Opportunities for Small-Scale Hydro Power in the Scottish Borders. Martin Schork

This report is the result of my work placement at the Southern Uplands Partnership during the time from 13.07.09 till 18.09.09 as part of the IAESTE scheme. It contains research about hydro schemes in the Scottish Borders, equipment/advice suppliers as well as a gathering of information concerning the issue of hydro power installation.

The investigation into hydro schemes in the Borders was not easy as there are unfortunately hardly any schemes in this part of Scotland. Polmood Hydro is the only one I could find. There are schemes in the stage of planning at Philiphaugh Estate/Selkirk and Buckholm Estate in Galashiels and an Archimedes screw is being developed in Hawick by the Green Rugby Club. The technology of the Archimedes screw is comparatively new and while promising is not yet widely known. There is only one working scheme in Scotland (in Aberdeenshire). More can be seen in England, the closest is in North Yorkshire. All the contact details are shown in the Appendix.

What is hydro energy?
Hydroelectricity systems generate electricity from running water - usually a small stream. Small or "micro" hydroelectricity systems can produce enough electricity for lighting and electrical appliances in an average home. Hydro power systems use running water to turn a small turbine which generates electricity. The faster the water flows and the more water there is, the more electricity can be generated.

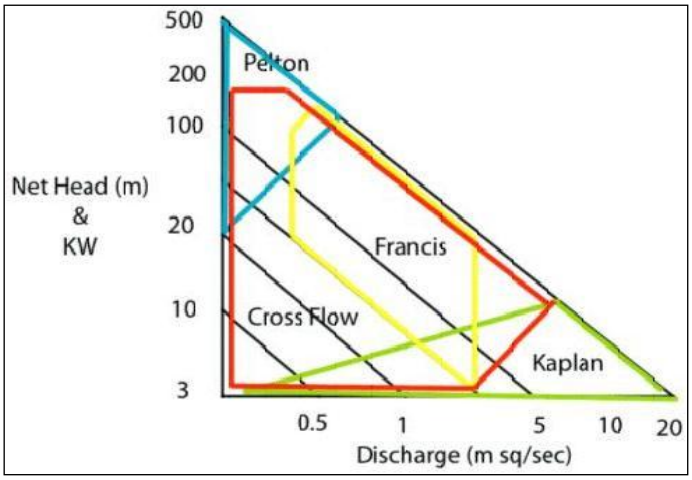
The amount of electricity a system actually generates depends on how efficiently it converts the power of the moving water into electrical power.

What technology exists?
A range of different technology exists whereas the following are well reliable and applied systems.

Impulse Turbine (require head, pipeline etc.)
- Pelton
- Turgo
- Cross-flow

Reaction Turbine (could be installed directly in (river) flow)
- Kaplan
- Francis
- Archimedean screw

As you can see in figure 4 the Cross flow turbine has the widest application range. However, it is not in demand as it is a “high tech” and expensive system. Kaplan turbine requires a high flow and the Pelton a particularly high head. The scope of Francis turbine is a kind of middle course between Kaplan and Pelton. The Archimedes screw is exclusively constructed for micro scale with an upper limit of 500 kW electricity generation, while the other technologies could be used up to several hundred MW. Images about the different technologies are attached in Appendix 3.



Micro hydro in the Borders

As mentioned above there are hardly any schemes installed, although there is a large potential for such schemes. Every kind of flowing water has a theoretical potential to generate electricity. Whether it is feasible has to be checked in each individual case.

Plenty of theoretical sites are available in the Borders region. Old mills for example (ideally where weirs and lades are still in place) are appropriate locations for installing an Archimedes screw. On the other hand it might be cheaper to run a water wheel for electricity generation provided that it is still at place, in good condition and working well. The image below shows an example. A map of the Tweed catchment is added in Appendix 2 to highlight the Borders rivers and streams in order to point out former mills.

Fig. 1 Former saw mill at Philiphaugh estate

But if there is an old mill without a water wheel it doesn't imply it's not an applicable site. It is still a good precondition for generating green energy.

Apart from the technology of the Archimedes screw and the water wheel, many more reliable ways of generating electricity on a small scale exist (eg Pelton turbine, Francis turbine). Unlike traditional technologies, these require the water to fall down a certain height which is called "head". The higher the head and the more water flows, the more electricity can be generated.

