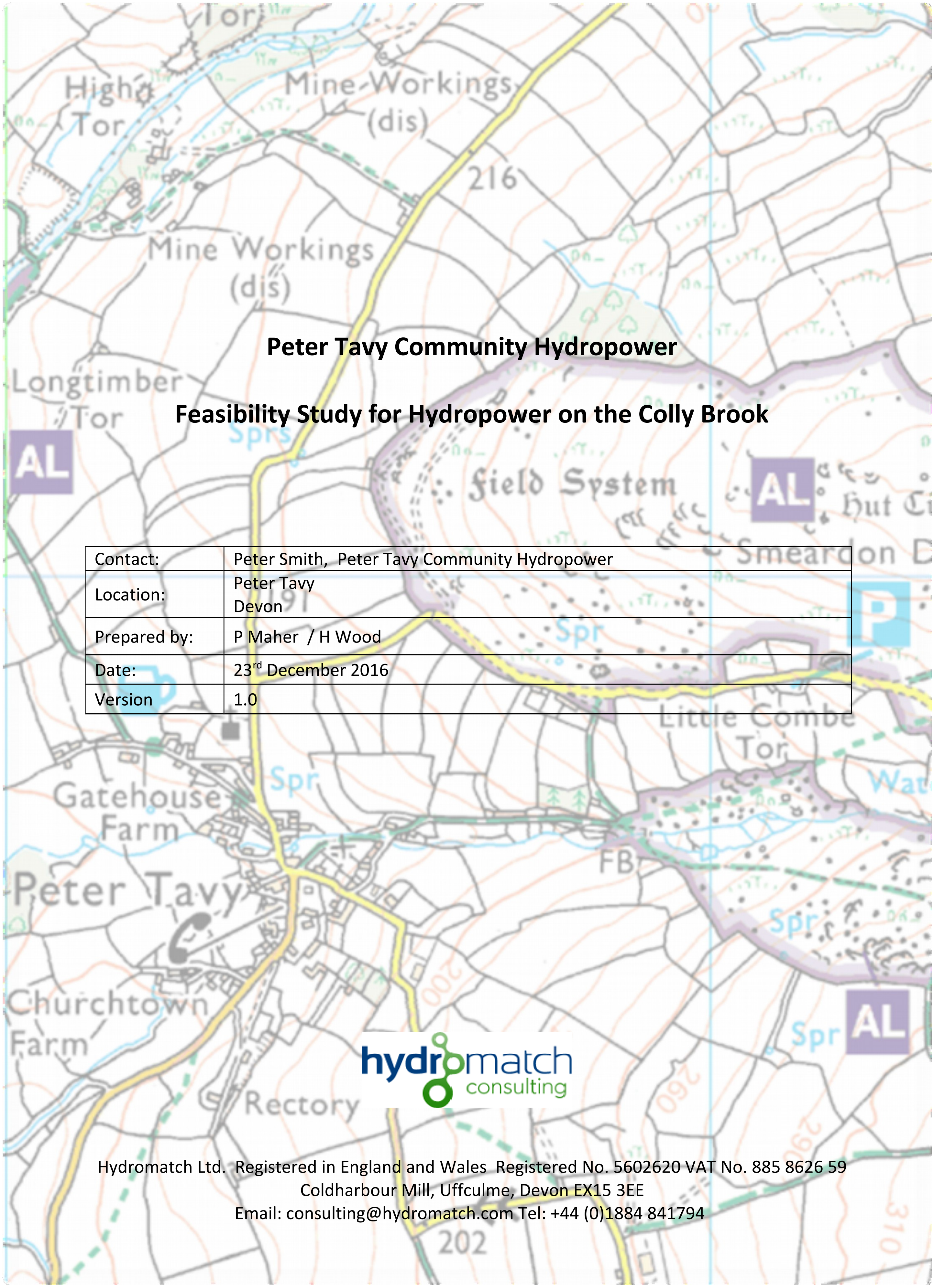

Peter Tavy Community Hydropower

Feasibility Study for Hydropower on the Colly Brook

Contact:	Peter Smith, Peter Tavy Community Hydropower
Location:	Peter Tavy Devon
Prepared by:	P Maher / H Wood
Date:	23rd December 2016
Version	1.0

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1 Executive Summary

Peter Tavy Community Hydropower Ltd (PTCH) is a community association set up in Devon with the aim of generating renewable energy for the benefit of local residents and the environment. The organisation is registered in England under the *Co-operative and Community Benefit Societies Act 2014*.

On behalf of PTCH, a detailed feasibility study for hydropower on the Colly Brook has been carried out by local hydropower specialists, Hydromatch Ltd.

This report is the culmination of a program of analysis and consultation which was supported by the Rural Community Energy Fund and administered by WRAP (Waste and Recycling Action Program). The report provides an overview of the work undertaken and proposals which have subsequently been developed. The work also builds on a scoping study completed in December 2015 which examined different layout options. This resulted in the identification of the most viable scheme configuration which formed the basis for the second phase of work presented here. Key parameters of the proposed system are as summarised in the table below. It has been concluded that if installed, the scheme could result in renewable energy production of around 428,000 kWh per year, equivalent to the annual electricity consumption of 107 typical UK households.

Turbine Type	Design flow, (m^3/s)	Gross head (m)	Power output at Q_{des} (kW)	Annual energy capture (kWh)	Annual CO2 saving (tonnes)
Pelton or Turgo	0.13	108	98	428,000	225.6

Table 1: Summary design for hydropower at Colly Brook, Peter Tavy

Consultations, including submission of comprehensive scheme documentation and site meetings with local regulators the Dartmoor National Park Authority, the Environment Agency, Natural England and Western Power Distribution have been undertaken. No significant objections were raised and useful feedback was obtained which enabled further refinement of the proposal. Key outcomes of the consultations were as follows:

- Dartmoor National Park Authority recommended a pipe route modification which has now been incorporated.
- The Environment Agency requires further assessment of the likely impact of the scheme on fish populations and movement and other environmental aspects. If adequate mitigation measures can be incorporated, the flow split to the hydropower system could be slightly increased over the assumptions made in the scoping study. The revised design proposals assume that the increased flow split from 50% to 70% is accepted.

Scheme costs have been investigated in detail with quotations sought for hydropower equipment and construction elements. Allowing a contingency of 20% for building works the total scheme budget is £457k to £572k + VAT depending on the choice of hydropower system.

Through a combination of Feed-in Tariff payments and electricity export purchase, the scheme has the potential to generate a typical annual income of £56,000. When balanced against the estimated implementation costs this could offer a return to investors of up to 7 % per annum. This could be sufficient to raise investor interest for financing via a community energy share issue and enable a community fund to be developed in support of other local initiatives and good causes.

The priority for the project now is to question the assumptions made in the current analysis and to obtain local consensus to progress the project through the development phase. Crucially, confirmation of support from all landowners within the scheme boundary should be obtained.

2 Methodology

This feasibility study was approached in a systematic manner to clearly establish the hydropower resource and identify the most favourable system configuration early in the design process. The process undertaken is described below.

1. An options analysis which compared different layouts was undertaken. The analysis concluded that the scheme which could capture the highest head and therefore maximise energy yields, was likely to be the most cost-effective to implement.

