HYDROLOGICAL SUMMARY FOR GREAT BRITAIN - JULY 1990

Data for this review have been provided principally by the regional divisions of the National Rivers Authority in England and Wales, the River Purification Boards in Scotland and by the Meteorological Office. The recent areal rainfall figures are derived from a restricted network of raingauges and a significant proportion of the river flow data may be subject to revision following reviews of the low flow stage-discharge relations.

For a fuller appreciation of the water resources implications, this hydrological review should be considered alongside assessments of the current reservoir storage and water demand situations in each region.

Summary

The cool and cloudy weather of June persisted into the early part of July; most areas had rain during the first eight days. Subsequently, the month was generally dry, being more showery in the north and west, with virtually all mainland Britain showing below average falls, even in the highlands and the west of Scotland. Thus, in the south and east of England, the sunny, warm and dry conditions which have predominated since late February were re-established.

The summer so far (June-July) has not been outstandingly dry but looking back over the 5 months to March large areas of lowland Britain were experiencing severe drought conditions (using the guideline of a return period greater than 50 years). Regional rainfall totals over 10 and 12 month periods remain unexceptional and within the normal range. Deficiencies of significant magnitude may be recognised regionally over the longer term (greater than 18 months), with rather more severe shortfalls in some eastern and southern localities.

Whilst the wet winter of 1989-90 dissuades comparison with the 1975-76 drought, particularly so for periods greater than 6 months, the mild nature of the last winter has ensured high rates of evaporation; coupled with the scarcity of rainfall from March onwards the result has been the rapid establishment of soil moisture deficits. Furthermore, the temporal distribution of the 1990 rain, being concentrated into the first two months (although much of Scotland is an exception here) has reduced its long term effectiveness in contributing to resources. As a consequence, the 1990 drought is rather more intense than the rainfall data alone would suggest.

River flows in the west and in Scotland responded to heavy frontal rain in the early and late parts of the month and runoffs are generally close to or above average. Elsewhere the rainfall had little hydrological impact and river flow recessions continued. Some lowland catchments registered their lowest monthly runoff since 1976, exceptionally paralleling them in some eastern catchments. More generally, however, July runoff totals were 50-100% greater than for those recorded in July 1976, in those areas most affected by drought.

The seasonal decline in groundwater levels has continued, and water tables generally stand well below the seasonal norm and below the corresponding levels of 1989. However, over much of the country, groundwater levels appear to be substantially above the equivalent levels for 1976. For some eastern districts, levels appear to be close to, or approaching, the minimum recorded, and are already at their lowest since the 1976 drought.

The exceptionally high soil moisture deficits will delay the upturn in runoff and recharge to aquifers as evaporation losses decline through the autumn. Should autumn rainfall be delayed or be modest, as happened in 1988 and 1989, the outlook for water resources in large areas of lowland Britain would arouse concern. A reliance upon above-average winter rainfall would be necessary to approach 1991 with confidence.

Rainfall

Early in the month frontal rainfall affected all districts; subsequent fronts mainly affected western and northern areas and showery weather characterised the northern districts into the middle of the month. Rainfall amounts lessened towards the south east, however. The weather was predominantly dry thereafter, many areas in the south and east experiencing little or no rain until late in the month when fronts from the south west brought heavy rain to western areas but modest or insignificant falls to the midlands and Pennines eastwards. England and Wales registered below 50% of average rainfall with the Thames and Southern NRA areas receiving below 30% of average (Table 1). Some localities in Berkshire and Kent recorded 15%, or less, of average.

The 5 month accumulations in the midlands and the south, apart from the south west, have return periods approaching or exceeding 50 years for the March/July period (Table 2). In the Thames catchment only 1976 and 1921 had lower rainfalls for this period. Longer accumulation periods, which include the 1989-90 winter rainfall, such as October 89-July 90, still record totals greater than average in most regions, but are within the normal range. On a 12 month basis Northumbria, Yorkshire and Anglia show appreciable deficits. The east and south generally exhibit significant rainfall deficits over the long term (>18 months) timeframe. The July rainfall has done little to change the persistent meteorological drought in parts of Kent, Lincolnshire, Humberside and the coastal strip of the north east.

In Scotland, July was the second month this year in which all regions recorded below average rainfall (although some north western localities exceeded it). This shortfall was not that great in the Highlands and the west, and record accumulations for the calendar year continue in the Highland and Clyde RPB areas. The north-east and east of Scotland recorded below 50% of average with the North East RPB area maintaining a significant long term deficiency.

On average, British rainfall is fairly evenly distributed throughout the year with a bias towards the winter months, particularly in those areas of higher relief and westerly aspect.. At the Wallingford meteorological site a remarkable series of three month accumulations has been recorded since the summer of 1989, with autumn, winter and spring showing large departures from the mean and a significant exaggeration of the normal seasonal distribution; e.g., accumulations compared with the 25 year mean, 1962-1986:

Jun89-Aug89	Sep89-Nov89	Dec89-Feb90	Mar90-May90	Jun90-Jul90
54%	79%	224%	32%	53%(2 months)

Such a pattern is more akin to the "hot dry summers, warm wet winters" of Mediterranean climate and would have a profound effect upon long term resource management strategies were such a pattern to become commonplace.

Evaporation and Soil Moisture Deficit (SMD)

Sunshine hours were appreciably above normal throughout Britain with Shropshire, Cheshire and the Inverness district recording 60% above average. Higher than average daytime temperatures resulted and potential evaporation (PE) climbed steadily throughout the month with most areas recording record levels. These evaporation values, in concert with the low rainfall, caused SMDs to increase again, after stabilising in June. Using the MORECS (grass) model as an indicator, most of central, southern and eastern England are registering notably high deficits; typically 25-50% above average for the end of July, representing over 40mm of water equivalent. In some coastal and hilly regions, SMDs are over twice the average, occasionally representing 50mm above normal, as on the north Cornwall coast, parts of the Welsh coast, the Cheviot Hills and Northumberland coast. SMDs in north western Scotland have again developed on the mainland, reaching appreciable levels in an area where average conditions are for modest deficits; three to five-fold increases in some locations, although this may only represent 20mm of deficit.

Record PE rates have not been restricted to July; over the 12 months August 1989 to July 1990, record or near record totals have been established throughout much of Britain. For example, in the Thames and Medway estuaries area the 12 month total was 25% above the previous August to July maximum. Actual evaporation (AE) estimates have shown a different pattern because of the negative feedback mechanism governing transpiration when SMDs are high. In lowland, eastern and southern England, AE rates were often among the lowest on record (the Medway estuary above has an AE total ranked 27 out of 31). In the west, however, AE rates were close to the highest accumulations recorded, reflecting a greater access to water for transpiration.

Comparison of August 1975-July 1976 with the 12 month period above indicates that evaporative response was similar; in England and Wales, the most obvious difference was the extension of the "high PE, low AE" areas into Wales and the south west. Many of the July 1976 SMD values were significantly greater than in July 1990 by some 20 to 30 mm. It should be stressed that these are modelled data, taking no account of spray or other irrigation which could decrease the SMDs and increase AE along with nurturing plants.

