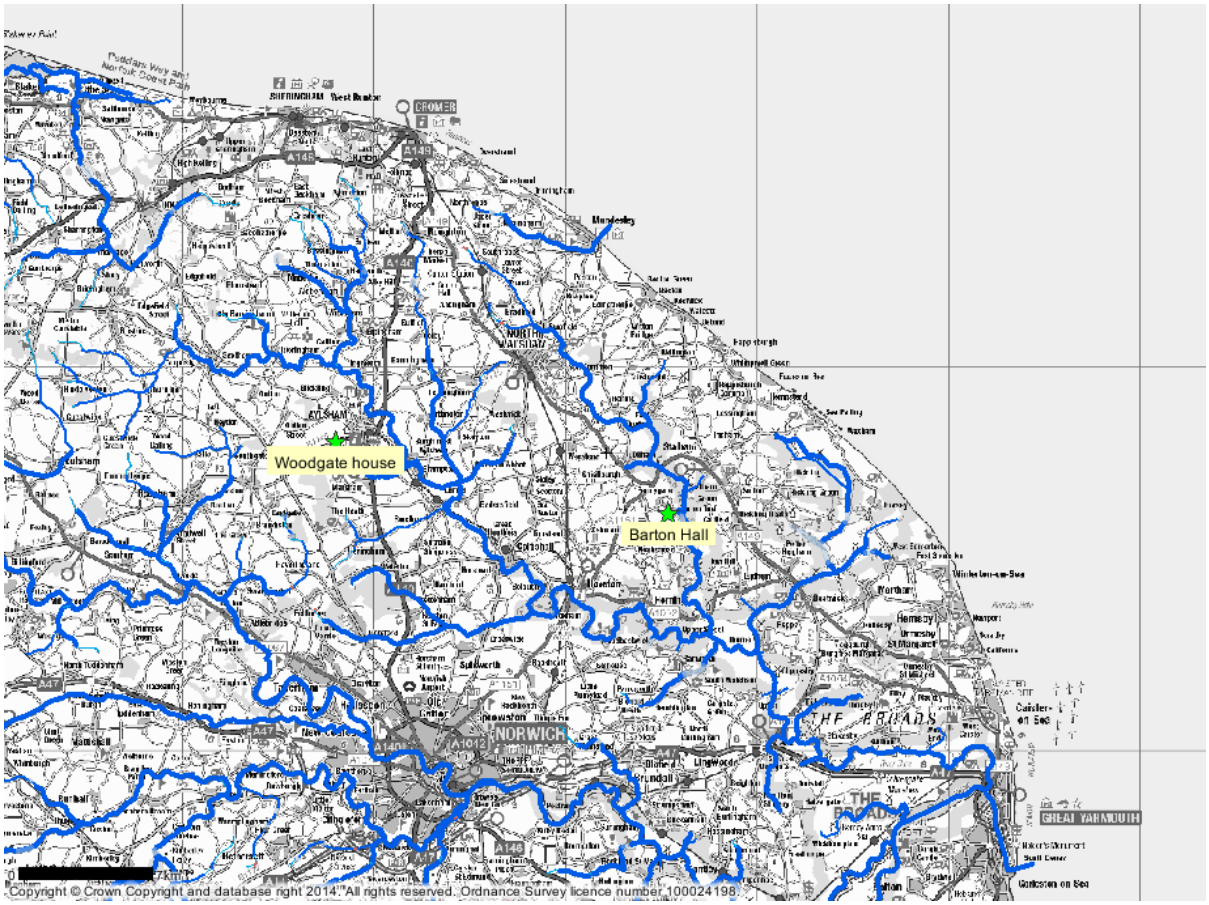
Recent Trends in Rainfall Patterns – Ant Broads and Marshes, North East Norfolk

A query has been raised regarding the potential for changes in rainfall patterns to affect the ecology of fen habitat distribution in North East Norfolk - with particular reference to localised areas of the Ant Broads and Marshes post 1986. This note is intended only to identify significant recent trends that may be relevant to scoping further investigations. Data is presented for the rain gauge record in closest proximity to the S.A.C. (Barton Turf and Hall). This record commences in 1966 and is therefore a little short to calculate a baseline period of record 1966-1986. It is also a combined record for two close by but separate recording locations. To identify the recent trends in context of longer term climate variability a Met Office approved rain gauge site at Woodgate House has also been assessed. The site benefits from a continuous record since 1955 and part record since 1933. Woodgate house is located 21km West of the study area.

