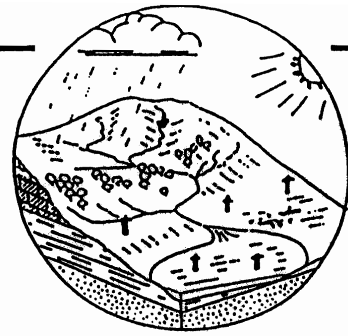
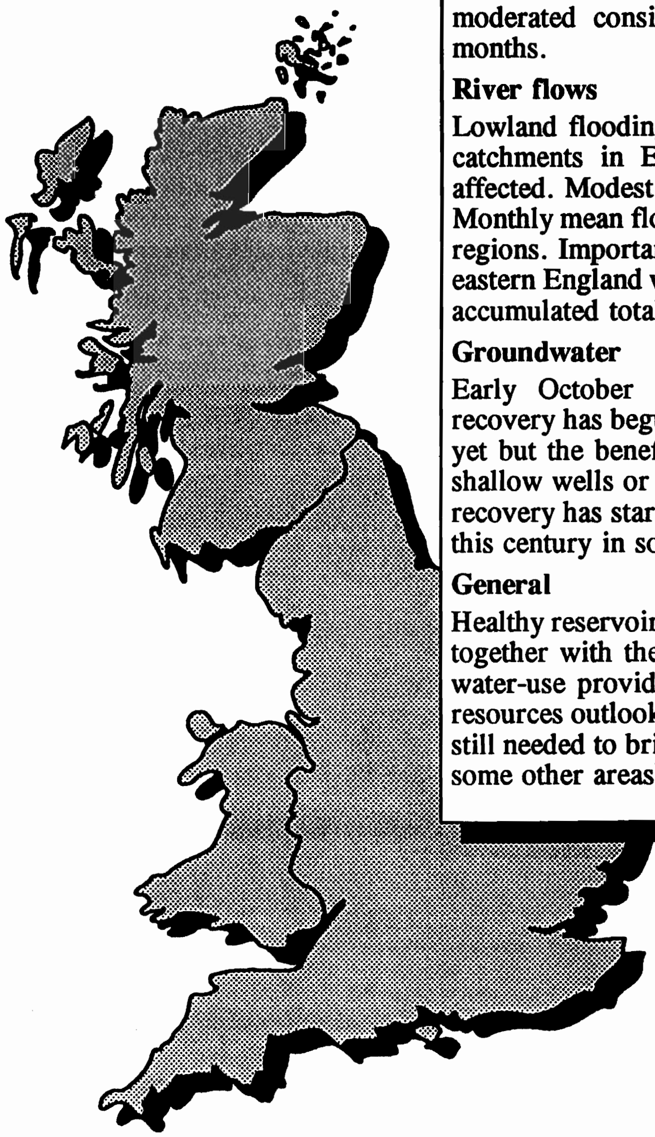
# Hydrological Summary for Great Britain





## SEPTEMBER 1992

### Rainfall

GB rainfall, around 130%, was above average for the third successive month. September rainfall greatly favoured the drought affected areas - the storm of 22nd/23rd producing notable rainfall totals in many catchments. The drought has moderated considerably, in rainfall terms, over the last six months.

### River flows

Lowland flooding was common late in the month, impervious catchments in E. Anglia and the London area being worst affected. Modest spate conditions typified many Scottish rivers. Monthly mean flows were above, to well above, average in most regions. Important exceptions include permeable catchments in eastern England where flows remain depressed - some long term accumulated totals are unprecedented.

### Groundwater

Early October groundwater levels indicate that the 1992 recovery has begun in most regions. Upturns are very modest as yet but the benefit of the september rainfall is evident only in shallow wells or fissured aquifers. In much of the lowlands the recovery has started from an exceptionally low base - the lowest this century in some areas.

### General

Healthy reservoir stocks, wet soils and a brisk increase in runoff together with the relaxation, in some areas, in restrictions on water-use provide clear evidence of a greatly improved water resources outlook. Nonetheless, above average winter rainfall is still needed to bring groundwater levels in eastern England (and some other areas) into the normal range by the spring of 1993.

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**HYDROLOGICAL SUMMARY FOR GREAT BRITAIN - September 1992**

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 has been supplied by the Water Services Companies, the NRA or, in Scotland, the Lothians Regional Council. The most 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 6) is provided to assist in the location of the principal monitoring sites.

## Rainfall

September was a cool, cloudy and, in most areas, a wet month. The weather was typically autumnal and continued in the unsettled vein which characterised much of July and August. In western areas, rainfall was distributed throughout the month but in parts of eastern and central England a large proportion of the monthly total was attributable to a notable event on the night of the 22nd/23rd. A slow moving frontal system with associated thunder cells, produced 6 to 12-hour falls exceeding 60 mm over much of Buckinghamshire, Northamptonshire, Cambridgeshire and Bedfordshire; Bedford itself registered 90 mm for the rainfall-day. Around the periphery of this zone rainfall was also heavy and persistent. At the Institute of Hydrology's meteorological station a 52.3 mm rainfall total was recorded, the fourth largest storm event in 30-year record. Localised, and more extensive flooding, was common throughout much of the English lowlands.

Prolonged droughts are not terminated by a single rainfall event but the September storm certainly changed the complexion of the lowland drought and substantially improved the water resources outlook over large areas. The greatest rainfall totals on the 22nd/23rd - typically one and a half times the monthly average - broadly coincided with the zone of maximum drought intensity. With evaporation rates declining and soils already wetting-up as a result of antecedent rainfall, the intense rainfall (and subsequent wet spells) triggered a rapid increase in runoff rates and, more importantly, created the conditions for a relatively early start to the 1991 recovery in groundwater levels in eastern England.

September rainfall totals were around twice the 1941-70 average in parts of East Anglia and the North-East but below average, albeit only modestly, in some western and northern regions - also in a few drought affected areas (e.g. the Itchen catchment) - see Figure 2a. Rainfall over the last three months is well above average in all regions. The July-September period was the wettest for 18 years in the Thames Valley and, in percentage terms, rainfall over East Anglia was even more notable. Relatively wet conditions have characterised most of Britain since the end of March (see Figure 2b) and the particularly unsettled weather since June has pushed rainfall totals close to, or above, average for the year thus far for all regions except the South-West; western Scotland is, once again, very wet in this timeframe. For the first time in 20 years, the summer half-year (Apr - Sept) rainfall for England and Wales exceeded that for the preceding winter six months; a marked contrast to the 1987-91 period when, on average, 60% of the annual rainfall was attributable to the winter half-year.

Accumulated rainfall deficiencies are generally much diminished relative to the end of February but remain notable in the east and south; particularly over the periods commencing in August 1988 and March 1990. In the four-year timeframe deficiencies in parts of East Anglia are still equivalent to around eight month's average rainfall. These deficiencies do not require to be fully satisfied before, in all practical terms, the drought is terminated but a wet winter is still needed to generate a sustained recovery in runoff and recharge rates.

**Evaporation and Soil Moisture Deficit (SMDs)**

September potential evaporation (PE) and actual evaporation (AE) totals - for grass - were well within the normal range in most areas. The moist soils (see below) encouraged relatively high transpiration losses in the lowlands - a notable contrast to the last four years. Considering 1992 as a whole, PE losses are substantially above average but still appreciably below the record totals computed for 1989 and 1990. AE losses are exceptionally high over wide areas - the highest in the MORECS series in parts of eastern England.

Away from the English lowlands soils are at, or very close to, field capacity (Figure 3a). Soils in parts of eastern and southern England are not yet saturated but SMD decreases of more than 40 mm through September were common. As a consequence October soils in the lowlands are generally considerably wetter than average (Figure 3b) and markedly wetter than mid-autumn soils in the last four years. Significant deficits are now largely confined to the lower Thames Valley and parts of Norfolk. The relative wetness of the soils increases the likelihood that the 1992/93 recharge season will be considerably longer than in any of the previous four winters in eastern England.

**Runoff**

With soils at field capacity in most of Scotland, the above average rainfall produced high flows and some notable monthly runoff totals, especially in rivers draining the Highlands. In eastern England, the storm of September 22nd/23rd, augmented by further rain later in the week, generated some very steep runoff recoveries but river flow responses varied greatly between impermeable and permeable catchments; antecedent soil conditions also had some effect in tempering lowland flooding.

Over the period 23-26 September, floodplain inundation was widespread in East Anglia especially in the Ouse and Nene systems. Flows on the Ouse at Bedford peaked at 120 $m^3s^{-1}$, comparable with the highest flow since 1979. Upstream, at Newport Pagnell levels rose to within six centimetres of the major 1947 flood peak. The Kym and other rivers draining predominantly clay catchments were also in spate. In north London, new record peak flows were established on the Silk Stream, River Brent and Dollis Brook - each event may be broadly categorised as around a one in 50-year event - and flooding was extensive, in Edgware especially. Whilst, for a time, the intensity of the convectional rainfall on the 22nd/23rd certainly exceeded the infiltration capacity of the soils, it is important to stress that apart from in some urban catchments, the majority of the September rainfall in the lowlands did not runoff directly. Over the Bedford Ouse catchment, for instance, provisional estimates suggest almost 60 per cent of the total September rainfall was available to decrease SMDs and, in a few localities, percolate down to replenish aquifer stocks.

Apart from a number of western catchments, September runoff totals testified to a brisk recovery relative to the early summer flow rates. With some important exceptions, September mean flows were around or above (some notably so) the monthly average. Catchments registering new record or near-record September runoff totals showed a wide distribution, examples include the Clyde, Soar and Teme as well as the Bedford Ouse. In the region most severely afflicted by the drought, monthly runoff from impervious catchments was typically the highest since February 1990. However, in many catchments where surface runoff contributes little to discharge, the recovery in flow rates was very modest and mean flows were well below the early autumn average. Flows remain depressed in, for example, the Lud, Mimram and the Little Ouse - in each catchment September rainfall approached twice the average - and in the Itchen which was relatively dry. In each of these rivers runoff has been depressed since late-1988 and the 30-month runoff total, to September, is the lowest on record (for ANY start month). Healthy flows in such rivers can be expected only when a baseflow recovery has been sustained over several months.

