HYDROLOGICAL SUMMARY - DECEMBER 1989

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 is of a provisional nature.

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

SUMMARY

Weather conditions in December provided a suitably noteworthy conclusion to a hydrologically exceptional year.

The capricious nature of the British climate achieved a very full expression in December 1989. Although rainfall for the United Kingdom was close to the long term average, the variations in its distribution - both spatially and temporally - were extreme. Parts of southern Britain were remarkably wet and throughout most of lowland England a significant amelioration in the drought occurred. Conversely, in north-east England and eastern Scotland rainfall was well below average and the drought intensified; in a few coastal districts the long term accumulated rainfall deficiency is now of an extraordinary magnitude.

There are few recent precedents for the within-month variation in rainfall amounts and runoff rates experienced in December especially in central and southern England. Early in the month, many rivers registered their lowest December discharges on record, in a few cases runoff rates were absolute minima. Throughout most of southern Britain, heavy rainfall beginning around the 11th, rapidly eliminated soil moisture deficits (SMDs) and subsequently produced dramatic increases in river flows such that limited floodplain inundation was commonplace over the Christmas period. In contrast some coastal areas in eastern Scotland missed much of the rainfall and field capacity has yet to be reached. Notwithstanding the surge of runoff from mid-December, accumulated runoff totals remain very low especially over nine and fourteen-month periods. For a number of rivers draining into the North Sea and the English Channel, they are unprecedented.

Groundwater levels which at the beginning of winter were inordinately low, particularly in some eastern aquifers, generally began a belated seasonal upturn over the latter part of December. In a few districts, infiltration over the second half of the month exceeded the accumulated total for the rest of the year. However, apart from some western areas, groundwater levels are still considerably below average and more, sustained rainfall is required to consolidate the recent improvement in groundwater stocks.

Several wet interludes have already punctuated the progress of the 1988/89 drought. The current unsettled spell may be considered pivotal in relation to its continuation. In England and Wales the impact on water resources through the summer and autumn of 1990 will be largely determined by rainfall amounts over the next three months.

REVIEW

Rainfall

Anticyclonic conditions dominated weather patterns over the UK for the first eleven days and final week of December; rainfall in these periods was negligible over wide areas. In between, a series of vigorous depressions crossed the British Isles bringing widespread and heavy rainfall to most regions, exceptions included some lowland districts along the eastern seaboard. Rainfall totals during this wet episode reached five times the average in a few localities in central and southern England with especially heavy falls on the 13th - the wettest day over England and Wales for more than three years. The contrast with the preceding dry spell is dramatic. At the Institute of Hydrology's meteorological station, for instance, no rainfall was registered for the 30 days up to December 10th - a very exceptional sequence for the time of year - the subsequent period up to the 24th was the second wettest 15-day period in the entire record (starting in 1962)! In some central and southern districts this extremely wet spell produced rainfall totals roughly equivalent to a quarter of the rainfall over the rest of the year and ensured that winter rainfall totals (from October 1st), thus far, are above average throughout most of England and Wales. Droughts are seldom brought to an end by a fortnight's rainfall but December 1989 certainly witnessed a major change in the drought complexion throughout southern Britain. In the Severn-Trent, Anglian, Wessex, South West and Welsh regions of the NRA, the meteorological drought declined to a moderate intensity and a significant amelioration may be recognised in the Thames and Southern regions although very considerable rainfall deficits remain, especially in eastern districts.

Throughout Britain December is normally one of the wettest months of the year. December was the wettest for England and Wales as a whole since January 1988 and large tracts of southern and central England recorded more than twice the average rainfall; the impact even on substantial accumulated rainfall deficits was considerable. Nonetheless, the provisional England and Wales rainfall total for the period November 1988 - December 1989 ranks as the third lowest (for the 14-month sequence) this century and a notable drought may still be recognised in the Southern NRA area. For most other regions in southern Britain the 1988/89 shortfall may be expected, on average, once every five to ten years.

Further north, mid-December rainfall amounts were relatively modest and monthly totals were generally below average - notably so in Scotland where in parts of the North East River Purification Board (RPB) area, rainfall was less than half of the 1941-70 average. Long term rainfall deficiencies thus increased in December and the accumulated rainfall totals over the last 8, 14 and 19 months for the Northumbrian area each testify to severe or very severe drought conditions. This extended drought is of unprecedented severity and now embraces two winter periods. A drought of the magnitude currently experienced in Northumbria (and in eastern Scotland - see below) would pose a severe threat to water resources further south where total demand represents a far higher proportion of the available residual rainfall.

Rainfall in Scotland over the period since September 1988 is close to the long term average. However, regional variations in rainfall amounts have been extreme. In the west, many areas have been very wet - the 1989 rainfall total for Fort William, for instance, is about 150% of the average. By contrast, a number of localities in the eastern lowlands have registered fourteen successive months, each with below average rainfall. This is a truly exceptional sequence and the accumulated rainfall since October 1988 represents significantly less than 60% of the average. In the eastern extremities of the Grampian and Borders Regions, some localities have registered little over half their average rainfall over the last fourteen months. There is no modern parallel in Scotland to a drought of this intensity; it is approaching - in rainfall terms - the severity attained at the peak of the 1975/76 drought in central and southern England. A very steep west to east rainfall gradient has existed for many months in Scotland and, generally, the headwater regions of the eastern RPBs have had rainfall well within the normal range. Nonetheless, provisional areal rainfall figures for the North East and Tweed RPB areas (see Table 1) indicate that return periods associated with accumulated rainfall over the periods commencing November 1988, April 1989 and July 1989 each approach, or exceed (in some instances, substantially), 100 years.

Soil Moisture Deficits

The large end-of-autumn soil moisture deficits (relative to the average) in lowland England and eastern Scotland increased marginally in early December. Throughout much of lowland Britain, particularly in the east, deficits in the second week, greatly exceeded the monthly average - by more than 50 mm over extensive areas - and soils were considerably drier even than in December 1988. Subsequent rainfall, aided by the cold, overcast, conditions served to greatly extend the area at, or close to, field capacity by the end of the year. Deficits had been eliminated in all western regions in November and, by the turn of the year, field capacity had been reached throughout central and southern areas; significant deficits remained in only a few eastern coastal districts. Some of these deficits were, however, remarkable. SMDs more than 50 mm greater than average were calculated for the eastern extremities of parts of Northumbria and Berwickshire and substantial deficits obtained further north along Scotland's eastern seaboard.

For more detailed data relating to the development and decay of the deficits through December, see the regular MORECS bulletins issued by the Meteorological Office.

Runoff

Broadly speaking, December runoff totals were well below average - in some cases unprecedented - in Scotland and parts of northern England but within the normal range throughout southern Britain. Significant regional and local variations arose from the steep rainfall gradients and geological control over runoff response was a significant factor in the south - in general, rivers draining predominantly impervious catchments registered above average mean flows whereas those rivers sustained principally from baseflow recorded modest runoff totals.

The variation in flow rates through the month was noteworthy. Some major rivers recorded a daily mean flow range approaching three orders of magnitude; such extreme variability is rare especially in the absence of any major snowmelt contribution. As a consequence of this within-month flow variation return period assessments based upon monthly mean flows are of limited utility. To provide a more relevant guide to drought severity, an analysis based upon minimum daily flow values (in December) have been used - see Table 4.

Over the period 1-12 December, new minimum daily flow rates (for the month) were commonplace in southern and eastern (especially north-eastern) catchments. Some rivers registered new winter (Dec-Feb) minima and in the extreme case of the Itchen - when allowance has been made for artificial augmentation from groundwater - an absolute minimum was established in a 32-year flow record. It is a measure of the severity of the long term rainfall deficiency in some southern catchments that the minimum runoff rates established at the end of the 1975/76 drought have been eclipsed (albeit marginally and accepting that modest changes in the pattern of water exploitation have occurred over the intervening years).

From around mid-month, river flows increased dramatically in southern Britain - more modestly to the north - as sustained precipitation fell onto increasingly saturated catchments (see Figure 3). By the 20th December, bankfull discharges characterised large parts of lowland England and flood alerts were in operation in some central and southern catchments. Floodplain inundation was widespread over the Christmas period. Peak flow rates hardly merited 'notable flood' status - most had return periods below five years - but in the context of the 1989 runoff pattern, the English rates were certainly exceptional. Provisional flow figures suggest that the total runoff for the latter half of December in the catchments of, for instance, the Rivers: Ouse (Bedfordshire), Medway (Kent), Stour (Dorset), Brue (Somerset) and Teme (Hereford and Worcester) was comparable to, or exceeded, the accumulated runoff for the preceding six months. Flow contrasts through the month in southern Britain were exemplified by the Kennet (Berkshire) where flow rates for each of the first 11 days were below the preceding December minimum. By the 21st, discharge had increased such that the daily mean was unsurpassed - in December - since 1972.

The transformation in runoff conditions produced healthy, and very welcome, replenishments to reservoirs in most regions - Scotland and parts of northern England were exceptions. Fifteen percent increases in stocks over the four weeks from mid-December were not unusual and, entering 1990, consideration was being given to scheduling flood drawdown releases from reservoirs in the Welsh mountains and in the southern Pennines.

Notwithstanding the recent sharp upturn in runoff rates, the extended delay in the expected seasonal increase has ensured that accumulated runoff totals particularly within the six to eighteen month timeframe remain modest. A few catchments in eastern Scotland - where, in the lower Tweed basin, January to

December runoff was around one-third of the average - registered their lowest annual runoff totals in 1989 and notably modest totals characterise large parts of southern and north-eastern England.

At the end of 1989 most rivers were in recession but with SMDs largely eliminated, and given average to above average rainfall, the prospects for a further significant increase in accumulated runoff totals early in 1990 are good.