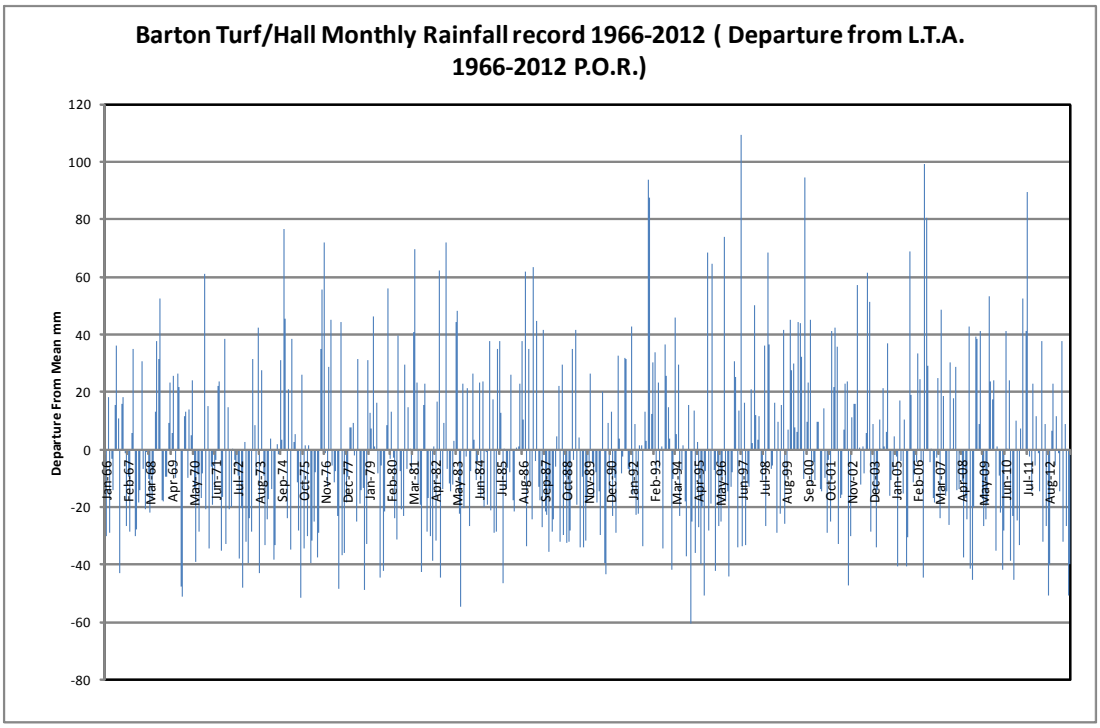
Location



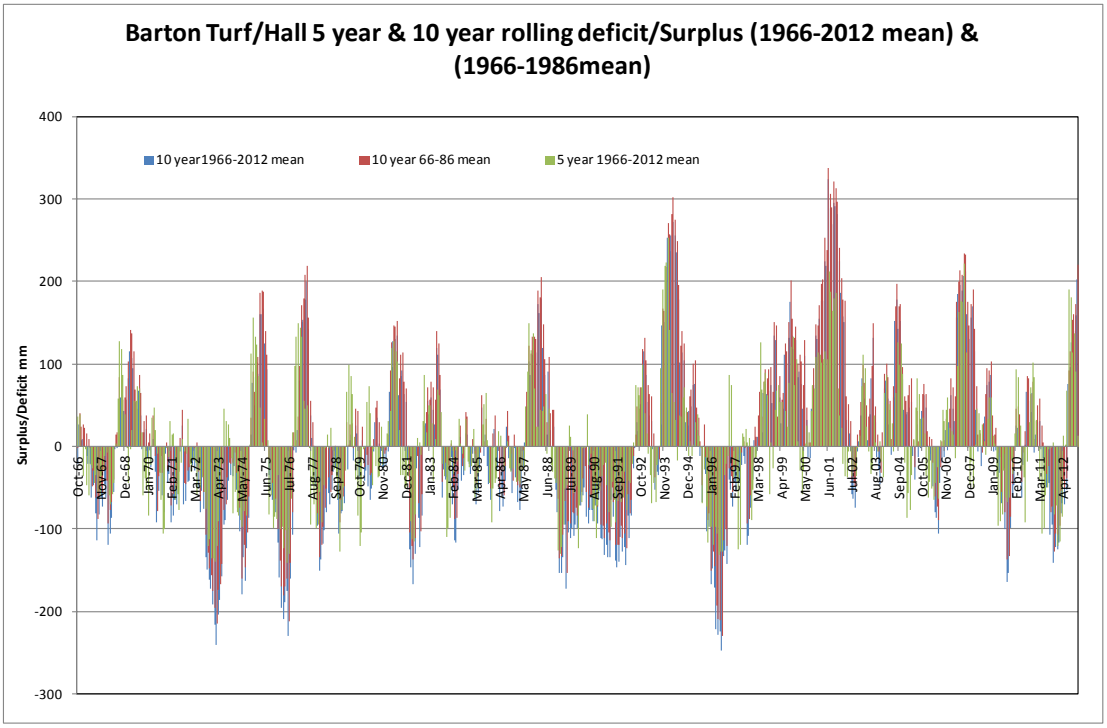
Local patterns in Rainfall distribution have also been assessed in context of the county record (derived from M.O. long term monthly county analysis).

Barton Record

Data is marked 98% good. Limited infilling has been carried out using county averages. Monthly departures from the mean (full P.O.R. 1966-2012) are in graph 1 below

