Hydrological Summary
for the United Kingdom

September 2016

General
September was changeable and unsettled at times, but many areas saw a good deal of summery weather with some very warm spells, particularly in the south east. Heatwave conditions in southern England during the second week brought the highest daily maximum temperature of 2016, with 34.4°C recorded at Gravesend on the 13th – the highest September maximum temperature since 1911. For the month as a whole, it was the equal second warmest September since 1910. September rainfall was near-average at the national scale, but there was a marked west/east contrast, with much of eastern England receiving below average rainfall. In some areas, a significant proportion of the monthly total was associated with intense convective downpours mid-month, when surface water flooding, along with lightning damage, caused severe disruption and localised property flooding. However, river flow responses were muted and average flows for September were predominantly in the normal range. Given the dry, warm conditions soil moisture deficits (SMDs) persisted in the south east and remained above average. Correspondingly, groundwater levels continued their seasonal recession, with levels remaining mainly in the normal range or above. While a few south-western reservoirs saw stocks more than 15% below average, stocks were otherwise above average, and substantially so in most major impoundments in northern and western Britain. The water resource outlook therefore remains healthy entering the winter half-year.

Rainfall
September began unsettled, with a west to south-westerly airflow, establishing a pattern that continued for much of the month in north-west Britain. In the second week, a more southerly regime ensued, drawing warm, humid air from the continent. Settled and unseasonably warm weather dominated until mid-month in southern Britain, with a wetter interlude from the 8th to the 10th. The warm temperatures triggered intense convective activity mid-month. On the 13th, downpours caused major transport disruption in the Manchester area and flooded businesses in the city centre. Thunderstorms and surface water flooding caused severe disruption in south-east England on the 15th/16th, with motorways and major rail lines affected (including several flooded train stations, e.g. Didcot and Newbury). Daily totals of over 45mm were reported on these two days, but the majority of the rain fell in short periods: 40mm in three hours on the 16th in Wallingford. The latter half of the month saw a return to more changeable conditions, with the passage of several frontal systems bringing strong winds and heavy rainfall to western areas, although southern England received little appreciable rainfall. While the convective nature of the rainfall led to some localised contrasts, the main characteristic of the total rainfall for September as a whole was a pronounced west/east contrast. Upland western areas saw above average rainfall, with more than 130% of average in some areas (over 150% in some pockets of the west coast and western Northern Ireland). Elsewhere was drier than average, particularly along the east coast: parts of north-east Scotland and south-east England received less than half the September average. September was the third successive month with an exaggerated north-west/south-east gradient: Southern region received 57% of its typical July-September rainfall (the driest for this period since 2003) while the Highland region received more than 130%.

River flows
Entering September, flows in most responsive catchments were near- or below-average. Frontal rainfall early in the month triggered moderate flow responses in some western catchments, while the convective activity on the 13th led to flood warnings. Brief recessions followed during the settled conditions around mid-month, before further spates in the final week. In contrast, some drier eastern catchments saw recessions develop through most of September. On the 15th/16th, numerous flood alerts were issued in southern England, with flood warnings focused on small urban catchments in London. Rapid flow responses ensued in some catchments: the Wallington registered its highest September peak flow on record, while the Mimram and Lambourn (permeable catchments, albeit with significant lower-valley urban development) registered their second and fourth highest September peak flows on record, respectively. Across most of the country, September average flows were in the normal range, with above-normal flows in a few catchments. By contrast, flows were below normal across the far north of Scotland and in some catchments in coastal eastern Scotland, with less than half the September average in some cases, e.g. the Naver and Whiteadder. In central England the Soar registered a notably low flow for the second successive month, while flows were also appreciably below average (but in the normal range) in much of south-west England. Flow accumulations for the July-September period were predominantly in the normal range, but moderately below-average accumulations typify southern and eastern areas, except in some groundwater fed catchments where late spring/early summer rainfall has kept flows elevated. Moderate flow deficiencies can be traced over the summer half year (April-September) for the Soar and some catchments in south-west England.

Groundwater
With above average SMDs across much of the Chalk outcrop, and generally low rainfall, groundwater levels continued to recede although recessions stabilised at Dial Farm and Westdean No. 3. All the Chalk index boreholes were in the normal range, except Well House Inn and Little Bucket Farm where levels were were above normal, and Dial Farm where levels remained below the seasonal average. In the Permo-Triassic sandstones, levels also continued to recede apart from a modest increase at Newbridge where levels remained exceptionally high. Levels were in the normal range in the Permo-Triassic sandstones of south-west England and above normal in the Midlands, north-east Wales and north-west England. In the Jurassic limestones, levels fell but remained in the normal range at New Red Lion, and were above normal at Ampney Crucis. In the Magnesian Limestone aquifer levels fell but were in the normal range at Aycliffe, and remained high at Brick House Farm. Levels in the Carboniferous Limestone fell at Alstonefield but remained above normal for the end of September. In south Wales, levels rose overall and remained in the normal range at Pant y Lladron and below normal at Greenfield Garage.

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 1971-2000 average.

