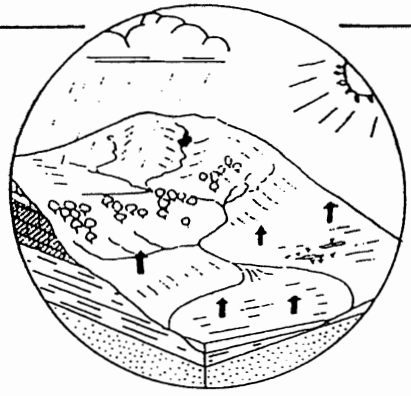
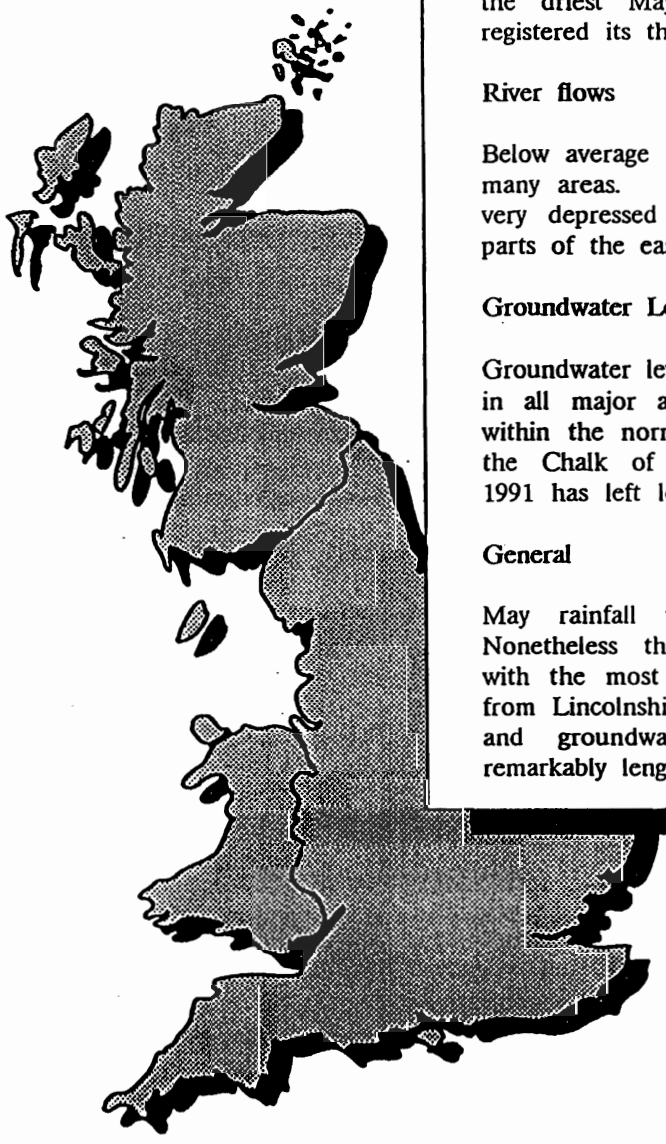
Hydrological Summary for Great Britain





MAY 1991

Rainfall

Provisional figures indicate that the May rainfall for Great Britain was comparable with that for 1919 - the driest May this century. England and Wales registered its third driest May in over 220 years.

River flows

Below average throughout Great Britain, notably so in many areas. Exceptionally low May mean flows and very depressed accumulated runoff totals characterise parts of the eastern lowlands of England.

Groundwater Levels

Groundwater levels have begun their summer recession in all major aquifers. Generally water-tables stand within the normal range, albeit below average, but in the Chalk of eastern England meagre recharge in 1991 has left levels close to the minimum on record.

General

May rainfall was very low in almost all areas. Nonetheless the drought remains distinctly regional with the most severe conditions confined to a zone from Lincolnshire to Kent where depressed river flows and groundwater levels are a response to a remarkably lengthy period of rainfall deficiency.

Institute of Hydrology

British Geological Survey

HYDROLOGICAL SUMMARY FOR GREAT BRITAIN - MAY 1991

Data for this report 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. Reservoir contents information for England and Wales has been supplied by either the Water Services Companies or the NRA. The recent areal rainfall figures are derived from a restricted network of raingauges (particularly in Scotland) and a proportion of the river flow data is of a provisional nature.

A map (Figure 4) is provided to assist in the location of the principal monitoring sites.

Rainfall

Weather conditions over Great Britain during May were, in large part, determined by the persistence of a high pressure cell centred to the south of Iceland. This relatively unusual synoptic pattern produced lengthy spells with prevailing north-easterly winds and a month dominated by cool and very cloudy weather. Atypically under such circumstances, rainfall totals were remarkably low with precipitation in some areas restricted to a few light showers.

Apart from the northern tip of Scotland, May rainfall totals were well below average with exceptionally dry conditions characterising most of Britain south of the Scottish Highlands. Much of western and southern England recorded less than a quarter of the monthly average rainfall and totals of less than 10 mm were registered in a number of localities within most regions; South Wales was especially dry. With the benefit of winds off the North Sea eastern England fared a little better but only in eastern Suffolk and Kent did rainfall exceed half the May average.

For England and Wales as a whole, the 1990 provisional May rainfall total is the lowest for nearly 100 years - 12 mm were recorded in May 1896. Since the 1959 drought there have been only two drier months (April 1984 and April 1974). The recent sequence of dry Mays constitutes a notable cluster - three of the six lowest May rainfall totals this century have occurred since 1988.

Accumulated regional rainfall totals for the spring (March-May) are generally a little below average - especially in the east - but substantially greater than for the same period in 1990. For 1991 thus far, and for the period beginning in October 1990, provisional regional totals fall well within the normal range. However, a significant gradation may be seen from above average rainfall in Scotland and parts of northern England to appreciably below in East Anglia. A notable drought embracing much of the English lowlands becomes apparent as the timeframe is extended back through the summer and, especially, the spring of 1990. Over the 15 months commencing in March 1990 the rainfall total for England and Wales was the third lowest (for that period) this century. For sequences beginning in any month, substantially drier 15-month periods have been recorded during the droughts of 1975/76, 1933/34 and 1920/21. The figures presented in Table 2 underline the regional nature of the drought with severe 15-month rainfall deficiencies largely confined to the Anglian and Thames regions (but extending into adjacent areas). The hydrological significance - particularly in relation to groundwater - of the meteorological drought in this timeframe is accentuated by its spatial association with very long term rainfall deficiencies extending back to the spring of 1988. In the 34-month timeframe the estimated return periods quoted in Table 2 testify to a remarkable accentuation in the normal rainfall gradient; western Scotland being extremely wet and South-East England exceptionally dry.

Evaporation and Soil Moisture Deficits (SMDs)

In contrast to both 1989 and 1990, temperatures and sunshine hours for May 1991 were substantially below average throughout most of Great Britain. Correspondingly, evaporative losses were generally below average and markedly lower than in the preceding two years. For the year so far potential and actual evaporation totals have also been unexceptional. Longer term accumulations clearly show the effect of the extremely warm conditions which characterised most of 1990 (and 1989). Over the last 12 months MORECS potential evaporation totals remain close to the highest on record in parts of southern Britain, albeit appreciably lower than the corresponding figures for 1989/90. By contrast, 12-month actual evaporation totals in the English lowlands in particular are commonly the lowest on record - a consequence of the inhibiting affect of sustained high SMDs on transpiration rates during 1990.

SMDs, having declined sharply at the end of April over much of England and Wales, increased briskly through May and, entering June, were significantly above average in central and southern Scotland, South Wales and south-western England but close to the normal throughout much of the South-East. Rainfall in May produced an unusual uniformity in calculated SMDs (for grass), deficits being in the range 55-75 mm across the greater part of Britain. Throughout large parts of the eastern lowlands these represent much less severe conditions than in May 1990 when SMDs were typically 30-50 mm higher.