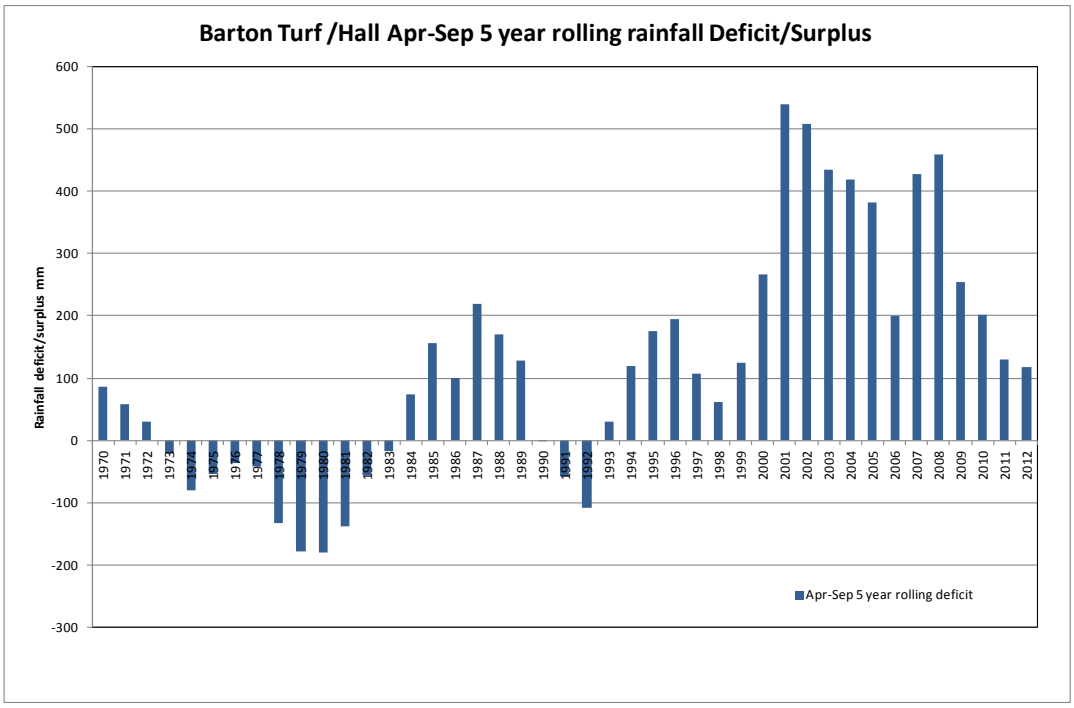


Graph 1.



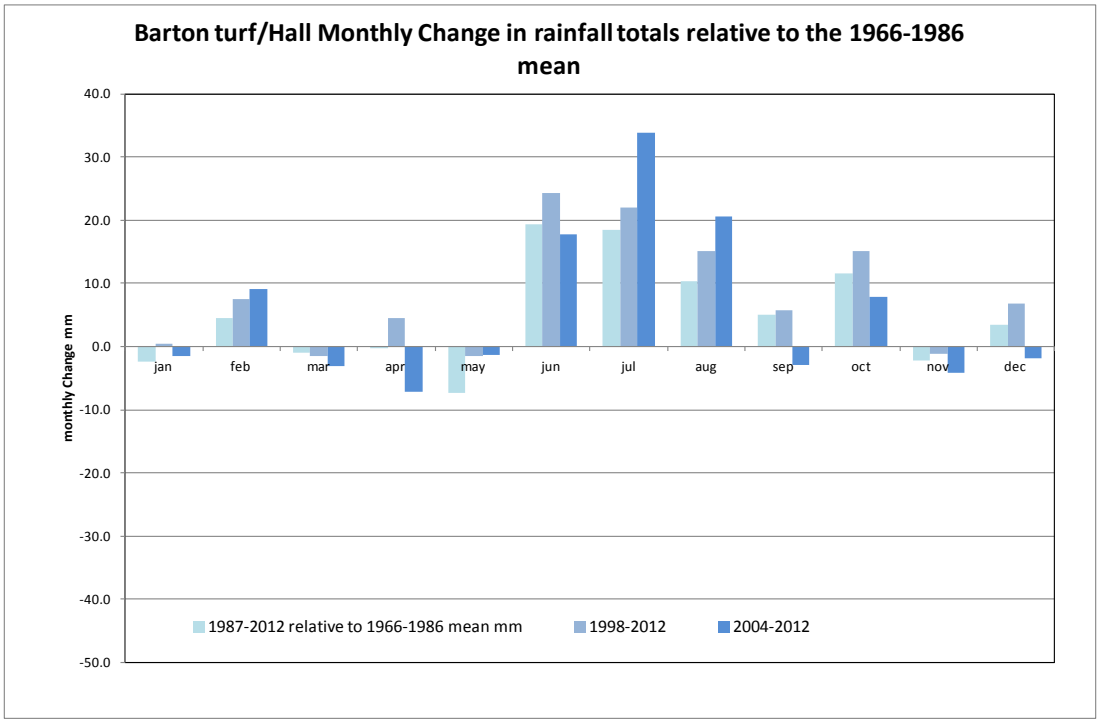
Graph2.

A more useful overview of the data comes from the 5 year and 10 year rolling deficit plot (*graph 2*). Due to the short record available for the baseline the 10 year departure has been assessed against two periods for the mean 1966-1986 (baseline) and 1966-2012 (P.O.R.). In practice the period adopted for the mean has little impact on this type of analysis due to the length of the rolling period being assessed. The general pattern of droughts and excessively wet periods are clearly evident in the local record. The well established droughts in the early 1970's and between 1989-1992 and 1995-1997 were the result of cumulative deficits over several consecutive dry summer/ winter periods. Interestingly the more recent drought of 2006/2007 scarcely registers. Likewise the 2010-2012 period does not feature as particularly significant. Whilst these were both periods of low groundwater levels resulting from low winter rainfall. The intervening summer periods experienced rainfall significantly above the long term average.



Graph3

The graph immediately above limits the assessment of rainfall deficit to the summer months Apr-Sep only. This assessment is by definition of a discontinuous data set. It is however useful in highlighting the consistent increase in summer rainfall observed since 1998. The droughts of the 1970's and early 1990's were severe because they occurred alongside dry summers. This information is also useful since we may expect vegetation communities to respond not to a single wet or dry year but to short term climate variability over a few years.



