# Hydrological Summary
# *for the* United Kingdom

*June 2019*

## General

June was generally an unsettled month and, while there were warmer and drier periods, much of the month was notably cool and, for large parts of the country, very wet, with persistent and heavy rainfall more characteristic of the winter half-year. The most exceptional rainfall occurred over low-lying areas of central and eastern England, leading to some notably high peak river flows and localised (but severe and damaging, particularly in Lincolnshire) flooding. However, June rainfall totals and river flows were not as outstanding as in other recent very wet summers (e.g. 2007 and 2012). The wet June contrasts markedly with previous months and the rainfall has reduced soil moisture deficits (SMDs) across England, bringing short-term relief from agricultural and environmental stress. The long-term impact of the persistent dryness is still evident in southern and eastern England. Groundwater levels continued to decline in the Chalk and were notably low across East Anglia and, while June river flows were typically normal or above, recessions recommenced in late June into early July. Reservoir stocks were moderately above average at the national scale, with only two impoundments (in the south west) having stocks around 10% below average at month-end. Overall, the water resources situation has improved and the recent rainfall has diminished the likelihood of water resources pressures in summer 2019. However, July began very dry and current outlooks for the next three months suggest a continuation of below normal flows and groundwater levels in parts of eastern England, so agricultural and environmental impacts remain a risk through to the autumn.

## Rainfall

The first few days of June were warm and dry in the south east, under the influence of anticyclonic conditions. From the 3rd, a marked change in synoptic conditions heralded a very unsettled period until around the 20th, which was dominated by cool, overcast and wet weather as an 'omega' blocking pattern in the North Atlantic, with low pressure stationed over the continent, drove a train of fronts eastwards across the UK. Mid-month saw an exceptional summer rainfall episode. On the 10th, daily rainfall totals of over >80mm were recorded in Kent and parts of the Lincolnshire Wolds (where 96mm was recorded at Stenigot, with a provisional return period of over 80 years; the corresponding 48h total was 123mm); while significant falls were also observed on the 11th across north Wales and Shropshire, and on the 12th in south-east Scotland (with over 80mm in places, e.g. 106mm at Abbey St Bathans, Berwickshire). The last third of the month was generally more settled, albeit with thundery outbreaks. June rainfall totals were notable across most of the UK (the UK June rainfall was 157% of average) and exceptional in parts of central England and north Wales – over twice the typical June rainfall was received across a large swathe stretching from the Wash to the Severn and Mersey estuaries and into Wales. The Severn-Trent region experienced its third wettest June, after the notable flood years of 2007 and 2012, and Wales its fourth wettest (both in records 1910). Notable rainfall accumulations over the last few months were generally dominated by the wet June, although May was also wet in parts of Scotland – it was the sixth wettest May-June period on record for the North East Scotland region. Over longer timeframes, in general rainfall accumulations were moderately below average over the last year.

## River flows

In many catchments in England and Wales, flows were in recession or tracking below average in early June. Towards the end of the first week flows generally increased steeply in response to the increasingly unsettled conditions, leading to widespread flood alerts and flood warnings mid-month, particularly across central England, north Wales and the Scottish borders. Flooding in north Wales (e.g. on the Alyn) on the 11th/12th prompted evacuations. The worst affected area was Lincolnshire, where a breach in flood defences on the Steeping led to the evacuation of nearly 600 homes in Wainfleet, with close to 130 properties flooded. A major incident was declared and RAF helicopters were used to drop ballast into the breach to prevent further flooding. Flood warnings continued thereafter, particularly in slower responding major rivers (e.g. the Severn where demountable flood defences were deployed). New peak flow records for June were established in a number of catchments, e.g. the Severn (at Montford, the highest June peak flow in a record from 1956), Whiteadder and Weaver. Correspondingly, mean flows for June were exceptionally high in some catchments in central England and Wales, e.g. the Lud (that saw its second highest June mean flow in a record from 1969), Wharfe and Witham, where June flows were over twice the average. The Severn and Weaver saw over three and four times the typical June flows respectively. Notably high flows were also registered in eastern Scotland, Northern Ireland and across Wales. In southern England, June flows were typically below average, with less than 70% of the typical June flow in some groundwater dominated catchments, extending long-term flow deficiencies.

## Groundwater

Late May SMDs were well above average across most aquifer areas, but declined steeply following the June rainfall and were below normal at the end of June in central and eastern England, with near- or moderately below average SMDs in southern England. Despite this, levels fell at all Chalk boreholes (apart from Killyglen) and were generally below normal or notably low, especially so in eastern England where levels at Dial Farm were exceptionally low. Levels at this site, along with Frying Pan Lodge, Washpit Farm and Dalton Holme were at their lowest in June since 1997. However, four sites in southern England and Northern Ireland were in the normal range in June, including Westdean No. 3 and Killyglen that had been below normal in May. In the Jurassic limestone, levels increased rapidly from below normal to above normal at New Red Lion and to notably high at Ampney Crucis. Levels in the Magnesian limestones fell and remained below average. In the Carboniferous limestone, levels fell in south Wales and remained below average, but rose at Alstonfield and returned to the normal range. In the Permo-Triassic sandstones and at Lime Kiln Way (Upper Greensand), levels generally fell, remaining normal or above, but at Llanfair DC levels increased and returned to within the normal range. Levels in the Fell Sandstone at Royalty Observatory receded and remained in the normal range.

Centre for Ecology & Hydrology
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British Geological Survey
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# Rainfall . . . Rainfall . . .

Met Office

## Rainfall accumulations and return period estimates

Percentages are from the 1981-2010 average.