The larger SMDs will require more than two or three months average rainfall to clear, particularly if evaporation rates remain high into the autumn. This does not augur well for the water resources situation should winter rainfall not be plentiful and/or optimally timed.

River Flows

The continuation of the cool and wet conditions of late June into July resulted in an upturn in runoff in those responsive catchments in the west and north but steep recessions soon re-established themselves. The late rainfall on the 27th to 30th, particularly in the west, caused a further runoff upturn, and many catchments recorded above average or average flows for the month. These included most Scottish catchments, and those in Wales and the north west. North Devon and Cornish rivers were their highest since March or April, generally below average but significantly above comparable flows in 1989. In the midlands, south and east of England, the modest rainfall and declining baseflows meant recessions were maintained and rivers were generally well below average levels. The resultant flows were at or below those of July 1989 but some 50 to 100% above flows recorded in 1976. Along the south coast, rivers were among the lowest since 1976 (see Table 3) and estimates of return periods for July flows were between 10 and 25 years (Table 4). A similar situation obtained with the Trent at Colwick (Nottingham). The Yorkshire Derwent again recorded a runoff figure close to long term minima and July was the 22nd month below average flow conditions. More impermeable catchments, such as the Mole and the Sussex Ouse have shown some response even from the modest rainfalls that were recorded, and this is reflected in the lower return periods of around 2 years.

Accumulated runoff totals for the 5 months since the beginning of March present a picture broadly similar to the July situation, although the partition of Scotland into those catchments draining from the central highland or to the west (wet) and the eastern catchments (dry) remains a distinct feature. This partition is continued through the longer time frames; the 10, 12 and 22 month periods illustrated in Table 3 for the Dee, Tay and Clyde demonstrate it well. The longer term accumulations in England and Wales reflect the extent of baseflow support and the long term rainfall deficiencies. High baseflow catchments are less responsive to even heavy rain and the less significant and/or summer rainfalls are highly damped in the flow response. Figure 2 hydrographs are instructive here: the Medway has exceeded the average for only two months in the last 24 - the spring 1989 and winter 1989-90 rainfalls followed below, or close to, historically minimum flows. The Medway is a mixed catchment, containing Chalk and clays and would be expected to respond to significant rainfall. The Itchen, a typical high baseflow catchment, from similarly low flow conditions, showed a subdued response in the spring of 1989; The 1989-90 winter, with its large, effective recharge volume, promoted above average flows for two months and sustained flows greater than those in 1989 through the spring and early summer. More responsive rivers show less significant shortfalls over the medium time frame owing to the domination of runoff by the exceptional winter rainfall, exemplified by the Teme, even though the long term shortfalls are again appreciable.

Groundwater

With the unusually low rainfall during July, there has been little, if any, recharge, even to fissure-type aquifers such as the Jurassic oolites or the Magnesian limestone, both of which generally react rapidly to rainfall even during the summer months. The recessions which commenced generally in late February have continued unabated, and by the end of July most index boreholes show groundwater levels substantially below the mean seasonal values. Table 5 illustrates the July 1990 situation with that obtaining in 1976 for a number of observation sites. In much of the south of England levels are well above those recorded in 1976. However, in eastern Yorkshire, parts of East Anglia, and eastern Kent, water tables appear to be especially low and are likely to approach (or possibly be less than) recorded minima by the end of the summer. If the winter rainfall is again delayed to, or beyond, the end of the year, it is probable that in these eastern districts, groundwater levels will pass below recorded minima.

With the general lack of rainfall, particularly in eastern districts, river flow and reservoir storage have already been substantially reduced. This may have a further deleterious effect upon groundwater levels should aquifer storage be further called upon to make good the shortfall.

Institute of Hydrology / British Geological Survey

15 August 1990

TABLE 1 1989/90 RAINFALL AS A PERCENTAGE OF THE 1941-70 AVERAGE

		Jun 1989	Jul	Aug	Sep	Oct	Nov	Dec	Jan 1990	Feb	Mar	Apr	May	Jun	Jul
England and	mm	55	38	58	41	98	61	134	133	142	20	38	25	72	35
Wales	%	90	52	65	49	118	63	149	154	219	34	66	37	118	47
NRA REGIONS															
North West	mm	82	33	116	29	145	84	100	196	187	47	52	49	108	55
	%	99	32	93	24	123	69	83	175	231	65	68	60	130	53
Northumbria	mm	51	19	77	20	71	35	75	111	133	33	28	51	84	40
	%	84	25	76	25	95	37	100	139	202	63	51	80	137	52
Severn Trent	mm	53	40	44	38	82	52	135	107	110	21	30	19	65	29
	%	95	62	54	57	126	66	193	155	208	40	58	30	115	44
Yorkshire	mm	69	43	41	20	77	45	98	118	112	24	24	29	90	34
	%	119	61	46	28	112	51	132	153	175	45	43	48	155	48
Anglia	mm	56	41	35	30	41	36	98	52	74	15	36	16	45	22
	%	114	72	55	58	79	58	185	101	177	38	90	34	93	39
Thames	mm	39	37	44	28	65	37	141	91	114	12	35	7	48	15
	%	75	62	63	45	102	51	214	147	242	26	76	13	92	25
Southern	mm	41	28	29	37	79	50	142	121	135	6	43	11	54	12
	%	82	54	40	52	101	53	175	159	238	12	90	20	108	21
Wessex	mm	32	37	43	49	101	58	165	124	157	15	35	13	65	30
	%	59	60	52	62	123	60	183	147	265	26	65	19	120	49
South West	mm	40	31	62	107	148	100	196	195	238	25	47	24	96	58
	%	62	37	61	103	131	75	145	151	264	30	66	29	148	69
Welsh	mm	67	48	91	62	180	109	199	240	214	37	45	33	93	48
	%	82	51	76	50	140	76	137	176	223	43	52	36	113	50
Scotland	mm	76	49	184	96	187	60	96	248	291	183	97	55	156	67
	%	83	44	143	70	126	42	62	181	280	199	108	60	170	60
RIVER PURIFICATION BOARDS															
Highland	mm	90	65	222	118	252	79	109	293	364	395	148	57	137	99
	%	82	51	150	75	135	47	56	179	274	346	130	55	125	78
North-East	mm	57	25	84	57	87	29	54	103	145	87	51	48	108	41
	%	81	27	79	66	90	28	53	114	195	140	84	62	154	45
Tay	mm	58	30	140	83	136	51	86	236	249	186	62	43	122	48
	%	70	29	119	72	111	43	64	200	270	227	83	45	147	47
Forth	mm	64	27	144	69	112	39	79	220	221	134	50	39	119	51
	%	85	28	124	64	106	36	72	222	287	194	74	46	159	52
Tweed	mm	51	23	113	47	68	30	78	166	180	53	47	46	101	54
	%	75	27	99	51	77	29	87	179	260	91	77	61	149	61
Solway	mm	71	42	176	77	145	59	119	250	282	97	50	77	120	77
	%	79	38	135	51	101	41	79	179	303	107	57	84	133	70
Clyde	mm	90	63	252	120	244	73	107	316	343	290	144	58	134	88
	%	87	48	177	69	133	44	58	196	304	276	140	60	130	68

Note: July figures for England and Wales for 1990 are based upon MORECS figures supplied by the Meteorological Office

Scottish RPB data for July 1990 are estimated from the isohyetal map of July rainfall in the MORECS bulletin.