Note: The cool and cloudy weather conditions during May provided some compensation for the meagre rainfall in relation to soil moisture conditions. As a consequence the surges in peak water demand - often associated with increased crop and garden watering - which triggered hose-pipe bans and other demand control measures in May 1989 and 1990 were, in 1991, relatively muted in most regions.

Runoff

Although flow rates in many catchments were reasonably healthy at the beginning of May - a consequence of the widespread and sustained rainfall at the end of April - recessions thereafter were steep and generally extended until month-end. Runoff totals for May were below average for all index catchments. Notably low mean flows typified a number of impermeable catchments in the west and north (a response to the very limited May rainfall) and exceptionally low flows characterised some eastern permeable catchments (a response to rainfall deficiencies extending over 24-36 months).

The rankings for May presented in Table 3 confirm that May runoff rates were depressed throughout Great Britain but well above historical minima except for a few lowland rivers. In the great majority of catchments mean flows for May were greater than the corresponding flows in 1990 (often 1989 also). Important exceptions include some rivers in the English lowlands supported principally from groundwater. In such catchments the 1991 drought has achieved its greatest severity. Flows on the Lud and Mimram, for instance, have remained below the monthly mean since the summer of 1988 and the steady decline in flow rates during the spring of 1991 has resulted in daily flows approaching those registered in May during the droughts of 1976 and 1973. For the Little Ouse, the May 1991 runoff is unprecedented in a 24-year record. Generally, however, flows remain substantially greater than the corresponding flows in 1976 - see Table 3.

The accumulated runoff totals presented in Table 3 emphasise both the persistence of low flow rates over large parts of England and Wales and the restricted area of the English lowlands over which exceptionally low accumulations obtain. Runoff totals over a range of durations for the Mimram, Colne, Lud and Little Ouse are amongst the lowest on record. For the latter two, representative of the most severely affected rivers, runoff over the last two years has been around half of the pre-1989 average. No comparable deficiencies exist in their periods of record. Long

term runoff totals for rivers draining from the Scottish Highlands present a dramatic contrast - new maxima have been established over wide areas.

Unsurprisingly, the healthy recovery in reservoir stocks during April gave way to a relatively brisk decline by late May as demand exceeded replenishment. Nonetheless, throughout most of southern Britain storage at the beginning of the summer was only a little below capacity and - marginally in some areas - above the corresponding storage for 1990, even where, in meteorological terms, the drought is currently most severe (see Table 4).

Groundwater

As in most years groundwater storage showed only moderate change over the month from late-April. With SMDs climbing through May, infiltration to all major aquifers was minimal and no further substantial recharge may now be expected before the autumn.

Some modest rises in groundwater level were recorded during May for deeper boreholes in the Chalk - primarily a lagged response to the April rainfall. Generally however, groundwater recessions had become firmly established by late-May. Recharge patterns, consequent upon variations in winter rainfall and soil moisture conditions, have produced very appreciable differences in the regional and local magnitude of the winter recovery in the Chalk aquifer. Abstraction rates have also exerted an influence in areas of high demand. Some broad generalisations may, however, be made. An eastward deterioration in groundwater storage may be recognised; at the western and northerly limit of the Chalk outcrop groundwater levels by late-May were close to the monthly average. By contrast, the water-table in a zone extending north (to Lincolnshire) and east from the Chilterns is close to the minimum level on record. In this region the 1973 recession represents the worst period of groundwater depletion in the recent past. Over much of the eastern Chalk the effect of the moderate infiltration in April was to nudge groundwater levels marginally above those registered in the early summer of 1973. At Fairfield (Suffolk) levels remain below any previously recorded but, significantly, the observation borehole was commissioned in 1974.

Groundwater levels in the Oolitic Limestone of the Cotswolds and in the Lincolnshire Limestone are close to the early summer average. Similarly, water-tables stand well within the normal range in the Permo-Triassic Sandstones in the South-West. In parts of North Wales and the Midlands, however, groundwater levels are substantially more depressed. At Weeford Flats near Lichfield, levels in the Sherwood sandstone were still showing an upward trend in May - a normal recharge pattern exhibiting some lag - but are unlikely to recover much more before the onset of the summer recession; levels are the most depressed since 1976.

The regional nature of the 1991 groundwater drought is clearly evident in Table 5 - depletion being most severe in those areas where the May level ranks among the two or three lowest on record. Concern currently focuses on the Chalk of East Anglia and the east of the Thames region with more localised problems in part of Sussex and Kent. In these areas, and in parts of the Permo-Triassic sandstones of the Midlands, levels are now significantly below those registered at the same time in 1990. The relatively modest SMDs in May provide grounds for believing that the autumn recovery will not be as inordinately delayed as in the last three years. Should a dry autumn intervene, it may be expected to result in groundwater levels depressed to new minima over large parts of the lowlands.

Institute of Hydrology / British Geological Survey

14 May 1991

TABLE 1 1990/91 RAINFALL AS A PERCENTAGE OF THE 1941-70 AVERAGE

		May 1990	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 1991	Feb	Mar	Apr	May 1991
England and	mm	25	72	35	46	53	103	65	97	92	63	73	72	15
Wales	%	37	118	47	51	64	124	67	108	107	97	124	124	22
NRA REGIONS														
North West	mm	49	99	58	73	86	175	68	142	97	86	89	61	18
	%	60	119	56	58	70	148	56	118	87	106	124	79	22
Northumbria	mm	51	69	40	53	53	107	61	109	85	114	84	40	18
	%	80	113	52	52	66	143	65	145	106	173	162	73	28
Severn Trent	mm	19	63	27	37	46	93	52	92	78	41	59	66	11
	%	30	113	42	46	69	143	66	131	113	77	113	127	17
Yorkshire	mm	29	83	32	47	39	92	55	121	72	89	62	49	15
	%	48	143	46	52	54	133	62	163	94	139	117	88	24
Anglia	mm	16	45	21	31	32	51	52	48	44	39	29	44	14
	%	34	92	37	48	62	98	84	91	85	93	73	110	29
Thames	mm	7	47	17	35	34	58	34	65	80	39	45	62	14
	%	13	90	28	50	55	91	47	99	129	83	98	135	25
Southern	mm	10	61	13	33	38	105	59	63	98	40	59	56	18
	%	18	122	22	45	54	135	63	77	129	70	113	117	33
Wessex	mm	12	62	31	41	49	87	52	74	105	43	88	69	11
	%	18	115	50	50	62	106	54	83	125	73	152	128	16
South West	mm	25	99	61	59	69	128	107	112	151	82	127	99	9
	%	30	152	73	58	66	113	80	83	117	91	151	139	10
Welsh	mm	34	98	53	64	85	152	109	152	150	96	125	121	11
	%	37	120	56	54	68	118	76	105	110	100	144	141	12
Scotland	mm	54	128	75	119	149	213	101	184	146	83	128	92	50
	%	59	139	67	92	109	143	71	108	107	80	139	102	55
RIVER PURIFICATION BOARDS														
Highland	mm	54	140	93	156	234	225	144	236	173	70	141	129	68
	%	52	127	73	105	148	121	85	120	105	53	124	113	66
North-East	mm	49	110	43	75	86	136	94	89	56	77	80	59	47
	%	64	157	47	70	99	140	91	87	62	104	129	97	61
Tay	mm	44	128	38	73	68	186	65	136	164	89	117	107	35
	%	46	154	37	62	59	152	55	101	139	97	143	143	37
Forth	mm	39	125	49	83	68	194	57	137	120	84	104	90	18
	%	46	167	50	72	63	183	53	126	121	109	151	132	22
Tweed	mm	46	106	52	61	69	159	52	148	107	103	93	60	16
	%	61	156	58	54	74	181	50	164	115	149	160	98	21
Solway	mm	76	121	74	106	81	218	79	189	140	108	153	146	16
	%	83	134	67	82	54	151	54	125	100	116	168	166	17
Clyde	mm	57	138	96	151	172	301	90	223	181	88	162	181	23
	%	59	134	74	106	98	164	54	120	112	78	154	176	24

Note: The recent monthly rainfall figures for England and Wales for 1991 are based upon MORECS figures supplied by the Meteorological Office. Earlier areal figures are derived from a far denser raingauge network.
Scottish RPB data for May 1991 were estimated from the isohyetal map provided with the MORECS bulletins.