Groundwater

Early in December, groundwater levels were exceptionally low in most regions, extremely so in some eastern and southern areas. Throughout most major aquifers water tables stood close to, or below, the seasonal minimum and, in the Yorkshire Chalk, levels by mid-month had declined to significantly below the previous lowest in a 106-year record. The very depressed water levels reflected: first, the limited recharge during the winter of 1988/89; second, the sustained recessions since the spring; and third, the failure of the modest recoveries recorded in late October in heralding a sustained seasonal rise in groundwater levels.

Substantial SMDs, in many areas, initially limited the effectiveness of the December rainfall but subsequently a complex picture emerged with infiltration widespread but water table responses varying according to local rainfall amounts, the prevailing soil moisture status and the characteristics of the aquifer. Some very brisk increases were reported from shallow boreholes in superficial or fissured aquifers whereas deep wells in, for instance, the Chalk of Kent showed no discernible upturn by the end of the year.

Those aquifers in western, and some central regions, which recorded increases in levels in late October benefited further from the December rainfall and by the end of the year groundwater levels in, for example, the Oolitic Limestone aquifers of Wiltshire and Dorset increased briskly and stood above the seasonal average entering 1990. Elsewhere recoveries were far more muted. At Dalton Holme, in the Yorkshire Chalk, levels remained below the pre-1989 minimum throughout the month. The Washpit Farm Well, in the East Anglian Chalk, is known to exhibit a slight lag of 2 to 4 weeks between rainfall peaks and hydrograph reaction, and had not responded to the December rainfall by the end of the month. At Peggy Ellerton Farm, in the Magnesian Limestone of northern England, late December levels were not available when this report was written, but there was only a very limited response to the October rainfall.

The well hydrograph at Woodhouse Grange, in the Midlands Trias, is somewhat unusual. It shows an almost continual fall from May 1988 to mid-December 1989. Some of this is undoubtedly due to a lack of recharge, but much may be due to groundwater abstraction being increased - possibly to meet a shortfall in surface supplies.

In southern and south-east England, the soil moisture deficits over the Chalk outcrop, judging from the well hydrographs, do not appear to have been eradicated by the October rainfall. By the end of December, the upturns in most of the hydrographs indicate that the soil moisture deficits had been satisfied. If there is a lack of rainfall through January 1990, it is probable that soil moisture deficits will build again.

Early spring rainfall in 1989 demonstrated the particularly beneficial effect of above average rainfall late in the normal recharge season. However, if less than average rainfall is experienced during the period January to March 1990, groundwater levels are unlikely to recover to near-average seasonal levels. There would then be a potentially serious shortfall in groundwater resources for the summer months. The areas most seriously at risk are those depending on the Chalk outcrop of Yorkshire and parts of East Anglia, Kent and Sussex.

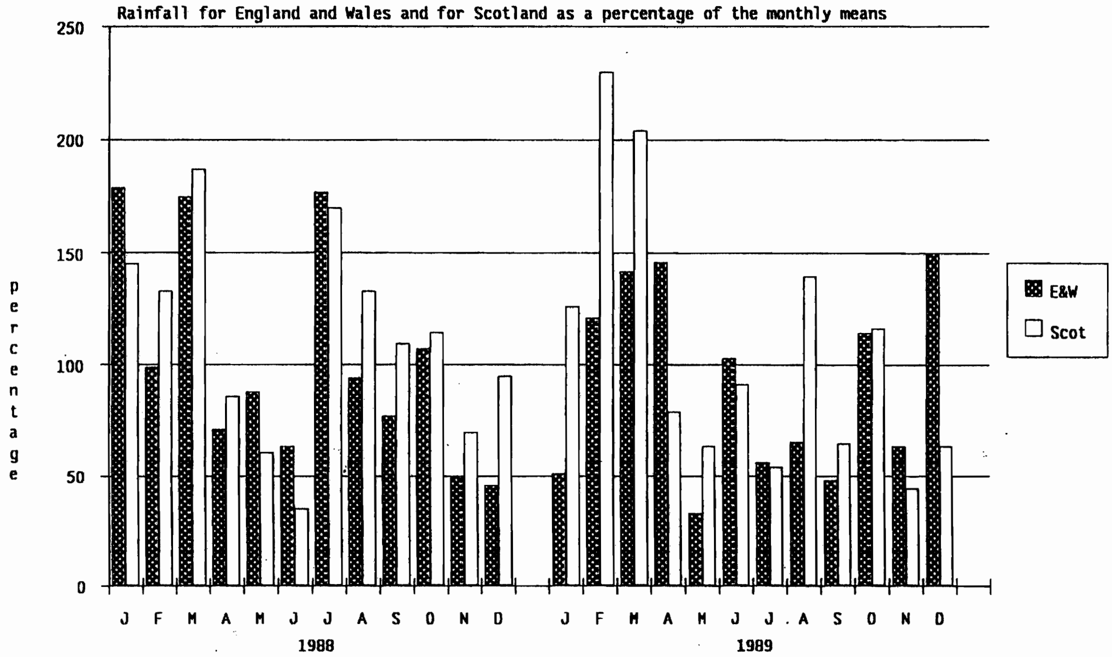
IH/BGS
15/1/90

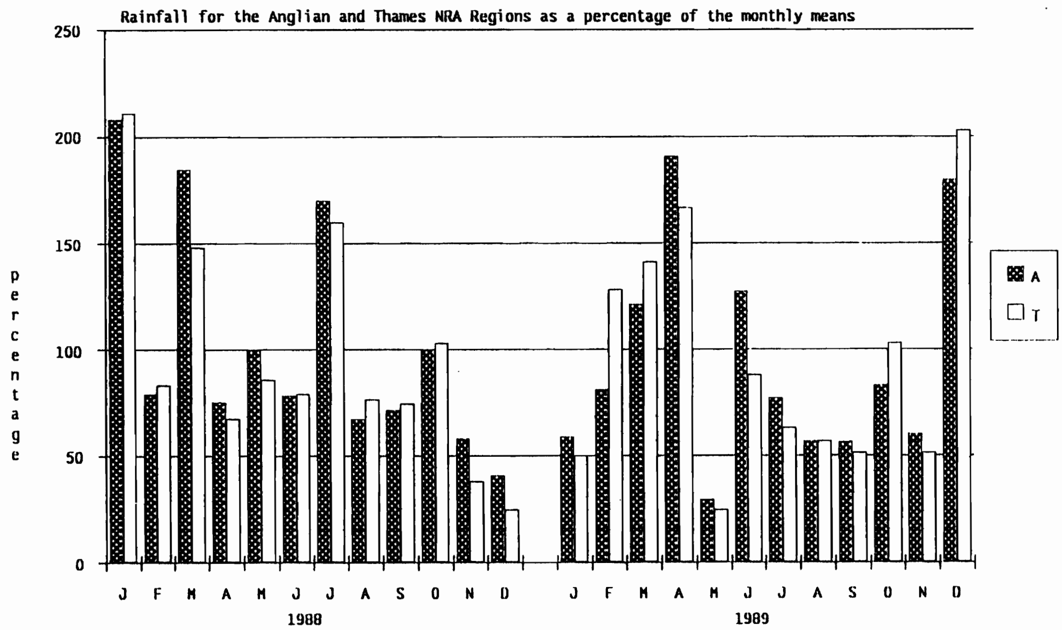
TABLE 1 1988/89 RAINFALL IN MM AND AS A PERCENTAGE OF THE 1941-70 AVERAGE

