UK Hydrological Review 2008

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

2008

UK HYDROLOGICAL REVIEW

This hydrological review, which also provides an overview of water resources status throughout 2008, was undertaken as part of the National Hydrological Monitoring Programme (NHMP). The NHMP was set up in 1988 to document hydrological and water resources variability across the UK. It is a collaborative programme between the Centre for Ecology & Hydrology, which maintains the National River Flow Archive and the British Geological Survey which maintains the National Groundwater Level Archive. Both organisations are component bodies of the Natural Environment Research Council.

This report has been compiled with the active cooperation of the principal measuring authorities in the UK: the Environment Agency[a], the Scottish Environment Protection Agency and, in the Northern Ireland, the Rivers Agency. These organisations provided the great majority of the required river flow and groundwater level data. The Met Office provided almost all of the rainfall and climatological information featured in the report and the reservoir stocks information derive from the Water Service Companies, Scottish Water and Northern Ireland Water. Groundwater level data for Northern Ireland was provided by the Northern Ireland Environment Agency. The provision of the basic data, which provides the foundation both of this report and the wider activities of the NHMP, is gratefully acknowledged.

A primary source of information for this review is the series of monthly UK Hydrological Summaries (for further details please visit: http://www.ceh.ac.uk/data/nrfa/water_watch.html). Financial support for the production of the Hydrological Summaries is provided by Defra, the Environment Agency, the Scottish Environment Protection Agency, the Rivers Agency (Northern Ireland) and the Office of Water Services (OFWAT).

Authors

This report was compiled by: Terry Marsh and Felicity Sanderson.

Cover photo

Flooding on the Six Mile Water in August 2008, looking downstream to the town of Antrim with Lough Neagh in the background (Rivers Agency).

Publication Address

Centre for Ecology & Hydrology
Maclean Building
Benson Lane
Crowmarsh Gifford
Wallingford
Oxfordshire OX10 8BB
UK
General and business enquiries: 01491 692562
E-mail: enquiries@ceh.ac.uk

[a] Including the Environment Agency Wales which is both an Assembly Public Body (obtaining a proportion of its funding and direction from the Welsh Assembly) and part of the corporate Environment Agency for England & Wales.

CONTENTS

Note: the Location Map gives the location of many of the rivers, reservoirs, aquifer outcrop areas and wells and boreholes mentioned in the Hydrological Review.

UK Hydrological Review of 2008

2008 Summary

Exceptionally high annual rainfall totals and, as in 2007, a very atypical distribution of the rainfall through the year were defining features of weather conditions in 2008. Overall it was an extremely wet year: for the UK, the annual rainfall total was the 3rd highest in the National Climate Information Centre (Met Office) series, which begins in 1914[a]. Many regions registered exceptionally high rainfall accumulations over the first 10 months of the year, with the July-October period being outstandingly wet.

Apart from some very localised water supply difficulties (e.g. in the Western Isles during the early summer), water resources stress was rare during 2008. Relatively depressed reservoir stocks were registered during the late spring and early summer in parts of Northern Ireland and western Scotland but, generally, reservoir levels remained healthy throughout the year. Estimated overall reservoir stocks for England & Wales averaged over 2008 were the highest for any year in the national series (which begins in 1988). Despite a relatively dry end to 2008, almost all index reservoirs in the UK were close to capacity entering 2009. Significant regional variations characterised the status of groundwater resources in 2008 but generally groundwater levels remained within, or above, the normal seasonal range. A wet spring extended the 2007/08 aquifer recharge season in most areas and, following the exceptionally wet summer, an early onset of aquifer replenishment in the autumn increased the risk of groundwater flooding in vulnerable areas during the winter (2008/09). These concerns moderated through November and December but groundwater levels generally remained above average. Correspondingly, the overall water resources outlook for 2009 was very good.

Consistent with the rainfall pattern, countrywide runoff for 2008 was exceptionally high: the 2nd highest (after 2000) on record for Great Britain in a series from 1961. Monthly runoff totals were outstanding in January and, in relation to the seasonal average, very high throughout the late summer and autumn when extreme flooding occurred in Northern Ireland (August) and in parts of north-east England (in September); locally severe flooding also followed a remarkably intense storm at Ottery St Mary (Devon) in October. Generally however the frequency of damaging flood events was unexceptional, particularly in the context of the annual rainfall total and the high soil moisture conditions. 2008 was a year in which the capability of UK rivers to cope naturally with sequences of moisture-laden Atlantic frontal systems was well demonstrated. Although notably depressed runoff rates were reported from some western catchments during June (in Northern Ireland especially), exceptionally low flows were also uncommon in 2008. As in 2007, an unusual hydrological feature of the year was the notably high runoff rates maintained throughout much of the summer half-year (April-September) in many catchments across the country. Correspondingly, annual minimum flows for many rivers in 2008 were among the highest on record particularly in southern groundwater-fed streams and rivers where summer flows during both 2007 and 2008 have been remarkable.

Overview of the recent past

This section places the hydrological conditions experienced in 2008 in the context of the recent past and within a broader historical perspective.

Following extended drought conditions in 1988-92, which were punctuated by the exceptionally wet winter of 1989/90, a sustained wet interlude heralded a second protracted drought (1995-97) which impacted most severely on southern Britain – groundwater resources in particular. The drought terminated in the autumn of 1997, heralding the wettest five-year sequence on record for the UK; England & Wales registered its highest five-year rainfall total in a series from 1766[1]. Severe flooding occurred in April 1998 (across the Midlands), throughout most of southern Britain during the autumn and winter of 2000/01, and again in early 2003. Maximum recorded river flows were widely eclipsed – mostly by modest margins – and groundwater levels, responding to unprecedented rates of aquifer recharge (especially in the winter of 2000/01), exceeded previous maxima for extended periods in many southern outcrop areas. In 2007 outstanding rainfall over the May-July period, across much of England & Wales, triggered widespread fluvial and urban flooding.

[a] Unless otherwise stated, all national and regional climatological comparisons are based on the corresponding NCIC series.

Table 1 2008 rainfall in mm and as a % of the 1971-2000[a] average — Data source: Met Office

2008		J	F	M	A	M	J	J	A	S	O	N	D	Year	Oct-Mar 2007/08	Apr-Sep 2008
United Kingdom	mm	190	82	123	76	48	78	108	134	106	156	107	88	1295	675	551
	%	162	98	132	115	76	113	163	166	110	138	93	73	120	105	124
England & Wales	mm	145	44	99	68	62	64	107	117	104	113	88	64	1076	508	523
	%	157	66	138	116	107	99	195	168	134	125	96	64	120	99	136
England	mm	129	38	92	64	62	59	101	106	96	95	82	58	982	460	488
	%	156	64	141	116	113	96	193	163	134	116	100	66	120	100	136
Scotland	mm	276	161	166	98	26	107	107	153	108	238	146	136	1720	1001	598
	%	167	136	125	122	36	136	124	153	81	155	92	84	119	113	109
Wales	mm	246	81	147	90	61	94	150	189	155	229	128	95	1664	811	739
	%	161	74	128	112	80	114	204	186	132	156	84	58	121	96	139
Northern Ireland	mm	186	61	132	47	19	76	122	201	119	147	81	80	1271	635	584
	%	156	70	141	67	27	107	164	222	126	128	74	68	114	99	124
North West	mm	225	78	115	74	33	107	136	153	142	228	88	103	1482	742	645
	%	186	90	116	111	50	137	175	161	138	181	71	78	126	108	132
Northumbrian	mm	156	39	77	94	22	88	132	128	152	96	63	70	1117	466	615
	%	191	66	112	160	37	144	230	181	218	126	76	82	134	102	164
Severn Trent	mm	122	36	82	66	56	46	94	94	109	84	77	53	919	415	465
	%	164	66	138	121	105	73	191	150	163	118	109	66	121	101	133
Yorkshire	mm	172	46	88	78	26	83	116	124	105	83	65	71	1056	493	532
	%	212	79	131	134	47	132	218	188	154	108	82	80	130	109	146
Anglian	mm	78	21	80	47	60	48	58	82	59	59	81	31	702	313	353
	%	146	56	175	104	130	87	128	159	107	103	143	54	116	102	119
Thames	mm	96	22	87	56	81	52	85	80	68	53	82	42	803	392	422
	%	140	47	162	110	153	92	195	148	107	74	124	58	115	103	131
Southern	mm	108	27	90	64	90	36	66	72	74	70	110	40	846	415	401
	%	131	50	152	123	182	64	148	134	103	79	132	46	108	91	123
Wessex	mm	128	38	104	58	99	45	107	100	92	88	84	63	1005	509	501
	%	138	56	149	103	177	75	229	153	119	101	97	62	116	101	139
South West	mm	151	57	132	69	106	52	179	158	114	145	97	92	1352	635	678
	%	107	54	137	97	155	72	291	191	115	115	73	61	112	84	149
Welsh	mm	231	76	141	88	65	88	147	185	150	215	125	91	1602	772	724
	%	158	73	128	112	88	110	206	189	132	152	85	58	121	96	140
Highland	mm	308	237	209	114	22	114	92	127	111	295	228	160	2018	1278	580
	%	153	161	129	123	28	127	97	116	70	163	113	81	118	117	93
North East	mm	182	69	102	111	29	82	83	121	68	128	86	93	1153	627	495
	%	186	103	132	174	46	125	125	174	77	127	86	102	121	118	119
Tay	mm	300	132	130	86	33	82	103	160	89	167	95	116	1492	851	553
	%	191	123	109	128	45	118	140	193	79	124	72	83	118	108	115
Forth	mm	274	111	113	82	28	91	107	205	95	182	66	94	1449	778	608
	%	216	123	110	131	43	132	151	250	91	154	58	76	128	115	133
Clyde	mm	320	190	214	90	32	124	141	184	134	294	152	163	2037	1189	704
	%	160	133	133	99	40	140	131	146	82	155	81	83	118	110	107
Tweed	mm	212	66	102	97	27	108	128	180	127	150	63	86	1344	610	666
	%	211	94	127	161	41	166	198	242	158	158	67	83	141	112	162
Solway	mm	272	114	152	73	26	113	143	201	136	290	105	145	1770	902	692
	%	175	101	124	92	34	144	165	189	110	187	70	90	126	105	125
Western Isles, Orkney and Shetland	mm	217	143	140	78	11	117	76	95	86	213	152	136	1465	900	464
	%	134	123	107	100	17	170	94	101	64	139	91	86	104	101	89

a The 1971-2000 averages are the mean of monthly, half-yearly and annual averages stored on the National River Flow Archive (and supplied by the Met Office) for the 30-year standard period. They may differ slightly from averages derived using different analytical procedures.

In northern Britain and Northern Ireland, with most rain-bearing frontal systems following more southerly tracks than normal, 2001 witnessed the development of a further drought episode. More intense drought conditions extended across much of the UK during the exceptionally hot spring and summer of 2003. Sustained rainfall during the late autumn had a clear moderating effect but very limited replenishment of groundwater resources in the late winter and early spring of 2004 signalled the onset of a further sustained drought episode. The drought intensified through the following two winters and impacted most severely on parts of eastern, central and southern England in both 2005 and 2006. By contrast, annual rainfall totals for these two years were notably high across much of Scotland.

The 21st century thus far has seen major departures from typical seasonal river flow patterns but, for the UK as whole, overall runoff for the 2001-08 period has exceeded the 1971-2000 mean by around 8%. In addition, although low flow patterns have shown substantial year-on-year variability, the Q_{95} flows (an index of low flows) averaged over the last nine years, exceed the mean Q_{95} for the preceding 30 years for the great majority of UK rivers.

Rainfall

Annual rainfall

Annual rainfall totals for 2008 were exceptionally high, relative to the long term average, across much the greater part of the UK – see Table 1[b] and Figure 1. Based on the 95-year National Climate Information Centre (Met Office) data series, Scotland recorded its 3rd highest annual total on record with Northern Ireland, Wales and England registering their 6th, 5th and 7th wettest years respectively. Many regions of the country recorded around 20% more rainfall than the preceding annual average; some were outstandingly wet – the Northumbrian Region exceeded its previous annual maximum and rainfall over the Tweed basin was the highest since 1916.

[b] To allow better spatial differentiation, the rainfall data for Britain are presented for the regional divisions of the precursor organisations to the Environment Agency and the Scottish Environment Protection Agency.

