Chapter 5
Study area; background, description and model application

5.1 Choice of field area

The catchment of Cam Gill Beck, above Starbotton, Upper Wharfedale, Yorkshire UK, was selected for three reasons. Firstly, the Yorkshire dales are representative of much of the UK's uplands, with relief, morphology and vegetation that are largely typical. Secondly, there are many well documented investigations of the hydrological and sedimentological history of the Yorkshire Dales (Coulthard *et al*;. 1996, 1998, 1999, Longfield; 1999, Merett and Macklin; 1998a , 1998b, 1999, Taylor and Macklin; 1998, Howard and Macklin; 1998, Howard *et al;* 1998, Black *et al.;* 1998, Martlew; 1998, White; 1998). Therefore, the Yorkshire Dales arguably now have the most comprehensive Holocene record of upland, piedmont and lowland fluvial activity in the UK. Finally, within this region Cam Gill Beck itself is ideal for numerical modelling, as it is a small catchment with a simple network morphology. This is important as it allows a rapid development and validation of the model. The catchment contains flood deposits dated to an extreme event in 1686, which appear relatively undisturbed, allowing easy validation as there has been limited re-working or subsequent deposition. Furthermore, the catchment is accessible, lies on private ground and remains relatively undisturbed, especially from recent land use practices such as gripping (moorland drainage).

5.2 Geology, physiography and history of the Yorkshire Dales

The Yorkshire Dales are located in central northern England, north west of Leeds between the Peak District and Northern Pennines (Figure 5.1). They encompass a range of landscapes, with bleak peat-covered moorland plateaus, deeply entrenched glacial valleys, ancient settlements and steep limestone outcrops that contain some of the finest examples of karst landscape in the UK (Howard and Macklin 1998).
The pre-Quaternary geology of the Yorkshire dales (Figure 5.2) is dominated by the Carboniferous unit of the Askrig block formed of Great Scar Limestone. This is sharply cut to the south near Malham by the Craven fault system and to the west by the Dent fault. There is considerable exposure of the Great Scar Limestone in the

outcrops of Kilnsey and of upper Wharfedale. Overlying this are a series of limestones, sandstones and shales of the Yoredale series, topped by coarse sandstones of the Millstone Grit series. The strong horizontal bedding and differential erosion of these layers by glacial and fluvial action has led to a characteristic bench and plateau landscape (Howard and Macklin, 1998).

During the Pleistocene, the Yorkshire Dales have been glaciated on several occasions (Figure 5.3), which has led to the formation of spectacular glacial valleys such as upper Wharfedale (Figure 5.4). During the last glacial period, it is likely that ice covered the whole region, with the peaks appearing as nunatuks during the glacial retreat (Raistrick, 1931). There is evidence of a local ice cap or centre above Langstrothdale and at the top of Wharfedale, which fed the main valley glaciers flowing eastwards down Wharfedale, Wensleydale, and Swaledale into the Vale of York. Melt-water drainage created dry valleys whose formation was aided by permafrost restricting subsurface karst drainage. Deposition of moraines in the valley floors is thought to have led to the development of post glacial lakes within the valley floors of Wharfedale (near Kettlewell) and Wensleydale (Raistrick, 1927). Glacial erosion has left large volumes of till which represent important sediment sources for present day alluvial systems.

As described in chapter 2.2.1, there is evidence of human influence from 5000 BP to present, with a steady deforestation of first the valley floors and later the uplands. Aside from tree clearance and agriculture, the greatest impact on the landscape of the Yorkshire dales has been mining, principally for lead (Raistrick and Jennings, 1965). There has been evidence of mining during the Roman occupation, but in Wharfedale, there was a massive expansion in the 17th and 18th century. In some areas the practice of hydraulic mining using flash floods released from dams, termed ‘hushing’, has had a significant and direct impact upon the fluvial system and valley floor (Raistrick and Jennings, 1965).