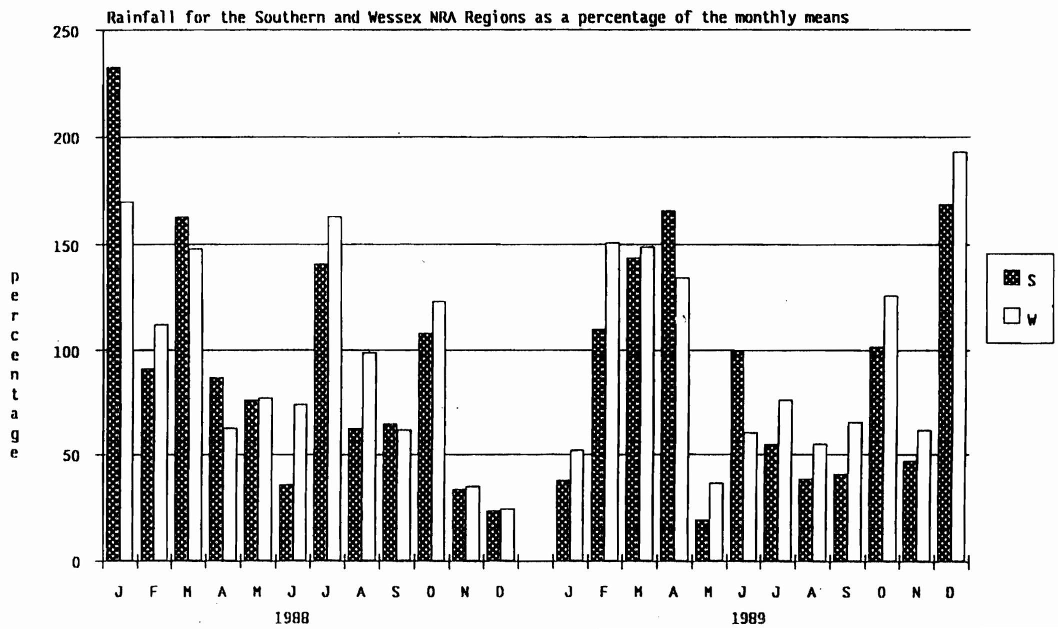
		Jan	Feb	Mar 1989	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan-Dec	Nov88 -Dec	Shortfall Nov88-Dec mm
England and Wales	mm	44	78	84	85	22	63	41	60	40	95	62	135	808	903	196
	%	51	120	142	147	33	103	56	66	48	114	64	150	89	82	
NRA REGIONS																
North West	mm	68	123	113	92	33	102	34	118	28	136	75	103	1025	1211	247
	%	61	152	157	119	40	123	33	94	22	115	62	86	84	83	
Northumbrian	mm	32	70	55	49	25	65	19	87	21	85	36	61	604	732	316
	%	40	106	106	89	39	107	25	86	26	113	38	81	69	70	
Severn Trent	mm	35	65	69	87	23	53	37	40	37	83	51	126	706	777	145
	%	51	123	133	167	36	95	57	49	54	128	65	181	91	84	
Yorkshire	mm	24	64	63	79	24	84	38	47	19	83	46	93	664	766	220
	%	31	100	119	141	39	145	54	52	27	120	52	126	80	77	
Anglia	mm	31	34	48	74	14	62	44	37	29	43	37	95	548	605	120
	%	60	81	120	185	30	127	77	57	56	83	60	180	90	83	
Thames	mm	31	60	65	77	14	46	38	40	32	66	37	134	640	684	159
	%	50	128	141	167	25	88	63	57	51	103	51	203	91	81	
Southern	mm	29	62	75	81	11	50	32	28	29	80	44	137	658	709	260
	%	38	109	144	169	20	100	54	39	41	102	47	169	83	73	
Wessex	mm	44	89	87	74	25	33	47	45	52	103	60	174	833	888	168
	%	52	151	150	137	37	61	76	55	66	126	62	193	96	84	
South West	mm	65	135	115	92	18	38	36	63	99	141	97	192	1091	1205	258
	%	50	150	137	130	21	58	43	62	96	125	72	142	91	82	
Welsh	mm	80	140	151	89	23	65	49	78	57	164	100	189	1186	1328	294
	%	59	146	174	103	25	79	52	66	46	127	70	130	89	82	
Scotland	mm	172	239	188	71	58	84	60	181	89	173	62	100	1477	1725	4
	%	126	230	204	79	64	91	54	140	65	116	44	64	103	100	
RIVER PURIFICATION BOARDS																
North-East	mm	52	113	83	54	59	57	25	84	57	87	30	61	761	878	350
	%	57	153	134	89	77	81	27	78	66	90	29	60	74	72	
Tweed	mm	71	105	105	48	43	51	23	114	47	67	30	72	775	893	304
	%	76	152	181	79	57	75	27	100	51	76	29	80	77	74	

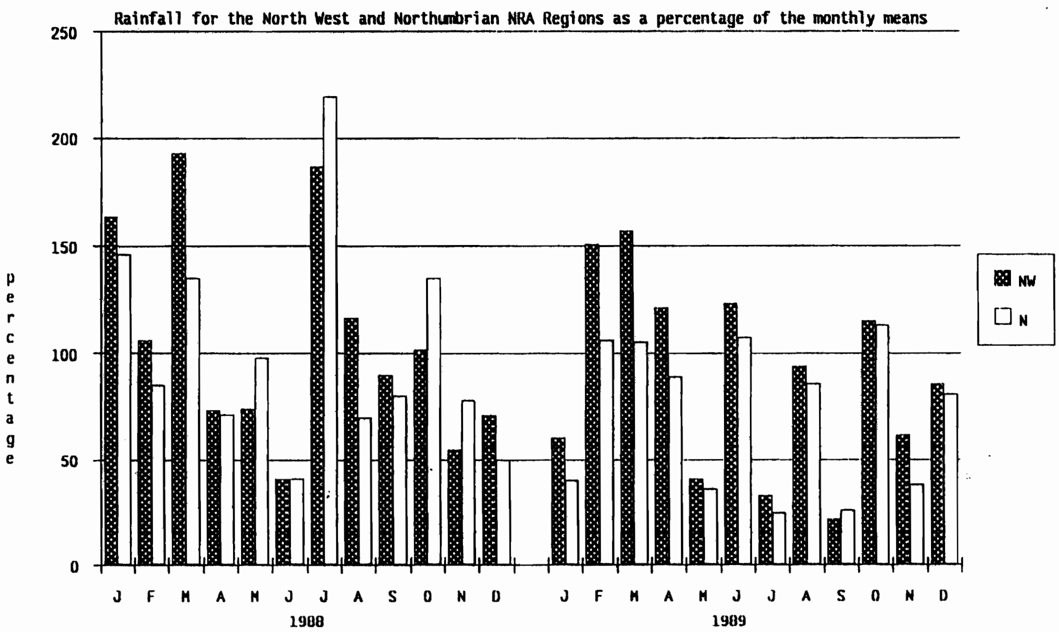
Note: January to December rainfalls are based upon MORECS figures supplied by the Meterological Office.

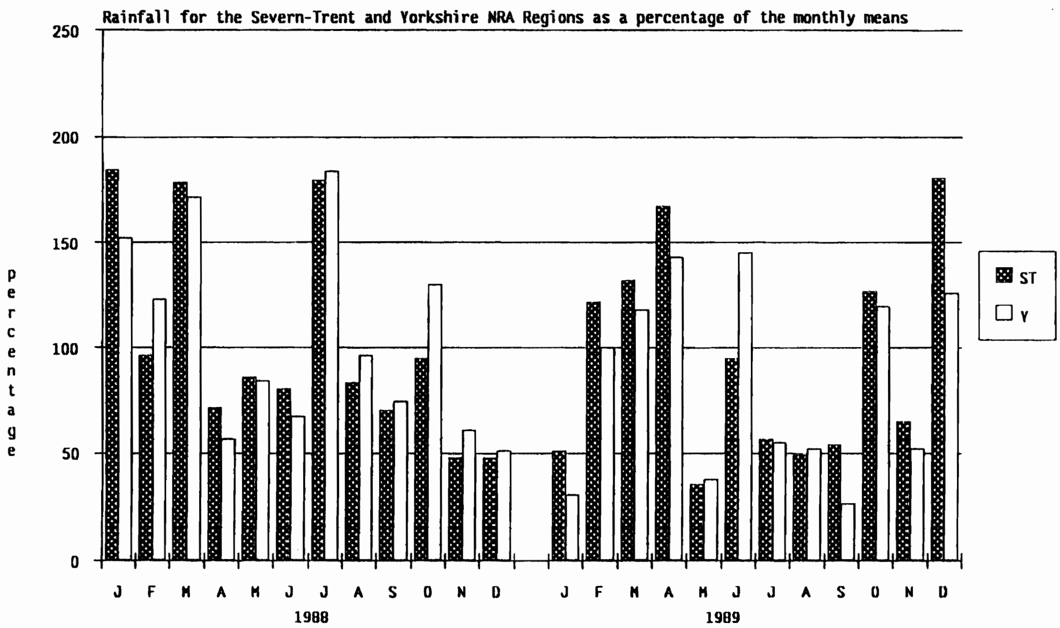
FIGURE 1 HISTOGRAMS OF RAINFALL AS MM. AND AS A PERCENTAGE OF THE MONTHLY MEAN








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 O N D
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 O N D
1989

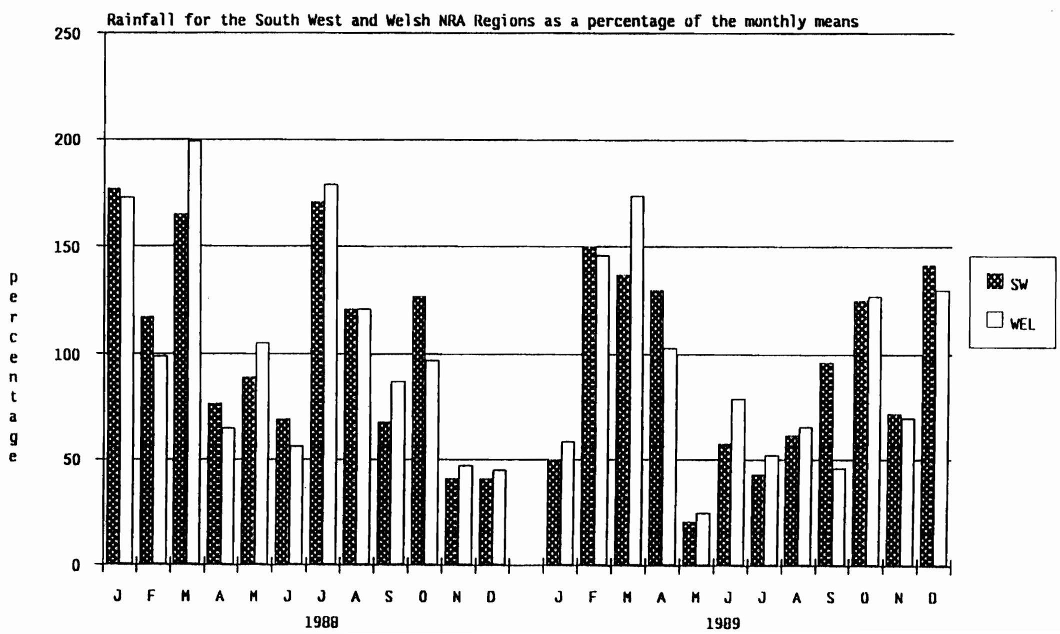

Rainfall for the South West and Welsh NRA Regions as a percentage of the monthly means
250
200
150
100
50
0
percentage
SW
WEL
J F M A M J J A S O N D
1988
J F M A M J J A S O N D
1989

