

1. Introduction

- Winter 2015/2016 was defined by a procession of severe storms, bringing extreme rainfall, and widespread flooding.
- There were severe impacts on properties, infrastructure and livelihoods across northern Britain.
- This paper¹ describes the hydrological characteristics, impacts, and historical context of the event.
- Meteorological aspects and records are explored in companion papers^{2,3}.
- The full National Hydrological Monitoring Programme report on the winter 2015/2016 will be published by November 2016.

2. Rainfall

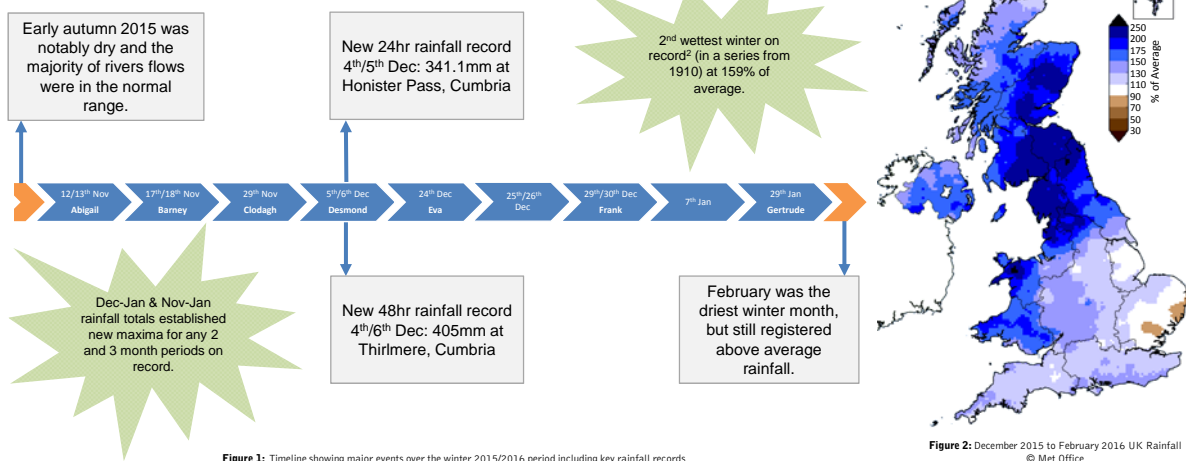


Figure 1: Timeline showing major events over the winter 2015/2016 period including key rainfall records

Figure 2: December 2015 to February 2016 UK Rainfall © Met Office

3. River Flows

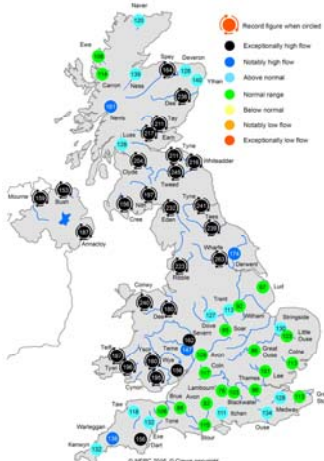


Figure 3: Average November 2015 to January 2016 river flows as % of long term average. New period of record maxima circled with arrows

- November to January mean flows (Fig. 3) show the widespread nature of peak flow maxima – with many catchments recording more than 200% of average.
- Great Britain outflows for winter 2015/2016 were the largest on record in a series from 1961 (Fig. 4).
- Highest recorded peak flow in the England & Wales instrumented record. The Eden, Lune & Tyne each recorded ~1700m³s⁻¹ on 5th/6th December (Fig. 5).
- Return periods over 1-in-200 years in many catchments across northern Britain (Table 1).

