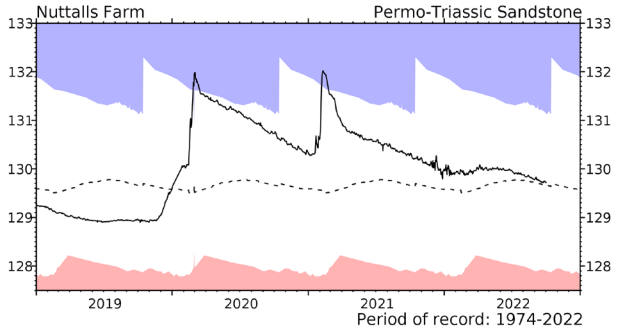


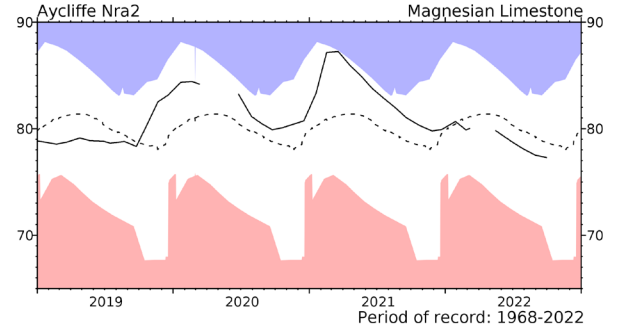


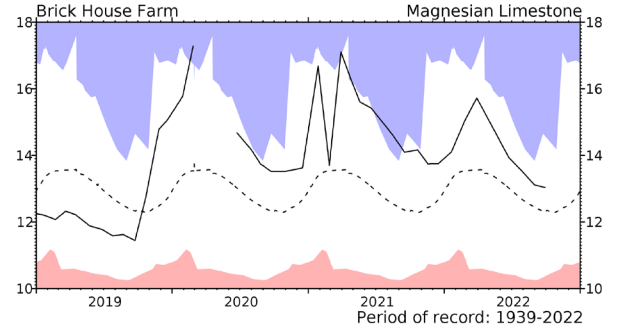


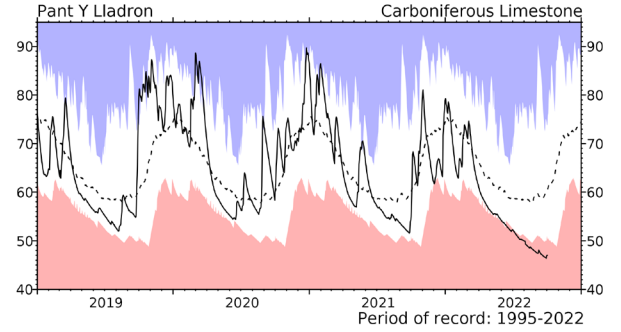


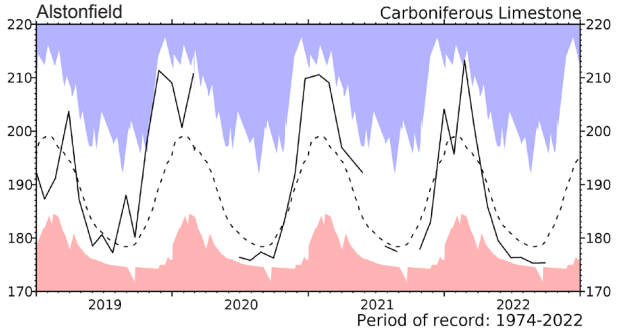


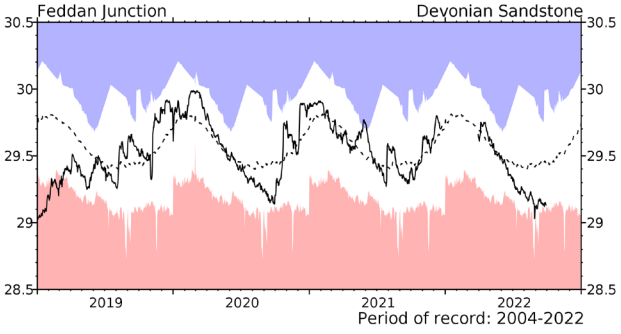


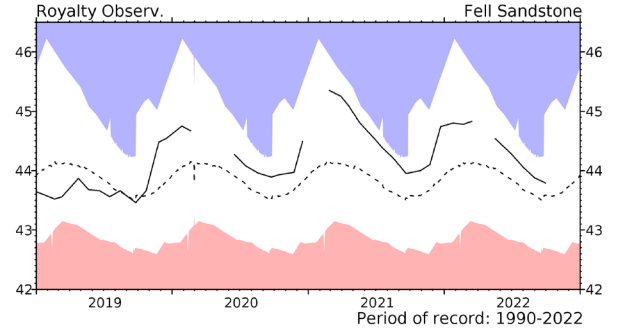




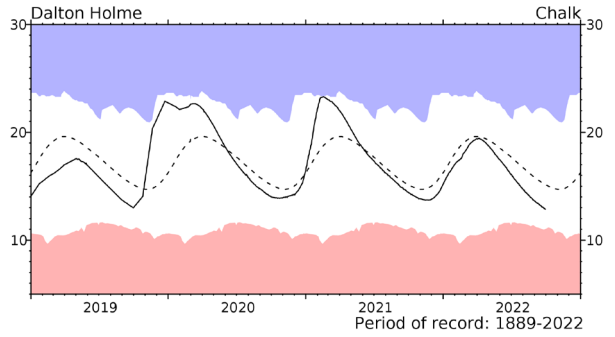


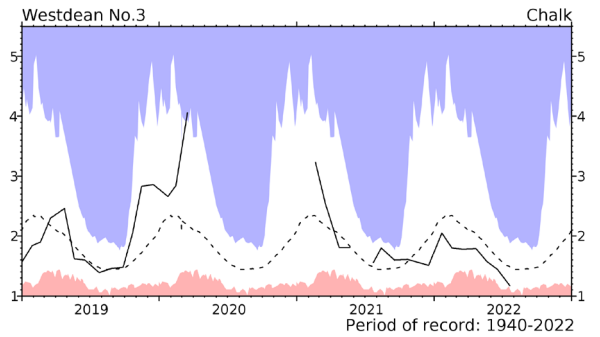


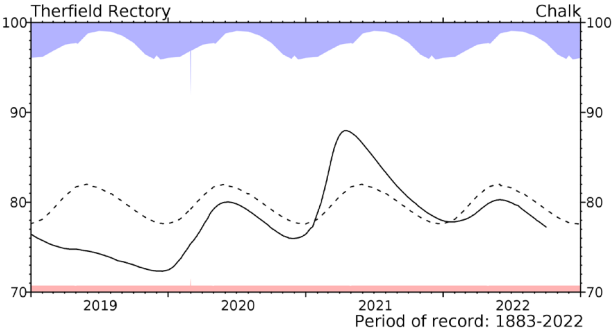


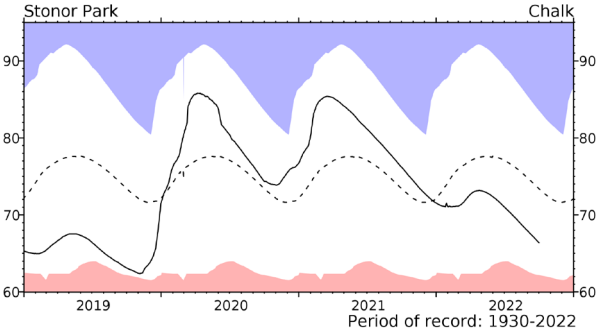


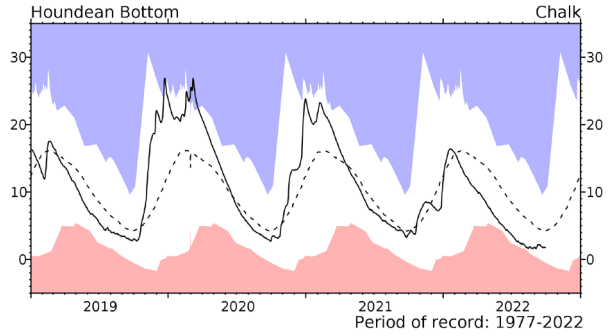
