HYDROLOGICAL SUMMARY - SEPTEMBER 1989

Data for this review have been provided, principally, by the regional divisions of the National Rivers Authority and by the Meteorological Office. Some rainfall and runoff figures are included for Scotland; a more extensive coverage will be given in future summaries.

The rainfall figures are derived from a restricted network of raingauges and some of the flow data are of a provisional nature.

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

Summary

The rainfall distribution in September was rather different from that which has characterised much of the late spring and summer. Nonetheless, monthly rainfall totals were again well below average in most areas. A few active cyclonic episodes brought relief especially in the South West but generally the drought intensified and extended its range through the month, especially in northern England.

An intense five-month drought of relatively uniform severity - in rainfall terms - has now developed throughout England and Wales and part of eastern Scotland. Longer-term rainfall deficits of a large magnitude - particularly for the periods commencing in April and November 1988 - may also be recognised. There remains a clear regional dimension to these extended droughts. The worst affected areas are in the English lowlands (with the exception of East Anglia) and the North-East; on the eighteen month timescale there is an especially notable drought in the Southern NRA region.

River flows, in most areas, responded to the heavy frontal rainfall in mid-month but, overall, monthly runoffs were below, or comparable with, those registered in August. Flows are substantially below average in all regions and less than one-third of the normal September runoff was recorded for some rivers where baseflow support is minimal. The rapid increase in autumn discharge rates during the terminal phase of the 1976 and 1984 droughts make comparisons with these events increasingly meaningless. Current flows, over wide areas are now broadly similar those experienced in the autumn of 1959 or 1964. In return period terms, September runoff totals were, typically, in the range to be expected once every 10-20 years or so but a few rivers draining high baseflow catchments in the East and, especially, the South are now registering unprecedented flows. A number of rivers draining relatively impervious catchments in the north of England have registered exceptionally low runoff totals over the May to September period.

No significant recharge to major aquifers normally occurs in late summer and early autumn and groundwater levels continued their seasonal recession. Water tables are everywhere below, to well below, the seasonal mean and in east Yorkshire and along parts of the southern coastal belt are approaching their lowest recorded values.

The limited rainfall over the last year and the consequent depressed runoff and recharge rates, together with the large soil moisture deficits obtaining over wide areas, are evidence of a fragile water resources situation. If the current unsettled conditions prove to be merely another wet interlude then real concern for the adequacy of water resources will be justified. Abundant rainfall over the next two months will be required to facilitate significant reservoir and aquifer replenishment and to improve the resources situation both in the immediate future and in relation to the outlook for 1990.

Review

Though September was relatively cloudy with sunshine hours a little below average, dry days were unusually common - an enduring feature of weather conditions, especially in the lowlands, for a year or more. Unsettled weather in the middle of the month brought significant rainfall to most regions but anticyclonic conditions then became re-established and, throughout much of Great Britain, little more than a trace of rainfall was recorded in the fortnight up to October 4th. September rainfall totals exceeded the average in parts of Devon and Cornwall and a few localities in north-eastern Scotland. Most regions however received less than three-quarters of normal rainfall, northern England being exceptionally dry (see Table 1).

Rainfall over England and Wales as a whole was substantially below average for the third month in a row (see Figure 1) and the accumulated total since May 1st (225 mms) is the lowest this century with the exception of the 1921 (221 mm) and 1959 (183 mm) droughts. The intensification of the drought in northern areas, especially since June, has resulted in an unusually uniform rainfall deficiency - expressed as a percentage of the mean - over the last five months. In all NRA regions except Anglia, rainfall has been between 49 and 61 per cent of the average (Table 2). In most areas such shortfalls would be expected less often than once every 20-30 years, considerably so in Northumbria, Wales and the Southern NRA region. Rainfall over the February to April period was a moderating influence everywhere and rainfall deficits in the 6 to 9 month timescale are, generally, unremarkable. The two-phase nature of the 1988/89 drought is, however, evident when the full period since last November is considered; Table 2 also testifies to the large spatial variation in intensity within this timeframe. Additionally, a severe long term (18-month) drought may also be recognised in the Southern NRA area where the rainfall deficit since April 1988 exceeds 340 mm.

Estimated return periods for the current drought in a number of regions, and covering a number of durations, are well in excess of 30 years. It is to be expected, therefore, that water supply systems will be under considerable stress in various parts of Great Britain. A repeat of last year's dry winter may be expected to result in substantial water resources problems next year. Such a scenario would require, however, that a rainfall total of less than 1000 mm was recorded for the period November 1988 to March 1990 over England and Wales (17 months); there has been only one corresponding period - 1932 to 1934 - for which rainfall has been this limited in the last 140 years. To allow water resources to return to an average - as opposed to an adequate - status by next April, will require rainfall over the 1989/90 winter half-year to be well above the 1941-70 mean, especially in the South.

Mean temperatures were, again, above average in September particularly in the South-East. However, the potential for further increases in soil moisture deficits remained small. Some fluctuations did occur through the month with a widespread decline early in the third week followed by a steady increase into October. By the 27th September, SMDs exceeded 125 mm throughout eastern England and the Midlands and substantial deficits had built up in eastern Scotland. In England and Wales, SMDs were greater than the long term average in all districts, often by more than 50 mm. Deficits of this magnitude will clearly limit the hydrological effectiveness of rainfall over the next couple of months; this serves to emphasise the need for prolonged rainfall to generate a sustainable upturn in runoff and recharge rates.

In some areas, most importantly the South-West, heavy rainfall - which exceeded the infiltration capacity of the soils - did contribute significantly to river discharge in September. In some western and upland catchments, a brisk flow increase was, typically, reported in mid-September but subsequently steep recessions became established. Elsewhere, monthly runoff totals were generally similar to those recorded for August (Table 3). This implies a continuing decline in flow rates relative to the seasonal average (see Figure 2). Monthly flows, broadly speaking, are now less than those experienced in September 1976 and 1984. Exceptions are for rivers sustained largely from baseflow where the response to the heavy rainfall, which terminated the last two droughts, was considerably delayed.

The September runoff rankings presented in Table 3 and the associated return periods given in Table 4 testify to a moderately severe drought - in river flow terms - with extremely low flows confined to a few catchments. Catchment geology is a more important determining factor than geographical location; the longer return periods show little regional coherence. Very low flows characterise both relatively impervious catchments in the west and north (a response to the limited rainfall since May) and high baseflow rivers in the east and south (where the long term rainfall deficit is a major factor). In a few rivers, flows are unprecedented. With the September flow adjusted to allow for the impact of artificial augmentation from groundwater, the River Itchen (Hampshire), for instance, registered an absolute minimum monthly runoff total in a 31-year record. Over the 1988/89 water-year (Oct-Sept) total runoff is well below average but not remarkably so in most catchments; Figure 3 illustrates the greater severity of a selection of droughts in four English catchments. Throughout much of the English lowlands the same is true of May-September 1989. For moch of the North, however, flows have been very low since late spring and the accumulated runoff over the last five months is the lowest on record for several rivers. The associated return periods exceed 50 years in parts of Northumbria and are notable, also, in Yorkshire and the North-West.