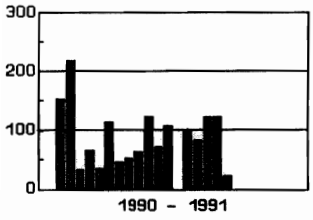
TABLE 2 RAINFALL RETURN PERIOD ESTIMATES

		OCT 90 - MAY 91		MAR 90 - MAY 91		MAY 89 - MAY 91		AUG 88 - MAY 91	
		Est Return Period, years		Est Return Period, years		Est Return Period, years		Est Return Period, years	
England and	mm	573		865		1645		2288	
Wales	% LTA	95	2-5	79	30-40	87	10-15	88	15-20
NRA REGIONS									
North West	mm	736		1203		2219		3229	
	% LTA	94	2-5	83	10-15	88	5-10	93	5
Northumbria	mm	618		941		1558		2157	
	% LTA	110	2-5	90	2-5	86	15-20	86	20-30
Severn Trent	mm	492		732		1416		1921	
	% LTA	98	2-5	78	20-30	88	5-10	87	10-20
Yorkshire	mm	555		834		1476		2060	
	% LTA	102	2-5	83	10-15	85	15-20	87	10-20
Anglia	mm	321		515		993		1372	
	% LTA	83	5-10	70	100-150	78	70-100	80	80-120
Thames	mm	397		584		1195		1644	
	% LTA	86	2-5	69	80-120	82	15-20	82	30-50
Southern	mm	498		707		1375		1858	
	% LTA	92	2-5	74	30-40	84	10-20	82	30-50
Wessex	mm	529		773		1561		2149	
	% LTA	89	2-5	74	30-40	86	10	86	10-20
South West	mm	815		1199		2328		3204	
	% LTA	97	2-5	84	5-10	94	2-5	93	2-5
Welsh	mm	916		1335		2571		3592	
	% LTA	100	<.2	84	10	93	2-5	94	2-5
Scotland	mm	997		1865		3211		4646	
	% LTA	104	2-5	109	5-10	109	5-10	114	50-70
RIVER PURIFICATION BOARDS									
Highland	mm	1186		2408		4075		6085	
	% LTA	101	2-5	117	15-20	115	30-40	121	>>200
North-East	mm	638		1133		1840		2664	
	% LTA	96	2-5	93	2-5	87	15-20	90	10-15
Tay	mm	899		1489		2641		3970	
	% LTA	107	2-5	99	2-5	101	2-5	108	5-10
Forth	mm	804		1365		2379		3506	
	% LTA	112	2-5	102	2-5	103	2-5	108	5-10
Tweed	mm	738		1155		1953		2769	
	% LTA	115	5-10	96	2-5	94	2-5	95	2-5
Solway	mm	1049		1673		2936		4405	
	% LTA	111	2-5	99	2-5	100	<2	106	2-5
Clyde	mm	1249		2285		3937		5817	
	% LTA	112	2-5	116	10-20	115	20-30	120	>200

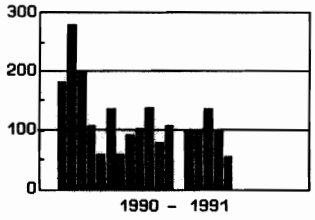
Return period assessments are based on tables provided by the Meteorological Office*. These assume a start in a given return periods for a start in any month may be expected to be an order of magnitude less.
The tables reflect rainfall totals over the period 1911-70 only and the estimate assumes a sensibly stable climate.

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

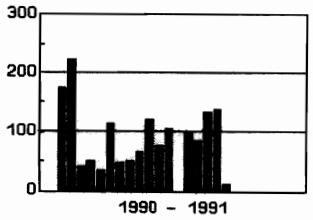
FIGURE 1 MONTHLY RAINFALL FOR 1990/91 AS A PERCENTAGE OF THE 1941-70 AVERAGE