Groundwater…Groundwater

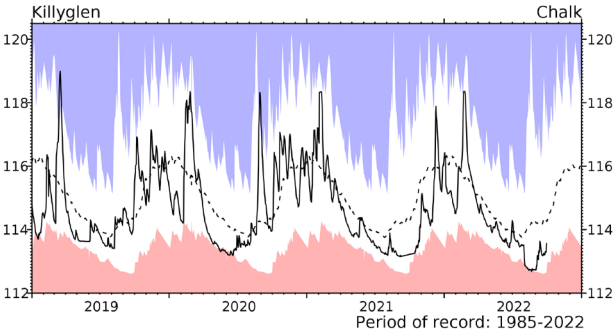


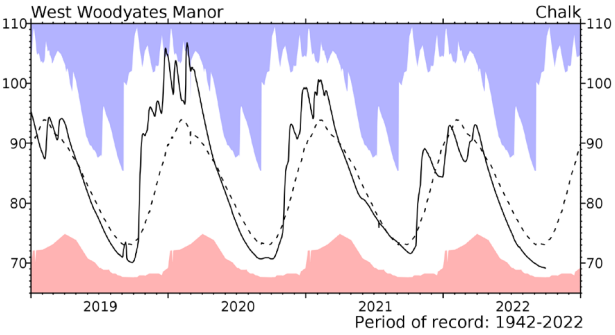


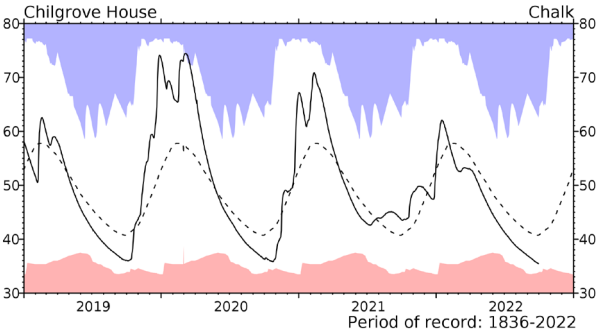


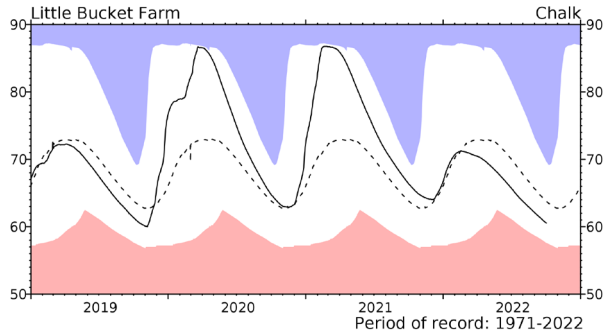


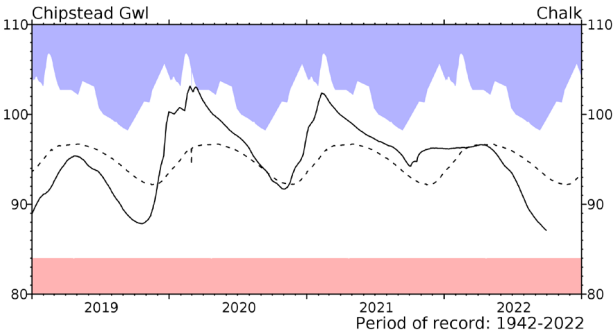












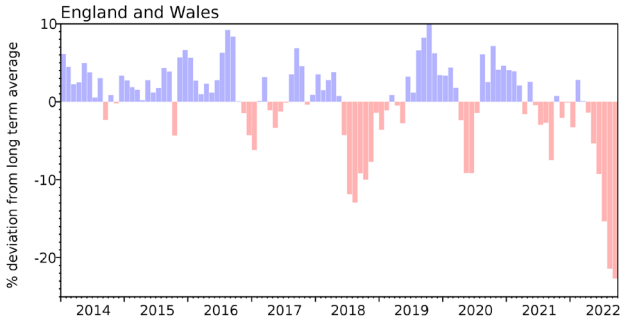
Groundwater levels (measured in metres above ordnance datum) normally rise and fall with the seasons, reaching a peak in the spring following replenishment through the winter (when evaporation losses are low and soil moist). They decline through the summer and early autumn. This seasonal variation is much reduced when the aquifer is confined below overlying impermeable strata. The monthly mean and the highest and lowest levels recorded for each month are calculated with data from the start of the record to the end of 2018. Note that most groundwater levels are not measured continuously and, for some index wells, the greater frequency of contemporary measurements may, in itself, contribute to an increased range of variation.

