Frequency analysis of extreme rainfall in Cumbria 16–20 November 2009

APPENDIX

The fitting of the new DDF model requires estimates of *RMED*, the median annual maximum rainfall with an associated return period of 2 years, for a number of key durations to be available at every site of interest. Grids of *RMED* at a resolution of 1 km were established over the two catchments of interest for durations of 1, 2, 4, 6, 12, 18, 24, 48, 96 and 192 hours. These were for what are termed 'fully sliding' durations (i.e. annual maxima that would have been obtained from continuously recording raingauges, as opposed to annual maxima extracted from gauges recording at discrete hourly or daily intervals) and their computation included the preliminary step of multiplying the observed hourly or daily-based annual maxima by an appropriate discretisation conversion factor (see Table J.5 in Stewart *et al*. 2010a).

The first grid to be derived was for 24-hour duration ($RMED_{24h}$), using data from all available gauges, both hourly and daily. Using only gauges in the Cumbria area, the following regression equation was derived, relating $RMED_{24h}$ to 1961–1990 standard annual average rainfall (*SAAR*) in mm:

$$\ln(RMED_{24h}) = -2.656 + 0.9169 \times \ln(SAAR) \quad (1)$$

This relationship was based on 166 gauges and has a correlation coefficient of 0.969. Equation (1) was applied at all locations on a 1 km grid covering Cumbria to produce an initial $RMED_{24h}$ grid. A correction grid was derived by interpolating the factorial residuals ($RMED_{24h}$ from observations/$RMED_{24h}$ from Equation (1) at all gauges, using the ArcGIS implementation of inverse distance weighting interpolation. The final $RMED_{24h}$ grid was produced by multiplying the initial grid by the correction grid.

Table A1 | Regression coefficients for the *RMED* ratio in Equation (2)

Duration (h)	*a*	*b*
1	2.103	–0.4836
2	0.9918	–0.2820
4	0.1991	–0.1262
6	–0.1635	–0.05062
12	–0.2005	–0.003355
18	–0.08146	0.0
48	–0.2700	0.06800
96	–0.2392	0.1005
192	–0.2581	0.1509

RMED grids for other durations (for *nn* hours) were derived by working in terms of the ratio of $RMED_{nnh}$ to $RMED_{24h}$ at each gauge. Hourly gauges were used for durations below 24 hours and daily gauges for durations above. A regression equation for the Cumbria area was established for each duration:

$$\ln(RMED_{nnh}/RMED_{24h}) = a + b \times \ln(SAAR) \quad (2)$$

where the values of the coefficients *a* and *b* are as shown in Table A1.

Regarding the $RMED_{24h}$ grid, grids of the ratio for each duration were established as the product of a regression equation grid and a correction grid. Finally, each of these grids was multiplied by the $RMED_{24h}$ grid to obtain the *RMED* grid for each duration.

REFERENCE

Stewart, E. J., Jones, D. A., Svensson, C., Morris, D. G., Dempsey, P., Dent, J. E., Collier, C. G. & Anderson, C. W. 2010a Reservoir Safety – Long return period rainfall (two volumes). R&D Technical Report WS 194/2/39/TR, Joint Defra/EA Flood and Coastal Erosion Risk Management R&D Programme.