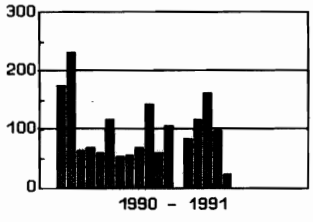
England and Wales



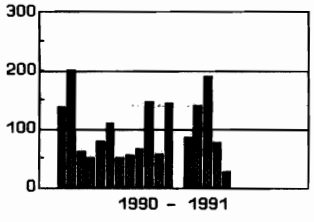
Scotland



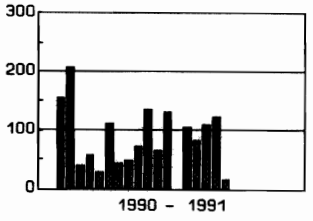
Welsh Region



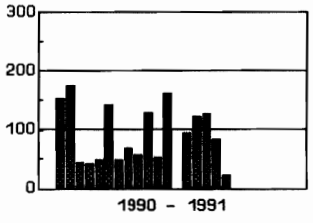
North West Region



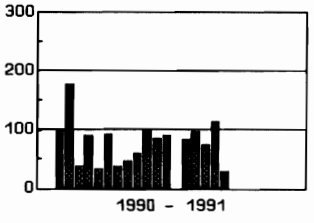
Northumbria Region



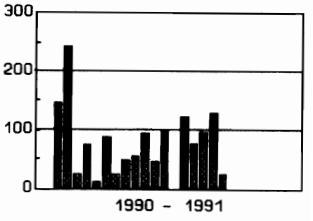
Severn-Trent Region



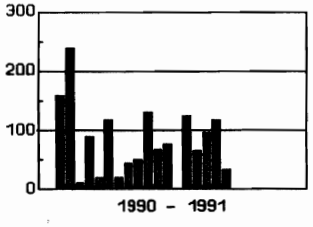
Yorkshire Region



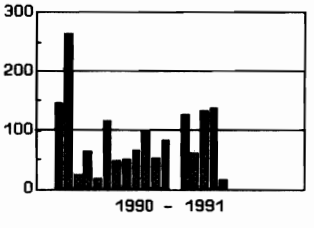
Anglian Region



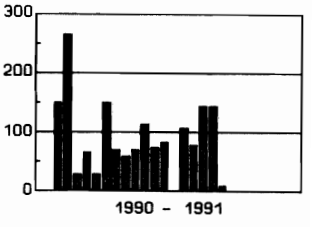
Thames Region



Southern Region

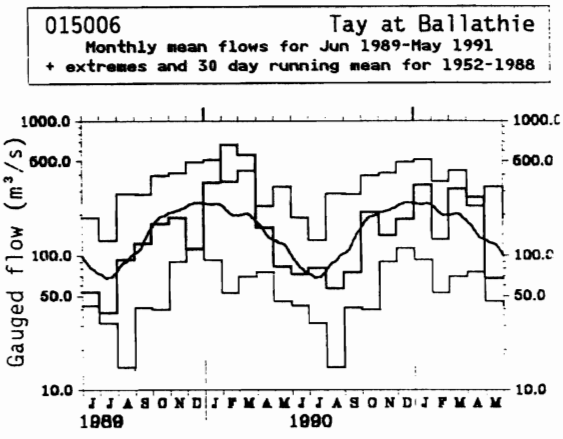


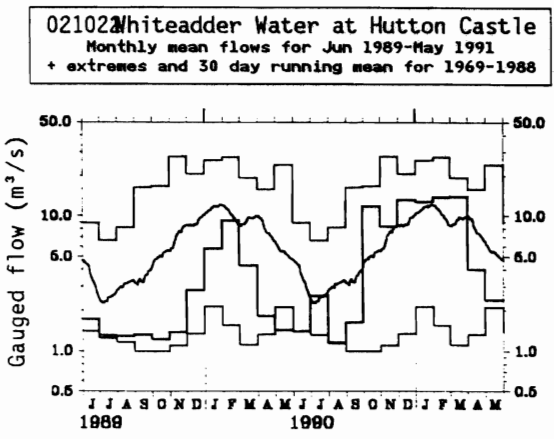
Wessex Region

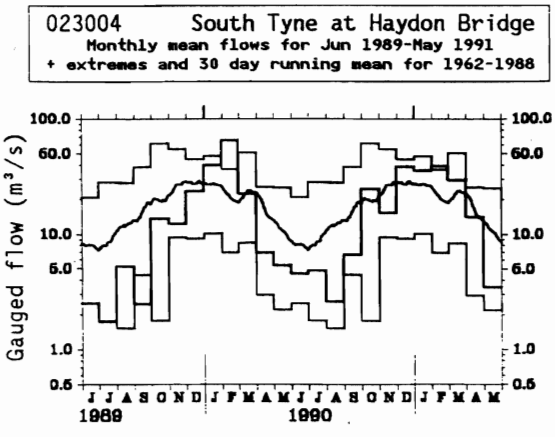


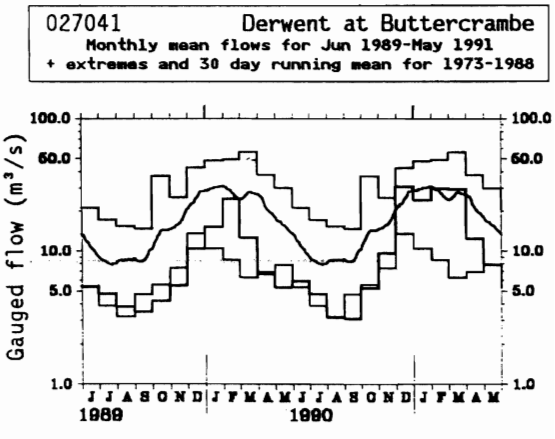
South West Region

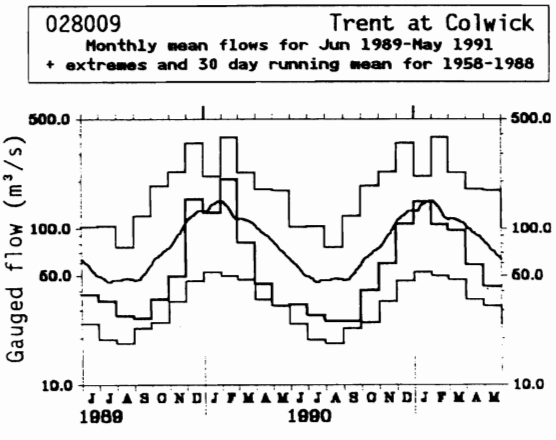
FIGURE 2 MONTHLY RIVER FLOW HYDROGRAPHS

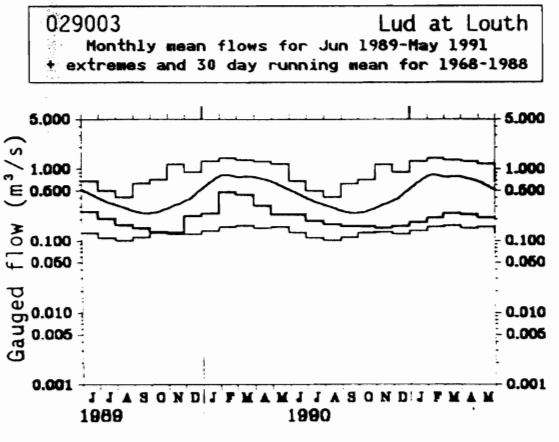


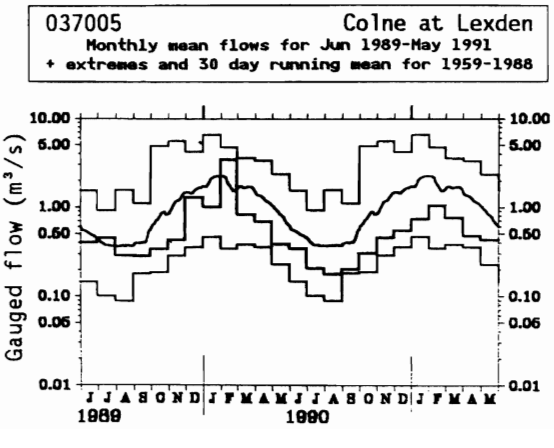


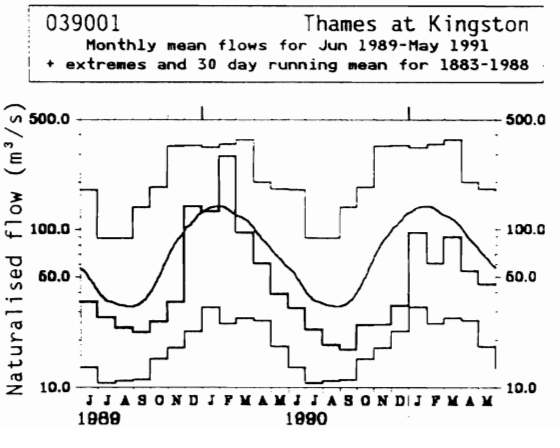






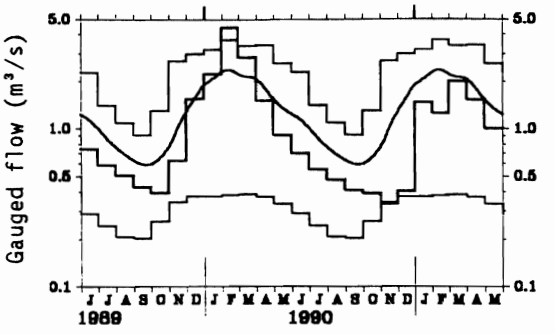






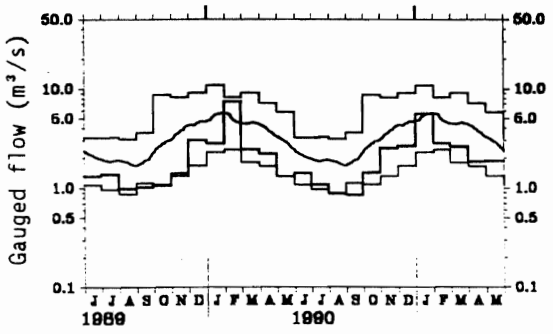
039020 Coln at Bibury

Monthly mean flows for Jun 1989-May 1991
+ extremes and 30 day running mean for 1963-1988