Fig. 2 Typical Borders sites

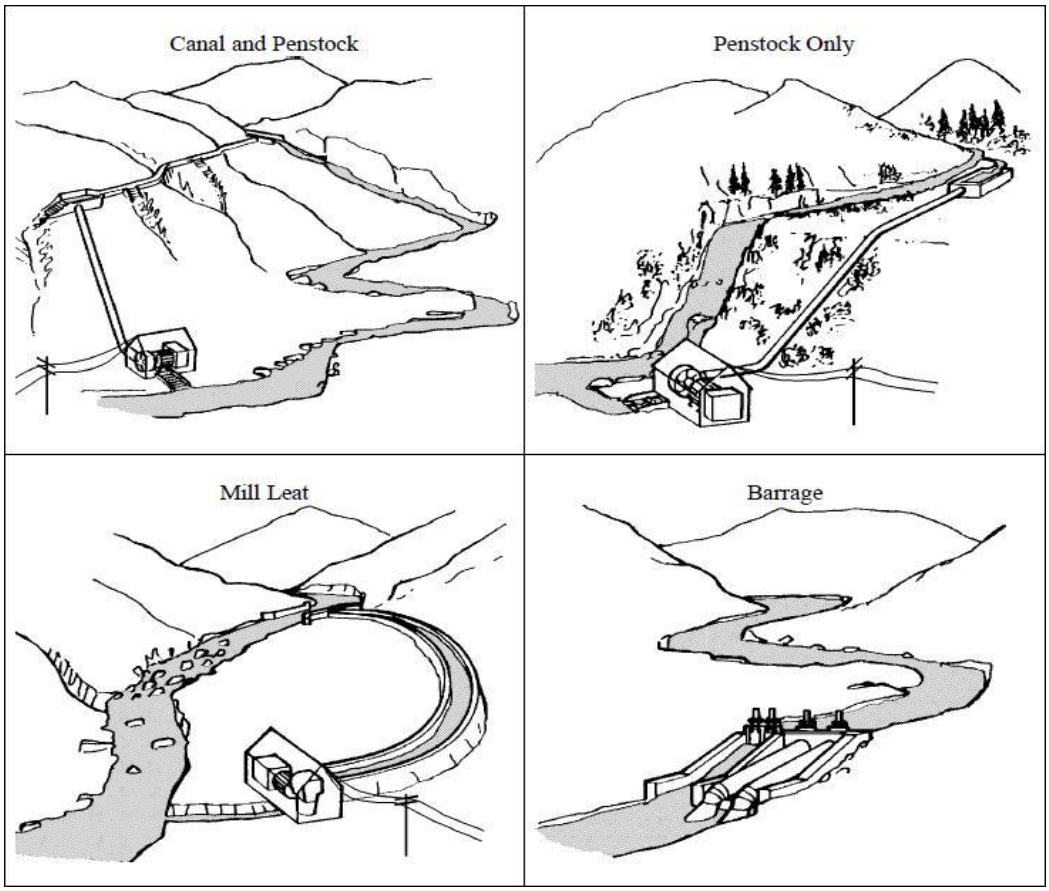


Fig. 3 Possible ways of micro hydro installations

Bigger rivers with higher flow rate would be favourable to install an Archimedes screw or with an abundant flow rate to install a barrage in combination with a propeller turbine like it is shown in fig. 3. Accurate determination of the flow rate (flow duration analysis) is critical to assess the feasibility of a project.

The discharge of St. Mary's Loch into the Yarrow water is a good example of a higher flow rate, at least in summer 2009. It's a typical site where it might be appropriate to install a propeller turbine or an Archimedes screw depending on the durable average flow. The situation at St. Mary's Loch is shown on photographs in Appendix 2.

What do you need to know before you start a project?

It should be clear whether there is a significant energy resource. Estimating flow/head in order to appraise annual energy capture is essential. In addition the applicant has to be certain that permissions will be granted. The most important issue is the destination for the generated power. It must be clear whether there is a connection to the distribution network or otherwise a nearby load that needs to be supplied.

All hydropower developments require a CAR (Controlled Activities Regulations) authorisation for the abstractions, impounding works (weirs and dams) and any other engineering works associated with the scheme.