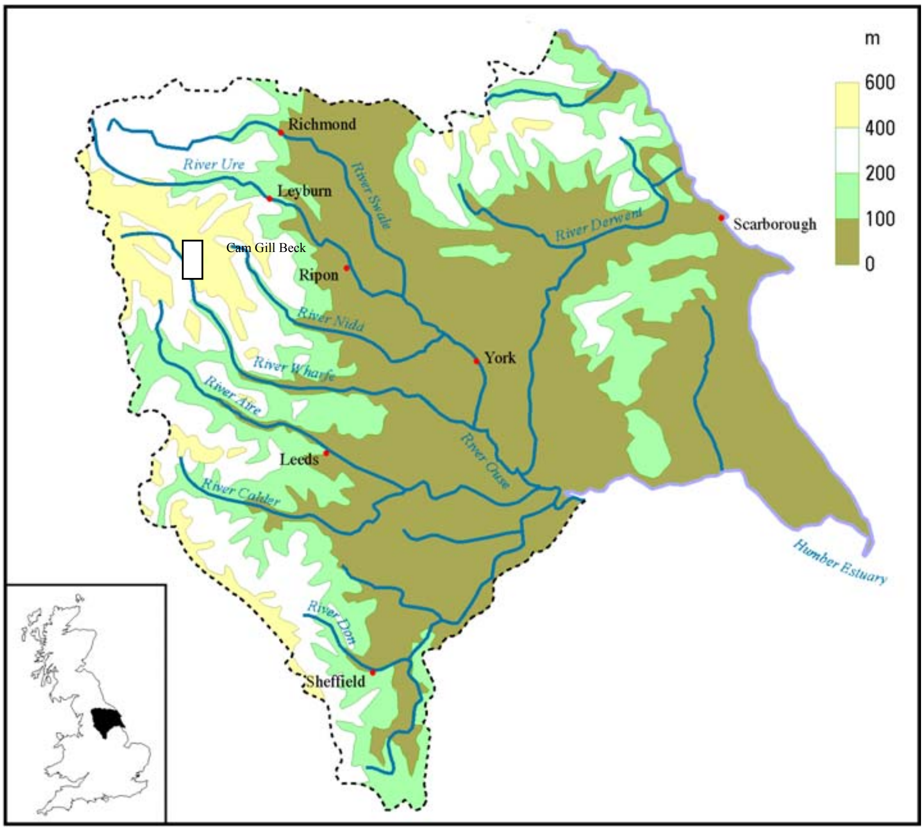


Figure 5.1. Relief of Yorkshire Ouse catchment (scale as below).