Whilst groundwater levels through the late winter of 1988 and the early spring of 1989 were the lowest since the equivalent period of 1975-76 over wide areas, the subsequent infiltration, although limited compared with winter recharge in a normal year, boosted groundwater resources at a time when a seasonal decline in levels is generally under way. Consequently, in early summer, water tables stood at around average levels in some regions (see, for instance, the Compton and Rockley well hydrographs - Figure 4), although most observation boreholes showed levels somewhat below the average for June. However, only in parts of the Chalk aquifer in Sussex, Kent and Yorkshire were levels reported comparable with those registered in June 1976; increased abstraction rates (to supplement overground supplies) as well as the meteorological conditions are an important factor in some of these localities.

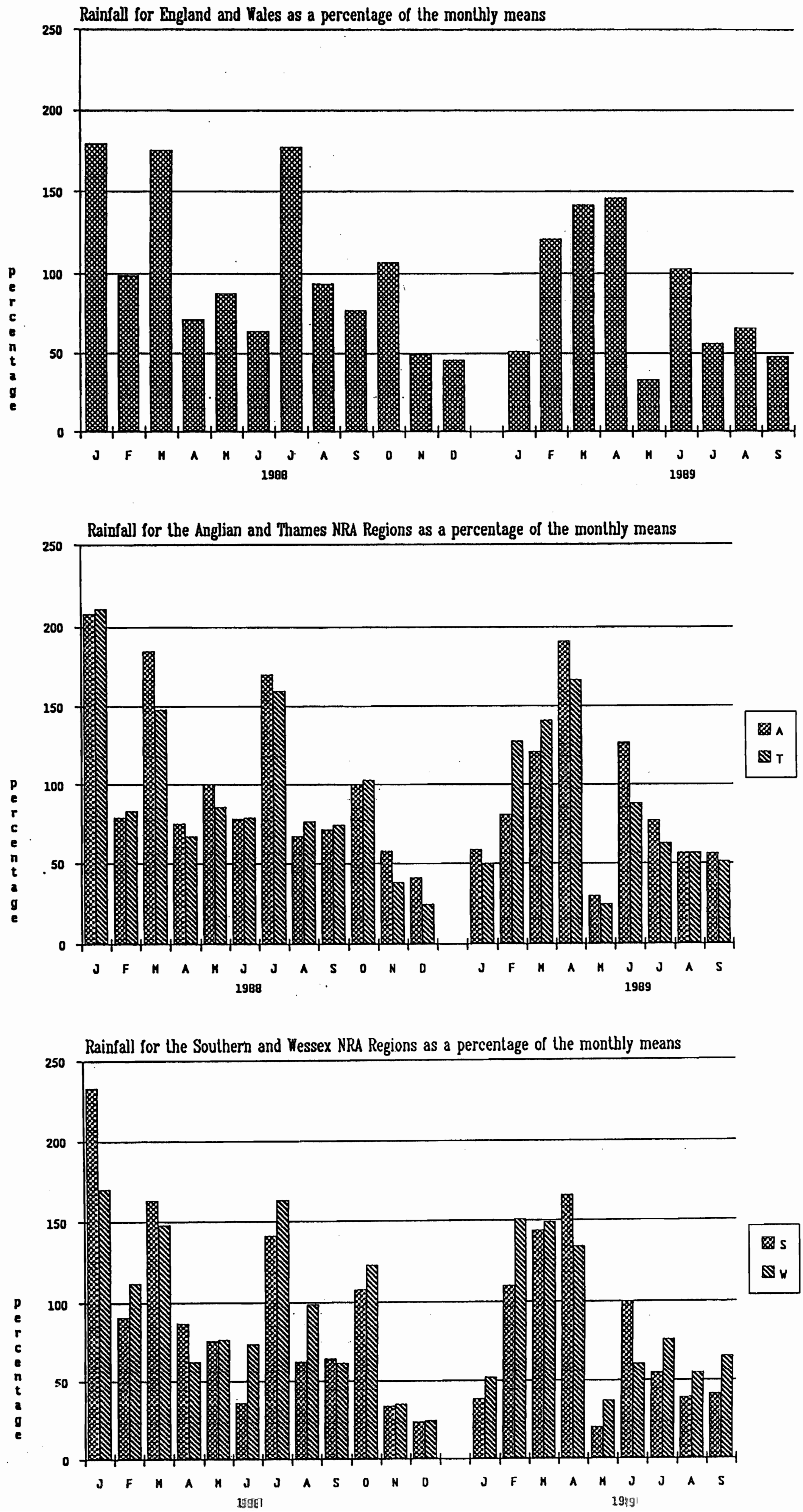
Infiltration appears generally to have ceased by June 1989, and groundwater hydrographs have since followed a steady recession. By mid-September, levels were for the most part well below the seasonal mean. At the Dalton Holme site, located in the Yorkshire Chalk, where the winter recharge of 1988-89 had been very modest, the groundwater level was close to the monthly minimum in a 100-year record. In the south-west of England, which has experienced particularly low summer rainfall after only a limited winter recharge, a steep recession has apparently been halted for the moment by mid-September rainfall.