The year in brief

After a settled start to 2008, a sequence of vigorous Atlantic low pressure systems brought boisterous weather conditions across the UK with accompanying pulses of heavy frontal rainfall –

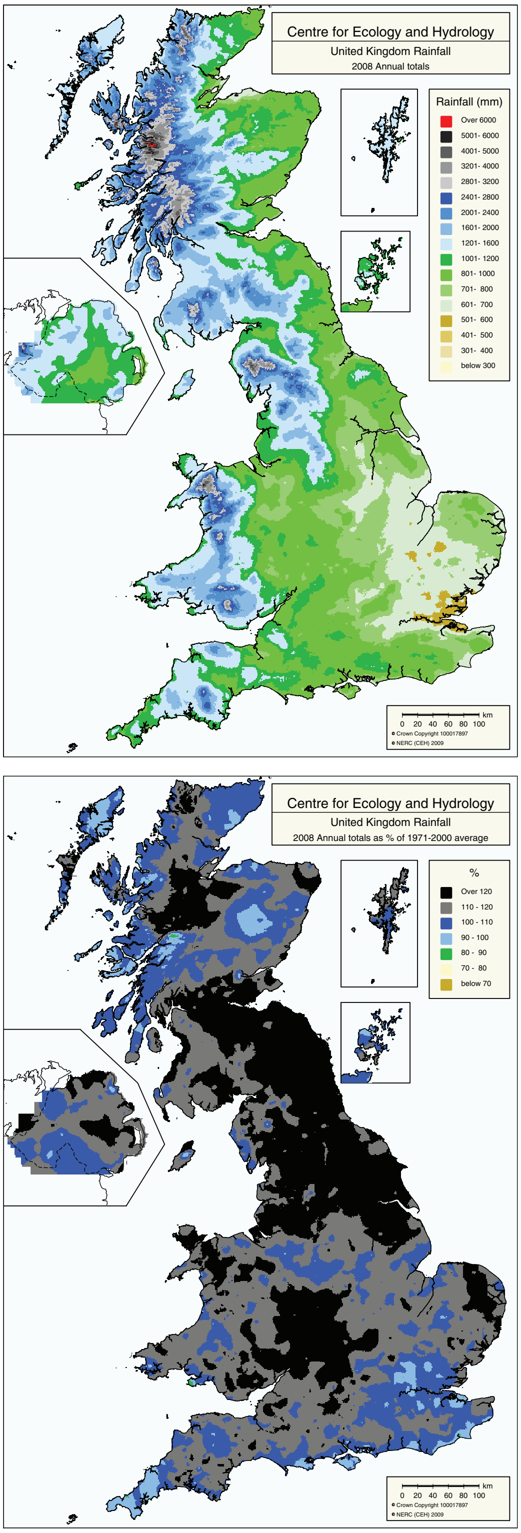

Figure 1 *2008 annual rainfall totals in mm and as a % of the 1971-2000 average.*
Data source: Met Office

approximately 350mm was reported over the ten days beginning on the 13th January in the Centre for Ecology & Hydrology's research catchments on Plynlimon (central Wales). This wet spell contributed to the wettest January since 1928 for the country as a whole; Northern Ireland eclipsed its previous maximum January rainfall. During February synoptic patterns remained largely cyclonic in western Scotland where a sequence of notable daily precipitation totals were recorded (Kinlochewe reported 76mm, 68mm and 58mm on the 21st, 23rd and 26th respectively); snowfall across the Highlands was substantial. To the south however, high pressure dominated and monthly rainfall totals fell below 50% of average in large parts of southern England. Continuing a tendency, which began in the early 1980s, winter (December-February) rainfall totals were notably high across much of northern Britain (see Figure 2); for Scotland, seven of the wettest eight winters on record have occurred in the last 20 years[c]. To the south, winter regional totals were generally within the normal range but moderately below average in parts of southern England.

March was a month of damaging gales and wintry interludes. The 15/16th was especially wet in southern Britain – some areas reported 18 hours of continuous rain (amounting to 60mm in Raunds, Northants). Correspondingly, precipitation totals for the month were above average in most areas, with exceptional totals across much of southern and central England; western Scotland was also notably wet. Weather patterns remained unsettled throughout much of April when seasonally late snowfall extended into southern England on the 6th (some areas recorded >10cm). April rainfall totals displayed substantial spatial variation but much of Northern Ireland was notably dry.

In May, most frontal systems followed more southerly tracks than normal and convective storms during the final week (Marston, in Kent, reported 121mm of rainfall from the 24-28th) contributed to notably high monthly rainfall totals in southern England. In parts of the Thames and Southern Regions, May rainfall totals were around four times those for the Highland Region (see Figure 3); reversals of this magnitude in the normal north-west/south-east rainfall gradient across the UK are relatively rare. Notwithstanding the substantial spatial and temporal variability in the March-May rainfall, spring regional rainfall totals were generally well above average, notably so in many southern catchments.

The dominant synoptic patterns during June were a reversal of those experienced in May with particularly wet weather characterising northern regions late in the month. This marked change in weather conditions was especially welcome in the Western Isles, where only 3mm of rain was recorded over an eight-week period on the Isle of Eigg, and in parts of Northern Ireland which also experienced an exceptional dry spell. Very unsettled weather patterns across much of the remainder of the country continued through most of July although cool and wet conditions gave way to a hot and humid interlude during the final week. This triggered convectional storms, the associated intense downpours contributed to the 3rd wettest July for the UK since 1960.

With the Jet Stream continuing to follow an unusually southerly track, synoptic patterns during August were dominated by a further sequence of vigorous Atlantic frontal systems; late in the month the ingress of a humid sub-tropical airmass was associated with further convective activity. Exceptional rainfall totals were common: the 9/10th was wet nationwide and a confirmed 24-hr rainfall total of 101.2mm was reported for Fair Isle; on the 31st an intense thunderstorm generated 63mm of rain in less than two hours at Chalfont St Peter (Bucks), the associated return period is around 100 years. More hydrologically significant was the sustained frontal rainfall which generated rainfall totals of 100-120mm in around 24 hrs in parts of Country Antrim on the 15/16th; this exceptional interlude contributed to Northern Ireland's wettest August on record. Summer (June-August) rainfall totals were exceptional across northern England, Northern Ireland and large parts of southern Scotland (south-west England also). Three of the wettest 11 summers on record for England & Wales now cluster into the post-2003 period.

In the early autumn, a protracted dry spell continued in the far north of the country whilst in much of England & Wales cyclonic conditions

[c] A decreasing proportion of snowfall – which is under-recorded in many circumstances – in total winter precipitation totals may be a contributory factor.

persisted through September. On the 6th, 24-hr rainfall totals in excess of 40mm were widely reported in western areas and in the Midlands, but in Northumbria the rainfall was substantially more extreme. Morpeth recorded 80mm, its highest 24-hr total in a record from 1898 and, over 3 days, Goldscleugh (in the Northumbria National Park) recorded >250mm (equivalent to around 10 weeks average rainfall). October was also a very cyclonic month but with a notably balmy interlude and a decidedly wintry fourth week when a polar airflow brought significant October snowfall to London for the first time since 1934. Notable storm rainfall totals were again common. On the 4/5th, 24-hr totals of around 90mm were reported in north Wales, with comparable figures on the 25th; in the Lake District around 300mm was recorded at Honister Pass over the three days from the 24th. Near Ottery St Mary (Devon) a remarkable convective event on the 29/30th generated estimated precipitation totals of around 100mm in a few hours, leaving deep drifts of hail, the melting of which contributed to the ensuing flooding.

In the first ten months of 2008 only February and May registered below average rainfall at the national scale. Correspondingly, the accumulated rainfall total for January-October exceeded the previous maximum for the UK by an appreciable margin. Synoptic patterns during the late autumn were particularly variable but airflows from the polar quadrant were unusually common, bringing dull and, occasionally, very cold conditions with attendant snowfall. Unsettled conditions continued through much of November in the English Lowlands but rainfall in most western and northern catchments fell moderately below average. Nonetheless, regional rainfall totals for the autumn (September-November) mostly exceeded the 1971-2000 average.

Weather conditions varied markedly through December but, generally, it was a cold and sunny month. The first week however was unsettled with damaging blizzards on the 4th (20cm of snow was reported in Wensleydale) and substantial rainfall totals were recorded in the western hills during the second week. From mid-month, in southern Britain particularly, precipitation was largely confined to fog-drip, light drizzle and snow flurries. Many areas registered rainfall totals of <5mm over three weeks or more with <2mm in parts of central southern England (e.g. parts of Bucks) – a relatively rare occurrence during the early winter in relation to the last 30 years. This dry spell contributed to below average December rainfall in most regions and

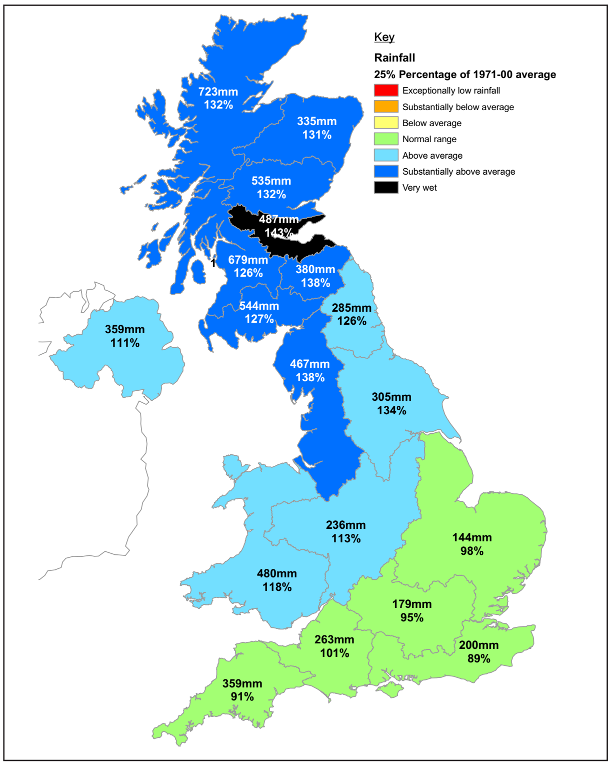

Figure 2 *December 2007 - February 2008 rainfall in mm and as a % of the 1971-00 average*
Data source: Met Office

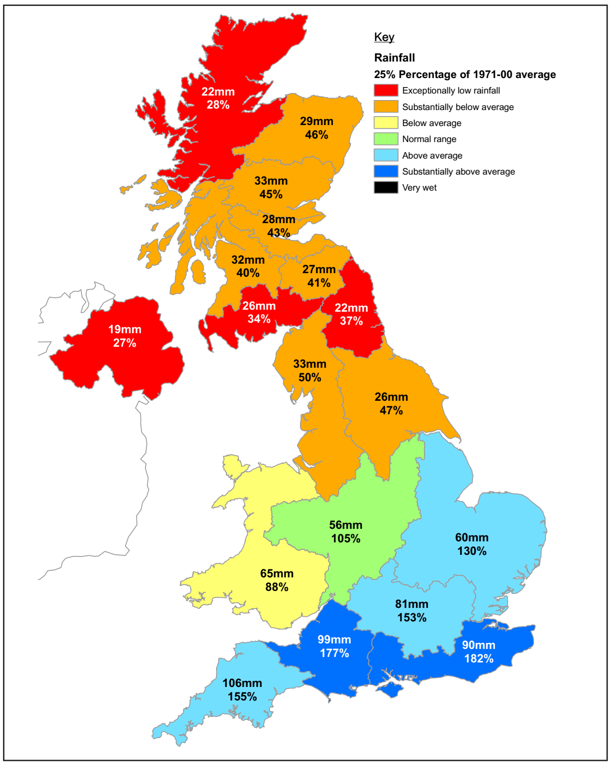

Figure 3 *May 2008 rainfall in mm and as a % of the 1971-00 average*
Data source: Met Office

appreciable three-month rainfall deficiencies had become established across southern England by year-end (see Figure 4).

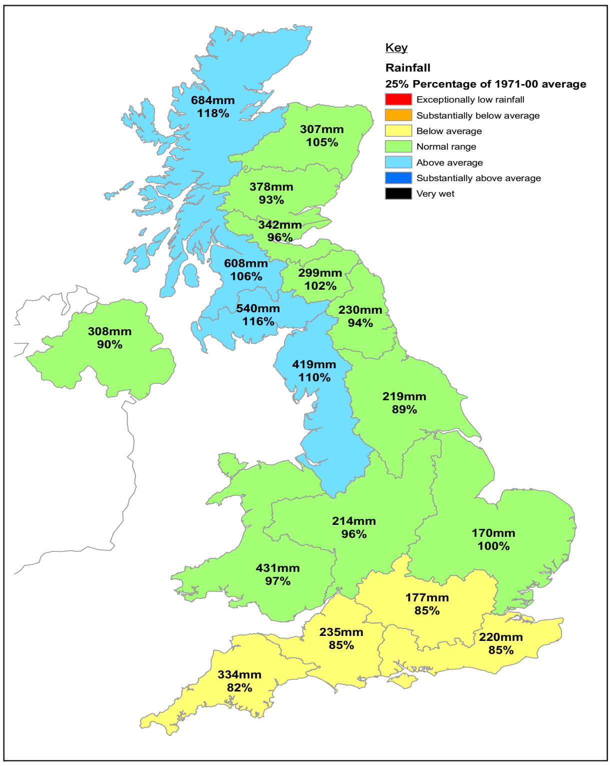

Figure 4 *October- December 2008 rainfall in mm and as a % of the 1971-2000 average.*
Data source: Met Office

Evaporation and Soil Moisture Deficits

Background

On average, over 40% of UK rainfall is accounted for by evaporative losses – but the proportion varies greatly from region to region, reaching around 80% in the driest parts of the English Lowlands. Evaporation may occur directly from open water surfaces, from the soil or as transpiration from plants. Potential evaporation (PE) is the maximum evaporation that would occur from a continuous vegetative cover amply supplied with moisture. Temperature, particularly during the late spring and summer, is the primary influence on evaporative demands, but windspeed, sunshine hours, humidity and patterns of land use are all contributory factors. By comparison with rainfall, evaporation losses exhibit very muted spatial variability but do follow a strong seasonal cycle, peaking normally in June or July; typically, only 10-20% of the annual PE loss occurs during the October-March period.

