Proposed mitigation of extraction effects: generation of a mist spray to compensate for reduced waterfall splashing in very dry conditions.

Introduction

The Abstraction Licence only permits the abstraction of water for hydro-electric power (HEP) when the stream is flowing at over 4 litres/second, this being the Q95 (95th centile) point in the hydrology prediction. The stream is expected to be lower than this for 5% of the year.

The HEP abstraction is limited to $\frac{7}{10}$ of the flow above this "Hands-Off Flow" i.e. when the stream flow is $4\frac{3}{7} \approx 4.43$ litres/second I will be allowed to extract $\frac{3}{7} \times \frac{7}{10} = 0.3$ litres/sec for HEP (values to be explained later).

The flow duration curves suggest that this condition will be met 99.4% of the time in the winter months (October-March) and 87.9% of the time in Summer (April-September).

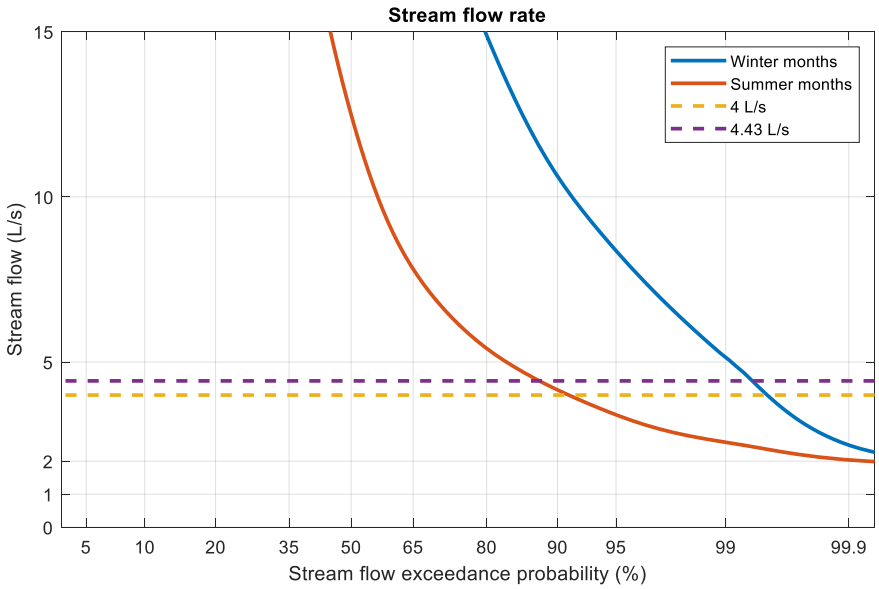

Figure 1. Predicted flow duration curves for Afon y Foel. The micro-hydro system will only be useful at times when it can take at least 0.3 litre/sec: this is permitted when the stream flow exceeds 4..43 L/s.

With the current system design, 0.3 litre/second is the minimum extraction rate that can provide a basic level of power in the cottage (see *Justification for extraction rates beyond Q95* spreadsheet).

This would power the UV water sterilizer and an A*-rated refrigerator continuously plus a daily ration of 5 hours broadband & phone, 4 hours TV and 3 hours "full" lighting (or pro-rata with fewer lights).

The 6.3% of the year when this will not be possible (23 days, almost all in Summer) are a serious nuisance given that Hafod y Rhedwydd is completely off-grid. Without a steady electricity supply we

cannot run the UV sterilizer to treat the domestic water supply and even turning lights on will require guests to start the petrol generator.

Reasons for the Q95 Hands-Off limit

The Q95 “hands-off” limit is common for hydro-power schemes and is imposed to protect the plants and wildlife along the depleted reach from even the slightest drop in stream flow under very dry conditions.

Most hydro-electric systems and grid-connected and do not rely on the turbine for their personal electricity supply. For grid-connected systems the Q95 limit is no drawback; at these low flows the efficiency with a single-turbine system is so low that little or no useful power can be produced for sale to the grid. (Hafod y Rhedwydd will have a second, small alternator for better efficiency at low flow conditions).

Regarding Afon y Foel, the site has both SSSI and SAC status. One concern is that the gorges naturally maintain a humid environment that supports a valuable population of bryophytes (mosses and liverworts). The humidity is maintained by evaporation from the stream banks, as moisture runs down into the stream, and by splashing from the many waterfalls along the gorge.

In prolonged dry conditions the ground naturally becomes less moist and the waterfalls will trickle without splashing.

A possible mitigation measure.

It is proposed that a buried hosepipe should carry water from the settling tank down to where the stream crosses the 408m contour (Figure 2), giving about 15 m head. In very dry weather a nozzle at this point would generate a fine, cool mist that would drift down through the gorges and raise the humidity slightly. This would be a useful and interesting piece of research, made possible by the weather station power/communications link which would read humidity sensors etc.