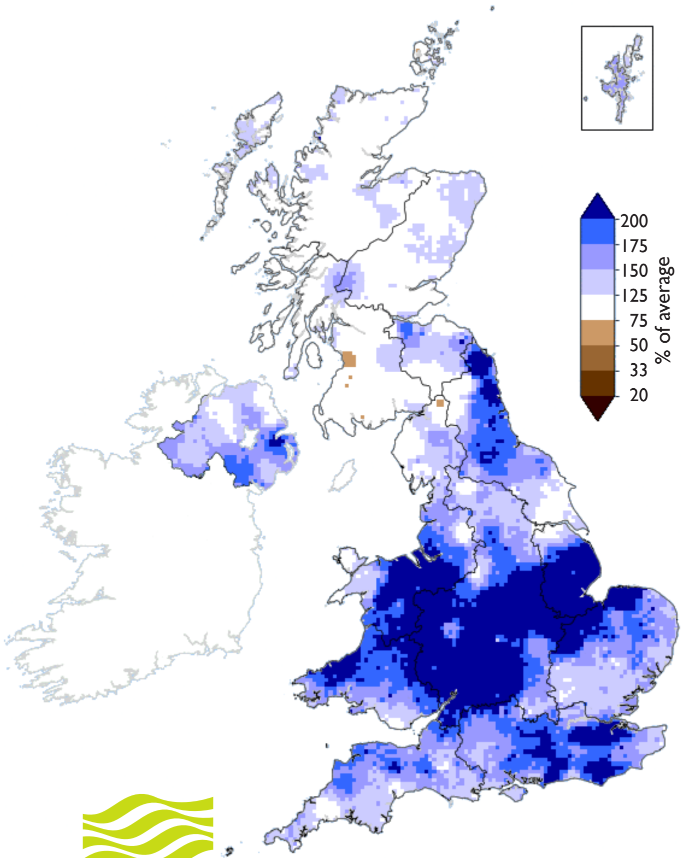
| Region | Rainfall | Jun 2019 | Apr19 – Jun19 | RP | Jan19 – Jun19 | RP | Oct18 – Jun19 | RP | Jul19 – Jun19 | RP |
|---|---|---|---|---|---|---|---|---|---|---|
| United Kingdom | mm | **112** | 228 | | 497 | | 844 | | 1088 | |
| | % | **157** | 109 | 2-5 | 98 | 2-5 | 97 | 2-5 | 97 | 2-5 |
| England | mm | **109** | 191 | | 366 | | 623 | | 787 | |
| | % | **179** | 108 | 2-5 | 96 | 2-5 | 96 | 2-5 | 93 | 2-5 |
| Scotland | mm | **103** | 264 | | 658 | | 1114 | | 1476 | |
| | % | **123** | 106 | 2-5 | 96 | 2-5 | 94 | 2-5 | 97 | 2-5 |
| Wales | mm | **159** | 307 | | 681 | | 1188 | | 1497 | |
| | % | **192** | 122 | 5-10 | 109 | 2-5 | 106 | 2-5 | 106 | 2-5 |
| Northern Ireland | mm | **113** | 250 | | 536 | | 861 | | 1101 | |
| | % | **148** | 111 | 2-5 | 103 | 2-5 | 99 | 2-5 | 97 | 2-5 |
| England & Wales | mm | **116** | 207 | | 410 | | 701 | | 885 | |
| | % | **182** | 111 | 2-5 | 99 | 2-5 | 99 | 2-5 | 96 | 2-5 |
| North West | mm | **122** | 238 | | 570 | | 930 | | 1224 | |
| | % | **153** | 107 | 2-5 | 107 | 2-5 | 99 | 2-5 | 100 | 2-5 |
| Northumbria | mm | **113** | 219 | | 399 | | 624 | | 827 | |
| | % | **172** | 120 | 5-10 | 101 | 2-5 | 95 | 2-5 | 95 | 2-5 |
| Severn-Trent | mm | **138** | 226 | | 381 | | 590 | | 742 | |
| | % | **220** | 127 | 8-12 | 106 | 2-5 | 100 | 2-5 | 95 | 2-5 |
| Yorkshire | mm | **103** | 186 | | 362 | | 599 | | 768 | |
| | % | **151** | 102 | 2-5 | 93 | 2-5 | 93 | 2-5 | 91 | 2-5 |
| Anglian | mm | **104** | 163 | | 266 | | 436 | | 548 | |
| | % | **194** | 110 | 2-5 | 93 | 2-5 | 94 | 2-5 | 88 | 2-5 |
| Thames | mm | **95** | 156 | | 291 | | 511 | | 630 | |
| | % | **188** | 98 | 2-5 | 89 | 2-5 | 93 | 2-5 | 88 | 2-5 |
| Southern | mm | **92** | 148 | | 306 | | 592 | | 743 | |
| | % | **185** | 95 | 2-5 | 87 | 2-5 | 94 | 2-5 | 93 | 2-5 |
| Wessex | mm | **93** | 180 | | 360 | | 669 | | 815 | |
| | % | **167** | 103 | 2-5 | 91 | 2-5 | 97 | 2-5 | 92 | 2-5 |
| South West | mm | **107** | 217 | | 485 | | 957 | | 1161 | |
| | % | **153** | 98 | 2-5 | 88 | 2-5 | 98 | 2-5 | 95 | 2-5 |
| Welsh | mm | **156** | 300 | | 656 | | 1142 | | 1440 | |
| | % | **194** | 122 | 5-10 | 109 | 2-5 | 107 | 2-5 | 105 | 2-5 |
| Highland | mm | **112** | 292 | | 811 | | 1315 | | 1762 | |
| | % | **123** | 105 | 2-5 | 97 | 2-5 | 92 | 2-5 | 97 | 2-5 |
| North East | mm | **89** | 283 | | 490 | | 797 | | 1007 | |
| | % | **125** | 140 | 10-20 | 108 | 2-5 | 103 | 2-5 | 100 | 2-5 |
| Tay | mm | **95** | 263 | | 546 | | 977 | | 1268 | |
| | % | **124** | 114 | 2-5 | 88 | 2-5 | 93 | 2-5 | 95 | 2-5 |
| Forth | mm | **97** | 241 | | 482 | | 811 | | 1061 | |
| | % | **125** | 112 | 2-5 | 87 | 2-5 | 88 | 2-5 | 88 | 2-5 |
| Tweed | mm | **98** | 221 | | 456 | | 739 | | 983 | |
| | % | **138** | 111 | 2-5 | 98 | 2-5 | 95 | 2-5 | 96 | 2-5 |
| Solway | mm | **91** | 239 | | 651 | | 1177 | | 1531 | |
| | % | **106** | 93 | 2-5 | 99 | 2-5 | 103 | 5-10 | 103 | 2-5 |
| Clyde | mm | **114** | 256 | | 715 | | 1287 | | 1732 | |
| | % | **118** | 90 | 2-5 | 88 | 2-5 | 92 | 2-5 | 95 | 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.

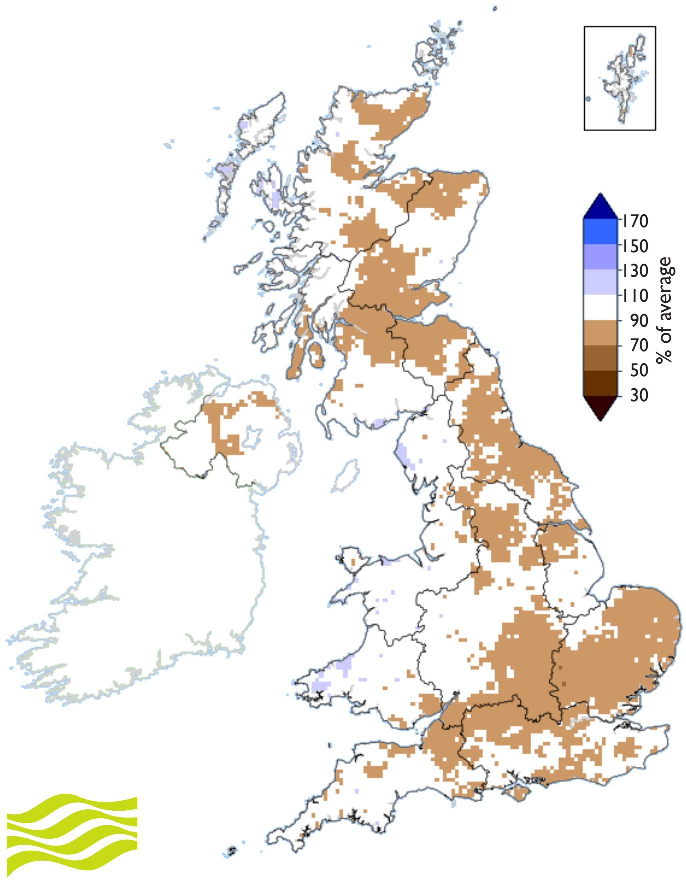
# Rainfall . . . Rainfall . . .