- **single application** form for abstraction, impounding works and any engineering works directly associated with intake structures or tailrace outfalls
- **separate application** form for any engineering works that are not associated with intake or outfall structures (for example, pipeline crossings or bank protection)

CAR applications fees
Application fee: ≤ 100 kW: A simple licence fee for all abstractions and impounding works
Subsistence fee: ≤ 2 MW > Exempt

Table 1: Summary of other development consent requirements

Size (installed capacity)	Consent	Determining Authority	Environmental impact assessment?
Over 1MW	Section 36, Electricity Act 1989	Scottish Ministers	Yes
500kw – 1MW	Town & Country Planning Act 1997	Local Authority	Yes
Under 500kw	Town & Country Planning Act 1997	Local Authority	If in a sensitive area

Further organisations and their requirements/remits:

- Local Planning Authority: all issues concerning building activities and engineering works, flood defences
- Scottish Environment Protection Agency: water quantity and quality issues
- Scottish Natural Heritage: impacts on natural heritage, access and designated sites
- Local Fishery Boards: protect, preserve and develop salmon fisheries; represent, co-ordinate and promote the interests of Scottish salmon and sea trout fisheries

General information required by SEPA:

- Outline description of scheme design, including a map of the scheme showing the location of each controlled activity being proposed.
- National grid reference of the location of each proposed controlled activity and photographs showing character of the river or loch at those locations (with a reference scale in the photograph).
- Maximum installed capacity (kilowatts) of the scheme and an estimate of the mean annual power expected to be generated (gigawatt hours).
- Minimum and maximum abstract flow for each intake, including minimum river flow at which generation will commerce.
- The "Hands off" flow proposed and the residual flow at maximum abstraction.
- Photographs of the river taken from the same point near the proposed impounding works at low downstream toe of the works to the crest or top of the spillway; and, where practicable, an estimate of the length, surface area and volume of the impoundment (i.e. the pool) expected to be created upstream of each intake structure.
- Details of fish screening measures planned for each intake structure.
- Details of the river flow that will pass over, through or around the intake structure into the downstream river, including how the flow will vary and how the design of the intake structure enables downstream flow to be provided.
- Detailed description of each proposed engineering works in, or likely to affect, the water environment, including temporary works during the construction of the scheme. The location, construction details (including materials) and dimensions of each works must be provided.

Further information required by SEPA:

- Hydrological information: evidence about river flows,
- Information on fish: assessment of the suitability for fish of the river habitat; identification likely natural barriers to fish migration upstream and downstream of the intake structure.
- Information on fish for schemes in Protected Areas Special Areas

- Information on other protected species for example freshwater pearl mussels, otters
- Morphological information requirements
- Built heritage information: Scheduled Ancient Monuments, Listed buildings or other sites or monuments which may be directly or indirectly affected by any of the controlled activities involved in constructing or operated proposed scheme.
- Landscape information requirement:
- Information on recreational use:

Sources of Help
There are many companies offering advice on hydro power and/or equipment in Scotland, but again hardly any in the Borders region (though this issue is secondary as it is not necessary for companies to be close to potential sites). Ampliflaire Ltd. is a local consultant and installer based in Kelso. Other companies are Gilbert Gilkes & Gordon Ltd., or Faber Maunsell Ltd. A comprehensive list of companies is attached in the Appendix.

Sources of funding.
It is worth noting that the Government is keen to support appropriate schemes and financial help is available to reduce the inevitable costs.

For householders:

1. **Energy Saving Scotland home renewables grant scheme**, [old name: Scottish Community and Householder Renewables Initiative (SCHRI)] provides grants to householders of up to 30% of the costs of the installation, to a maximum of £4,000

2. **Low Carbon Buildings Programme (LCBP)** Phase 1 is open to householders, public, not for profit and commercial organisations across the UK. You can apply for up to £2,500 per property towards the cost of microgeneration technologies. Phase 1 of the Low Carbon Buildings Programme is managed for DECC by the Energy Saving Trust. Tel: 0800 915 0990 Email: info@lowcarbonbuildings.org.uk

For communities:

1. **Communities and Renewable Energy Scheme (CARES).** CARES continues the support available for communities under the previous SCHRI
   Community Energy Scotland, 2b Fodderty Way, Dingwall Business Park, Dingwall IV 15 9XB Tel: 01349 860 120 Email: info@communityenergyscotland.org.uk

2. **Low Carbon Buildings Programme (LCBP)** Phase 2 is a new capital grant stream for the installation of microgeneration technologies by community organisations such as local housing authorities, housing associations, schools and other public sector buildings and charitable bodies. It is not open to householders or businesses. Low Carbon Buildings Programme - Phase 2, BRE Building 17 Garston, Watford WD25 9XX Tel: 08704 23 23 13 Email: info@lcbpphase2.org.uk

3. **Community Heritage Grant Programme "Windmill and waterwheel Challenge"**
   Grants will be available for community groups for the restoration and/or enhancing public access to windmills and watermills www.grantscape.org.uk
   Tel: 01908 545 780