Graph4

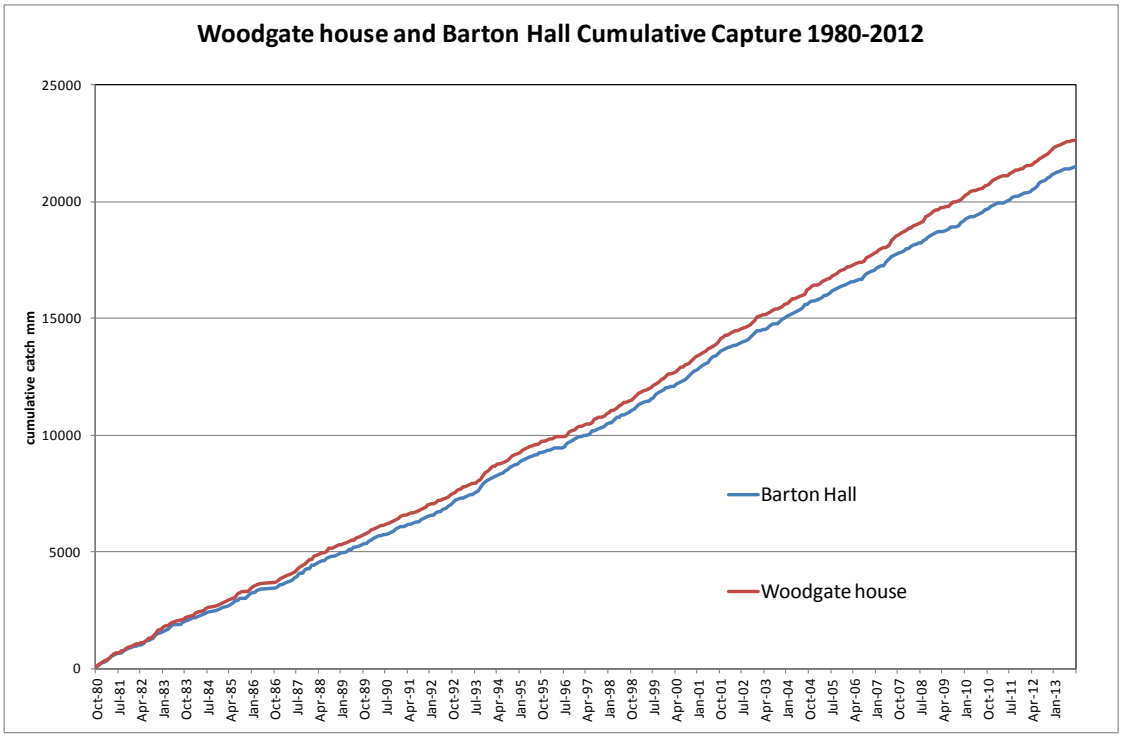
At a more detailed monthly level the data confirms the sustained increase in summer rainfall – the three time periods show a marked increase in the monthly average rainfall totals between June to October. These periods represent a sustained trend over 8, 14 and 25 years and are not therefore likely to be artefact of the period selection. Again cautious use of these figures is advised due to the relatively short baseline period of 1966-1986. A summary of this data is to be found in Table 1 below

mm	66-86	1987-2012	1998-12	2004-12
January	57	54	57	55
February	40	45	48	49
March	45	44	43	42
April	43	43	48	36
May	48	41	47	47
June	45	64	69	63
July	47	65	69	81
August	56	66	71	76
Septembe	52	57	57	49
October	58	69	73	65
November	71	68	69	66
December	57	61	64	56
Annual	618	677	715	685
Apr-Sep	290	336	360	351
Jun-Aug	147	195	209	220

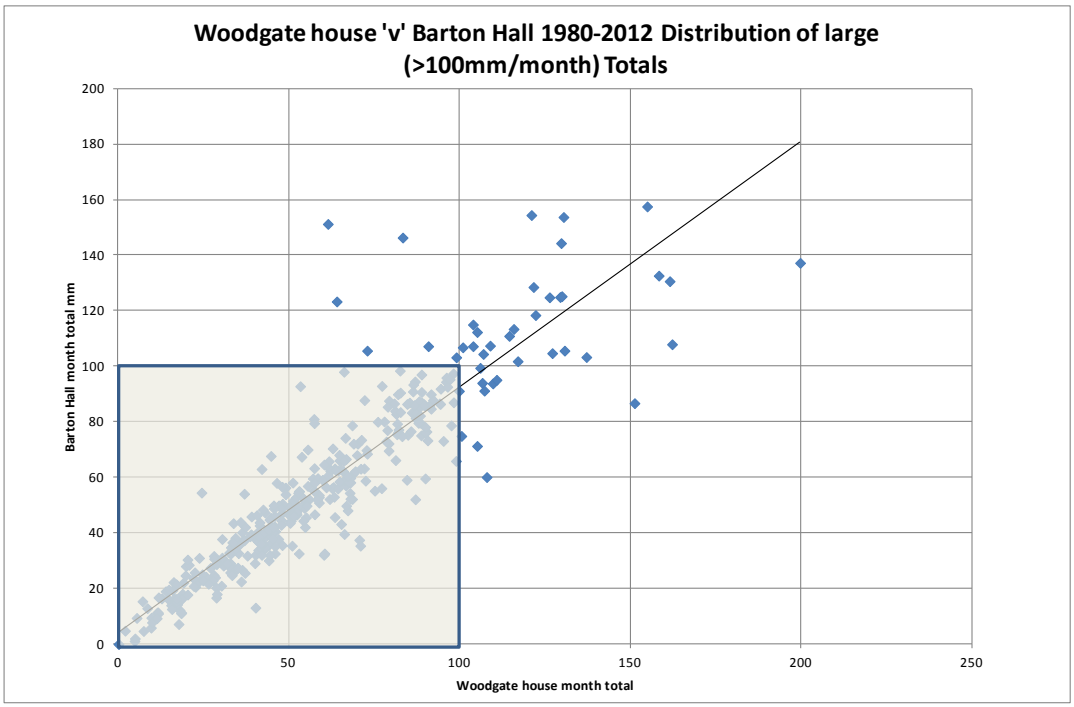
In the 25 year period since 1986 annual rainfall totals have increased form 618mm to 677mm. Whole Summer (Apr-Sep) from 290mm to 336mm, high summer from 147mm to 195mm. Significantly greater change has occurred since 1998 , with the annual total increasing by 97mm and the high summer totals increasing from 147mm to 209mm.