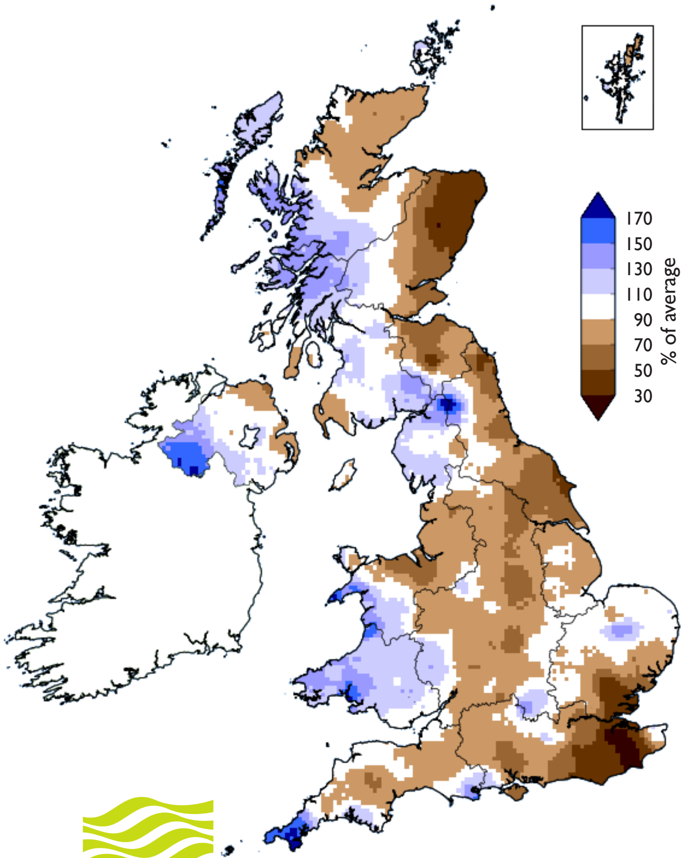
Area	Rainfall	Sep 2016	Aug16 – Sep16	RP	Jul16 – Sep16	RP	Apr16 – Sep16	RP	Jan16 – Sep16	RP
United	mm	**99**	187		269		516		897	
Kingdom	%	**102**	106	2-5	110	2-5	117	2-5	122	25-40
England	mm	**64**	131		173		392		674	
	%	**89**	96	2-5	91	2-5	109	2-5	119	5-10
Scotland	mm	**144**	264		408		686		1198	
	%	**109**	114	2-5	128	5-10	125	5-10	124	20-30
Wales	mm	**145**	254		337		655		1171	
	%	**124**	116	2-5	115	2-5	123	2-5	129	15-25
Northern	mm	**104**	174		276		515		872	
Ireland	%	**111**	94	2-5	107	2-5	110	2-5	114	5-10
England &	mm	**75**	148		195		429		742	
Wales	%	**96**	100	2-5	96	2-5	112	2-5	121	8-12
North West	mm	**108**	249		354		630		1044	
	%	**105**	125	2-5	128	2-5	129	5-10	131	20-35
Northumbrian	mm	**64**	160		232		428		718	
	%	**92**	114	2-5	117	2-5	114	2-5	123	5-10
Severn-Trent	mm	**58**	121		159		392		642	
	%	**87**	94	2-5	89	2-5	112	2-5	119	5-10
Yorkshire	mm	**53**	145		192		400		694	
	%	**77**	108	2-5	103	2-5	110	2-5	122	5-10
Anglian	mm	**49**	89		121		331		504	
	%	**90**	84	2-5	80	5-10	111	2-5	116	2-5
Thames	mm	**55**	93		114		333		569	
	%	**87**	79	2-5	71	5-10	104	2-5	116	2-5
Southern	mm	**40**	76		97		303		585	
	%	**56**	61	5-10	57	15-25	93	2-5	112	2-5
Wessex	mm	**70**	128		144		362		680	
	%	**91**	90	2-5	76	5-10	100	2-5	115	2-5
South West	mm	**98**	176		206		414		879	
	%	**99**	97	2-5	85	2-5	91	2-5	110	2-5
Welsh	mm	**140**	245		321		628		1124	
	%	**123**	115	2-5	113	2-5	122	2-5	128	15-25
Highland	mm	**176**	325		485		785		1349	
	%	**112**	121	2-5	134	5-10	126	5-10	119	8-12
North East	mm	**63**	135		249		518		878	
	%	**71**	85	2-5	111	2-5	124	2-5	133	30-50
Tay	mm	**111**	188		304		573		1098	
	%	**98**	96	2-5	113	2-5	120	2-5	127	15-25
Forth	mm	**100**	177		283		521		927	
	%	**95**	95	2-5	110	2-5	114	2-5	119	5-10
Tweed	mm	**72**	170		273		478		860	
	%	**89**	110	2-5	124	2-5	117	2-5	130	10-20
Solway	mm	**142**	255		394		668		1205	
	%	**115**	111	2-5	124	2-5	121	2-5	128	25-40
Clyde	mm	**198**	342		514		826		1430	
	%	**120**	118	2-5	129	5-10	126	5-10	123	15-25

% = percentage of 1971-2000 average *RP = Return period*

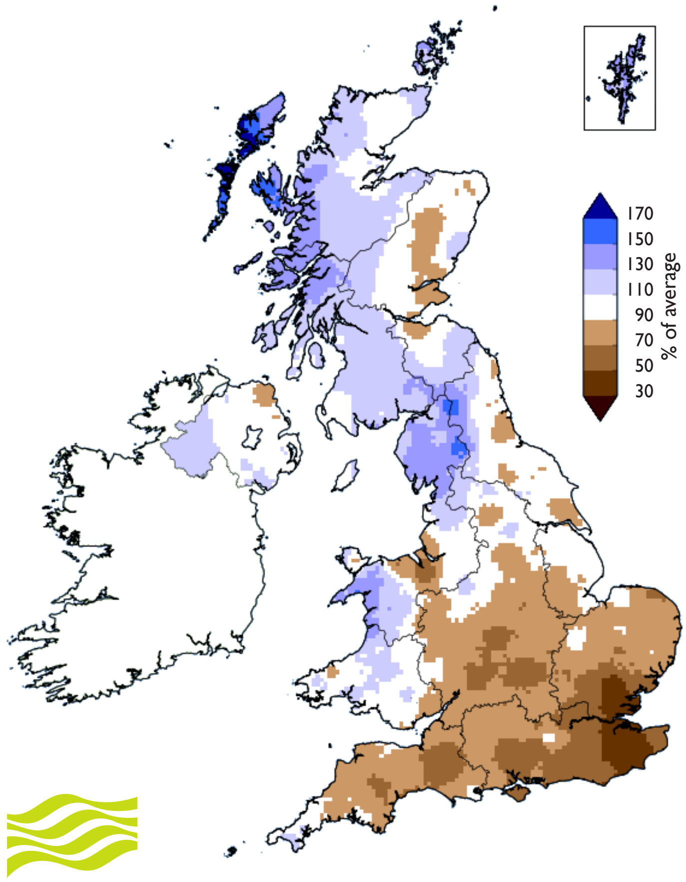
Important note: Figures in the above table may be quoted provided their source is acknowledged (see page 12). Where appropriate, specific mention must be made of the uncertainties associated with the return period estimates. The RP estimates are based on data provided by the Met Office and reflect climatic 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 from February 2016 (inclusive) are provisional.

Rainfall . . . Rainfall . . .

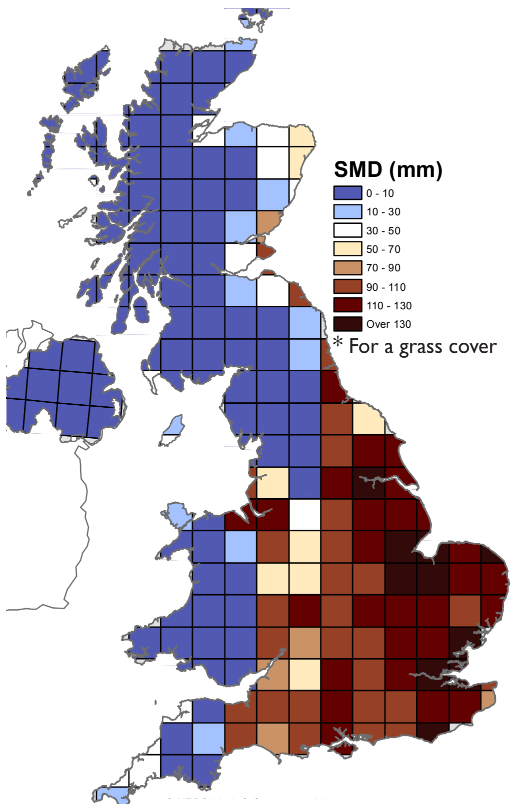
September 2016 rainfall as % of 1971-2000 average