Groundwater levels - September 2022

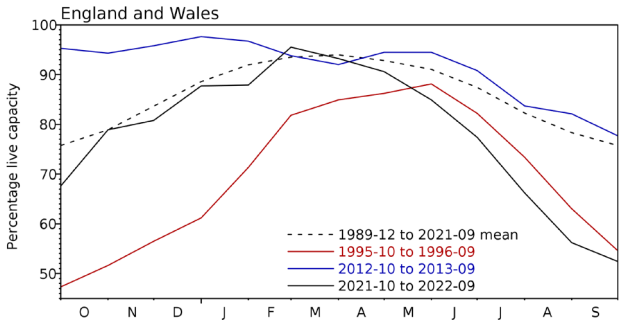
The calculation of ranking has been modified from that used in summaries published prior to October 2012. It is now based on a comparison between the most recent level and levels for the same date during previous years of record. Where appropriate, levels for earlier years may have been interpolated. The rankings are designed as a qualitative indicator, and ranks at extreme levels, and when levels are changing rapidly, need to be interpreted with caution.

Reservoirs . . . Reservoirs . . .

Guide to the variation in overall reservoir stocks for England and Wales



Comparison between overall reservoir stocks for England and Wales in recent years



Percentage live capacity of selected reservoirs at end of month

Area	Reservoir		Capacity (Ml)	2022 Jul	2022 Aug	2022 Sep	Sep Anom.	Min Sep	Year* of min	2021 Sep	Diff 22-21
North West	N Command Zone	•	124929	53	45	38	-21	13	1995	30	7
	Vyrnwy		55146	57	46	37	-34	26	1995	62	-25
Northumbrian	Teesdale	•	87936	73	66	79	8	31	1995	41	38
	Kielder		(199175)	82	79	88	3	59	1989	76	12
Severn-Trent	Clywedog		49936	66	52	40	-33	24	1989	73	-33
	Derwent Valley	•	46692	45	36	29	-35	24	1989	47	-19
Yorkshire	Washburn	•	23373	50	37	28	-39	24	1995	66	-38
	Bradford Supply	•	40942	47	35	28	-40	15	1995	51	-24
Anglian	Grafham		(55490)	78	66	58	-26	46	1997	92	-34
	Rutland		(116580)	83	76	70	-10	61	1995	86	-16
Thames	London	•	202828	75	62	60	-17	53	1997	81	-21
	Farmoor	•	13822	89	72	63	-27	54	2003	84	-21
Southern	Bewl		31000	64	57	48	-15	32	1990	74	-26
	Ardingly		4685	57	31	25	-39	21	2020	73	-48
Wessex	Clatworthy		5662	60	45	30	-27	25	2003	60	-30
	Bristol	•	(38666)	62	53	46	-17	31	1990	58	-12
South West	Colliford		28540	43	31	38	-29	38	2006	59	-21
	Roadford		34500	60	47	20	-49	20	2022	79	-58
	Wimbleball		21320	49	37	23	-42	23	2022	69	-46
	Stithians		4967	44	27	19	-38	19	2022	52	-33
Welsh	Celyn & Brenig	•	131155	65	55	46	-35	39	1989	71	-25
	Brianne		62140	64	52	49	-39	48	1995	80	-31
	Big Five	•	69762	54	40	32	-38	19	1995	61	-29
	Elan Valley	•	99106	53	39	31	-44	31	2022	66	-35
Scotland(E)	Edinburgh/Mid-Lothian	•	97223	77	71	71	-7	43	1998	64	7
	East Lothian	•	9317	80	67	67	-17	52	1989	91	-24
Scotland(W)	Loch Katrine	•	110326	88	79	75	0	41	2021	41	34
	Daer		22494	71	62	70	-8	32	1995	37	33
	Loch Thom		10721	82	75	69	-13	40	2021	40	29
Northern Ireland	Total+	•	56800	77	65	69	-7	29	1995	63	6
	Silent Valley	•	20634	73	60	64	-8	27	1995	51	13