**June 2019 rainfall as % of 1981-2010 average**



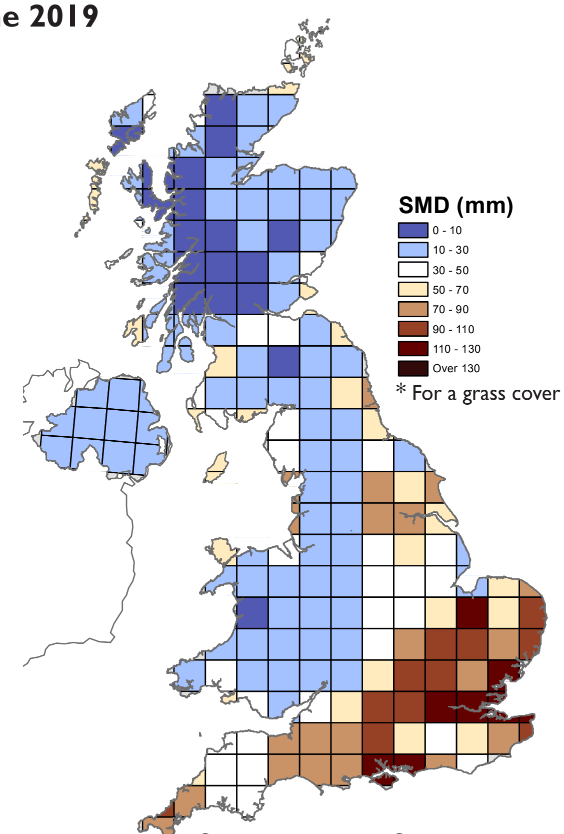

Met Office

**July 2018 - June 2019 rainfall as % of 1981-2010 average**




Met Office

**MORECS Soil Moisture Deficits* June 2019**






## Hydrological Outlook UK

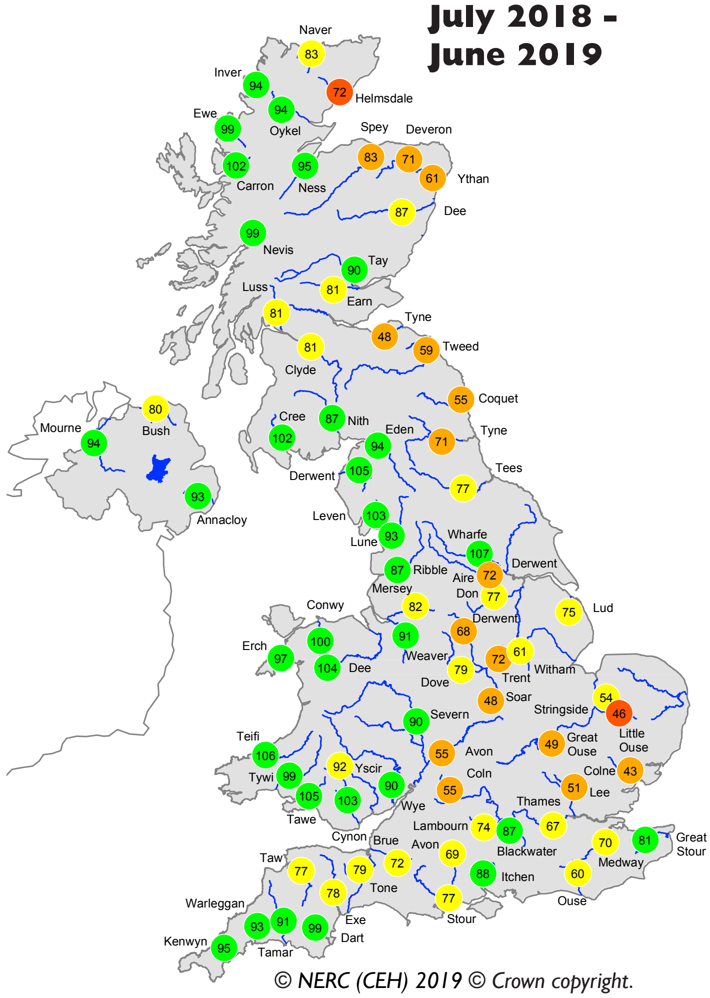
The Hydrological Outlook provides an insight into future hydrological conditions across the UK. Specifically it describes likely trajectories for river flows and groundwater levels on a monthly basis, with particular focus on the next three months.

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

**Period:** **from July 2019**
**Issued:** **10.07.2019**
**using data to the end of June 2019**

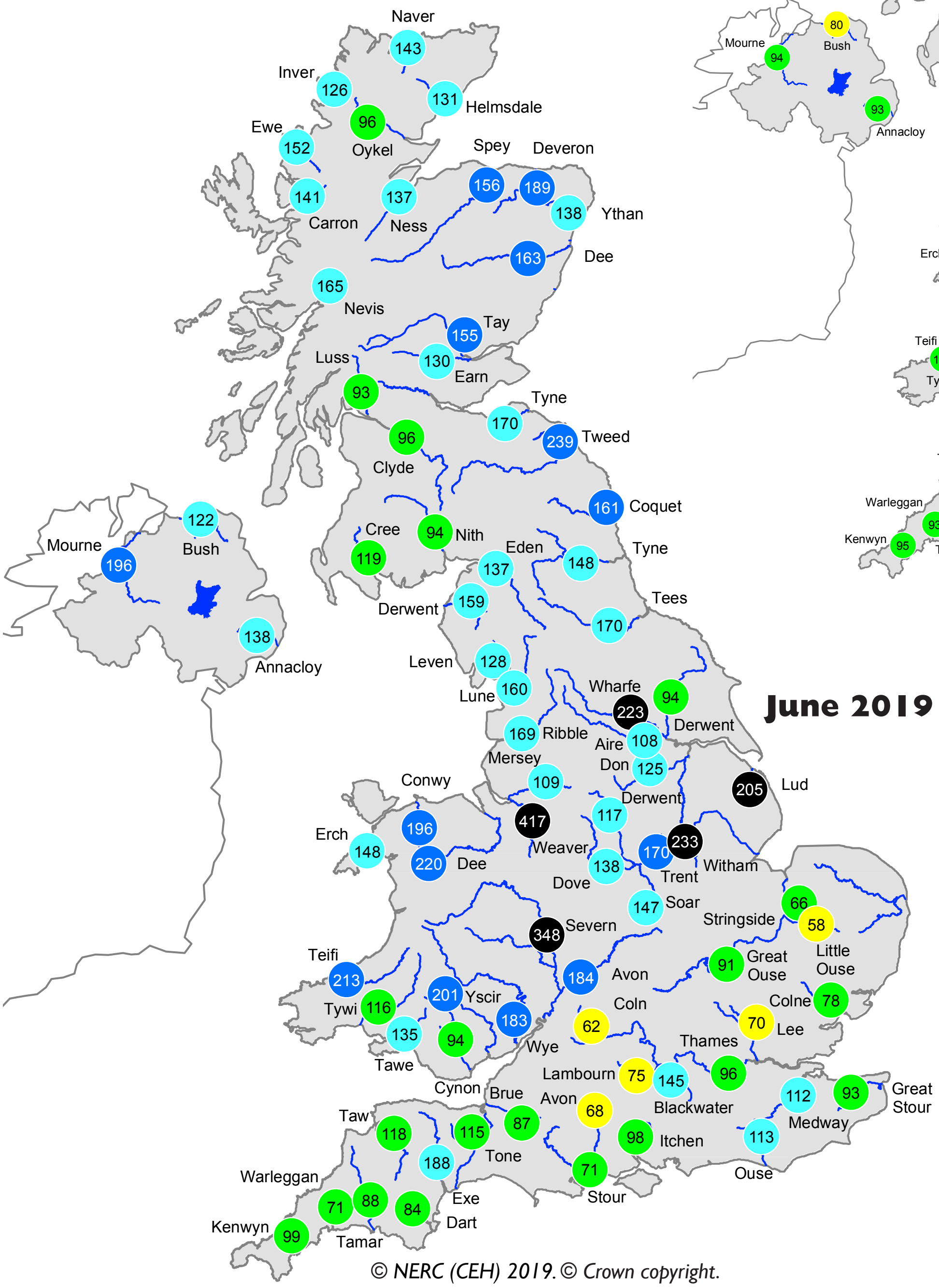
The outlook is for below normal river flows in southern and eastern England both in July and for the next three months, while elsewhere river flows are most likely to be normal to above normal in July, and in the normal range over the July-September period. Groundwater levels in the eastern Chalk are likely to be notably low over both the one- and three-month timeframes. Elsewhere, groundwater levels are generally likely to be normal to below normal in July, except for some central and northern areas which may see above normal levels. Normal to below normal levels are likely to predominate over the July-September timeframe.

# River flow . . . River flow . . .





**July 2018 - June 2019**





**June 2019**

**Key**

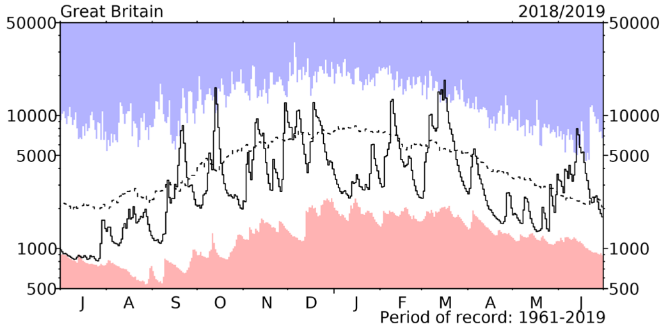
- 25 — % of long-term average (record figure when circled)
- Exceptionally high flow
- Notably high flow
- Above normal
- Normal range
- Below normal
- Notably low flow
- Exceptionally low flow

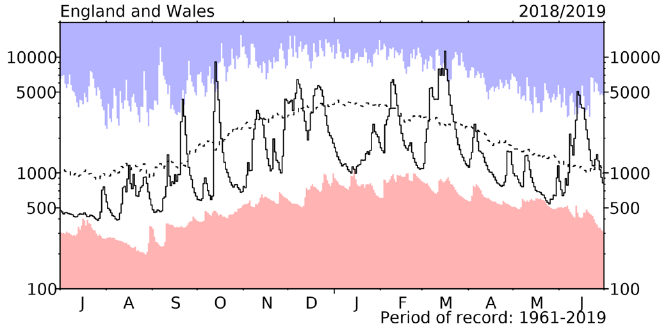
*Based on ranking of the monthly flow**

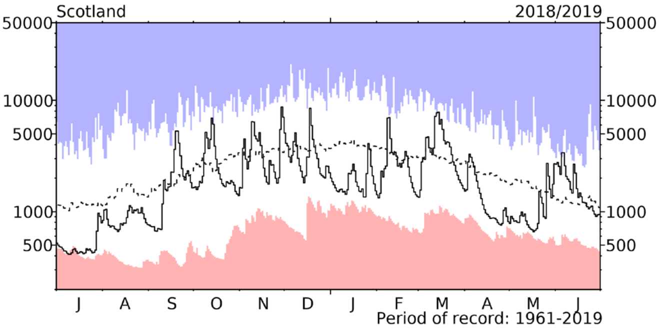
## River flows

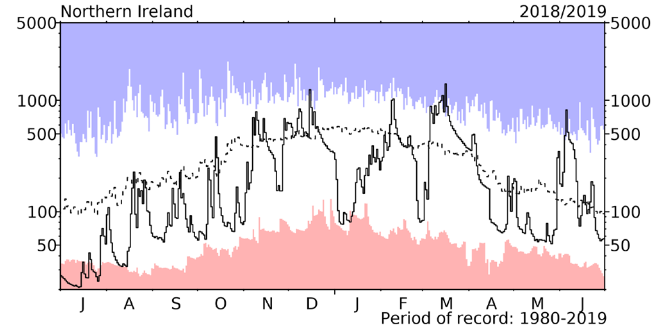
*Comparisons based on percentage flows alone can be misleading. A given percentage flow can represent extreme drought conditions in permeable catchments where flow patterns are relatively stable but be well within the normal range in impermeable catchments where the natural variation in flows is much greater. Note: the averaging period on which these percentages are based is 1981-2010. Percentages may be omitted where flows are under review.