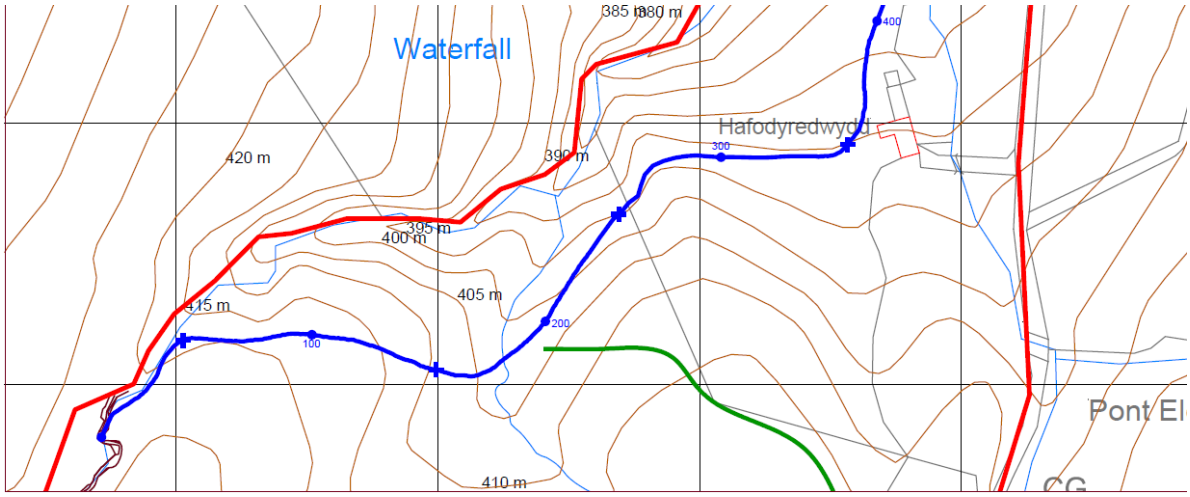

Figure 2. Proposed spray point.

As a starting point, a very low flow of perhaps 0.05 litre/second (4.3m^3/day) would be trialled. This flow is so little that it would have no measurable effect on the stream itself through

the depleted reach (for reference, a typical hose flow rate is 0.24 litre/sec with nozzle removed or 0.17 litre/sec with nozzle wide open).

Figure 3. Proposed spray position (panoramic photo; see bucket at left for scale). The stream disappears down a waterfall at the right centre.

Figure 4. Demonstration of the mist obtained from a 0.05 L/s spray. This is with 3 bar pressure; at 1.5 bar (15m head) the spray would be slightly coarser and would take longer to evaporate.

The predicted annual Q95 and Q99.9 flows (litres/sec) for Afon y Foel are:

	Annual	Lowest month	
Q95	4	3.1	June
Q99	2.6	2.2	August
Q99.9	1.8	1.8	September

The spray raises the humidity (as happens naturally with a waterfall) because the evaporation has a cooling effect. At any given temperature, humid air is less dense than dry air and tends to rise and form clouds. The evaporation process however has a cooling effect (the latent heat of vapourisation): this is large enough that the overall effect is for density to increase, so the humid air hugs the ground rather than rising (Figure 5).

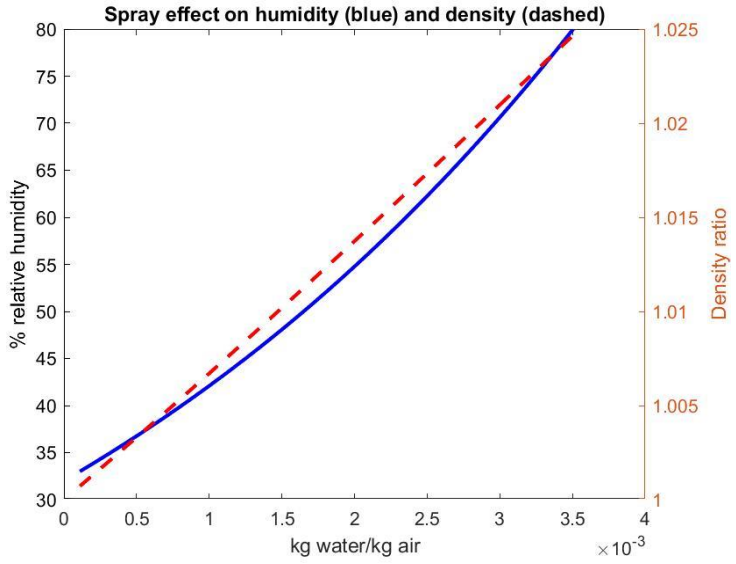

Figure 5. Effect of vapourisation on relative humidity and air density.

The graph starts with a guess of a 25°C air temperature with 7°C dew point (32% relative humidity). To increase this to (say) 50% RH would require about 0.00165 kg water /kg air. Then 0.05 kg/s water would humidify 30 kg/sec of air (26 m3/sec).

If this made a humid "blanket" 5 m deep * 10 m wide * 700m long as it sank down through the gorges (35000 m^3), that would take about 22 minutes of spraying (in practice it would only drift down very slowly, of course: I'm thinking the spray will operate continuously in very dry weather). This is only a back-of-envelope calculation but it suggests that even a very small flow like this could have a significant effect on local humidity. [That's if there's no wind - in windy conditions the humidity will just depend on the weather and probably won't depend much on the stream flow rate in any case].