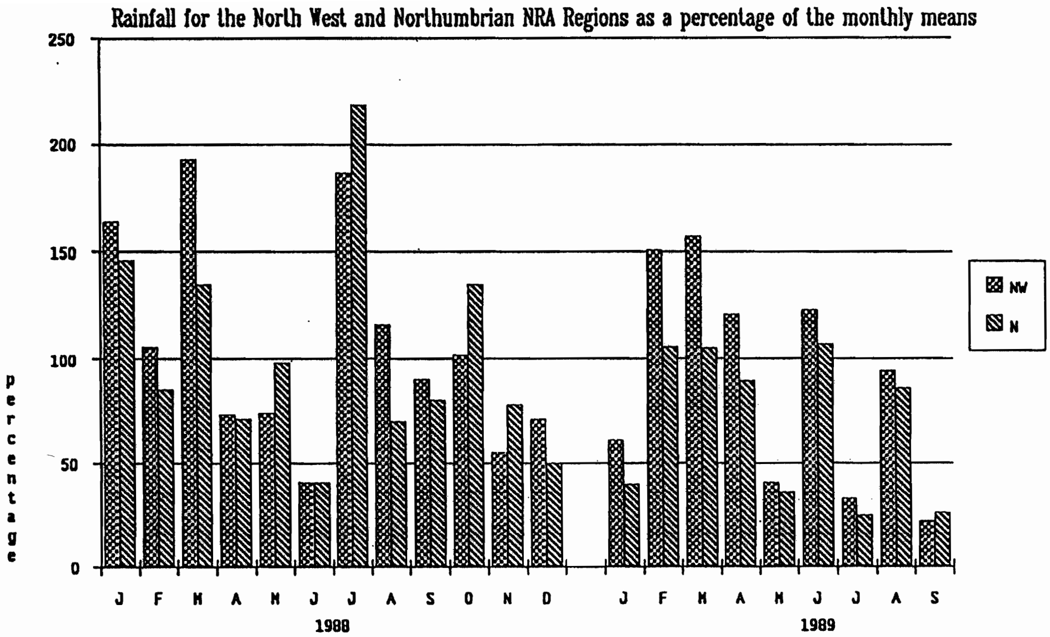
In a normal year, rainfall in September is sufficient to considerably reduce soil moisture deficits and permit infiltration to take place from early October. This year, over most of England and Wales, the September rainfall has been insufficient for this purpose. Consequently, even with mean October precipitation, the upturn in groundwater levels is unlikely to take place generally before the end of the month. Serious groundwater shortages, other than those of a localised nature, may be anticipated only if, as happened in 1988, autumn and early winter rainfall is inadequate to allow normal recharge to produce a substantial upturn in groundwater levels.

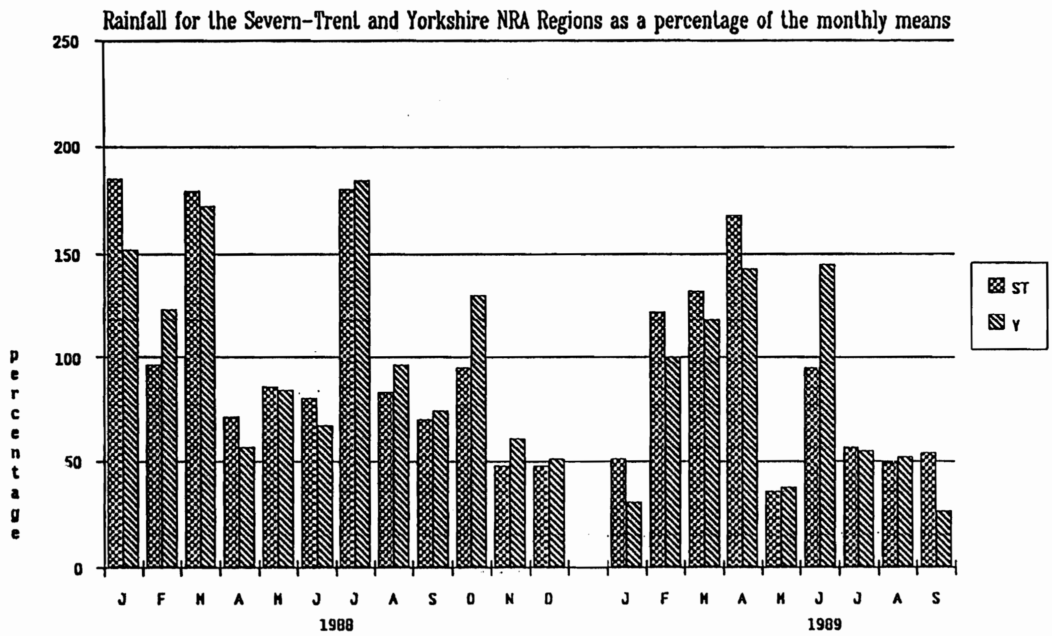
IH/BGS

13/10/89

FIGURE 1 MONTHLY RAINFALL - JANUARY 1988 TO SEPTEMBER 1989




Rainfall for the North West and Northumbrian NRA Regions as a percentage of the monthly means
250
200
150
100
50
0
percentage
NW
N
J F M A M J J A S O N D
1988
J F M A M J J A S
1989


Rainfall for the Severn-Trent and Yorkshire NRA Regions as a percentage of the monthly means
250
200
150
100
50
0
percentage
ST
Y
J F M A M J J A S O N D
1988
J F M A M J J A S
1989

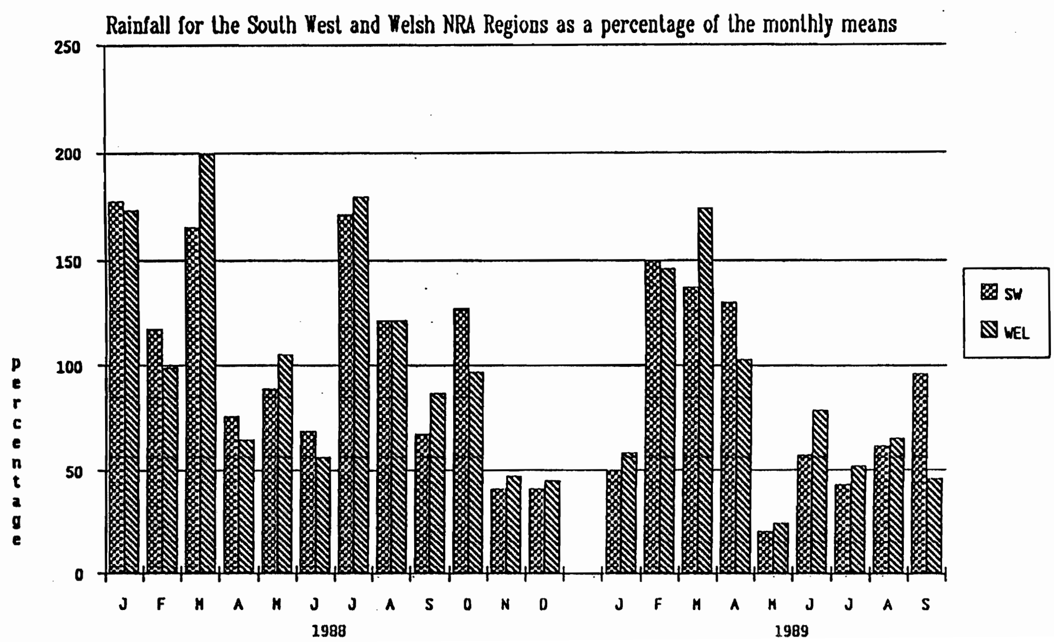

Rainfall for the South West and Welsh NRA Regions as a percentage of the monthly means
250
200
150
100
50
0
percentage
SW
WEL
J F M A M J J A S O N D
1988
J F M A M J J A S
1989