Given normal rainfall, the increasing temperatures and accelerating evaporative demands through the spring lead to a progressive drying of the soil and the creation of what is termed a soil moisture deficit (SMD). Eventually, the ability of plants to transpire at the potential rate is reduced as a result of the drying soil conditions, the associated reduced capability of plants to take up water, and the measures they take to restrict transpiration under such conditions. Thus in the absence of favourable soil moisture conditions actual evaporation (AE) rates fall below corresponding PE rates, appreciably so during dry summers. When plant activity and evaporation rates slacken in the autumn, rainfall wets-up the soil profile once more – allowing runoff rates to increase and infiltration to groundwater to re-commence.

Knowledge of the soil moisture status and evaporation rates are essential for understanding water resource variability. The following commentary on evaporation patterns and soil moisture deficits during 2008 relies, in large part, on monthly figures derived using the Met Office Rainfall and Evaporation Calculation System (MORECS)[2].

Temperatures and evaporation losses

Provisional data indicate that mean temperatures for the UK in 2008 were the lowest since 2000 but still around 0.4°C degrees above the 1971-2000 average, ranking the year as the 18th warmest in a series from 1914. Summer temperatures were close to the average but much of the remainder of the year was warmer than average, January and May especially. Sunshine hours were also above average across most of the country and, generally, weather conditions were conducive to high evaporative demands. Across much of the UK the wetness of the summer moderated potential evaporation demands but the moist soil conditions (see below) allowed transpiration rates to be largely unrestricted; actual evaporation losses were therefore notably high.

Figure 5a shows the variation in monthly PE losses (black trace) and AE losses (red trace)

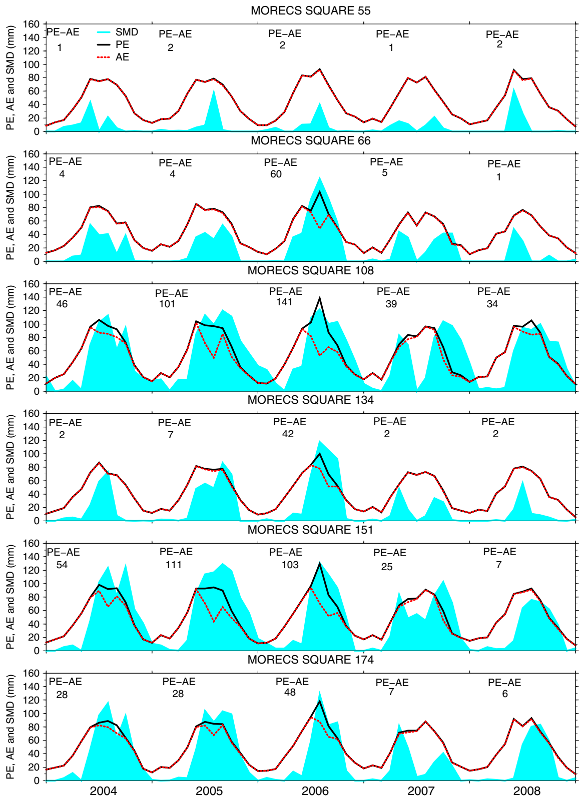

Figure 5a *The variation in Potential Evaporation, Actual Evaporation and SMDs for 2004-2008*
Data source: MORECS

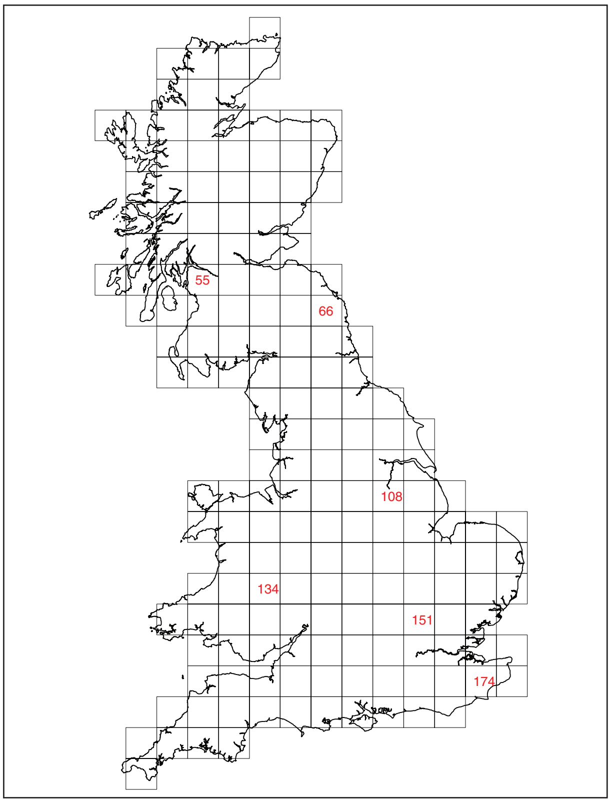

Figure 5b *Location of the MORECS squares featured in Figure 5a*

for six representative MORECS squares in Great Britain (their location is given on Figure 5b). As is normally the case in the wettest parts of the country, monthly AE losses remained very close to their PE equivalents throughout 2008. In contrast, and unusually, a defining characteristic of 2008 (as in 2007) across much of the UK, was the close matching of the PE and AE traces throughout the summer half- year in the English Lowlands.

Figure 6a shows 2008 PE totals (for a grass cover) across the UK. Annual losses exceeded 650mm in many coastal area (where higher windspeeds can be an influential factor) but fell below 500mm in much of northern Britain where evaporative demands are normally lower. In relation to the 1971-2000 average, 2008 PE totals were within 10% of the annual mean in almost all parts of the UK (Figure 6b). By contrast, AE totals were substantially above average in most southern and many eastern regions (see Figures 7a and 7b). This is reflected in the ranking of the annual AE losses for Great Britain as a whole: the 2008 total only marginally exceeded that for 2007 but is still the 3rd highest (after 2004 and 1999) in the 48-year national series. The exceptionally high 2008 AE losses across almost all of the UK accounts for the high degree of congruency between Figures 6a and 7a.

Soil moisture deficits

For the second successive year the development and decay of soil moisture deficits (SMDs) departed markedly from normal, especially across southern Britain. The cyan shading in Figure 5a illustrates end-of-month soil moisture variations for a small selection of MORECS squares across Great Britain (note: within-month variations in soil moisture conditions were unusually large in many areas during much of 2008).

Although there was no close replication of the dramatic decline in SMDs which characterised large parts of England & Wales in the early summer of 2007, the rapid drying of soils during the first half of June in 2008 did not, as would often be the case, herald exceptionally high soil moisture deficits in the late summer and

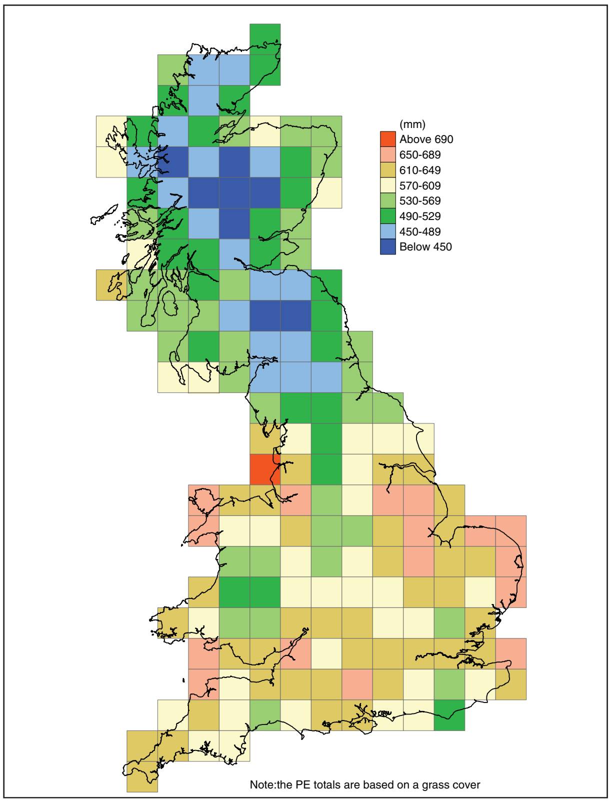

Figure 6a *Potential Evaporation totals for 2008*
Data source: MORECS

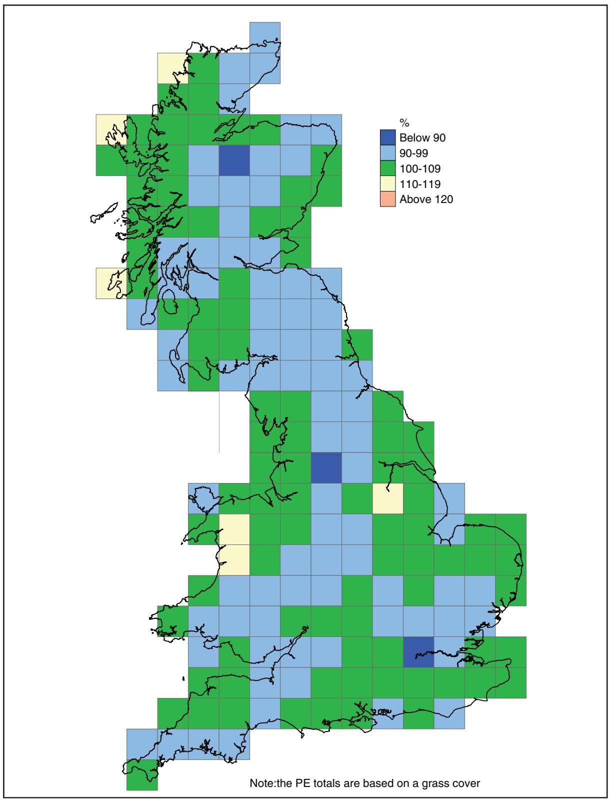

Figure 6b *Potential Evaporation totals for 2008 as a % of the 1971-2000 average*
Data source: MORECS

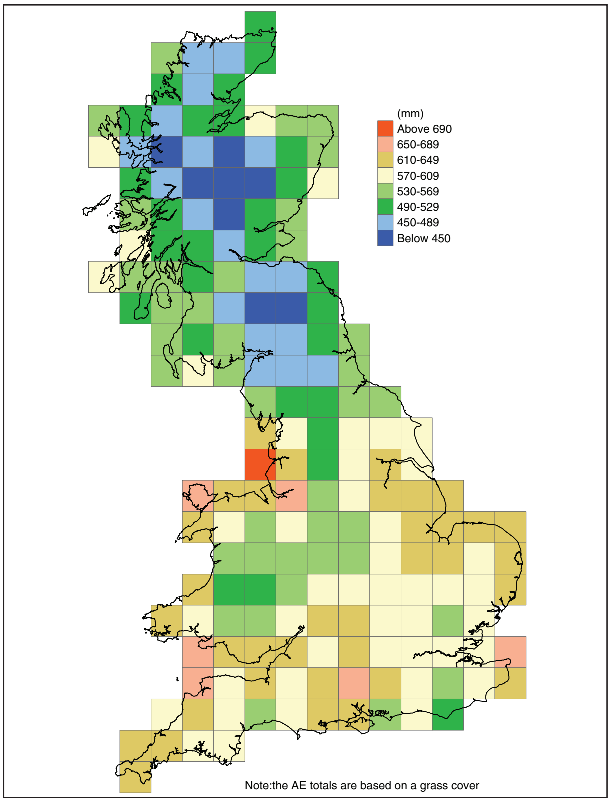

Figure 7a *Actual Evaporation totals for 2008*
Data source: MORECS

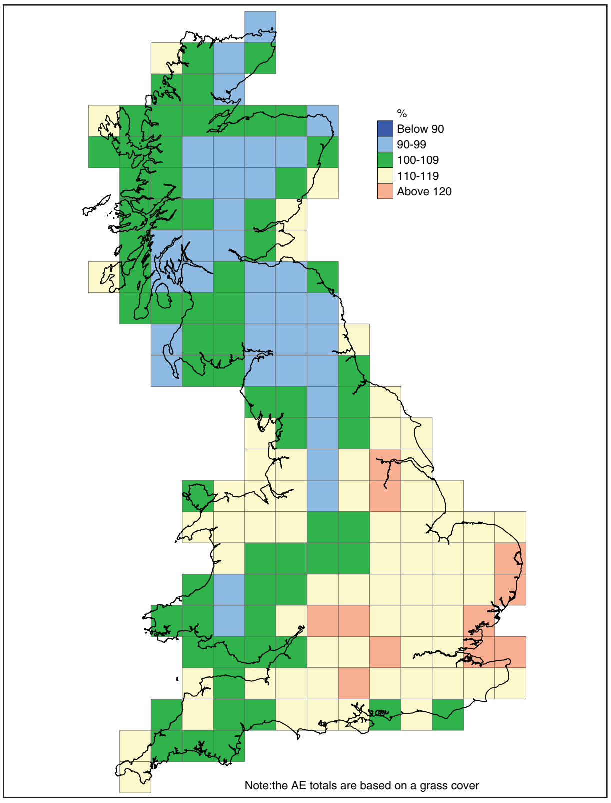

Figure 7b *Actual Evaporation totals for 2008 as a % of the 1971-2000 average*
Data source: MORECS

early autumn. The dry and warm conditions of the early summer were followed by very unsettled synoptic patterns. These brought substantial rainfall through the remainder of the summer and, over wide areas, reversed the growth in SMDs – producing an erratic, and very unseasonal, increase in soil moisture. Many northern and western areas registered their driest soil conditions for 2008 during mid-June, around 10-12 weeks earlier than normal. More generally, maximum SMDs in 2008 were considerably lower than those which have characterised the recent past (2007 excepted).