TABLE 2 RAINFALL RETURN PERIOD ESTIMATES

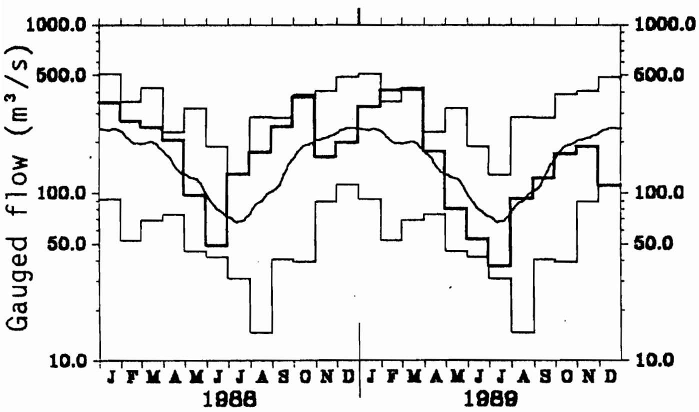
		OCT-DEC 1989	Est Return Period	MAY-DEC 1989	Est Return Period	NOV-DEC 1988-89	Est Return Period	APR-DEC 1989	Est Return Period
England and Wales	mm	292		517		903		1408	
	% LTA	108	<5	80	10	82	10-20	87	10
NRA REGIONS									
North West	mm	315		629		1211		1928	
	% LTA	88	<5	72	20-30	83	10	89	5-10
Northumbrian	mm	182		399		732		1262	
	% LTA	74	5-10	64	70-100	70	100-200	81	20-50
Severn-Trent	mm	261		450		777		1207	
	% LTA	122	<5	82	5-10	84	5-10	88	5-10
Yorkshire	mm	222		434		766		1245	
	% LTA	96	<5	74	10-20	77	20-30	85	10-20
Anglia	mm	175		361		609		950	
	% LTA	105	<5	83	5	83	10	87	5-10
Thames	mm	237		407		684		1065	
	% LTA	117	<5	81	5-10	81	10	85	20
Southern	mm	261		411		709		1070	
	% LTA	103	<5	73	10-20	73	20-50	76	50
Wessex	mm	337		539		888		1346	
	% LTA	125	5	88	<5	84	5-10	88	5-10
South West	mm	430		684		1205		1860	
	% LTA	113	<5	83	5-10	82	10	89	5-10
Welsh	mm	453		726		1328		2072	
	% LTA	109	<5	78	10	82	10-20	88	5-10
Scotland	mm	335		807		1725		2571	
	% LTA	75		80	0-5	100	0-5	102	0-5
RIVER PURIFICATION BOARDS									
North-East	mm	178		459		879		1483	
	% LTA	59	20-50	62	200-500	77	200		
Tweed	mm	169		465		893		1504	
	% LTA	60	20	65	50-100	74	50-100	84	20

Return period assessments 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.
The tables reflect rainfall totals over the periods 1911-70 and 1941-70 only and the estimate assumes a sensibly stable climate.
The December 1989 RPB estimates are estimated from the isopleth map within the December summary published in the Meteorological Office's MORECS bulletin.

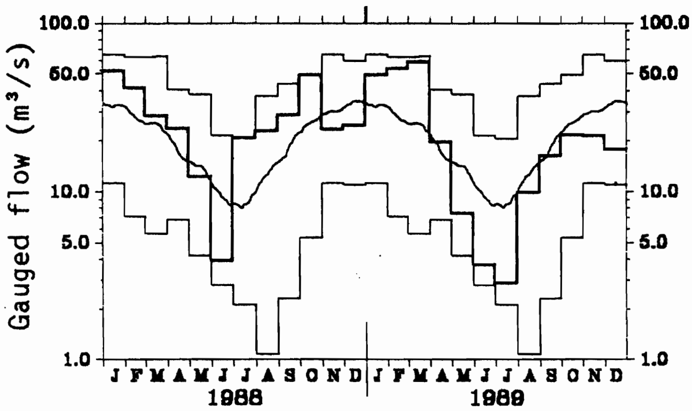
* Tabony, R. C., 1977, The Variability of long-duration rainfall over Great Britain, Scientific Paper No. 37, Meteorological Office (HMSO).

FIGURE 2 MONTHLY RIVER FLOW HYDROGRAPHS

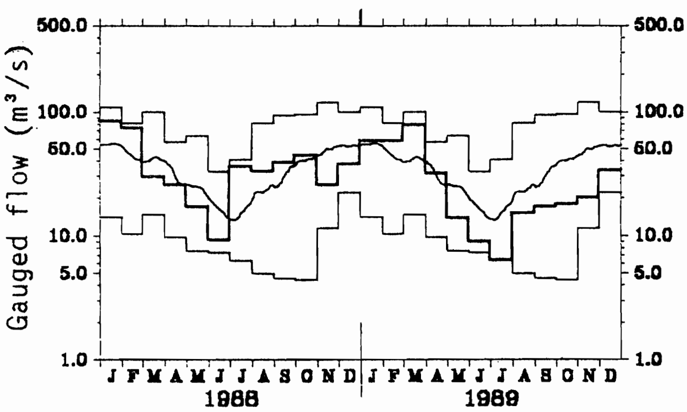
015006 Tay at Ballathie
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1952-1987



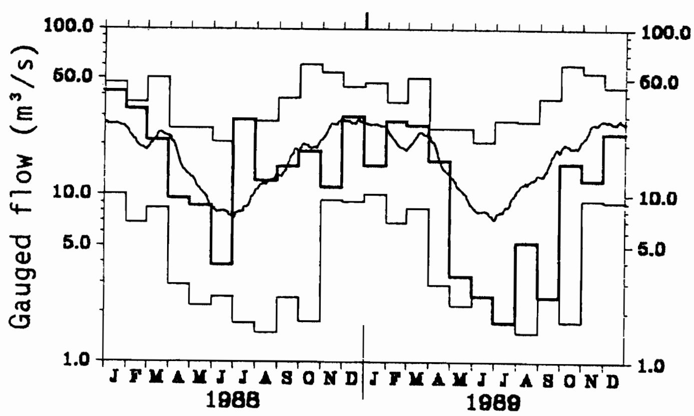
016001 Earn at Kinkell Bridge
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1948-1987



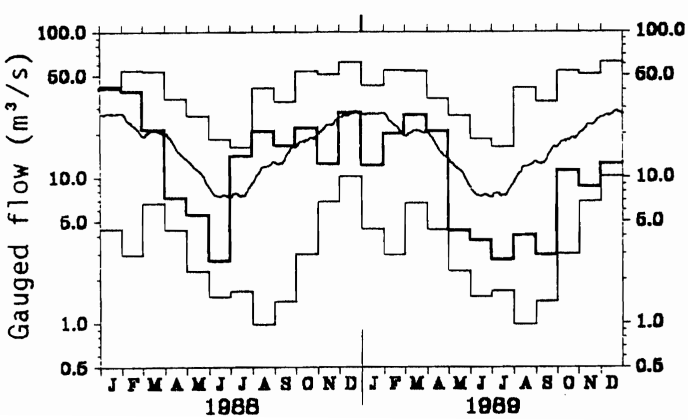
021006 Tweed at Boleside
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1961-1987



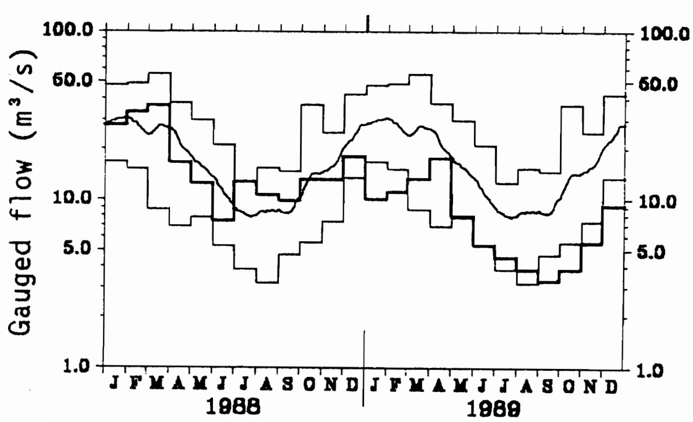
023004 South Tyne at Haydon Bridge
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1962-1987



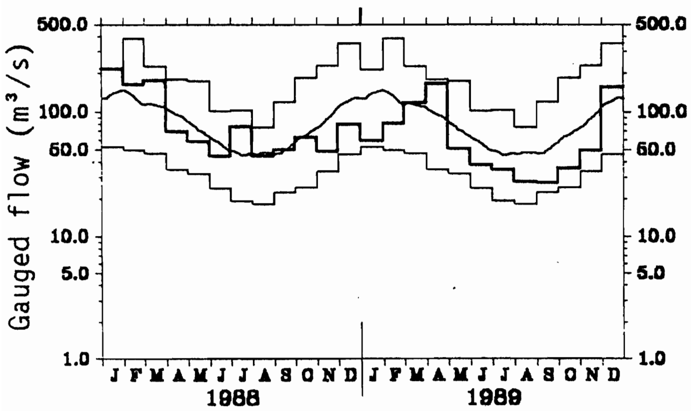
027002 Wharfe at Flint Mill Weir
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1955-1987