Unusually for September, certainly in the lowlands, reservoir replenishment was considerable; stocks in Rutland Water, for instance, increased by around seven per cent. Autumn recoveries were generally less marked in the South-West but stocks, on a regional basis, are very healthy and greatly improved relative to the early autumn of 1991 and 1990; in the east the contrast with current groundwater levels is stark.

**Groundwater**

The unusually heavy rainfall in parts of southern England had little immediate effect on depressed groundwater levels. Although the rate of fall has clearly slowed at some sites, levels continue to fall gently in others. In assessing the significance of the recent groundwater level behaviour illustrated on Figure 5, it is important to note the corresponding date of the latest level reading (see Table 5). Many of the featured hydrographs show, as yet, a response only to the late-summer rainfall. Limited data for early October show small upturns in, for example, the eastern Chilterns and the Chalk outcrop north of London; some further improvement following the later September rainfall may be anticipated.

At the Dalton Holme borehole in the Yorkshire Chalk the end-of-September level is the lowest for any September in a 103-year record. At the Washpit Farm and Redlands Hall sites, the end-of-month levels are the lowest on record, irrespective of month, in 42-year and 28-year records respectively. At the Wetwang, Little Brocklesby and Little Bucket Farm sites, groundwater levels are near to the seasonal minimum and were still falling in September. A similar picture emerges across the Midland belt, levels at Llanfair DC and Stone were still falling and are only a little above the seasonal minimum. The Weeford Flats well is still dry. At the New Red Lion site, the groundwater level appears to have ceased falling but remains well below the seasonal mean. Rising water-tables are shown by the traces at West Woodyates, Rockley and Ampney Crucis, (at the latter site, the fissured nature of the aquifer encourages a more rapid response to rainfall than at most observation wells), the rise has been quite substantial to a point above the seasonal mean, the only site to be so in September.

At the Redbank site in south-western Scotland the groundwater level is rising and seems to be near to mean seasonal values (the record is from 1981 only). In Northern Ireland, water-tables appear to be near or above the seasonal mean, although at Killyglen the levels are rising while at Dunmurry they are falling.

The situation in eastern England and in the Midland belt remains fragile. Taking the Chalk and Permo-Triassic sandstones (in southern Britain) aquifers as a whole, it appears - on the basis of limited data - that the water-table depression in mid-September was without recorded precedent. Over large parts of the eastern Chalk groundwater levels were probably at their lowest level since the turn of the century (and even more notable where groundwater abstraction is an aggravating factor). Something approaching double the mean annual recharge will be required to bring groundwater resources to anything approaching a comfortable level by the start of the 1993 recession. Significant infiltration will have occurred over the last month or so and, with SMDs modest in most areas, the outlook for substantial autumn percolation is encouraging. However, in order for this early onset of the 1992 recovery to translate into the required sustained rise in groundwater levels a wet winter extending through into the spring of 1993 is still required.

**Institute of Hydrology/British Geological Survey**
**13 October 1992**

## TABLE 1 1991/92 RAINFALL AS A PERCENTAGE OF THE 1941-70 AVERAGE

| | | Sept | Oct | Nov | Dec 1991 | Jan 1992 | Feb | Mar | Apr | May | June | July | Aug | Sept |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| England and | mm | 62 | 77 | 95 | 49 | 48 | 47 | 85 | 75 | 49 | 45 | 87 | 126 | 103 |
| Wales | % | 75 | 93 | 98 | 54 | 56 | 72 | 144 | 129 | 73 | 74 | 119 | 140 | 124 |
| NRA REGIONS | | | | | | | | | | | | | | |
| North West | mm | 69 | 125 | 169 | 119 | 57 | 100 | 142 | 89 | 62 | 31 | 72 | 137 | 114 |
| | % | 56 | 106 | 140 | 99 | 51 | 123 | 197 | 116 | 76 | 37 | 70 | 110 | 93 |
| Northumbria | mm | 42 | 75 | 109 | 78 | 33 | 45 | 107 | 103 | 31 | 19 | 61 | 104 | 108 |
| | % | 53 | 100 | 116 | 104 | 41 | 68 | 206 | 187 | 48 | 31 | 79 | 103 | 137 |
| Severn-Trent | mm | 54 | 55 | 68 | 39 | 59 | 31 | 67 | 50 | 59 | 55 | 87 | 117 | 72 |
| | % | 81 | 85 | 86 | 56 | 86 | 58 | 129 | 96 | 92 | 98 | 134 | 144 | 107 |
| Yorkshire | mm | 40 | 63 | 94 | 62 | 47 | 42 | 96 | 66 | 34 | 33 | 81 | 94 | 98 |
| | % | 56 | 91 | 106 | 84 | 61 | 66 | 170 | 118 | 56 | 57 | 116 | 104 | 136 |
| Anglian | mm | 63 | 26 | 54 | 24 | 45 | 17 | 63 | 43 | 48 | 34 | 89 | 82 | 92 |
| | % | 121 | 50 | 87 | 45 | 87 | 40 | 158 | 108 | 102 | 69 | 156 | 128 | 176 |
| Thames | mm | 52 | 36 | 66 | 16 | 28 | 25 | 52 | 65 | 60 | 39 | 77 | 107 | 89 |
| | % | 84 | 56 | 90 | 24 | 45 | 53 | 113 | 141 | 107 | 75 | 128 | 153 | 144 |
| Southern | mm | 51 | 51 | 81 | 23 | 18 | 33 | 59 | 84 | 30 | 26 | 75 | 105 | 73 |
| | % | 72 | 65 | 86 | 28 | 24 | 58 | 113 | 175 | 55 | 52 | 127 | 144 | 102 |
| Wessex | mm | 71 | 83 | 72 | 30 | 36 | 39 | 57 | 81 | 24 | 49 | 64 | 127 | 94 |
| | % | 90 | 101 | 74 | 33 | 43 | 66 | 98 | 150 | 35 | 91 | 103 | 155 | 119 |
| South West | mm | 85 | 123 | 112 | 52 | 44 | 69 | 75 | 100 | 31 | 23 | 83 | 171 | 100 |
| | % | 82 | 109 | 84 | 39 | 34 | 77 | 89 | 141 | 37 | 35 | 99 | 169 | 96 |
| Welsh | mm | 85 | 154 | 142 | 65 | 76 | 80 | 129 | 91 | 80 | 48 | 93 | 212 | 112 |
| | % | 68 | 119 | 99 | 45 | 56 | 83 | 148 | 107 | 88 | 59 | 98 | 178 | 89 |
| Scotland | mm | 131 | 165 | 227 | 141 | 139 | 167 | 208 | 123 | 80 | 52 | 103 | 217 | 187 |
| | % | 96 | 111 | 160 | 90 | 101 | 161 | 226 | 137 | 88 | 57 | 92 | 168 | 136 |
| RIVER PURIFICATION BOARDS | | | | | | | | | | | | | | |
| Highland | mm | 182 | 193 | 305 | 166 | 197 | 229 | 248 | 138 | 105 | 46 | 97 | 250 | 177 |
| | % | 115 | 104 | 180 | 85 | 120 | 172 | 218 | 121 | 102 | 42 | 76 | 169 | 112 |
| North-East | mm | 58 | 120 | 133 | 53 | 67 | 52 | 113 | 68 | 57 | 50 | 48 | 128 | 113 |
| | % | 67 | 124 | 129 | 52 | 74 | 70 | 182 | 111 | 74 | 71 | 52 | 120 | 130 |
| Tay | mm | 111 | 155 | 154 | 97 | 117 | 111 | 172 | 90 | 57 | 30 | 78 | 197 | 152 |
| | % | 97 | 127 | 129 | 72 | 99 | 121 | 210 | 120 | 60 | 36 | 76 | 167 | 132 |
| Forth | mm | 103 | 111 | 124 | 108 | 110 | 111 | 164 | 76 | 45 | 25 | 67 | 174 | 156 |
| | % | 95 | 105 | 115 | 99 | 111 | 144 | 238 | 112 | 54 | 33 | 68 | 150 | 144 |
| Tweed | mm | 67 | 101 | 127 | 92 | 63 | 70 | 138 | 98 | 52 | 27 | 60 | 151 | 126 |
| | % | 71 | 115 | 122 | 102 | 68 | 101 | 238 | 161 | 68 | 40 | 67 | 132 | 135 |
| Solway | mm | 81 | 172 | 203 | 162 | 91 | 140 | 206 | 144 | 66 | 30 | 99 | 214 | 166 |
| | % | 54 | 119 | 140 | 107 | 65 | 151 | 226 | 164 | 72 | 33 | 90 | 165 | 110 |
| Clyde | mm | 157 | 193 | 274 | 208 | 170 | 231 | 267 | 144 | 93 | 41 | 123 | 270 | 195 |
| | % | 90 | 105 | 164 | 112 | 106 | 204 | 254 | 140 | 96 | 40 | 95 | 190 | 111 |

Note: The most recent monthly rainfall figures correspond to the MORECS areal assessments derived by the Meteorological Office. The regional areal rainfall figures are regularly updated (normally one or two months in arrears) using figures derived from a far denser raingauge network.