July 2016 - September 2016 rainfall as % of 1971-2000 average



MORECS Soil Moisture Deficits* September 2016



Met Office 3-month outlook Updated: September 2016

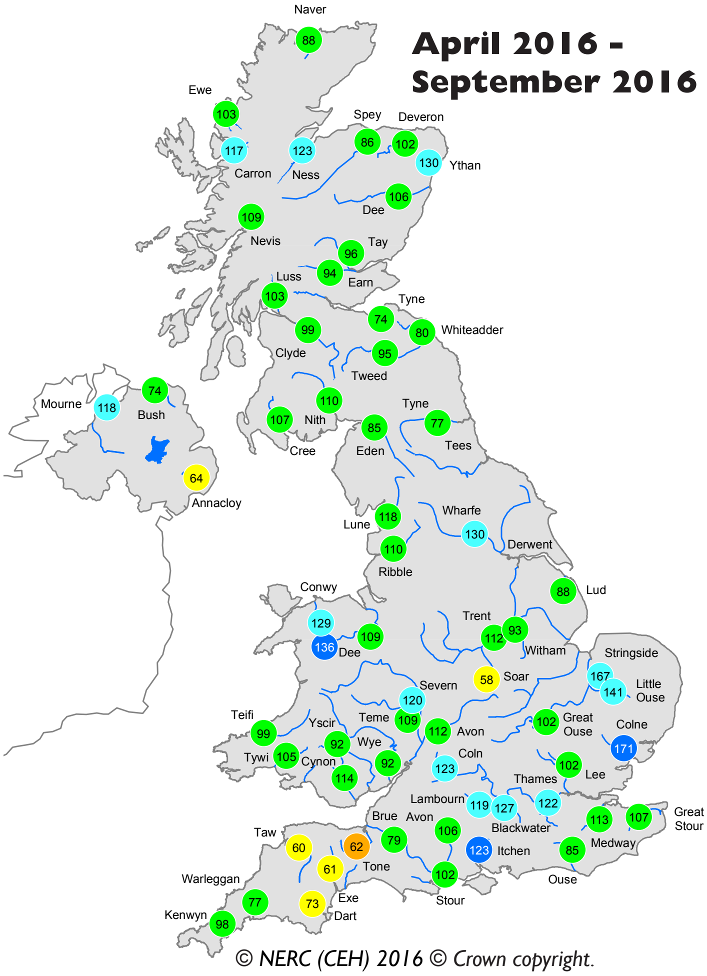
For October-November-December as a whole, there are equal chances of above-average and-below-average precipitation.

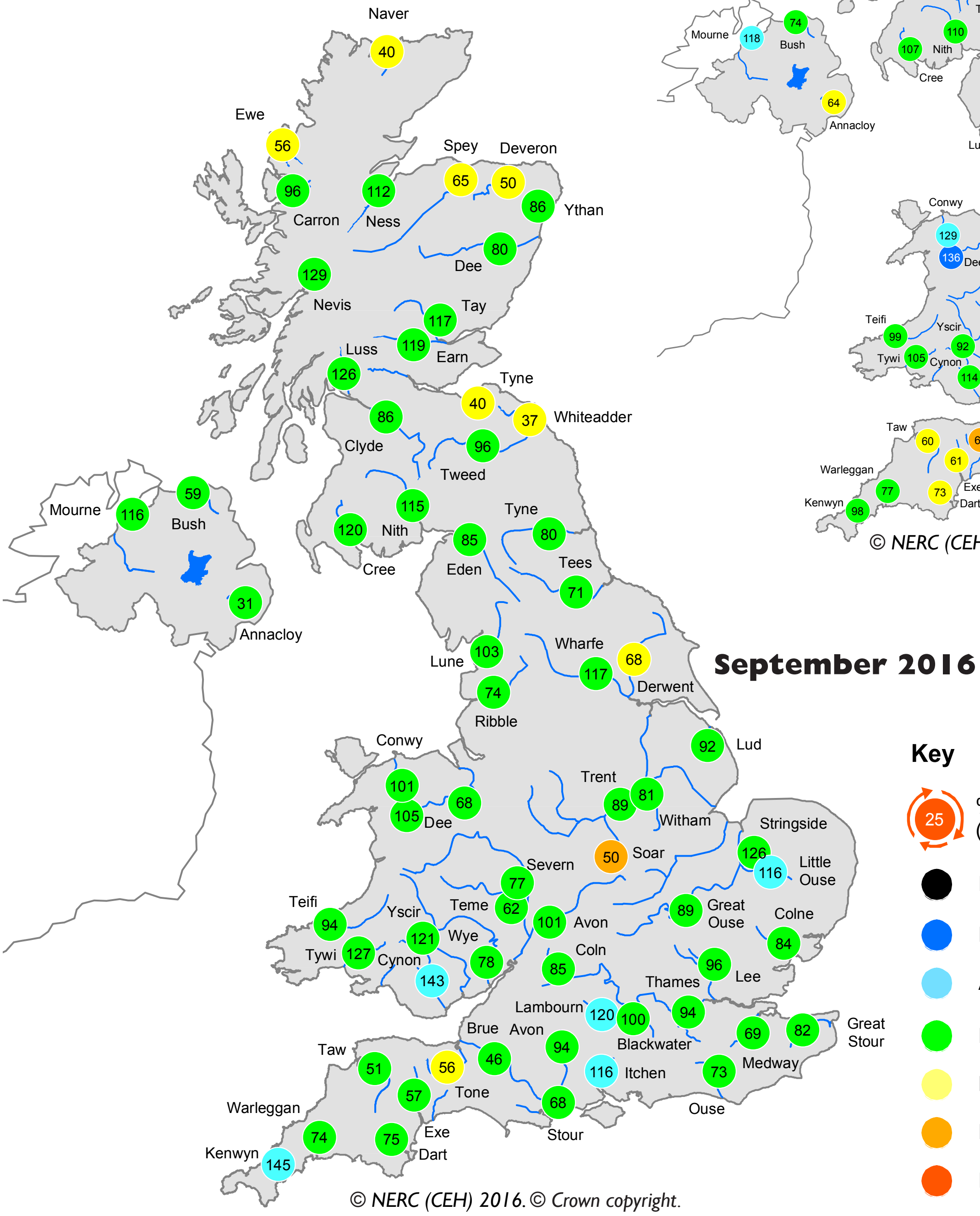
The probability that UK precipitation for October-November-December will fall into the driest of our five categories is 20% and the probability that it will fall into the wettest of our five categories is also 20% (the 1981-2010 probability for each of these categories is 20%).

The complete version of the 3-month outlook may be found at:
http://www.metoffice.gov.uk/publicsector/contingency-planners
This outlook is updated towards the end of each calendar month.

The latest shorter-range forecasts, covering the upcoming 30 days, can be accessed via:
http://www.metoffice.gov.uk/weather/uk/uk_forecast_weather.html
These forecasts are updated very frequently.

River flow . . . River flow . . .





Key

25 — % of long-term average (record figure when circled)

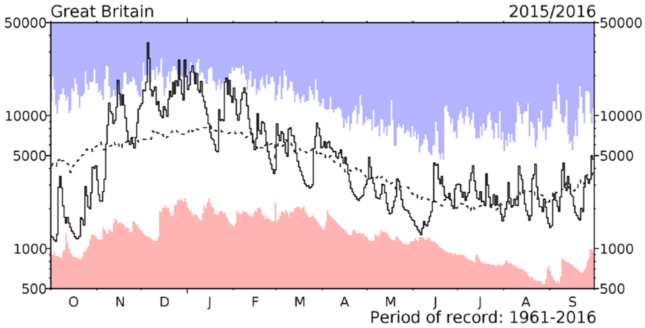
- Exceptionally high flow
- Notably high flow
- Above normal
- Normal range
- Below normal
- Notably low flow
- Exceptionally low flow