2. The results were presented in an interim report in December 2015 and discussed at a well-attended community meeting held at the Peter Tavy Village Hall in January 2016. A community mandate was received to investigate the most favourable scheme layout in more detail.

3. Further refinements to the positions of the intake, generator and pipeline route were subsequently made and a topographical survey commissioned from Preston Engineering Survey Ltd to assess the hydraulic head, required depth of excavation for the pipeline and accurate landscape data for setting out intake and powerhouse structures.

4. Following this, a series of 2D and 3D drawings were produced to illustrate the proposals and help inform the wider consultations.

5. In order to ensure that regulatory guidance was correctly interpreted, drawings and documentation describing the proposals were submitted to the Environment Agency through the hydropower pre-application process and to Dartmoor National Park Authority (DNPA) in order to obtain planning advice. Western Power Distribution were also contacted to refine the budget for grid connection based on the selected generator power rating.

Environment Agency and DNPA officers walked over the site to discuss the proposals with the consultants and community members. As a result of these consultations, several design modifications were agreed.

The consultation responses also prescribed additional design and survey information which would be required prior to submission of formal applications. The outcomes of all consultations is summarised in Section 5 with complete responses provided in Appendix 12.2.

6. Solicitors Stephens Scown LLP were used to undertake land registry checks and prepare a draft easment document for use by the community group to begin discussion with landowners who would be affected by the proposed scheme layout. A draft Heads-of Terms agreement was also prepared.

7.The outline budgets provided for the interim report were further developed with manufacturer quotations. A particular difficulty with projects of this type is accurate assessment of civil engineering costs at the feasibility stage. A schedule of requirements was produced to compliment the outline drawings and the requirements were discussed with a trusted local building firm. The firm were subsequently able to provide a detailed cost estimate which has been incorporated into scheme budget.

8. A cashflow projection over the lifetime of the project (assumed to be 40 years) was carried out when capital expenditure and income estimates were complete. Funding options available to a community scheme of this type have also been considered.

9. A project implementation plan in the form of a Gantt Chart has been prepared based on knowledge of the applications process and experience of typical time-scales from other projects.

10. A risk register was developed to identify the likely challenges to successful project implementation and suggested mitigation strategies in priority order of adoption.

3 Design summary

3.1 Scheme layout

Of the layout options considered in the interim report the most viable was the Lower Godsworthy intake option as can be seen in Table 2. The report concluded: *"In terms of the hydropower resource, an intake location at Lower Godsworthy and a turbine situated near the village maximise the head available whilst maintaining a pipe route with reasonable gradient."* This layout would yield the most energy and although having the longest (and therefore most costly) penstock pipeline, is likely to have the lowest overall cost per kilowatt to implement.

No.	Reference	Design Flow (l/s)	Head net (m)	Power (kW)	Annual Energy (kWh)
1	Lower Godsworthy intake	140.0	90.3	98.0	303,000
2	Middle intake	165.0	77.7	99.0	269,000
3	Mill leat Intake	165.0	37.9	45.0	124,000

Table 2: Interim report layout options

Further refinement of the pipe route has taken place following topographical survey and stakeholder consultations. The proposed intake is located 40 metres upstream of the bridge at Lower Godsworthy. A penstock pipe would run downhill on the northern bank leading to the turbine located in the corner of a field close to the edge of the bank of the Colly Brook. The layout is illustrated in Figure 1, with intake location, pipe route and powerhouse location shown.

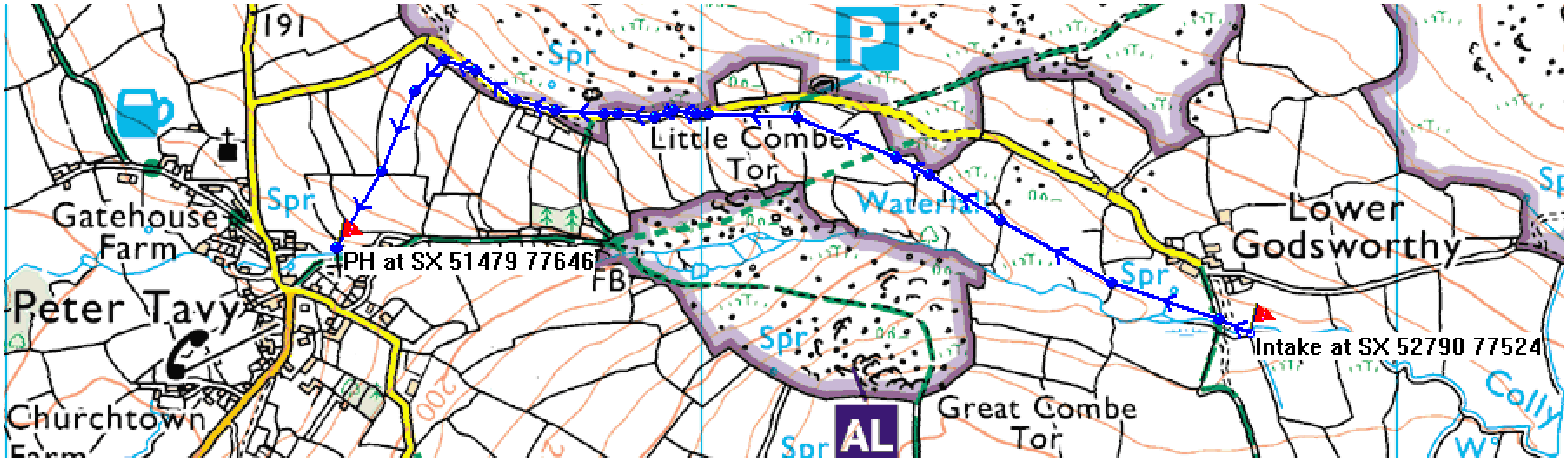


Figure 1: Ordnance Survey map showing proposed location of intake, powerhouse and pipe route

3.2 Hydropower resource, design and generation estimates

Hydromatch Online software was used to model the scheme operation and results are summarised in Figure 2. Detailed flow and head information derived from the resource assessment is combined with typical efficiency characteristics of an appropriately sized turbine and generator system in order to predict performance over all expected operating conditions. This results in a realistic calculation of energy generation and should be a reliable prediction typical annual generation.

3.3 Hydraulic head

The topographical survey data indicated that a gross hydraulic head of 107.9 metres is available between the specified intake and turbine positions. The length of the pipe route between these two points is a distance of 1,520 metres. The survey results can be found in Appendix 12.1.4

A net head of 97.3 metres was calculated after pressure losses of 9.8% of gross head were considered assuming a high density polyethylene (HDPE) penstock of 400mm diameter. Details of the complete calculation are given in Appendix 12.1.3.

For the purposes of scheme design the head is assumed to be fixed across all flow conditions.

3.4 River flow rates

Flow rates in the Colly Brook have been assessed and characterised using 'Catchments UK' and 'Low Flows 2' software. This has determined an average river flow rate (Q mean) at the intake location of 204 litres per second (l/s) and a 'Q95' base flow rate of 35 litres per second. This is the flow rate with a probability of being equalled or exceeded 95% of the time. Results of the flow analysis are provided in Appendix 12.1.2.