## TABLE 2 RAINFALL RETURN PERIOD ESTIMATES

| | | Mar - Sep92 | Est Return Period, years | Oct91-Sep92 | Est Return Period, years | Mar90-Sep92 | Est Return Period, years | Aug88-Sep92 | Est Return Period, years |
|---|---|---|---|---|---|---|---|---|---|
| England and Wales | mm | 569 | | 790 | | 2017 | | 3439 | |
| | % LTA | 116 | 5-10 | 104 | <5 | 87 | 10-20 | 90 | 10-20 |
| NRA REGIONS | | | | | | | | | |
| North West | mm | 647 | | 1060 | | 2781 | | 4807 | |
| | % LTA | 97 | <5 | 104 | <5 | 90 | 5-10 | 94 | 5 |
| Northumbria | mm | 533 | | 795 | | 2035 | | 3251 | |
| | % LTA | 109 | <5 | 109 | <5 | 91 | 5-10 | 88 | 20-35 |
| Severn Trent | mm | 507 | | 669 | | 1714 | | 2903 | |
| | % LTA | 116 | 5 | 103 | <5 | 86 | 10-20 | 90 | 10-20 |
| Yorkshire | mm | 496 | | 715 | | 1805 | | 3032 | |
| | % LTA | 108 | <5 | 103 | <5 | 85 | 20-35 | 87 | 25-45 |
| Anglian | mm | 451 | | 555 | | 1328 | | 2185 | |
| | % LTA | 129 | 10-20 | 107 | <5 | 85 | 15-25 | 85 | 50-90 |
| Thames | mm | 489 | | 607 | | 1491 | | 2551 | |
| | % LTA | 125 | 5-10 | 102 | <5 | 83 | 20-35 | 87 | 15-25 |
| Southern | mm | 452 | | 607 | | 1648 | | 2799 | |
| | % LTA | 111 | <5 | 92 | <5 | 83 | 20-35 | 84 | 30-70 |
| Wessex | mm | 496 | | 681 | | 1797 | | 3174 | |
| | % LTA | 108 | <5 | 94 | <5 | 82 | 25-45 | 87 | 10-20 |
| South West | mm | 583 | | 870 | | 2530 | | 4535 | |
| | % LTA | 98 | <5 | 89 | <5 | 85 | 15-25 | 91 | 5-10 |
| Welsh | mm | 765 | | 1126 | | 2986 | | 5243 | |
| | % LTA | 112 | <5 | 102 | <5 | 89 | 5-15 | 94 | 5 |
| Scotland | mm | 970 | | 1503 | | 4119 | | 6899 | |
| | % LTA | 130 | 30-70 | 126 | 70-130 | 114 | 30-70 | 115 | >200 |
| RIVER PURIFICATION BOARDS | | | | | | | | | |
| Highland | mm | 1061 | | 1725 | | 5070 | | 8606 | |
| | % LTA | 121 | 10-20 | 121 | 20-35 | 117 | 60-120 | 120 | >200 |
| North-East | mm | 577 | | 883 | | 2429 | | 3880 | |
| | % LTA | 104 | <5 | 103 | <5 | 93 | 5 | 91 | 10-20 |
| Tay | mm | 776 | | 1182 | | 3271 | | 5635 | |
| | % LTA | 116 | 5-10 | 113 | 5-10 | 103 | <5 | 107 | 5-10 |
| Forth | mm | 707 | | 1050 | | 3003 | | 5040 | |
| | % LTA | 114 | 5 | 111 | 5 | 105 | <5 | 107 | 5-10 |
| Tweed | mm | 652 | | 972 | | 2532 | | 4053 | |
| | % LTA | 117 | 5-10 | 116 | 5-10 | 99 | <5 | 96 | <5 |
| Solway | mm | 925 | | 1463 | | 3721 | | 4300 | |
| | % LTA | 123 | 10-20 | 123 | 20-35 | 103 | <5 | 105 | <5 |
| Clyde | mm | 1133 | | 1808 | | 4997 | | 8367 | |
| | % LTA | 133 | 30-70 | 130 | 100-150 | 119 | 120-180 | 120 | >200 |

Return period assessments are based on tables provided by the Meteorological Office*. These assume a start in a specified month; return periods for a start in any month may be expected to be an order of magnitude less - for the longest durations the return period estimates converge. "Wet" return periods underlined.
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 1990-1992 AS A PERCENTAGE OF THE 1941-1970 AVERAGE