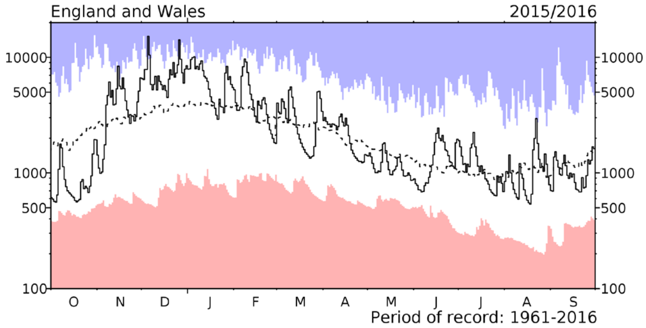
*Based on ranking of the monthly flow**

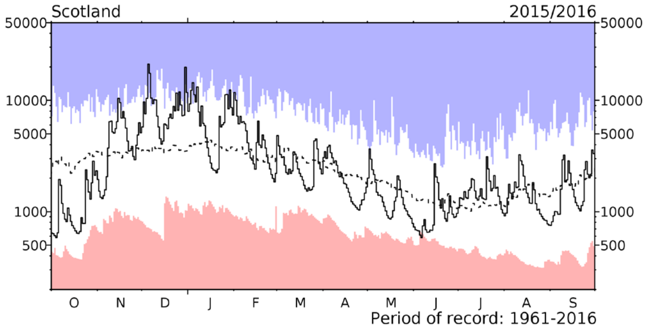
River flows

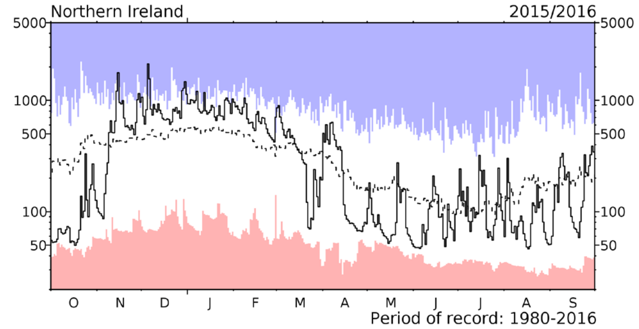
*Comparisons based on percentage flows alone can be misleading. A given percentage flow can represent extreme drought conditions in permeable catchments where flow patterns are relatively stable but be well within the normal range in impermeable catchments where the natural variation in flows is much greater. Note: the period of record on which these percentages are based varies from station to station. Percentages may be omitted where flows are under review.

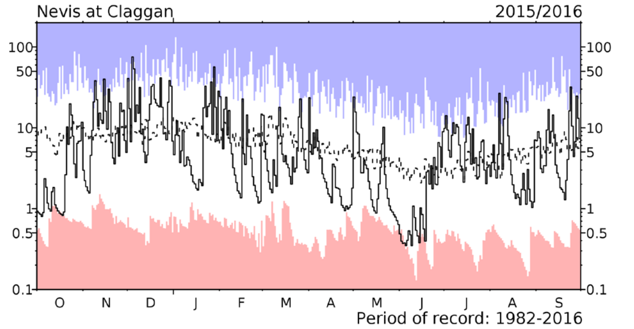
River flow . . . River flow . . .

