Hydrological Summary
for the United Kingdom

September 2018

General
September was an autumnal mix of fine warm weather, some crisp frosty mornings, sunshine and showers, and an intense stormy interlude. Rainfall was near average for the UK, but this disguised stark regional variations. Intense storms and persistent unsettled weather brought above average rainfall to large parts of the north and west, but areas further south and east received relatively meagre rainfall in September. Correspondingly, soil moisture deficits (SMDs) decreased across most of the UK (they increased in the south-east) and soils mostly remained drier than average for the time of year. River flows were below average in central, southern and eastern England and above average in parts of the north and west. In catchments draining the Highlands of Scotland, river flows ranged from exceptionally high in the west to exceptionally low in the east, reflecting the influence of storms from the west in September and longer-term rainfall deficiencies, respectively. Groundwater levels continued to fall following their usual seasonal recession, but generally remained in the normal range for the time of year apart from the Chalk of south-east England where many levels were below average. Despite substantial increases in reservoir stocks in Scotland and Wales, storage remained more than 10% below average in Wales and a number of impoundments across the English Lowlands (where stocks decreased notably in September). With many reservoir stocks in the south and east remaining markedly below average for the time of year and groundwater recharge yet to commence across the major aquifers, the onset of replenishment will be influential in the outlook for water resources in 2019.

Rainfall
After a pleasant start to the month, the middle fortnight of September was characterised by unsettled weather delivered by a succession of frontal systems that traversed the country, predominantly affecting northern and western areas. This period culminated in a stormy interlude with three intense depressions in five days. On the 17th/18th, ex-Tropical Storm Helene dissipated with fewer weather impacts than initially envisaged. On the 19th, storm 'Ali' tracked across the north-west of the UK causing substantial damage (although primarily wind-related) and delivering heavy rainfall in western Scotland (e.g. 67mm at Cluanie Inn, Ross and Cromarty). On the 20th/21st, storm 'Bronagh' traversed England and Wales, depositing notably heavy rainfall (e.g. 72mm at Sennybridge, Brecon Beacons; 61mm at Sheffield) which caused pluvial flooding in parts of Wales and central and north-eastern England. Thereafter, anticyclonic conditions became increasingly influential bringing pleasant weather in the south, though there was continued unsettled weather in the far north. The influence of rainfall from a succession of frontal systems from the Atlantic is reflected in the overall rainfall anomalies for September. Wales, the Scottish Borders and parts of north-west England received more than 130% of the long-term average rainfall, and exceeded 150% of average across the Scottish Highlands (where it was the second wettest September in a series from 1910). Conversely, most of Northern Ireland, south-east England and coastal north-east Scotland received less than 70% of average, with less than half of average registered around Lough Neagh and the Wash. Rainfall accumulations over the June-September period were less than 90% of average across a majority of the UK, and less than three quarters of average in north-east Scotland and south of a line from North Yorkshire to the Severn estuary.

River flows
In most catchments, recessions that were established in late August continued into early September. In some localised regions, particularly in north-east Scotland and parts of central and southern England, low flows continued throughout the month, approaching or eclipsing daily flow minima mid-month or towards month-end (e.g. the Deveron, Ythan, Soar and Tone). More commonly, and most notably in responsive catchments of the north and west, flows increased steadily throughout the middle fortnight in response to the persistent unsettled weather. In some catchments, this culminated in some of the highest September river flows on record in response to the heavy rainfall associated with storm 'Ali' (e.g. the Ness) and particularly with storm 'Bronagh' (e.g. the Tawe, Tywi, Conwy and Welsh Dee, all in records that exceed 50 years), when it was reported that a car was swept away by a river in Carmarthenshire. Under more settled anticyclonic conditions, recessions generally resumed in the final week. River flows for September were below average across the English Lowlands, notably so in Wessex and Suffolk and exceptionally so for the Soar. There were also notably low flows in eastern Northern Ireland (where the Annacloy registered less than a fifth of average flows) and north-east Scotland (where flows on the Deveron were exceptionally low). Flows were substantially above average in Wales and more than 150% of average in parts of north-west Scotland. The Nevis registered its highest September mean flow in a series from 1982, recording twice the average flow. Flows over the June-September period were substantially below average across the UK, most notably in eastern parts of Scotland and Northern Ireland, and north-east, central and south-west England. River flows were exceptionally low on the Deveron (the lowest on record in a series from 1960), Spey and Soar and around a third of average or less on the Deveron, Annacloy and Taw.

Groundwater
SMDs increased across the south-east of the UK in September and remained substantially drier than average for the time of year, ranking amongst the highest late September SMDs for the Anglian region in a series from 1961. Groundwater levels receded in the Chalk boreholes during September. At the end of the month, levels were mainly in the normal range, but were below average in parts of East Anglia and the North and South Downs, notably low at Killyglen and remained above normal at Aylesby. In the more rapidly responding Jurassic and Magnesian limestones, levels also fell and remained normal for the time of year in the former, and normal to above normal in the latter. Levels in the Upper Greensand at Lime Kiln Way fell and remained in the normal range. In the Permo-Triassic sandstones, levels fell except at Newbridge, where a small increase was recorded and levels were notably high. Elsewhere, levels remained in the normal range but below normal at Llanfair DC. Levels in the Carboniferous Limestone in both the Peak District and south Wales rose and were in the normal range for the time of year. In the Fell Sandstone, levels decreased at Royalty Observatory but remained above normal.

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

British Geological Survey
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Rainfall . . . Rainfall . . .

Met Office

Rainfall accumulations and return period estimates

Percentages are from the 1981-2010 average.