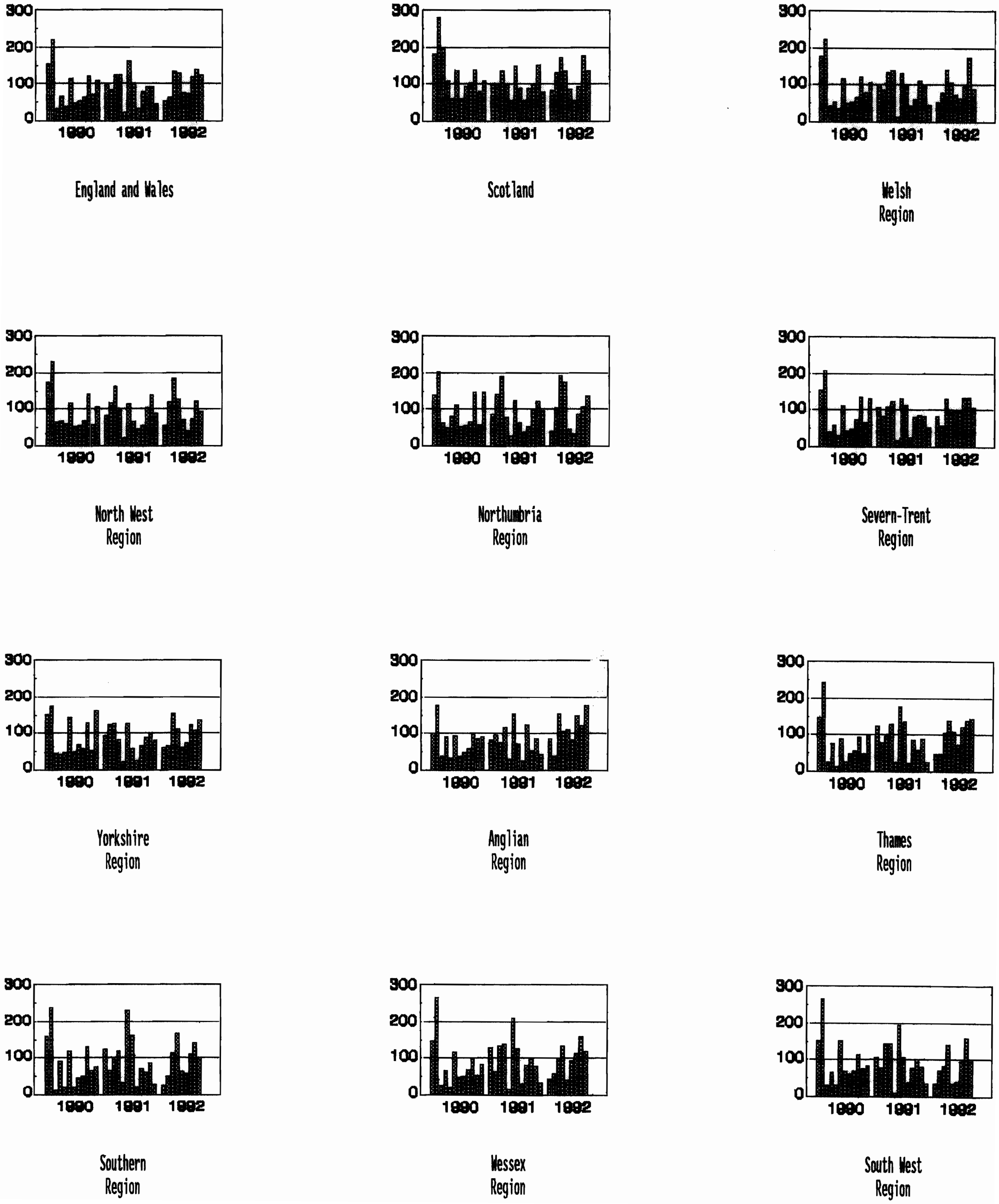


FIGURE 2a SEPTEMBER MORECS RAINFALL AS % LTA

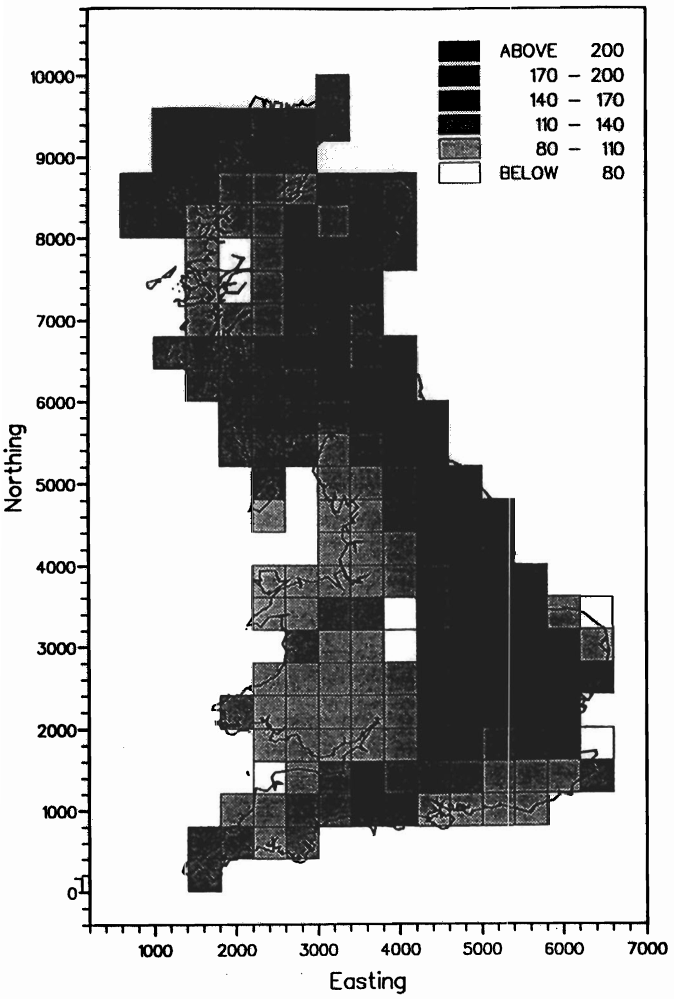



FIGURE 2b APRIL TO SEPTEMBER MORECS RAINFALL AS % LTA

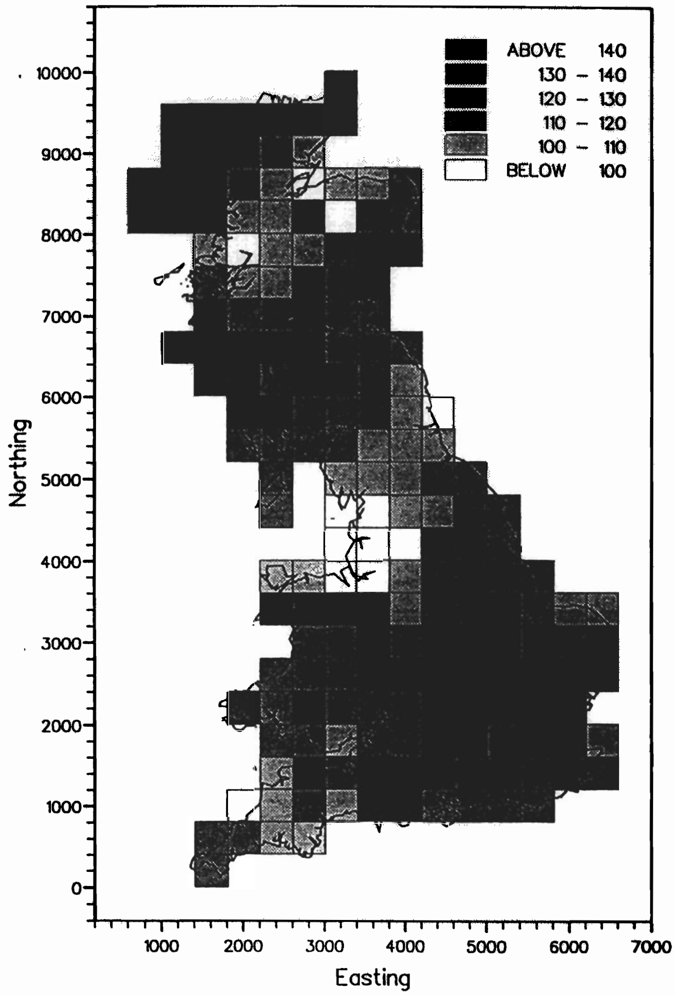



FIGURE 3a END OF SEPTEMBER 1992 SMD (MORECS)

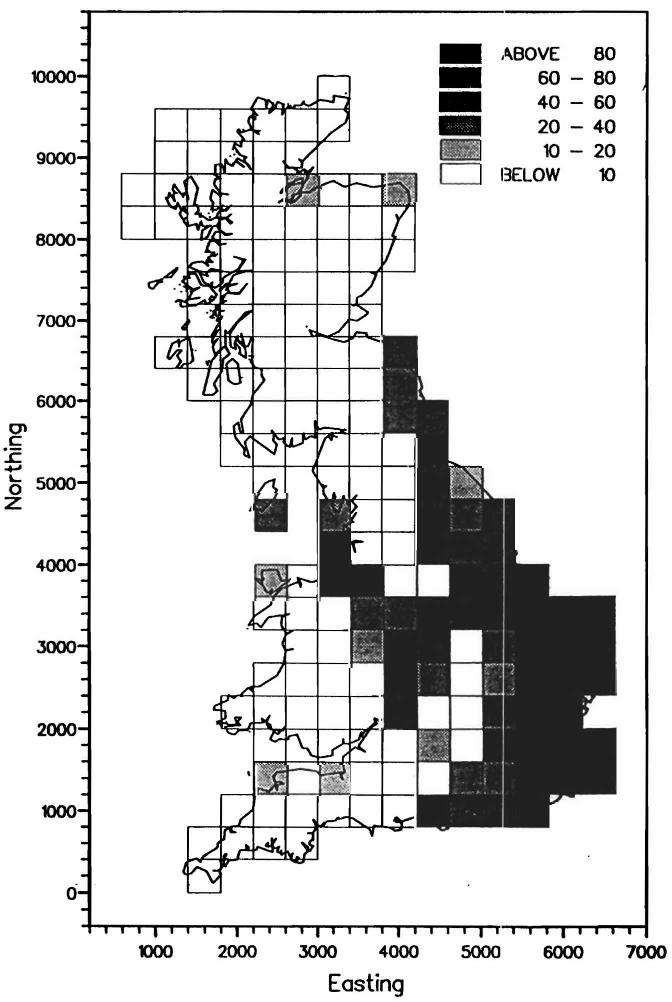



FIGURE 3b SMD (MORECS) ANOMALIES FOR END OF SEPTEMBER 1992

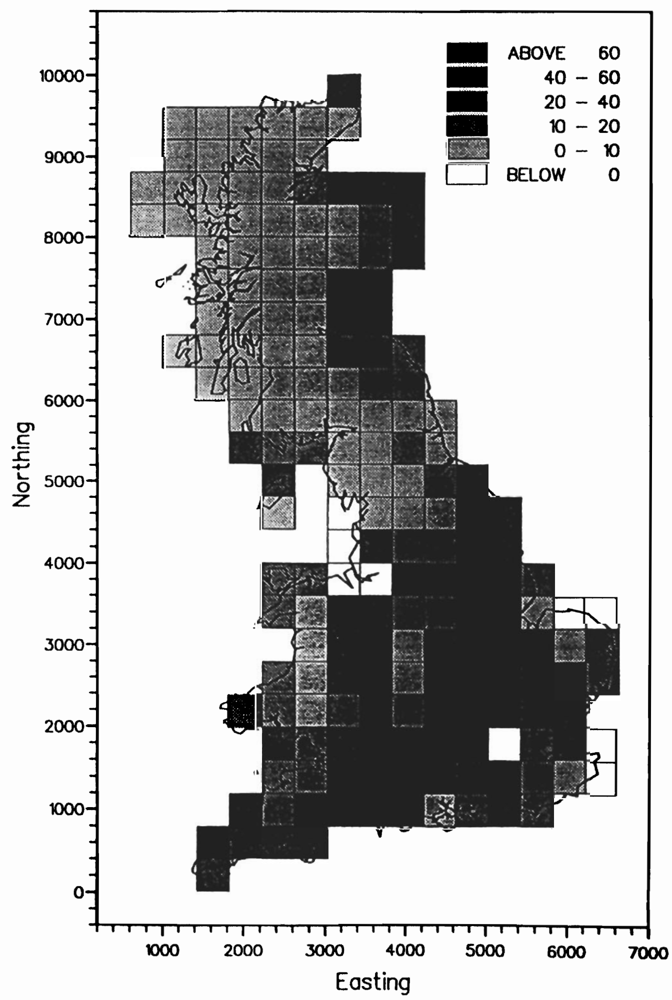
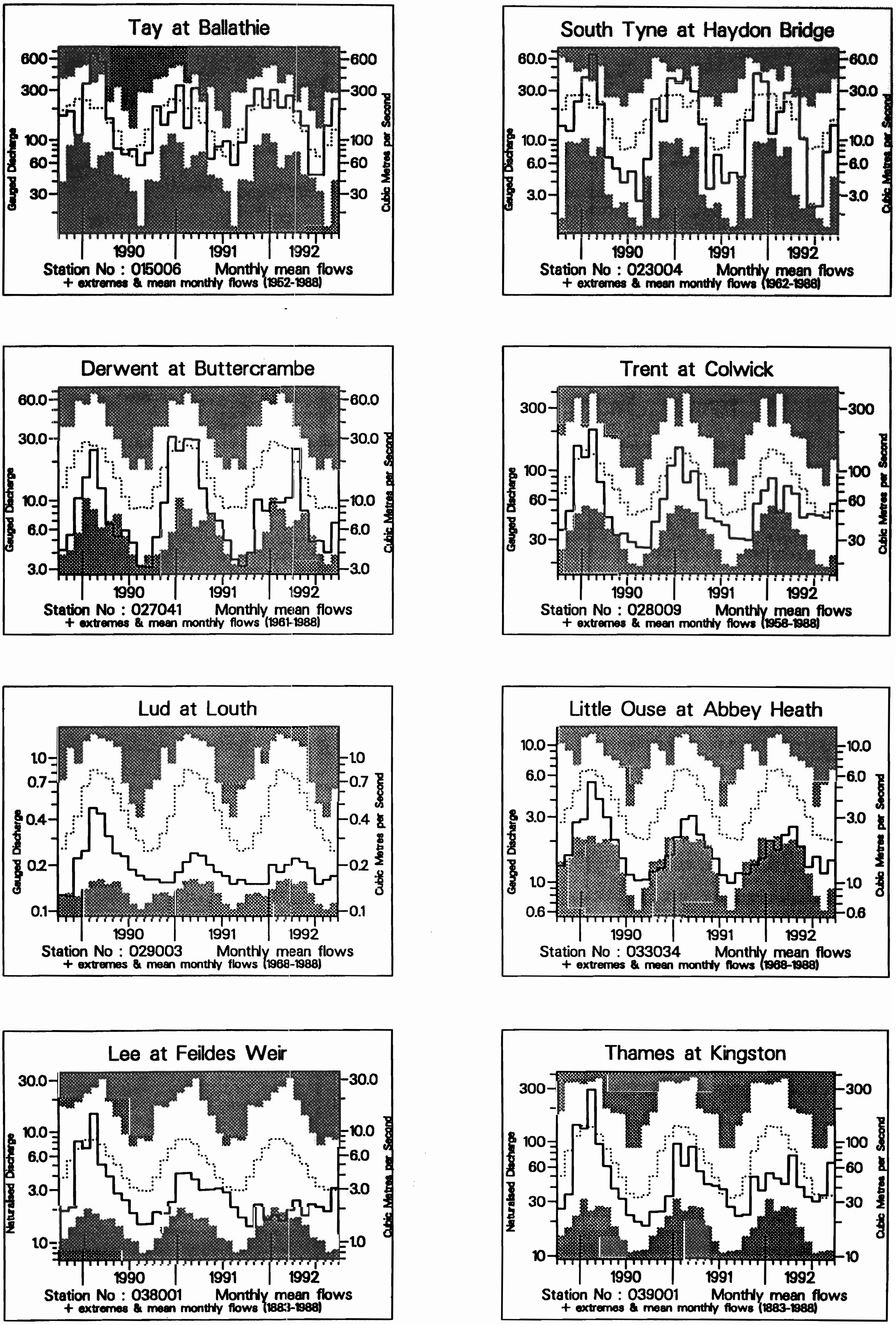
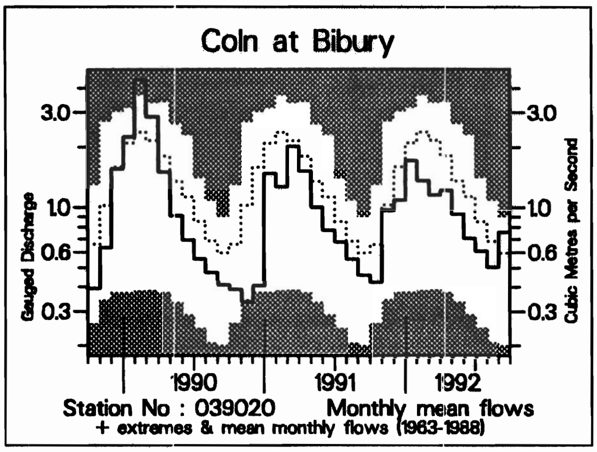
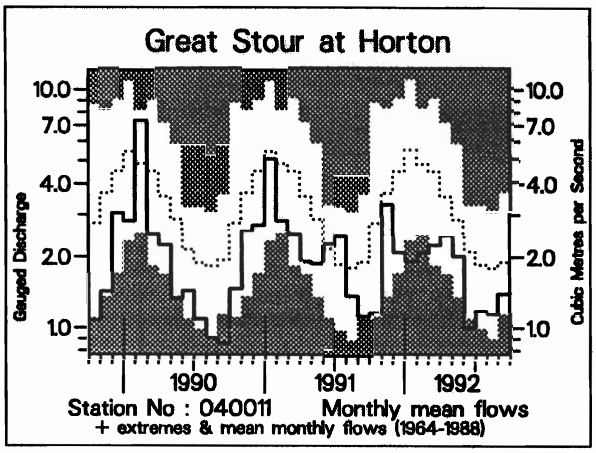
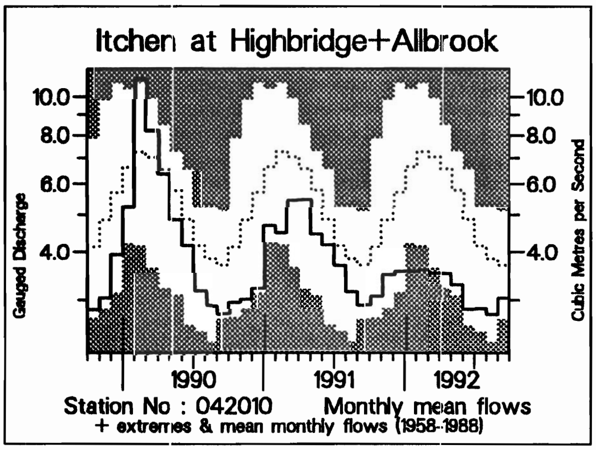