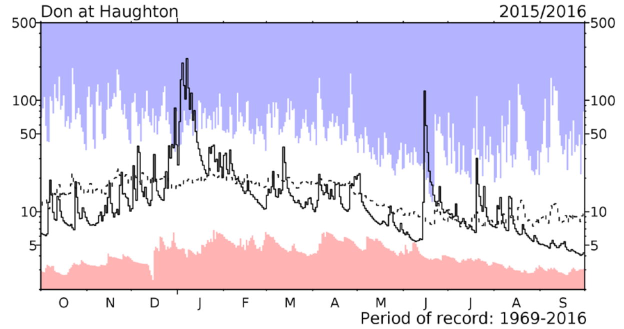


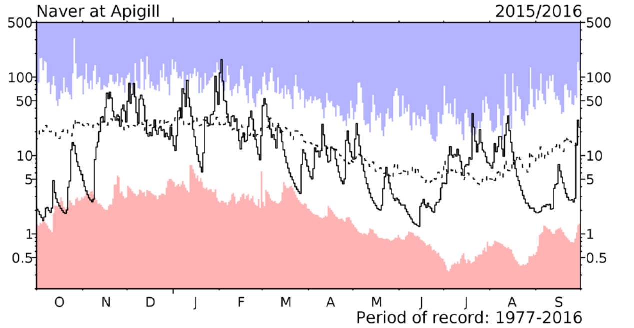


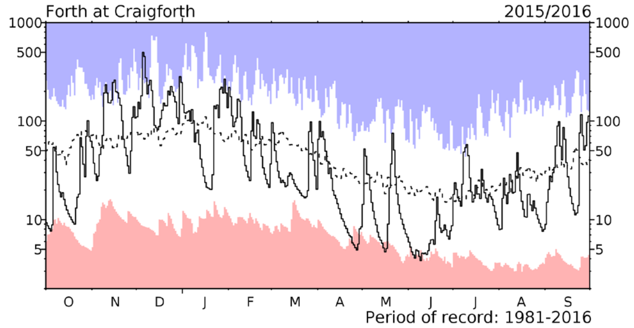


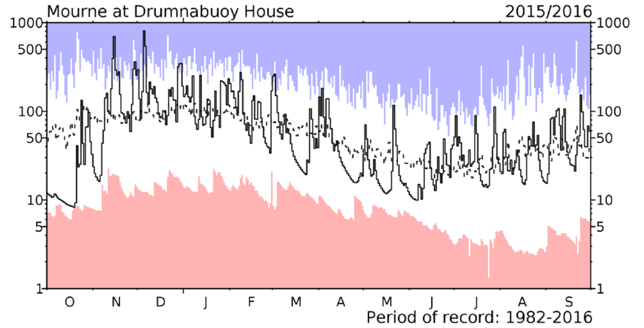


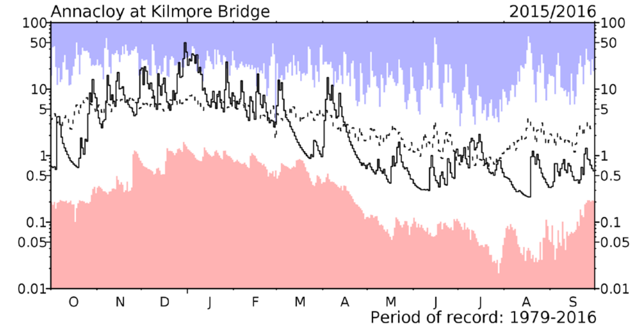








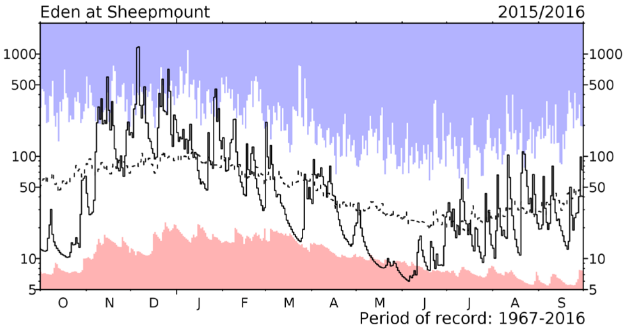


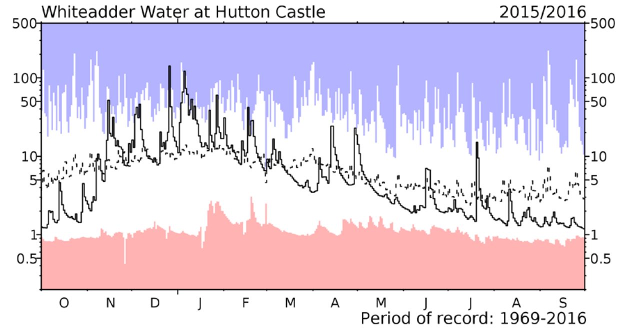


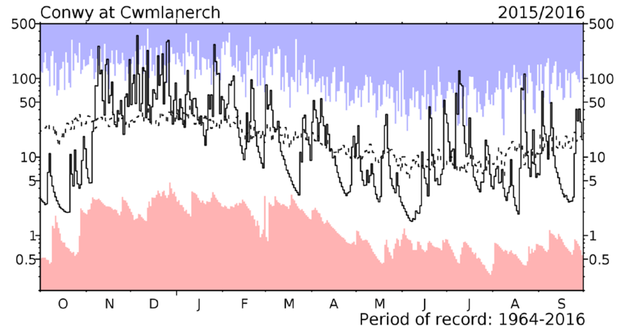
River flow hydrographs

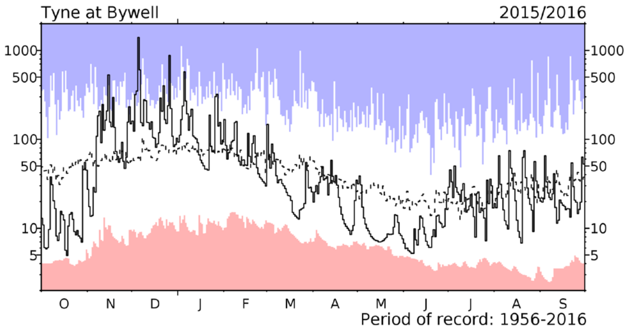
The river flow hydrographs show the daily mean flows together with the maximum and minimum daily flows prior to October 2015 (shown by the shaded areas). Daily flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas. Mean daily flows are shown as the dashed line.

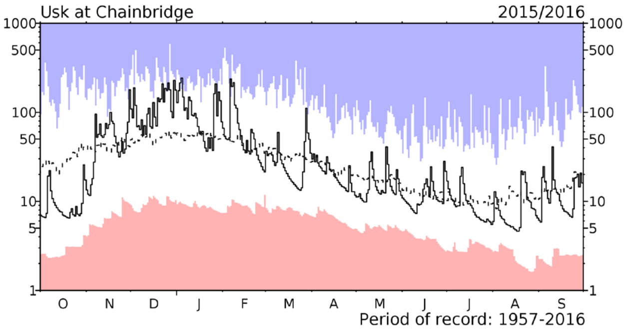
River flow ... River flow ...

