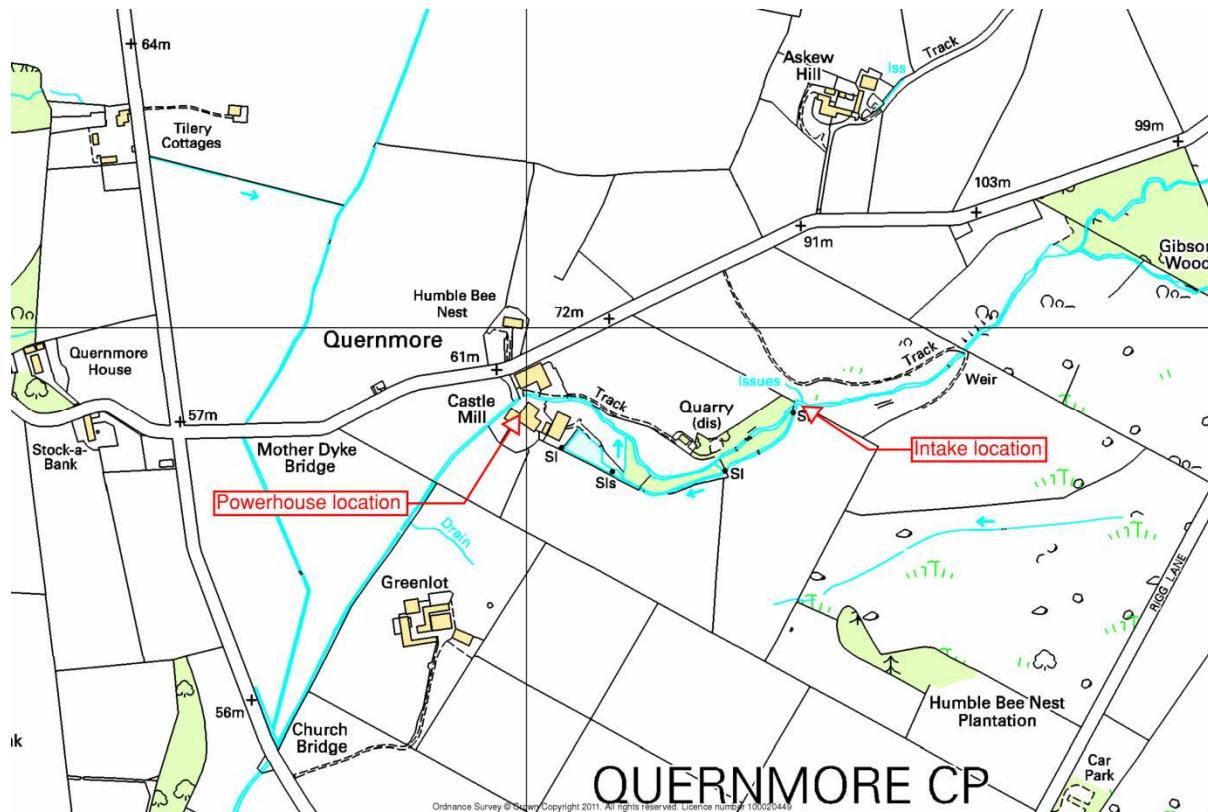


# Site I8: Castle Mill Farm, Quernmore

## Site Assessment

Figure 1 Map showing general layout



Castle Mill predates 1786 as a flour mill and then a corn mill. The present mill was built in 1818. It has an overshot external waterwheel, 11 metres in diameter and one metre wide, and was fed via a wooden trough. The wheel is of metal construction (arms and tie bars) but with wooden buckets, and has a rim drive. Water is taken from the River Conder by a weir, 460 metres upstream, which feeds a mill pond to the east. The mill is a three storey stone building with a drying kiln at the rear, and an adjacent miller's house, now a farm. The mill was operational until 1951 and the machinery remains in situ. The 34ft high water wheel with cogs and wheels leads into the building containing two querns (millstones), hoppers and wooden cog wheels. The mill was in working order in 1940. The wooden aqueduct and stone pillars for support are not in a good state of repair. The mill is a Grade II listed building.