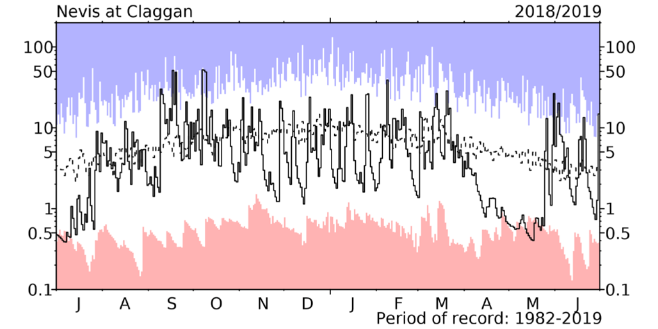
# River flow . . . River flow . . .

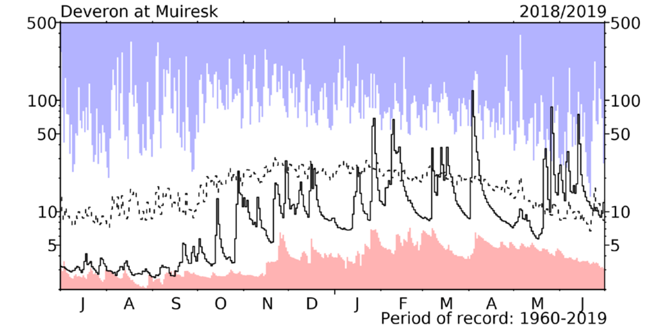


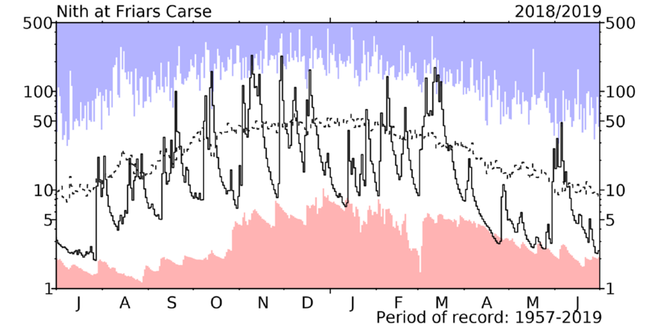



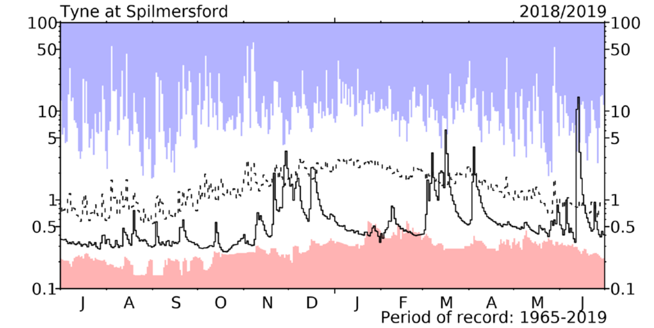



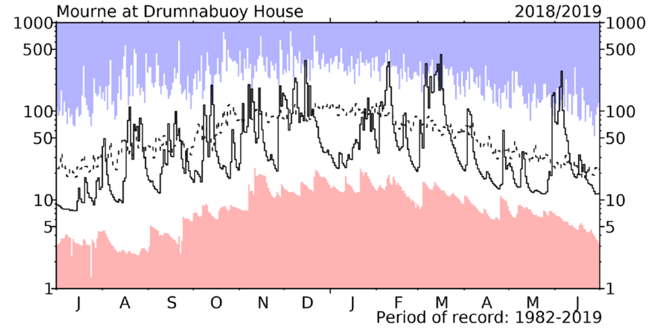



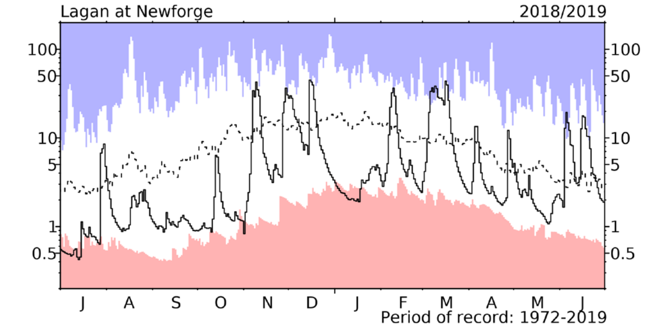



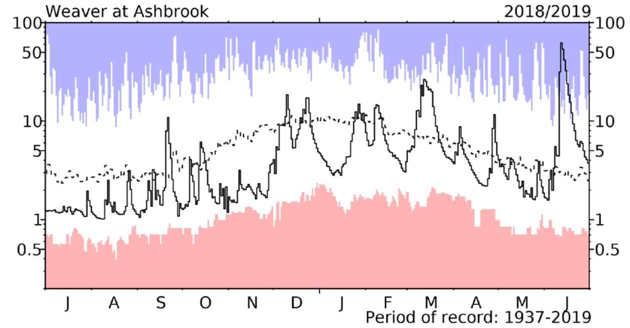



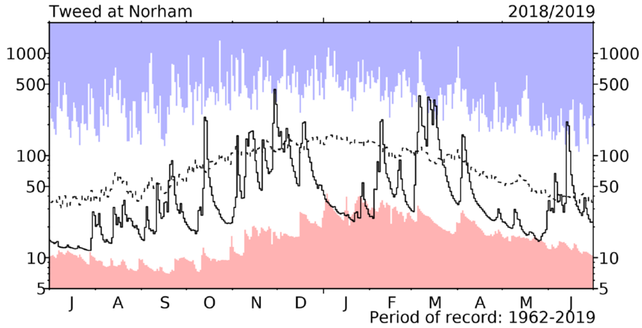



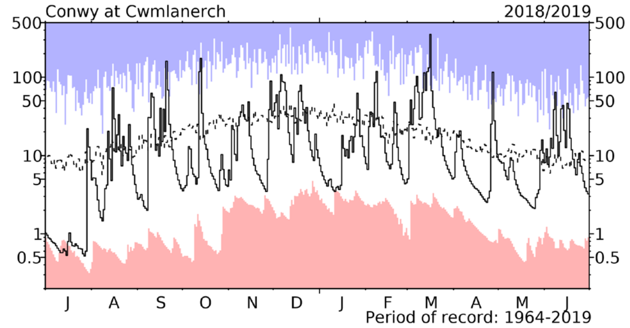

## River flow hydrographs

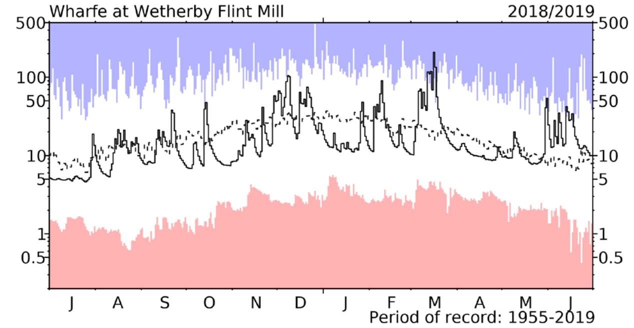
*The river flow hydrographs show the daily mean flows (measured in $m^3s^{-1}$) together with the maximum and minimum daily flows prior to July 2018 (shown by the shaded areas). Daily flows falling outside the maximum/minimum range are indicated where the bold trace enters the shaded areas. The dashed line represents the period-of-record average daily flow.

