# Characteristics of the Northampton rainstorm, 9th April 1998.

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On Thursday 9th April and Good Friday 1998, sustained heavy rain fell over an area of the UK spanning south Wales and central England. The resulting flooding made national news, but more significantly, 4500 homes were inundated, five people lost their lives, and the cost of the damage was estimated to exceed £350 million (Bye and Horner, 1998a). Following the flood, it became apparent that whilst many areas close to water courses suffered some damage, four locations stood out due to the severity of the flooding (Table 1).

Table 1. Details of the locations most affected by the April 1998 floods (adapted from data in Bye and Horner, 1998a and 1998b).

| Location | River | Number of properties affected | Return period of flood |
|---|---|---|---|
| Northampton (Anglian region) | Nene | c2500 | c100 - 150 years |
| Leamington Spa (Midlands region) | Leam | c400 | >175 years |
| Kidlington (Thames region) | Cherwell | >90 | c100 years |
| Skenfrith | Monnow | 21 | 20 years |

(E.A. Wales)

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As table 1 shows, Northampton was particularly badly affected by the flood, with some properties still unoccupied 15 months after the event. This article intends to examine the precipitation at Northampton during April 1998, with particular reference to the rainstorm on April 9th.

**Location of Northampton and its susceptibility to flooding.**

Due to its location in the east Midlands, Northampton receives substantially less precipitation than western England or Wales, with a mean annual precipitation of only 630mm. The town of Northampton has developed on both sides of the River Nene, with significant development of the floodplain occurring within the last 140 years. The Nene catchment (Figure 1) drains eastwards from the upland area around Daventry, across to its outfall in the North Sea, via the Wash. The catchment area of the upper Nene is 1510km$^2$ (NRA, 1994) but despite the size of the upper catchment, the River Nene can only be reliably used for water supply during the winter months, due to low annual precipitation.

Despite the low annual precipitation, Northampton has a long history of flooding by the River Nene. The valleys in the upper reaches of the catchment tend to be narrow, and a large percentage of the catchment is underlain by Lias clay. The average fall on the entire length of the river is approximately 1m per kilometre, however, there is 91m of fall between Badby and Northampton occurring over only 27km. This means that two thirds of the total fall for the entire length of the River Nene takes place in the

27km of channel above Northampton (Dallas, 1943). The catchment topography and geology can therefore result in the rapid generation of runoff following heavy rain.

The likelihood of flooding occurring at Northampton is further increased by the narrowing of the floodplain, due to the construction of the Grand Union Canal in the early 19$^{th}$ century, and the building of both domestic and industrial properties on the floodplain over the last 150 years. In addition, the two branches of the River Nene meet at Northampton. Prior to the flooding in April 1998, the low lying parts of Northampton had escaped inundation since March 1947, when rain falling on a snow covered and frozen catchment led to some flooding. It is interesting to note that not all flooding in Northampton has been induced by prolonged rain falling in the winter or spring. At least two examples of flooding initiated by thunderstorms, July 1880 (Northampton Herald, 1880) and May 1663 (Brooks and Glasspoole, 1928), have been identified in the literature.

**Characteristics of precipitation at Northampton**

Annual average precipitation measured at Moulton Park, Northampton, amounts to 630mm (Table 2), with an almost uniform distribution in each month. A long term data set of Northampton precipitation is also available, analysis of which indicates that mean monthly precipitation (1880 to 1999) is almost 52mm. Over the last twenty years, 1992 stands out as the wettest year with almost 850mm (Table 2), however, no flooding was experienced at Northampton during that year.

Table 2: Annual Precipitation at Moulton Park, Northampton (1978-1997)

| Mean (mm) | Standard deviation | Minimum precipitation (mm) | Maximum precipitation (mm) |
|---|---|---|---|
| 629.9 | 95.8 | 444.2 (1990) | 859.4 (1992) |

Whilst it may be assumed that high rainfall during a month may cause flooding, this does not appear to be the case at Northampton (Table 3). Of the eight months with precipitation exceeding 157mm, only three can be definitely connected to flooding in the town. July, 1880 was especially wet, with a thunderstorm on the 15$^{th}$ producing rapid runoff from a catchment already saturated by a wet early summer.

Daily precipitation is currently only available for Moulton Park (1976 to the present day). The daily mean for 1978 to 1999 is only 1.7mm, although the highest daily precipitation recorded to date is 66.2mm which fell on 14$^{th}$ August 1980.

Table 3  Eight wettest months at Northampton and the occurrence of flooding

| Year | Month | Precipitation (mm) | Flooding? | Number of standard deviations from the mean |
|---|---|---|---|---|
| 1880 | 7 | 186.9 | Yes | 4.6 |
| 1980 | 7 | 185.2 | No | 4.5 |
| 1940 | 11 | 179.6 | No | 4.3 |
| 1912 | 8 | 171.7 | Unknown | 4.1 |
| 1939 | 10 | 165.6 | Yes | 3.9 |
| 1900 | 2 | 164.9 | Yes | 3.8 |
| 1998 | 4 | 164 | Yes | 3.8 |
| 1960 | 10 | 157.7 | No | 3.6 |

At Northampton, April is generally one of the drier months, however, during April 1998, a total of 164mm of precipitation was recorded (Figure 2), making it the wettest April since the station at Moulton Park was established in 1976.  In over 100 years, it appears that the rainfall total for April 1998 has not been exceeded when considering just April.  Prior to April 1998, the highest total was 130.5mm which fell in 1920.  Clearly this makes April 1998 unusually wet for Northampton, as well as being the seventh wettest month since records began in 1880, representing less than 1% of all the months.