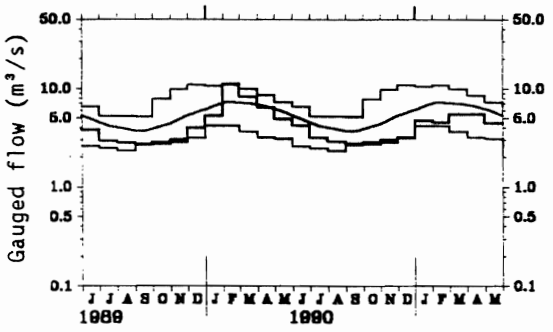
040011 Great Stour at Horton

Monthly mean flows for Jun 1989-May 1991
+ extremes and 30 day running mean for 1964-1988



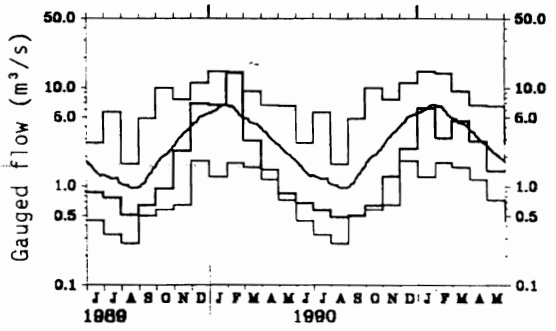
042010 Itchen at Highbridge+Allbrook

Monthly mean flows for Jun 1989-May 1991
+ extremes and 30 day running mean for 1958-1988



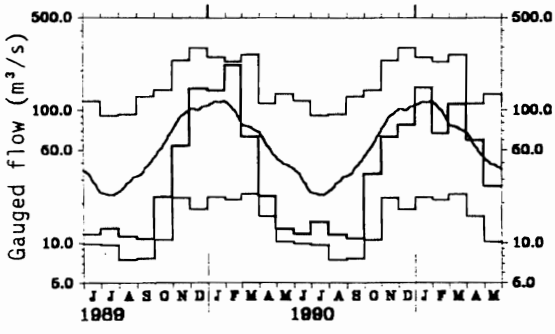
052005 Tone at Bishops Hull

Monthly mean flows for Jun 1989-May 1991
+ extremes and 30 day running mean for 1961-1988



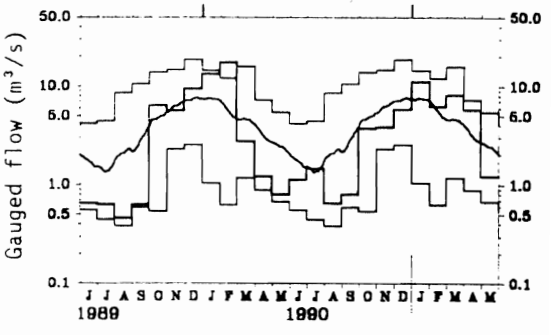
054001 Severn at Bewdley

Monthly mean flows for Jun 1989-May 1991
+ extremes and 30 day running mean for 1921-1988



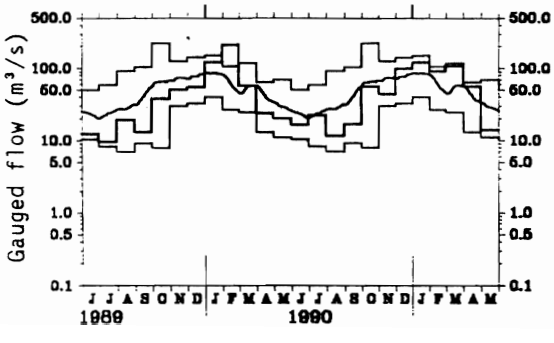
057004 Cynon at Abercynon

Monthly mean flows for Jun 1989-May 1991
+ extremes and 30 day running mean for 1957-1988



076007 Eden at Sheepmount

Monthly mean flows for Jun 1989-May 1991
+ extremes and 30 day running mean for 1967-1988



084013 Clyde at Daldowie

Monthly mean flows for Jun 1989-May 1991
+ extremes and 30 day running mean for 1963-1988

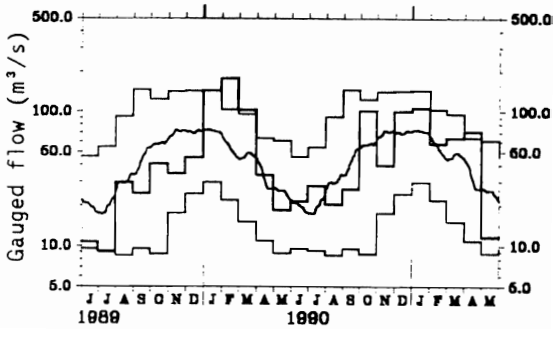


TABLE 3 RUNOFF AS MM. AND AS A PERCENTAGE OF THE PERIOD OF RECORD AVERAGE WITH SELECTED PERIODS RANKED IN THE RECORD

River/ Station name	Jan 1991	Feb	Mar	Apr	May 1991		May 1976		10/90 to 5/91		3/90 to 5/91		5/89 to 5/91		8/88 to 5/91	
	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	mm %LT	rank /yrs
Dee at	83	59	149	80	41	4	46	8	620	6	887	5	1376	2	2019	2
Park	92	79	162	104	65	/19	75	/19	95	/18	87	/18	83	/17	86	/16
Tay at	193	69	180	152	39	3	86	30	940	22	1562	31	2604	30	4014	35
Ballathie	135	60	142	183	56	/39	125	/39	103	/39	111	/38	112	/37	122	/36
Whiteadder Water at	67	65	74	21	13	4	15	9	415	17	490	8	635	6	885	5
Hutton Castle	114	134	149	57	48	/22	57	/22	125	/22	96	/21	78	/20	76	/19
South Tyne at	127	125	105	49	12	6	30	12	694	25	880	12	1455	9	2047	5
Haydon Bridge	130	172	125	91	34	/29	87	/29	115	/29	94	/27	93	/25	91	/23
Derwent at	41	45	49	20	13	2	16	8	245	10	314	5	452	2	641	1
Buttercrambe	89	113	120	64	54	/30	67	/30	91	/30	74	/29	66	/28	66	/27
Trent at	53	34	35	20	15	6	12	2	231	7	326	2	585	2	833	2
Colwick	106	78	87	62	60	/33	46	/33	80	/33	72	/32	79	/31	80	/30
Lud at	9	9	12	11	10	2	8	1	73	2	156	1	264	1	398	1
Louth	30	26	33	34	37	/23	29	/23	36	/23	44	/22	49	/21	53	/21
Witham at	19	19	21	11	9	11	3	1	97	9	152	5	273	6	363	5
Claypole Mill	74	71	80	52	57	/33	18	/33	63	/32	61	/31	71	/31	68	/30
Bedford Ouse at	18	12	24	10	9	29	3	2	92	8	140	5	350	15	528	15
Bedford	50	35	76	49	68	/59	22	/59	48	/58	50	/58	78	/57	82	/56
Little Ouse at	8	10	12	8	7	1	7	3	61	2	113	1	198	1	330	1
Abbey Heath	34	45	54	43	47	/24	49	/24	44	/23	50	/22	55	/22	66	/21
Colne at	8	10	8	5	5	5	3	1	51	4	82	2	173	2	279	3
Lexden	35	54	43	37	57	/32	30	/32	43	/32	46	/31	61	/30	70	/29
Mimram at	7	6	6	6	6	5	4	1	47	3	109	2	197	3	290	6
Panshanger Park	60	51	45	47	49	/39	35	/39	53	/38	67	/38	74	/37	81	/36
Thames at	26	15	24	14	12	30	6	2	113	12	189	6	390	20	544	15
Kingston (natr.)	70	45	77	62	69	/109	31	/92	55	/108	60	/108	77	/107	76	/106
Blackwater at	35	21	29	18	15	14	9	2	161	9	261	7	514	13	711	11
Swallowfield	98	71	98	78	78	/39	48	/39	76	/39	78	/38	93	/37	92	/36
Coln at	37	29	50	37	25	7	8	1	206	5	388	5	693	5	894	3
Bibury	72	53	92	85	75	/28	26	/28	66	/28	74	/27	84	/26	78	/25
Great Stour at	43	20	20	14	15	8	10	2	162	6	240	1	403	1	557	1
Horton	106	58	59	52	70	/27	49	/27	69	/25	63	/24	65	/23	64	/21
Itchen at	35	30	40	39	33	4	23	1	245	3	482	2	793	2	1054	1
Highbridge+Allbrook	73	61	77	83	78	/33	55	/33	71	/33	80	/32	82	/31	80	/30
Stour at	59	26	58	35	20	10	8	1	236	3	344	2	717	5	948	2
Throop Mill	99	43	112	102	85	/19	34	/19	69	/18	69	/18	88	/17	82	/16
Piddle at	36	29	53	47	28	11	11	1	234	4	402	3	706	4	914	2
Baggs Mill	69	49	93	111	88	/28	35	/28	71	/27	75	/26	83	/24	77	/22
Exe at	160	71	106	52	22	14	12	1	654	11	792	4	1465	8	2133	6
Thorverton	123	67	125	92	58	/36	31	/36	91	/35	79	/34	86	/34	87	/33
Tone at	82	37	60	36	19	6	10	1	291	4	389	2	835	4	1159	4
Bishops Hull	103	49	104	93	69	/31	36	/31	71	/30	65	/30	85	/29	83	/28
Severn at	91	37	68	35	16	24	10	8	354	27	443	11	826	20	1196	19
Bewdley	128	64	147	111	68	/71	41	/71	93	/70	80	/69	89	/69	90	/68
Wye at	226	196	171	192	34	9	88	21	1595	20	2210	9	3999	9	5836	10
Cefn Brwyn	92	113	97	153	35	/37	93	/37	102	/36	90	/32	94	/27	97	/24
Cynon at	280	140	204	141	31	11	29	10	1128	21	1348	8	2692	17	3769	15
Abercynon	147	101	172	189	52	/33	50	/33	107	/33	89	/31	104	/29	102	/27
Dee at	175	164	147	166	22	5	75	14	1374	8	1785	5	3279	5	4968	5
New Inn	72	96	82	161	33	/22	115	/22	95	/22	83	/21	89	/20	93	/20
Lune at	146	183	135	89	10	3	51	18	964	19	1219	6	2137	9	3285	9
Caton	99	184	136	122	20	/29	106	/29	109	/27	90	/27	92	/25	99	/23
Clyde at	150	73	89	96	16	5	35	19	761	26	1108	24	1821	22	2629	22
Daldowie	142	96	119	232	46	/28	101	/28	125	/28	121	/27	116	/26	117	/25