The local record is limited to data collected since 1966. The baseline period of 20 years is considered too short to infer that the recent trend is significant in the context of past climate that may have influenced fen development. We cannot reliably extend the local record. We have therefore carried out a similar analysis to the above on the nearest long period record at Woodgate House (21km to the West).

It should be noted that these two sites will have a different long term average climate due to elevation and geographical location. FEH SAAR for the two gauges is 623mm (Barton Hall) and 648mm (Woodgate House). Cumulative captured rainfall for the two gauges between 1980-2013 was recorded at 35mm per annum greater at Wood gate house - 671mm 'v' 706mm (1980-2013). Cumulative mass plots confirm that this local climate difference is constant over the period of record and is not a function of changes in relative gauge performance. (Graph 5.)



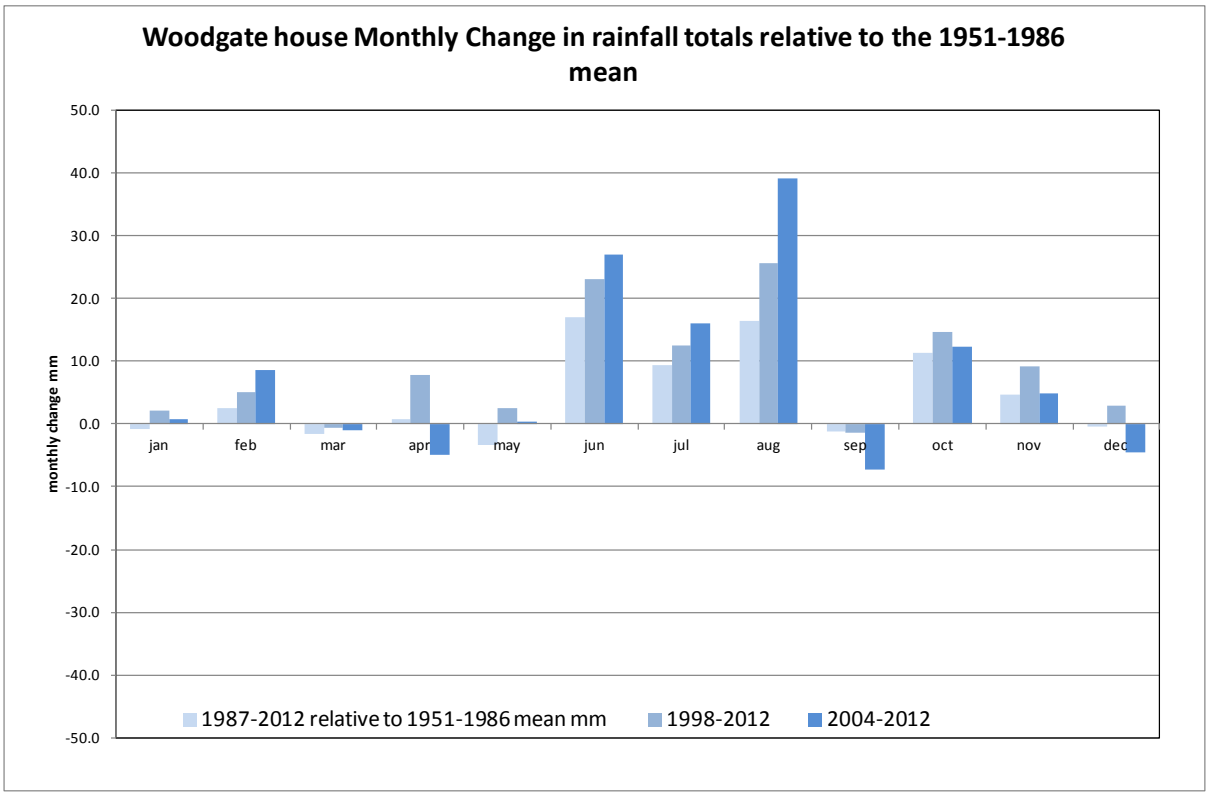
Graph 5.



Graph6

Comparison of the occurrence of high monthly total outliers in Graph 6 shows there to be no consistent difference in the pattern of capture between the two sites. Neither site is recording consistently greater frequency of high totals than the other. This tends to suggest that differences in capture are not due to site exposure and therefore we can have confidence in the validity of recent trends at Barton relative to the longer term record.