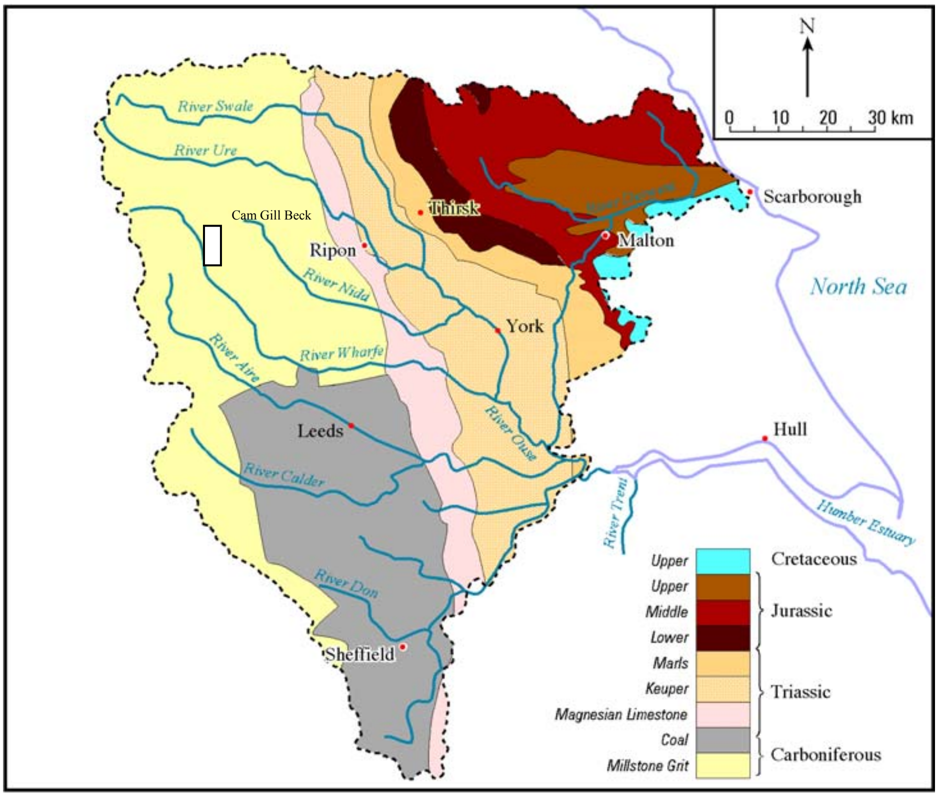


Figure 5.2. Geology of Yorkshire Ouse catchment.

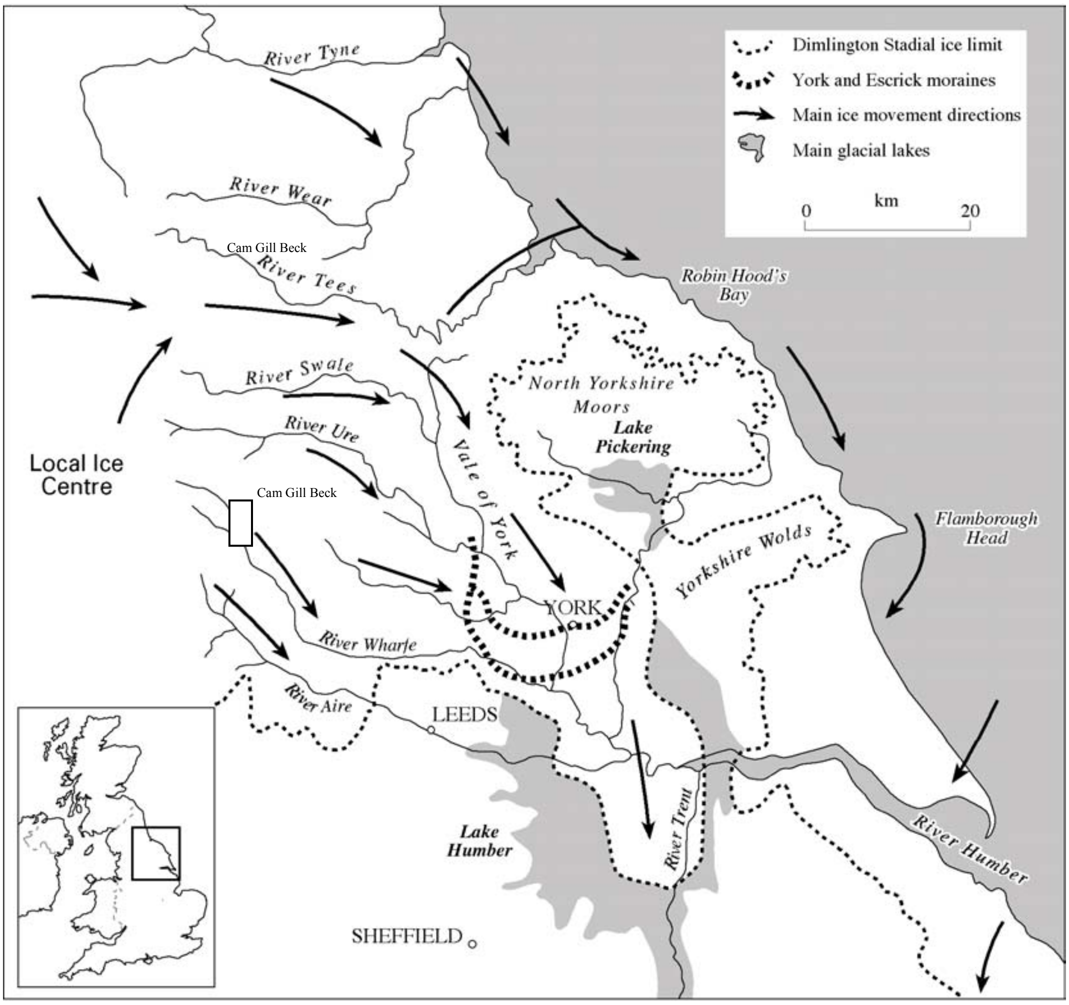


Figure 5.3. Quaternary glaciation of the Yorkshire Dales.