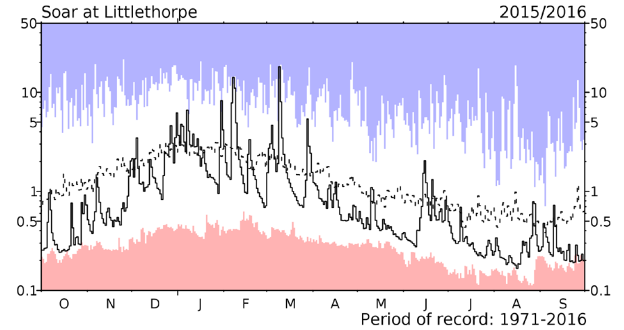


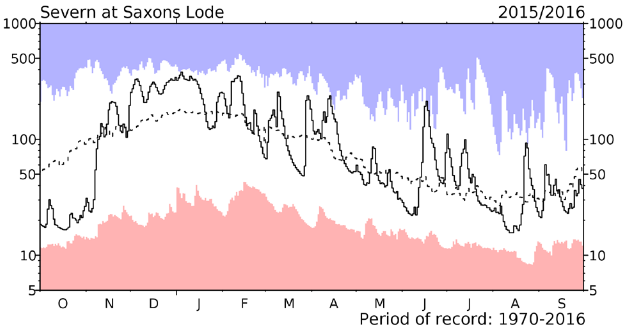


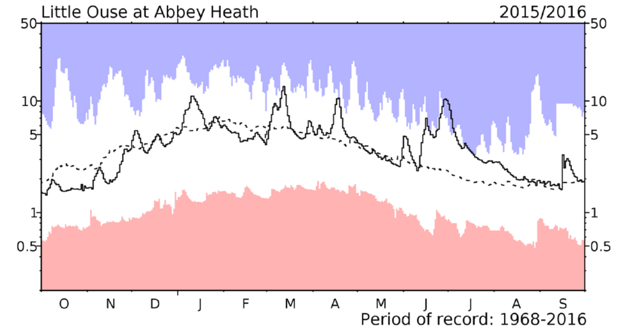


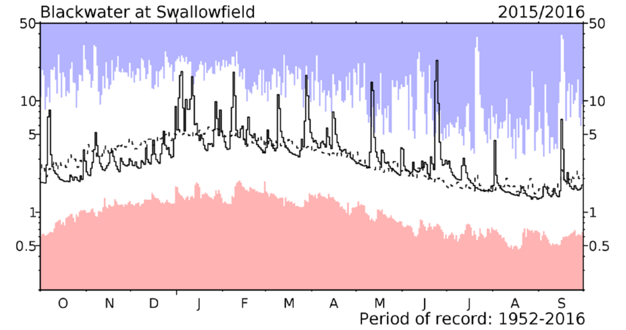


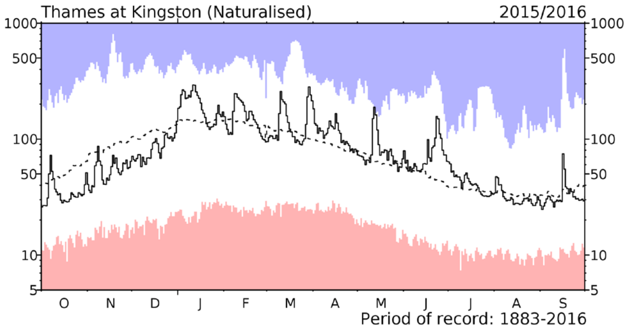


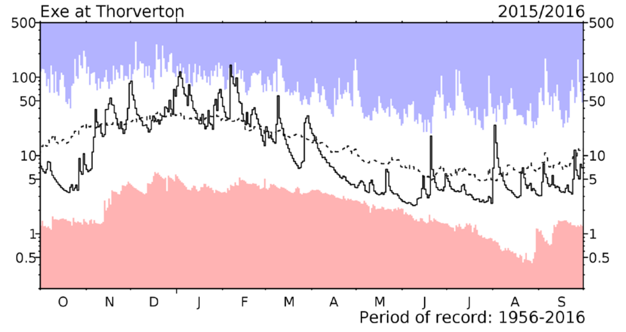


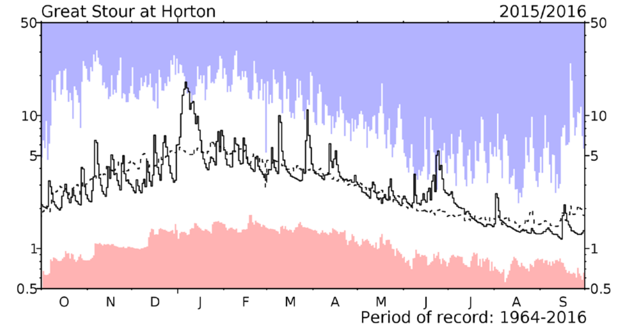




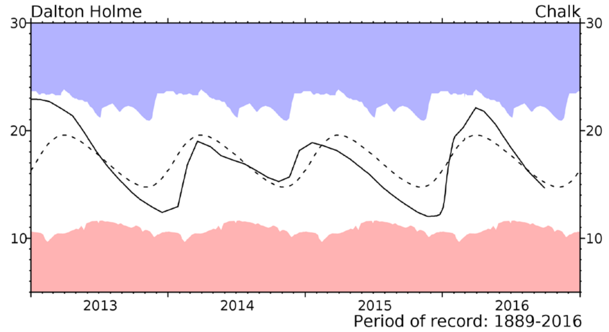


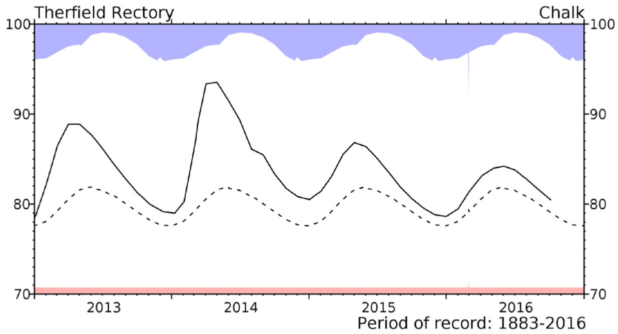


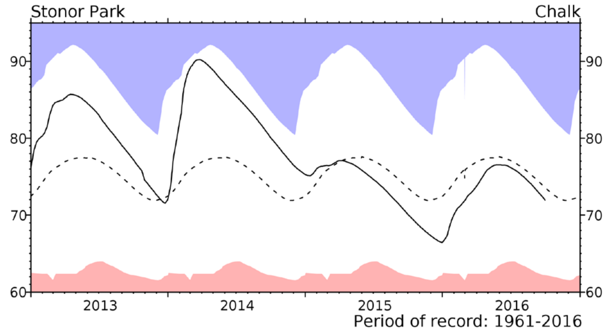


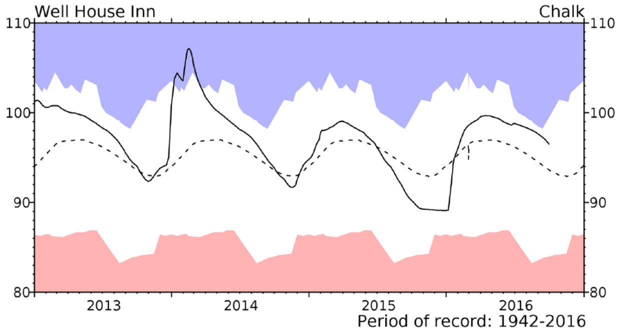


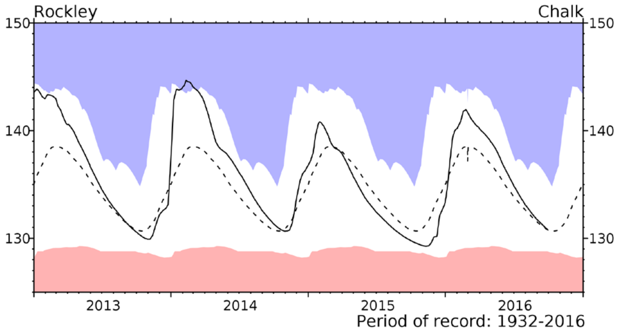
Groundwater . . . Groundwater

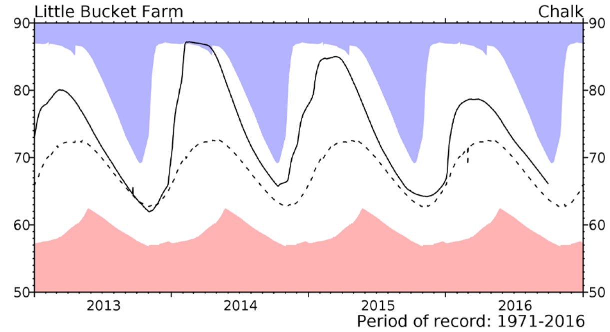


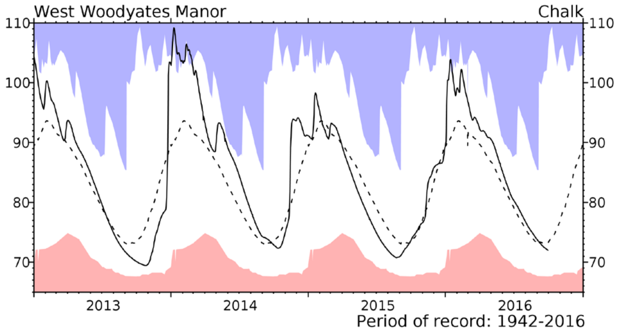


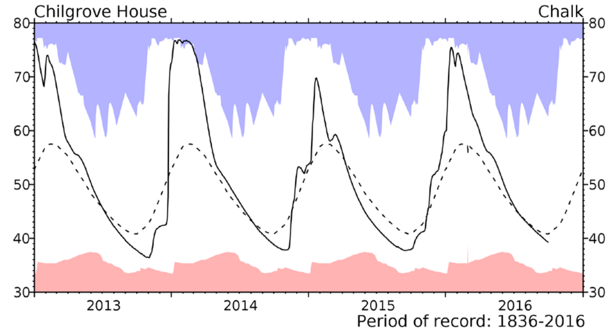