TABLE 1 1988/9 RAINFALL IN MM AND AS A PERCENTAGE OF THE 1941-70 AVERAGE

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct-Sep	Shortfall in mm	Oct75 - Aug76
		1988			1989											
England and Wales	mm	89	48	47	44	78	84	85	22	63	41	60	40	700	212	618
	%	107	49	52	51	121	142	146	33	103	56	66	48	77		68
Scotland	mm	170	99	149	172	239	188	71	58	84	60	181	89	1560	-129	117
	%	114	70	96	126	230	204	79	64	91	54	140	65	109		82
WATER AUTHORITIES																
North West	mm	120	69	117	68	123	113	92	33	102	34	118	28	1016	201	925
	%	102	55	97	61	151	157	120	40	123	33	94	22	83		76
Northumbria	mm	101	74	53	32	70	55	49	25	65	19	87	21	651	228	667
	%	135	79	71	40	106	105	89	38	107	25	86	26	74		76
Severn Trent	mm	62	38	33	35	65	69	87	23	53	37	40	37	579	195	543
	%	95	48	47	51	122	132	168	35	95	57	49	54	75		70
Yorkshire	mm	90	55	47	24	64	63	79	24	84	38	47	19	634	199	651
	%	130	62	63	31	100	118	140	40	145	55	52	27	76		78
Anglia	mm	52	35	22	31	34	48	74	14	62	44	37	29	482	129	399
	%	100	57	41	59	81	121	186	30	127	77	57	56	79		65
Thames	mm	66	28	16	31	68	65	77	14	46	38	40	32	513	191	390
	%	103	38	24	50	129	141	167	25	88	63	57	51	73		55
Southern	mm	84	32	19	29	62	75	81	11	50	32	28	29	532	262	455
	%	108	34	23	38	109	144	169	20	100	55	39	41	67		57
Wessex	mm	101	33	22	44	89	87	74	25	33	47	45	52	642	217	525
	%	123	35	24	52	151	149	137	36	61	76	55	66	75		60
South West	mm	144	55	59	65	135	115	92	18	38	36	63	99	919	275	749
	%	127	41	44	50	151	137	130	21	58	43	62	96	77		63
Welsh	mm	125	69	73	80	140	151	89	23	65	49	78	57	999	335	869
	%	97	48	50	59	146	174	103	25	79	52	66	46	75		65

Note: January to September rainfalls are based upon MORECS figures supplied by the Meterological Office.

TABLE 2 A GUIDE TO RAINFALL RETURN PERIODS

		MAY-SEP 1989	Est. Return Period	NOV-SEP 1988-89	Est. Return Period	APR-SEP 1988-89	Est. Return Period
England and Wales	mm	225		611		1116	
	% LTA	60	40-50	74	20-30	83	20
Scotland	mm	472		1390		2236	
	% LTA	84	0-5	108	0-5	107	0-5
WATER AUTHORITIES							
North West	mm	314		896		1614	
	% LTA	61	30-40	82	10	89	5-7
Northumbria	mm	217		550		1080	
	% LTA	57	50-80	68	70-100	82	20
Severn Trent	mm	190		517		947	
	% LTA	57	40-50	73	20-30	82	15-20
Yorkshire	mm	212		544		1023	
	% LTA	60	25-35	71	40-50	83	15-20
Anglia	mm	186		430		775	
	% LTA	69	10-20	77	10-20	84	10
Thames	mm	170		447		828	
	% LTA	57	30	70	20-30	79	20
Southern	mm	150		448		809	
	% LTA	49	70-100	63	70-100	70	70-100
Wessex	mm	202		551		1009	
	% LTA	59	20-30	70	25-35	80	15-20
South West	mm	254		775		1430	
	% LTA	58	30-40	72	25-35	84	10-15
Welsh	mm	272		874		1618	
	% LTA	53	70-100	73	30-40	84	10-15

Return period estimates are based principally on tables provided by the Meteorological Office; the tables reflect rainfall totals over the period 1911-70 only and the estimates assume a sensibly stable climate.

TABLE 3 CATCHMENT RUNOFF IN MM AND AS A PERCENTAGE OF LTA

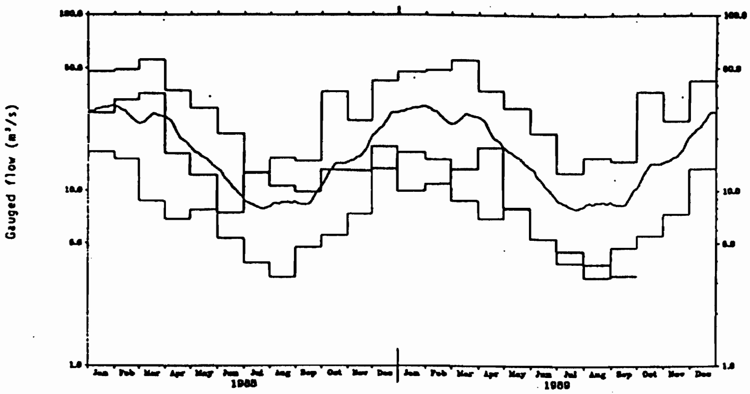
River/Station Name		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Sep Rank	Min Sep/ Year	Oct 88- Sep 89	Rank/No. of years	Oct 75- Sep 76	May 89- Sep 89
Dee at Park	mm	62	55	116	52	48	23	11	17	29	6/17	20	653	2/16	508	128
(Grampian Region)	%	68	80	127	65	74	62	39	52	69		'86	81		63	62
S Tyne at Haydon Br	mm	53	92	93	55	12	9	6	19	8	1/26	15	553	3/26	460	54
	%	55	135	111	100	31	31	20	44	16		'83	74		61	29
Wharfe at Flint Ml	mm	42	64	95	71	15	13	10	14	10	2/34	5	551	3/34	435	62
	%	43	84	127	131	39	51	37	34	22		'59	77		61	35
Derwent at B'crambe	mm	17	17	22	29	13	9	8	6	5	1/16	5	198	1/16	200	41
	%	33	39	49	85	52	51	59	47	40		'89	58		58	49
Trent at Colwick	mm	21	26	42	57	18	13	12	10	9	2/31	8	277	2/31	159	62
	%	41	59	105	178	69	68	77	58	54		'59	77		44	65
Lud at Louth	mm	15	12	16	17	15	12	10	9	8	8/22	5	158	4/21	78	54
	%	48	33	42	50	54	60	61	66	73		'74	57		28	61
Witham at Claypole	mm	8	8	12	31	14	8	6	4	4	5/31	2	114	5/30	41	36
	%	31	28	46	148	92	80	90	62	59		'59	61		22	78
Ouse at Bedford	mm	13	23	37	46	13	7	7	4	4	24/57	0	192	25/56	38	35
	%	36	85	119	242	101	94	125	83	90		'34	88		18	95
Colne at Lexton	mm	13	14	23	20	6	4	5	3	5	21/30	2	121	9/30	46	23
	%	59	74	128	154	75	82	129	85	113		'76	87		33	88
Thames at Kingston	mm	13	19	36	26	13	9	7	6	6	25/107	3	176	27/106	89	41
(nat)	%	35	59	116	118	76	75	75	70	62		'49	72		36	72
Kennet at Theale	mm	16	19	31	29	22	16	13	10	10	2/28	7	214	3/28	107	71
	%	46	32	82	94	78	76	77	67	72		'76	73		36	76
Coln at Bibury	mm	15	19	48	44	30	18	15	13	10	2/26	5	260	4/26	95	86
	%	30	56	91	102	89	86	67	73	62		'76	65		24	75
Medway at Teston	mm	7	17	27	41	7	6	4	3	4	4/32	2	140	2/27	104	24
	%	14	47	83	185	47	54	55	47	37		'59	49		37	50
Ouse at Gold Bridge	mm	8	12	44	37	16	9	10	6	5	4/30	3	174	2/28	151	46
	%	13	25	98	109	60	56	106	51	35		'61	44		38	61
Itchen at Highbrige	mm	26	26	39	40	36	23	22	21	19	1/31	19	333	3/31	302	121
	%	53	46	74	85	83	66	70	72	70		'89	73		63	74
Stour at Throop	mm	19	28	57	39	15	11	8	6	6	1/17	6	248	2/16	124	46
	%	31	51	110	118	63	66	70	58	49		'89	63		32	63
Kenwyn at Truro	mm	41	65	102	42	21	12	8	6	7	2/21	5	519	4/21	469	54
	%	36	66	132	98	75	62	64	47	42		'78	84		75	63
Taw at Umberleigh	mm	54	95	107	36	15	5	4	3	11	12/31	3	528	6/31	310	38
	%	46	116	162	80	48	31	30	15	47		'59	77		45	36
Tone at Bishops H	mm	25	54	80	40	19	11	10	7	9	3/29	6	344	5/28	171	56
	%	31	75	138	107	66	60	65	53	56		'64	72		36	63
Severn at Bewdley	mm	29	48	77	48	12	7	8	7	6	3/69	5	346	11/68	202	40
	%	41	84	168	152	49	41	35	39	29		'49	77		45	42
Yscir at Pont'yscir	mm	92	130	182	72	18	10	11	8	11	1/18	11	730	2/16	510	58
	%	64	123	160	120	41	33	58	26	24		'89	73		51	32
Dee at New Inn	mm	134	217	337	131	23	34	23	35	36	3/21	20	1386	2/20	1226	150
(Clywd)	%	55	139	194	122	31	57	35	36	25		'72	76		68	34
Lune at Caton	mm	94	167	196	82	20	14	12	44	13	3/27	7	1007	7/25	752	103
	%	65	192	207	196	37	35	24	63	15		'59	89		67	34