3.5 Design flow conditions

The proposed scheme design flow conditions are as follows

- Design flow = 130 l/s

  This has been selected to achieve a design power output of approximately 100 kW in order to obtain the highest Feed-in Tariff given the banding structure at the time of writing. This level is below the Environment Agency guideline value of 1.3 x Q mean.

- Hands-off Flow = 45 l/s

  This is calculated from a Q95 base flow of 35 l/s and an allowance of 10 l/s for other water abstractions within the depleted reach i.e. the flow to the former mill pond and the other small leat. These are thought to be fairly low but further investigations and flow measurements are required to validate this value and obtain EA permissions.

- Flow split of 70% to turbine and 30% to depleted reach after Hands-off-Flow

  This follows 'Table D' of the Environment Agency abstraction guidance for Run of River Hydropower and assumes that all Water Framework Directive objectives for maintenance of river conditions can still be met.

The Environment Agency consultation results and environmental flow constraints are described in Section 5.1.

1.0 Site Details for PTCH 1

hydromatch.com

Gross Head:	107.90 m	Head Loss	9.8 %
Design Flow:	0.130 m^3/s	Turbine Flow Split:	70.0 %
'Hands Off Flow'	0.045 m^3/s	Bypass Flow Split:	30.0 %

Flow and Head Duration Data

% PE =	5	10	20	30	40	50	60	70	80	90	95	98
Flow (m^3/s)	0.615	0.450	0.299	0.220	0.170	0.134	0.103	0.079	0.060	0.044	0.035	0.028
Head (m)	107.90	107.90	107.90	107.90	107.90	107.90	107.90	107.90	107.90	107.90	107.90	107.90

2.0 Turbine Matches

hydromatch.com

Selected Turbine Type: **Pelton** Selected Turbine System: **Pelton 50 - 100 (HM)**

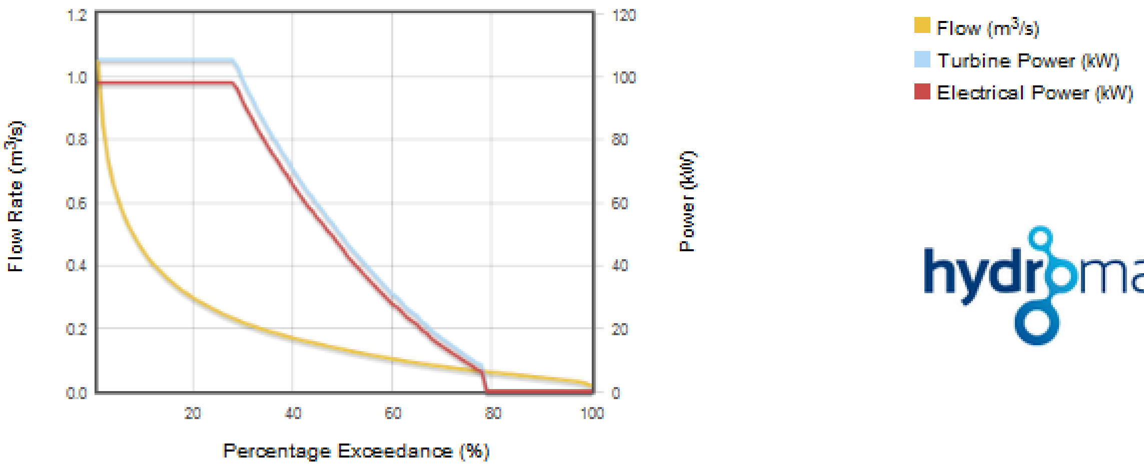
3.0 Design Summary

hydromatch.com

System Type:	Pelton	Design Flow:	0.130 m^3/s
Power:	**98.18 kW**	Net Head:	97.33 m
Energy Capture:	**428,079 kWh** (365 days)	CO_2 Saving:	225.60 tonnes

4.0 Operation Graph

hydromatch.com



5.0 System Details

hydromatch.com

Name:	**Pelton 50 - 100 (HM)**	
Manufacturer:	**Hydromatch**	
	Minimum	Peak
Flow	**0.013 m^3/s**	**0.130 m^3/s**
Turbine Power	**8.38 kW**	**105.50 kW**
Efficiency:		**85 %**
Site Adjustment Factor	**1.000**	

Description:
Designed for medium to high head and lower flow rates. Flow rates can be increased by adding further nozzles with some designs. Pelton turbines can operate over a range of flows and maintain high efficiency through the use of a spear valve.

Figure 2: Scheme design summary

4 Hydropower system components

This section provides an overview of the system components and explains the key design considerations for each.

4.1 Turbine, generator and control system

4.1.1 Turbine

An impulse turbine is a suitable match for a scheme with a gross hydraulic head in excess of 100 metres. Both a Turgo turbine and Pelton turbine are suitable impulse turbines and budgetary quotations have been sought from manufacturers. The information provided below is supplemented by manufacturer specifications from Gilkes Turbines in Appendix 12.5.1.

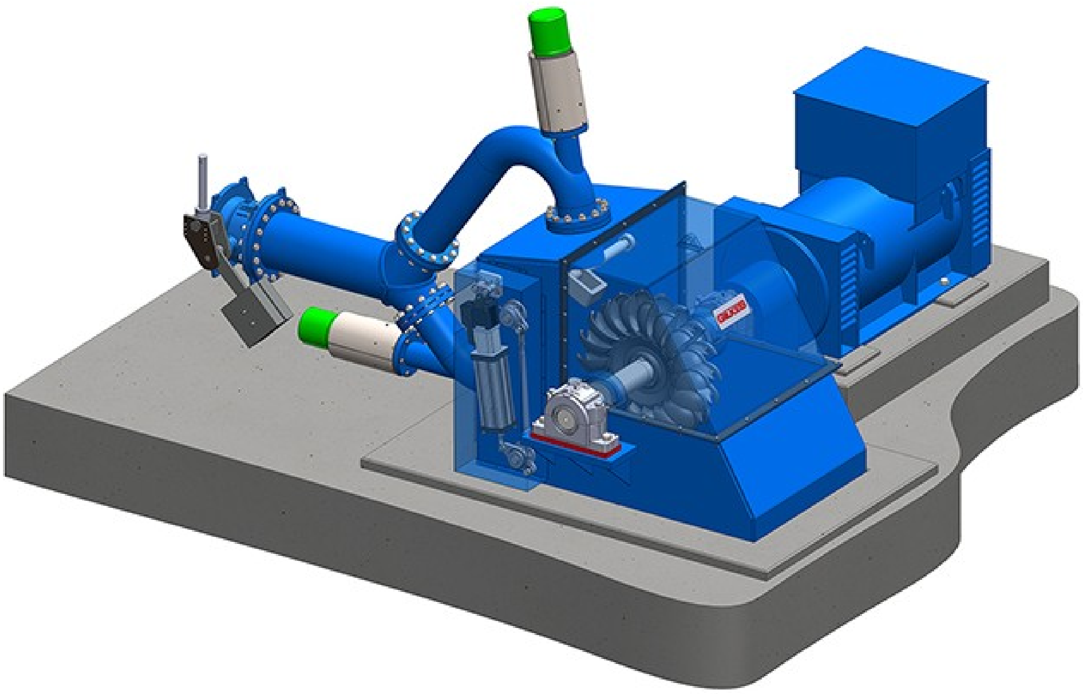


Figure 3: Gilkes ' Streamline' twin jet Pelton Turbine with directly-coupled generator (http://www.gilkes.com/hydropower)

An impulse turbine, is driven by a high-velocity jet (or multiple jets) of water.