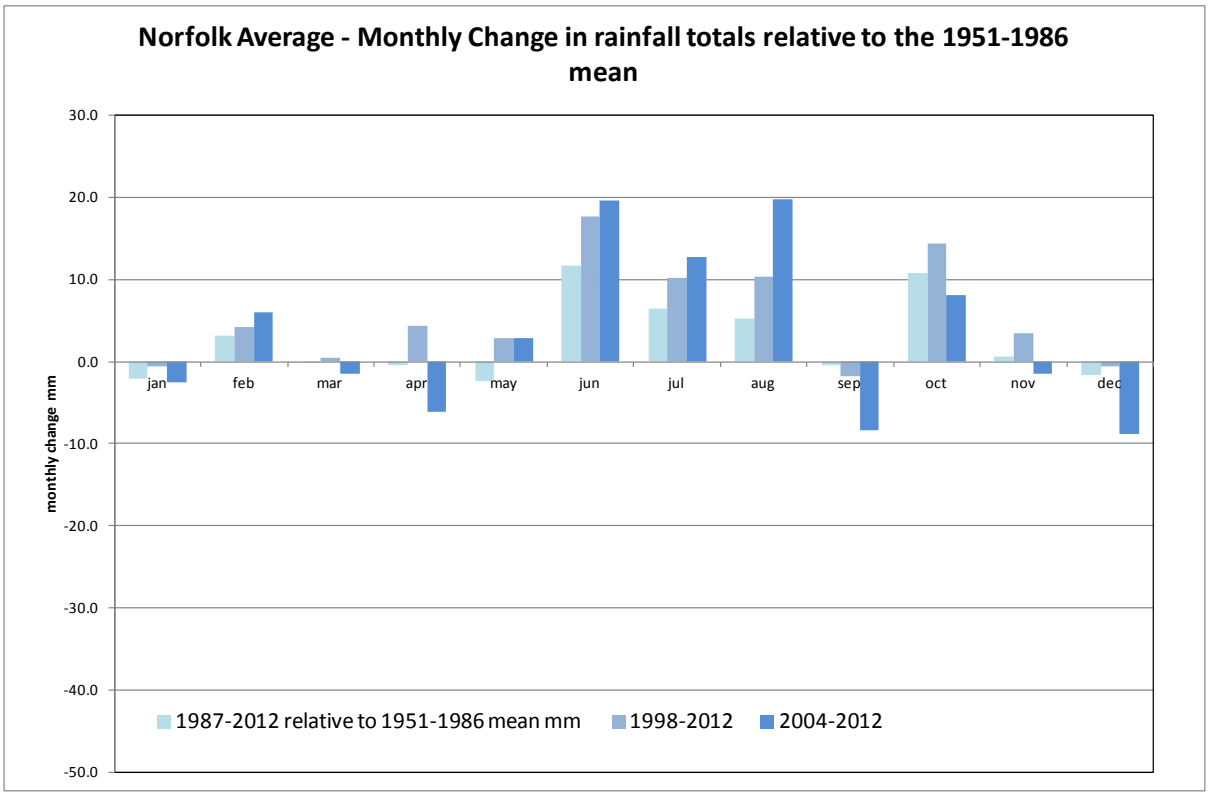
Graphs 7 and 8 below present the monthly change data relative to the 1951-1986 long term mean. The results are consistent for Woodgate House gauge and for the Norfolk average. We can therefore conclude that the Barton Hall measured trends relative to the short period baseline 1966-1986 are likely to be persistent relative to the longer baseline 1951-1986.



Graph 7

Woodgate house Rainfall statistics

mm	51-86 ave	87-12 ave	1998-12	2004-12
January	59	58	61	60
February	44	47	49	53
March	49	47	48	48
April	44	45	52	40
May	45	42	48	45
June	49	66	72	76
July	55	65	68	71
August	58	74	83	97
September	59	58	58	52
October	60	72	75	73
November	70	74	79	75
December	64	63	67	59
Annual	656	711	760	747
Apr-Sep	310	349	380	380
Jun-Aug	162	204	223	244



Graph 8

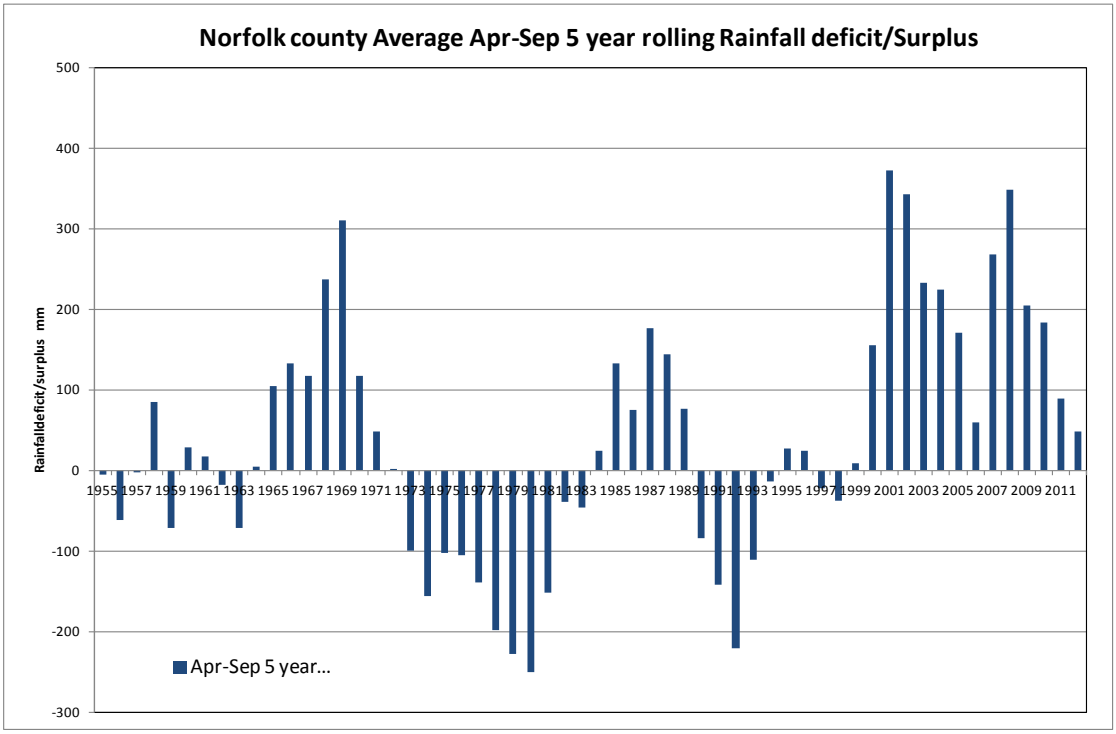
Norfolk Average Rainfall statistics

mm	51-86 ave	87-12 ave	1998-12	2004-12
January	57	55	57	55
February	42	45	46	48
March	45	45	45	44
April	44	43	48	38
May	45	43	48	48
June	49	61	67	69
July	54	61	65	67
August	60	65	71	80
Septembe	55	54	53	46
October	57	68	71	65
November	67	67	70	65
December	60	59	60	51
Annual	636	667	701	676
Apr-Sep	308	328	352	349
Jun-Aug	164	187	202	216