( ) figures in parentheses relate to gross storage

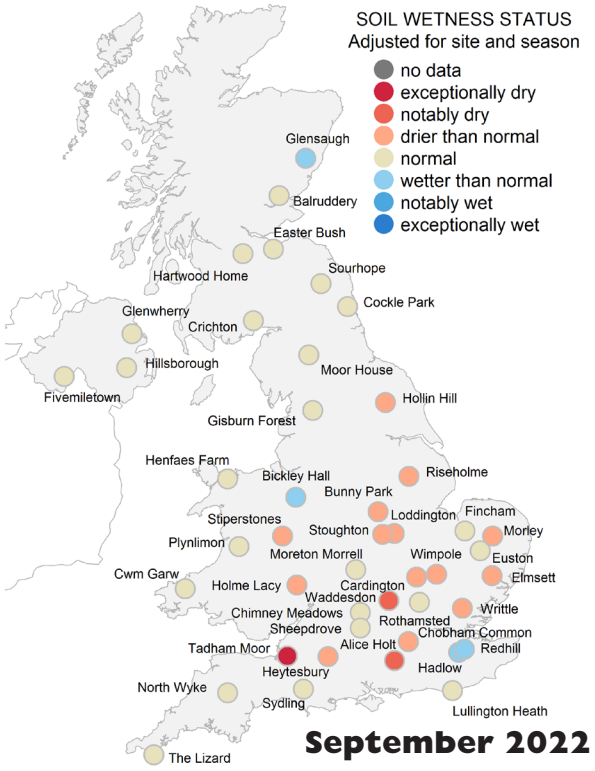
• denotes reservoir groups

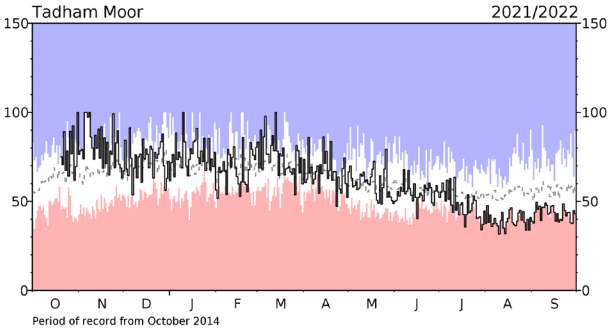
*last occurrence

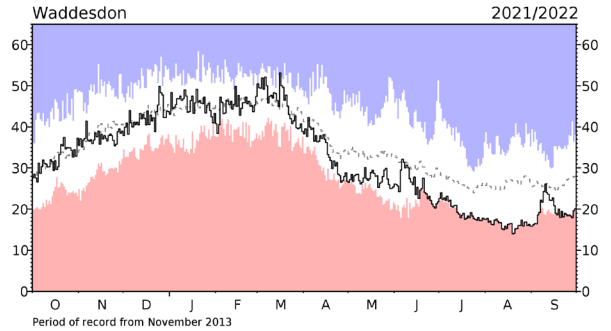
+ excludes Lough Neagh

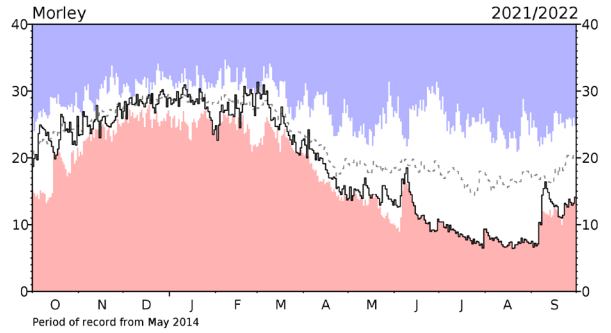
Details of the individual reservoirs in each of the groupings listed above are available on request. The percentages given in the Average and Minimum storage columns relate to the 1988-2012 period except for West of Scotland and Northern Ireland where data commence in the mid-1990s. In some gravity-fed reservoirs (e.g. Clywedog) stocks are kept below capacity during the winter to provide scope for flood attenuation purposes. Monthly figures may be artificially low due to routine maintenance or turbidity effects in feeder rivers.

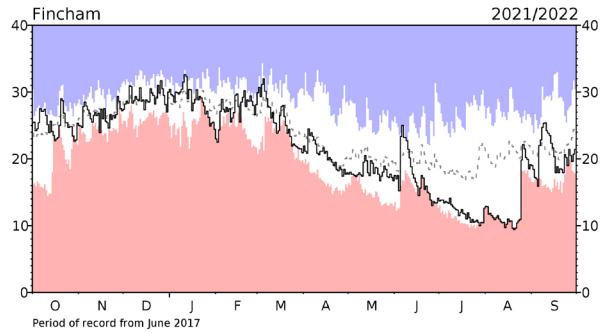
Soil Moisture . . . Soil Moisture

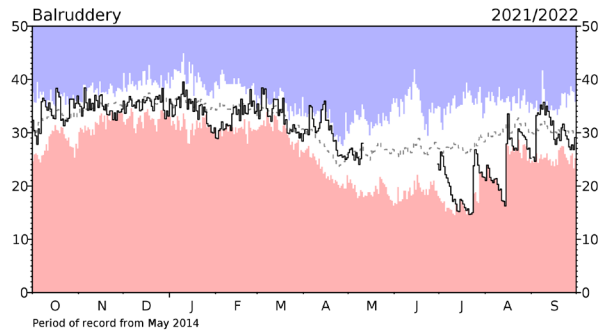












At the end of September, soils across the UK are gradually wetting up, following the extremely dry summer.