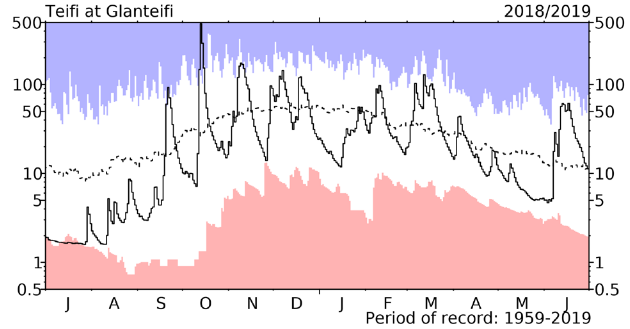
# *River flow . . . River flow . . .*

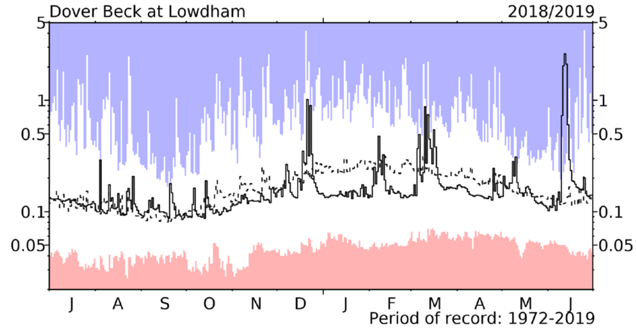


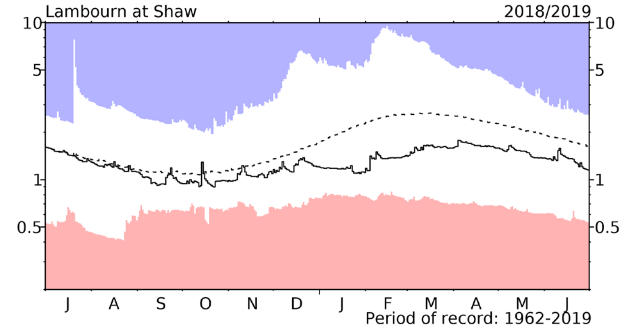



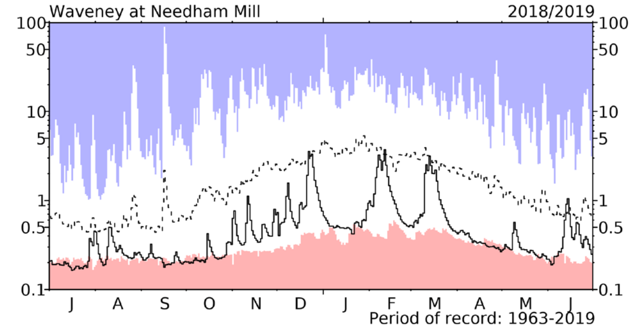



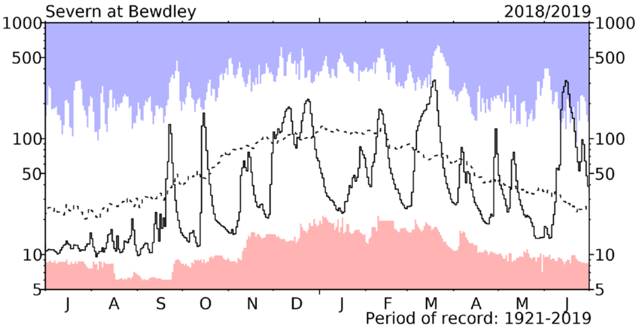



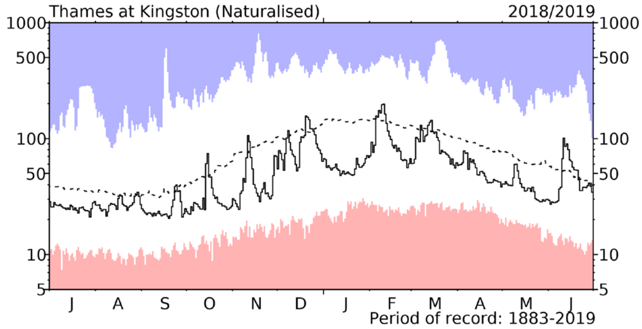



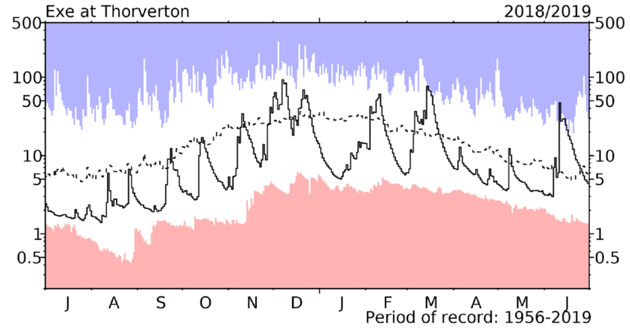



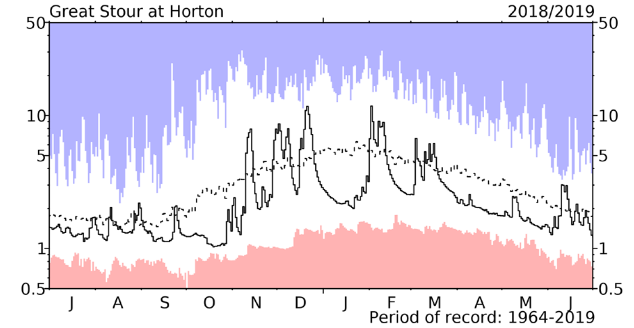



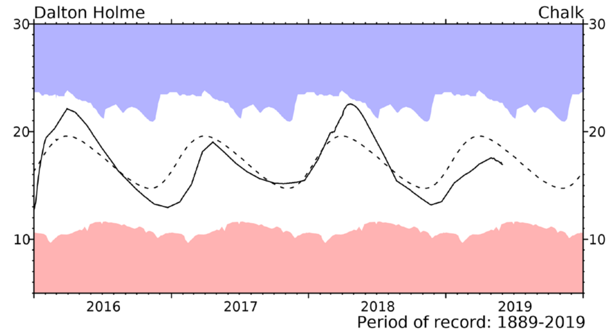



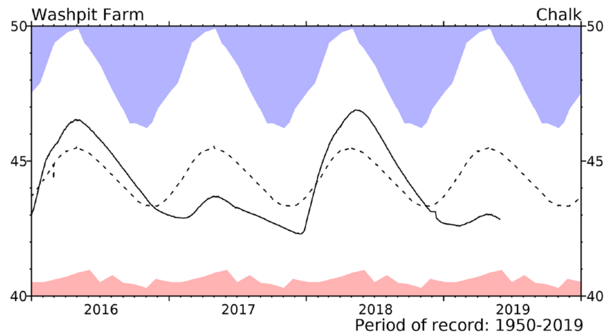



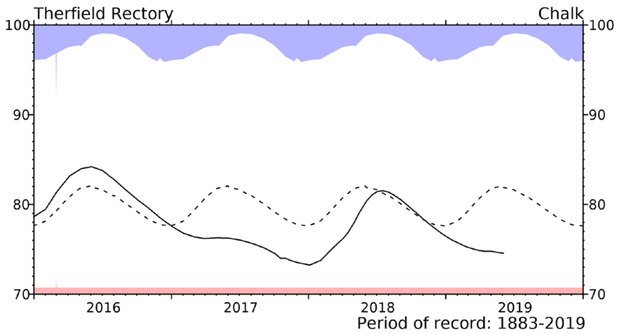



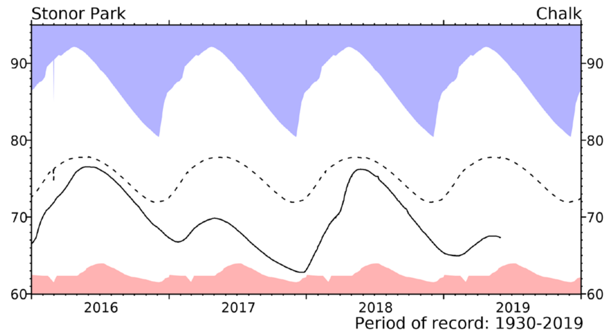



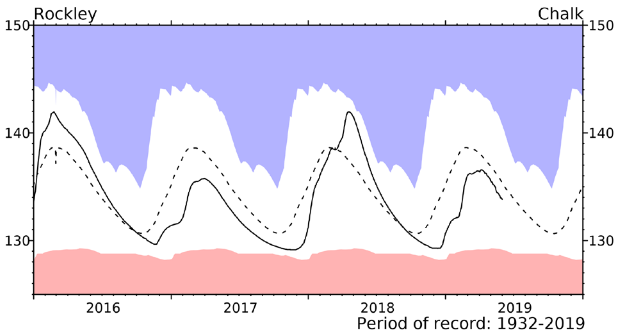
# Groundwater . . . Groundwater

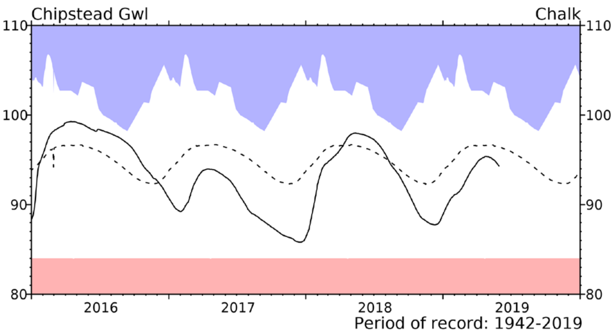