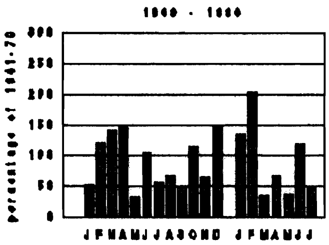
TABLE 2 RAINFALL RETURN PERIOD ESTIMATES

		MAR - JUL 90	Est Return Period, years	OCT 89 - JUL 90	Est Return Period, years	AUG 89 - JUL 90	Est Return Period, years	NOV 88 - JUL 90	Est Return Period, years
England and	mm	189		757		856		1375	
Wales	% LTA	60	50-80	102	2-5	94	2-5	88	5-10
NRA REGIONS									
North West	mm	311		1023		1168		1954	
	% LTA	75	5-10	106	2-5	96	2-5	94	2-5
Northumbria	mm	236		661		758		1214	
	% LTA	76	5-10	95	2-5	86	5-10	81	20-50
Severn Trent	mm	164		650		732		1179	
	% LTA	57	30-70	104	2-5	95	2-5	88	5-10
Yorkshire	mm	201		651		712		1198	
	% LTA	67	10-20	97	2-5	85	5-10	83	10-20
Anglia	mm	135		436		501		859	
	% LTA	58	30-70	88	2-5	82	5-15	84	10-30
Thames	mm	117		564		636		1010	
	% LTA	45	100-200	99	<2	90	2-5	83	10-20
Southern	mm	126		654		720		1101	
	% LTA	48	80-120	101	<2	91	2-5	81	15-25
Wessex	mm	158		763		855		1307	
	% LTA	53	50-70	108	2-5	98	2-5	87	5-10
South West	mm	250		1127		1296		1918	
	% LTA	65	10-20	114	5	109	2-5	93	2-5
Welsh	mm	255		1197		1350		2133	
	% LTA	58	30-70	110	2-5	101	<2	93	2-5
Scotland	mm	558		1440		1720		2841	
	% LTA	115	5-10	124	30-70	120	20-50	116	20-50
RIVER PURIFICATION BOARDS									
Highland	mm	836		1934		2274		3809	
	% LTA	147	150-250	137	>200	132	>200	129	>>200
North-East	mm	335		753		894		1454	
	% LTA	93	2-5	91	2-5	87	5-10	83	20-50
Tay	mm	461		1218		1441		2320	
	% LTA	105	2-5	119	10	115	5-10	108	5
Forth	mm	393		1063		1276		2047	
	% LTA	100	<2	119	10-20	114	5-10	108	5
Tweed	mm	301		823		983		1547	
	% LTA	86	2-5	103	2-5	98	2-5	90	5-10
Solway	mm	421		1276		1529		2477	
	% LTA	89	2-5	112	5	107	2-5	102	2-5
Clyde	mm	714		1797		2169		3479	
	% LTA	133	20-50	133	100-200	130	100-200	123	100-200

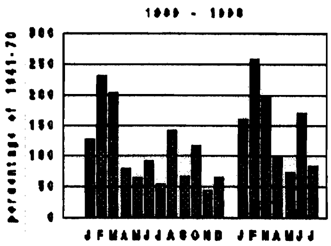
Return period assessments are based on tables provided by the Meteorological Office*. These assume a start in a specified month; return periods for a start in any month may be expected to be an order of magnitude less. "Wet" return periods underlined.
The tables reflect rainfall totals over the period 1911-70 only and the estimate assumes a sensibly stable climate.
The July 1990 RPB values are estimated from the isopleth map within the July summary published in the Met. Office's MORECS bulletin.

* Tabony, R C, 1977, The Variability of long duration rainfall over Great Britain, Scientific Paper No. 37, Meteorological Office (HMSO).

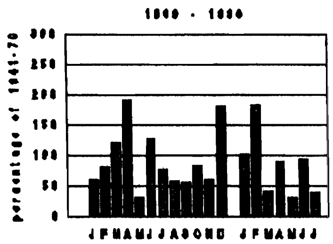
FIGURE 1. MONTHLY RAINFALL FOR 1989 – 1990 AS A PERCENTAGE OF THE 1941 – 1970 AVERAGE FOR ENGLAND AND WALES, SCOTLAND, AND THE NRA REGIONS



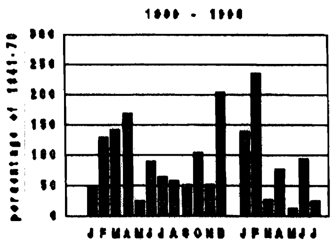
England and Wales



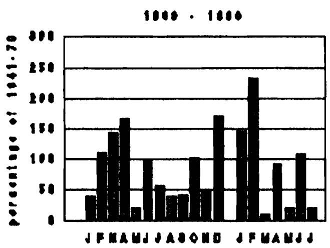
Scotland



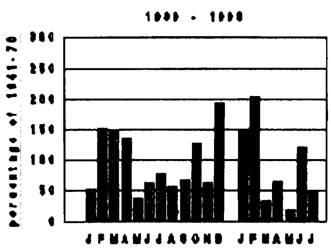
Anglian NRA Region



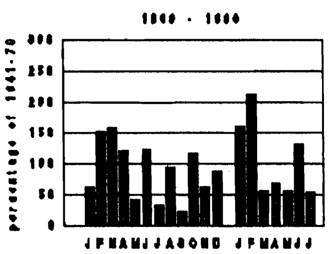
Thames NRA Region



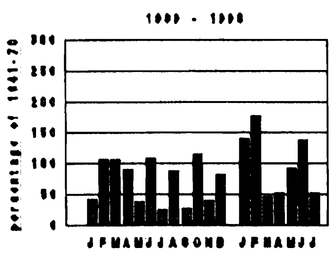
Southern NRA Region



Wessex NRA Region

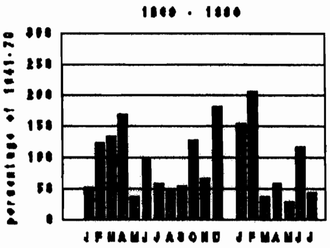


North West NRA Region

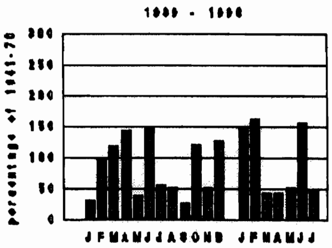


Northumbrian NRA Region

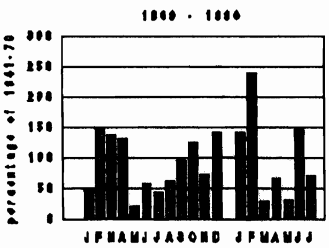
FIGURE 1 (continued)