By late July many areas had SMDs over 40mm below the end-of-month average and drier-than-average soils were largely confined to northern Scotland and parts of East Anglia. The summer ended with soils close to saturation throughout almost all northern and western regions of the country (Figure 8a). Soils were also considerably wetter than the late-August average throughout almost all of the English Lowlands (Figure 8b). With autumn rainfall totals also above average in 2008, significant late-November SMDs were restricted to a few areas in the English Lowlands (e.g. parts of East Anglia). In almost all regions of the country, the wetness of the July-November period meant that the limited rainfall in December (when evaporative demands are, in any case, low) had little impact on the very moist soil conditions. At year-end soils remained close to saturation across western and northern areas although, as is often the case, modest deficits remained in a few parts of the English Lowlands (e.g. adjacent to the Wash); in a more typical year, appreciable SMDs cover a substantially more extensive area.

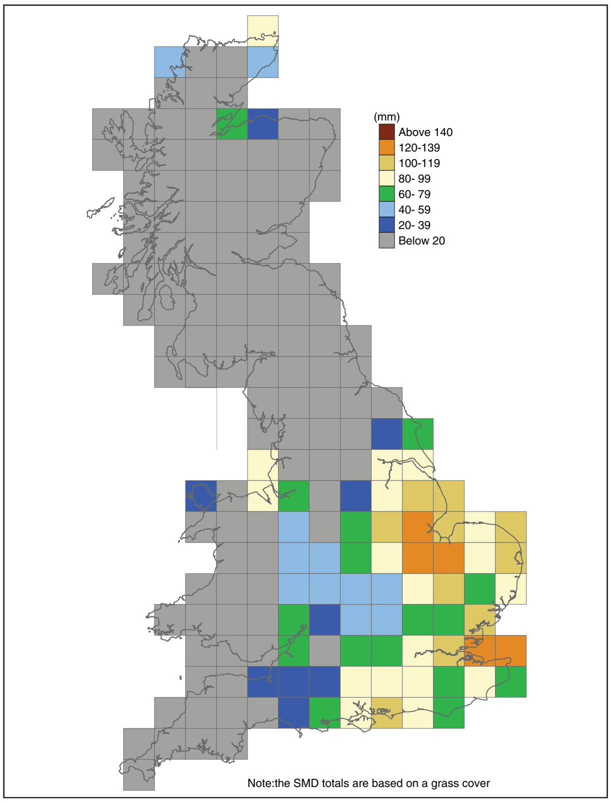

Figure 8a *Soil moisture deficits at the end of August 2008*
Data source: MORECS

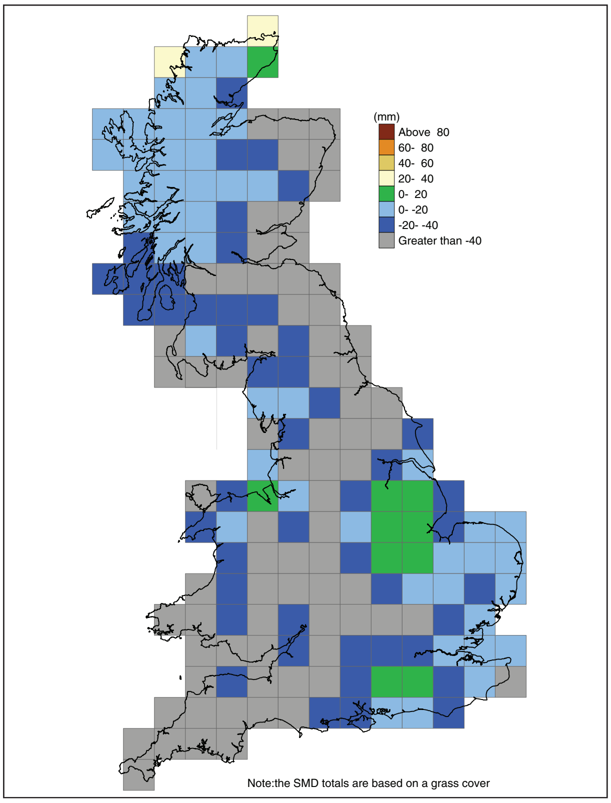

Figure 8b *Soil moisture deficit anomalies (relative to the 1971-2000 average) at the end of August*
Data source: MORECS

River flows

Overview of 2008 runoff

River flow patterns in 2008 were notable for the sustained nature of flows above the seasonal average – markedly so in January and over the August-October period. Extensive flooding was uncommon early and late in the year, when fluvial flood risk is normally at its highest, but the late summer and autumn included three exceptional flood episodes principally affecting Northern Ireland (August), north-east England (September) and Cumbria (October). As significantly, for the second successive year, summer runoff was markedly above average across much of the UK; the combined August and September runoff totals were outstanding in many catchments in England & Wales and in Northern Ireland. This seasonally exceptional runoff, at a time when river flows are normally at a minimum, contributed to the highest (albeit by a narrow margin) annual outflow on record for England & Wales in a series from 1961. For Northern Ireland, the 2008 runoff total ranks 4th highest in a 28-yr series. The notable magnitude of the 2008 runoff totals is confirmed by Figure 9 which shows the annual runoff as a percentage of the previous average for a network of index catchments across the UK. Rivers registering new annual maximum runoff totals show a wide distribution across northern Britain. In most regions, the minimum river flows recorded in 2008 were also very unusual, commonly well above the normal summer range. Considering England & Wales as a whole, the lowest daily outflow in 2008 (registered in late July) exceeded the annual minima in all previous years.

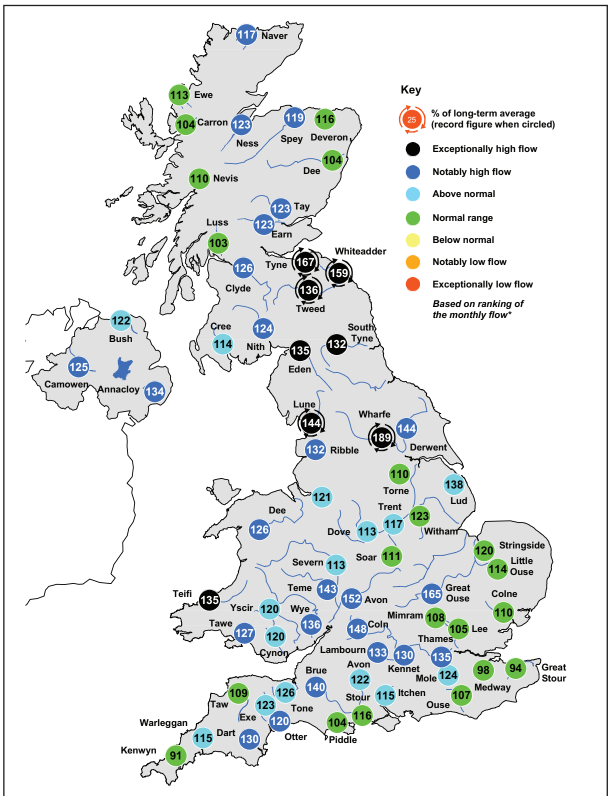

Figure 9 *2008 Annual catchment runoff totals as a % of the previous average*

The volatility of the summer flow patterns is most dramatically demonstrated in Northern Ireland where total outflows[d] approached the lowest on record (in a series from 1981) in June but, by the middle of August, they exceeded the previous maximum summer flows. Depressed river flows were also common in Scotland during the early summer, particularly in western catchments but, by contrast, outflows from England & Wales were above average for June and, contrary to the normal seasonal pattern, increased markedly into the late summer and autumn. The England & Wales outflows for the summer (June-August) ranked third highest on record – but still only 60% of those recorded in 2007 – and increased dramatically in September when outflows eclipsed the previous maximum for the month.

River flow patterns

Figure 10 shows 2007-2008 hydrographs representing the total outflows from Great Britain, England & Wales, Scotland, and Northern Ireland. The hydrographs are based on flows for a network of large rivers which, taken together, provide a convincing guide to runoff patterns at the national scale. The daily outflows are shown as a bold trace and a red infill is used to emphasise periods of below average flow; the use of a logarithmic scale also serves to give greater prominence to low flow episodes. Daily maximum and minimum flows for the preceding record are also shown – represented by the blue and pink envelopes. Similar hydrographs for 16 index rivers provide a more detailed breakdown of runoff patterns across the UK (see Figure 11).

[d] Controlled releases from Lough Neagh constitute around one-third of the total outflows from Northern Ireland.

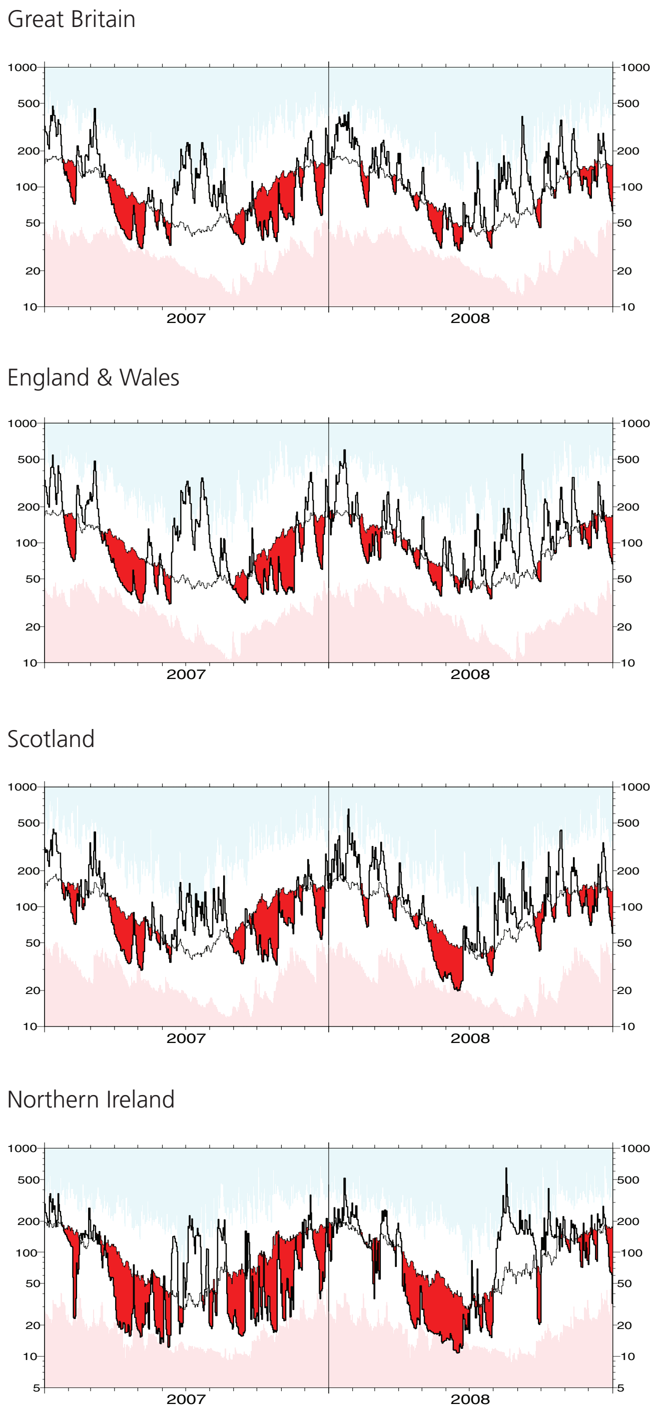

Figure 10 *2007-2008 daily flow hydrographs*

Table 2 features a selection of new high and low flow records established at primary UK gauging stations (with records ≥ 25 years) during 2008. Due to the uncertainties associated with capturing extreme flows, the table is necessarily provisional; individual entries may be subject to significant change following further investigation.

The year in brief

Entering 2008 river flows were generally close to the early-January average but runoff rates increased steeply and spate conditions were persistent – with snowmelt contributing significantly in northern catchments. Flood warnings were common on the 5th with some notable peak flows reported: the Allan Water in central Scotland exceeded its previous maximum in a record of over 50 years. A significant minority of index rivers registered new maximum January runoff totals (Figure 12). For the Wharfe, the January runoff was the highest for any month in a series from 1955. Such exceptional runoff contributed to the 2nd highest monthly outflow (after February 1990) on record for Great Britain. Significantly however, extensive floodplain inundations were largely avoided – in part a consequence of the rapid passage of many rain-bearing frontal systems, helping to moderate storm rainfall totals.

Brisk recessions became established over much of the country during February and end-of-month flows were notably depressed in a number of, mostly small, responsive southern catchments (e.g. the Kenwyn and Medway). At the same time, high spates characterised many rivers in northern Britain. These contributed to 2007/08 winter (December-February) runoff totals that were generally well above average, and notably high in many Scottish catchments – the River Tweed (at Norham) exceeded its previous winter runoff maximum in a series from 1960.