The potential hydro scheme for this site involves refurbishment of the millwheel and repair and rebuilding of parts of the mill race. It is recommended that the advice of a millwright specialist is sought for accurate costs for mill wheel refurbishment or replacement and the likely energy outputs.



Figure 2 The waterwheel, showing the rim



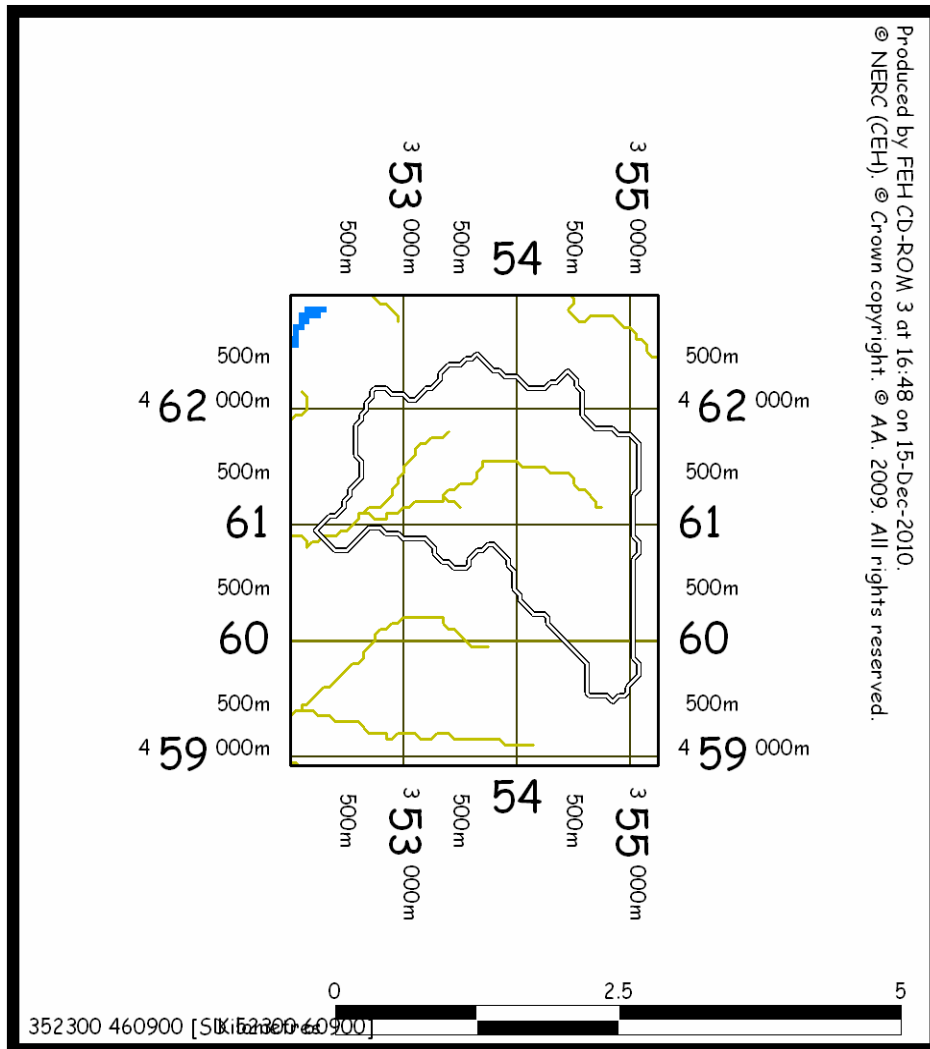
Figure 3 The waterwheel



Figure 4 The stone columns supporting the  
wooden lade, or launder

## Catchment Analysis

Figure 5 Catchment boundary defined by Flood Estimation Handbook Software



The Flood Estimation Handbook software is used to determine the following catchment descriptors, for the proposed intake location, selected during the site visit.

|                           |                     |
|---------------------------|---------------------|
| Intake Grid Reference     | 352330, 460910      |
| Powerhouse Grid Reference | 352050, 460880      |
| Catchment Area            | 4.4 km <sup>2</sup> |
| Annual Rainfall           | 1295 mm             |

## Annual Flow Statistics

Low Flows software is used to produce a Flow Duration Curve (FDC), which demonstrates how the river flow varies throughout the year. It presents the percentage time of the year each flow rate is exceeded. A particular notation is used to refer to FDC flow rates; e.g. 'Q<sub>95</sub>' refers to the flow rate which is exceeded for 95% of the year.