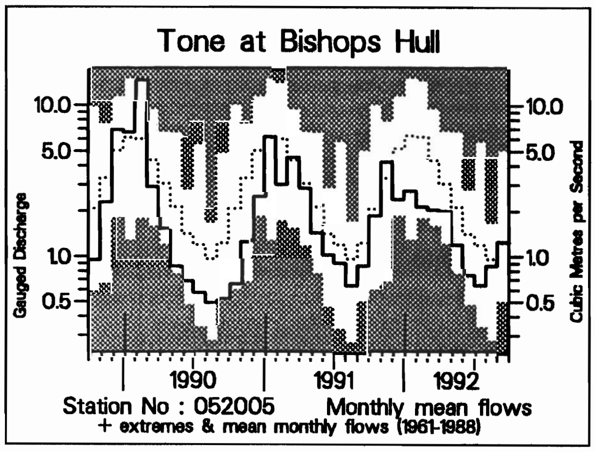
**FIGURE 4 MONTHLY RIVER FLOW HYDROGRAPHS**

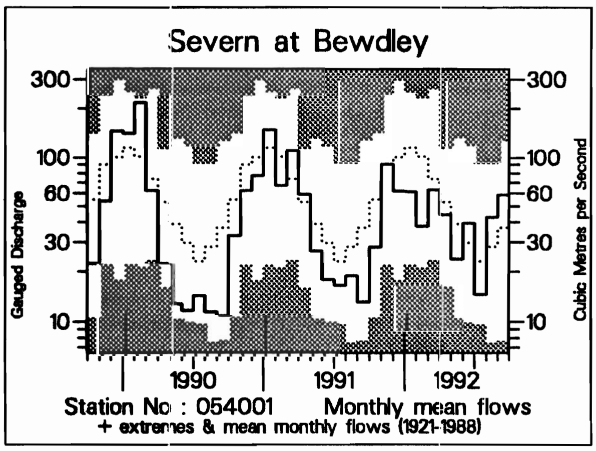


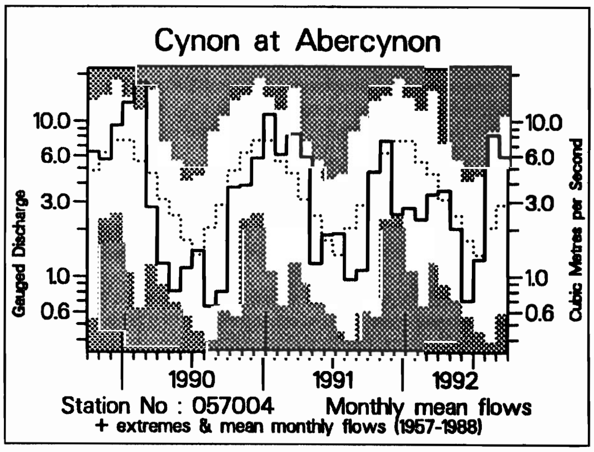

Coln at Bibury
Gauged Discharge
Cubic Metres per Second
3.0
1.0
0.6
0.3
1990
1991
1992
Station No : 039020 Monthly mean flows
+ extremes & mean monthly flows (1963-1988)

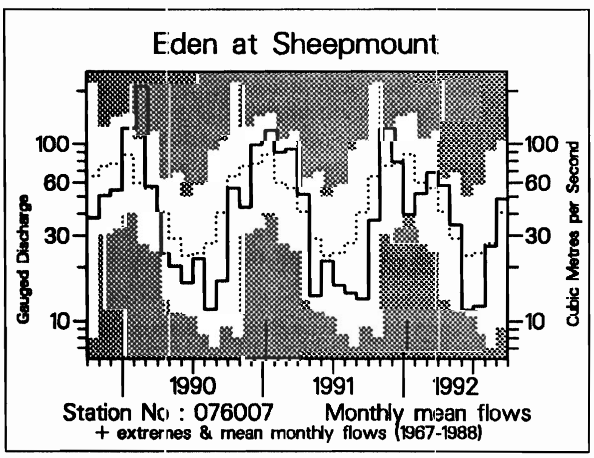

Great Stour at Horton
Gauged Discharge
Cubic Metres per Second
10.0
7.0
4.0
2.0
1.0
1990
1991
1992
Station No : 040011 Monthly mean flows
+ extremes & mean monthly flows (1964-1988)

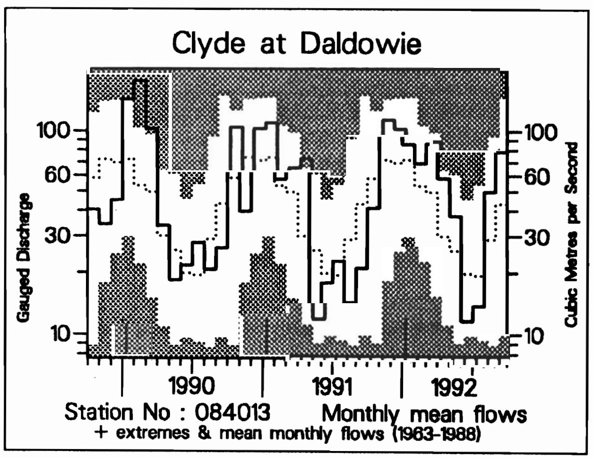

Itchen at Highbridge+Allbrook
Gauged Discharge
Cubic Metres per Second
10.0
8.0
6.0
4.0
1990
1991
1992
Station No : 042010 Monthly mean flows
+ extremes & mean monthly flows (1958-1988)


Tone at Bishops Hull
Gauged Discharge
Cubic Metres per Second
10.0
5.0
1.0
0.5
1990
1991
1992
Station No : 052005 Monthly mean flows
+ extremes & mean monthly flows (1961-1988)


Severn at Bewdley
Gauged Discharge
Cubic Metres per Second
300
100
60
30
10
1990
1991
1992
Station No : 054001 Monthly mean flows
+ extremes & mean monthly flows (1921-1988)


Cynon at Abercynon
Gauged Discharge
Cubic Metres per Second
10.0
6.0
3.0
1.0
0.6
1990
1991
1992
Station No : 057004 Monthly mean flows
+ extremes & mean monthly flows (1957-1988)


Eden at Sheepmount
Gauged Discharge
Cubic Metres per Second
100
60
30
10
1990
1991
1992
Station No : 076007 Monthly mean flows
+ extremes & mean monthly flows (1967-1988)