Graph 9 below presents a similar analysis of the data seen in Graph 3 for Barton Hall but extends the record to 1951 using the county average monthly totals. A very similar trend to that observed locally at Barton Hall can be identified in the regional context although it should be noted that the amplitude of increase in summer rainfall appears to increase in a North & Easterly direction within the county - a trend further supported by the data in a similar plot for Woodgate house (Graph 10).

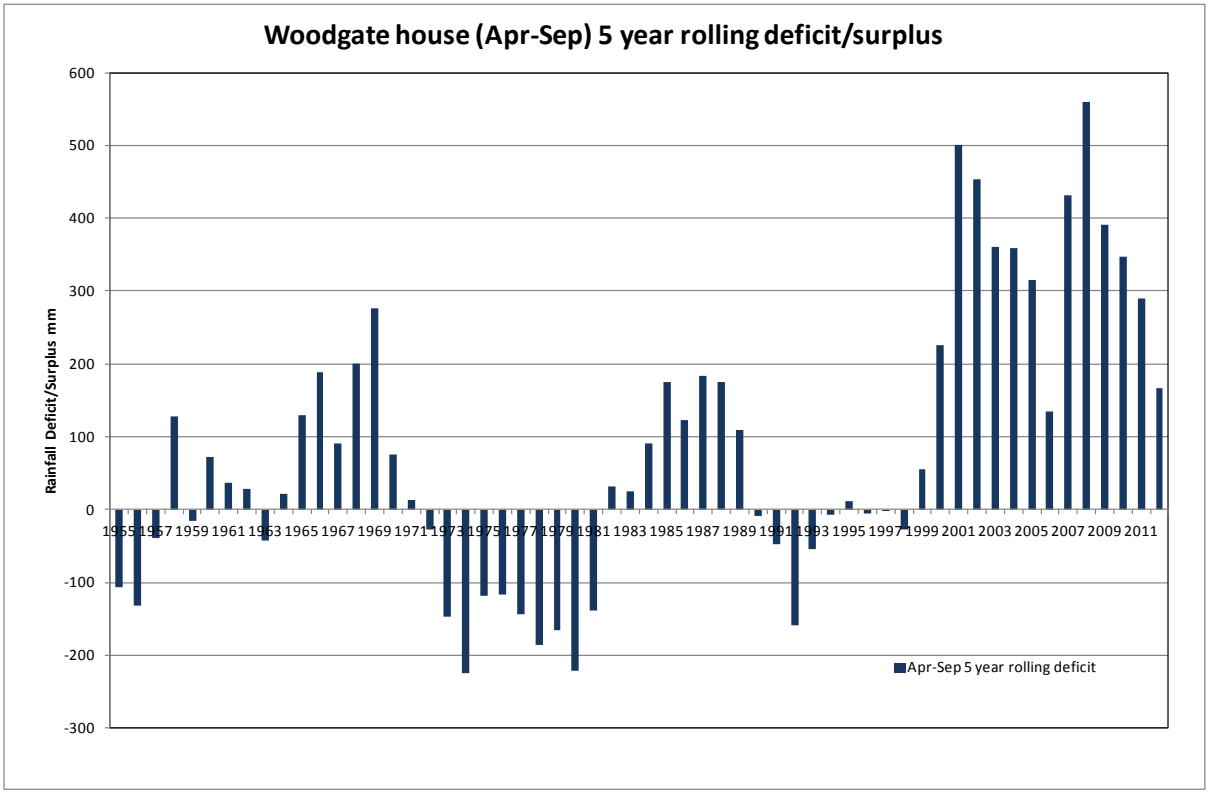
Both Woodgate House and Barton Hall record at least two periods since 1998 during which the summer surplus over 5 years reaches or exceeds 500mm. It is also significant that through the 1970's and again in the early 1990's deficits developed in excess of 200mm. Since these plots exclude winter rainfall they do not present a continuous deficit they are however very significant in highlighting large and persistent swings in seasonal climate trends within the long term record.