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 1990. For the long periods (at the right of this table),

TABLE 4 START-MONTH RESERVOIR STORAGES UP TO JUNE 1991

Area	Reservoir (R)/ Group (G)		Capacity● (Ml)	1991 Jan	Feb	Mar (%)▲	Apr	May	Jun	[1990 Jun]
North West	Northern Command Zone[1]	(G)	133375	95	89	98	99	90	72	72
	Vyrnwy	(R)	55146	96	91	100	99	96	88	68
Northumbria	Teesdale[2]	(G)	87936	96	91	97	93	82	64	89
Severn Trent	Clywedog	(R)	44922	91	89	96	95	97	98	97
	Derwent Valley[3]	(G)	39525	100	94	99	97	91	78	88
Yorkshire	Washburn[4]	(G)	22035	64	86	96	99	91	80	72
	Bradford supply[5]	(G)	41407	90	95	100	98	92	76	75
Anglian	Grafham	(R)	58707	61	70	76	85	91	96	92
	Rutland	(R)	130061	60	68	71	78	80	85	84
Thames	London[6]	(G)	206232	60	87	90	89	91	90	83
	Farmoor[7]	(G)	13843	71	82	64	95	100	100	98
Southern	Bewl	(R)	31300	44	56	60	68	79	69	62
	Ardingly	(R)	4627	72	100	100	100	100	100	97
Wessex	Clatworthy	(R)	5364*	76*	94*	98*	100*	95*	84*	67*
	Bristol WW[8]	(G)	36620	40	70	77	93	95	91	70
South West	Colliford	(R)	28540	73	81	85	92	94	91	88
	Roadford	(R)	34500	68	81	87	94	98	98	55[9]
	Wimbleball[10]	(R)	21320	48	68	74	82	84	81	80
	Stithians	(R)	5205	49	85	98	100	96	83	66
Welsh	Celyn + Brenig	(G)	131155	92	96	100	100	99	96	94
	Brianne	(R)	62140	100	100	100	100	97	88	90
	Big Five[11]	(G)	69762	71	83	93	95	96	87	70
	Elan Valley[12]	(G)	99106	100	99	100	99	97	91	85

● Live or useable capacity (unless indicated otherwise)

▲ Percentage of live or useable capacity in storage at or close to the beginning of the month according to data availability (unless indicated otherwise)

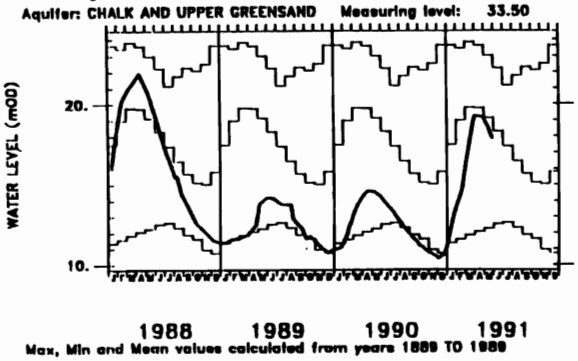
1. Includes Haweswater, Thirlmere, Stocks and Barnacre.
2. Cow Green, Selset, Grass Holme, Balderhead, Blackton and Hury.
3. Howden, Derwent and Ladybower,
4. Swinsty, Fewston, Thruscross and Eccup.
5. The Nidd/Barden group (Scar House, Angram, Upper Barden, Lower Barden and Chelker) plus Grimwith.
6. Lower Thames (includes Queen Mother, Wraysbury, Queen Mary, King George VI and Queen Elizabeth II) and Lee Valley (includes King George and William Girling) groups – **pumped storages.**
7. Farmoor 1 and 2 – **pumped storages.**
8. Blagdon, Chew Valley and others.
9. . The new Roadford reservoir was still filling after impounding.
10. Shared between South West (river regulation for abstraction) and Wessex (direct supply).
11. Usk, Talybont, Llandegfedd (**pumped storage**), Taf Fechan, Taf Fawr.
12. Claerwen, Caban Coch, Pen y Garreg and Craig Goch.

* Capacity and month-start storages expressed in terms of gross volume. A hydrographic survey to establish useable capacity is planned.