Figure 5.4. Upper Wharfedale, showing the wide glacially formed valley floor.

5.3 Cam Gill Beck, Starbotton

5.3.1 Description

Cam Gill Beck has a catchment area of 4.5km^2 and is situated above the village of Starbotton (Figure 5.5). It is a tributary of the River Wharfe, situated between the villages of Kettlewell and Buckden. The catchment is steep, rising from 210m at Starbotton to 700m at Buckden Pike (SE 961788) over 2.5km and is typical of many upland streams in the Yorkshire Dales. The catchment geology comprises Lower Carboniferous Limestone (Raistrick and Illingworth 1949, Rayner 1953) overlain by sandstones of the Yoredale Series, above 500 m O.D. The beck is incised into bedrock with short waterfall sections, although tracts of gravel and boulders are present where the valley floor widens to allow deposition. The limestone valley walls are covered with a thin veneer of soil and are currently used as rough pasture. The hydrology is influenced by the karst morphology with a series of shake and sink holes littering the catchment, particularly around the 500m contour. In summer, the upper sections run dry, and in wet conditions many springs emerge.

Figure 5.5. View of Cam Gill Beck and the village of Starbotton.

5.3.2 Human history at Cam Gill Beck

There is little or no evidence of when Starbotton was first inhabited with the oldest houses in the village dating from 1636. However, nearby lynchets and building platforms (Martlew, 1998) and an unearthed skeleton, dated 3000 to 4000 years old indicate man was active in the area long before this. There is therefore a strong chance that the catchment has been largely deforested since before Roman times, and has probably been used as rough grazing land (Howard pers comm.). Mining has been carried out since 16th century in Upper Wharfedale with evidence of early bell pits, mines and crushing mills. In Starbotton, records show extensive mining began in the 18th century with a line of mines around the 550m contour (Raistrick and Jennings, 1965). A smelter was built next to Cam Gill beck at SE 955750 and was in operation until the 1900s. Unlike other catchments such as Gunnerside in Swaledale (Raistrick and Jennings, 1965), there is very little direct impact on the channel from mining and no evidence of hushing.

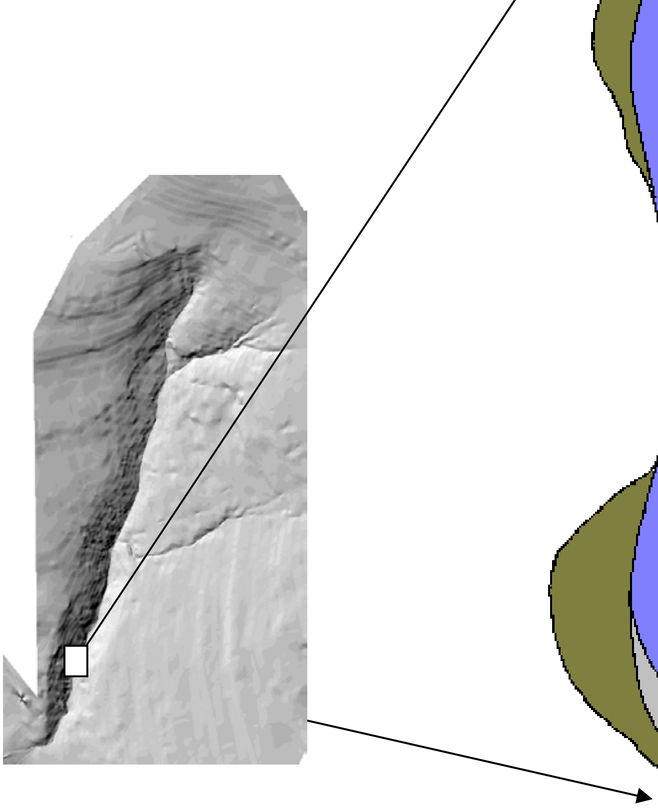
5.3.3 Flood history

Cam Gill Beck has a documentary record of one large flood event. This caused great destruction of sufficient magnitude to be mentioned in parliamentary records. One account reads how:

'1686, 18th Feb. *The whole of England was visited by a tempest, accompanied with thunder, which committed general devastation. The inhabitants of Kettlewell and Starbottom, in Craven, were almost all drowned in a violent flood. These villages are situate under a great hill, whence the rain descended with such violence for an hour and half, that the hill on one side opened, and casting up water into the air to the height of an ordinary church steeple, demolished several houses, and carried away the stones entirely*.' (Mayhall, 1860).