Following widespread spates conditions during March – with sustained periods of near-bankfull flows – relatively steep spring recessions became established and were maintained through much of April. Nonetheless, river flows generally remained within the normal spring range albeit well below average in some western catchments. In Cornwall, April was the 8th successive month for which below average flows were recorded on the River Kenwyn. By the second half of May, estimated daily outflows from Scotland and Northern Ireland were close to the lowest on record for the late spring. In contrast, during late May flood alerts were common in the English Lowlands (e.g. on the Warwickshire Avon).

Many responsive rivers registered their lowest

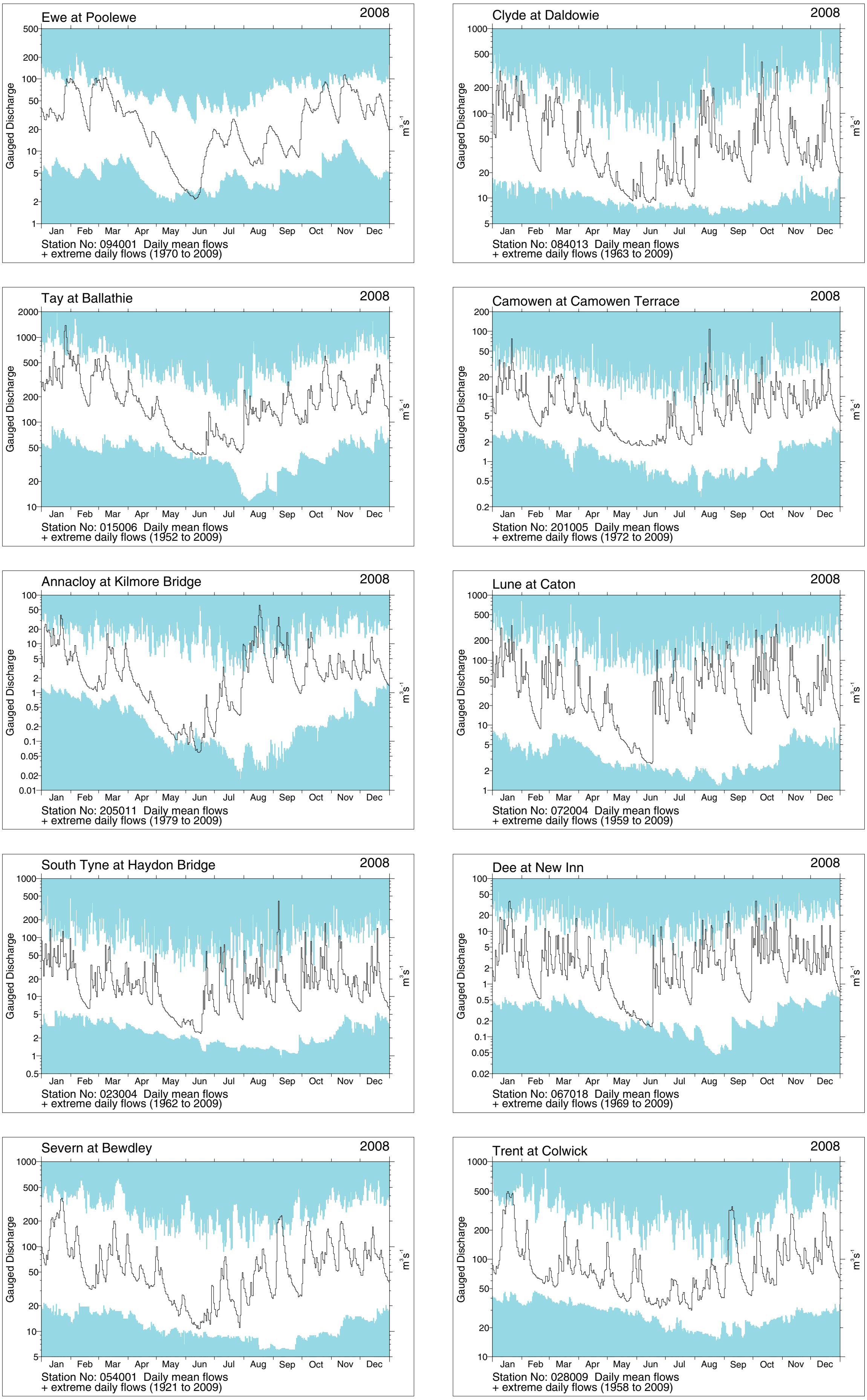

Figure 11 *2008 daily flow hydrographs for a selection of UK index catchments*

2008 flows during June – notably low early summer flows were registered for the CEH research catchments in central Wales and, more exceptionally, several rivers in Northern Ireland (including the Crumlin and Roe) fell below previous minima in mid-month. This was also true of the Oykel, Blackwater and Teviot in Scotland. In the Western Isles, dwindling stream flows interrupted whisky production (e.g. on Islay).

Contrary to the expected seasonal pattern, the late-June river flow recoveries heralded a series of summer spates. With the normal constraint exercised by very dry soil conditions on runoff not operating over wide areas, late summer flows in many rivers were more typical of the winter. Previous maximum recorded flows for July were widely eclipsed (e.g. on the Cynon and Warleggan, in flow series from 1969). Very high flows also characterised rivers in northern England and southern Scotland late in the month; on the 30/31st the River Garnock (Ayrshire) burst its banks.

The most extensive flood events during 2008 occurred in Northern Ireland where flows in mid-August contrasted dramatically with runoff rates in the early summer. On the 16/17th, previous maximum flows were exceeded at around one-third of the primary gauging stations, often by

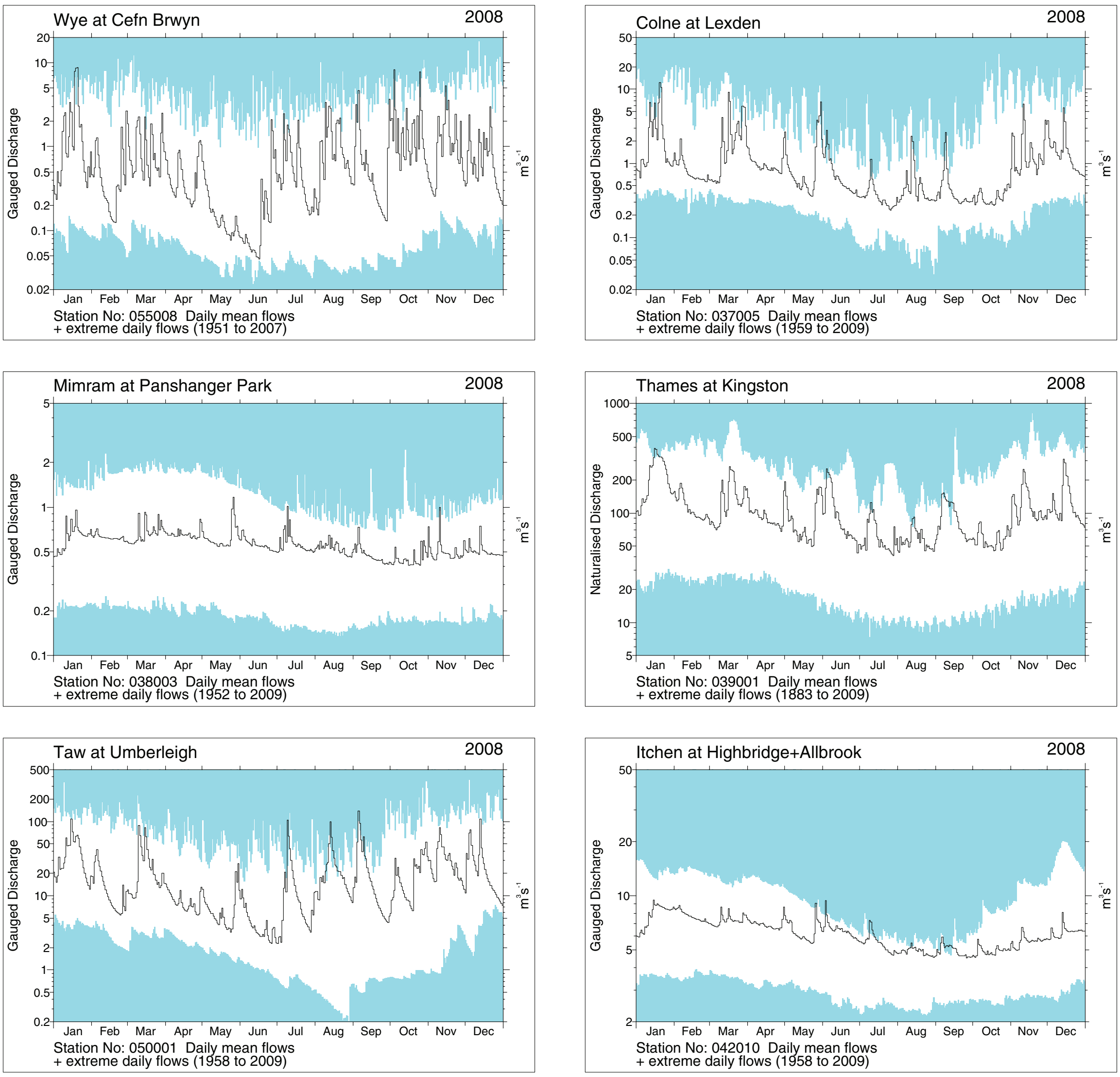

Figure 11 *(contd)*

Table 2 River Flow records established in 2008
Data sources: Environment Agency, Scottish Environment Protection Agency and Rivers Agency

Station Number	River	Station Name	First Year of Record	New Record (m3s-1)	Date
Lowest Gauged Daily Mean Flows					
3003	Oykel	Easter Turnaig	1977	0.321	09-Jun
21012	Teviot	Hawick	1963	0.325	16-Jun
80006	Blackwater	Loch Dee	1983	0.002	17-Jun
83007	Lugton Water	Eglinton Castle	1977	0.016	20-Jun
89007	Abhainn a' Bhealaich	Braevallich	1981	0.035	27-May
203042	Crumlin	Cidercourt Bridge	1981	0.01	16-Jun
203046	Rathmore Burn	Rathmore Bridge	1983	0.01	16-Jun
Highest Instantaneous Flow					
18001	Allan Water	Kinbuck	1957	139	25-Jan
22001	Coquet	Morwick	1963	467	06-Sep
22006	Blyth	Hartford Bridge	1966	243	06-Sep
22007	Wansbeck	Mitford	1968	360	06-Sep
22009	Coquet	Rothbury	1972	417	06-Sep
23002	Derwent	Eddys Bridge	1954	137	06-Sep
23007	Derwent	Rowlands Gill	1962	184	06-Sep
25009	Tees	Low Moor	1969	557	06-Sep
27038	Costa Beck	Gatehouses	1970	8.86	05-Sep
27075	Bedale Beck	Leeming	1983	140	06-Sep
28039	Rea	Calthorpe Park	1967	72.1	06-Sep
31026	Egleton Brook	Egleton	1978	2.47	15-Jan
55016	Ithon	Disserth	1968	174	05-Sep
55029	Monnow	Grosmont	1948	224	05-Sep
57009	Ely	St Fagans	1975	81.5	05-Sep
73010	Leven	Newby Bridge FMS	1939	145	26-Oct
73015	Keer	High Keer Weir	1976	33.3	25-Oct
75002	Derwent	Camerton	1960	302	25-Oct
203010	Blackwater	Maydown Bridge	1970	159	16-Aug
203011	Main	Dromona	1970	134	16-Aug
203018	Six-Mile Water	Antrim	1970	213	16-Aug
203019	Claudy	Glenone Bridge	1972	61.3	17-Aug
203021	Kellswater	Curry's Bridge	1971	193	16-Aug
203027	Braid	Ballee	1972	196	16-Aug
203039	Clogh	Tullynewey	1983	43.6	16-Aug
203040	Lower Bann	Movanagher	1980	378	16-Aug
203042	Crumlin	Cidercourt Bridge	1981	104	16-Aug
203046	Rathmore Burn	Rathmore Bridge	1983	17.7	16-Aug
203049	Clady	Clady Bridge	1983	56.6	16-Aug
203093	Main	Shane's Viaduct	1983	450	16-Aug
205005	Ravernet	Ravernet	1978	50.3	16-Aug
205011	Annacloy	Kilmore Bridge	1979	66.2	17-Aug

Note: The peak values are based on the highest recorded 15-minute flow for each featured gauging station. Many are beyond the confirmed range of the stage-discharge relationship and therefore subject to a wide uncertainty band.

substantial margins (see Table 2). The associated flooding caused severe transport disruption and many livestock were stranded on inundated floodplains. As a consequence of the exceptional summer flows, rivers establishing new maximum June-August runoff totals displayed a very wide distribution (including the Tweed, Dart, Cynon, Lune and Clyde each with record lengths of around 50 years).

The autumn began with many catchments very vulnerable to further rainfall. On the 5/6th September around 100 flood warnings were issued by the Environment Agency – embracing a broad swathe of Wales, south-west England, the Midlands and the North East. In the ensuing floods, the Ithon in central Wales exceeded its previous maximum flow in a series from 1968. Flows were even more exceptional in Northumbria where the Wansbeck registered a new maximum flow in a record from 1963 (the associated return period exceeds 100 years); around 1000 properties were affected in the Morpeth area. Many other rivers in the North East exceeded previous recorded maxima (e.g. the Coquet, Blyth and Derwent); flows were also outstanding in parts of the Midlands (e.g. in the Rea). A reflection of the extreme nature of the late summer and early autumn flooding is the proportion of catchments with exceptionally high July-September runoff totals – particularly for south-western catchments (see Figure 13).