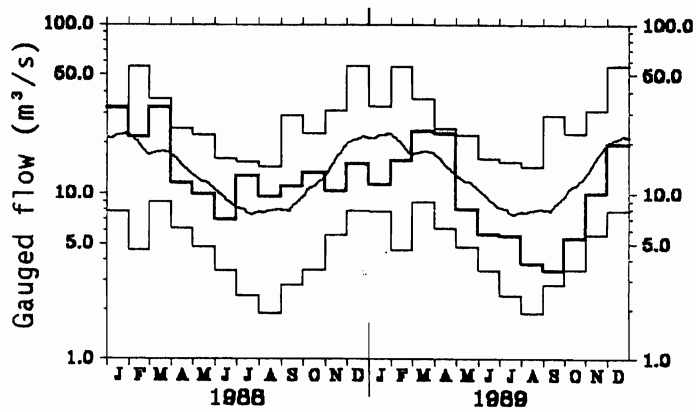
027041 Derwent at Buttercrambe
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1973-1987



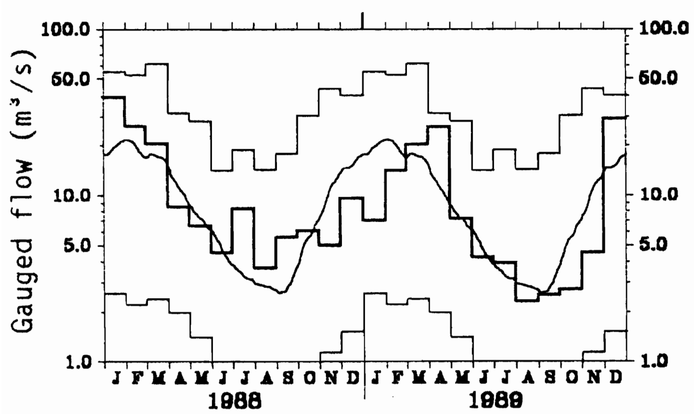
028009 Trent at Colwick
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1958-1987



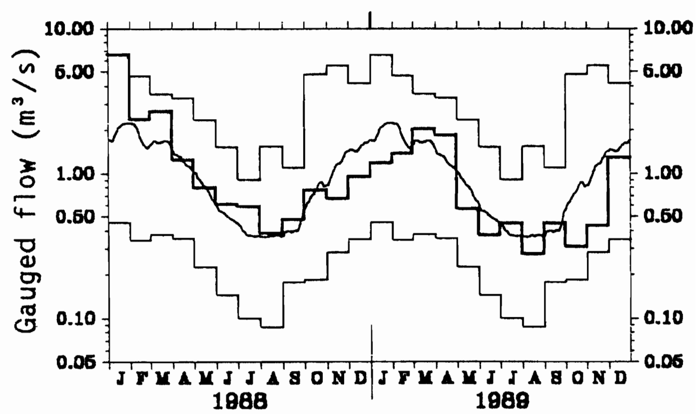
028018 Dove at Marston on Dove
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1961-1987



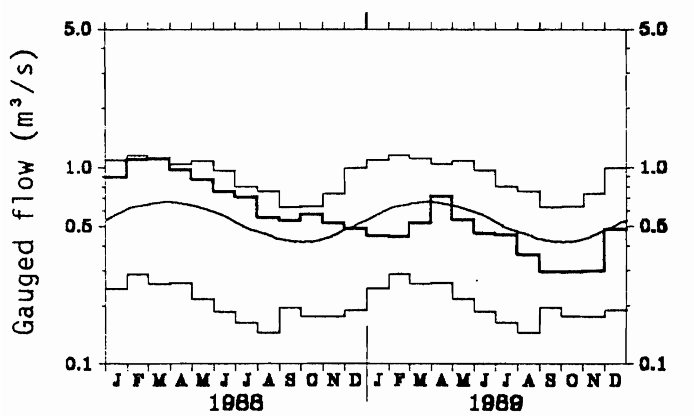
033002 Bedford Ouse at Bedford
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1933-1987



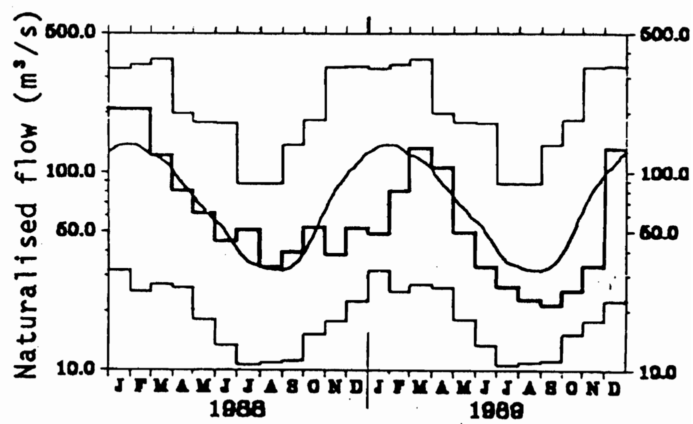
037005 Colne at Lexden
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1959-1987



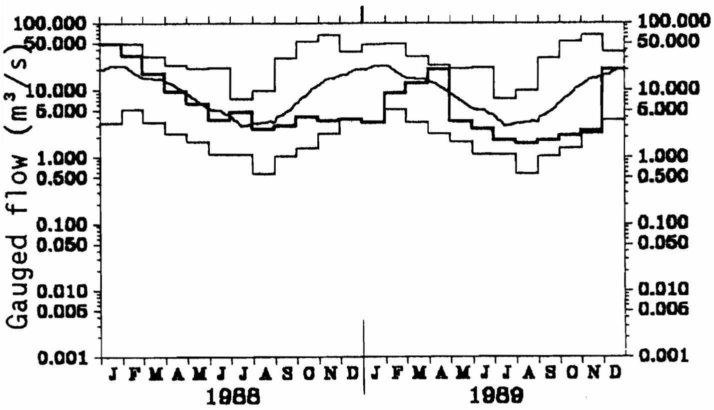
038003 Mimram at Panshanger Park
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1952-1987



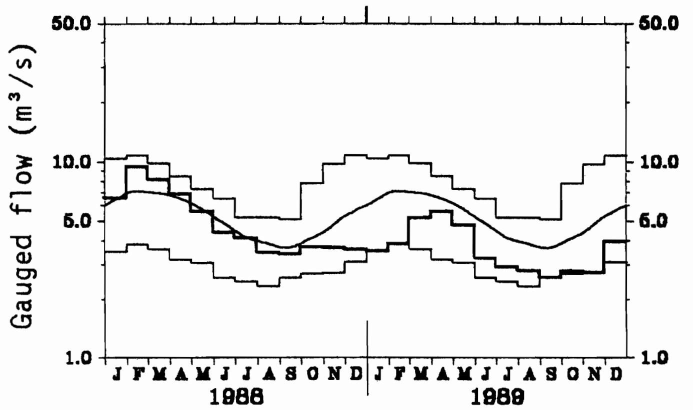
039001 Thames at Kingston
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1883-1987



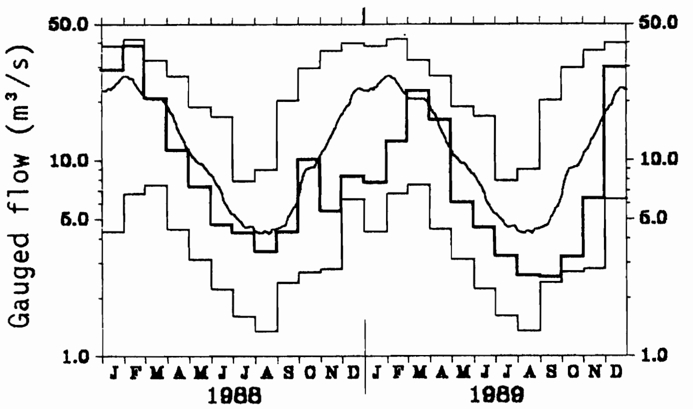
040003 Medway at Teston
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1956-1987



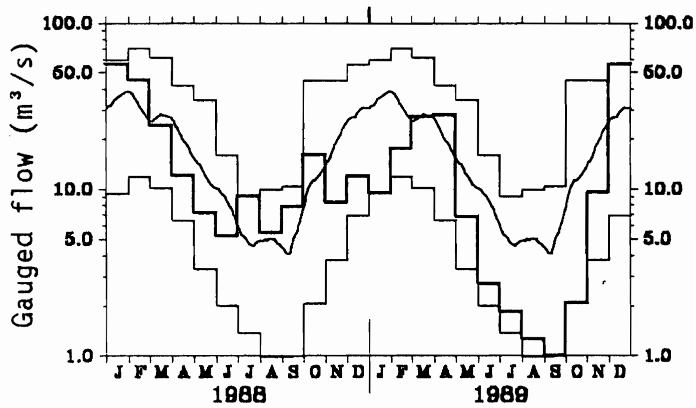
042010 Itchen at Highbridge+Allbrook
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1958-1987



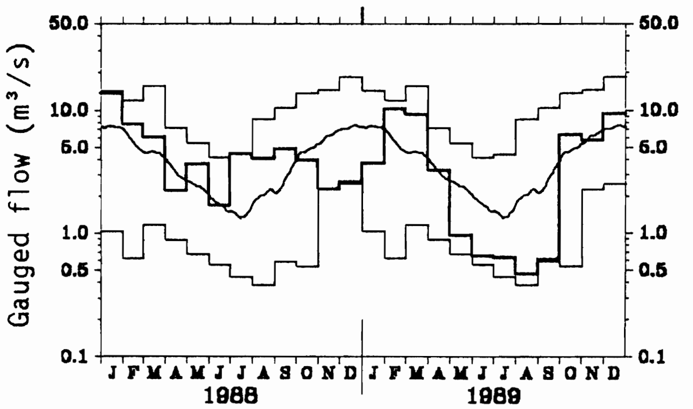
043007 Stour at Throop Mill
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1973-1987