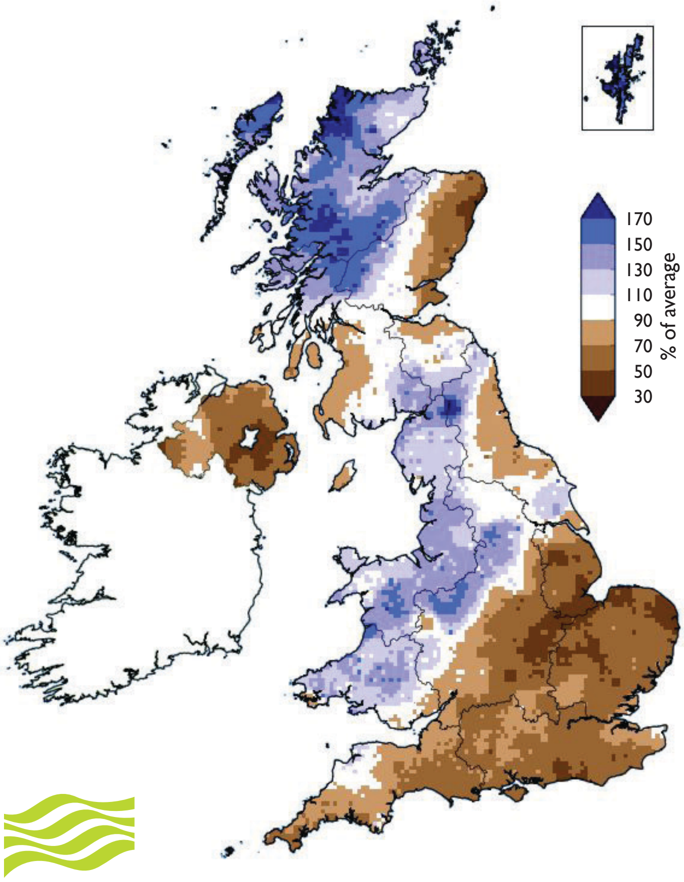
Region	Rainfall	Sep 2018	Jun18 – Sep18	RP	Apr18 – Sep18	RP	Jan18 – Sep18	RP	Oct17 – Sep18	RP
United	mm	**105**	280		415		717		1049	
Kingdom	%	**111**	86	2-5	89	2-5	94	2-5	93	2-5
England	mm	**61**	179		306		544		764	
	%	**89**	69	10-20	82	5-10	94	2-5	90	2-5
Scotland	mm	**174**	434		567		940		1431	
	%	**133**	103	2-5	97	2-5	92	2-5	94	2-5
Wales	mm	**145**	329		513		933		1360	
	%	**129**	85	2-5	92	2-5	100	2-5	96	2-5
Northern	mm	**57**	289		428		759		1093	
Ireland	%	**62**	83	5-10	86	5-10	96	2-5	96	2-5
England &	mm	**73**	200		335		597		846	
Wales	%	**98**	72	8-12	84	5-10	95	2-5	92	2-5
North West	mm	**137**	333		464		755		1190	
	%	**133**	90	2-5	90	2-5	92	2-5	97	2-5
Northumbria	mm	**78**	244		348		597		812	
	%	**109**	87	2-5	88	2-5	98	2-5	93	2-5
Severn-Trent	mm	**65**	165		308		530		714	
	%	**101**	65	10-15	84	2-5	97	2-5	91	2-5
Yorkshire	mm	**73**	189		311		560		758	
	%	**108**	70	5-10	81	5-10	95	2-5	90	2-5
Anglian	mm	**30**	121		235		401		543	
	%	**55**	56	25-40	75	5-10	89	2-5	87	2-5
Thames	mm	**39**	122		254		451		616	
	%	**67**	56	15-25	78	5-10	91	2-5	86	2-5
Southern	mm	**40**	154		294		525		713	
	%	**64**	70	8-12	91	2-5	101	2-5	89	2-5
Wessex	mm	**48**	150		279		544		775	
	%	**70**	61	15-25	76	8-12	93	2-5	88	2-5
South West	mm	**74**	216		353		758		1099	
	%	**82**	67	10-15	75	8-12	94	2-5	89	2-5
Welsh	mm	**137**	316		496		902		1310	
	%	**127**	84	2-5	92	2-5	100	2-5	96	2-5
Highland	mm	**249**	521		657		1051		1738	
	%	**159**	110	2-5	99	2-5	87	2-5	96	2-5
North East	mm	**94**	252		341		559		841	
	%	**107**	81	5-10	77	10-15	81	10-15	83	8-12
Tay	mm	**137**	361		477		815		1109	
	%	**121**	98	2-5	91	2-5	89	2-5	83	5-10
Forth	mm	**111**	328		443		769		1039	
	%	**106**	92	2-5	90	2-5	92	2-5	86	2-5
Tweed	mm	**94**	318		447		751		989	
	%	**114**	101	2-5	101	2-5	106	2-5	97	2-5
Solway	mm	**134**	426		584		996		1428	
	%	**111**	101	2-5	98	2-5	100	2-5	96	2-5
Clyde	mm	**185**	544		709		1197		1792	
	%	**116**	106	2-5	101	2-5	98	2-5	99	2-5

% = percentage of 1981-2010 average *RP = Return period*

Important note: Figures in the above table may be quoted provided their source is acknowledged (see page 12). 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 1910; 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 2018 are provisional.

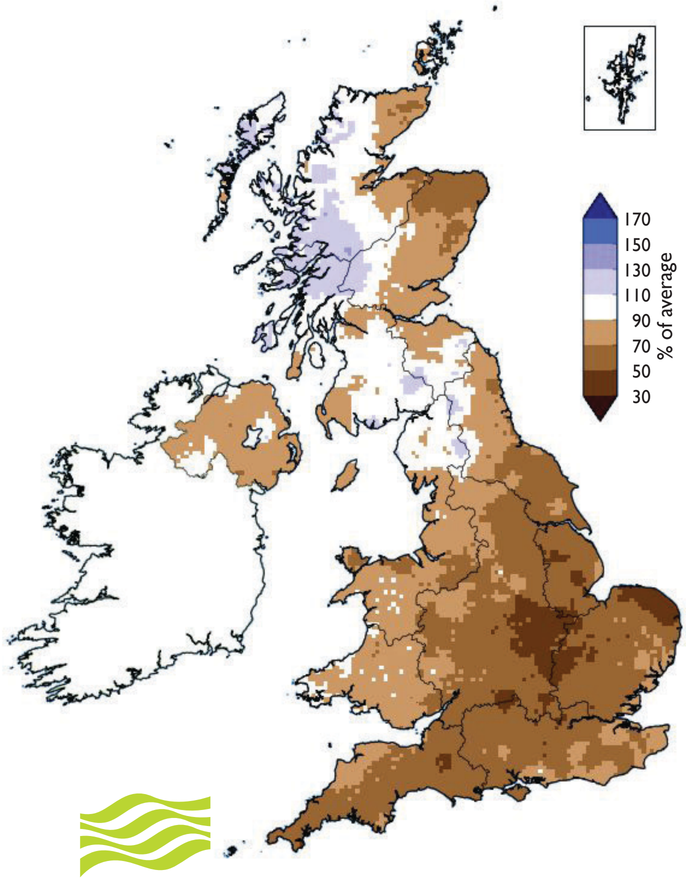
Rainfall . . . Rainfall . . .

September 2018 rainfall as % of 1981-2010 average



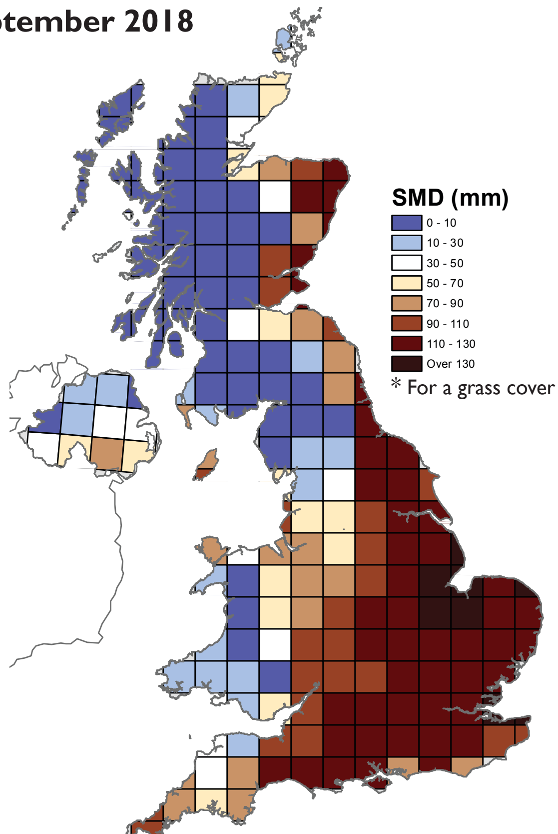
Met Office

June 2018 - September 2018 rainfall as % of 1981-2010 average



Met Office

MORECS Soil Moisture Deficits* September 2018



Hydrological Outlook UK

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.