Several large berm deposits bear testament to this flood, the largest of which is described on the field map, Figure 5.6. By dating lichens found on boulders upon this deposit it was formed c. 1700 AD (Merrett pers. comm.). Where this unit has been disected by channel incision a 3m deep section is revealed (Figure 5.6) containing poorly sorted material up to 0.5m in diameter (Figure 5.7).

Figure5 6. Plan view of Cam Gill Beck, detailing the surveyed main flood deposit



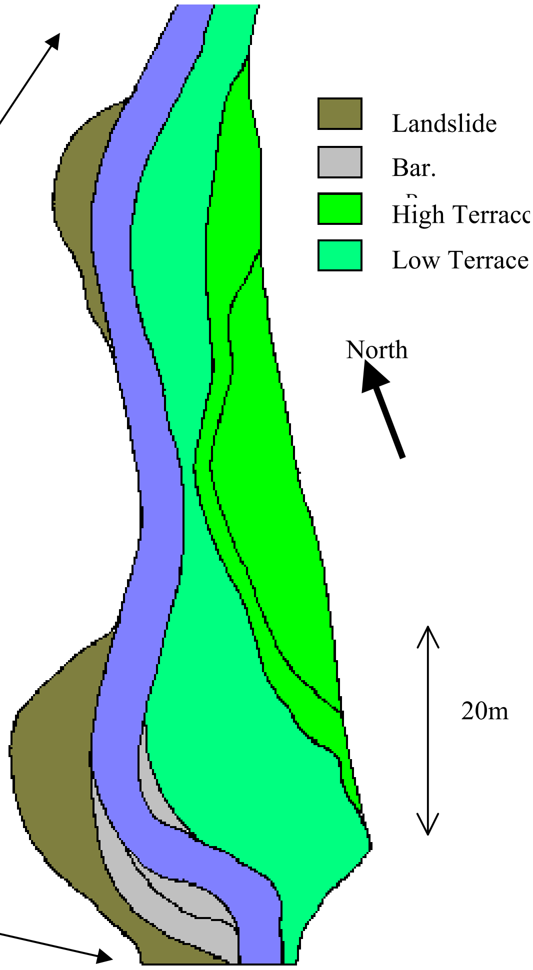


Figure 5.7

Photograph of section of flood deposit exposed by incision. Here the deposit is 1.8m deep and lying on top of boulder clay. Note the large boulder, c.0.5m diameter

5.4 Application of the model to Cam Gill beck

The main data requirement for the model is a high resolution DEM. For Cam Gill Beck, this was created from digitised contour data from a 1:10000 scale OS map. Additional data of channel location and spot heights along with valley floor were collected using EDM field survey, and referenced to the contour data from ground bench marks. This contour and additional EDM data were then used to created a DEM with the procedure outlined in section 4.3.1. This initial DEM was created at a 1m resolution and for studies at a coarser scale was re-sampled using the ARC-INFO GRIDRESAMPLE command. This created the DEM illustrated in Figure 5.8.