4. **Climate Challenge Fund**

Keep Scotland Beautiful, Wallace House, 17-21 Maxwell Place, Stirling FK8 1JU. Telephone: 01786 471333. Fax: 01786 464611. Email: ksb@ksbscotland.org.uk

For Land Managers

1. Scottish Rural Development Programme, Land Management Options.

Appendix 1

1. Working hydro schemes:

Ironmacannie Mill
Chris and Jean Mason
Balmaclellan
New Galloway
Castle Douglas
Scotland DG7 3QS
Email: cjmason@dircon.co.uk

Natural Power Consultants ltd
The Green House
Forrest Estate
Dalry, Castle Douglas
DG7 3XS
SCOTLAND, UK
Tel: +44 (0) 1644 430 008
Fax: +44 (0) 1644 430 009

Polmood Hydro
ML12 6QN
Scottish Borders

Working Archimedes screw:

John and Jaqueline Riley
Semeil Farm
Aberdeenshire
AB36 8XJ Strathdon

Scotland
johnrileysemeil@hotmail.com
Tel: 01975 651382

Renewable Heritage Trust
2 Sudnicton Croft
Westow,
York
YO60 7NB
info@rht.greenisp.org
Tel: 01653 619748

2. Chiefly advice supplier (some equipment supplier at the same time as well)**:**

Gavin King-Smith
Tel: 01848 200770
Email: gkingsmith@gmail.com
(Has been involved in a lot of hydro schemes in D&G, provides map based survey and sizing, site visit, guidance on net steps)

Nick Forrest Associates
Nick Forrest, Director
62/2 TemplePark Crescent
Edinburgh EH11 1HY
tel: 0131 622 0065
mob: 07784 066 445
email: nick@hydrobot.co.uk

Garbhaig Hydro Power Co Ltd
Mr D McKenzie
Campbell Dallas LLP, Chartered Accountants, 15 Gladstone Place, Stirling, FK8 2NX
fax: 01786 460030
email: david@davidjtmckenzie.co.uk

Napier university
SEBE, Merchiston Campus, Edinburgh, EH10 5DT
tel: 0131 455 2324
fax: 0131 455 2264
email: d.henderson@napier.ac.uk
web: http://www.napier.ac.uk

Search
Richard Langley
Laurieston Hall, Castle Douglas, Kirkuds, Scotland, DG7 2NB

tel: 01644 450 670
fax: 01644 450 670
email: richardlangley@btinternet.com

Energy4All Limited
Unit 33, Trinity Enterprise Centre
Furness Business Park
Barrow-in-Furness
Cumbria
LA14 2PN
Tel: 01229 821028
Email: info@energy4all.co.uk

Faber Maunsell Ltd
Dunedin House, 25 Ravelston Terrace, Edinburgh, EH4 3TP
tel: 0131 311 4000
fax: 0131 311 4090
email: ken.turnbull@fabermaunsell.com web: http://www.fabermaunsell.com

Ampliflaire
Off the Square Trade Center, Kelso,
Scotland TD5 7JH
tel: 01573 225209
fax: 01573 225886
email: jeanwarwick@talktalk.net
web: http://www.ampliflaire.co.uk

3. Mainly equipment supplier (certainly providing also advice):

Renewable Devices Energy Solutions
SAC Bush Estate, Penicuik, EH26 0PH
tel: 0131 535 3403
web: http://www.rdenergysolutions.com
email: sheila.drummond@rdenergysolutions.com

Weir Power and Industrial
Alloa Works, The Harlands, Alloa, Clackmannanshire, FK10 1TB
tel: 01259 727524
fax: 01259 725805
email: a.wilson@weir.co.uk
web: http://www.weirservices.co.uk

Swithenbanks Alternative Energy Ltd.
18 School House Drive
Seamer
Scarborough
North Yorkshire
YO12 4PP
Email: info@swithenbanks.co.uk
Tel/Fax: 01723 865809

Encraft
6b Park Street
Leamington Spa CV32 4QN
tel: 01926 312159
fax: 01926 882636
email: enquiries@encraft.co.uk

Enviko Ltd.
The Old Manse,
Rothiemurchus,
Aviemore,
Inverness-shire,
PH22 1QP
tel: +44 (0)1479 230302
fax: +44 (0)1479 810451
email: info@Enviko.com

Navitron Ltd.
2 Lands End Way
Oakham
Rutland
LE15 6RB
tel: 01572 725512
fax: 01572 724390
email: sales@navitron.org.uk