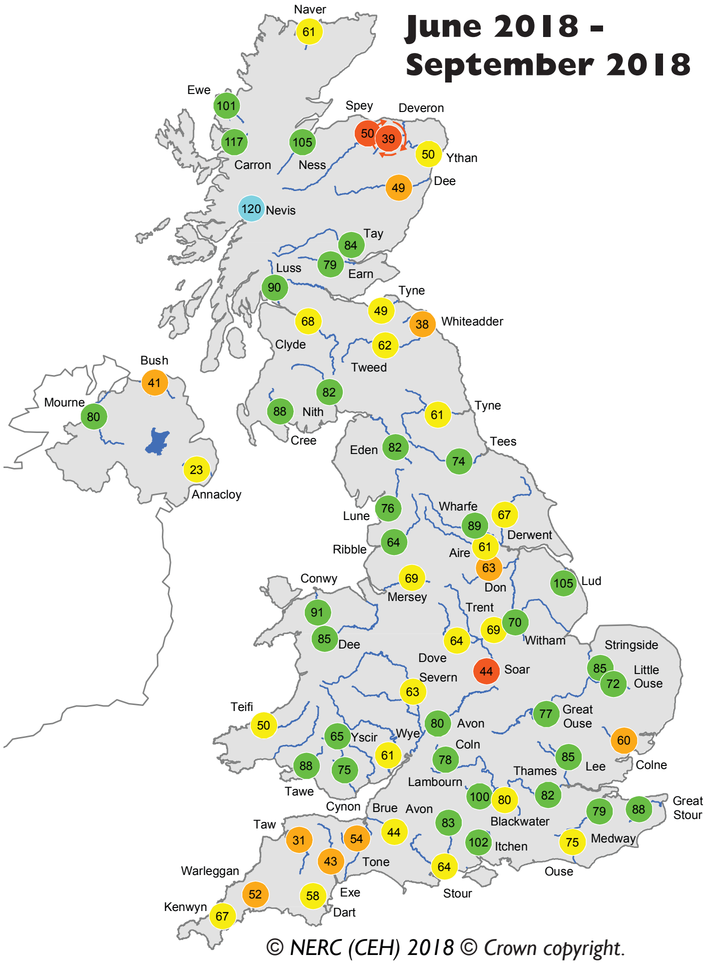
The complete version of the Hydrological Outlook UK can be found at: www.hydoutuk.net/latest-outlook/

Period: **from October 2018**
Issued: **09.09.2018**
using data to the end of September 2018

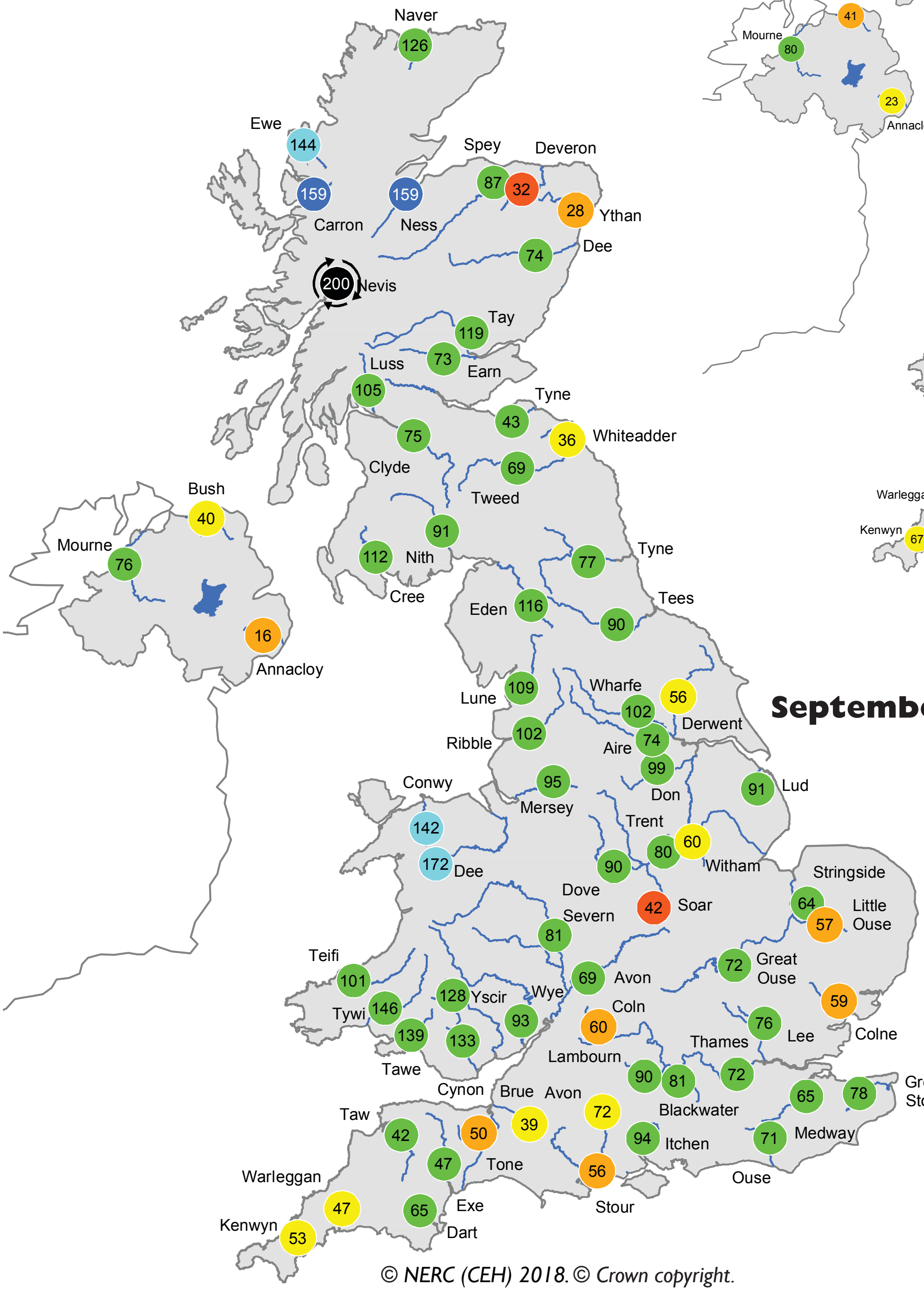
The outlook in north-eastern Scotland, and southern, southwestern, and eastern parts of England, is for river flows to be normal to below normal for the next one to three months. In Northern Ireland, flows are expected to be normal to below normal for October. In northern and western parts of England, Wales and the majority of Scotland river flows are likely to be within the normal range for October, and normal to above normal over October-November-December as a whole. Groundwater levels are likely to be normal to below normal over the next one to three months, with some local variability.

River flow . . . River flow . . .