The Pelton turbine consists of a turbine runner with a series of split buckets fixed to a central hub. A high velocity jet of water is directed tangentially at the centre of the buckets. A high proportion of the energy is extracted by the runner and the deflected water falls into a discharge channel below.

The Turgo turbine is similar to the Pelton but the jet strikes the plane of the runner at an angle (typically 20° to 25°) so that the water enters the runner on one side and exits on the other.

The optimum rotational speed of either turbine depends on the runner diameter and the 'head' of water. The speed of the generator is fixed by the frequency of the grid network to which it is connected. Certain generator speeds for small induction machines are available and due to the relatively high turbine speed it is often possible to match the generator speed with the turbine speed so that the two machines can be connected directly together. This is the simplest and most efficient arrangement.

4.1.2 Generator

Induction generators are the preferred choice for micro hydropower systems which are grid connected. They are robust and reliable machines which will provide service for decades providing that the bearings are maintained and water ingress is prevented.

Induction generators do not have brushes which reduces maintenance compared with synchronous generators. The final choice will depend on the system design, size and required rotational speed.

A 6-pole generator with a rotational speed of around 1030 rpm would provide a suitable speed match for at turbine runner with diameter of around 400 mm at an operating head of 98 metres net.

Figure 4: CINK Crossflow Turbine with directly-coupled 100 kW generator (Hydromatch Ltd)

4.1.3 Control system

A control unit enables the turbine to start and stop automatically or by manual control. Shut-down can be triggered by a range of fault conditions and automatic restart ensures that disruption to generation is minimised. The water level in the forebay tank is monitored and small adjustments to the spear valves allow the turbine to maintain efficient operation across the full range of operating flow conditions. This should typically be down to around 10% of the design flow for a Pelton turbine. The main inlet valve is often hydraulically operated to provide a fail-safe mechanism to close the turbine in the event of a system fault and prevent prolonged over speed which causes excessive wear of turbine and generator bearings.

The safety switchgear incorporating sensitive relays for connection and disconnection of power circuits must comply with regulations for embedded generators (currently G59/3) of the particular type and scale installed.

Modern hydropower control systems are internet-enabled and provide real-time system monitoring via a website. In addition to fault identification and notification, some systems also allow remote access to elements of the control panel. This greatly improves the diagnostic tools available to the operator and helps reduce downtime.

4.2 Intake, screening and fish passage

4.2.1 Intake sump and forebay tank

A correctly designed intake will ensure that the penstock pipe remains full under varying river conditions, does not allow significant quantities of air to be drawn into the system and prevents ingress of aquatic animals or debris. In order to prevent air entrainment, a sufficient depth of water must be provided over the entrance to the pipe which conveys the water to the turbine. Deep excavation in a rocky river bed can be difficult. Further problems may ensue with the subsequent pipe installation as the deeper the sump, the more challenging the excavation of the subsequent trench will be. To mitigate this issue, a shallow sump beneath the screen can be provided with a low pressure duct to a deeper chamber in a more convenient position. A second chamber, or forebay tank is proposed approximately 20 meters into the adjoining field where excavation and access is easier.

Temporary works will be required to provide a dry working area for the intakestructure to be built. This can be achieved by diverting flows upstream into a bypass pipe and routing around the working area.

4.2.2 Screen

The selected screen type is a 'Coanda' type intake screen. These are self-cleaning under most conditions and exclude debris greater than 1 mm diameter. An installed Coanda screen is illustrated in Figure 5. A screen width of 4 metres and height of 0.45 metres will be suitable for the proposed design flow rate 130 l/s. Careful intake design will ensure that a minimum continuous reserve flow of 45 l/s and a 30% flow split will always be provided to the depleted reach. This can be achieved in a 'fail-safe' manner by a suitably sized notch in the crest of the intake weir below the intake screen height, and 30 % of the weir crest without screen. The weir crest should be the same height along its length.

Figure 5: Conada type intake screen with fish pass flume alongside. Water is ducted from a sump beneath the screen via a low pressure pipe to a deeper chamber further into the bank where the water level sensor and penstock pipe are connected.

4.2.3 Fish Pass

A fish pass is proposed as part of this scheme. The design proposed is a pool pass constructed of boulders which are used to create natural pools of deeper water and mimic the conditions in other stretches of the brook. This should be an appropriate method of providing access across the intake structure for fish movement as the required change in water levels will be limited to approximately 600 mm. The Hands-off Flow notch needs to be appropriately shaped with a rounded profile to further facilitate fish movement. The precise design and dimensions of the fish pass needs to be refined once an assessment of fish species which are present has been conducted. This is a requirement of the Environment Agency license application.

4.3 Penstock pipeline

High density polyethylene (HDPE) is the preferred material for the penstock pipe and is now used extensively in the water supply industry. HDPE is a tough, low friction material with a long lifespan.

Calculations of head loss, based on design flow and 400 mm diameter have been carried out. Results are presented in the Appendices. Summary conditions as follows:

Gross head (m)	Pipe Length (m)	Pipe dia (mm)	HL pipe % / HL total %	Net head (m)
107.9	1,520	400	7.3 / 9.8	97.3

Table 3: Key parameters for head and pipe

In order to reduce the cost of the long pipeline, the pressure rating of the pipe could be varied according to the position with thicker-walled more expensive pipe used for the lower sections only where the pressure is greatest. The lowest pressure section (1) starting at the forbay could be SDR26 (SDR = standard dimension ratio and is the ratio of pipe diameter to wall thickness), followed by SDR21 (2), with a longer section (3) of SDR 17. This helps to minimise the cost of the more thicker walled most expensive SDR 11 as this is only where the pressure exceeds 10 bar (approx 102 metres). Note that current head loss calculations assume that the thicker-walled pipe SDR11 has been used throughout. The losses at maximum flow rates are therefore likely to be over estimated and optimising the pipeline in this way should result in a slight efficiency benefit.

Section	length (m)	SDR reference	Maximum pressure rating (m)
1	578	26	65
2	153	21	82
3	720	17	102
4	48	11	163

Table 4: Length and pressure ratings of pipe sections

4.4 Powerhouse

The powerhouse provides weather and flood protect for the turbine and electrical components. At unattended locations, a secure building also prevents unwanted access with potential vandalism, theft or safety implications. Access for installation, maintenance and future refurbishment together with adequate ventilation and sound-proofing are important design considerations.

The footprint of the powerhouse should be large enough to accommodate the turbine and generation equipment. A concrete floor slab with adequate foundations for the ground conditions is required. Set into the foundations is a sump area beneath the turbine and tailrace channel so the turbine flow can be directed smoothly back to the river. The tailrace design can be adapted to minimise noise emissions. Further details of noise mitigation methods are provided in Section 4.4.1.

The building walls will normally be concrete block construction for strength and sound insulation and in this case with timber cladding above a stone plinth on external faces (as recommend in the planning consultation response in Appendix 12.2.4). A 'beam and block' concrete ceiling is proposed with a mono -pitched metal corrugated sheet roof above.