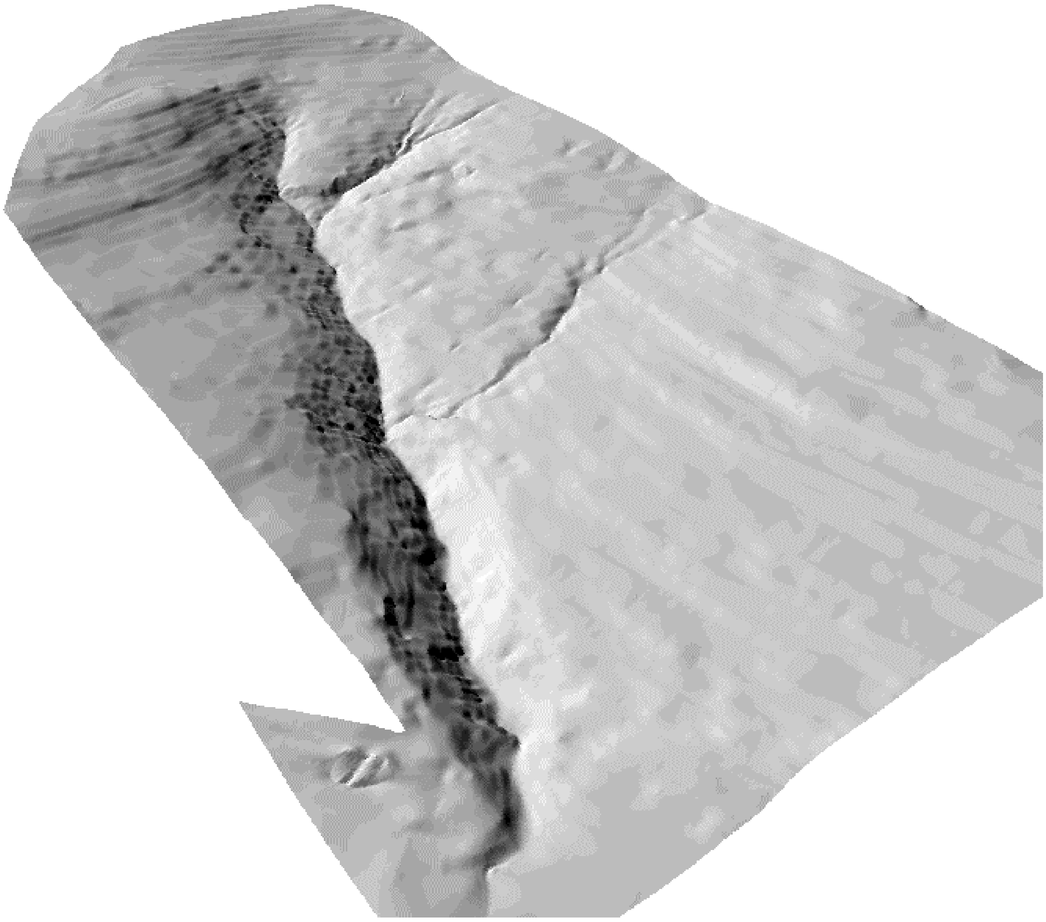


Figure 5.8. DEM of Cam Gill Beck. Scale 2800 by 1400m.

Additional grainsize and rainfall data were required to drive the model. Grainsize for the initial conditions was calculated from five samples from river bank, slope and the valley floor at different locations within the catchment. These were dried, sorted sieved into whole phi classes from 0.004 to 1.028m and the average distribution calculated (Figure 5.9). Mannings *n* was set as 0.03 for a natural gravel channel (Richards 1982).