Note : Because of changes in the pattern of water utilisation in certain catchments and the effect of measures to counteract the impact of a drought on river flow rates, direct comparisons between historical low flow sequences need to be undertaken with caution.

FIGURE 2 MONTHLY HYDROGRAPHS

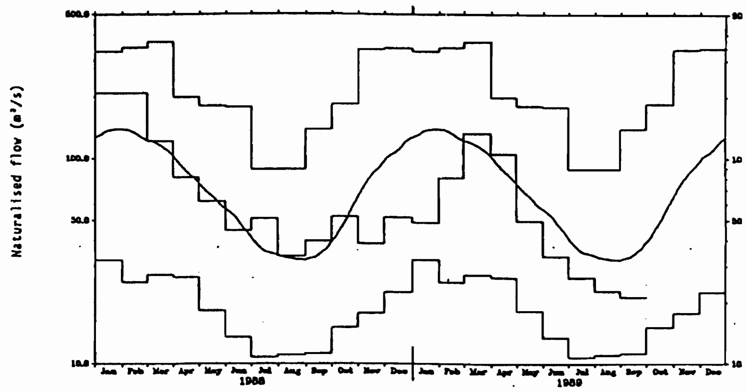
027041 Dervent at Buttercrambe

Monthly mean flows for 1988-1989
• extremes and 30 day running mean for 1973-1987



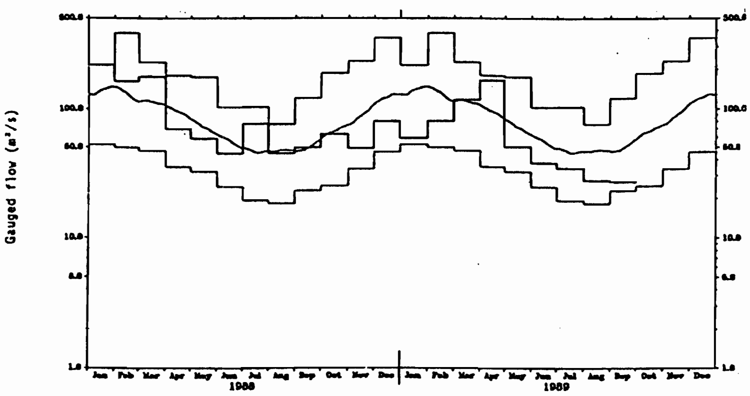
039001 Thames at Kingston

Monthly mean flows for 1988-1989
• extremes and 30 day running mean for 1883-1987



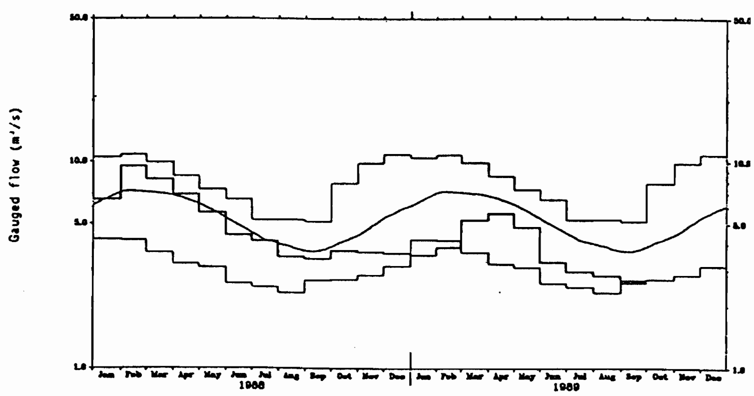
028009 Trent at Colwick

Monthly mean flows for 1988-1989
• extremes and 30 day running mean for 1958-1987