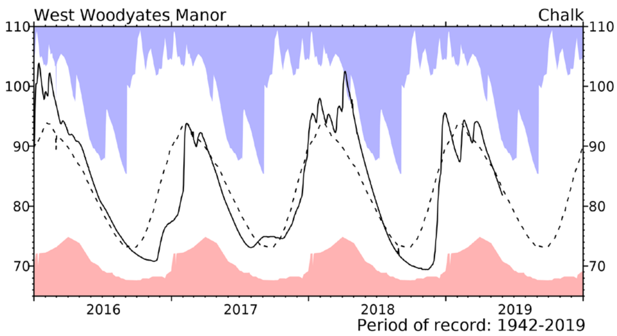



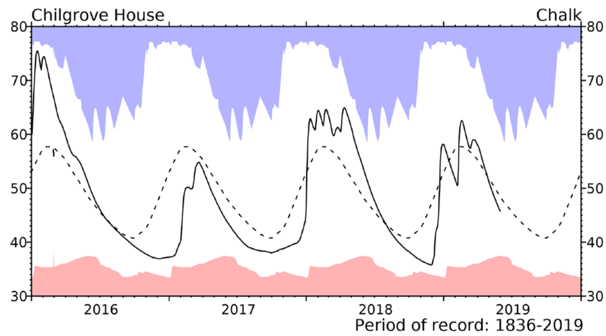



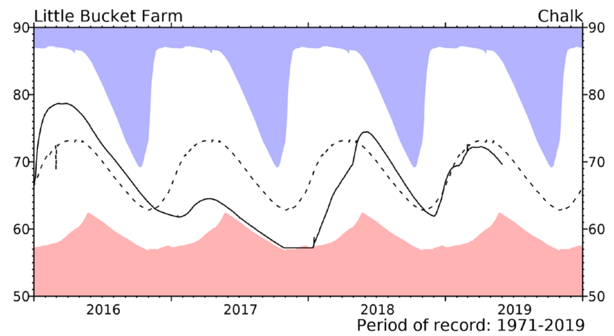



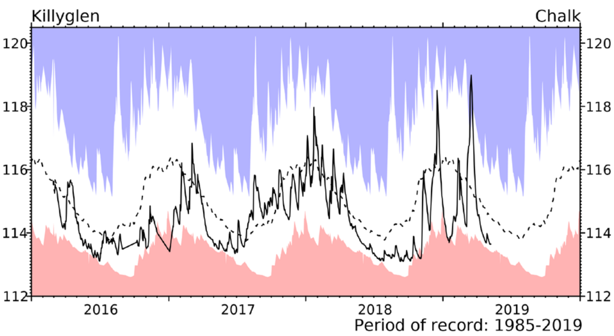



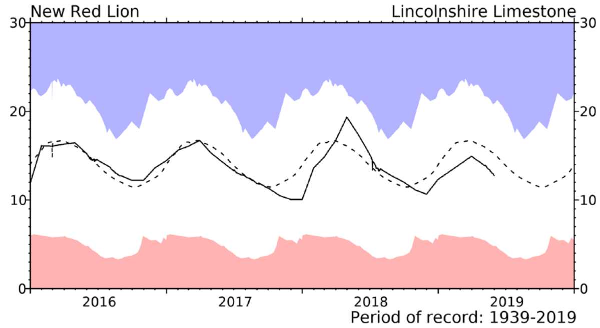



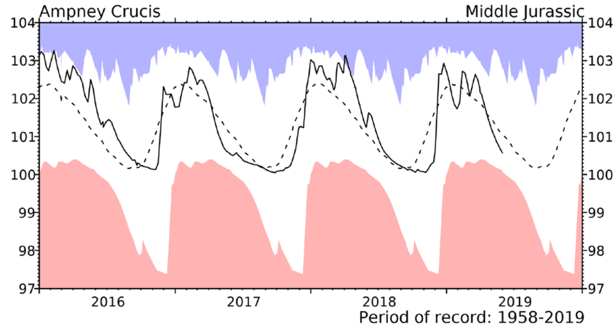



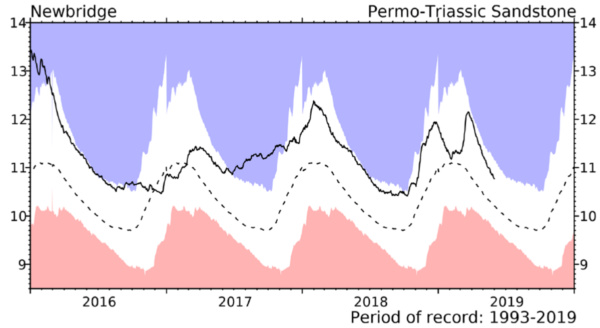



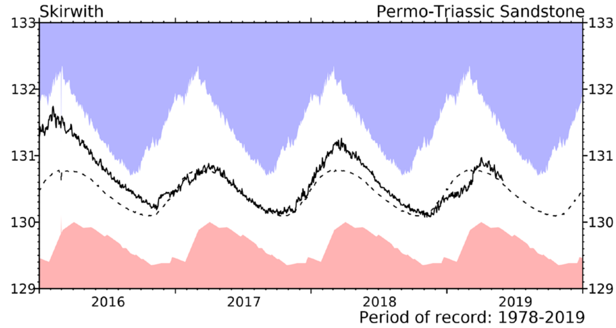

Groundwater levels (measured in metres above ordnance datum) normally rise and fall with the seasons, reaching a peak in the spring following replenishment through the winter (when evaporation losses are low and soil moist). They decline through the summer and early autumn. This seasonal variation is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