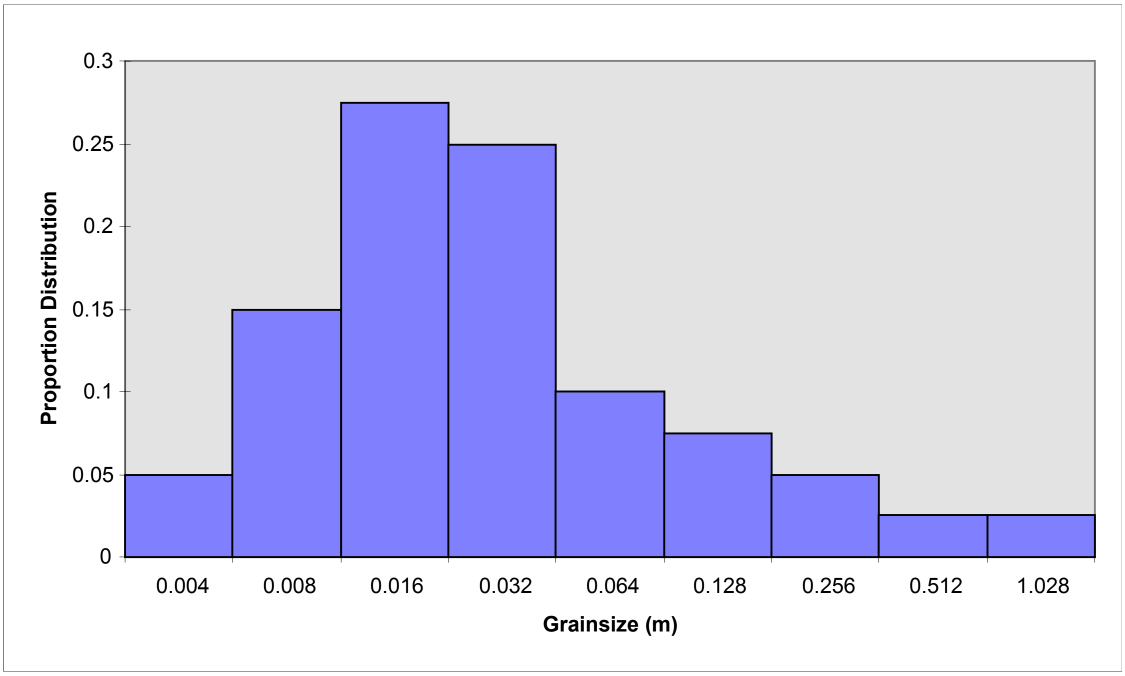


Figure 5.9. Average grainsize distribution for Cam Gill Beck.

A ten year rainfall data set (1985 to 1995) from Church Fenton (SE 515370 Alt. 15m) was used to drive the model (Figure 5.10). However, Cam Gill Beck is several hundred meters higher and will receive much higher rainfall. A rain-gauge was installed in Coverdale (situated beyond the northern interfluve SE 014 782, Alt 240m) and these data was used to adjust the Church Fenton rain data. Ideally an upland data set would be advantageous, but none were readily available. Figure 5.11 shows a comparison of the hourly intensity distribution for Coverdale, Church Fenton and Church Fenton multiplied by 2. This shows how a multiplication factor of 1.5 would probably represents contemporary conditions in Cam Gill Beck. The Coverdale data set could have been used, but it was thought that the frequency and timing of a ten year data set would be more representative than a one year record. Therefore the Coverdale data was used to calibrate the Church Fenton record.

This provided the data to drive the simulations detailed in chapters 6 to 9. However, some of these required modifications of the boundary conditions and initial data. Where this has occurred, details are provided in the method section of the appropriate chapter.