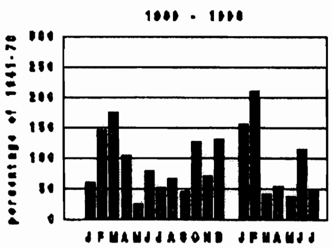
Severn-Trent NRA Region



Yorkshire NRA Region

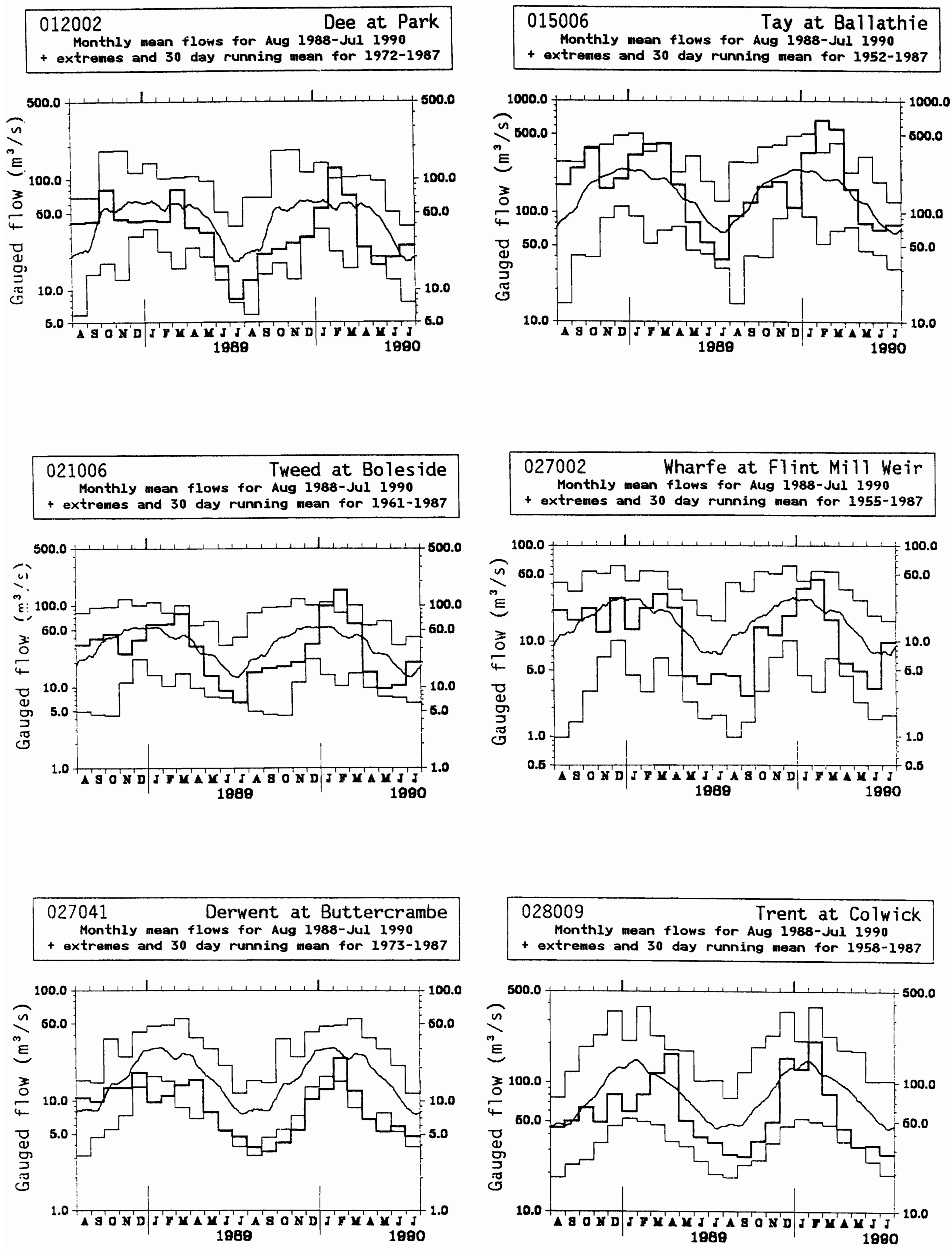


South West NRA Region

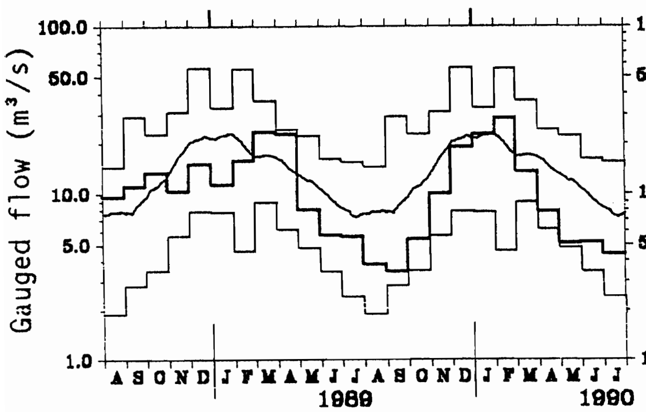


Welsh NRA Region

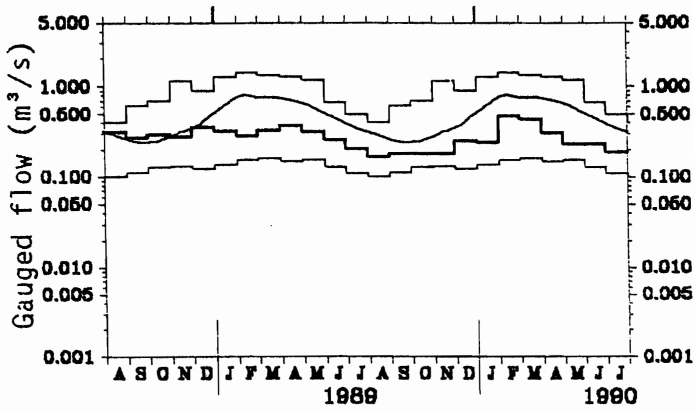
FIGURE 2 MONTHLY RIVER FLOW HYDROGRAPHS



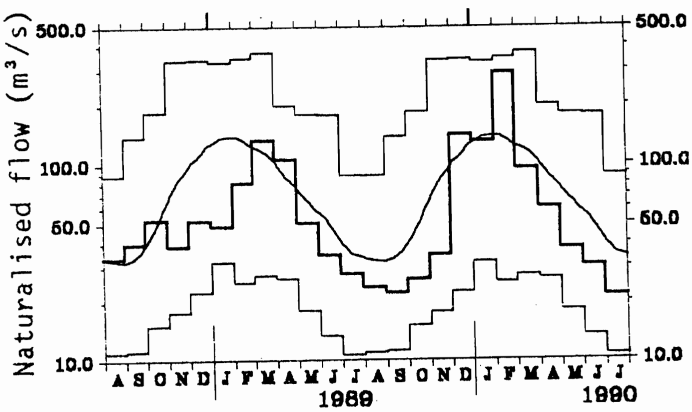
028018 Dove at Marston on Dove
Monthly mean flows for Aug 1988-Jul 1990
+ extremes and 30 day running mean for 1961-1987