A thrust block is required where the penstock enters the building to prevent forces being transmitted to the turbine installation. This is normally cast against the foundation slab and rear wall. Waterproofing and drainage is required to any retaining walls and damp proofing methods applied to ensure that the lifespan of the components within is maximised.

Figure 6: Taff Bargoed Hydropower scheme. A secure building of area approximately 5 x 5 m is required to house the hydropower equipment. The construction needs to consider future access for maintenance and comply with local planning preferences. The construction will influence whether operation of the equipment is audible from the outside.

4.4.1 Noise mitigation

With the door closed and assuming the listener is stood around 10 metres outside the building, the proposed design will ensure that, other than flowing water, there is no discernible sound from the hydro power system even when the equipment is working at maximum capacity. The installation will therefore also not be audible from the bridle path or nearby homes. The following design considerations are key:

1. To prevent vibration, all machinery should be firmly anchored to a reinforced concrete base and pipework should be anchored with a thrust block on entry to the building. All machine fixtures should be fully grouted and sealed into position after installation.

2. The building itself can be constructed from concrete blocks laid flat (reinforced concrete with a thickness of 200mm at retaining sections) with a ceiling of 'beam and block' construction with

concrete screed over.

3. The sump beneath the turbine where water flows are diverted back to the brook should be acoustically isolated. This can be achieved by incorporating a gulley (or ‘U’ bend) in the tailrace pipes to create an air lock.

4. Acoustically treated access doors (e.g. rockwool filled) for entry to the building should be specified and all ventilation points in the building can be fitted with foam baffles if necessary.

Inside the building, typical noise levels for the type of turbine and generator system proposed are comparable with a modern diesel car (i.e. 60 dB to 70 dB)

For noise comparison common benchmarks used for traffic are:

a) Car at 10 metres : 70 dB
b) Busy Traffic at 10 metres : 80 dB

There are two principle sources of noise with a turbine installation of this type:

1. Water entering and acting upon and leaving the turbine

2. Rotational of the generator and drive system

Noise produced by the turbine depends on the turbine type and manufacture. A turbine with a heavy gauged casing will generally run more quietly than a comparable system with thinner walled casing.

A larger turbine with lower rotational speed will also help to reduce noise levels and increase lifetime of turbine bearings. Similarly, a lower speed generator is preferred and if possible, matched to the speed of the turbine removing the requirement for a gearbox or pulley belt drive.

The specified 6 pole generator will run at 1000 rpm (therefore considerably less noisy than a 4 pole machine with rotational speed of 1500 rpm) and will not require a pulley or gearbox.

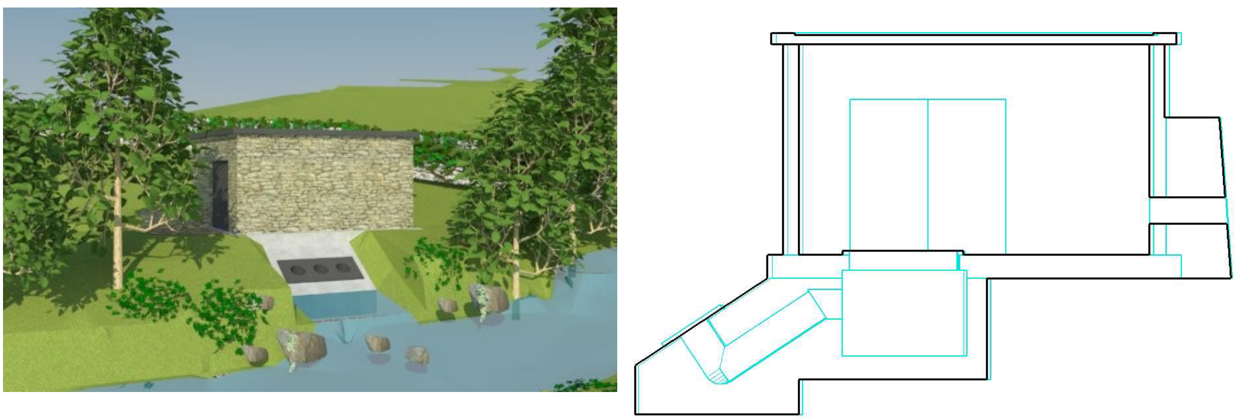


Figure 7: Acoustic isolation of the hydropower equipment is possible through the introduction of an airlock in the tailrace pipes as illustrated

5 Consultations, Licenses and Consents

5.1 Environment Agency

Hydropower developments in England are regulated by the Environment Agency. For new projects, a draft of the proposals may be submitted for consultation and feedback prior to formal application. A pre-application was submitted in July 2016 and a site meeting with the EA was held in September. A detailed response was issued on 24 November 2016 and is provided in Appendix 12.2.2

Minor design alterations and further supporting information are requested with the formal EA application. The main issue raised by the Environment Agency is the possible importance of the Colly Brook as a spawning ground for migrating salmon and the impact of the scheme in this regard requires further analysis.

Following the consultation, the maximum allowable flow could follow the conditions in Table D of '*Guidance for Run of River Hydropower Development'* Published by Environment Agency.

The design flow limits for high-head schemes set out in Table D are as follows:

- a Hands-off Flow (HoF) of Q95;
- a maximum turbine intake flow of 1.3 x Qmean;
- Percentage flow split using the following formula: 1 – (Q80/Qmean) x 100.

Any existing abstractions in the depleted reach must be taken into account to arrive at an appropriate HoF and flow split for the proposed scheme. See Section 3.5 for details of the proposed flow conditions which are in line with the conditions set out above.

Details of forms required, time-scales and costs for a formal application are given in Section 9.1.2.

5.2 Dartmoor National Park Authority

Details of the proposals were forwarded to the local planning authority, Dartmoor National Park Authority, for pre-application advice. The response from the case officer was received on 25 November 2016 and is provided in Appendix 12.2.4.

The proposal is supported in principle by national planning policy. Consideration of some further aspects have been recommended for submission with the formal application. These include: local ecology, powerhouse appearance and pipe route.

5.3 Design changes and supporting documentation

The design changes requested by the regulators are summarised in Table 5.

Design change	Comments	Implemented?
Abstracted flow in line with Table D, EA guidance 2016	This allows more flow than originally applied for to be abstracted. Depleted reach flows must allow for the other abstractions	**Yes**
6mm tailrace screen	Finer screen than originally proposed required to protect wildlife	**Yes**
Pipe route to avoid Section 3 Moorland	Recommended to avoid moorland of conservation importance for environmental reasons	**Yes**
Possible fish easement on waterfall	Requirement depends on impact of abstraction on fish movement	**No:** Incorporate after fish assessment

Table 5: Design changes requested by the EA and DNPA

Further information requested by the regulators is summarised in Table 6.