Further, mostly moderate, flood events occurred during October, for example in parts of Wales (e.g. Welshpool on the 5th) with exceptionally high river flows extending to catchments in parts of Cumbria and East Anglia. On the 9/10th localised flooding occurred in the Cynon Valley (South Wales) and exceptional autumn flows were registered during the final week (e.g. in northern Scotland and the Lake District where the Derwent eclipsed its previous highest flow in a series from 1960). At month-end, the intense east Devon storm triggered severe local flooding in Ottery St Mary and, subsequently, the Otter (at Dotton) registered its highest flow for 40 years. By contrast, below average runoff characterised many rivers draining impermeable catchments in the South East (e.g. the Colne and Medway).

Enhanced levels of flood risk continued into November and, on the 10th, the Warwickshire Avon (at Evesham) registered its 2nd highest November daily flow in a series from 1936. Flood

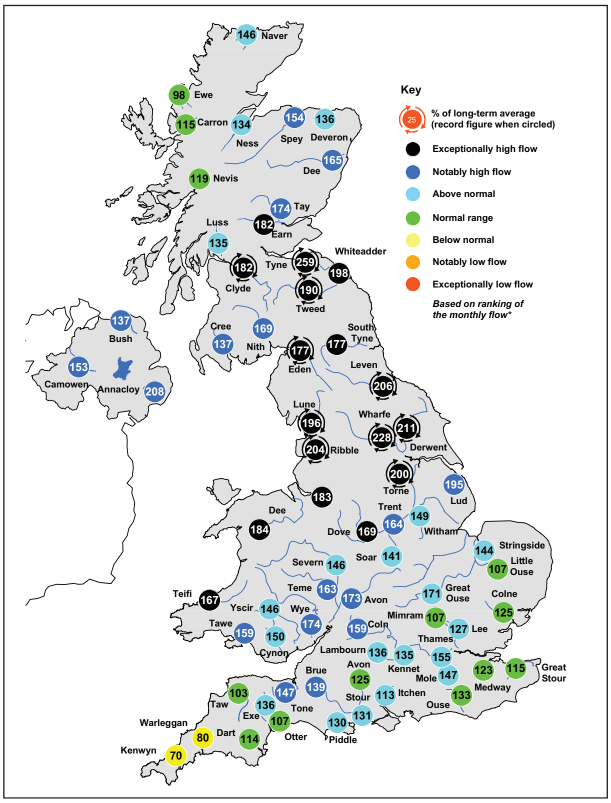

Figure 12 *January 2008 catchment runoff totals as a percentage of the previous average*

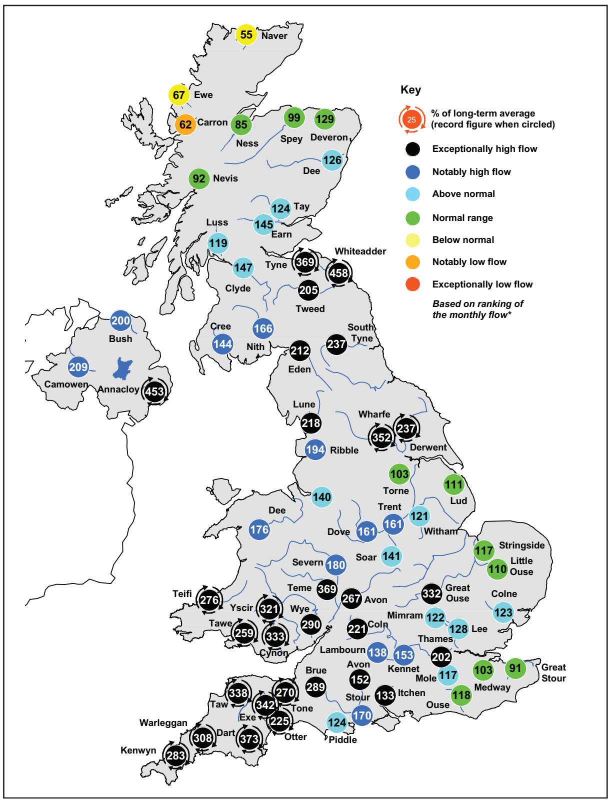

Figure 13 *July-September 2008 catchment runoff totals as a percentage of the previous average*

alerts were common and localised flooding was widely reported (e.g. at Guildford, Pontardulais, and many localities in the Midlands) resulting in considerable transport disruption. Flows in many rivers spanned a very wide range during December. Moderate floodplain inundations were common in mid-month and, locally, some flood events were severe (e.g. in Crawley where a nursing home was evacuated on the 13th). Thereafter, flow rates generally declined very rapidly – frozen upland catchments were a contributory factor in many areas. During the final week flows were depressed across much of the country; in Northern Ireland, the River Annacloy registered its lowest year-end flow in a 30-yr record. December runoff totals were notably low in a few responsive catchments; the 3rd lowest in a 36-yr series for the Yscir. In contrast, flows in most spring-fed rivers streams remained healthy, reflecting the substantial early autumn groundwater recharge. For the Lambourn and some other southern chalk rivers, flows remained above the daily average throughout 2008.

Flow regime characteristics

Flow duration curves allow the proportion of time that river flows are above, or below, any given threshold to be identified and provide a means of comparing the flow regime during a particular year with that for the previous record. Figure 14 provides flow duration curves for both 2008 and the preceding record for Great Britain, England & Wales and Northern Ireland; for the latter the distinctive shape of the duration curves reflects the major influence of controlled releases

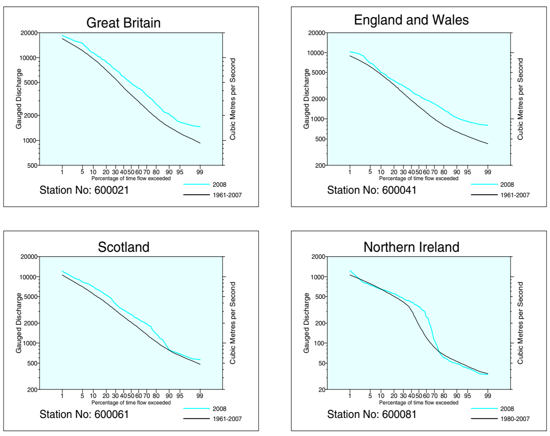

Figure 14 *Flow duration curves (national outflows)*

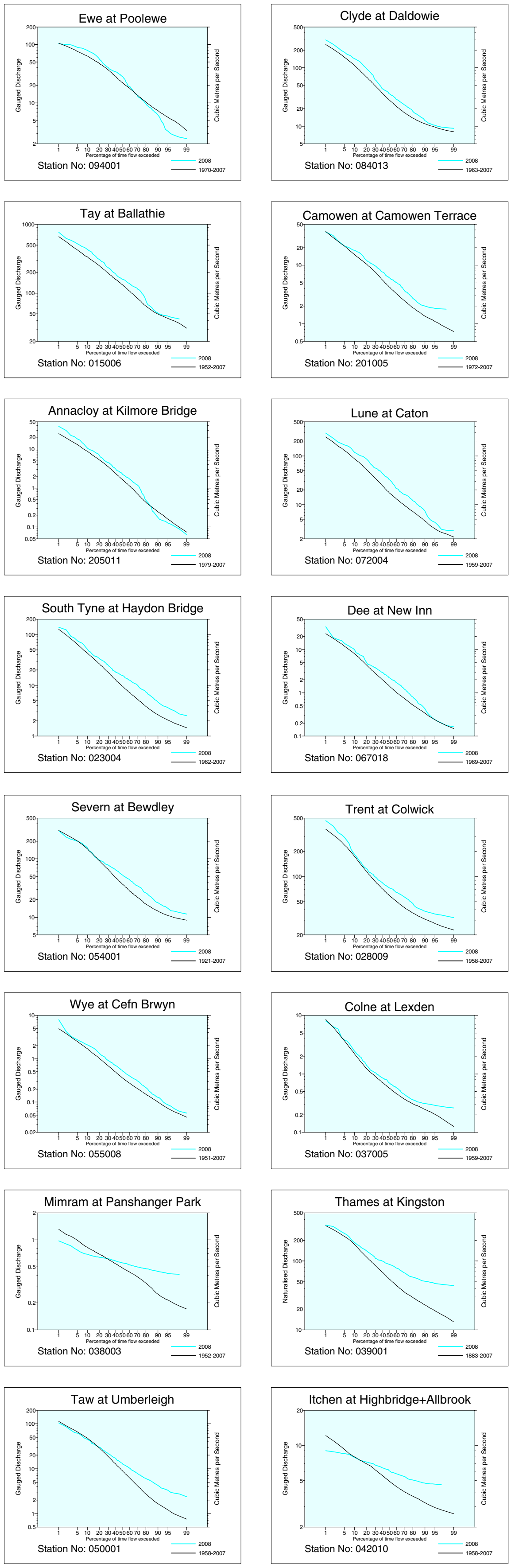

Figure 15 *Flow durations curves (for a selection of index catchments)*

from Lough Neagh. Each of the national 2008 curves departs markedly from the long-term average. For Northern Ireland and Scotland, the lowest flows during 2008 were well within the normal range but the enhanced frequency of spate conditions is evident from the departures of the 2008 duration curve from the period-of-record equivalent in the higher flow ranges. For England & Wales, the daily outflow exceeded 95% of the time (Q_{95}) for 2008 was 50% greater than average and eclipsed the previous maximum in the 48-year national series.

Figure 15 provides a set of flow duration curves for a selection of index rivers across the UK and allows regional variations in 2008 flow regime characteristics to be identified. For a substantial minority of the featured rivers (including the Teifi, Lune, Trent and Clyde) flows in 2008 exceeded the period-of-record mean throughout the entire flow range. Generally the low flows experienced in 2008 were substantially healthier than in a typical year. There were some significant exceptions, including the Ewe and Annacloy where the Q_{95} for 2008 fell well below that for the preceding record. In 2008, particularly unusual flow regimes characterised a number of spring-fed streams and rivers in southern England. Even accepting the characteristically stable nature of their flow regimes, flows in the Itchen and Mimram (both Chalk rivers) spanned a remarkably narrow range throughout the year.

Groundwater

Background

Most major aquifer outcrop areas (see the Location Map) are in the drier parts of the UK – predominantly the English Lowlands where groundwater is the principal source of public water supply. In water resources terms the Chalk, which outcrops in eastern and southern England, is the most important aquifer. The Permo-Triassic sandstones are also regionally important, especially in the Midlands and North-West. Limestone aquifers are regionally significant and a number of minor aquifers (e.g. the Norfolk Crag) are of local water supply importance.

Evaporation losses exhibit limited year-on-year variability but account for more than half the annual rainfall across many aquifer outcrop areas. Correspondingly there is a non-linear relationship between rainfall and aquifer recharge; a 20% reduction in annual rainfall can result in a reduction of 50% or more in groundwater replenishment in the drier, eastern outcrop areas. Annual recharge variations thus tend to be much greater than those for rainfall.

Away from the more westerly aquifer outcrop areas, groundwater replenishment (or recharge) in a typical year ranges from 500mm to less than 100mm in the most easterly outcrops. Recharge is normally concentrated in the November-April period when evaporation losses are modest. Infiltration and hence variations in groundwater levels are also affected by the properties of the deposits through which it passes to reach the saturated zone of an aquifer. The fluctuation in groundwater levels within an aquifer is also influenced by its storage characteristics; in those aquifer units with low storage coefficients, recharge with a given volume of water will result in a greater rise in water levels than where storage capacities are higher. Groundwater levels fall naturally as aquifer storage is depleted by outflows to rivers and springs but may also decline as a result of abstraction from boreholes.

The year in brief

2008 rainfall totals over most major aquifer outcrop areas were less exceptional than in many western and northern parts of the UK but they were still generally well above average – notably so for some aquifer units (e.g. the Jurassic limestone of the North York Moors). The benefit of the abundant rainfall was partly counterbalanced by the high proportion (>40% in some areas) of the annual rainfall that fell during the May-September periods when evaporation losses are normally at a maximum. The wet summer served to moderate soil moisture deficits but resulted in only localised pulses of groundwater replenishment. Importantly however, the unusually moist summer soils did allow the seasonal onset of recharge in the autumn to begin exceptionally early in many areas.

As is normally the case, antecedent aquifer recharge patterns were a primary influence on groundwater levels throughout much of 2008, in southern Britain especially. In 2007, the seasonally remarkable infiltration reported across many central and southern aquifers during the outstandingly wet late spring and early summer was followed by a brisk recovery in groundwater levels in the early autumn. This underlined concern regarding the likely increased risk of groundwater flooding through the winter of 2007/08. In the event, England & Wales recorded its 2nd driest autumn since 1964 and some southern aquifer outcrop areas registered five successive months with below average rainfall. Correspondingly, groundwater level recoveries stalled through October and November but regained momentum in early 2008 as residual soil moisture deficits were eliminated in eastern and southern England.