Table 1 Mean flow rate and flow rate at Q<sub>95</sub>

| Period    | Mean Flow Rate [m <sup>3</sup> /s] | Flow Rate at Q <sub>95</sub> [m <sup>3</sup> /s] |
|-----------|------------------------------------|--|
| Annual    | 0.114                              | 0.0189   |
| January   | 0.193                              | 0.0438   |
| February  | 0.160                              | 0.0430   |
| March     | 0.153                              | 0.0399   |
| April     | 0.102                              | 0.0299   |
| May       | 0.0754                             | 0.0241   |
| June      | 0.0528                             | 0.0170   |
| July      | 0.0525                             | 0.0161   |
| August    | 0.0610                             | 0.0135   |
| September | 0.0686                             | 0.0134   |
| October   | 0.116                              | 0.0190   |
| November  | 0.156                              | 0.0280   |
| December  | 0.180                              | 0.0423   |

Table 2 Annual flow duration data

| Exceedance Probability | Flow Rate [m <sup>3</sup> /s] |
|------------------------|-------------------------------|
| 5                      | 5.000                         |
| 10                     | 10.00                         |
| 20                     | 20.00                         |
| 30                     | 30.00                         |
| 40                     | 40.00                         |
| 50                     | 50.00                         |
| 60                     | 60.00                         |
| 70                     | 70.00                         |
| 80                     | 80.00                         |
| 90                     | 90.00                         |
| 95                     | 95.00                         |
| 99                     | 99.00                         |