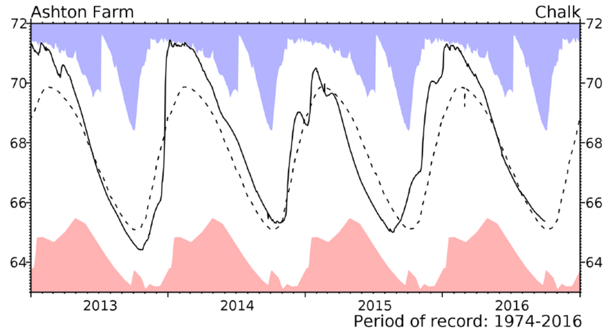


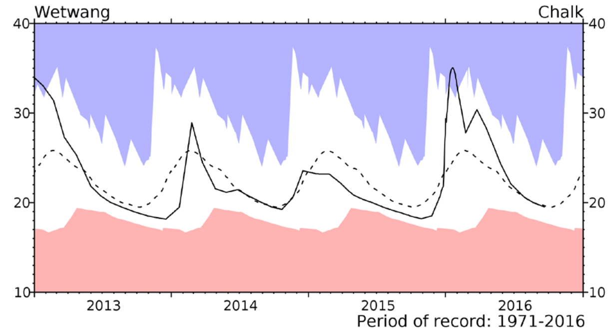






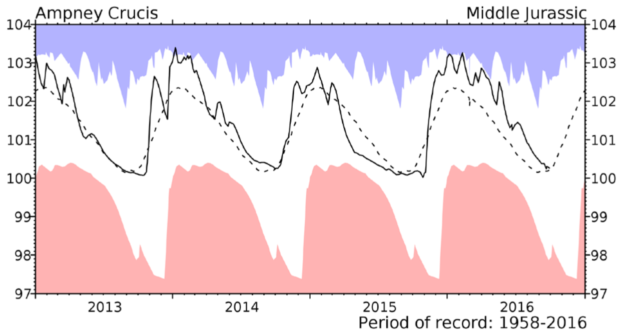


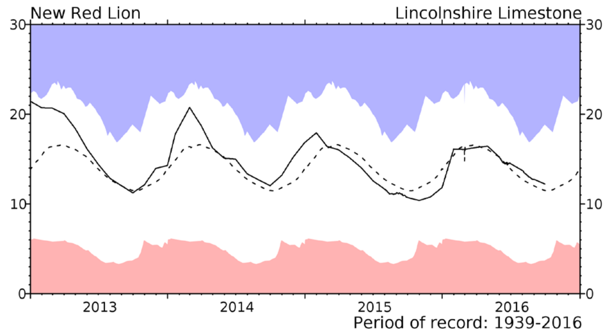


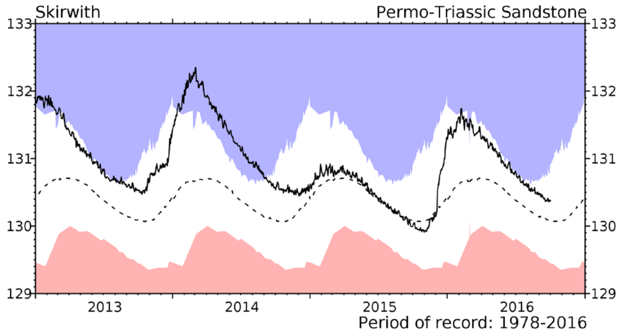


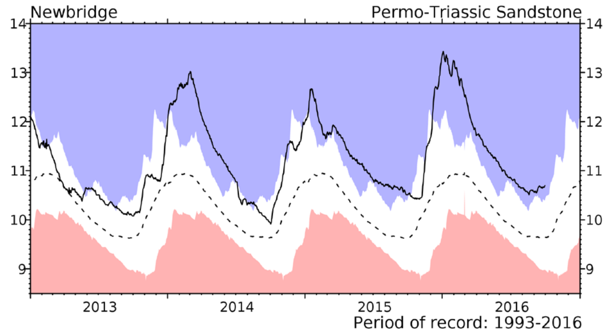
Groundwater levels normally rise and fall with the seasons, reaching a peak in the spring following replenishment through the winter (when evaporation losses are low and soil moist). They decline through the summer and early autumn. This seasonal variation is much reduced when the aquifer is confined 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. The latest recorded levels are listed overleaf.