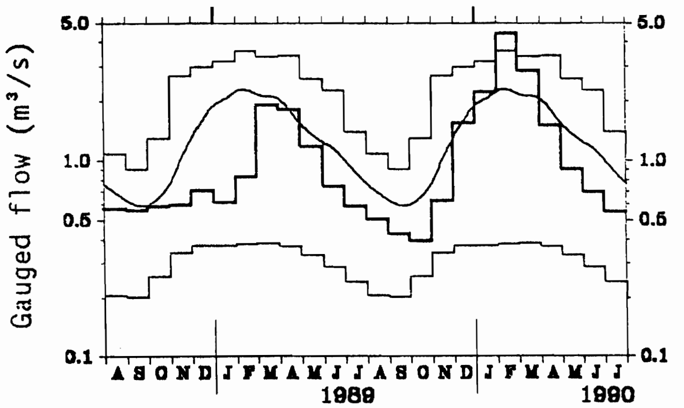
029003 Lud at Louth
Monthly mean flows for Aug 1988-Jul 1990
+ extremes and 30 day running mean for 1968-1987



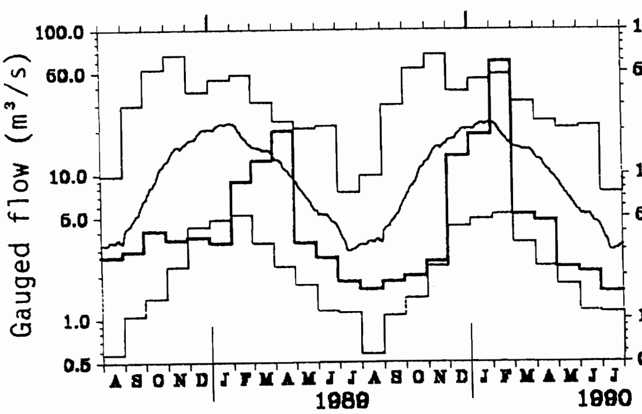
039001 Thames at Kingston
Monthly mean flows for Aug 1988-Jul 1990
+ extremes and 30 day running mean for 1883-1987



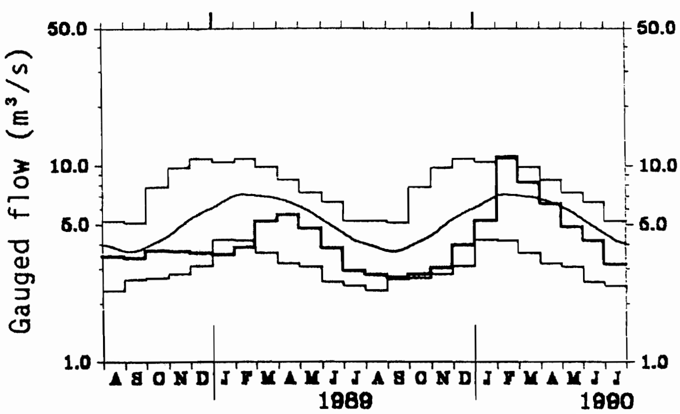
039020 Coln at Bibury
Monthly mean flows for Aug 1988-Jul 1990
+ extremes and 30 day running mean for 1963-1987



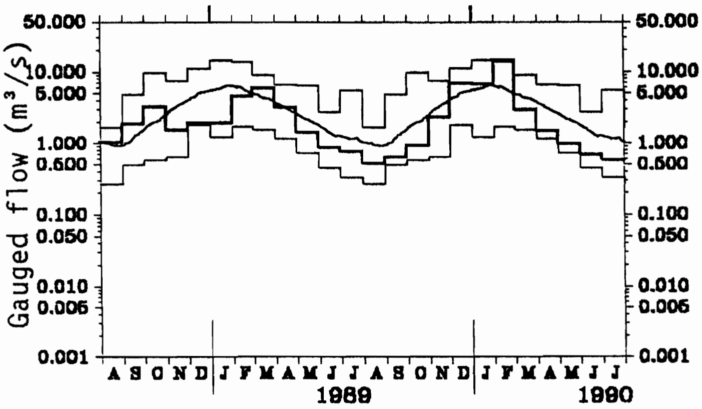
040003 Medway at Teston
Monthly mean flows for Aug 1988-Jul 1990
+ extremes and 30 day running mean for 1956-1987



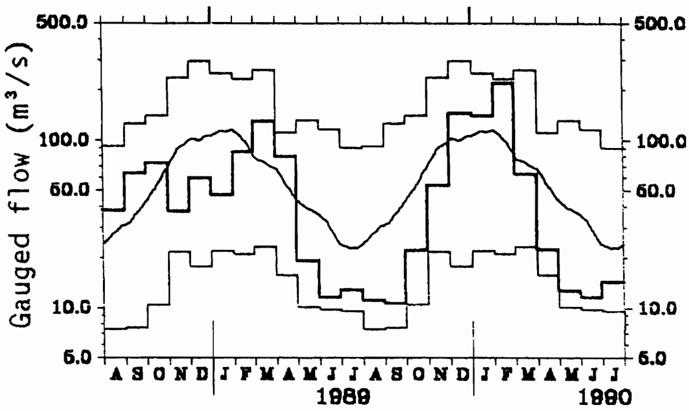
042010 Itchen at Highbridge+Allbrook
Monthly mean flows for Aug 1988-Jul 1990
+ extremes and 30 day running mean for 1958-1987



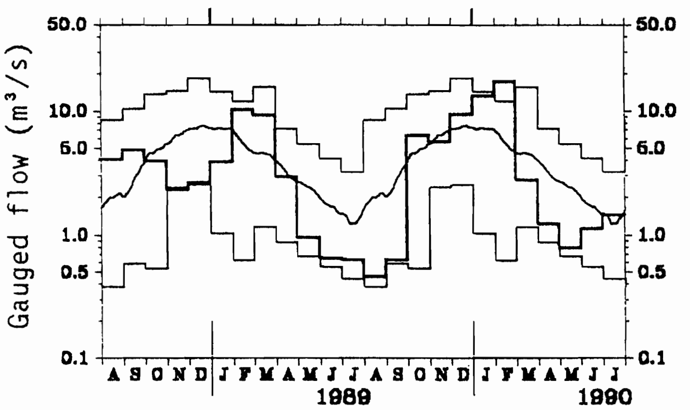
052005 Tone at Bishops Hull
Monthly mean flows for Aug 1988-Jul 1990
+ extremes and 30 day running mean for 1961-1987



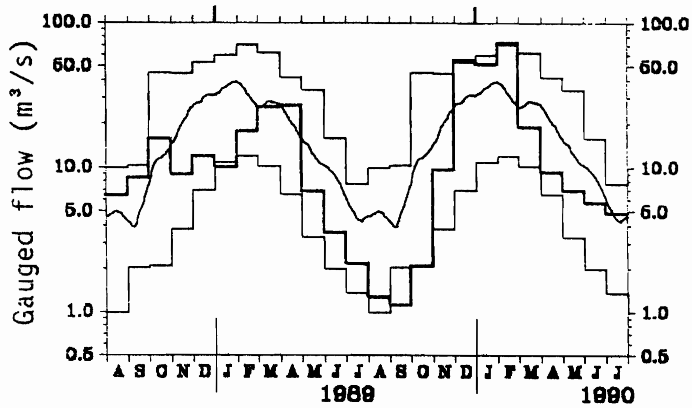
054001 Severn at Bewdley
Monthly mean flows for Aug 1988-Jul 1990
+ extremes and 30 day running mean for 1921-1987