June 2018 - September 2018



September 2018



Key

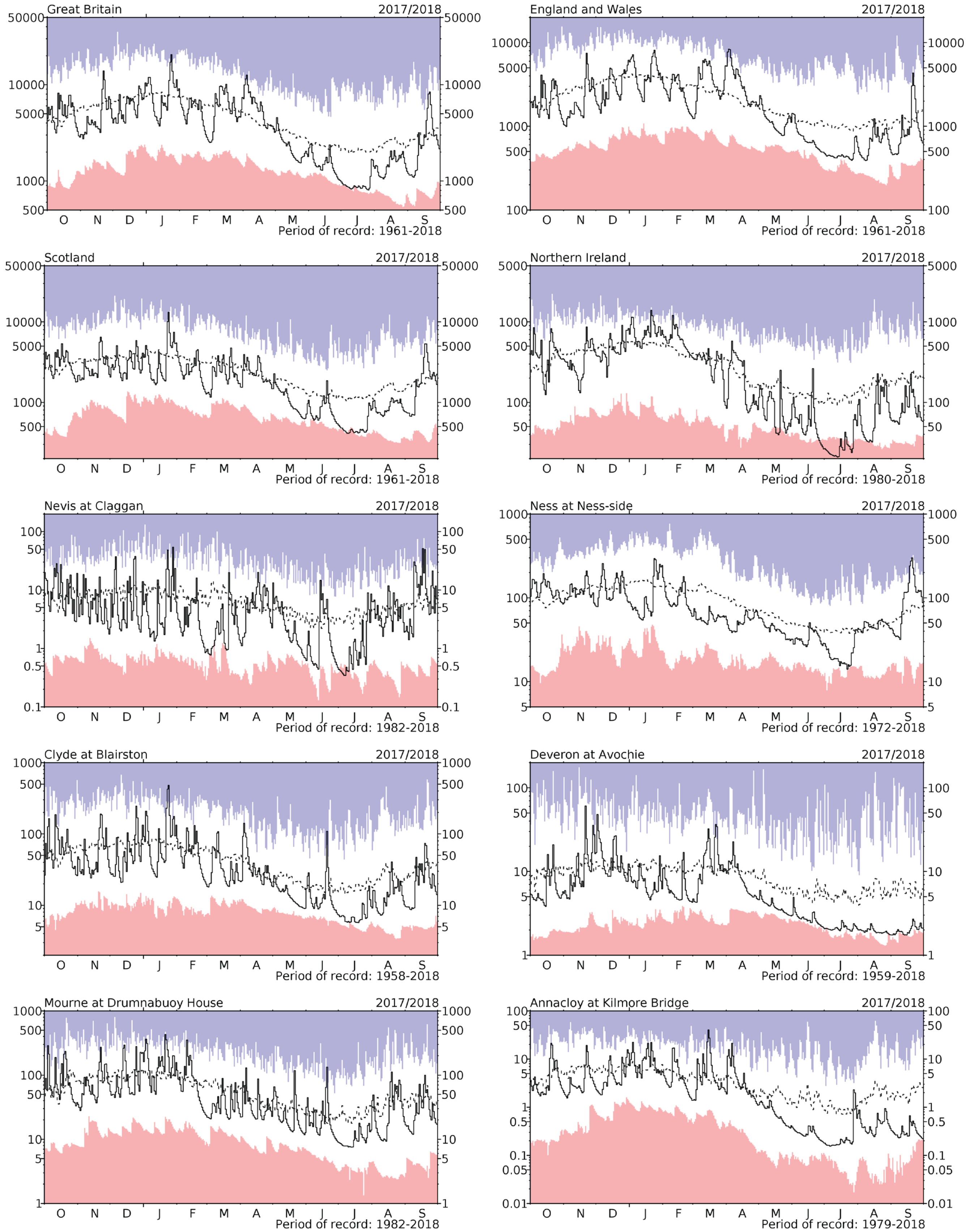
- 25 — % of long-term average (record figure when circled)
- Exceptionally high flow
- Notably high flow
- Above normal
- Normal range
- Below normal
- Notably low flow
- Exceptionally low flow

*Based on ranking of the monthly 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. Note: the averaging period on which these percentages are based is 1981-2010. Percentages may be omitted where flows are under review.

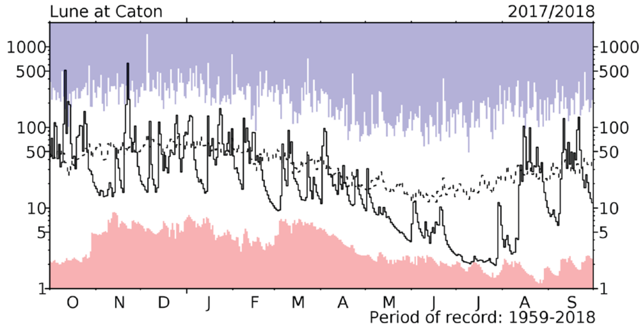
River flow . . . River flow . . .

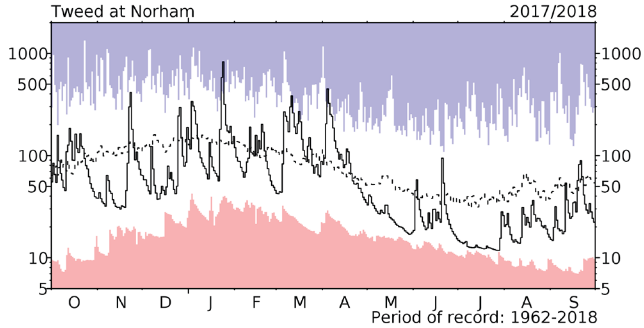


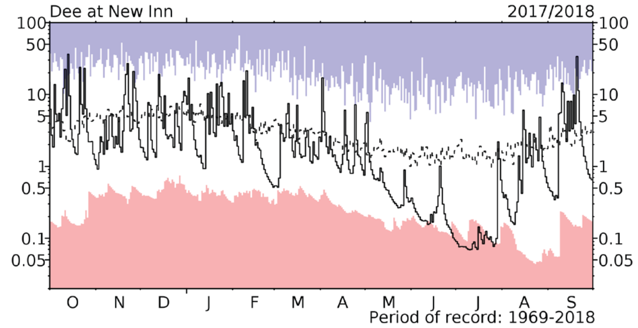
River flow hydrographs

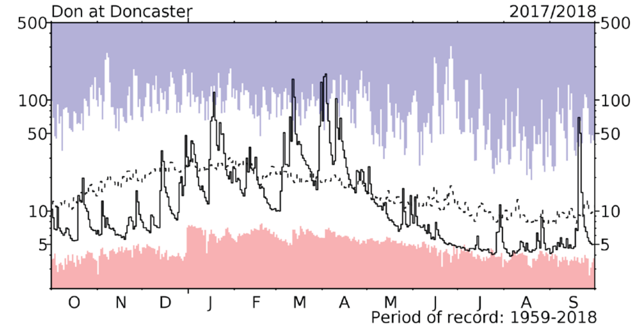
*The river flow hydrographs show the daily mean flows (measured in m^3s^{-1}) together with the maximum and minimum daily flows prior to October 2017 (shown by the shaded areas). Daily flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas. The dashed line represents the period-of-record average daily flow.

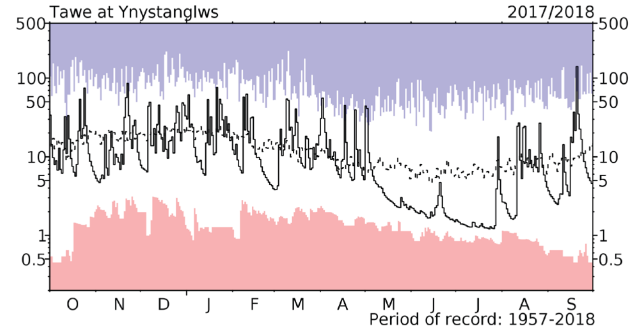
River flow . . . River flow . . .