FIGURE 3 GROUNDWATER HYDROGRAPHS

Site name: DALTON HOLME

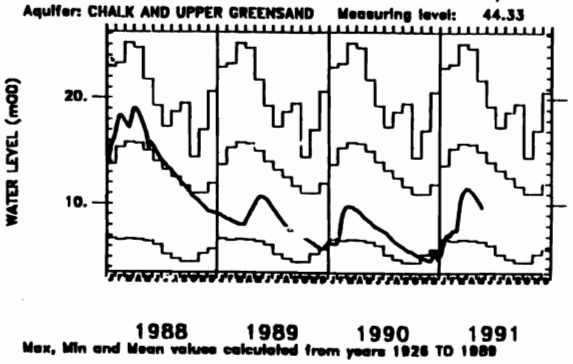
National grid reference: SE 9651 4530 Well number: SE94/5
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 33.50



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

Site name: LITTLE BROCKLESBY

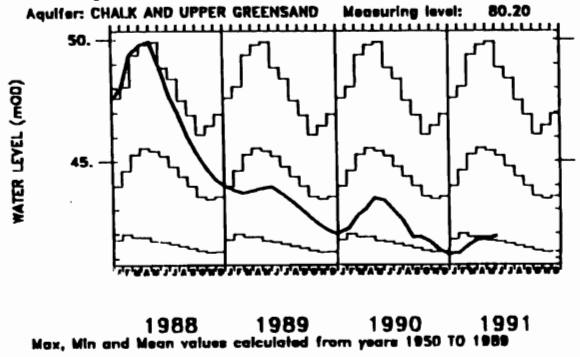
National grid reference: TA 1371 0888 Well number: TA10/40
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 44.33



Max, Min and Mean values calculated from years 1926 TO 1988

Site name: WASHPIT FARM

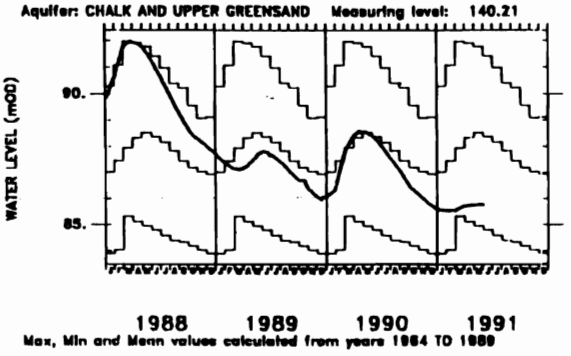
National grid reference: TF 8138 1960 Well number: TF81/2
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 80.20



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

Site name: THE HOLT

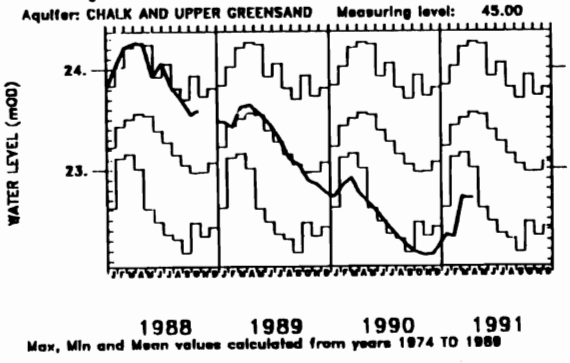
National grid reference: TL 1692 1985 Well number: TL11/9
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 140.21



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

Site name: FAIRFIELDS

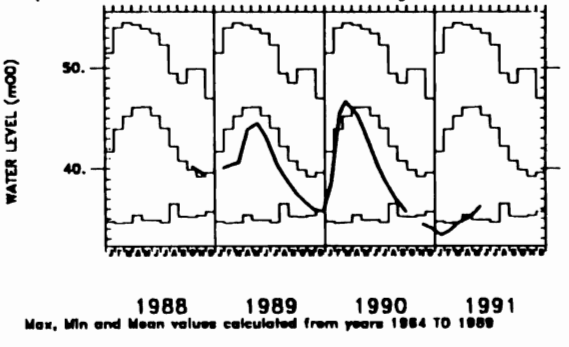
National grid reference: TM 2461 6109 Well number: TM26/46
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 45.00



Max, Min and Mean values calculated from years 1974 TO 1988

Site name: REDLANDS HALL,ICKLETON

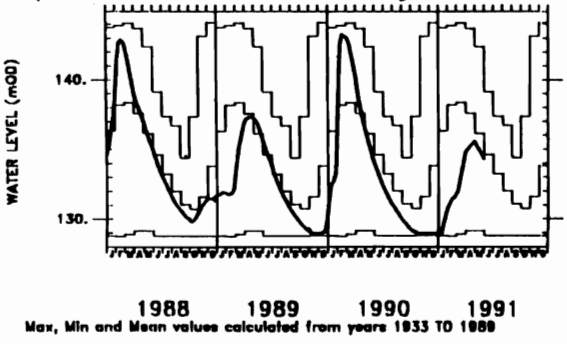
National grid reference: TL 4522 4182 Well number: TL44/12
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 76.19



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

Site name: ROCKLEY

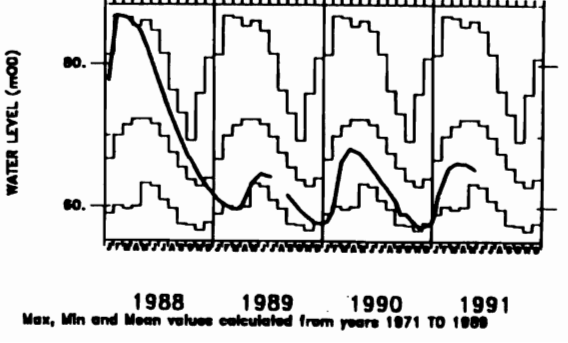
National grid reference: SU 1655 7174 Well number: SU17/57
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 146.39



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

Site name: LITTLE BUCKET FARM,WALTHAM

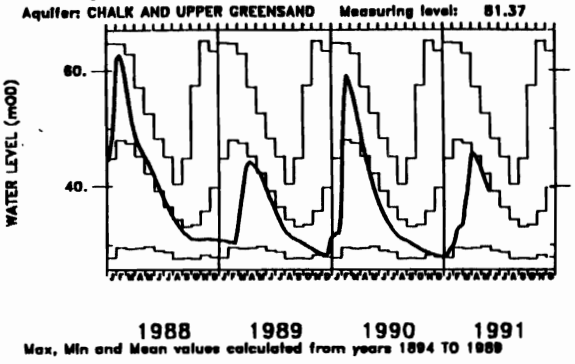
National grid reference: TR 1225 4690 Well number: TR14/9
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 87.33



Max, Min and Mean values calculated from years 1971 TO 1988

Site name: COMPTON HOUSE

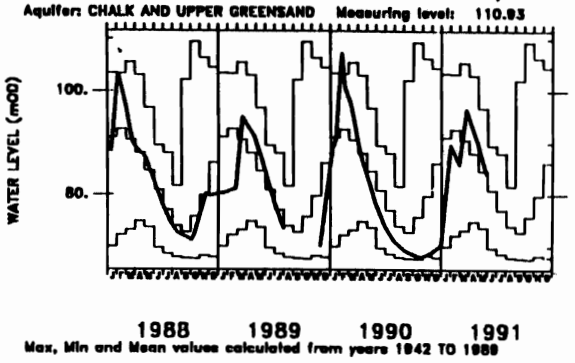
National grid reference: SU 7755 1490 Well number: SU71/23
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 81.37



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

Site name: WEST WOODYATES MANOR

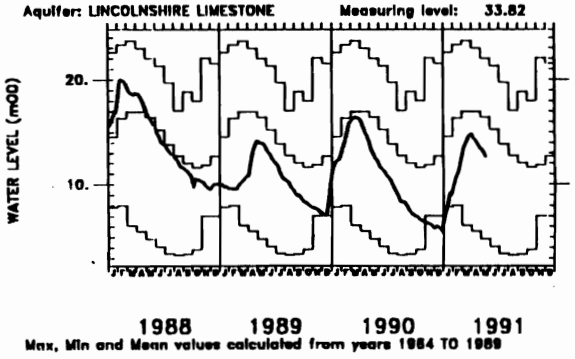
National grid reference: SU 0160 1960 Well number: SU01/58
Aquifer: CHALK AND UPPER GREENSAND Measuring level: 110.93