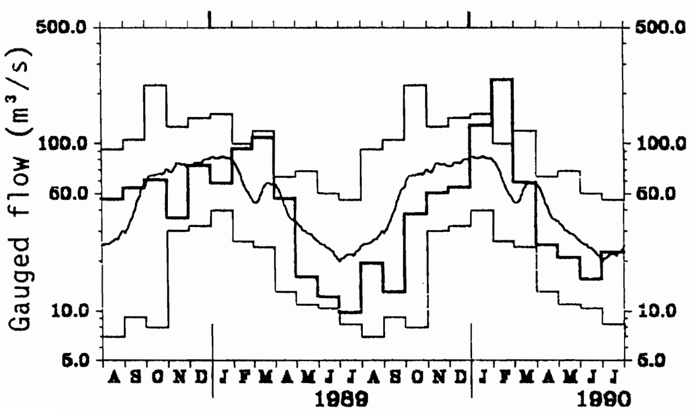
057004 Cynon at Abercynon
Monthly mean flows for Aug 1988-Jul 1990
+ extremes and 30 day running mean for 1957-1987



054029 Teme at Knightsford Bridge
Monthly mean flows for Aug 1988-Jul 1990
+ extremes and 30 day running mean for 1970-1987



076007 Eden at Sheepmount
Monthly mean flows for Aug 1988-Jul 1990
+ extremes and 30 day running mean for 1967-1987



084013 Clyde at Daldowie
Monthly mean flows for Aug 1988-Jul 1990
+ extremes and 30 day running mean for 1963-1987

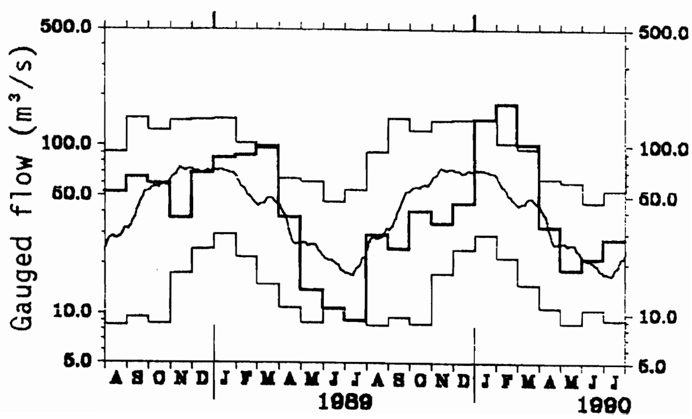


TABLE 3 RUNOFF AS MM. AND AS A PERCENTAGE OF THE PERIOD OF RECORD AVERAGE WITH SELECTED PERIODS RANKED IN THE RECORD

River/ Station name	Mar 1990	Apr	May	Jun	July 1990		3/90 to 7/90		10/89 to 7/90		8/89 to 7/90		11/88 to 7/90	
	mm %LT	mm %LT	mm %LT	mm %LT	mm %LT	rank /yrs	mm %LT	rank /yrs	mm %LT	rank /yrs	mm %LT	rank /yrs	mm %LT	rank /yrs
Dee at	103	34	24	28	37	13	226	6	584	2	631	2	1123	2
Park	113	43	37	75	134	/18	76	/18	81	/17	79	/17	79	/17
Tay at	324	91	47	40	46	27	548	38	1372	37	1495	34	2546	37
Ballathie	268	110	67	89	116	/38	150	/38	138	/38	133	/37	127	/37
Tweed at	105	26	17	18	36	24	202	12	748	26	805	19	1361	12
Boleside	133	51	39	64	134	/29	89	/29	114	/29	108	/28	102	/28
Wharfe at	59	20	17	11	34	25	142	5	562	9	586	6	1071	4
Flint Mill Weir	78	36	44	44	127	/35	65	/35	89	/35	81	/34	83	/34
Derwent at	21	11	9	10	8	3	59	1	151	1	163	1	326	1
Buttercrambe	46	33	35	59	60	/17	45	/17	49	/17	48	/16	52	/16
Trent at	29	15	11	11	10	2	77	2	274	9	293	7	528	4
Colwick	71	45	43	57	62	/32	58	/32	84	/32	82	/31	80	/31
Dove at	41	23	15	15	13	5	108	3	357	4	378	3	728	3
Marston on Dove	75	53	42	57	57	/29	60	/29	79	/29	76	/27	79	/27
Lud at	21	15	11	11	9	3	67	3	129	3	145	3	274	2
Louth	56	45	39	53	54	/22	50	/22	52	/22	54	/22	55	/21
Bedford Ouse at	17	10	6	5	4	25	42	16	216	31	225	31	402	26
Bedford	54	49	45	61	67	/58	53	/58	104	/57	103	/57	96	/56
Colne at	9	7	4	4	2	4	27	5	95	6	102	5	206	6
Lexden	48	52	45	73	47	/31	53	/31	73	/31	73	/30	78	/30
Mimram at	14	12	10	8	7	5	51	10	98	11	111	10	199	9
Panshanger Park	105	94	81	73	72	/38	87	/38	90	/37	88	/37	88	/36
Thames at	25	16	10	8	6	21	65	27	224	50	236	48	386	29
Kingston (natr.)	80	71	57	63	63	/108	69	/108	98	/107	96	/107	84	/106
Coln at	71	36	23	17	14	3	161	7	380	11	403	9	624	6
Bibury	132	83	69	63	66	/27	90	/27	104	/27	102	/26	84	/26
Mole at	21	22	14	18	18	14	93	2	422	10	443	8	738	1
Kinnersley Manor	40	63	52	100	141	/17	64	/16	99	/15	97	/15	86	/13
Medway at	11	10	5	4	3	2	33	2	225	10	232	8	355	1
Teston	35	44	34	41	47	/34	40	/29	85	/28	82	/27	68	/24
Ouse at	24	20	10	9	9	15	72	4	318	11	335	11	520	3
Gold Bridge	52	58	40	58	89	/30	56	/30	86	/29	85	/29	71	/27
Itchen at	61	46	36	30	23	3	196	7	382	10	422	8	691	2
Highbridge+Allbrook	117	98	84	86	75	/32	95	/32	93	/32	91	/31	82	/31
Stour at	47	22	15	10	6	2	101	5	421	11	434	11	660	4
Throop Mill	90	63	63	63	53	/18	74	/18	112	/17	109	/17	88	/16
Tone at	38	19	13	9	8	2	87	2	477	19	492	15	776	5
Bishops Hull	65	48	46	50	51	/30	55	/30	106	/29	103	/29	86	/28
Brue at	26	12	8	7	5	3	59	2	381	10	391	7	667	2
Lovington	50	39	34	46	30	/26	43	/26	94	/26	89	/25	82	/25
Severn at	39	13	8	7	9	17	76	7	418	39	432	33	722	16
Bewdley	84	41	33	40	63	/70	56	/69	101	/69	95	/69	87	/68
Teme at	34	16	12	10	9	12	82	4	413	18	417	16	617	5
Knightsford Bridge	67	45	56	70	109	/21	64	/20	115	/20	111	/20	87	/19
Cynon at	70	30	20	28	37	22	184	6	1445	30	1472	23	2285	15
Abercynon	58	39	33	69	109	/32	56	/32	129	/32	117	/30	102	/30
Lune at	77	43	28	15	68	21	231	6	1101	20	1147	14	1967	12
Caton	77	58	56	37	132	/28	74	/28	113	/26	101	/26	99	/24
Eden at	68	28	24	17	26	13	165	7	733	15	770	13	1287	10
Sheepmount	99	60	73	66	95	/20	83	/20	118	/19	112	/18	106	/17
Clyde at	143	45	26	29	39	23	282	26	873	26	948	24	1558	24
Daldowie	198	109	74	110	146	/27	138	/27	132	/27	124	/26	117	/26