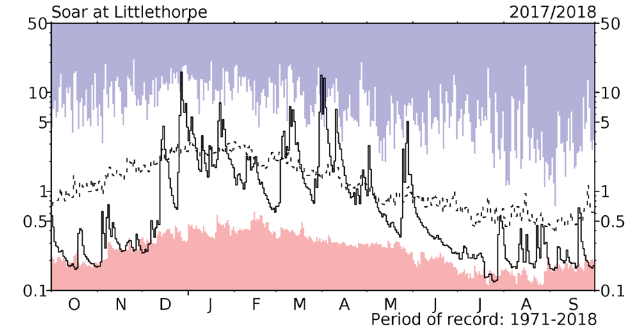


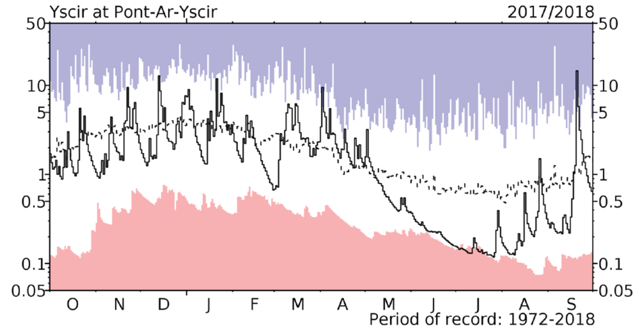


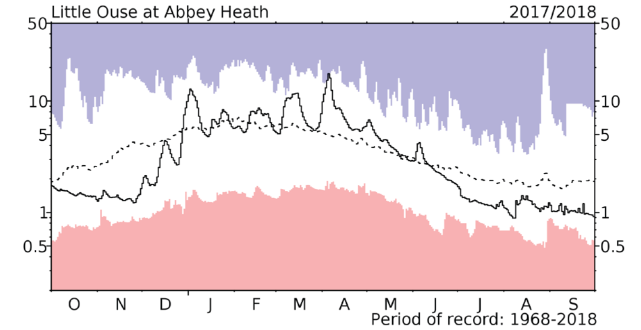


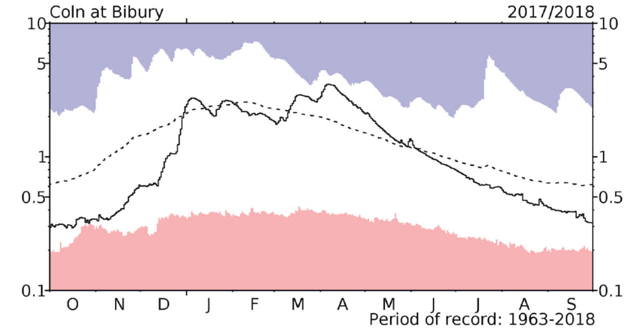


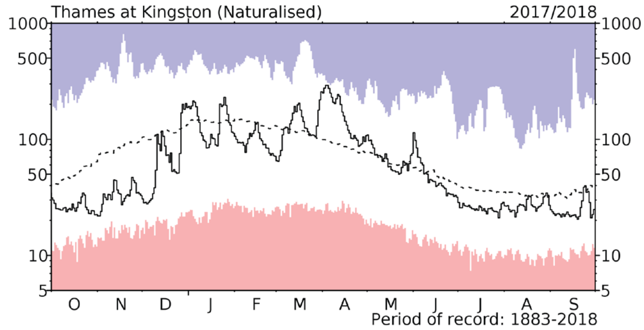


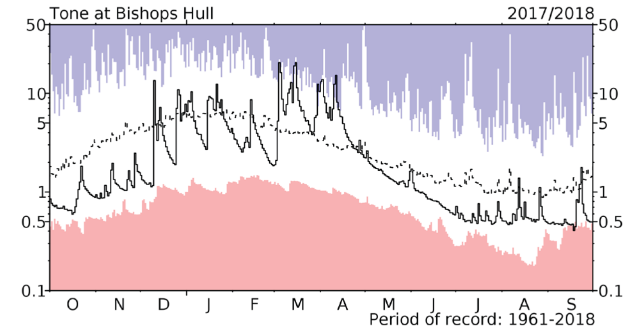


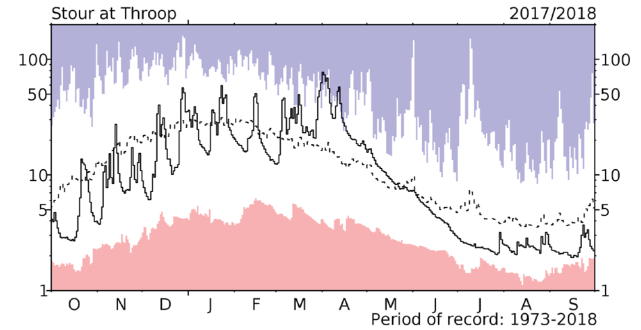




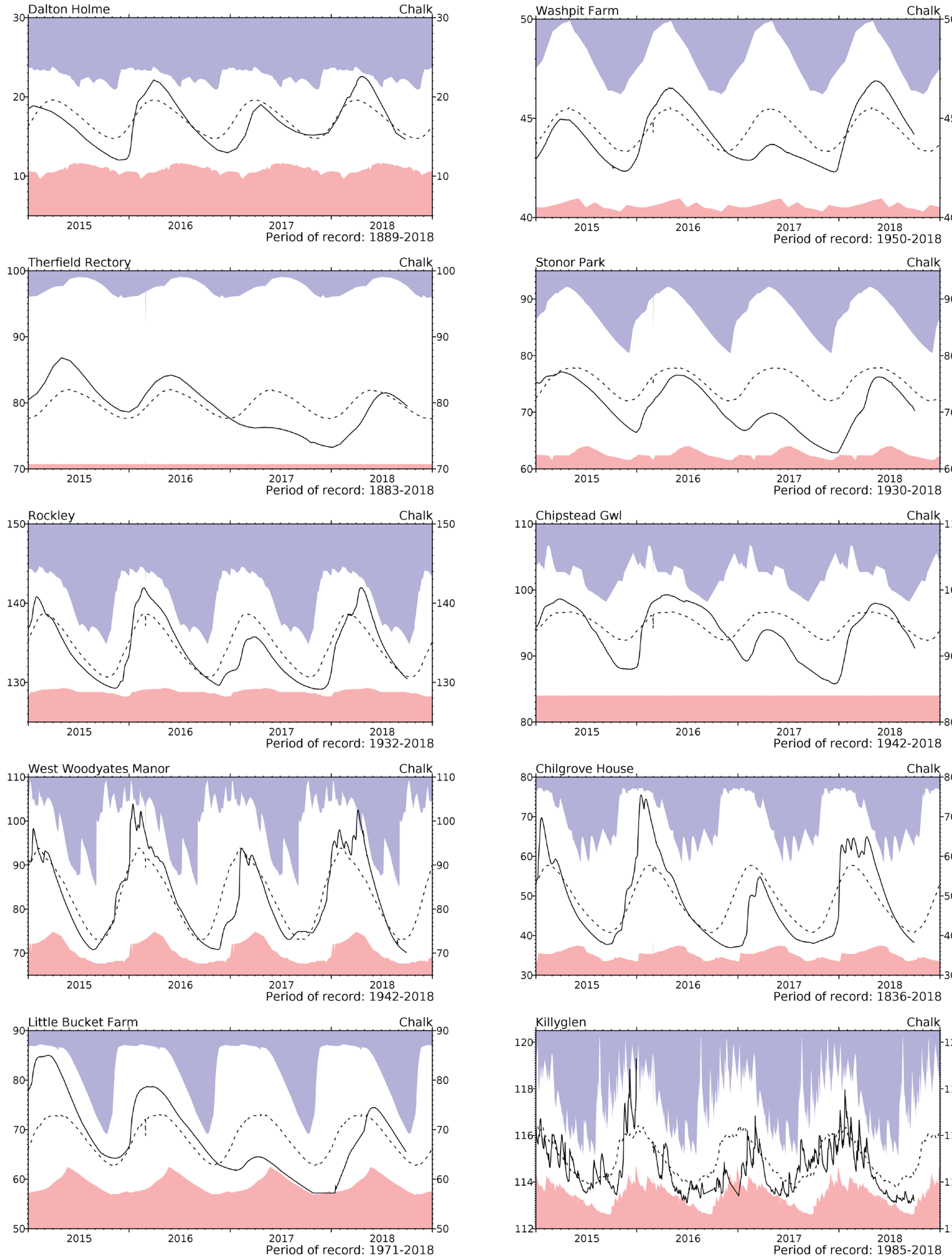






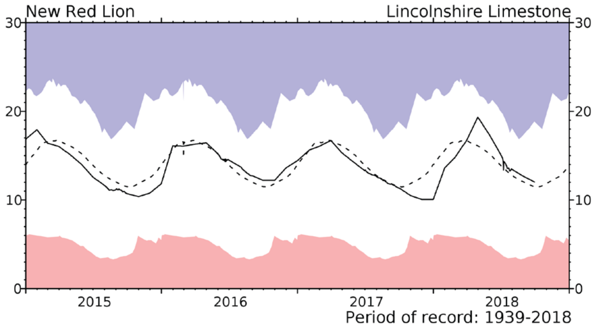


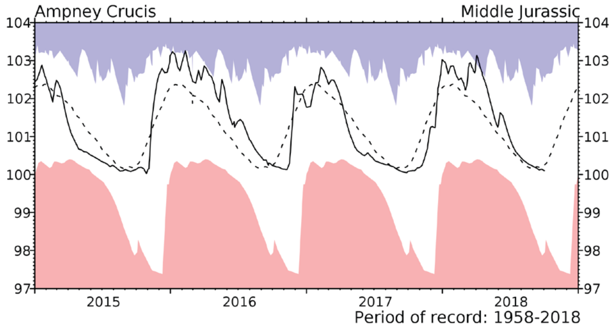
Groundwater . . . Groundwater

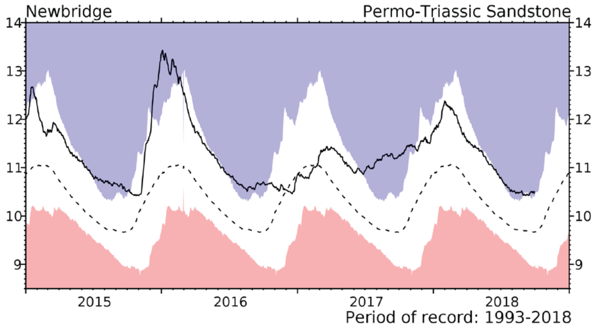


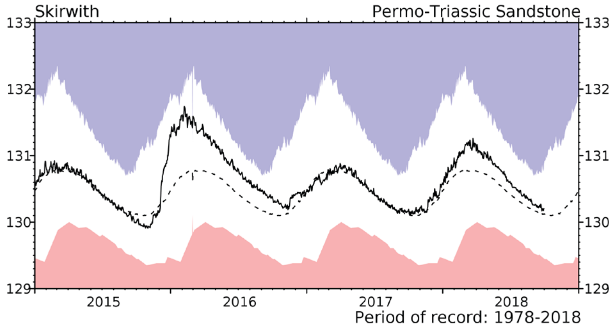
Groundwater levels (measured in metres above ordnance datum) normally rise and fall with the seasons, reaching a peak in the spring following replenishment through the winter (when evaporation losses are low and soil moist). They decline through the summer and early autumn. This seasonal variation is 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 displayed in a similar style to the river flow hydrographs. 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.