Table 1: Selected new peak flow records established December 2015, and their associated return periods

| River | Peak Flow (m ³ s ⁻¹) | Date | Return Period |
|--------------|---|----------------------|---------------|
| Scottish Dee | 1362.5 | 30 th Dec | >200 |
| Cree | 476.2 | 30 th Dec | 150-250 |
| Eden | 1680.0 | 6 th Dec | >200 |
| Tyne | 1730.0 | 5 th Dec | 100-200 |
| Lune | 1740.0 | 5 th Dec | 100-200 |
| Wharfe | 582.0 | 26 th Dec | >200 |
| Calder | 276.0 | 26 th Dec | >200 |

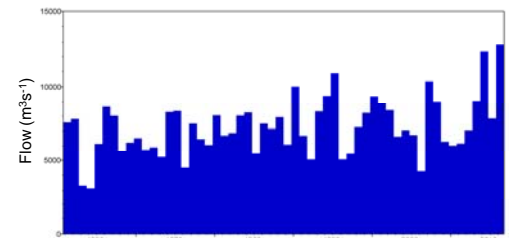


Figure 4: Average winter (December-February) outflows (m³s⁻¹) for Great Britain

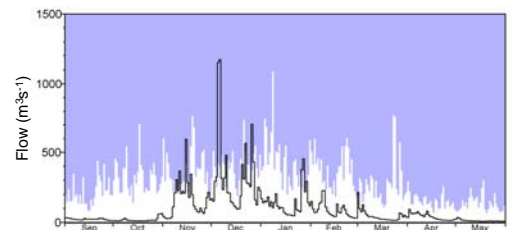


Figure 5: Daily mean river flows (m³s⁻¹) September 2015 to May 2016 – Eden at Sheepmount. Blue envelope shows previous daily maxima

4. Impacts

- **Flooding:** Widespread flooding across northern Britain, in rural areas as well as cities (e.g. Carlisle, Leeds, Manchester, York).
- **Property:** Approximately 16,000 properties flooded in England in December alone more than double that of winter 2013/2014 (7,000 properties flooded⁴).
- **Transport infrastructure:** Heavily affected with numerous roads, bridges, canals and sections of railway damaged and closed.
- **Business:** Nearly 5,000 affected businesses across Cumbria, Lancashire, Yorkshire, Greater Manchester & Northumberland.
- **Agriculture:** Extensive flood plain inundation, cattle swept downstream, 2,000 sheep were lost in Cumbria.
- **Cost:** At the time of writing, £200million additional investment pledged to aid recovery. Figures suggest pay-outs will be more than £1.3billion⁵.

5. Historical Context & Trends

- Events came only two years after winter 2013/2014 flooding, making these two winters the wettest on record for the UK (in records from 1910).

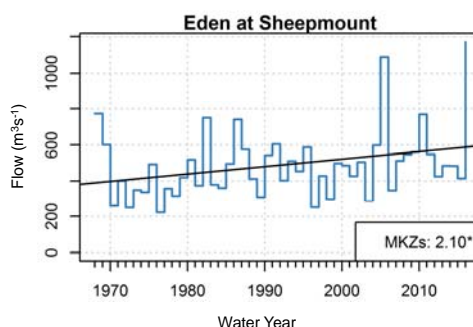


Figure 7: Trends in annual maximum daily flows. Trend line given by linear regression and evidence of monotonic trend by the non-parametric Mann-Kendall test.

- As well as further demonstrating the exceptional nature of winter 2015/2016, Fig. 7 shows a statistically significant increase in high flows on the Eden in Cumbria (since records began in 1967).

- Currently little compelling evidence for any upward trend in long instrumented records of flood magnitude or frequency⁶.

- A 'real time' attribution study published in December 2015, claimed that the Storm Desmond rainfall was made 40% more likely as a result of anthropogenic warming⁷.

6. Summary

- Winter 2015/2016 was an extreme hydrological episode in many ways; new peak flow maxima were established across northern Britain; November to January runoff was exceptional in terms of its magnitude, duration and spatial context.

- As with previous events there was intense media coverage, some of it highly politicised; a particular focus on land use management and natural flood protection.



Figure 6: L: An RAF Chinook airlifts supplies needed to repair the Foss Barrier on the River Foss in York © Environment Agency
R: Debris caught on metal fence at Ython at Eilon Gauging Station © Scottish Environment Protection Agency