Notes
(i) Values based on gauged flow data unless flagged (natr.), when naturalised data have been used.
(ii) Values are ranked so that lowest runoff as rank 1;
(iii) %LT means percentage of long term average from the start of the record to 1989. For the long periods (at the right of this table), the end date for the long term is 1990.

TABLE 4 RIVER FLOW RETURN PERIODS

River	Station Name	First Year of Rec.	Mean July Flow	1990 July Flow	Return Period (in years)	Base Flow Index [b]
Derwent	Buttercrambe (Yorks)	1973	7.12	4.76	5-10	0.68
Trent	Colwick	1959	45.1	28.0	15-25	0.64
Dove	Marston on Dove	1961	7.00	4.36	5-10	0.60
Lud	Louth	1968	0.34	0.19	5-10	0.90
Witham	Claypole Mill	1959	0.80	0.46	5	0.67
Colne	Lexden (Essex)	1959	0.38	0.20	5-10	0.53
Mimram	Panshanger Park	1952	0.49	0.33	5-10	0.94
Turkey Brook	Albany Park	1971	0.043	0.009	25-50	0.21
Thames	Kingston (nat)	1951*	39.76	21.3	20-40	0.64
Coln	Bibury	1963	0.85	0.55	10	0.94
Medway	Teston	1956	3.00	1.54	15-25	0.41
Ouse	Gold Bridge	1960	0.681	0.64	2	0.49
Itchen	Highbridge	1958	4.12	3.15	10	0.97
Stour	Throop Mill	1973	4.50	2.40	5-10	0.66
Tone	Bishops Hull	1961	1.18	0.57	15-20	0.58

Note (i) The stations featured are drawn from those areas where the hydrological drought is currently most severe

Note (ii) The precision of low flow measurement may be affected by gauge sensitivity and, further, by uncertainties in summer stage discharge relations which are generally addressed retrospectively. The pattern of water utilisation in certain catchments, particularly regulation and/or augmentation at low flows, plus the the influence of abstractions and the discharge of sewage effluent, means some return periods need to be treated with especial care.

* This shorter data series is used (rather than that dating from 1883), as it corresponds to the more accurate assessments of low flows at Teddington weir following structural alterations to the gauge.

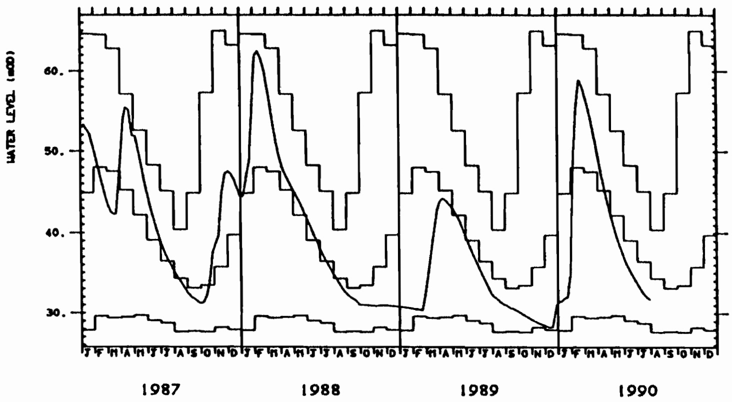
b The base flow index is an indicator of what proportion of the the hydrograph is represented by base flow following a hydrograph separation exercise on the whole record. The lower the index, the lower the base flow contribution and the more responsive the catchment is to rainfall.
See: Low Flow Studies, 1980 NERC

FIGURE 3 GROUNDWATER HYDROGRAPHS

Site name: COMPTON HOUSE

National grid reference: SU 7755 1490 — Well number: SU71/23

Aquifer: CHALK AND UPPER GREENSAND — Measuring level: 81.37

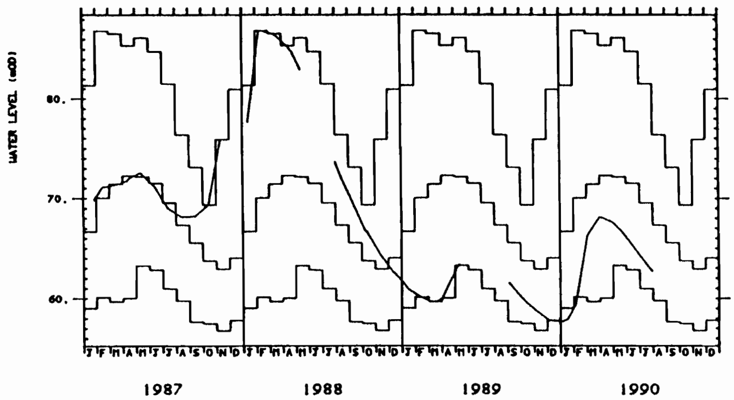


Max, Min and Mean values calculated from years 1894 TO 1989

Site name: LITTLE BUCKET FARM,WALTHAM

National grid reference: TR 1225 4690 — Well number: TR14/9

Aquifer: CHALK AND UPPER GREENSAND — Measuring level: 87.33



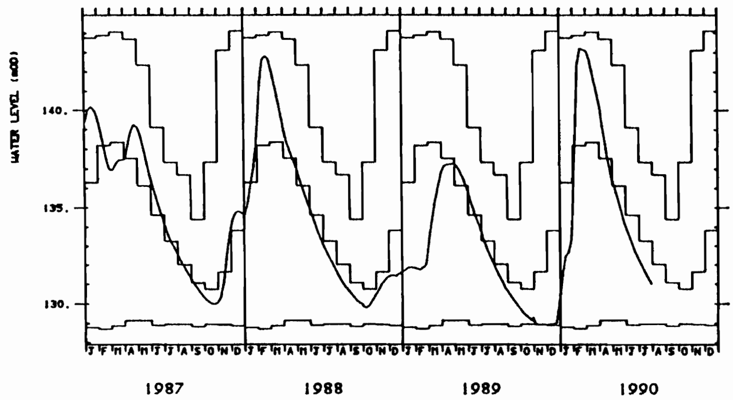
Max, Min and Mean values calculated from years 1971 TO 1989