Clyde at Daldowie
Gauged Discharge
Cubic Metres per Second
100
60
30
10
1990
1991
1992
Station No : 084013 Monthly mean flows
+ extremes & mean monthly flows (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 | May 1992 | Jun 1992 | Jul 1992 | Aug 1992 | Sep 1992 | Sep 1992 | 5/92 to 9/92 | 5/92 to 9/92 | 10/91 to 9/92 | 10/91 to 9/92 | 10/90 to 9/92 | 10/90 to 9/92 | 10/88 to 9/92 | 10/88 to 9/92 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mm %LT | mm %LT | mm %LT | mm %LT | mm %LT | rank /yrs | mm %LT | rank /yrs | mm %LT | rank /yrs | mm %LT | rank /yrs | mm %LT | rank /yrs |
| Dee at | 54 | 15 | 14 | 42 | 55 | 16 | 178 | 10 | 672 | 4 | 1422 | 4 | 2704 | 1 |
| Park | 87 | 40 | 49 | 134 | 137 | /20 | 90 | /20 | 85 | /19 | 90 | /18 | 84 | /16 |
| Tay at | 79 | 26 | 27 | 80 | 139 | 38 | 349 | 34 | 1312 | 35 | 2446 | 28 | 5279 | 34 |
| Ballathie | 115 | 58 | 67 | 157 | 200 | /40 | 126 | /40 | 117 | /40 | 109 | /39 | 118 | /37 |
| Whiteadder Water at | 16 | 9 | 8 | 12 | 19 | 20 | 64 | 9 | 318 | 6 | 765 | 9 | 1197 | 4 |
| Hutton Castle | 60 | 53 | 63 | 78 | 123 | /24 | 74 | /23 | 81 | /23 | 97 | /22 | 76 | /20 |
| South Tyne at | 36 | 8 | 8 | 28 | 48 | 14 | 127 | 8 | 767 | 17 | 1532 | 15 | 2790 | 5 |
| Haydon Bridge | 103 | 30 | 28 | 72 | 95 | /29 | 72 | /29 | 102 | /29 | 101 | /27 | 91 | /23 |
| Wharfe at | 32 | 10 | 11 | 26 | 41 | 17 | 119 | 7 | 631 | 9 | 1274 | 12 | 2466 | 2 |
| Flint Mill Weir | 86 | 40 | 41 | 65 | 93 | /37 | 70 | /37 | 88 | /37 | 89 | /36 | 85 | /34 |
| Derwent at | 14 | 8 | 8 | 7 | 11 | 10 | 48 | 4 | 174 | 2 | 450 | 4 | 812 | 1 |
| Buttercrambe | 59 | 48 | 57 | 49 | 82 | /31 | 59 | /31 | 54 | /31 | 69 | /30 | 61 | /28 |
| Trent at | 16 | 16 | 16 | 16 | 20 | 26 | 83 | 12 | 234 | 2 | 505 | 2 | 1074 | 2 |
| Colwick | 64 | 85 | 101 | 97 | 121 | /34 | 90 | /34 | 66 | /34 | 71 | /33 | 75 | /31 |
| Lud at | 10 | 9 | 7 | 8 | 8 | 8 | 42 | 4 | 102 | 2 | 206 | 1 | 503 | 1 |
| Louth | 38 | 45 | 44 | 60 | 72 | /25 | 50 | /24 | 40 | /24 | 41 | /23 | 49 | /21 |
| Witham at | 8 | 6 | 7 | 5 | 11 | 31 | 37 | 15 | 104 | 4 | 219 | 2 | 475 | 2 |
| Claypole Mill | 51 | 62 | 100 | 73 | 179 | /34 | 82 | /34 | 57 | /33 | 60 | /32 | 64 | /30 |
| Little Ouse at | 7 | 5 | 6 | 4 | 5 | 9 | 28 | 6 | 75 | 1 | 153 | 1 | 405 | 1 |
| Abbey Heath | 48 | 47 | 73 | 53 | 69 | /25 | 58 | /25 | 45 | /24 | 46 | /23 | 60 | /21 |
| Colne at | 5 | 4 | 4 | 3 | 9 | 31 | 25 | 17 | 65 | 5 | 132 | 2 | 351 | 1 |
| Lexden | 58 | 74 | 96 | 75 | 216 | /33 | 94 | /33 | 48 | /33 | 48 | /32 | 65 | /30 |
| Lee at | 4 | 5 | 5 | 5 | 8 | 70 | 28 | 19 | 60 | 3 | 144 | 4 | 414 | 3 |
| Feildes Weir (natr.) | 31 | 53 | 62 | 66 | 111 | /107 | 61 | /107 | 37 | /106 | 45 | /104 | 64 | /100 |
| Thames at | 11 | 9 | 8 | 9 | 17 | 105 | 54 | 53 | 141 | 12 | 288 | 6 | 700 | 6 |
| Kingston (natr.) | 63 | 71 | 84 | 103 | 191 | /110 | 95 | /110 | 58 | /109 | 59 | /108 | 71 | /106 |
| Coln at | 23 | 17 | 15 | 13 | 18 | 26 | 87 | 9 | 280 | 6 | 546 | 2 | 1207 | 2 |
| Bibury | 70 | 64 | 72 | 78 | 128 | /29 | 79 | /29 | 72 | /29 | 70 | /28 | 76 | /26 |
| Great Stour at | 15 | 7 | 9 | 9 | 11 | 8 | 51 | 4 | 165 | 1 | 377 | 2 | 744 | 1 |
| Horton | 71 | 45 | 63 | 67 | 81 | /28 | 66 | /27 | 57 | /25 | 64 | /23 | 63 | /19 |
| Itchen at | 24 | 20 | 21 | 20 | 22 | 7 | 108 | 2 | 285 | 1 | 632 | 1 | 1392 | 1 |
| Highbridge+Allbrook | 57 | 58 | 69 | 71 | 84 | /34 | 68 | /34 | 62 | /34 | 69 | /33 | 76 | /31 |
| Piddle at | 24 | 17 | 15 | 14 | 17 | 23 | 87 | 7 | 271 | 3 | 580 | 1 | 1233 | 1 |
| Baggs Mill | 76 | 73 | 84 | 90 | 113 | /29 | 84 | /29 | 68 | /28 | 73 | /26 | 76 | /22 |
| Exe at | 36 | 13 | 15 | 47 | 61 | 31 | 170 | 23 | 636 | 5 | 1376 | 6 | 2743 | 2 |
| Thorverton | 97 | 55 | 71 | 169 | 161 | /37 | 115 | /37 | 77 | /36 | 84 | /35 | 83 | /33 |
| Taw at | 28 | 8 | 7 | 30 | 38 | 29 | 110 | 19 | 480 | 4 | 1124 | 4 | 2333 | 3 |
| Umberleigh | 97 | 51 | 46 | 164 | 162 | /34 | 108 | /34 | 70 | /34 | 82 | /33 | 85 | /31 |
| Tone at | 16 | 10 | 8 | 11 | 16 | 25 | 61 | 6 | 288 | 2 | 623 | 1 | 1453 | 1 |
| Bishops Hull | 59 | 57 | 52 | 90 | 106 | /32 | 71 | /32 | 62 | /31 | 66 | /30 | 76 | /28 |
| Severn at | 15 | 24 | 9 | 26 | 35 | 56 | 109 | 51 | 343 | 10 | 737 | 9 | 1518 | 8 |
| Bewdley | 64 | 138 | 64 | 152 | 163 | /72 | 116 | /72 | 76 | /71 | 82 | /70 | 84 | /68 |
| Wye at | 113 | 41 | 44 | 214 | 204 | 30 | 616 | 23 | 2012 | 16 | 4085 | 15 | 7818 | 5 |
| Cefn Brwyn | 120 | 48 | 40 | 149 | 125 | /40 | 103 | /38 | 98 | /37 | 99 | /32 | 94 | /22 |
| Cynon at | 51 | 17 | 32 | 199 | 140 | 32 | 439 | 30 | 1100 | 8 | 2371 | 12 | 4791 | 12 |
| Abercynon | 87 | 42 | 93 | 408 | 213 | /34 | 173 | /34 | 89 | /34 | 96 | /32 | 96 | /28 |
| Dee at | 83 | 40 | 29 | 160 | 156 | 16 | 468 | 17 | 1639 | 7 | 3256 | 6 | 6426 | 1 |
| New Inn | 128 | 68 | 43 | 178 | 120 | /24 | 111 | /23 | 91 | /23 | 90 | /22 | 88 | /20 |
| Eden at | 40 | 13 | 14 | 31 | 55 | 15 | 153 | 12 | 672 | 11 | 1393 | 10 | 2744 | 7 |
| Sheepmount | 126 | 51 | 52 | 104 | 132 | /22 | 98 | /22 | 97 | /21 | 102 | /19 | 100 | /15 |
| Clyde at | 53 | 16 | 19 | 70 | 107 | 28 | 264 | 28 | 1024 | 29 | 1890 | 28 | 3596 | 25 |
| Daldowie | 155 | 61 | 69 | 176 | 189 | /29 | 141 | /29 | 133 | /29 | 123 | /28 | 118 | /26 |

Notes:
(i) Values based on gauged flow data unless flagged (natr.), when naturalised data have been used.
(ii) Values are ranked so that lowest runoff as rank 1.
(iii) %LT means percentage of long term average from the start of the record to 1991. For the long periods (at the right of this table), the end date for the long term is 1991.