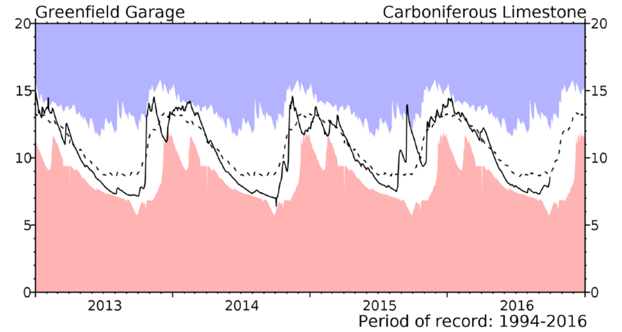
Groundwater... Groundwater

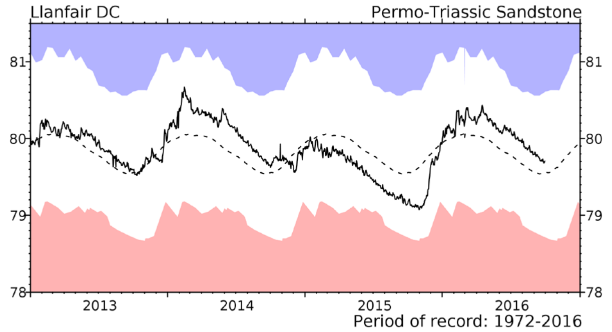


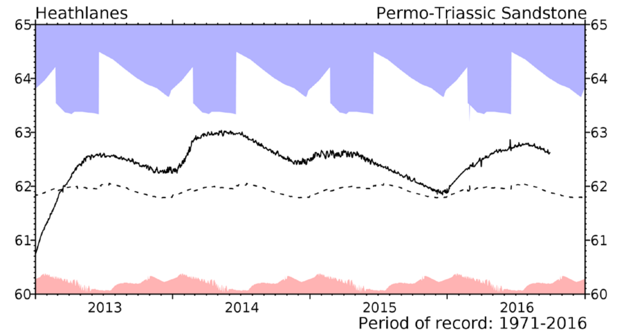


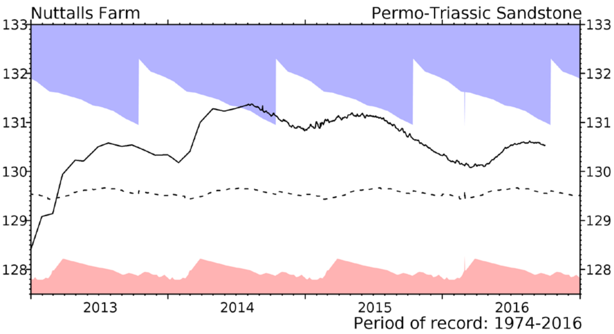


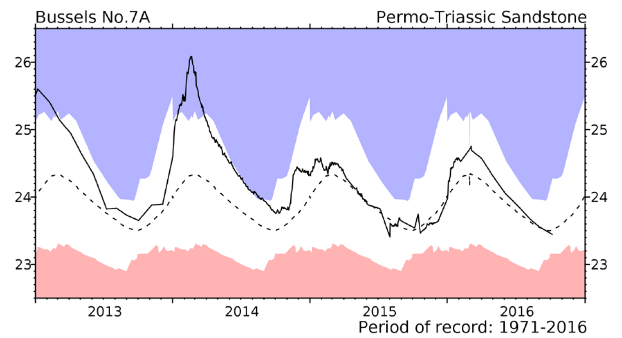


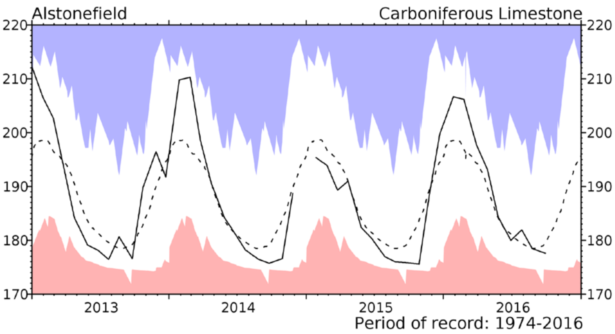










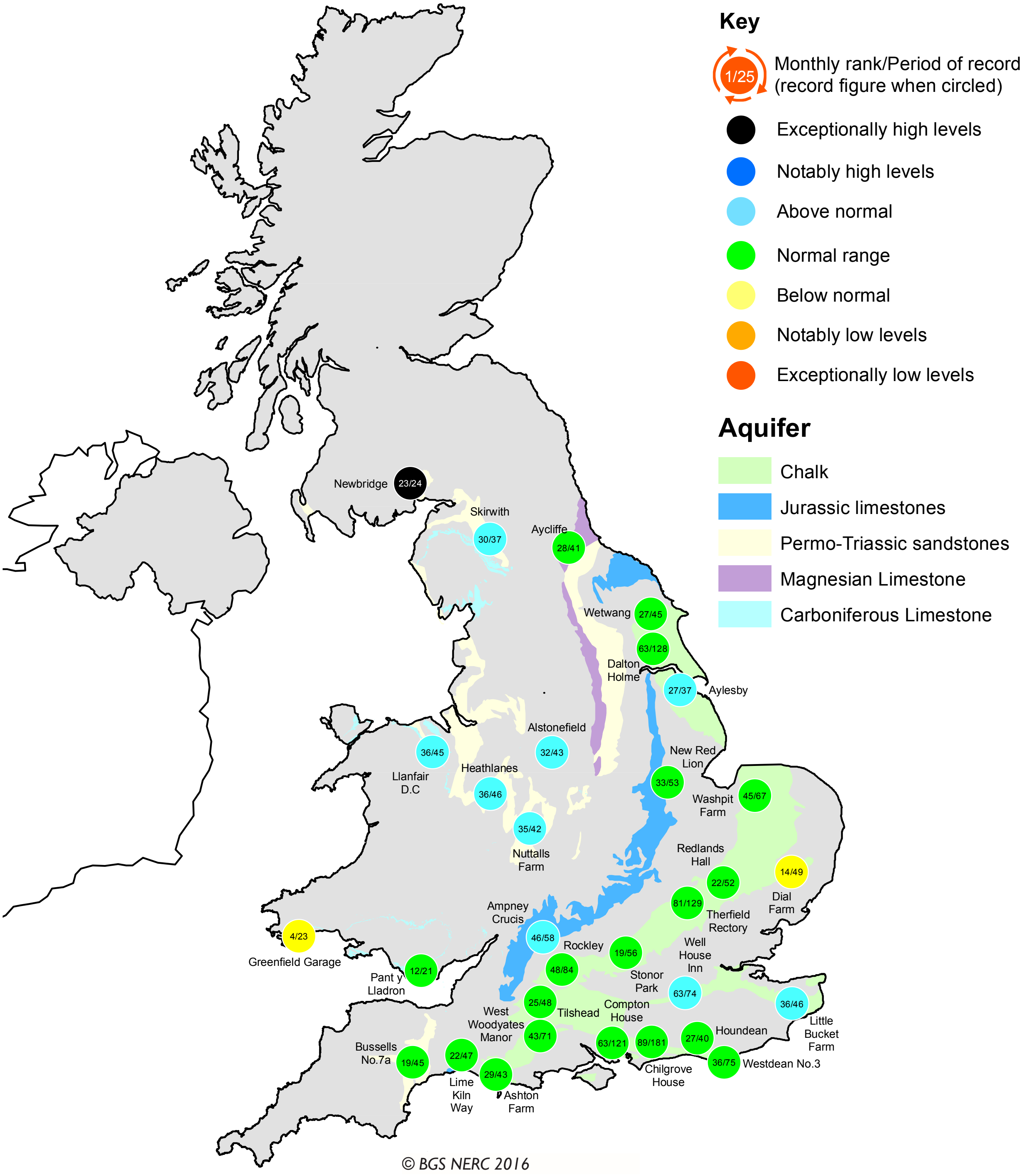


Groundwater levels September 2016 / October 2016

Borehole	Level	Date	Sep av.	Borehole	Level	Date	Sep av.	Borehole	Level	Date	Sep av.
Dalton Holme	14.68	28/09	15.44	Chilgrove House	39.20	30/09	40.72	Ayecliffe NRA2	79.84	22/09	78.83
Therfield Rectory	80.46	04/10	80.03	Ashton Farm	65.36	30/09	65.30	Llanfair DC	79.71	30/09	79.55
Stonor Park	71.94	30/09	74.36	Wetwang	19.51	20/09	19.69	Heathlanes	62.62	30/09	61.96
Tilshead	80.57	30/09	81.28	Ampney Crucis	100.26	28/09	100.17	Nuttalls Farm	130.54	30/09	129.67
Rockley	130.73	30/09	131.09	New Red Lion	12.20	30/09	11.66	Bussells No.7a	23.44	06/10	23.53
Well House Inn	96.47	30/09	93.89	Skirwith	130.37	01/10	130.16	Alstonefield	177.56	28/09	178.46
West Woodyates	71.98	30/09	73.17	Newbridge	10.70	30/09	9.72				

Levels in metres above Ordnance Datum

Groundwater...Groundwater

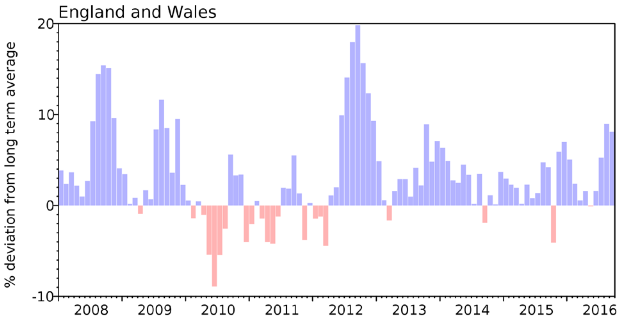


Groundwater levels - September 2016

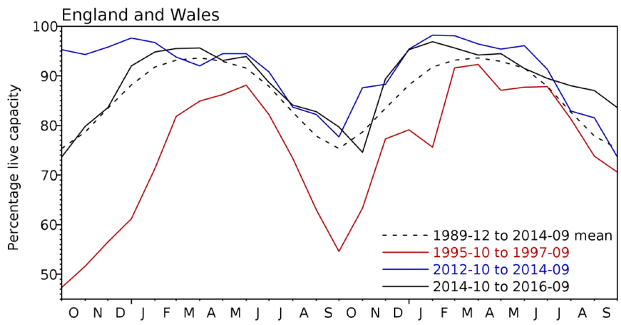
The calculation of ranking has been modified from that used in summaries published prior to October 2012. It is now based on a comparison between the most recent level and levels for the same date during previous years of record. Where appropriate, levels for earlier years may have been interpolated. 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)	2016 Jul	2016 Aug	2016 Sep	Sep Anom.	Min Sep	Year* of min	2015 Sep	Diff 16-15
North West	N Command Zone	•	124929	64	72	72	14	13	1995	58	14
	Vyrnwy		55146	94	98	99	30	26	1995	78	21
Northumbrian	Teesdale	•	87936	76	88	83	13	31	1995	78	4
	Kielder		(199175)	92	96	92	7	59	1989	85	7
Severn-Trent	Clywedog		44922	98	98	89	18	24	1989	90	-1
	Derwent Valley	•	39525	88	90	82	19	24	1989	57	25
Yorkshire	Washburn	•	22035	69	68	65	-2	24	1995	67	-2
	Bradford Supply	•	41407	73	75	70	3	15	1995	70	1
Anglian	Grafham		(55490)	93	91	90	6	46	1997	96	-6
	Rutland		(116580)	93	90	89	10	61	1995	83	6
Thames	London	•	202828	91	84	81	4	53	1997	82	-1
	Farmoor	•	13822	97	97	98	8	54	2003	98	0
Southern	Bewl		28170	88	81	69	5	32	1990	64	4
	Ardingly		4685	93	80	62	-4	32	2003	59	3
Wessex	Clatworthy		5364	63	53	40	-17	25	2003	69	-29
	Bristol	•	(38666)	79	71	64	1	31	1990	71	-7
South West	Colliford		28540	84	76	69	0	38	2006	77	-8
	Roadford		34500	86	77	68	-3	26	1995	79	-11
	Wimbleball		21320	72	60	50	-15	30	1995	70	-20
	Stithians		4967	73	61	60	3	22	1990	67	-7
Welsh	Celyn & Brenig	•	131155	100	99	95	14	39	1989	86	9
	Brianne		62140	98	99	100	13	48	1995	100	0
	Big Five	•	69762	88	85	81	11	19	1995	84	-3
	Elan Valley	•	99106	97	86	85	10	33	1976	79	6
Scotland(E)	Edinburgh/Mid-Lothian	•	96518	86	86	87	9	43	1998	74	13
	East Lothian	•	9374	98	96	92	10	52	1989	89	3
Scotland(W)	Loch Katrine	•	110326	81	79	95	21	43	1995	81	14
	Daer		22412	84	86	93	15	32	1995	81	12
	Loch Thom		10798	100	100	100	18	56	1995	100	0
Northern Ireland	Total+	•	56800	80	77	75	2	29	1995	88	-13
	Silent Valley	•	20634	77	75	72	1	27	1995	91	-20

( ) 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 Rivers Agency 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 1971-2000 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

10/2016

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