A break in the data line indicates a recording interval of greater than 8 weeks

Site name: ROCKLEY

National grid reference: SU 1655 7174 — Well number: SU17/57

Aquifer: CHALK AND UPPER GREENSAND — Measuring level: 146.39

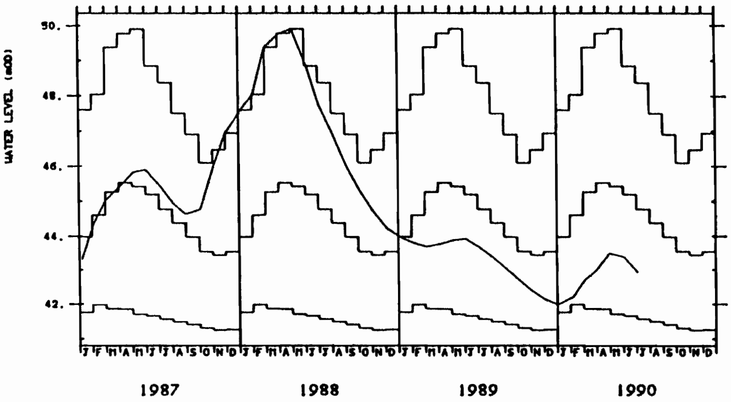


Max, Min and Mean values calculated from years 1933 TO 1989

Site name: WASHPIT FARM

National grid reference: TF 8138 1960 Well number: TF81/2

Aquifer: CHALK AND UPPER GREENSAND Measuring level: 80.20

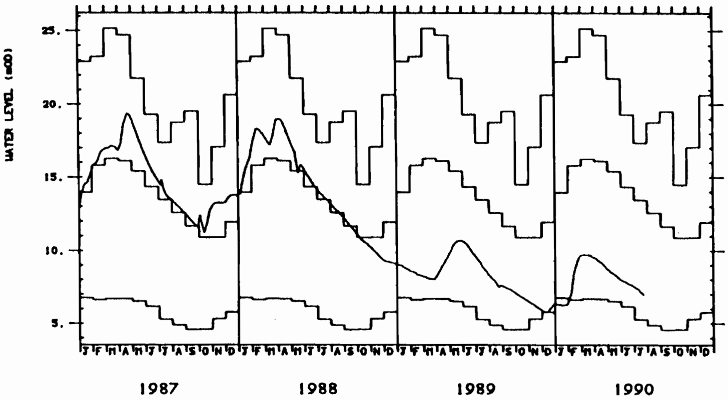


Max, Min and Mean values calculated from years 1950 TO 1989

Site name: LITTLE BROCKLESBY

National grid reference: TA 1371 0888 Well number: TA10/40

Aquifer: CHALK AND UPPER GREENSAND Measuring level: 44.33

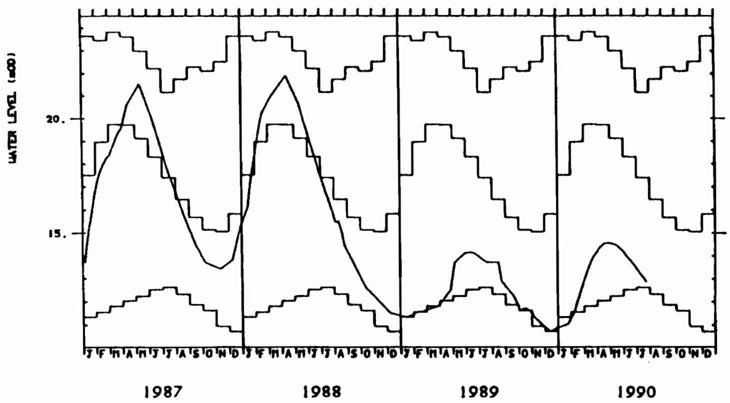


Max, Min and Mean values calculated from years 1926 TO 1989

Site name: DALTON HOLME

National grid reference: SE 9651 4530 Well number: SE94/5

Aquifer: CHALK AND UPPER GREENSAND Measuring level: 33.50

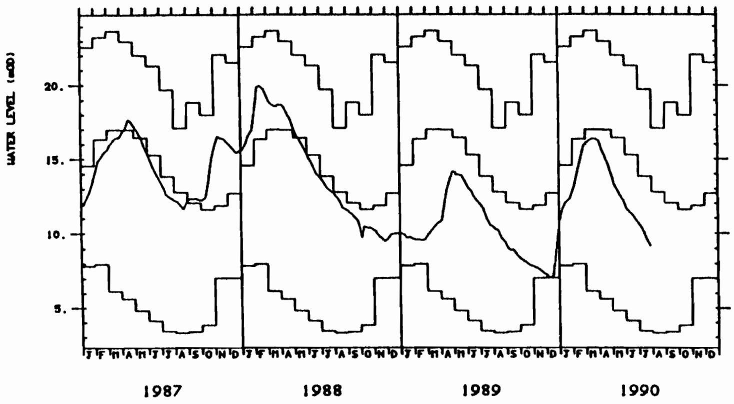


Max, Min and Mean values calculated from years 1889 TO 1989

Site name: NEW RED LION

National grid reference: TF 0885 3034 Well number: TF03/37

Aquifer: LINCOLNSHIRE LIMESTONE Measuring level: 33.82



Max, Min and Mean values calculated from years 1964 TO 1989

FIGURE 4 LOCATION MAP OF GROUNDWATER INDEX WELLS

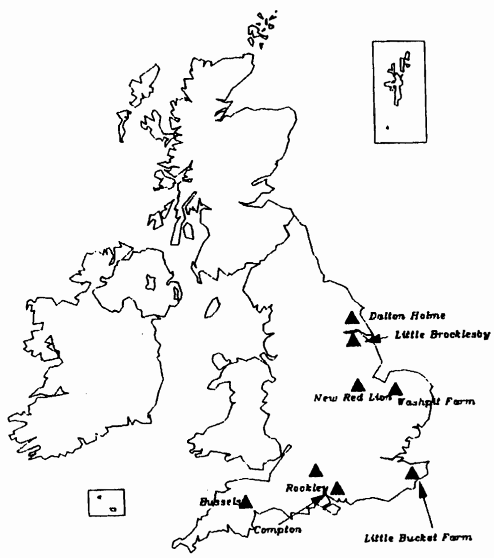


TABLE 5 A COMPARISON OF JULY GROUNDWATER LEVELS: 1990 AND 1976

Borehole	Aquifer	Fisrt year of record	Av. July level	Jul Day	1976 level	Jul Day	1990 level	No. of years of record with Jul. levels <1990
Dalton Holme	C & U.G.	1889	17.43	24	13.20	25	12.85	1
L. Brocklesby	"	1926	13.44	30	5.26	24	6.96	1
Washpit Farm	"	1950	44.77	1	42.20	5	42.92	3
Rockley	"	1933	133.25	25	128.97	31	130.98	7
Compton House	"	1894	36.44	22	28.75	31	31.75	4
L. Bucket Farm	"	1971	69.53	13	60.97	25	63.08	2
New Red Lion	L.L	1964	13.83	20	3.42	30	9.17	1

C & U.G. Chalk and Upper Greensand;
L.L Lincolnshire Limestone
PTS Permo - Triassic Sandstone