Recent variations in groundwater resources can be deduced from Figure16 which shows 2005-08 groundwater level hydrographs for a selection of index wells and boreholes across the UK. The broken line indicates the long-term monthly average and the upper and lower shaded envelopes delineate the highest and lowest monthly levels on record. A four-year period is featured

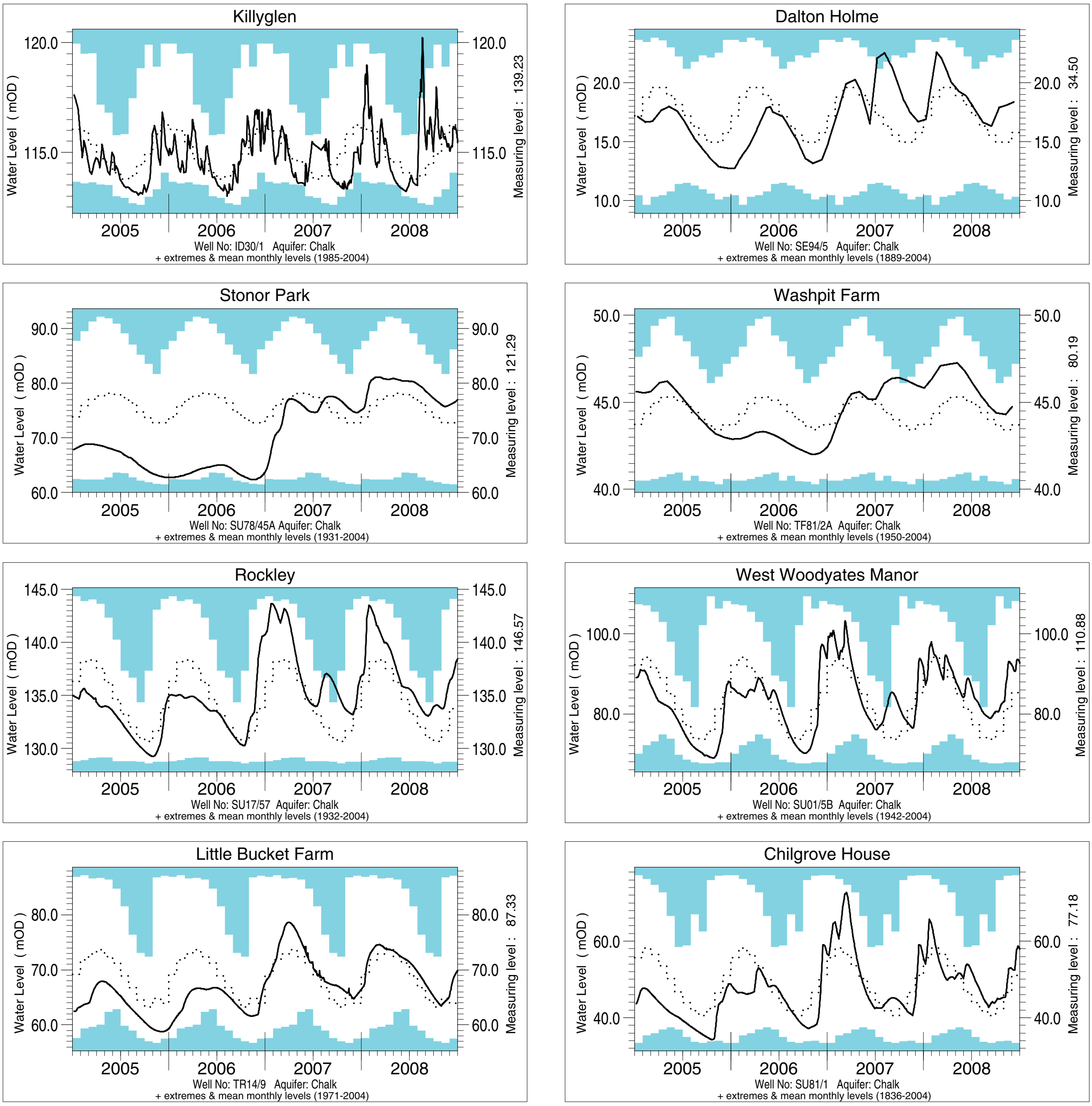

Figure 16 *2005-2008 groundwater level hydrographs*

because groundwater levels in many areas reflect recharge over a number of winter/spring periods.

The groundwater level hydrographs for most index wells and boreholes testify to notably volatile recharge patterns through the winter of 2007/08 but in January, with soils close to saturation in almost all western and central

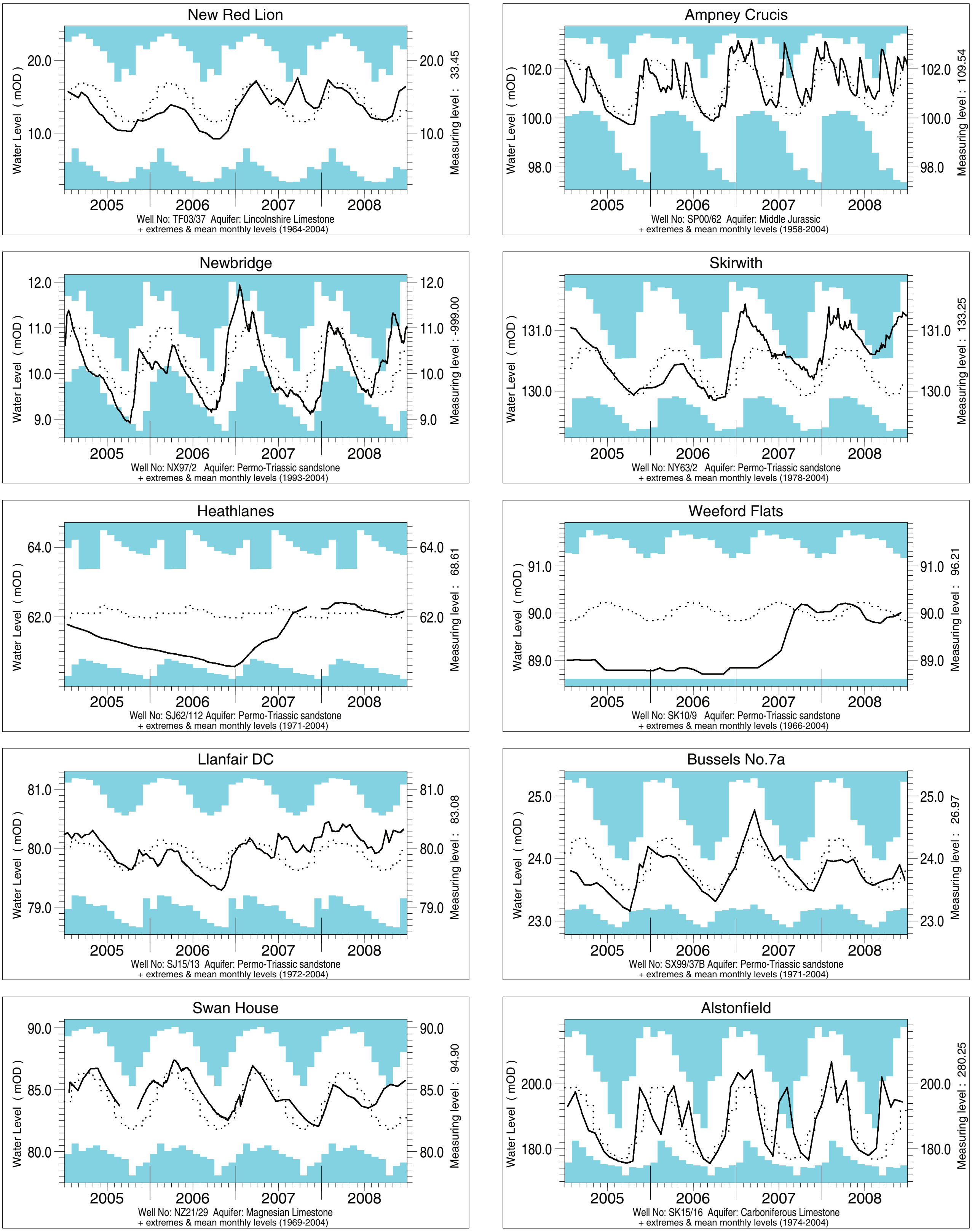

Figure 16 *(contd)*

aquifers, the well above average rainfall generated abundant groundwater recharge, initiating significant replenishment in even the most easterly of outcrop areas. In the western Chalk at Rockley, this major pulse of recharge triggered a rise of around 10 metres over four weeks leaving groundwater levels close to the long term maximum. By the latter half of February, groundwater levels in most areas were within, or above, the normal late-winter range.

Sustained March rainfall generated significant further rises in groundwater levels which stood close to, or above the monthly average in all but the most southerly index wells and boreholes (see Figure 17). The unsettled early spring usefully delayed the onset of the 2008 groundwater recessions in eastern aquifer outcrop areas. As is commonly the case away from the more northern and western aquifer units, infiltration during April was patchy and, apart from the slowest-responding aquifer units, groundwater levels were generally declining briskly – following typical spring recessions. In some southern aquifers however, natural outflows via springs and seepages broadly balanced recharge through the late winter and early spring, resulting in unusually level groundwater hydrographs (see, for example, Stonor in the Chalk and Bussels in the Permo-Triassic sandstones). The rainfall distribution in May favoured the outcrop areas of the major aquifers, the southern Chalk especially. However, the intensity of some of the storms exceeded the infiltration capacity of the soils and, more generally, with soil moisture deficits only a little below the late-spring mean, groundwater recharge was mostly local and modest (e.g in parts of Kent). Groundwater levels generally remained above average through May but in Northern Ireland, a sustained dry spell resulted in levels at Killyglen falling marginally below the previous monthly minimum in a 24-yr series.

Summer (June-August) rainfall totals were high across most outcrop areas but the rain served to moderate soil moisture deficits rather than contribute any widespread groundwater replenishment. Nonetheless, the lagged impact of sustained rainfall earlier in the year resulted in June groundwater levels in the Chalk remaining mostly above the seasonal average with notably high levels recorded at West Woodyates Manor,

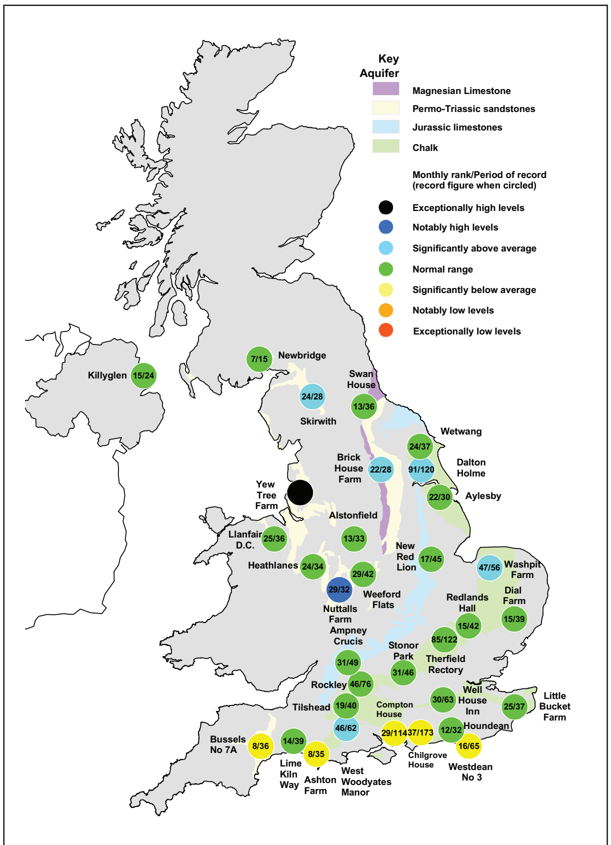

Figure 17 *Groundwater levels in March 2008*

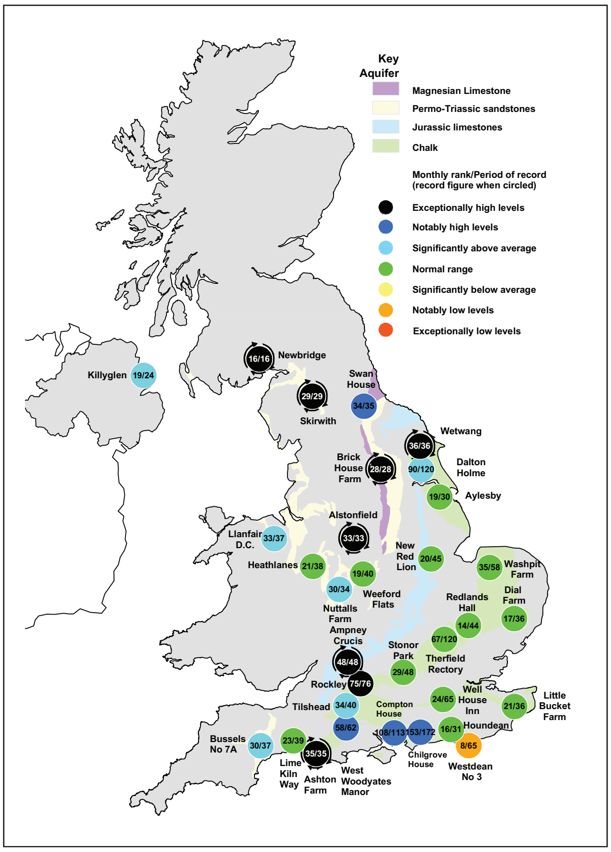

Figure 18 *Groundwater levels in September 2008*

Compton House and Chilgrove House in southern England. By the late summer, soil moisture deficits were of a much lower magnitude than normal (see page 9) and significant, but mostly localised, infiltration was reported. Groundwater levels rose during August in some responsive aquifers (e.g. in the Carboniferous Limestone at Alstonfield) and, locally, in some superficial deposits (e.g. in parts of the Chilterns). In Antrim, the exceptional August storms triggered a very steep rise in groundwater levels at Killyglen; the short-lived peak on the 19th was the highest in a 24-year series (see Figure 16). Seasonally exceptional groundwater levels were also reported for the Skirwith borehole (Permo-Triassic sandstones) and for some Chalk and Limestone index wells (e.g. Ampney Crucis and West Woodyates).