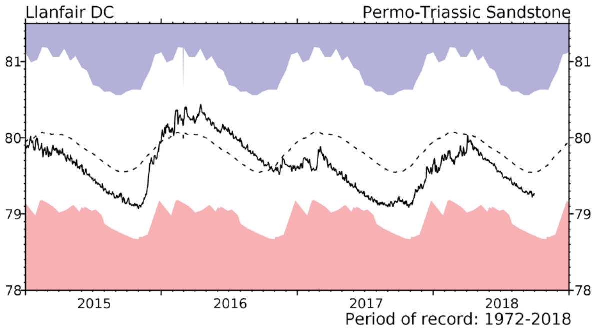
Groundwater... Groundwater

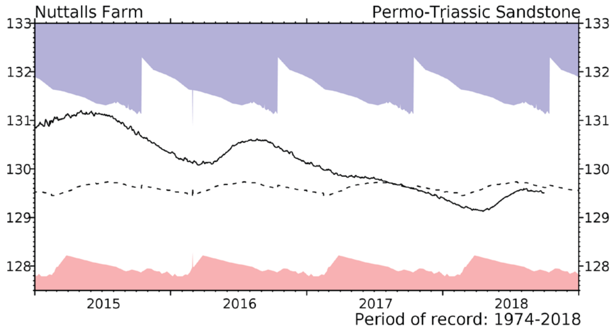


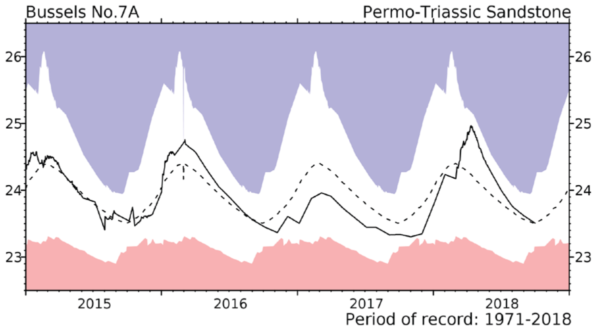


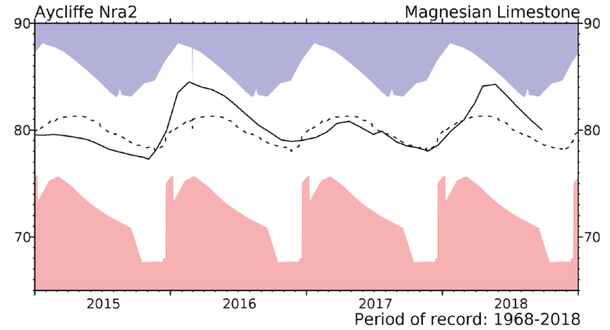


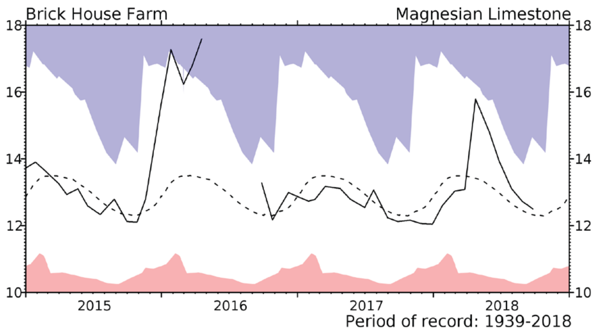


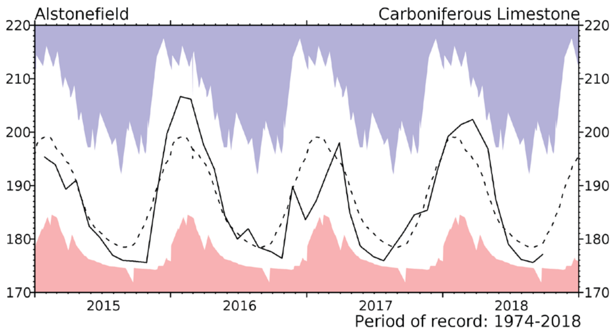


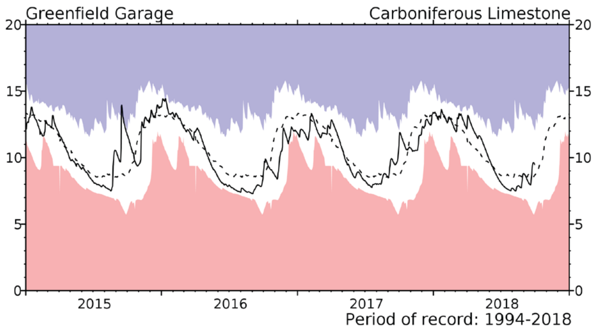


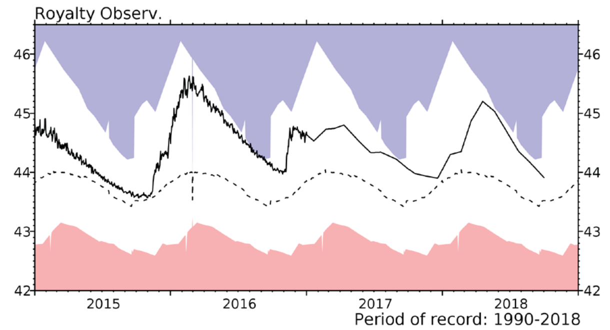




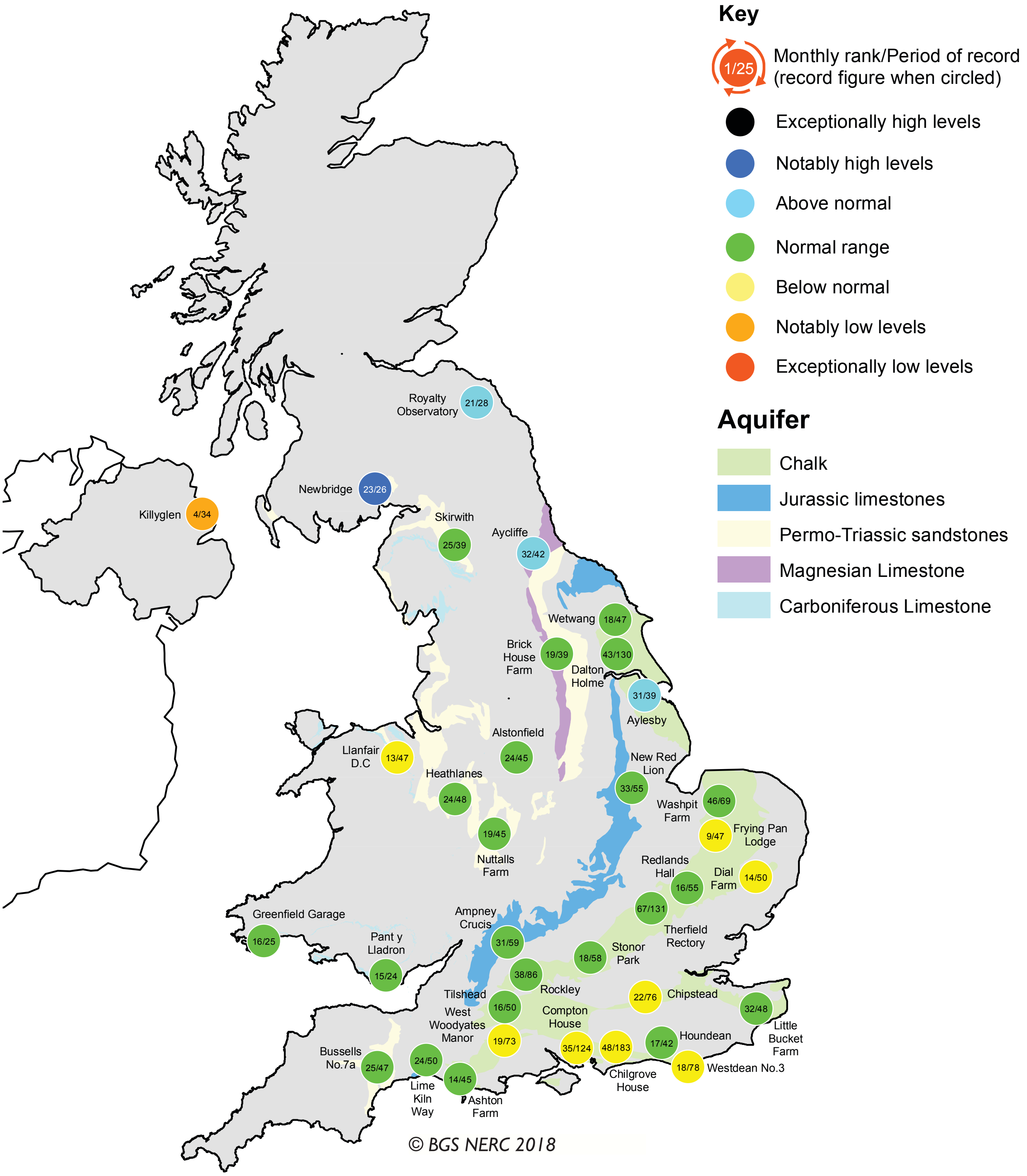








Groundwater...Groundwater

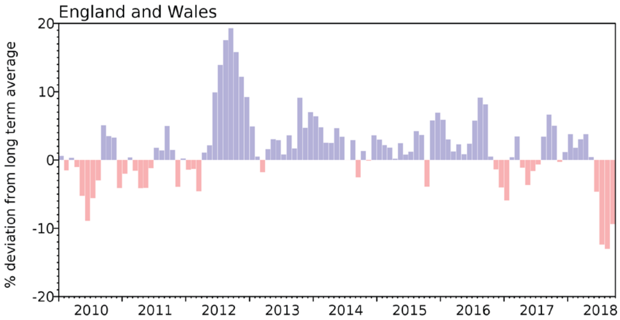


Groundwater levels - September 2018

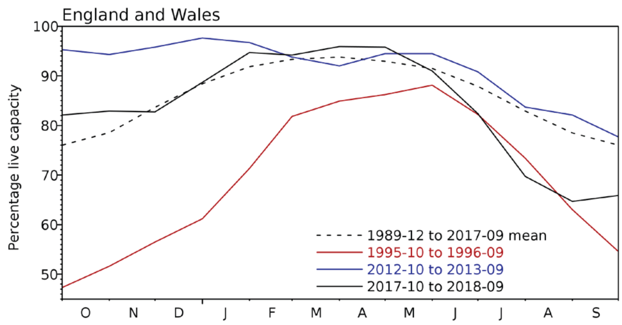
The calculation of ranking has been modified from that used in summaries published prior to October 2012. It is now based on a comparison between the most recent level and levels for the same date during previous years of record. Where appropriate, levels for earlier years may have been interpolated. 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