Topic	Information requirements	Implementation
1.0 Resource and Design		
Water balance model (EA)	Flow measurements in depleted river section and at other abstraction points	Next step
Design Detail (EA)	Intake dimensions and HoF notch Fish Passage at intake and waterfall	After fish assessment
2.0 Biodiversity and fish		
Biodiversity studies (EA & DNPA)	1. Preliminary Ecological Appraisal (PEA) 2. Additional protected species surveys if need is identified through PEA 3. Biodiversity Mitigation and Enhancement Strategy	Next step Ecologist quotes have been obtained
Natural England consultation (EA)	Completed	
Fish assessment (EA)	What is impact on spawning gravels and migration. Will there be an increase in siltation?	Next step HM to obtain quotes from fish specialist
3.0 Water Framework Directive		
WFD impacts and Geomorphology (EA)	To include biological, chemical, morphological and flow-related features. In particular: • depth at obstacles to fish • Impact of siltation of fines • impact on movement of gravels • Presented in an environmental report	After survey and design work
4.0 Other information		
Other (EA)	Flood Risk Assessment Consultation with other river users	Prior to Formal application

Table 6: Supporting information requested by the EA and DNPA

5.4 Natural England

Natural England were consulted by email. A copy of the draft Design and Access Statement and supporting technical documentation were sent. A response was received from on 19 October 2016 and available in Appendix 12.2.5

Natural England concluded that the proposal would not impact on designated conservation sites. They did not consider the potential impacts on protected species, but recommended reference to the 'Standing Advice' available on the NE website. It is likely NE will be statutory consultees for the formal planning application.

5.5 Western Power Distribution

The Distribution Network Operator (DNO), Western Power Distribution, have provided a revised grid connection offer for 100 kW export capacity, with metering now located on the same side of the river as the powerhouse. The budget offer letter and drawing can seen in Appendix 12.2.6

The connection offer proposes metering located within the powerhouse and connected to the existing substation via a new underground service. The quote for this connection is included in the project budget.

This price excludes all civil works such as trenching and reinstatement and a pipe bridge at the river cross point. The distance between the existing substation and the powerhouse is approximately 65 metres. The excluded items have been budgeted separately.

Cost are subject to wayleave agreements which will be negotiated by the DNO.

5.6 Landowners and wider community

A community event was held on the 28th of January 2016 in order to explain the results of the stage 1 feasibility study. Presentations were given by Hydromatch and Regen SW. All residents of the Peter Tavy Parish were invited. At the meeting residents were invited to contact the consultants with further questions or feedback. This invitation was also presented on the PTCH website, along with Hydromatch Ltd contact details. The questions received from residents, along with replies provided are listed in Appendix 12.2.7.

Hydromatch wrote to landowners to inform them of surveys work which could cross their boundaries. The letters also gave a brief overview of the scheme and a chance for landowners to correspond.

Further community engagement work has been undertaken by the PTCH committee.

6 Implementation Budget

6.1 Summary of project implementation costs

The implementation costs for two hydropower system options are summarised in Table 7. The full budget is provided in Appendix 12.6.1. Sections 6.2 and 6.3 explain how the costs have been derived.

	Item	Option 1	Option 2
1	Project Development (applications, planning and legal fees)	37,245	37,245
2	Civil engineering (intake, powerhouse and pipeline) + 20%	174,700	174,700
3	Penstock (pipeline materials)	96,300	96,300
4	Hydropower equipment (turbine, generator and controls)	60,300	175,400
5	Hydropower installation and commissioning	18,100	18,100
6	Project management, CDM and subcontracting	44,300	44,300
7	Grid connection (WPD and cable installation)	26,500	26,500
	Total (ex VAT)	**457,400**	**572,500**

Table 7: Budget costing summary (see Appendix 12.6.1 for full breakdown)

6.2 Project development costs

Project development, implementation and installation costs are based on likely Hydromatch Consulting fees for direct provision or subcontracting to external suppliers where applicable. Project development costs have been itemised in Table 8. This includes fees for license applications and a 10% deposit towards grid connection costs.

	Item	(£)	£
1	**Project Development**		**26,745**
1.1	Archeology survey	500	
1.2	Fish Surveys	1500	
1.3	Flow measurements	1500	
1.4	EA formal license applications	2,200	
1.5	Planning consent application	1,925	
1.6	Survey and application co-ordination and correspondence	2,000	
1.7	Application fees and advertising	2,485	
1.8	DNO formal offer application	275	
1.9	WPD offer acceptance (10% deposit of grid connect fee)	1,860	
1.10	Legal fees – Land ownership agreements	2,500 per landowner	
2	**Project Planning**		**10,500**
2.1	Construction drawings	7,000	
2.2	Ground investigations	2,000	
2.3	Tender preparation	1,500	

Table 8: Project development and project planning costs

6.3 Project Construction Costs

6.3.1 Civil Engineering

The civil engineering building costs have been estimated by developing a detailed schedule of the works required (see Appendix 12.5.2). A well regarded local contractor was then approached to provide a provisional quotation against the schedule of works and accompanying drawings. The quotation is provided Appendix 12.5.3. Due to uncertainty with the precise construction costs a further 20% contingency sum has been applied.

The planning consultation suggested that a timber-clad building above a stone plinth and a mono-pitch sheet-metal roof would be acceptable finishes for the powerhouse. Provisional sums have been added to the original quote to cover these additions.

6.3.2 Penstock

Budget pipe component prices were sought from a UK manufacturers GPSUK & Wolseley for pipeline components of appropriate diameter and pressure rating. A typical commercial margin has then been applied to estimate realistic costs for the project budget.

6.3.3 Hydropower equipment

Hydropower system costs are based on provisional quotes received from two UK manufacturers; Hydrover Turbines Ltd and Gilbert Gilkes & Gordon Ltd. Costs for each system have been applied separately to the project budget. The intake screen assumes supply from Dulas Ltd. A typical commercial margin has been added to all equipment supplied assuming that components will be supplied by the Principle Contractor / Installer.

6.3.4 Grid connection

A budget quote was obtained for grid connection from Western Power Ltd. The offer terms are provided in 12.2.6. Installation costs including provision of a pipe bridge to duct the cable across the river have been added.

6.3.5 Hydropower system installation and commissioning

The cost for these elements are based on labour and materials prices for similar projects and a breakdown of activities is provided.

6.3.6 Project management

The cost for these elements are based on commercial rates for similar projects. Activities include safety planning (CDM), civils contractor supervision and subcontracting, archaeology watching brief and liaison with DNPA and the Environment Agency during project implementation.

7 Scheme operation and income

7.1 Operating costs

Maintenance requirements for hydropower systems of this type should be relatively small. Intake screens and the turbine installation require periodic inspection and cleaning usually around once per week. Remote monitoring via internet helps to reduce requirement for maintenance visits further. Interim servicing is required quarterly and a more thorough service on an annual basis. Some income from the scheme should be set aside to cover eventual overhaul or replacement of components such as bearings and switchgear. A recommended minimum allowance to cover periodic visits from an engineer including annual servicing, providing support and technical backstopping for volunteer operators is £1,500 per annum.

An annual maintenance budget of £3,500 to £4,250 would enable a modest repair fund to be established and this sum has been used for the financial modelling.

Annual insurance costs of £1,500 have been anticipated. Landowner agreements should also be factored in to operating costs. At present 10 % of the annual income has been set aside for this purpose (2% per landowner) and appears under the heading 'Rent' in the financial model.

It has been assumed that the implementing organisation, Peter Tavy Community Hydro, is eligible for small business relief from business rates.