Away from the more easterly outcrop areas, soil moisture deficits were further reduced in September, albeit modestly, allowing groundwater level recoveries to become established in many areas. In the northern and western extremities of the Chalk outcrop, new September maximum levels were registered for Wetwang (East Yorks) and Ashton Farm (Dorset) – see Figure 18. By October, groundwater levels in most responsive index wells and boreholes were increasing briskly, resulting in new monthly maximum levels in some northern Magnesian Limestone and Permo-Triassic sandstones outcrops. In the Chalk at Rockley (where monitoring began in 1933), higher October mean levels have occurred only in 2007, 1968 and 1958. Elsewhere, the more limited autumn infiltration was reflected in seasonally typical groundwater levels.

Late-autumn infiltration was spatially very variable, falling below 50% of the November mean in parts of the eastern Chalk (e.g. to the north of London) – a consequence of the limited rainfall and residual soil moisture deficits. Nonetheless, groundwater levels in most index wells remained well above the late-autumn average and, in vulnerable parts of southern England, levels in the Chalk were again within the range that might allow groundwater flooding to occur in the event of well above average rainfall over the winter of 2008/09. This risk moderated considerably through December when rainfall over the major outcrop areas was substantially below average, declining to less than 40% in a few parts of the south-eastern Chalk. However, despite modest replenishment in the early winter, groundwater levels at year-end were generally above, to well above, the long tern average across the great majority of the UK. There were a few exceptions (e.g. Killyglen in Northern Ireland) but the overall groundwater resources outlook, entering 2008, was very healthy.

The impact of long term groundwater abstraction

The majority of observation wells and boreholes for which data are held on the National Groundwater Level Archive monitor natural variations in levels. However, in several parts of the UK, groundwater levels have been influenced by pumping for water supply or other purposes, sometimes over very long periods. As a consequence, some local or regional water-tables have become substantially depressed. For instance, contemporary levels at a number of boreholes in the Permo-Triassic sandstones of the Midlands are indicative of a significant regional decline. In contrast, rising groundwater levels have been reported from some conurbations. A decline in abstraction rates is normally the primary cause but leakage from water mains is considered a significant factor in some cases. The implications of rising groundwater levels extend beyond the potential improvement in water resources that the rise represents. Groundwater quality may be adversely affected as levels approach the surface and a number of geotechnical problems may result, for instance the flooding of tunnels and foundations.

Artificial influence on groundwater levels have been particularly pervasive in London where increasing groundwater abstraction through the nineteenth and the first half of the twentieth centuries led to a 70m decline in groundwater levels in the Trafalgar Square borehole. Since the 1950s however, much reduced abstraction rates have resulted in a recovery of around 40m with levels rising by 1-2m a year through much of the 1980s and 1990s (see Figure 19). The potential disruption and damage (e.g. to the stability of buildings) which would result from a continuation of this rise, stimulated the development of a strategy to control rising groundwaters below London. Implementation of this strategy has contributed to a modest decline, around 5m, in levels at Trafalgar Square over the post-2000 period.

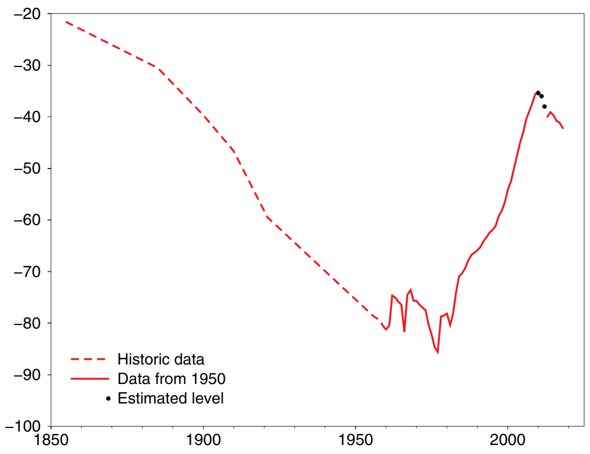

Figure 19 *Groundwater levels at Trafalgar Square 1840-2008*

Reservoir stocks

Reservoir stocks have shown substantial spatial and temporal variation over the last 20 years. For England & Wales, estimated overall reservoir stocks were relatively low during the 2003 drought and, less extensively, the 2004-06 drought (see Figure 21) when particular water resources stress was experienced in the parts of the English Lowlands. Stocks also fell to relatively depressed levels in parts of Scotland and Northern Ireland during the early years of the 21st century. However, reservoir stocks over the last decade have generally been healthy – notably so by comparison with those registered during the extended droughts of the early and mid-1990s.

Stocks in the great majority of index reservoirs have remained above the monthly average for most of the post-2006 period and, with a few exceptions, were very healthy throughout 2008. For England & Wales, overall stocks remained around, or above, 90% of capacity throughout the year – an unprecedented circumstance in a series beginning in 1988 (see Figure 20).

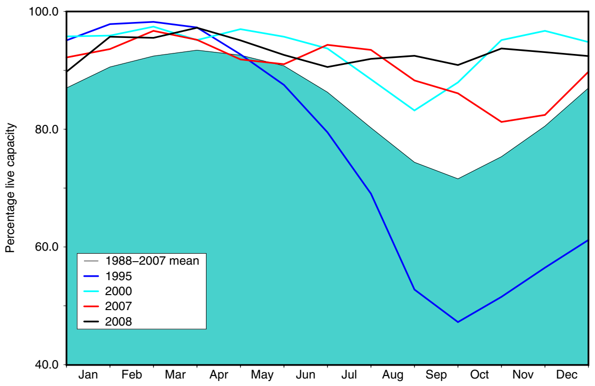

Figure 20 *Variation in overall reservoir stocks for England & Wales*
Data sources: Water Service Companies and the Environment Agency

Due in part to the unusually abundant late spring and early summer replenishment during 2007, overall reservoir stocks for England & Wales remained modestly above average entering 2008 despite five successive months of below average rainfall in some eastern areas. Of the national index reservoirs only Stithians (Cornwall) was >10% below capacity (and then only marginally so) and stocks for much of England & Wales were the highest since 2000, for early January. Stocks were seasonally low in parts of Scotland however; Loch Katrine reported its lowest early January level in a 15-yr series. In northern England, stocks in Kielder, one of the largest reservoirs in western Europe, were at their lowest (for early January) in 18 years; this was largely due to a scheduled drawdown during the latter months of 2007.

Inflows to most major reservoirs were exceptional during January 2008 – stocks at Kielder rose by almost 25%, the highest monthly increase on record – and despite the need for some drawdown to moderate flood risk (e.g. in Wales), overall reservoir stocks increased appreciably.

At month-end, almost all reservoirs stood above average (Stithians remained an exception) and most were at, or very close to, capacity. This was true across most of Scotland and Northern Ireland also. Despite below average February rainfall, all index reservoirs in Britain remained at, or above, 90% of capacity; in Northern Ireland however, levels at Silent Valley declined considerably.

Well above average March rainfall ensured that all index reservoirs remained close to, or at, capacity – most were full. Early April stocks for England & Wales were, remarkably, the 2nd highest for any month in the 21-yr national series. The health of the water resources outlook was further reinforced when moderately wet conditions postponed the onset of the normal seasonal decline in reservoir stocks until the late spring. Notable declines in reservoir stocks during May were registered in Scotland (e.g. Loch Katrine) and Northern Ireland, where particularly arid conditions resulted in the lowest stocks on record for late May and early June. Many western and northern reservoirs registered their minimum 2008 levels during June – a very unusual circumstance, in a normal year the lowest stocks are registered in mid-autumn. A notable change in synoptic patterns in late June signalled the onset of an exceptional episode of summer replenishment for many reservoirs across the UK. Although early July stocks for Silent Valley (Northern Ireland) were approaching the minimum for mid-summer, stocks remained generally above the monthly average across England & Wales.

In July, a cryptosporidium outbreak at Pitsford Reservoir (Northants) triggered local water use restrictions but overall reservoir stocks for England & Wales remained above average for the 12th successive month. The seasonally rare late-summer runoff was particularly welcome in Northern Ireland where Silent Valley stocks increased by nearly 40% through July and August. Contrary to the normal seasonal pattern (but having parallels with the summer of 2007), overall reservoir stocks for England & Wales also increased over this period, albeit modestly. Consequently, overall end-of-summer stocks for England & Wales were the highest on record by an appreciable margin.

New early September maximum levels were registered for many, widely distributed reservoirs (including Daer, Colliford, Wimbleball and Silent Valley) – a substantial proportion of the national index reservoirs were close to capacity. There were some important exceptions (e.g. in parts of Northern Ireland and Scotland where stocks had been relatively depressed in the early summer) but throughout much of the autumn stocks were the highest on record for England & Wales, and healthy across the remainder of the UK.

Existing maximum early October stocks for many individual reservoirs were also eclipsed in 2008, often by substantial margins (e.g. Clatworthy). By mid-month, when stocks in many reservoir are often close to their minimum for the year, reservoir levels across much the greater part of the UK were more typical of the late winter. Stocks in a few reservoirs declined modestly through November but, generally, the month ended with healthy stocks across the country. A notable dry spell late in December resulted in a brisk decline in reservoir stocks and levels in a few impoundments (e.g. in Northumbria) were modestly below the mid-winter average entering 2009. However, stocks for early January were within 5% of capacity in the majority of index reservoirs and for England & Wales, overall stocks were the highest since 2003. This made for a healthy water resources outlook.

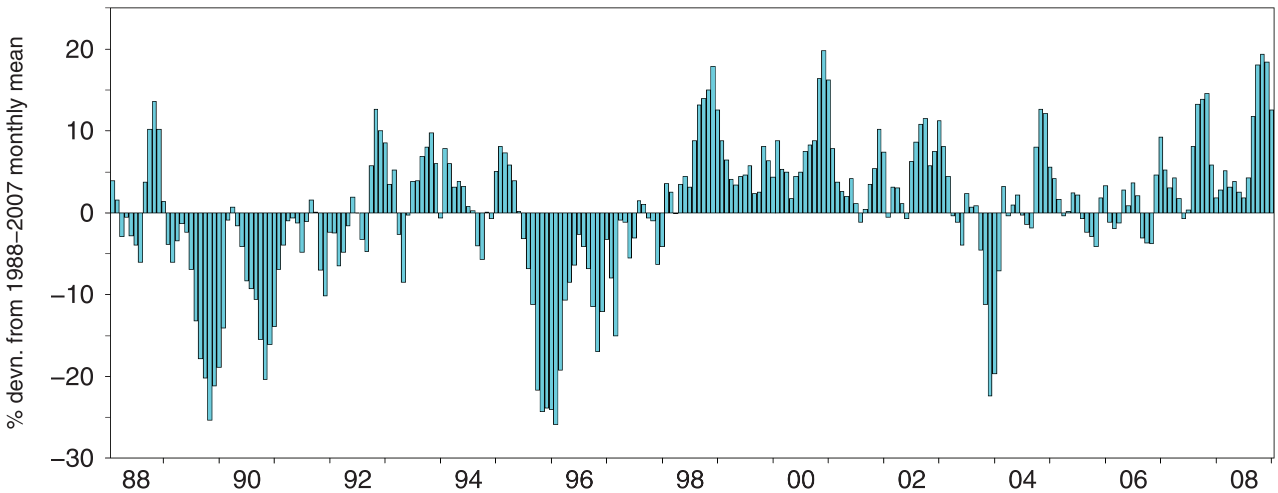

Figure 21 *A guide to England & Wales reservoir stocks, 1988-2008*
Data sources: Water Service Companies and the Environment Agency

References

1. Wigley, T. M., Lough, T. M. & Jones, P. D. (1984). Spatial patterns of precipitation in England and Wales and a revised homogeneous England and Wales precipitation series. Int Jour. Climatol., 1-27

2. Hough, M. and Jones, R. J. A. (1997). The Meteorological Office Rainfall and Evaporation Calculation System: MORECS Version 2.0 an overview. Hydrol. Earth. Sys. Sci. 1, 227-239

3. Manley, G. (1974) Central England Temperatures: monthly means 1659 to 1973. Quart. J. Roy. Met. Soc., 100, 389-405

4. CET updates source: http://www.met-office.gov.uk/ research/hadleycentre/CR_data/Monthly/HadCET_act.txt

Location Map

NATURAL
ENVIRONMENT
RESEARCH COUNCIL

enquiries@ceh.ac.uk
www.ceh.ac.uk

RIVERS Agency

SEPA Scottish Environment Protection Agency

Environment Agency

Met Office