054029 Teme at Knightsford Bridge
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1970-1987



057004 Cynon at Abercynon
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1957-1987



076007 Eden at Sheepmount
Monthly mean flows for 1988-1989
+ extremes and 30 day running mean for 1967-1987

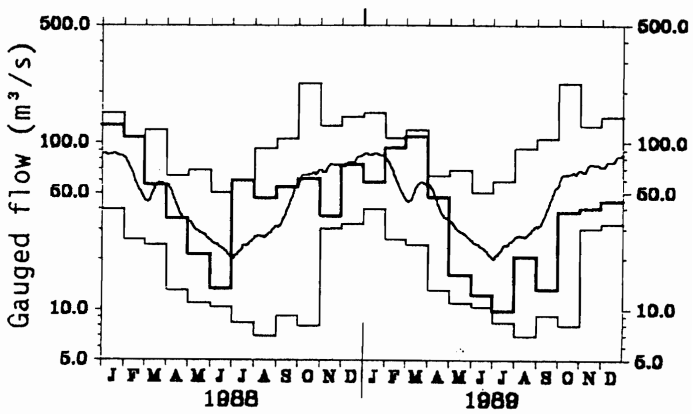


TABLE 3 RUNOFF AS MM. AND AS A PERCENTAGE OF THE PERIOD OF RECORD AVERAGE WITH SELECTED PERIODS RANKED IN THE RECORD

River/ Station name	Jan 1989 mm %LT	Feb mm %LT	Mar mm %LT	Apr mm %LT	May mm %LT	Jun mm %LT	Jul mm %LT	Aug mm %LT	Sep mm %LT	Oct mm %LT	Nov mm %LT	Dec mm %LT	5/89 to 12/89 mm %LT	rank /yrs	1/89 to 12/89 mm %LT	rank /yrs	11/88 to 12/89 mm %LT	rank /yrs	4/88 to 12/89 mm %LT	rank /yrs
Tay at	192	214	239	99	47	30	22	54	69	99	106	65	491	5	1235	28	1443	25	2177	34
Ballathie	138	201	203	120	66	66	55	104	97	89	88	45	75	/37	111	/37	105	/37	117	/36
Earn at	223	219	267	86	34	16	13	45	72	98	94	81	453	6	1248	31	1463	27	2185	33
Kinkell Bridge	152	190	231	115	53	39	34	79	90	83	71	52	67	/40	110	/40	104	/39	117	/38
South Tyne at	53	89	93	55	12	9	6	19	8	55	42	83	234	1	524	2	667	3	1003	3
Haydon Bridge	54	133	111	100	32	32	20	45	15	79	45	86	52	/26	70	/26	71	/26	79	/24
Wharfe at	42	64	95	71	15	13	10	14	10	39	29	44	174	1	446	1	587	1	897	2
Flint Mill Weir	43	87	126	131	38	51	37	33	21	60	36	45	42	/34	62	/34	66	/34	75	/33
Derwent at	17	17	22	29	13	9	8	6	5	6	9	15	72	1	157	1	209	1	346	1
Buttercrambe	33	40	47	85	50	51	58	42	37	25	35	36	42	/16	46	/16	51	/16	62	/15
Trent at	21	26	42	57	18	13	12	10	9	13	17	56	148	6	294	6	339	4	483	4
Colwick	41	60	103	177	70	67	74	59	52	54	55	127	77	/31	82	/31	78	/31	82	/30
Lud at	15	12	16	17	15	12	10	9	8	9	8	12	84	3	145	3	175	3	336	5
Louth	47	33	42	50	52	56	59	64	69	72	53	59	63	/21	54	/21	57	/21	77	/20
Witham at	8	8	12	31	14	8	6	4	4	5	6	20	68	14	126	6	140	6	209	6
Claypole Mill	30	30	45	148	87	80	84	56	63	57	49	105	79	/31	67	/30	64	/30	71	/29
Bedford Ouse at	13	23	37	46	13	7	7	4	4	5	8	53	103	33	222	29	249	23	327	26
Bedford	36	69	117	231	98	85	117	77	80	49	40	189	107	/57	102	/57	93	/56	98	/56
Colne at	13	14	23	20	6	4	5	3	5	3	5	14	46	6	116	5	133	5	187	10
Lexden	55	77	122	150	67	73	119	73	115	34	39	82	70	/30	83	/30	79	/30	86	/29
Mimram at	9	8	10	14	11	9	9	7	6	6	6	10	63	5	104	5	124	8	222	20
Panshanger Park	77	68	74	110	88	82	92	77	73	71	68	98	81	/37	82	/37	85	/36	102	/36
Thames at	13	20	36	28	13	9	7	6	6	7	9	38	94	31	190	25	214	19	310	27
Kingston (natr.)	35	61	115	124	74	71	74	68	67	52	41	126	77	/107	77	/107	72	/106	79	/106
Kennet at	16	19	31	29	22	16	13	10	10	9	11	27	118	4	214	4	244	4	377	3
Theale	46	55	81	91	81	73	77	67	74	56	55	102	76	/28	73	/28	72	/28	78	/27
Coln at	15	19	48	44	30	18	15	13	10	10	15	39	149	5	275	3	308	3	458	3
Bibury	29	35	89	101	89	66	70	76	69	61	60	98	78	/26	70	/26	67	/26	72	/25
Medway at	7	17	27	41	7	6	4	3	4	4	5	43	76	4	168	1	183	1	253	1
Teston	14	46	85	185	47	60	62	41	40	21	16	106	54	/26	60	/26	53	/25	57	/23
Itchen at	26	26	39	40	36	23	22	21	19	21	20	29	190	2	321	1	374	1	606	1
Highbridge+Allbrook	53	53	74	85	84	66	71	73	71	68	57	68	71	/31	69	/31	69	/31	77	/30
Stour at	19	28	57	39	15	11	8	6	6	8	15	74	145	6	288	2	322	1	434	1
Throop Mill	31	49	110	112	62	68	70	55	49	35	46	134	79	/17	75	/17	66	/16	70	/16
Tone at	25	54	80	40	19	11	10	7	9	13	29	91	189	10	388	5	434	3	600	5
Bishops Hull	31	74	139	102	67	61	63	55	57	47	68	136	83	/29	81	/28	74	/28	81	/28
Severn at	29	48	77	48	12	7	8	7	6	14	32	81	167	7	368	12	427	8	606	12
Bewdley	41	84	168	152	50	39	56	40	27	41	59	130	68	/69	81	/68	75	/68	83	/68
Yscir at	92	130	182	72	18	10	11	8	11	90	125	209	482	5	958	6	1063	3	1524	5
Pontaryscir	62	128	165	120	40	32	49	25	22	97	101	140	88	/17	99	/17	84	/16	95	/16
Cynon at	94	232	232	80	24	16	16	12	15	160	139	238	619	8	1257	13	1380	9	2001	12
Abercynon	50	182	199	105	39	38	46	23	21	132	90	126	84	/30	101	/30	87	/30	97	/28
Dee at	133	215	333	129	23	34	23	34	36	226	169	224	768	2	1579	6	1849	4	2763	7
New Inn	55	136	189	125	32	57	33	35	25	113	68	90	68	/20	87	/20	80	/20	90	/19
Lune at	94	167	196	82	20	14	12	44	13	121	81	84	389	1	928	6	1164	4	1737	7
Caton	64	186	203	110	39	34	23	61	14	99	60	54	55	/27	83	/27	83	/25	90	/25
Eden at	68	98	127	53	19	14	11	24	15	44	45	52	224	1	571	5	697	4	1032	8
Sheepmount	67	152	194	114	56	53	39	75	33	57	53	58	56	/19	84	/19	82	/18	92	/17

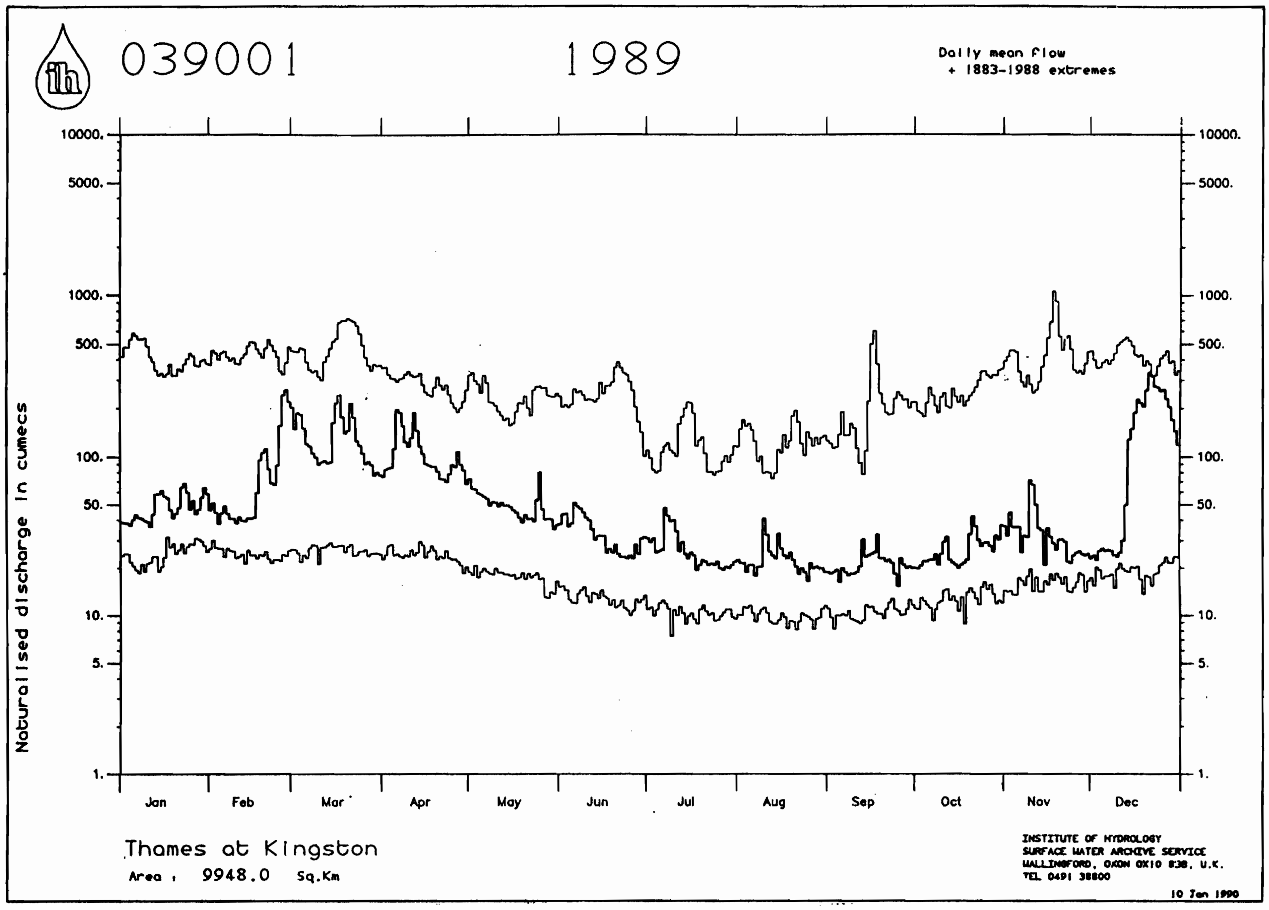
Notes:

(i) Values based on gauged flow data unless flagged (natr.), when naturalised data have been used.

(ii) Values are ranked so that the lowest runoff is rank 1.

(iii) %LT means percentage of the long term average from the start of the record to 1988. For the long periods (at the right of this table), the end date for the long term is 1989.

FIGURE 3 ANNUAL HYDROGRAPHS FOR THE RIVER THAMES AND SEVERN



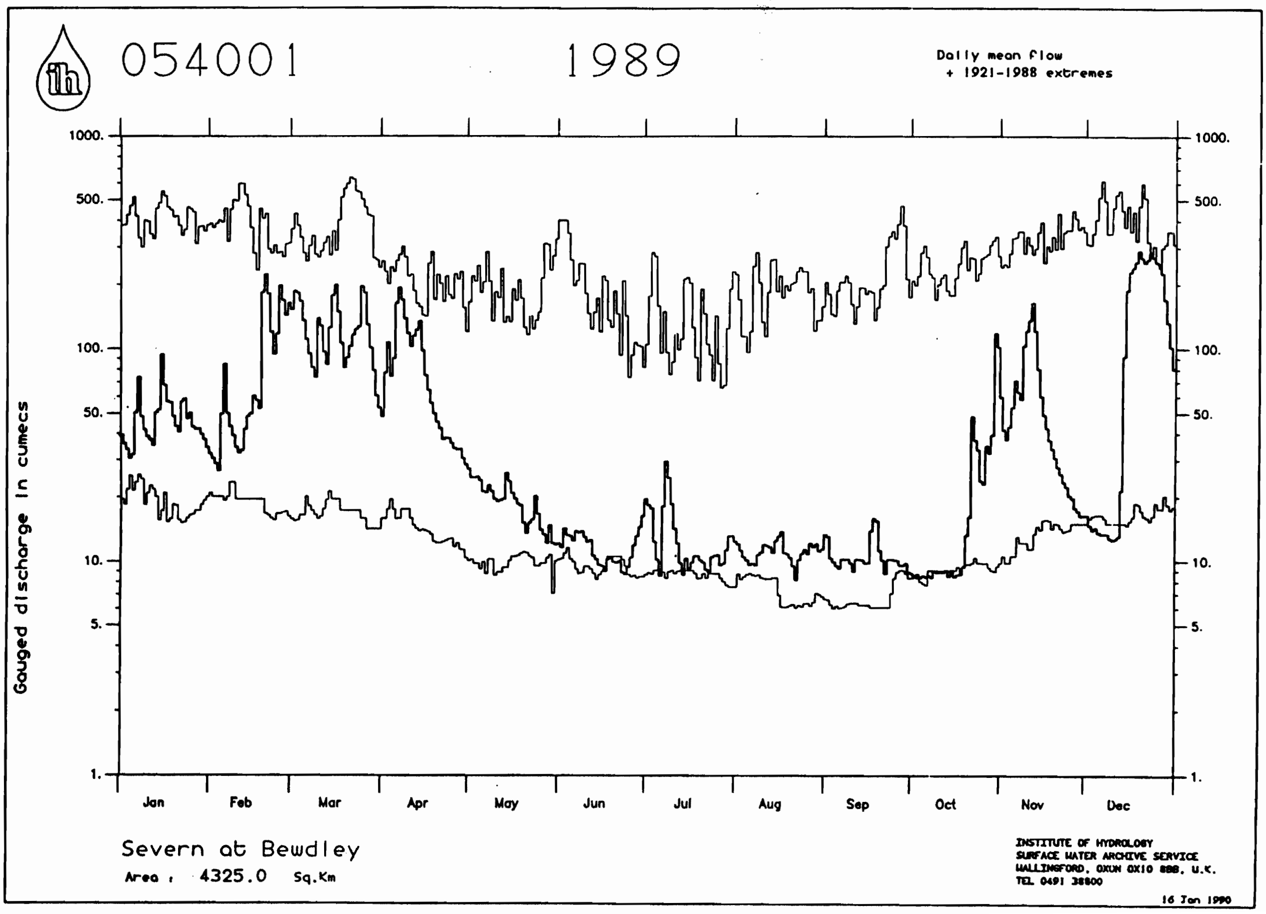


TABLE 4 RIVER FLOW RETURN PERIODS - DECEMBER 1989

River	Station Name	First Year	December One Day Min. 1989	One day as % of Dec LTA	Return Period (in years)	Base Flow Index
Dee	Park	1972	7.22	11.2	50-100	0.54
Tay	Ballathie	1952	42.20	17.1	100	0.65
Earn	Kinkell Bridge	1948	5.00	21.5	20	0.48
Tweed	Boleside	1961	7.10	13.4	50-100	0.50
Wharfe	Flint Mill Weir	1955	2.43	8.8	50	0.39
Derwent	Buttercrambe (Yorks)	1973	4.20	16.5	50	0.68
Trent	Colwick	1959	26.00	20.9	50-100	0.64
Dove	Marston on Dove	1961	4.00	18.5	50	0.60
Derwent	St Mary's Bridge (Derby)	1953	4.50	17.1	50-100	0.62
Lud	Louth	1968	0.16	37.9	5-10	0.90
Colne	Lexden (Essex)	1959	0.16	10.4	100	0.53
Mimram	Panshanger Park	1952	0.27	53.8	15-20	0.94
Thames	Kingston (nat)	1952	22.60	20.1	100	0.64
Kennet	Theale	1962	3.60	34.7	50	0.87
Mole	Kinnersley Manor	1972	0.62	16.9	2- 5	0.37
Medway	Teston	1957	1.9(e)	9.8	15-20	0.41
Rother	Iping Mill	1966	0.60	20.1	25	0.63
Test	Broadlands	1957	6.00	50.8	15-20	0.94
Itchen	Highbridge	1959	2.00	34.6	200	0.97
Avon	Amesbury	1965	1.18	29.6	10	0.91
Stour	Throop Mill	1973	3.24	14.1	5-10	0.66
Tone	Bishops Hull	1961	0.81	15.7	25	0.58
Brue	Lovington	1964	0.27	7.7	50	0.47
Severn	Bewdley	1921	12.60	12.5	150	0.53
Teme	Knightsbridge	1970	3.0(e)	10.4	50	0.57
Yscir	Pontaryscir	1972	0.46	12.6	50	0.47
Cynon	Abercynon	1957	0.83	12.6	100	0.42
Dee	New Inn	1969	0.35	7.5	50-100	0.27

		First Year	Dec. Flow	Return Period (yrs)	Base Flow Index
Dee	Park	1972	29.66	20-25	0.54
Derwent	Buttercrambe (Yorks)	1973	9.114	25-50	0.68
Mimram	Panshanger Park	1952	0.48	2	0.94
Test	Broadlands	1957	10.4	2-4	0.94
Itchen	Highbridge	1959	3.94	10	0.97
Avon	Amesbury	1965	3.04	2-5	0.91

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.