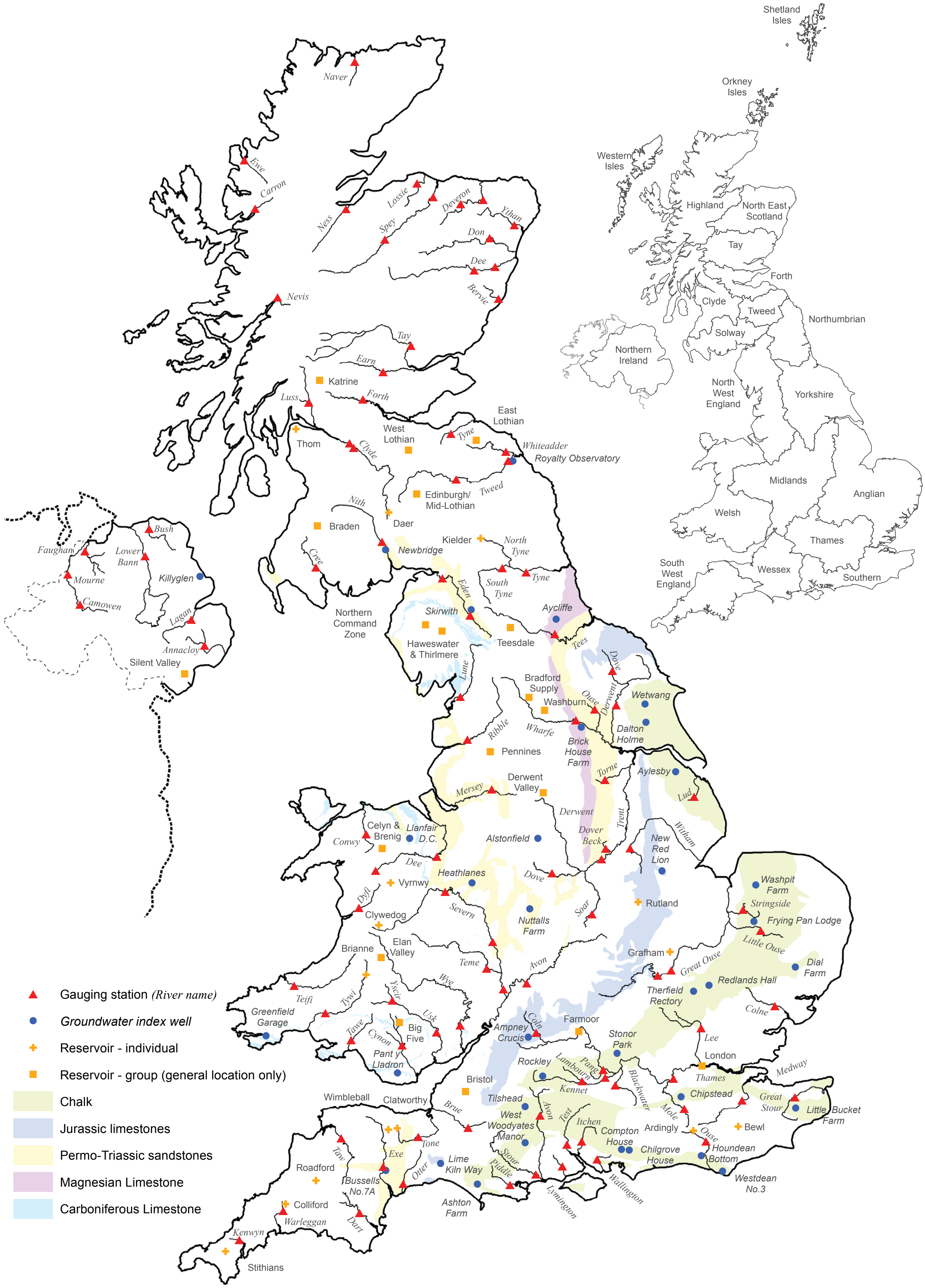
Area	Reservoir		Capacity (Ml)	2018 Jul	2018 Aug	2018 Sep	Sep Anom.	Min Sep	Year* of min	2017 Sep	Diff 18-17
North West	N Command Zone	•	124929	41	45	56	-3	13	1995	77	-21
	Vyrnwy		55146	69	60	73	2	26	1995	97	-24
Northumbrian	Teesdale	•	87936	61	62	66	-5	31	1995	98	-32
	Kielder		(199175)	77	78	80	-5	59	1989	82	-2
Severn-Trent	Clywedog		49936	72	63	71	-1	24	1989	92	-21
	Derwent Valley	•	46692	52	40	41	-23	24	1989	68	-27
Yorkshire	Washburn	•	23373	57	48	45	-22	24	1995	79	-34
	Bradford Supply	•	40942	52	47	49	-19	15	1995	80	-31
Anglian	Grafham		(55490)	83	79	74	-11	46	1997	94	-21
	Rutland		(116580)	89	85	82	2	61	1995	90	-9
Thames	London	•	202828	80	72	62	-15	53	1997	71	-8
	Farmoor	•	13822	98	95	90	-1	54	2003	93	-3
Southern	Bewl		31000	84	78	69	6	32	1990	43	26
	Ardingly		4685	80	62	48	-18	32	2003	81	-33
Wessex	Clatworthy		5364	59	48	36	-21	25	2003	69	-33
	Bristol	•	(38666)	71	66	58	-6	31	1990	61	-4
South West	Colliford		28540	75	66	56	-13	38	2006	81	-25
	Roadford		34500	70	59	48	-22	26	1995	71	-23
	Wimbleball		21320	73	61	47	-18	30	1995	76	-28
	Stithians		4967	67	56	41	-16	22	1990	75	-34
Welsh	Celyn & Brenig	•	131155	71	61	67	-15	39	1989	93	-26
	Brianne		62140	71	72	87	-1	48	1995	100	-13
	Big Five	•	69762	58	52	61	-10	19	1995	77	-16
	Elan Valley	•	99106	62	48	57	-19	33	1976	80	-23
Scotland(E)	Edinburgh/Mid-Lothian	•	96518	81	78	80	1	43	1998	84	-4
	East Lothian	•	9374	83	77	74	-9	52	1989	98	-25
Scotland(W)	Loch Katrine	•	110326	62	59	68	-8	43	1995	95	-28
	Daer		22494	64	64	75	-4	32	1995	86	-11
	Loch Thom		10798	83	93	100	17	56	1995	89	11
Northern Ireland	Total+	•	56800	68	70	67	-8	29	1995	98	-31
	Silent Valley	•	20634	64	66	63	-9	27	1995	100	-37

( ) 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.

Location map... Location map



NHMP

The National Hydrological Monitoring Programme (NHMP) was started in 1988 and is undertaken jointly by the Centre for Ecology & Hydrology (CEH) 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 CEH) and National Groundwater Level Archive (NGLA; maintained by BGS), including rainfall, river flows, borehole levels, and reservoir stocks.

Data Sources

The NHMP depends on the active cooperation of many data suppliers. This cooperation is gratefully acknowledged. 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 5km 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 1910 and form the official source of UK areal rainfall statistics which have been adopted by the NHMP. The gridding technique used is described in Perry MC and Hollis DM (2005) available at
http://www.metoffice.gov.uk/climate/uk/about/methods

Long-term averages are based on the period 1981-2010 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: 0870 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

Some of the features displayed on the maps contained in this report are based on the following data with permission of the controller of HMSO.

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