## TABLE 4 START-MONTH RESERVOIR STORAGES UP TO OCTOBER 1992

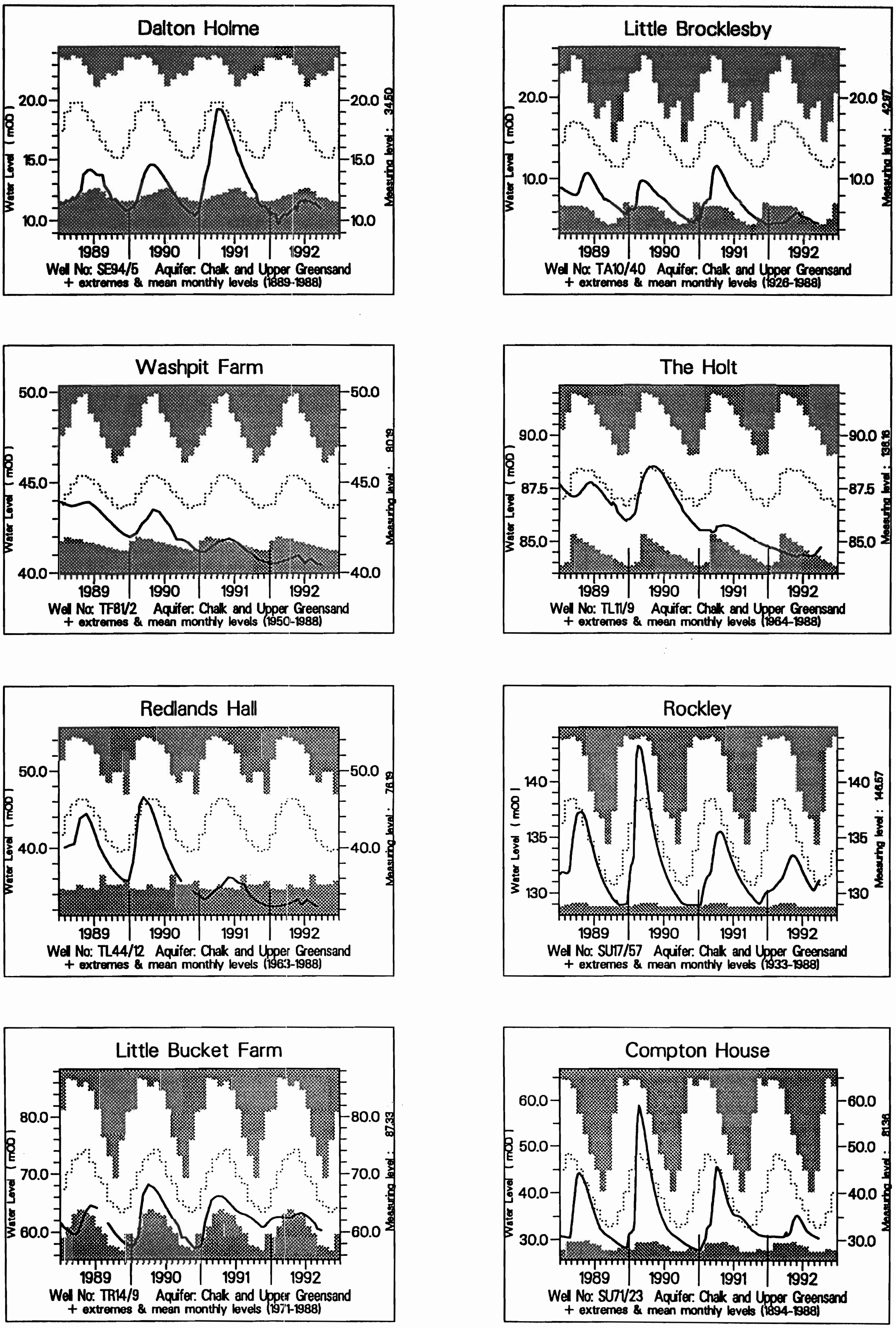
| Area | Reservoir (R)/ Group (G) | | Capacity● (Ml) | 1992 May | Jun | Jul | Aug | Sep | Oct | 1991 Oct |
|---|---|---|---|---|---|---|---|---|---|---|
| North West | Northern Command Zone[1] | (G) | 133375 | 93 | 86 | 66 | 55 | 60 | 66 | 33 |
| | Vyrnwy | (R) | 55146 | 100 | 94 | 89 | 80 | 96 | 93 | 71 |
| Northumbria | Teesdale[2] | (G) | 87936 | 97 | 89 | 71 | 58 | 63 | 68 | 31 |
| | Kielder | (R) | 199175* | 91* | 90* | 86* | 77* | 84* | 89* | 85* |
| Severn-Trent | Clywedog | (R) | 44922 | 99 | 97 | 93 | 85 | 87 | 92 | 74 |
| | Derwent Valley[3] | (G) | 39525 | 100 | 91 | 79 | 73 | 66 | 62 | 35 |
| Yorkshire | Washburn[4] | (G) | 22035 | 99 | 95 | 85 | 72 | 64 | 64 | 36 |
| | Bradford supply[5] | (G) | 41407 | 99 | 91 | 76 | 58 | 56 | 65 | 38 |
| Anglian | Grafham | (R) | 58707 | 96 | 96 | 95 | 95 | 94 | 94 | 81 |
| | Rutland | (R) | 130061 | 82 | 82 | 81 | 81 | 86 | 93 | 68 |
| Thames | London[6] | (G) | 206232 | 100 | 93 | 86 | 85 | 89 | 94 | 66 |
| | Farmoor [7] | (G) | 13843 | 100 | 98 | 98 | 97 | 99 | 99 | 82 |
| Southern | Bewl | (R) | 28170 | 70 | 73 | 71 | 64 | 60 | 68 | 62 |
| | Ardingly | (R) | 4730 | 100 | 100 | 100 | 88 | 71 | 79 | 84 |
| Wessex | Clatworthy | (R) | 5364* | 85* | 77* | 65* | 43* | 35* | 40* | 40* |
| | Bristol WW [8] | (G) | 38666* | 86* | 80* | 71* | 61* | 58* | 65* | 46* |
| South West | Colliford | (R) | 28540 | 82 | 80 | 71 | 66 | 63 | 65 | 81 |
| | Roadford | (R) | 34500 | 92 | 91 | 83 | 75 | 70 | 72 | 84 |
| | Wimbleball[9] | (R) | 21320 | 79 | 76 | 63 | 53 | 48 | 50 | 52 |
| | Stithians | (R) | 5205 | 65 | 69 | 61 | 54 | 53 | 63 | 40 |
| Welsh | Celyn + Brenig | (G) | 131155 | 100 | 100 | 99 | 87 | 89 | 93 | 68 |
| | Brianne | (R) | 62140 | 100 | 97 | 88 | 77 | 90 | 99 | 84 |
| | Big Five[10] | (G) | 69762 | 98 | 92 | 77 | 66 | 83 | 86 | 69 |
| | Elan Valley[11] | (G) | 99106 | 100 | 96 | 91 | 87 | 100 | 100 | 77 |
| Lothian | Edinburgh/Mid Lothian | (G) | 97639 | 100 | 98 | 87 | 79 | 86 | 92 | 71 |
| | West Lothian | (G) | 5613 | 85 | 76 | 60 | 49 | 60 | 82 | 59 |
| | East Lothian | (G) | 10206 | 89 | 91 | 81 | 72 | 68 | 78 | 67 |

● Live or usable capacity (unless indicated otherwise)
* Gross storage/percentage of gross storage

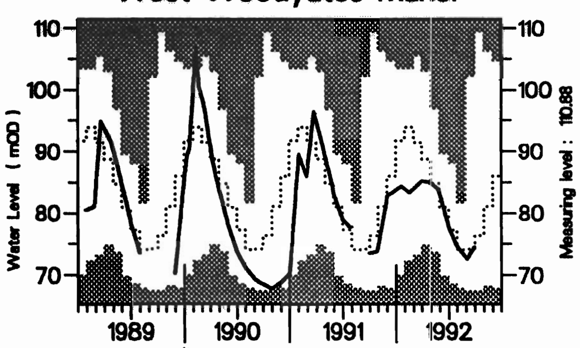
1. Includes Haweswater, Thirlmere, Stocks and Barnacre.
2. Cow Green, Selset, Grassholme, Balderhead, Blackton and Hury.
3. Howden, Derwent and Ladybower.
4. Swinsty, Fewston, Thruscross and Eccup.
5. The Nidd/Barden group (Scar House, Angram, Upper Barden, Lower Barden and Chelker) plus Grimwith.
6. 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. Shared between South West (river regulation for abstraction) and Wessex (direct supply).
10. Usk, Talybont, Llandegfedd (pumped storage), Taf Fechan, Taf Fawr.
11. Claerwen, Caban Coch, Pen y Garreg and Craig Goch.

Note: Variations in storage depend on the balance between inputs (from catchment rainfall and any pumping) and outputs (to supply, compensation flow, HEP, amenity). There will be additional losses due to evaporation, especially in the summer months. Operational strategies for making the most efficient use of water stocks will further affect reservoir storages. Table 4 provides a link between the hydrological conditions described elsewhere in the report and the water resources situation.

**FIGURE 5 GROUNDWATER LEVEL HYDROGRAPHS**

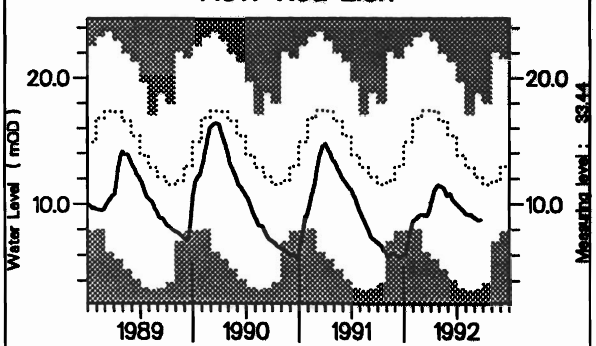


## West Woodyates Manor



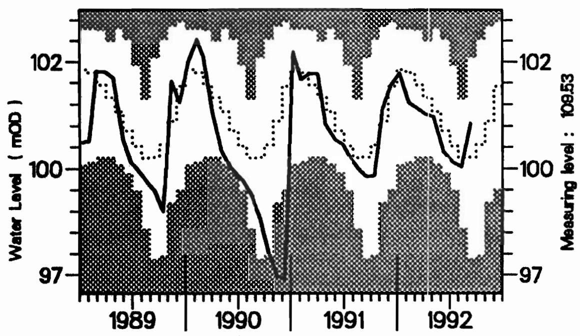

Well No: SU01/5B Aquifer: Chalk and Upper Greensand
+ extremes & mean monthly levels (1942-1988)