**Precipitation on 9$^{th}$ April 1998**

In the months leading up to April, a rainfall deficit had started to develop.  January experienced fractionally more than the twenty year mean (+1mm).  During February only 4.6mm of precipitation were recorded, compared with the mean for the month of 45mm, thereby initiating the onset of a major precipitation deficit, which if sustained could have led to problems for water supply later in the year.  Fortunately, the deficit began to diminish during March, when rainfall was 10mm above the average (61.8mm, March 1998) .  Despite a wetter than average March, by the beginning of April there was still a cumulative precipitation shortfall of 30mm.  April effectively reversed this situation, in part by a single storm event on the 9th, but also due to the fact that over the entire month, only one day was recorded as receiving no rain.

Up to and including the rain day of the 8th, 37mm of rain had fallen at Moulton Park (see Figure 3).  This represented over 80% of the mean precipitation total for April, and would have led to the saturation of the soil.  Unfortunately, rainfall throughout most of the upper Nene catchment was similarly high (Figure 4), with comparable rainfall totals at Flore (30mm), Althorp Park (34mm), Pitsford Reservoir  (37mm) and Little Houghton (31mm).

By the 9th April, two parallel fronts straddled the UK with a west-east orientation. The fronts were associated with a depression centred over Brittany (Figure 5), which had formed near Iceland a few days earlier.  The most northern of the two fronts, was a cold front, moving south, whereas the southern front, an occlusion, was moving north.  Both fronts were slow moving.  Thunderstorms developed ahead of the occlusion which probably explains the occasional intensification (Figure 6) of the frontal rain that was falling in Northampton and across a band running through central England and southern Wales.  With the eventual collision and merger of the two fronts into a single  front, the rainfall became more sustained.  The result of this series of events was an additional 54mm of rain falling on Northampton, with almost 90% of this precipitation (48mm) falling during a thirteen hour period, between 0930 and 2230GMT (Figure 6).

Although most of the rain on April 9th fell between 0930 and 2230 GMT, there is considerable temporal variation in precipitation intensity. Due to the fifteen minute resolution of the recording gauge, it is impossible to determine the full extent of continuous rainfall. A total of 48mm of rain was recorded during the thirteen hours of the storm, of which more than half had fallen by 1430 GMT (27.8mm of storm total). The precipitation began as intermittent, moderate rainfall, before becoming continuous from 1030 onwards (Figure 6). The shift from intermittent to continuous rainfall coincided with a rapid intensification, culminating in the highest intensities recorded during the storm of 10.4mm/hr between 1130 and 1230GMT. However, greater intensities were recorded during two fifteen minute intervals, ending at 1115 and 1230 (see Figure 6), during which rain was falling at a rate of 12.0mm/hr. Following the heavy rainfall, intensity declined to 3.6mm/hr between 1230 and 1330. This was followed by a brief intensification to 5.8mm/hr, before subsiding once more and degenerating into intermittent, though still moderate intensity rainfall (according to the Meteorological Office (1982) standard classification), lasting until 1730. Between 1830 and 1930 there is a final intensification with rainfall increasing to 6.4mm/hr, after which the rainfall became intermittent, moderate to slight rainfall lasting until the end of the storm at 2330GMT.

Elsewhere, in the affected areas of England and Wales, higher precipitation values were recorded, for example at Pershore, south of Worcester, a total of 76.6mm of rain fell in 14 hours, averaging 5.5mm/hr (Bye and Horner, 1998a). Bedford, to the south east of Northampton, received 36mm over 12 hours, with a maximum rainfall of 6.4mm over a one hour period, which contrasts markedly with the 10.4mm that fell within an hour at Pershore (Bye and Horner, 1998a), and the 9mm recorded at Moulton Park, Northampton.

Northampton appears to have been on the edge of the area affected by the higher intensity rain fall, but even the highest intensities recorded during this storm at Moulton Park, are unremarkable when compared with maximum rainfall intensities for other storms around the country, for example, during July 1982, a maximum precipitation intensity of >250mm/hr was recorded at Birmingham (Kings *et al*., 1983). At Northampton the greatest proportion of the precipitation during the rain day was attributable to over eight hours of moderate rainfall with an intensity of up to 4mm per hour, and not due to a long duration of high intensity precipitation.

**Conclusion**

At Moulton Park, Northampton, the quantity of rain produced by the storm (54mm), was clearly unusual for April, and indeed came close to the highest daily fall recorded at Moulton Park in August 1980 (66mm). April, 1998 will be remembered for the flooding, which at Northampton was initiated by sustained rain falling on an already saturated catchment, resulting in estimated peak flows through the town in excess of 150m$^3$/s (Bye and Horner, 1998b). Whilst this may have been the first flood to affect Northampton in over 50 years, prior to the installation of more appropriate flood defences, flooding was a regular occurrence in the floodplain developments of Northampton.

**Acknowledgements**

The author would like to thank Tina Fairless and Paul Stroud at UCN, and the Environment Agency for their help and data.

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Fig. 1  Location of rain gauges around Northampton in the River Nene catchment.

Fig. 2  Precipitation totals at Moulton Park, Northampton, for April (1977-1998).

Fig. 3  Cumulative precipitation at Moulton Park during April 1998.

Fig.  4  Daily precipitation in the Upper Nene catchment, April 1998.

Fig.  5  Surface charts at 1200 and 2400 GMT, 9th April  (Based on Met. Office data).

Fig.  6  Rainfall intensities (mm/minute) between 0930 and 2330 GMT at Moulton Park.