Max, Min and Mean values calculated from years 1942 TO 1989

Site name: NEW RED LION

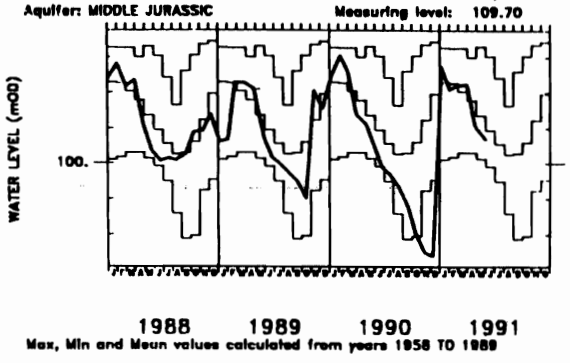
National grid reference: TF 0885 3034 Well number: TF03/37
Aquifer: LINCOLNSHIRE LIMESTONE Measuring level: 33.82



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

Site name: AMPNEY CRUCIS

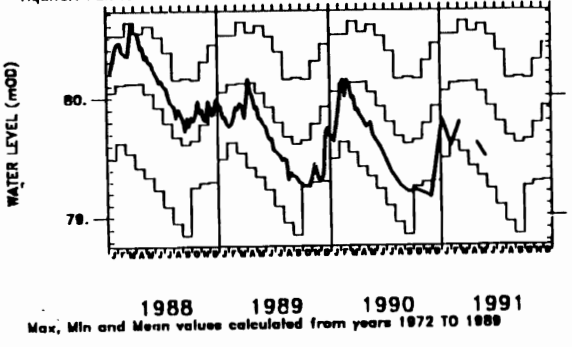
National grid reference: SP 0595 0190 Well number: SP00/62
Aquifer: MIDDLE JURASSIC Measuring level: 109.70



Max, Min and Mean values calculated from years 1958 TO 1989

Site name: LLANFAIR DC

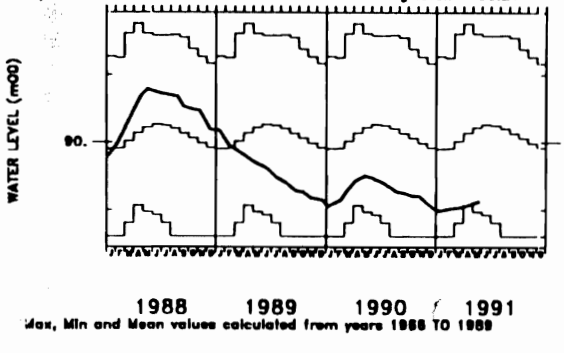
National grid reference: SJ 1374 5556 Well number: SJ15/15
Aquifer: PERMO-TRIASSIC SANDSTONE Measuring level: 82.00



Max, Min and Mean values calculated from years 1972 TO 1989

Site name: WEEFORD FLAT,WEEFORD

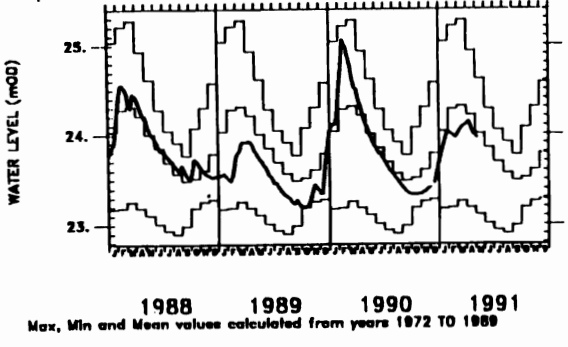
National grid reference: SK 1440 0464 Well number: SK10/9
Aquifer: PERMO-TRIASSIC SANDSTONE Measuring level: 96.21



Max, Min and Mean values calculated from years 1966 TO 1989

Site name: BUSSELS NO.7A

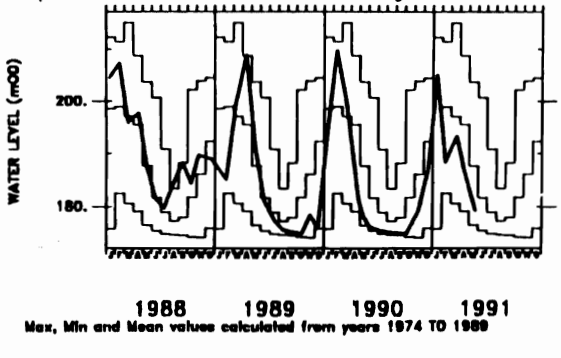
National grid reference: SX 9528 9872 Well number: SX99/378
Aquifer: PERMO-TRIASSIC SANDSTONE Measuring level: 26.07



Max, Min and Mean values calculated from years 1972 TO 1989

Site name: ALSTONFIELD

National grid reference: SK 1292 5547 Well number: SK15/16
Aquifer: CARBONIFEROUS LIMESTONE Measuring level: 280.25



Max, Min and Mean values calculated from years 1974 TO 1989

TABLE 5 A COMPARISON OF MAY GROUNDWATER LEVELS: 1991 AND 1976

Borehole	Aquifer	First year of record	Av. May level	May/June 1976		May/June 1991		No. of years of record with May levels ≤ 1991	Lowest recorded level before 1991 for any month
				Day	level	Day	level		
Dalton Holme	C & U.G.	1889	19.13	29/05	14.00	30/05	17.84	30	10.34
L. Brocklesby	"	1926	15.07	06/05	6.50	20/05	9.70	3	4.56
Washpit Farm	"	1950	45.42	01/05	42.90	04/06	41.88	1	41.24
The Holt	"	1964	88.53	27/05	85.68	01/06	85.76	3	83.90
Fairfields	"	1974	23.54	25/05	22.96	13/05	22.57	0	22.15
Redlands Farm	"	1964	46.12	01/05	37.90	31/05	36.16	1	34.53
Rockley	"	1933	136.13	23/05	129.21	01/06	134.29	15	128.78 dry
L. Bucket Farm	"	1971	72.27	03/05	64.10	23/05	65.23	3	56.77
Compton House	"	1894	42.20	27/05	29.71	28/05	39.14	35	27.64
West Dean	"	1940	1.89	28/05	1.42	31/05	1.40	7	1.01
Ashton Farm	"	1974	69.10	26/05	65.29	29/05	68.30	4	63.10
West Woodyates	"	1942	84.60	01/05	73.83	29/05	84.10	23	67.62
New Red Lion	L.L.	1964	16.42	28/05	4.80	20/05	12.65	5	3.29
Ampney Crucis	M.J.	1958	101.35	30/05	100.12	01/06	100.68	10	97.38
Dunmurry (N.I.)	PTS	1985	28.38			28/05	28.01	1	27.47
Llanfair D.C.	"	1972	80.04	01/05	79.34	29/05	79.50	1	78.85
Morris Dancers	"	1969	32.58	25/05	31.96	08/05	32.06	2	30.87
Weeford Flats	"	1966	90.22	27/05	88.97	23/05	89.12	1	88.61
Bussels 7A	"	1972	24.00	25/05	23.11	07/05	23.96	8	22.90
Rushyford N.E.	M.L.	1967	76.27	25/05	65.76	17/05	75.54	12	64.77
Peggy Ellerton	"	1968	34.82	24/05	31.45	17/05	33.43	4	31.10
Alstonfield	C.B.	1974	187.65	27/05	176.53	24/05	179.18	6	174.22

Groundwater levels are in metres above Ordnance Datum

C & U.G. Chalk and Upper Greensand;
L.L. Lincolnshire Limestone
PTS Permo-Triassic Sandstones
M.J. Middle Jurassic Limestone
C.B. Carboniferous Limestone
M.L. Magnesian Limestone

FIGURE 4 LOCATION MAP OF GAUGING STATIONS AND GROUNDWATER INDEX WELLS