5 year Summer Rainfall Deficits Relative to the 1951-1986 Mean



Graph 9

5 year Summer Rainfall Deficits Relative to the 1951-1986 Mean



Graph10

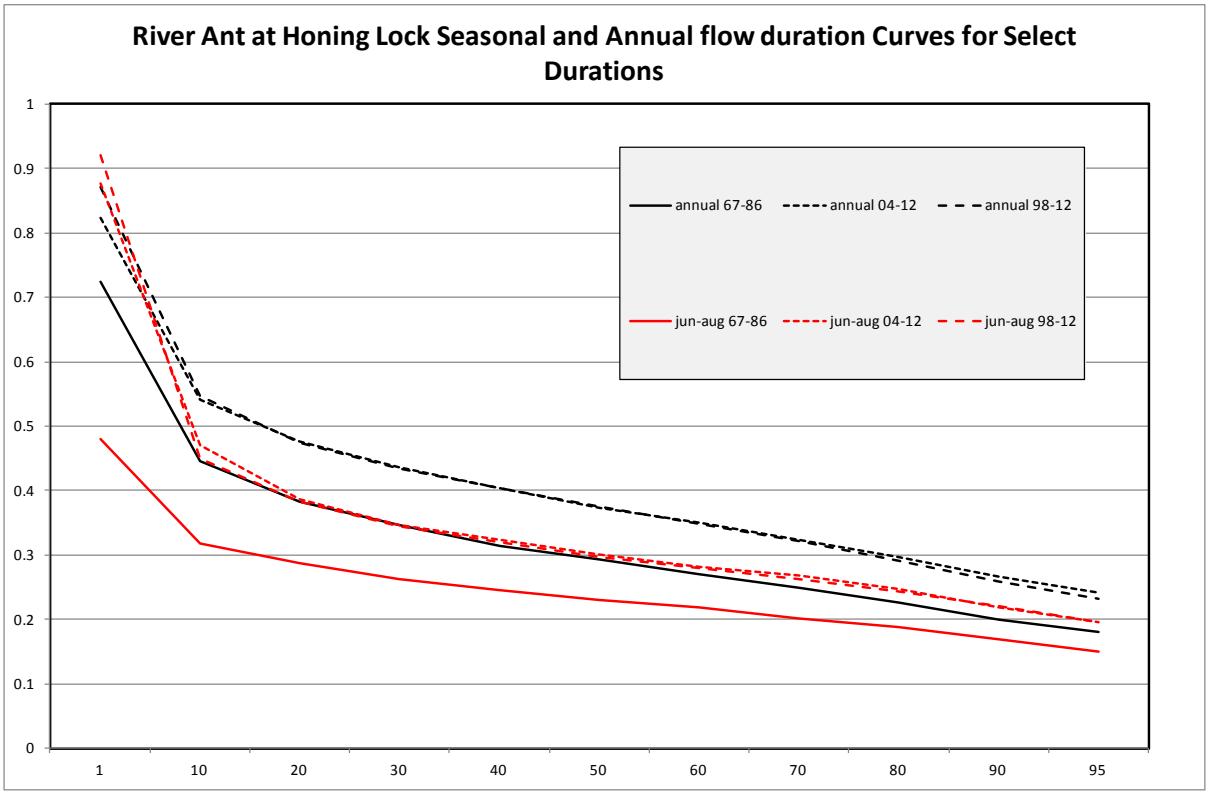
Supporting Evidence for Hydrological Change

Additional hydrological evidence for the impact of increased rainfall is to be found in the flow record for Honing Lock Gauging station on the river Ant (station number 34008). The gauge is a crump weir design located in the old navigation and records flows from an upstream catchment area of 49.3km$^{2.}$ Continuous flow recording commenced in 1967 therefore it is not possible to compare the full rainfall baseline time period with the flow gauge. Nevertheless the observed increase in flow relative to the 1967-1986 baselines at Barton Hall is very significant. Average flow over the most recent 14 year period has been recorded as 0.395 m^3/sec. Relative to the baseline mean flow (1967-1986) of 0.313 m^3/sec this represents an increase of 0.083 m^3/sec. This suggests an increase in annual runoff from 200mm per year to 253 mm per year. The high summer (Jun-Aug) mean flow has shown a similar significant increase from 0.240m^3/sec to 0.328m^3/sec, indicating that the runoff increase is derived mainly from baseflow. The increase in runoff of 53mm is consistent with the observed increase in annual rainfall of 97mm over the same period. These figures together indicate that at least 55% of the increased rainfall is hydrologically effective i.e either recharging the aquifer or routed into the river as rapid runoff.

River Ant at Honing Lock Flow duration statistics for Select time periods

percentile	annual 1967-1986	annual 2004-2012	annual 1998-2012	jun-aug 1967-1986	jun-aug 2004-2012	jun-aug 1998-2012
1	0.724	0.824	0.872	0.481	0.877	0.92
10	0.445	0.541	0.546	0.318	0.47	0.45
20	0.382	0.476	0.475	0.288	0.387	0.382
30	0.347	0.437	0.435	0.262	0.347	0.345
40	0.315	0.403	0.403	0.246	0.323	0.32
50	0.293	0.374	0.375	0.231	0.3	0.296
60	0.271	0.35	0.349	0.218	0.281	0.279
70	0.25	0.324	0.321	0.201	0.268	0.263
80	0.226	0.296	0.291	0.189	0.247	0.243
90	0.2	0.266	0.259	0.169	0.218	0.22
95	0.181	0.242	0.232	0.15	0.195	0.196
mean	0.313	0.395	0.395	0.24	0.33	0.328

River Ant at Honing Lock Flow duration curves for Select time periods



Summary of Notable Findings

- Since 1986 recorded rainfall at Barton Hall and in the area around North East Norfolk has shown a consistent increase relative to the 1951-1986 mean. Between 1987 – 2012 this increase has averaged 59mm per year and since 1998 the increase has averaged 97mm per year.
- The most significant increase in rainfall has occurred during the months of high summer (Jun-Aug). Since 1998 the increase in summer rainfall during these 3 months (62mm) has accounted for 64% of the observed annual increase.
- River flow records indicate that 55%of the observed increase in rainfall has been hydrologically effective resulting in a significant increase in annual runoff totals. Gauged run off has increased from 200mm per year to 253mm per year since 1998.
- The increase in direct precipitation over an area of 1.3km^2 would be equivalent to the following quantity of water.

  97mm per year = 126000m^3 (annual increase since 1998)

  59mmper year = 76700m^3 (annual increase since 1987)

  62mmper year = 80600m^3 (Jun-Aug) average increase since 1998.

  53mmper year = 68900m^3 increase in run off since 1998. Riparian recharge?

P.J.W. 31/12/2013