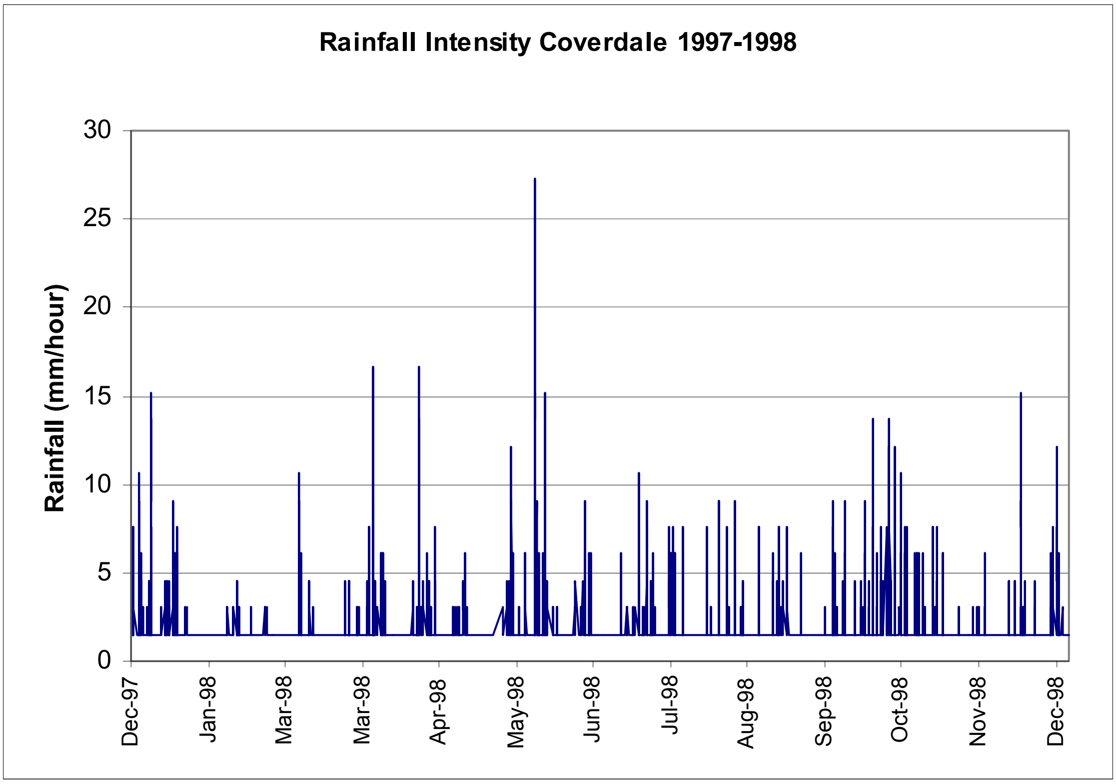


Figure 5.10. Rainfall intensity, Coverdale, 1/1/1997 to 31/12/1998.

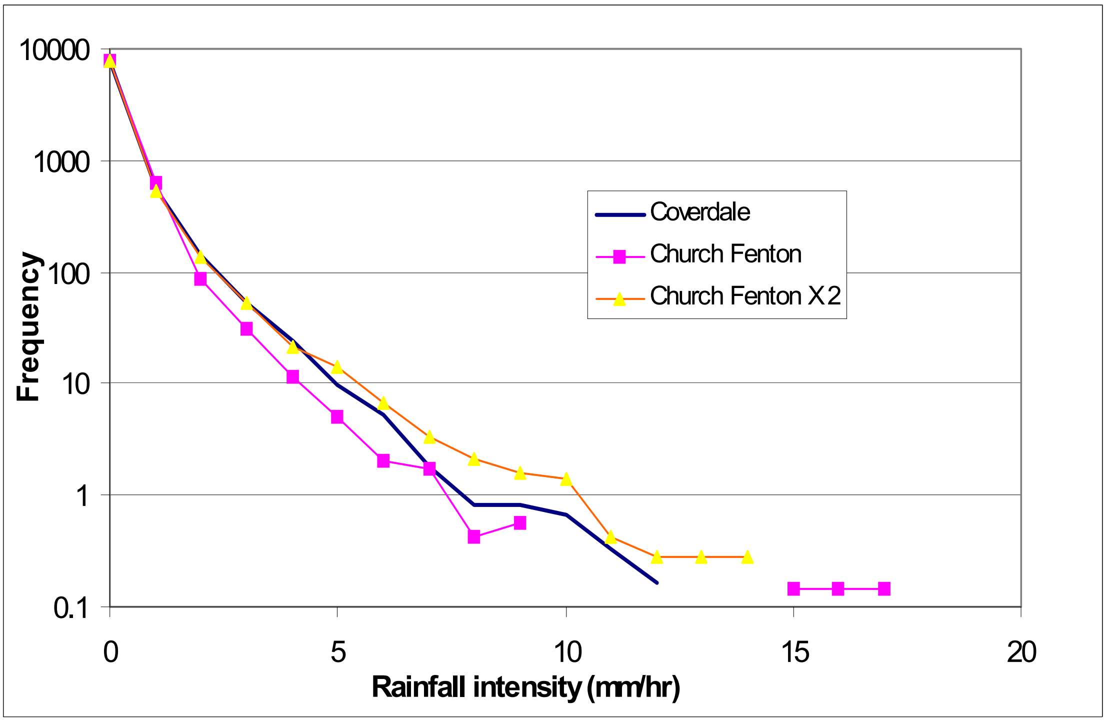


Figure 5.11. Frequency distribution of hourly rainfall intensity for Coverdale and Church Fenton.