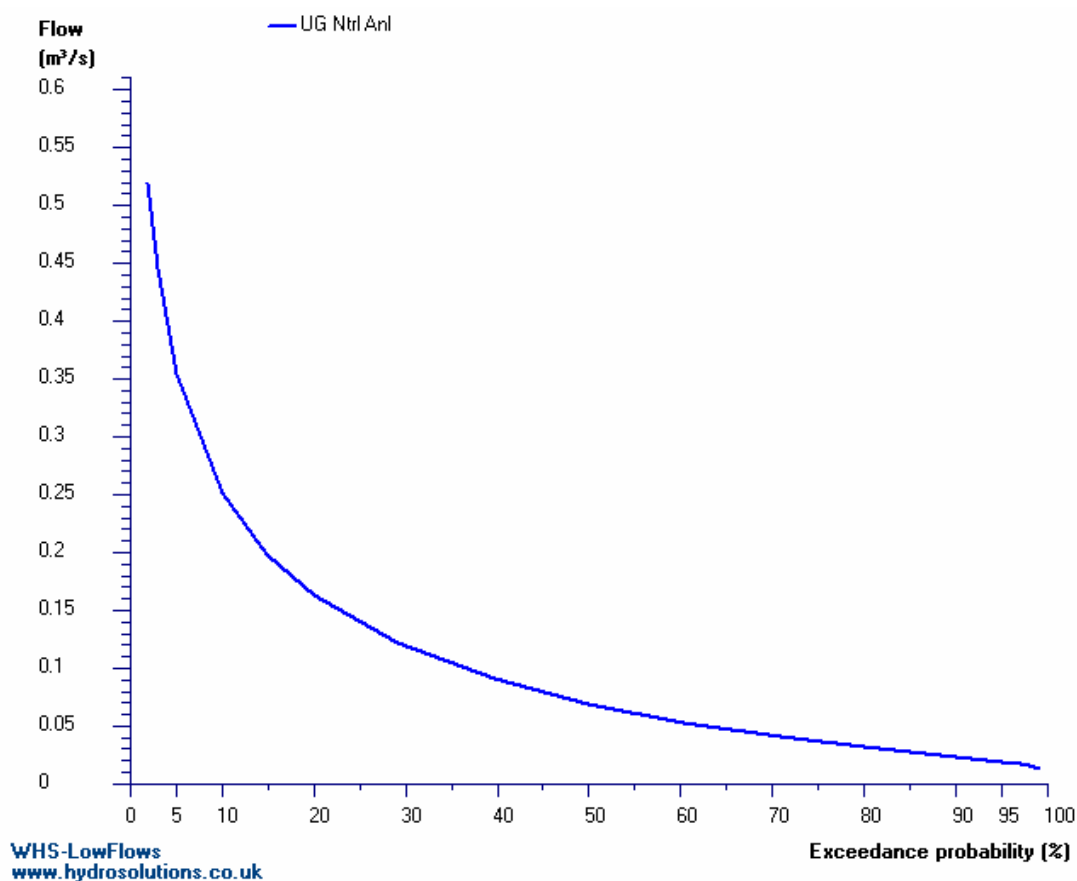


Figure 6 Annual flow duration curve produced using low flows software

## Hydropower Analysis

The power output of this scheme is fairly low, but would make a significant contribution to the energy needs of aspects of the farm. It is recommended that a millwright specialist is consulted for advice on power and energy predictions. If an alternative machine were employed, the maximum power achievable is 10 kW. The power and energy from a waterwheel is likely to be less than this.

| <b>Site:</b> Castle Hill Farm                         |                             |                            |   |                |                          |
|---|-----------------------------|----------------------------|---|----------------|--------------------------|
| <b>Run Date / Time:</b> 15 December 2010 at 17:00     |                             |                            |   |                |                          |
| <b>Mean Flow:</b> 0.13 m <sup>3</sup> /s              |                             |                            | <b>Rated Flow:</b> 0.13 m <sup>3</sup> /s |                |                          |
| <b>Provisional Rated Flow:</b> 0.15 m <sup>3</sup> /s |                             |                            | <b>Gross Hydraulic Head:</b> 11.00 m      |                |                          |
| <b>Residual Flow:</b> 0.023 m <sup>3</sup> /s         |                             |                            | <b>Nett Hydraulic Head:</b> 10.45 m       |                |                          |
| Applicable Turbines                                   | Gross Annual Average Output | Nett Annual Average Output | Maximum Power Output                      | Rated Capacity | Minimum Operational Flow |
| Propellor   | 32.9                        | 32.6                       | 11.4                                      | 10.9           | 0.11                     |
| Crossflow   | 43.6                        | 43.2                       | 10.4                                      | 9.7            | 0.042                    |
|   | <b>MWh</b>                  | <b>MWh</b>                 | <b>kW</b>                                 | <b>kW</b>      | <b>m<sup>3</sup>/s</b>   |

Table 3 Hydropower Analysis for propellor and crossflow turbines

|                                      |                        |
|--------------------------------------|------------------------|
| Gross Head [m]                       | 11                     |
| Net Head [m]                         | 11                     |
| Design Flow [m <sup>3</sup> /s]      | 0.13 m <sup>3</sup> /s |
| Rated Capacity [kW]                  | 5-10 kW                |
| Average Annual Energy Output [MWh]   | <30MWh                 |
| Average annual Carbon Dioxide offset | <16 tonnes             |

## Impact Assessment

Quernmore is within the Forest of Bowland Area of Outstanding Natural Beauty and has been assessed as having a landscape character assessment type of Undulating Lowland Farmland.

The weir and mill race already exist, and this type of development is unlikely to have a negative visual impact.

The mill building is Grade II listed, and any conservation of the mill wheel and associated infrastructure would need to be carried out sensitively.

## Statutory Requirements

It will be necessary to apply to the Environment Agency for an abstraction license, and get advice on whether planning permission is required to rebuild the elevated wooden lade.

The mill is a Grade II listed building and alterations to the building would require listed building consent. An ecologist will be able to advise on whether any environmental assessment is required.

## Budget Development Cost

The total budget cost for the whole scheme is **£270,700**. It should be noted that the civil works costs can vary considerably as material costs fluctuate. Likewise, mechanical and electrical (M&E) equipment costs vary in accordance with demand. Professional fees should be considered subject to change, as the scope of licensing and planning requirements are not yet defined. Consequently the budget estimate at this stage should be considered accurate to plus or minus 20%.

## Revenue and Simple Payback period

It is thought that the most suitable use for the energy produced by a waterwheel at this site would be on the farm, and because there would be little excess, a grid connection is not economic.