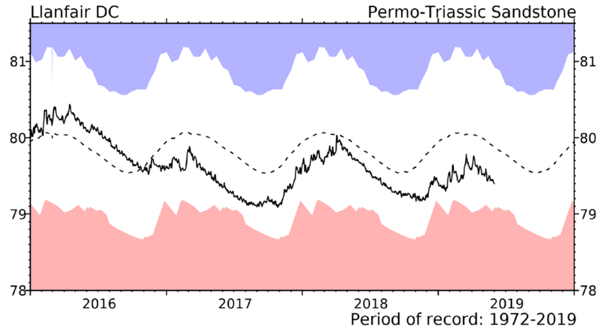
# Groundwater... Groundwater

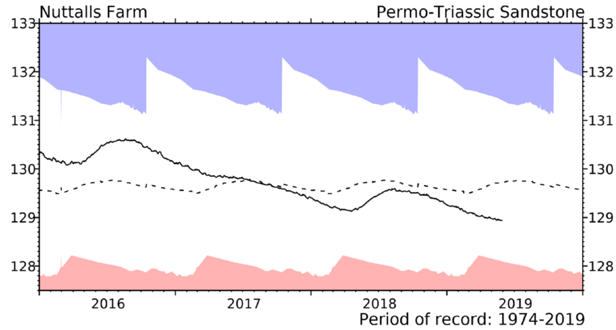


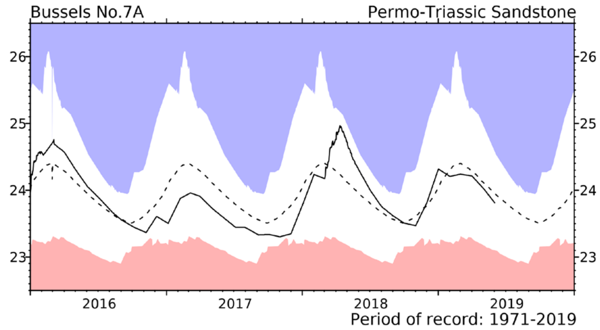



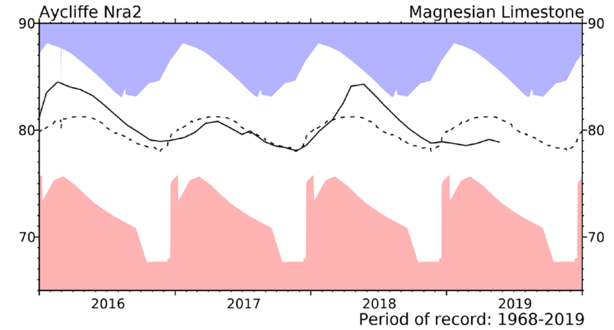



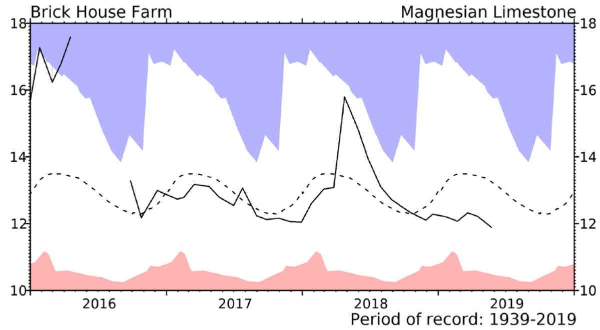



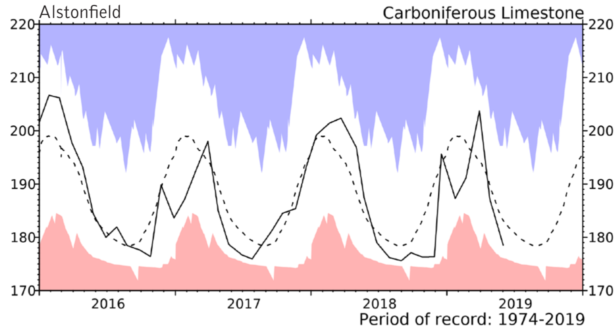



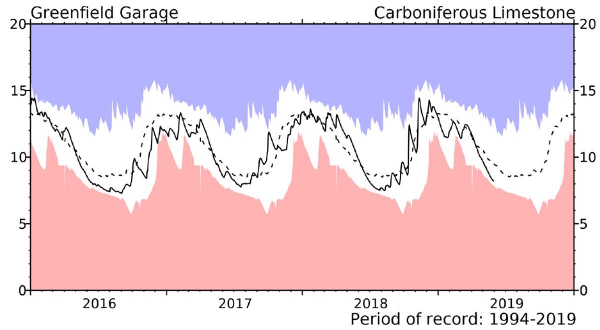



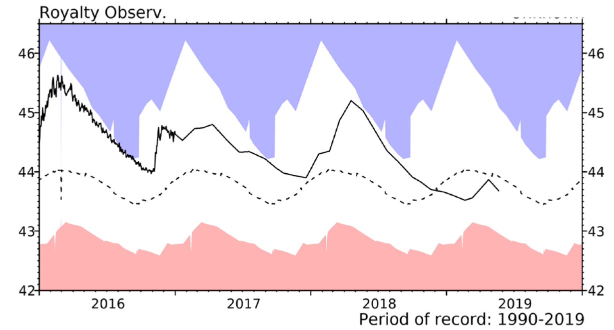



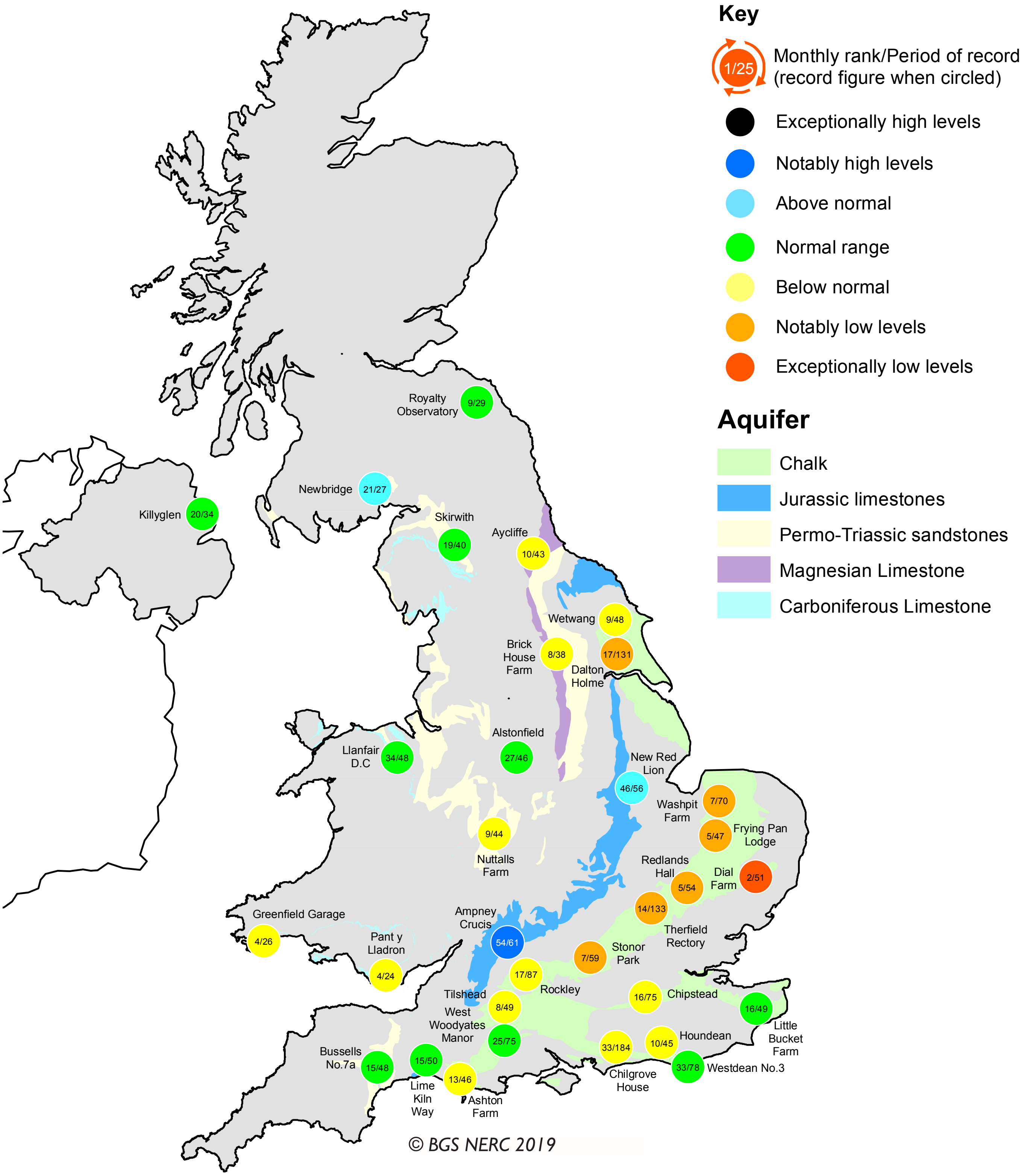



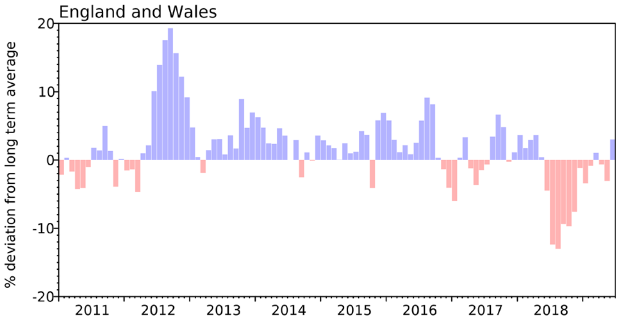



## Groundwater levels - June 2019

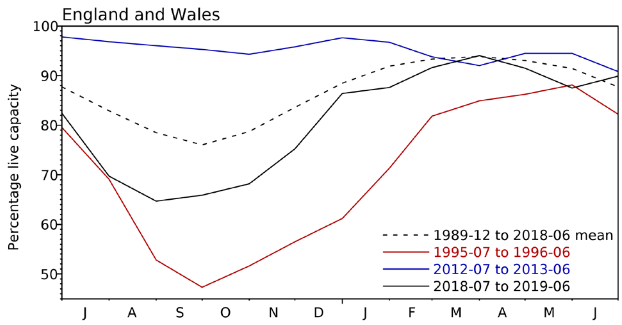
The calculation of ranking has been modified from that used in summaries published prior to October 2012. It is now based on a comparison between the most recent level and levels for the same date during previous years of record. Where appropriate, levels for earlier years may have been interpolated.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