## New Red Lion



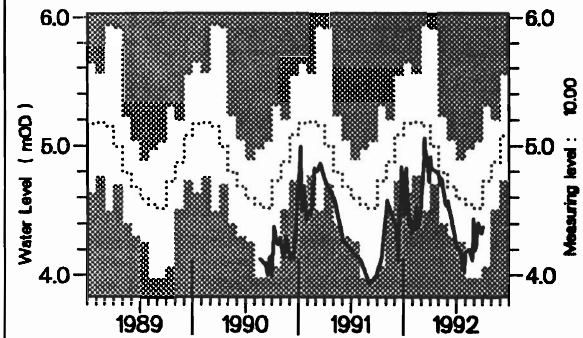

Well No: TF03/37 Aquifer: Lincolnshire Limestone
+ extremes & mean monthly levels (1964-1988)

## Ampney Crucis



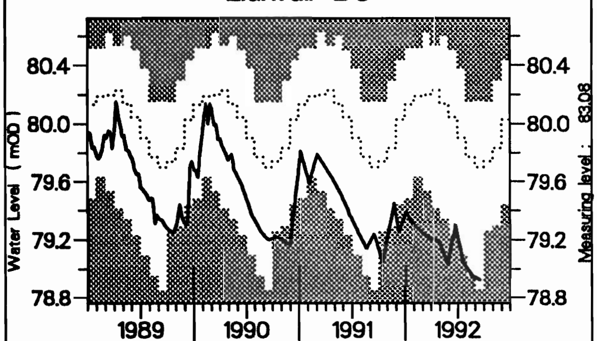

Well No: SP00/62 Aquifer: Middle Jurassic
+ extremes & mean monthly levels (1958-1988)

## Redbank



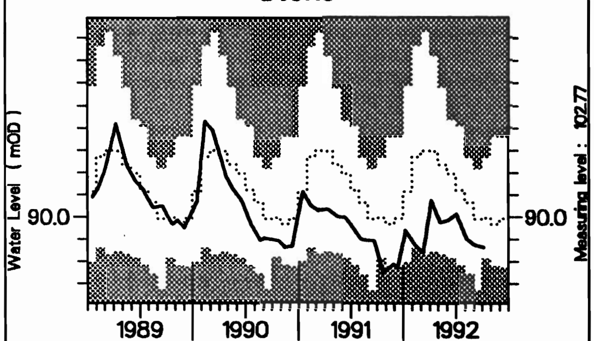

Well No: NX97/1 Aquifer: Permo-triassic Sandstone
+ extremes & mean monthly levels (1961-1988)

## Llanfair Dc



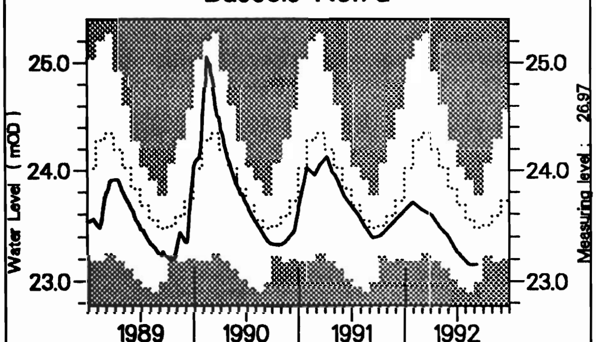

Well No: SJ15/15 Aquifer: Permo-triassic Sandstone
+ extremes & mean monthly levels (1972-1988)

## Stone



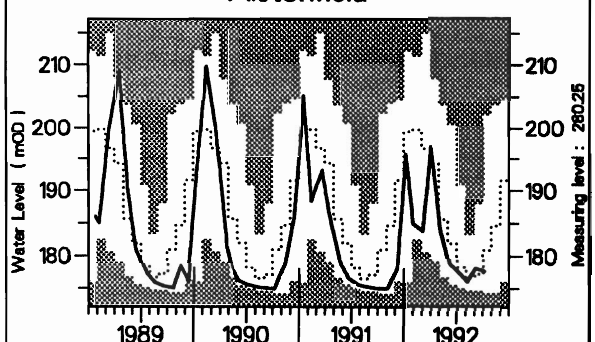

Well No: SJ83/1A Aquifer: Permo-triassic Sandstone
+ extremes & mean monthly levels (1974-1988)

## Bussels No.7a




Well No: SX99/37B Aquifer: Permo-triassic Sandstone
+ extremes & mean monthly levels (1971-1988)

## Alstonfield




Well No: SK15/16 Aquifer: Carboniferous Limestone
+ extremes & mean monthly levels (1974-1988)

## TABLE 5 A COMPARISON OF SEPTEMBER GROUNDWATER LEVELS : 1992, 1991 AND 1976

| Site | Aquifer | Records commence | Average September Level | September 1976 | | September 1991 | | September /October 1992 | | No of years Sept/levels <1992 | Lowest pre-1992 level (any month) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Day | Level | Day | Level | Day | Level | | |
| Wetwang | C & UGS | 1971 | 19.52 | 16/09 | 18.29 | 26/09 | 17.85 | 25/09 | 17.91 | 2 | 16.84 |
| Dalton Holme | C & UGS | 1889 | 15.67 | 25/09 | 11.87 | 29/09 | 12.83 | 29/09 | 10.98 | 0 | 10.34 |
| Little Brocklesby | C & UGS | 1926 | 11.72 | 24/09 | 4.56 | 24/09 | 5.85 | 15/09 | 4.69 | 1 | 4.54 |
| Washpit Farm | C & UGS | 1950 | 43.98 | 01/09 | 41.70 | 03/09 | 41.21 | 01/10 | 40.43 | 0 | 40.61 |
| The Holt | C & UGS | 1964 | 87.45 | 02/09 | 84.59 | 29/09 | 85.18 | 01/10 | 84.75 | 2 | 83.90 |
| Therfield Rectory | C & UGS | 1883 | 79.84 | 01/09 | 73.63 | 29/09 | 73.04 | 01/10 | dry | _ | dry (below 71.60) |
| Redlands | C & UGS | 1964 | 40.79 | 01/09 | 36.00 | 16/09 | 33.90 | 11/09 | 32.40 | 0 | 32.46 |
| Rockley | C & UGS | 1933 | 131.06 | 26/09 | dry | 23/09 | 130.03 | 27/09 | 131.15 | >10 | dry (below 128.94) |
| Little Bucket Farm | C & UGS | 1971 | 65.56 | 30/09 | 57.64 | 25/09 | 62.30 | 21/09 | 60.29 | 3 | 56.77 |
| Compton House | C & UGS | 1894 | 33.11 | 30/09 | 27.72 | 24/09 | 32.99 | 24/09 | 30.51 | 6 | 27.64 |
| Chilgrove House | C & UGS | 1836 | 41.24 | 25/09 | 33.68 | 24/09 | 42.31 | 24/09 | 37.89 | >10 | 33.46 |
| West Dean No 3 | C & UGS | 1940 | 1.46 | 24/09 | 1.37 | 27/09 | 1.47 | 28/09 | 1.47 | >10 | 1.01 |
| Lime Kiln Way | C & UGS | 1969 | 125.09 | 15/09 | 124.12 | 10/09 | 124.48 | 28/09 | 123.85 | 0 | 124.09 |
| Ashton Farm | C & UGS | 1974 | 65.28 | 24/09 | 63.23 | 02/09 | 65.90 | 28/09 | 64.80 | 5 | 63.10 |
| West Woodyates | C & UGS | 1942 | 72.84 | 01/09 | 67.67 | 30/09 | 73.50 | 28/09 | 74.50 | >10 | 67.62 |
| New Red Lion | LLst | 1964 | 12.03 | 28/09 | 3.68 | 09/09 | 7.42 | 24/09 | 8.78 | 5 | 3.29 |
| Ampney Crucis | Mid Jur | 1958 | 100.28 | 26/09 | 97.87 | 16/09 | 99.81 | 11/09 | 101.06 | >10 | 97.38 |
| Dunmurry (NI) | PTS | 1985 | 28.19 | no | levels | 26/09 | 27.51 | 24/09 | 27.98 | 4 | 27.47 |
| Redbank | PTS | 1981 | 4.58 | no | levels | 05/09 | 3.93 | 01/10 | 4.37 | 5 | 3.93 |
| Llanfair DC | PTS | 1972 | 79.61 | 01/09 | 78.85 | 16/09 | 79.24 | 15/09 | 78.92 | 1 | 78.85 |
| Morris Dancers | PTS | 1969 | 32.58 | 21/09 | 31.85 | 10/09 | 32.05 | 16/09 | 31.88 | 1 | 30.87 |
| Weeford Flats | PTS | 1966 | 90.13 | 29/09 | dry | 19/09 | dry | 02/10 | dry | _ | dry (below 88.61) |
| Stone | PTS | 1974 | 90.07 | 03/09 | 89.34 | 23/09 | 89.79 | 05/10 | 89.73 | 1 | 89.34 |
| Bussels 7A | PTS | 1972 | 23.49 | 28/09 | 23.09 | 12/09 | 23.39 | 09/09 | 23.15 | 1 | 22.90 |
| Rushyford NE | MgLst | 1967 | 71.83 | 27/09 | 71.10 | 04/09 | 75.21 | 16/09 | 74.47 | >10 | 64.77 |
| Peggy Ellerton | MgLst | 1968 | 34.28 | 27/09 | 31.10 | 05/09 | 33.08 | 09/09 | 31.23 | 1 | 31.10 |
| Alstonfield | CLst | 1974 | 178.02 | 01/09 | 174.56 | 20/09 | 175.11 | 05/10 | 177.56 | >10 | 174.22 |

Groundwater levels are in metres above Ordnance Datum

C & UGS Chalk and Upper Greensand
LLst Lincolnshire Limestone
PTS Permo-Triassic sandstones
Mid Jur Middle Jurassic limestones
MgLst Magnesian Limestone
CLst Carboniferous Limestone

# FIGURE 6 LOCATION MAP OF GAUGING STATIONS AND GROUNDWATER INDEX WELLS