The patchy precipitation picture has resulted in COSMOS-UK stations wetting up in general, but with exceptions and generally more slowly than would be expected for September. Air temperatures remained warm until mid-September, particularly in central and southern England, increasing evaporation rates. Tadham Moor remains exceptionally dry, with less than 33% of average rainfall in the area, and there has been relatively little recovery of soil moisture at Alice Holt and Waddesdon, both remaining notably dry at the end of the month, despite Alice Holt receiving over 70mm of rain in the first nine days of the month.

Scottish sites have had generally low rainfall during September, but having remained relatively wet over the summer, they are now at or above normal soil moisture levels. The East Anglian sites (Fincham, Morley and Euston) have had low rainfall, with Morley remaining drier than normal, whilst Fincham and Euston being normal or close to normal, having received significant rain in late August.

Soil moisture data

These data are from UKCEH's COSMOS-UK network. The time series graphs show volumetric water content as a percentage in black together with the maximum and minimum daily values for the period-of-record of the sites. The dashed line represents the period-of-record mean VWC. For more information visit cosmos.ceh.ac.uk.

NHMP

The National Hydrological Monitoring Programme (NHMP) was started in 1988 and is undertaken jointly by the UK Centre for Ecology & Hydrology (UKCEH) and the British Geological Survey (BGS). The NHMP aims to provide an authoritative voice on hydrological conditions throughout the UK, to place them in a historical context and, over time, identify and interpret any emerging hydrological trends. Hydrological analysis and interpretation within the Programme is based on the data holdings of the National River Flow Archive (NRFA; maintained by UKCEH) and National Groundwater Level Archive (NGLA; maintained by BGS), including rainfall, river flows, borehole levels, and reservoir stocks.

The Hydrological Summary is supported by the Natural Environment Research Council award number NE/R016429/1 as part of the UK-SCAPE programme delivering National Capability.

Data Sources

The NHMP depends on the active cooperation of many data suppliers. This cooperation is gratefully acknowledged. A location map of all sites used in the Hydrological Summary can be found on the NHMP website. River flow and groundwater level data are provided by the Environment Agency (EA), Natural Resources Wales - Cyfoeth Naturiol Cymru (NRW), the Scottish Environment Protection Agency (SEPA) and, for Northern Ireland, the Department for Infrastructure - Rivers and the Northern Ireland Environment Agency. In all cases the data are subject to revision following validation (high flow and low flow data in particular may be subject to significant revision).

Details of reservoir stocks are provided by the Water Service Companies, the EA, Scottish Water and Northern Ireland Water.

The Hydrological Summary and other NHMP outputs may also refer to and/or map soil moisture data for the UK. These data are provided by the Meteorological Office Rainfall and Evaporation Calculation System (MORECS). MORECS provides estimates of monthly soil moisture deficit in the form of averages over 40 x 40 km grid squares over Great Britain and Northern Ireland. The monthly time series of data extends back to 1961.

Rainfall data are provided by the Met Office. To allow better spatial differentiation the rainfall data for Britain are presented for the regional divisions of the precursor organisations of the EA, NRW and SEPA. The areal rainfall figures have been produced by the Met Office National Climate Information Centre (NCIC), and are based on the HadUK-Grid 1km resolution gridded data from rain gauges. The majority of the full rain gauge network across the UK is operated by the EA, NRW, SEPA and Northern Ireland Water; supplementary rain gauges are operated by the Met Office. The Met Office NCIC monthly rainfall series extend back to 1836 and form the official source of UK areal rainfall statistics which have been adopted by the NHMP. The gridding technique used is described in Hollis, 2019 available at https://doi.org/10.1002/gdj3.78

Long-term averages are based on the period 1991-2020 and are derived from the monthly areal series.

The regional figures for the current month in the hydrological summaries are based on a limited rain gauge network so these (and the associated return periods) should be regarded as a guide only.

The monthly rainfall figures are provided by the Met Office NCIC and are Crown Copyright and may not be passed on to, or published by, any unauthorised person or organisation.

For further details on rainfall or MORECS data, please contact the Met Office:

Tel: 0370 900 0100
Email: enquiries@metoffice.gov.uk

Enquiries

Enquiries should be directed to the NHMP:

Tel: 01491 692599
Email: nhmp@ceh.ac.uk

A full catalogue of past Hydrological Summaries can be accessed and downloaded at:

http://nrfa.ceh.ac.uk/monthly-hydrological-summary-uk

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