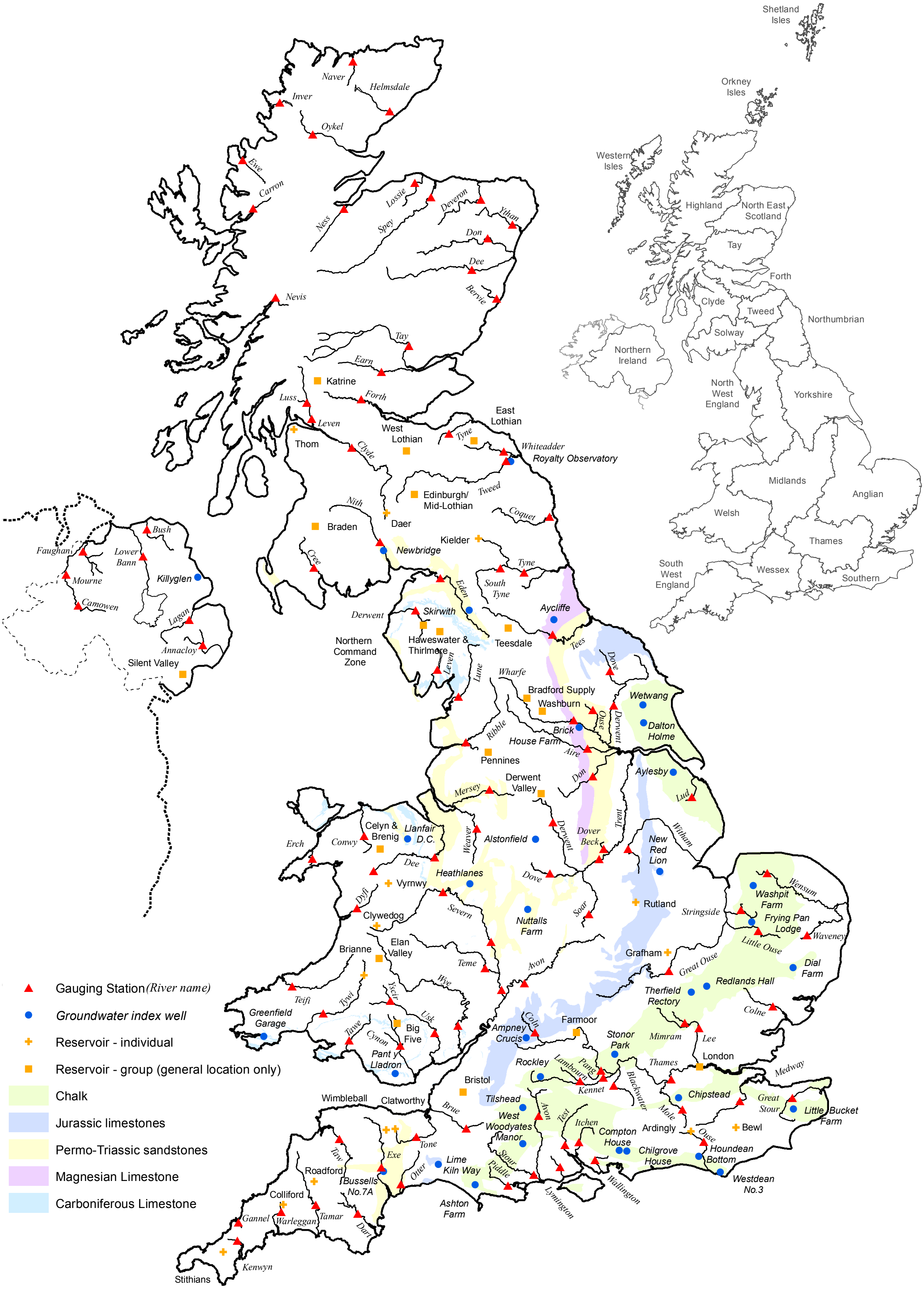
| Area | Reservoir | | Capacity (Ml) | 2019 Apr | 2019 May | 2019 Jun | Jun Anom. | Min Jun | Year* of min | 2018 Jun | Diff 19-18 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| North West | N Command Zone | • | 124929 | 80 | 67 | 69 | -3 | 38 | 1984 | 57 | 12 |
| | Vyrnwy | | 55146 | 100 | 97 | 100 | 17 | 58 | 1984 | 82 | 18 |
| Northumbrian | Teesdale | • | 87936 | 93 | 85 | 84 | 3 | 58 | 1989 | 71 | 12 |
| | Kielder | | (199175) | 91 | 91 | 90 | -1 | 71 | 1989 | 87 | 3 |
| Severn-Trent | Clywedog | | 49936 | 100 | 100 | 99 | 7 | 32 | 1976 | 93 | 7 |
| | Derwent Valley | • | 46692 | 86 | 77 | 81 | 0 | 53 | 1996 | 69 | 12 |
| Yorkshire | Washburn | • | 23373 | 86 | 84 | 95 | 15 | 63 | 1995 | 71 | 25 |
| | Bradford Supply | • | 40942 | 77 | 73 | 88 | 9 | 54 | 1995 | 67 | 21 |
| Anglian | Grafham | | (55490) | 91 | 90 | 93 | 1 | 70 | 1997 | 90 | 3 |
| | Rutland | | (116580) | 95 | 94 | 96 | 7 | 75 | 1997 | 94 | 3 |
| Thames | London | • | 202828 | 90 | 88 | 95 | 3 | 85 | 1990 | 94 | 1 |
| | Farmoor | • | 13822 | 98 | 98 | 98 | 1 | 94 | 1995 | 95 | 3 |
| Southern | Bewl | | 31000 | 97 | 92 | 89 | 6 | 52 | 1990 | 93 | -4 |
| | Ardingly | | 4685 | 100 | 95 | 94 | -1 | 82 | 2005 | 91 | 3 |
| Wessex | Clatworthy | | 5364 | 91 | 89 | 100 | 18 | 61 | 1995 | 72 | 28 |
| | Bristol | • | (38666) | 95 | 90 | 86 | 3 | 64 | 1990 | 85 | 1 |
| South West | Colliford | | 28540 | 88 | 83 | 75 | -8 | 51 | 1997 | 88 | -13 |
| | Roadford | | 34500 | 76 | 73 | 70 | -11 | 49 | 1996 | 83 | -13 |
| | Wimbleball | | 21320 | 98 | 94 | 95 | 10 | 63 | 2011 | 86 | 9 |
| | Stithians | | 4967 | 97 | 93 | 89 | 9 | 53 | 1990 | 82 | 8 |
| Welsh | Celyn & Brenig | • | 131155 | 95 | 93 | 94 | 0 | 77 | 1996 | 86 | 8 |
| | Brianne | | 62140 | 96 | 90 | 98 | 5 | 76 | 1995 | 83 | 15 |
| | Big Five | • | 69762 | 95 | 85 | 87 | 2 | 61 | 1989 | 72 | 15 |
| | Elan Valley | • | 99106 | 95 | 93 | 97 | 9 | 68 | 1976 | 77 | 20 |
| Scotland(E) | Edinburgh/Mid-Lothian | • | 97223 | 95 | 88 | 85 | -2 | 54 | 1998 | 90 | -5 |
| | East Lothian | • | 9317 | 100 | 100 | 100 | 5 | 81 | 1992 | 94 | 6 |
| Scotland(W) | Loch Katrine | • | 110326 | 91 | 88 | 91 | 11 | 55 | 2010 | 80 | 11 |
| | Daer | | 22494 | 89 | 85 | 83 | -1 | 62 | 1994 | 78 | 5 |
| | Loch Thom | | 10798 | 93 | 88 | 97 | 9 | 69 | 2000 | 90 | 7 |
| Northern Ireland | Total+ | • | 56800 | 93 | 93 | 93 | 11 | 61 | 2008 | 75 | 17 |
| | Silent Valley | • | 20634 | 93 | 96 | 96 | 17 | 54 | 1995 | 72 | 23 |

( ) 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.

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.
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.



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



07/2019