7.2 Income projections

The Peter Tavy Community Hydro could receive income from two streams;

1. Feed-in Tariff

2. Export payments via a Power Purchase Agreement

It is estimated that the Feed-in Tariff the scheme could access is 7.61 p/kWh, assuming pre-accreditation prior to October 2017 for a scheme of up to 100 kW electrical output. Feed-in Tariff levels are being periodically reduced (a process known as 'degression'). The tariff is currently reduced by around 0.01 pence per quarter. Greater reductions could be triggered if uptake levels for hydropower increase over coming months. However, no triggers are currently predicted for this band. The current OFGEM rates can be viewed in Appendix 12.6.3 This was accessed on the 19/12/2016 at https://www.ofgem.gov.uk/publications-and-updates/feed-tariff-fit-generation-export-payment-rate-table-01-october-31-december-2016.

It is assumed that all electricity would be exported. A quote for the export payments has been provided by Good Energy Ltd at a rate of £56.81/MWh ex VAT. This can be found in Appendix 12.6.4.

7.3 Financial summary

The capital and operating costs together with income projections and assumptions are summarised in Table 9. An important point to note is that the energy capture estimate does not reflect the choice of turbine equipment. It is possible that the current estimate of energy generation (and therefore scheme income) underestimates the potential generation with the Gilkes Pelton Turbine. Further scrutiny of likely operation based on the final flow conditions agreed with the Environment Agency is recommended.

	Financial summary	**Option 1**	**Option 2**
	Turbine	Turgo	Pelton
	Installed system size and output		
1	Design power (kW)	98	98
2	Estimated annual energy generation (kWh)	428,079	428,079
3	Maintenance downtime (2%) (kWh)	-8,562	-8,562
4	Net generation (kWh)	419,517	419,517
5	**CAPEX Cost of scheme (ex VAT)**	£ 457,400	£ 572,500
6	OPEX Annual maintenance costs (ex VAT)	£ 4,250	£ 3,500
	Value of energy generated		
7	FIT rate (2016)	£ 0.076	£ 0.076
8	Export tariff (2016) VAT deducted	£ 0.057	£ 0.057
9	Assumed export	100%	100%
10	Income from FIT	£ 31,925	£ 31,925
11	Income from Export	£ 23,833	£ 23,833
12	Total value of electricity generated	£ 55,758	£ 55,758
	Financial modelling		
13	Annual community fund	£ 6,000	£ 6,000
14	Average annual return to members	7.1%	5.6%

Table 9: Summary of costs, income and return for the community hydropower scheme

The costs and income rates summarised in Table 9 have been incorporated into a financial model which is referred to in Appendix 12.6.2 and provided to the client in spreadsheet format. This will enable modification to the financial projections as the scheme details are further refined.

The current financial model indicates that the project could be financially viable and provide a return of 5.6 – 7.1 % depending on the turbine option chosen. This equates to the average annual interest which could be offered to local shareholders who chose to invest in the scheme and assumes that a community fund of £6,000 a year was set aside from the annual income.

The set up and annual administration costs assume funding is raised through a community share offer. A breakdown is in the Funding Report in Appendix 12.6.5.

8 Community Benefits

The aim of the Peter Tavy Community Hydropower Community (PTCH) Benefit Society is create an income to fund worthwhile local projects. The financial model shows that a community fund of £6,000 a year could be supported.

A reliable source of revenue from the hydropower project could support a set of collectively identified community goals. The income could be saved in a community trust fund and administered by a group of appointed members who would co-ordinate community agreement on how the funds were used.

Possible use of funds which have currently been identified include:

- Upkeep and improvement of St Peter's Church, Methodist Hall and Village Hall
- An additional weekly mini-bus service to Tavistock
- Installation of energy-saving measures for low-income households

9 Project Plan

A possible schedule of project implementation from formal licence applications to commissioning is illustrated by a Gantt chart in Appendix 12.6.6 and discussed below.

9.1 Project development

Following technical feasibility and financial appraisal, community hydropower projects require formal consent from land-owners and environmental, planning and electricity regulators.

9.1.1 Legal aspects

Negotiation of long term legal agreements in the form of a lease or easement will be required with all affected land-owners. There are five landowners whose land the proposed pipe route is likely to cross.

The recommended legal agreement with the owners of the powerhouse and intake locations is a lease. A 'legal toolkit' for community energy groups can be found on the Devon County Council website at: https://new.devon.gov.uk/energyandclimatechange/community-energy-legal-toolkit

A Heads of Terms has been drafted from the template available here. Find in Appendix 12.3.2. A template lease is also available as part of this toolkit.

The recommended legal agreement for land affected by the pipe route is a Deed of Easement. A draft document has been prepared by Stephens Scown LLP and can be found in Appendix 12.3.1.

A legal agreement showing that the applicant has right of access to the abstraction point will need to be in place prior to an abstraction licence being issued. This agreement can take a separate form from the lease to enable the licenses to progress prior to leases being formally agreed. A standard agreement is available from the Environment Agency.

The landowners should be approached early in the development phase to discuss the draft documents. A solicitor may be required for lease negotiations.

9.1.2 Environment Agency

Design alterations and preparation of additional supporting documents are required prior to submission of full application to the Environment Agency as detailed in Section 5.1. Allow 3 months for surveys and compilation of supporting documentation.

Forms required for full application:

- WR317 Who you are
- WR 330 and WR 332 Full abstraction licence application
- WR 334 for an impounding licence
- FP002 Fish pass approval
- Application for an environmental permit - Part A – About you
- Application for an environmental permit - Part B11: standard rules permit for flood risk activities
- Application for an environmental permit - Part B10 – Flood Risk Activities

The fee for the formal application to the Environment Agency is currently £1,500 plus advertising costs of around £500 + VAT. The determination period is 4 months from application submission.

9.1.3 Planning

A summary of additional information requested to support a formal planning application at this site is detailed in Section 5.1.

Once these documents are in place a formal planning application can be made to DNPA via the Planning Portal Website. The fee for this application is £385. The determination period is usually around 8 weeks.

9.1.4 Grid Connection

A firm offer should be obtained from the network operator (Western Power) and a deposit of 10% of the connection cost is likely to be due on acceptance of the offer.

9.1.5 Generator Accreditation

In order to access the Feed-in Tariff, a hydropower scheme must currently be accredited by the industry regulator, Office for Gas and Electricity Markets (OFGEM). At present it is possible to pre-accredit for the Feed-in Tariff giving the scheme a two year construction window from the date of registration.

In order to apply for pre-accreditation the documents required are:

- Planning permission
- Grid connection agreement
- Abstraction and impoundment license
- Flood risk permit

It is recommended to apply for pre-accreditation for OFGEM at the earliest opportunity in order to confirm the FIT rate for which the scheme will be eligible.

9.2 Design and procurement

A close assessment of building costs is required prior to preparation of a refined project budget. From experience, the Principle Contractor for most micro hydropower projects will either be a hydropower specialist or a building contractor. It is rare for them to be combined as a single organisation. Prior to project tendering, a detailed project specification should be developed so that bidding firms can price against a clearly defined system. This is the best way to achieve comparable bids and to avoid cost over-runs during construction.

A cost competitive quote has been obtained from one contractor for the civils elements. It is recommended to obtain quotes from two more contractors.