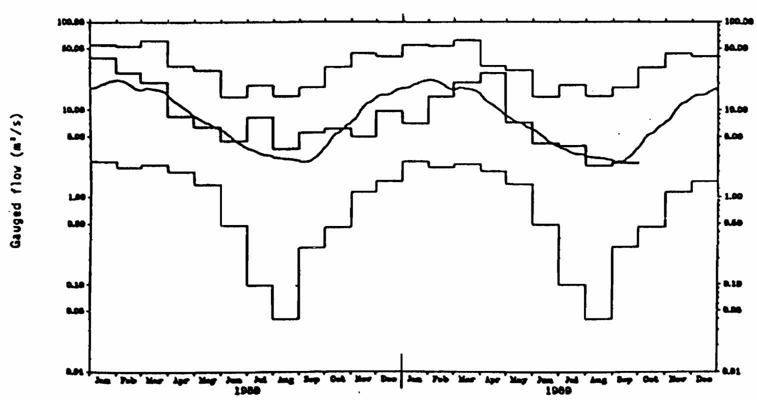
042010 Itchen at Highbridge+Allbrook

Monthly mean flows for 1988-1989
• extremes and 30 day running mean for 1958-1987



033002 Bedford Ouse at Bedford

Monthly mean flows for 1988-1989
• extremes and 30 day running mean for 1933-1987



054001 Severn at Bewdley

Monthly mean flows for 1988-1989
• extremes and 30 day running mean for 1921-1987