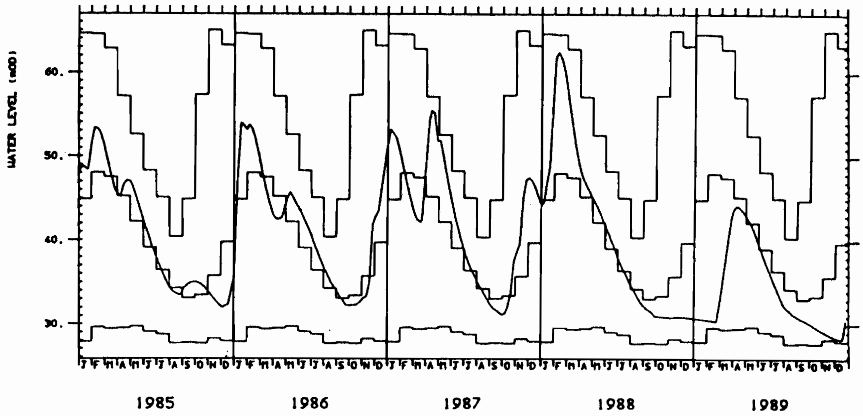
* The Itchen flow is adjusted to compensate for groundwater augmentation

FIGURE 4 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

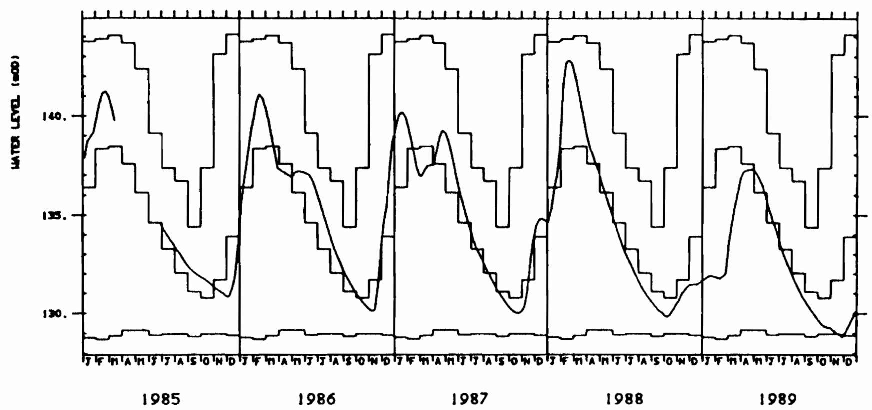


Max, Min and Mean values calculated from years 1894 TO 1989

Site name: ROCKLEY

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

Aquifer: CHALK AND UPPER GREENSAND Measuring level: 146.39



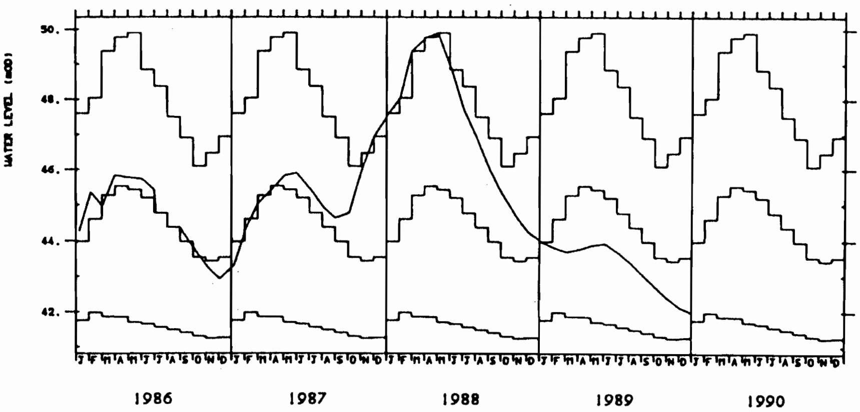
Max, Min and Mean values calculated from years 1933 TO 1988

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

Site name: WASHPIT FARM

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

Aquifer: CHALK AND UPPER GREENSAND Measuring level: 80.20

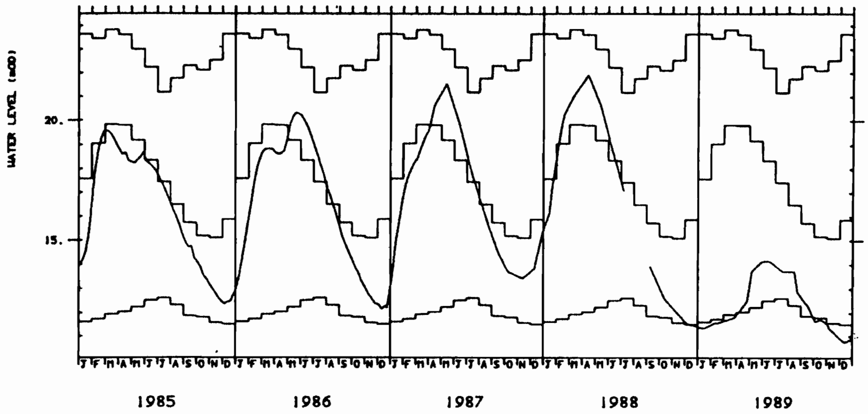


Max, Min and Mean values calculated from years 1950 TO 1989

Site name: DALTON HOLME

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

Aquifer: CHALK AND UPPER GREENSAND — Measuring level: 33.50



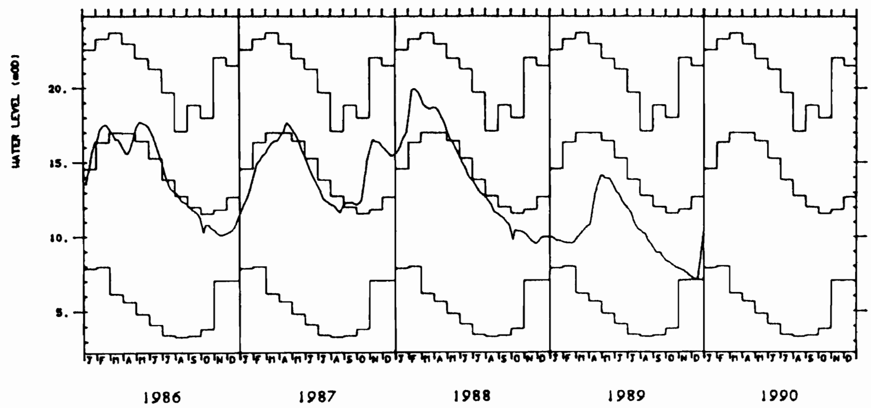
Max, Min and Mean values calculated from years 1889 TO 1988

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

Site name: NEW RED LION

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

Aquifer: LINCOLNSHIRE LIMESTONE — Measuring level: 33.82

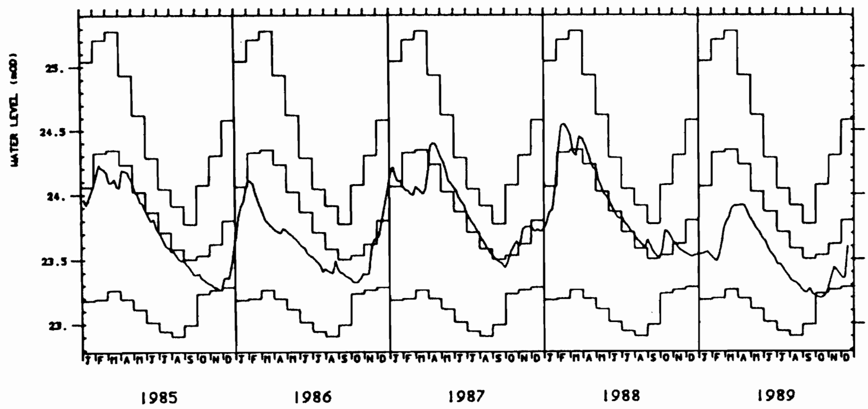


Max, Min and Mean values calculated from years 1964 TO 1989

Site name: BUSSELS NO.7A

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

Aquifer: PERMO-TRIASSIC SANDSTONE — Measuring level: 26.07

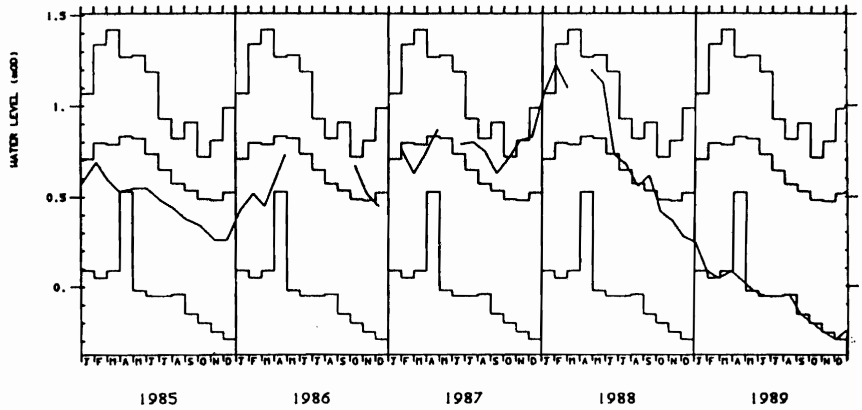


Max, Min and Mean values calculated from years 1972 TO 1988

Site name: WOODHOUSE GRANGE

National grid reference: SE 6784 0709 Well number: SE60/76

Aquifer: PERMO-TRIASSIC SANDSTONE Measuring level: 4.35



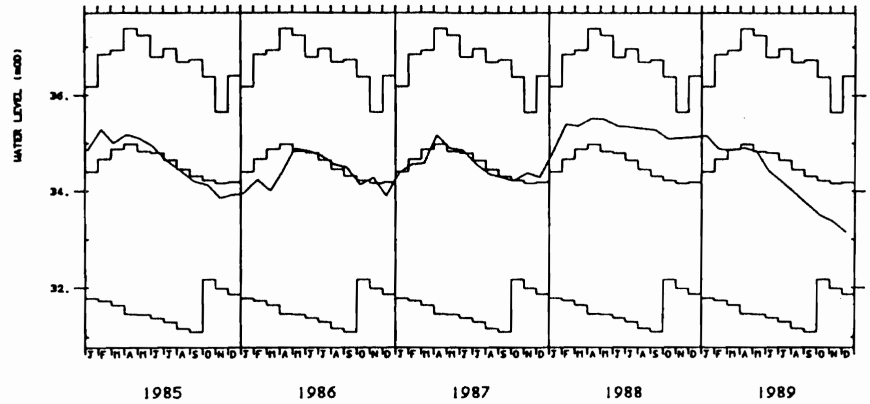
Max, Min and Mean values calculated from years 1980 TO 1989

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

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