All available site information including locations of any buried services should be provided to contractors. A suitable contract form for a project of this scale is an NEC3 type contract. An alternative is for the project to be divided into parts to be contracted separately and managed by the client. This would normally place a greater risk on the client but may have cost advantages. The client should use the services of a trusted consultant during the implementation process and adopt 'value engineering' strategies and engage volunteers from the community where possible to help to minimise implementation costs.

9.3 Hydropower system order

Hydropower systems are typically built to order and lead time to delivery is typically 6 months for turbines and 4-5 months for control panels and generators. A deposit of 30% to 50% of the equipment total is usual to secure order and often a further interim payment is necessary for the turbine. Maintenance, part flow efficiency, guarantee terms, duty rating and life expectancy of components such as bearings and switchgear should be all be specified and scrutinised before placing an order.

9.4 Civil works

The building works usually form the most costly and lengthy element of a hydropower project. There are often Environment Agency restrictions on the time of year when work on a watercourse can be undertaken and the timing of construction may need to take this into account. Usually the majority of construction work is completed during the lead time for hydropower equipment order. Civil works could take 12 to 16 weeks for a project of this size.

9.5 Installation, commissioning and handover

Careful planning can enable the system installation to be completed in a relatively short time often around two weeks. Following installation and curing of any secondary concreting phase, the system can be energised for operational tests. Once all parts of the system have been thoroughly tested, the generator grid connection tests can be carried out which may require witnessing by the DNO. Finally, the scheme operators should receive a copy of all related documentation and instruction manuals and be trained on how to operate and maintain the project in a safe and reliable manner.

9.6 Summary of next actions

1. Review design proposals and costs
2. Discuss draft legal documents with landowners
3. Undertake environmental surveys
4. Commission planning level design and drawings
5. Apply for formal consents
6. Apply for OFGEM pre-accreditation

10 Project Risk Register

The top ten risks to the delivery of the project have been identified and scored using qualitative estimates of probability and impact. The scoring table is set out below.

High risk 15 - 25
Significant potential impact on financial viability of scheme. Risk will be difficult or costly to mitigate. Requires further investigation immediately
Medium risk 5 - 15
Marginal potential impact on the financial viability of the scheme. Risk can be minimised by simple solutions or changes. May require further investigation during development of the project
Low risk 1 - 5
Minimal or zero impact on the financial viability of the scheme. No further assessment required

Table 10: Risk scoring table

Probability and Impact ranked from 1 = low to 5 = high Score = probability x Impact

No	Risk Description	Probability	Impact	Score	Mitigation
		1-5	**1-5**	**1-25**	
1	Flow rates are lower than predicted	1	4	4	Ensure that resource investigation is thorough
2	Machinery doesn't perform as expected	1	3	3	Use machinery from an established manufacturer Maintain machinery and screen
3	Planning permission not obtained	2	5	10	Follow pre-application guidance and obtain strong local support
4	EA licence conditions restrict flow take	2	2	4	Follow pre-application guidance and make a clear case for proposed rates
5	Lease and way-leaves not obtained	3	5	15	Maintain good levels of communication with Landowners
6	Civil engineering cost overrun	3	4	12	Design project to minimise civil engineering requirements. Ensure all construction details are specified at project tender
7	FiT reduction or removal jeopardises financial viability	3	5	15	Pre-accredite the scheme through OFGEM as soon as permissions are in place.
8	Increased O&M costs	1	3	3	Train community members to carry out project maintenance
9	Insufficient funds are raised via share issue	1	1	1	Ensure that offer is adequately and attractively marketed
10	Unrealistic cash flow forecast	2	3	6	Take advice from different sources and compare with other community schemes

Table 11: Project risks and mitigation measures

11 Conclusions and Recommendations

Environment

The site is classified as environmentally sensitive due to its location within Dartmoor National Park. Survey work is required to establish the impact of the scheme on fish and identify suitable mitigation for the introduction of a pipeline intake and flow reduction over an extended length of the Colly Brook. It should be possible to mitigate any adverse environmental impacts through careful design and planning. However, these impacts will need to be carefully assessed and mitigation methods articulated through design refinements and supporting documentation.

Further flow measurements are required to establish the size of any existing (unlicensed) abstractions within the depleted river section to assess the cumulative impact.

Land ownership

The scheme crosses five ownership boundaries and therefore agreements between landowners and the community organisation should to addressed early in the development phase so that any impact on scheme design or financial viability can be identified quickly.

Budget

A provisional budget has been prepared as realistically as possible at this stage of the project by obtaining quotes from equipment suppliers and a local construction firm. Other costs have been based on the consultants experience of implementing hydropower in the UK over a number of years. The budget should be refined further during the development phase and the current provision critically assessed. The principle area of budgetary uncertainty is around the likely civil engineering costs and hence a contingency amount has been applied to the provisional quotes received. Financial modelling indicates that a budget turbine system could deliver a higher rate of return over assumed 40 year lifespan of the project than a high-end turbine from a more established manufacturer. The assumptions around performance, productivity and life-expectancy should be refined when design flow conditions are confirmed.

Financial Viability

Through a combination of Feed-in Tariff and electricity export, the scheme has the potential generate an annual income of £56,000. An average annual return of up to 7% could be offered to members. This could be sufficient to raise investor interest for financing via a community energy share issue. This level of return is comparable to other community energy share issues open for investment in Devon in 2016.

Community

The community organisation Peter Tavy Community Hydropower has demonstrated competence to win the funding from RCEF. Work has been undertaken to involve all members of the local parish and to ensure that approval for the scheme development to progress is obtained in a democratic manner. There is also experience within the PTCH Executive Committee of managing diverse infrastructure projects and with the successful implementation of micro hydropower. The local capability to deliver and maintain a working hydropower scheme therefore seems favourable.

Recommended next actions

- Review design proposals and costs and discuss at an open community meeting
- Discuss draft legal documents with landowners
- Commission environmental surveys
- Commission planning level design and drawings
- Apply for formal consents
- Apply for OFGEM pre-accreditation

12 Appendices

12.1 Surveys and hydropower resource

12.1.1 Site photographs

12.1.2 Hydrology and flows

12.1.3 Pipe loss calculation

12.1.4 Topographical survey

12.2 Consultations

12.2.1 Documents submitted for EA pre-application

12.2.2 EA consultation response

12.2.3 Documents submitted for planning consultation

12.2.4 Planning consultation response

12.2.5 Natural England Response

12.2.6 WPD Budget letter

12.2.7 Community Questions

12.3 Legal documents

12.3.1 Draft Easement

12.3.2 Draft Heads of Terms

12.4 Drawings

12.4.1 359 A.02 Location plan B

12.4.2 359 A.04 Ownership map B

12.4.3 359 A.20 Intake drawings A

12.4.4 359 A.22 3D model view of proposed intake

12.4.5 359 A.32 Powerhouse section A

12.5 Supplier quotes

12.5.1 Gilkes turbine specification and quotation

12.5.2 Civils schedule

12.5.3 Cann Bros. civils quote

12.6 Financial appraisal

12.6.1 Project Budget

12.6.2 Financial model

12.6.3 OFGEM FiT rates table

12.6.4 Good Energy PPA quote

12.6.5 Funding report

12.6.6 Project implementation Gantt chart