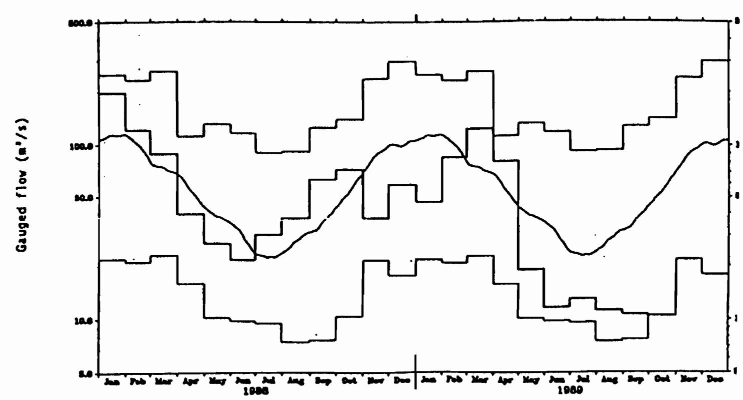


FIGURE 3 CUMULATIVE RUNOFF DIAGRAMS

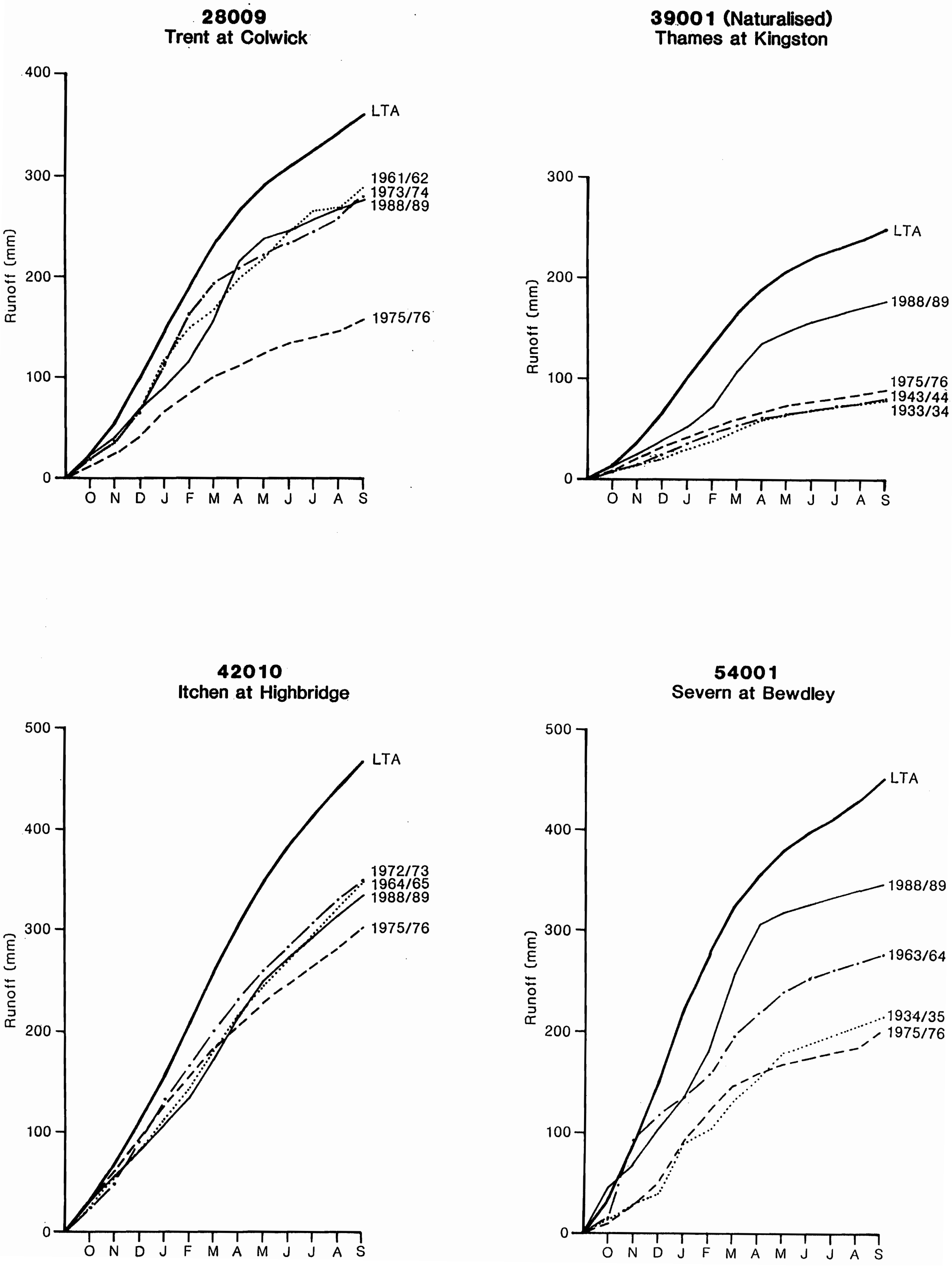


TABLE 4 RIVER FLOW RETURN PERIODS - SEPTEMBER 1989

River/Station Name	First Year of Record	Sept Flow (m^3s^{-1})	Return Period (years)	Base Flow Index
South Tyne at Haydon Bridge	1963	2.45	50	.35
Trent at Colwick	1959	27.00	10-20	.64
Dove at Marston	1962	3.42	10	.60
Derwent at St Mary's Bridge	1936	4.25	20	.62
Lud at Louth	1968	0.10	25-50	.90
Witham at Claypole Mill	1959	0.43	5	.67
Colne at Lexdon	1960	0.45	<2	.53
Thames at Kingston (nat)	1883	21.24	5	.64
Kennet at Theale	1962	3.90	10	.87
Mole at Kinnersley Manor	1973	0.58	2	.37
Medway at Teston	1957	1.81	5	.41
Ouse at Gold Bridge	1960	0.37	5-10	.49
Rother at Iping Mill	1967	0.65	10-20	.65
Test at Broadlands	1958	5.30	25	.94
Itchen at Highbridge	1959	1.95*	>100	.97
Stour at Throop	1973	2.53	20	.66
Dart at Austins Bridge	1959	2.50	5	.52
Kenwyn at Truro	1969	0.05	10-20	.66
Taw at Umberleigh	1959	3.56	2-5	.42
Tone at Bishops Hull	1961	0.67	5-10	.58
Brue at Lovington	1965	0.26	10	.47
Severn at Bewdley	1921	10.61	20	.53
Teme at Knightsford Bridge	1970	1.5E	50	.57
Lune at Caton	1959	5.09	10-20	.32
Eden at Sheepmount	1968	13.08	10	.50

TABLE 4a RIVER FLOW RETURN PERIODS - MAY TO SEPTEMBER 1989

River/Station Name	First Year of Record	May-Sept Flow (m^3s^{-1})	Return Period (years)	Base Flow Index
Coquet at Morwick	1966	1.66	25	.44
South Tyne at Haydon Bridge	1963	3.03	>100	.35
Warfe at Flint Mill	1956	3.54	25-50	.39
Derwent at Buttercrambe	1974	4.97	25	.68
Lune at Cation	1959	7.63	25-50	.32

Note: Because of changes in the pattern of water utilisation in certain catchments and the effects of measures to counteract the impact of a drought on river flow rates, some return periods need to be treated with particular caution.

*The Itchen flow is naturalised to compensate for groundwater augmentation.