Under the current government feed-in tariff regulations, hydropower schemes receive a generation tariff according to their rated capacity. Schemes less than 15kW receive 19.9p/kWh. This generation tariff is received regardless of how the electricity is used. The owner has indicated that the electricity would be used on site, thereby offsetting import costs. This increases the value of the generated electricity by the import tariff, which we have assumed is 5p/kWh.

In conclusion, the total value of the generated electricity would be 24.9p/kWh, giving an average annual value of approximately **£6870**. The simple payback period for this scheme is 40 years.

## Conclusion

The refurbishment of this scheme has obvious conversation benefits, but it unlikely to be economic. The owners are interested in principle, but the pay back time would suggest development is unfeasible, unless construction can be done very cheaply. It should be noted that grant-funded development may render the scheme ineligible for the Feed in Tariff.

## Further Information

This site report is produced by Inter Hydro Technology on behalf of Forest of Bowland AONB, and funded by a partnership including Lancashire County Council, Lancaster & District Local Strategic Partnership, Pendle Borough Council and Ribble Valley Local Strategic Partnership.

This site report should be read in conjunction with the rest of the Forest of Bowland AONB Hydro Feasibility Study which can be downloaded at

<http://www.forestofbowland.com/climatechange#hydro>

Table 4 Development Budget Cost

**Budget Scheme Cost Estimate**

**Castle Mill Farm, Quernmore**

|                          | ITEM                            | UNIT           | QUANTITY | MIN         | MAX         |
|--------------------------|---------------------------------|----------------|----------|-------------|-------------|
| <b>Turbine</b>           |                                 |                |          |             |             |
|                          | Turbine Quotation               | No             | 1        | £50,000.00  | £62,500.00  |
| <b>Grid Connection</b>   |                                 |                |          |             |             |
|                          | Grid Connection                 | No             | 1        | £5,000.00   | £6,250.00   |
| <b>Civils</b>            |                                 |                |          |             |             |
|                          | Weir                            | m <sup>3</sup> | 20       | £10,000.00  | £12,500.00  |
|                          | Fish Pass                       | m <sup>3</sup> | 2        | £1,000.00   | £1,250.00   |
|                          | Weir Screen Length              | m              | 3        | £6,000.00   | £7,500.00   |
|                          | Fish Pass Length                | m              | 2        | £4,000.00   | £5,000.00   |
|                          | Mill Race                       | m              |          |             |             |
|                          | Aqueduct                        | m              | 100      | £11,000.00  | £13,750.00  |
|                          | Gravels                         | m              | 50       | £2,000.00   | £2,500.00   |
|                          | Soft                            | m              | 350      | £19,250.00  | £24,062.50  |
|                          | Pipe Materials                  | No             | 1        | £0.00       | £0.00       |
|                          | Temporary Access                | m              |          |             |             |
|                          | Rock                            | m              | 0        | £0.00       | £0.00       |
|                          | Gravels                         | m              | 0        | £0.00       | £0.00       |
|                          | Soft                            | m              | 0        | £0.00       | £0.00       |
|                          | Temporary Access on Good Ground | m              | 500      | £20,000.00  | £25,000.00  |
| <b>Powerhouse</b>        |                                 |                |          |             |             |
|                          | Powerhouse                      | kW             | 5        | £15,000.00  | £18,750.00  |
| <b>Prelims</b>           |                                 |                |          |             |             |
|                          | Duration                        | Months         | 9        | £27,000.00  | £33,750.00  |
| <b>Sub Total</b>         |                                 |                |          |             |             |
|                          | Sub Total                       |                |          | £170,250.00 | £212,812.50 |
| <b>Professional Fees</b> |                                 |                |          |             |             |
|                          | Professional Fees               |                |          | £25,537.50  | £42,562.50  |
| <b>Sub Total</b>         |                                 |                |          |             |             |
|                          | Sub Total                       |                |          | £195,787.50 | £255,375.00 |
| <b>Contingency</b>       |                                 |                |          |             |             |
|                          | Contingency                     |                |          | £39,157.50  | £51,075.00  |
| <b>GRAND TOTAL</b>       |                                 |                |          | £234,945.00 | £306,450.00 |