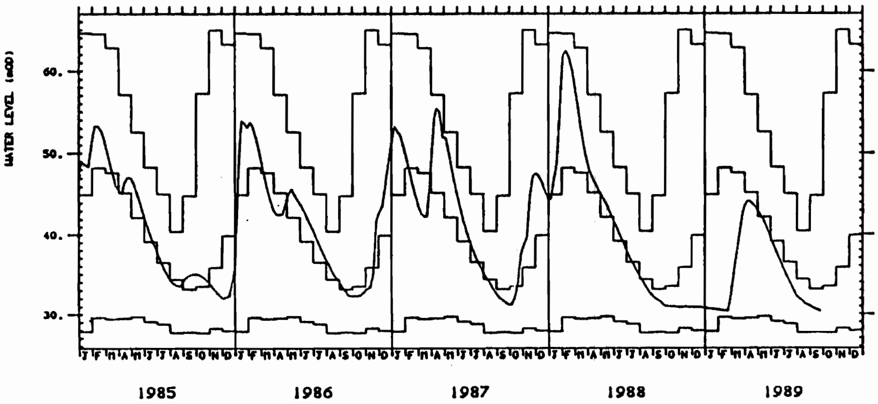
E = estimated

FIGURE 4   GROUNDWATER WELL OBSERVATION HYDROGRAPHS

Site name: COMPTON HOUSE

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

Aquifer: CHALK AND UPPER GREENSAND   Measuring level: 81.37

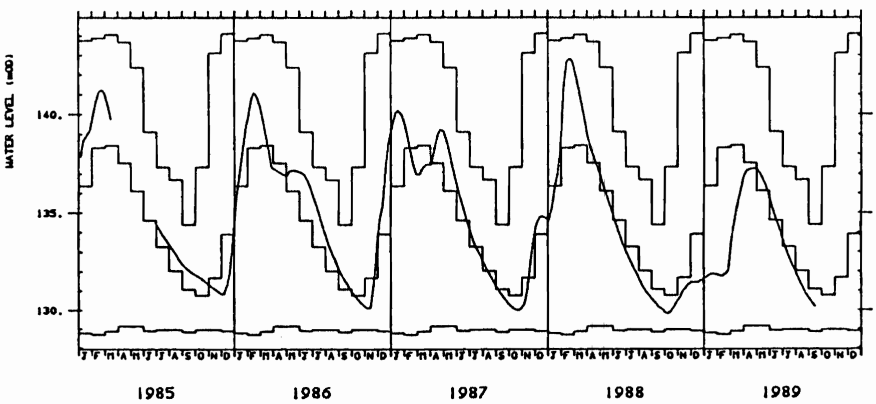


Max, Min and Mean values calculated from years 1894 TO 1988

Site name: ROCKLEY

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

Aquifer: CHALK AND UPPER GREENSAND   Measuring level: 146.39

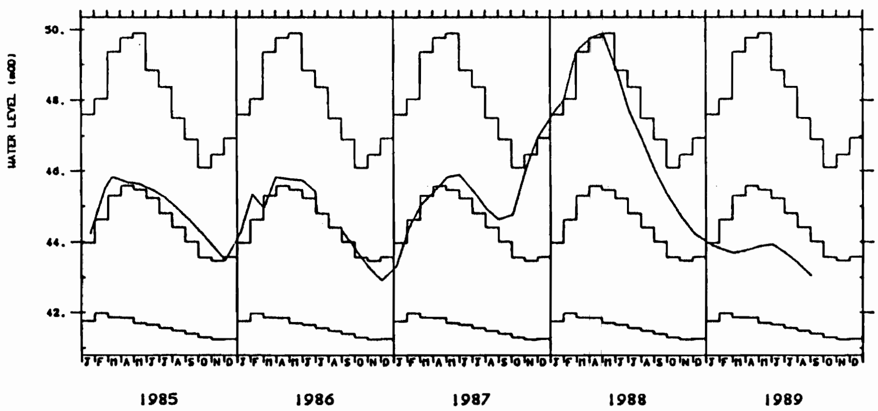


Max, Min and Mean values calculated from years 1933 TO 1988

Site name: WASHPIT FARM

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

Aquifer: CHALK AND UPPER GREENSAND   Measuring level: 80.20

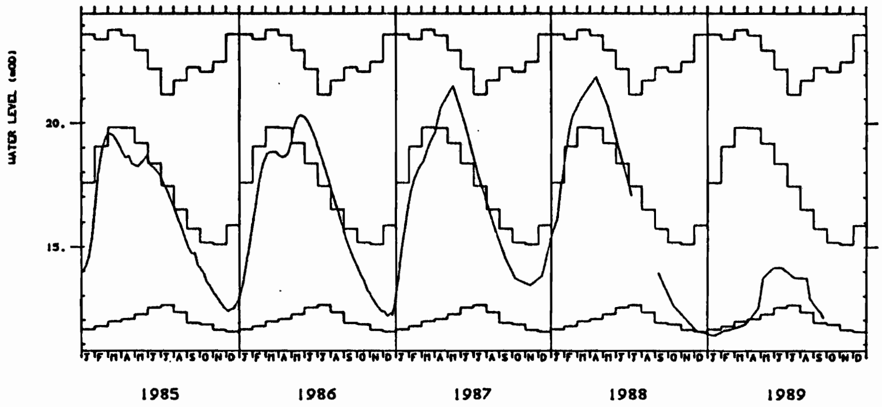


Max, Min and Mean values calculated from years 1950 TO 1988

Site name: DALTON HOLME

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

Aquifer: CHALK AND UPPER GREENSAND Measuring level: 33.50

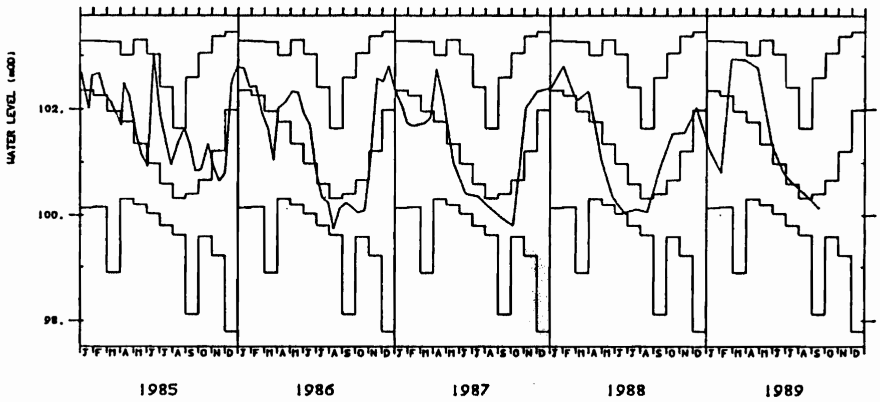


Max, Min and Mean values calculated from years 1889 TO 1988

Site name: AMPNEY CRUCIS

National grid reference: SP 0595 0190 Well number: SP00/62

Aquifer: MIDDLE JURASSIC Measuring level: 109.70

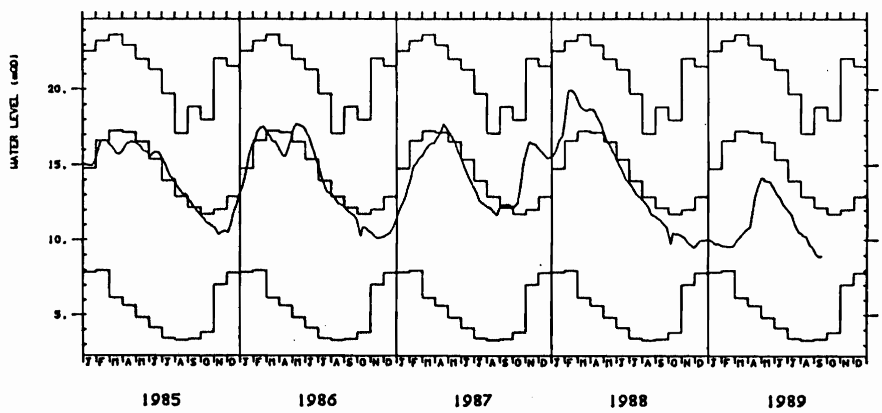


Max, Min and Mean values calculated from years 1958 TO 1988

Site name: NEW RED LION

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

Aquifer: LINCOLNSHIRE LIMESTONE Measuring level: 33.82

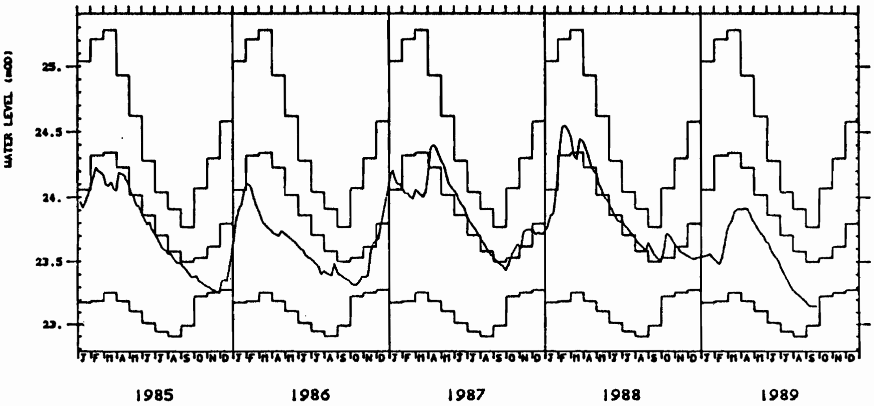


Max, Min and Mean values calculated from years 1964 TO 1988

Site name: BUSSELS NO.7A

National grid reference: SX 9528 9872 Well number: SX99/37B

Aquifer: PERMO-TRIASSIC SANDSTONE Measuring level: 26.07

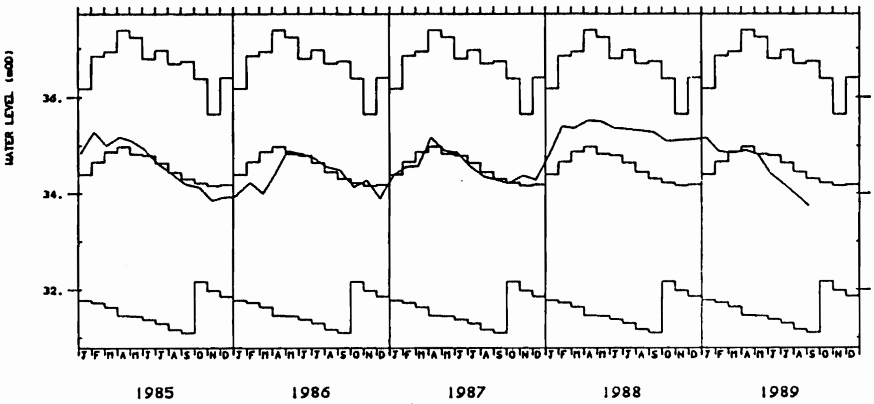


Max, Min and Mean values calculated from years 1972 TO 1988

Site name: PEGGY ELLERTON FARM,HAZLEWOOD

National grid reference: SE 4535 3964 Well number: SE43/9

Aquifer: MAGNESIAN LIMESTONE Measuring level: 51.40



Max, Min and Mean values calculated from years 1968 TO 1988

Site name: RUSHYFORD NORTH EAST,GREAT CHILTON

National grid reference: NZ 2875 2896 Well number: NZ22/22

Aquifer: MAGNESIAN LIMESTONE Measuring level: 92.53