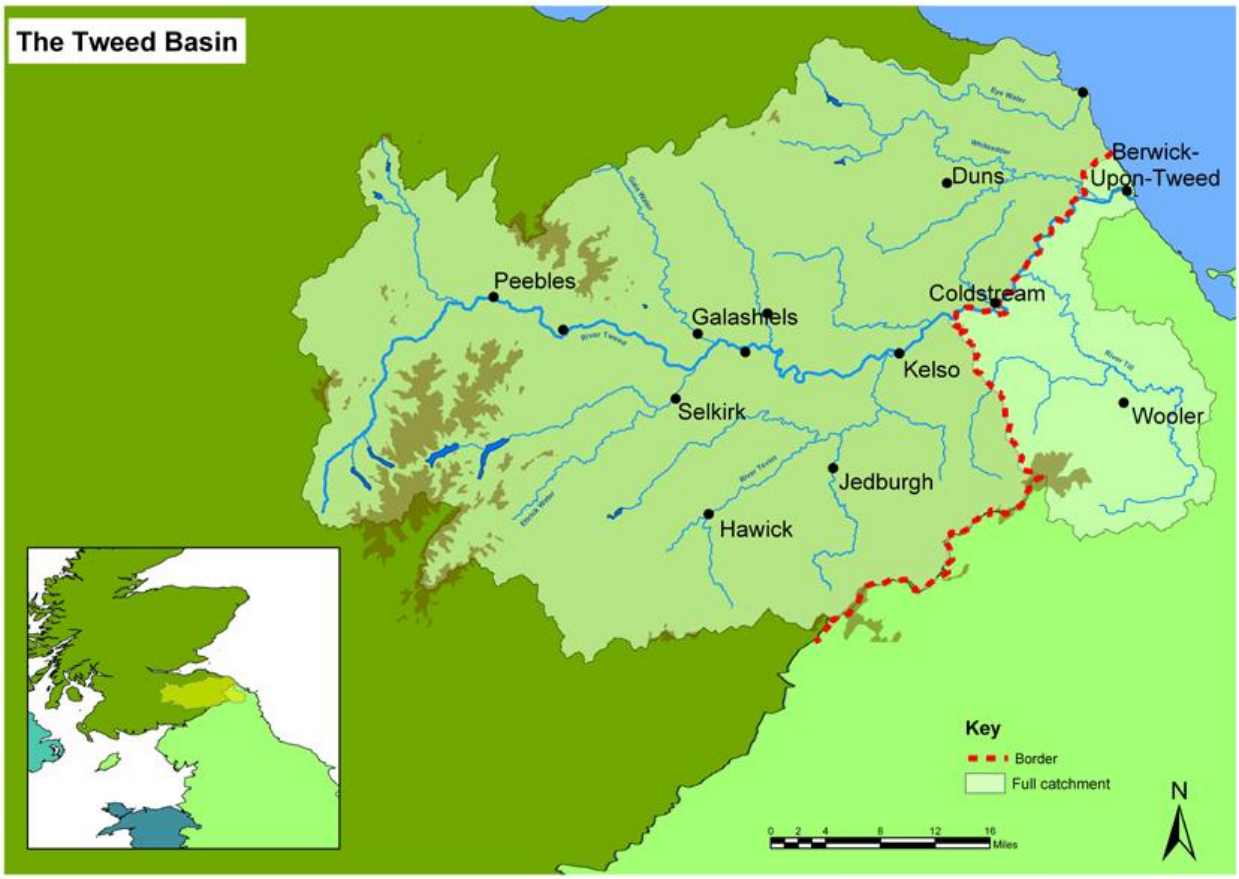
Gilbert Gilkes & Gordon Ltd
Canal Head North, Kendal, Cumbria LA9 7BZ
Registration No. 173768
Tel: 01539 720028
Fax: 01539 732110
enquiries@gilkes.com

Segen Ltd			
Aldershot Office Wesley Hall Barrack Road Aldershot Hants GU11 3NP	**Stroud Office** Wimberley Mill Knapp Lane Brimscombe Stroud GL5 2TH	**Bolton Office** Unit 2, Northgate Close Horwich Bolton BL6 6PQ	**Lancaster Office** CityLab 4-6 Dalton Square Lancaster LA1 1PP
tel: 0845 094 2445 fax: 0845 094 1803			

Appendix 2

Images of St. Mary's Lochs discharge which show the high potential for hydro power. Much of the work required for a hydro scheme is already in place.

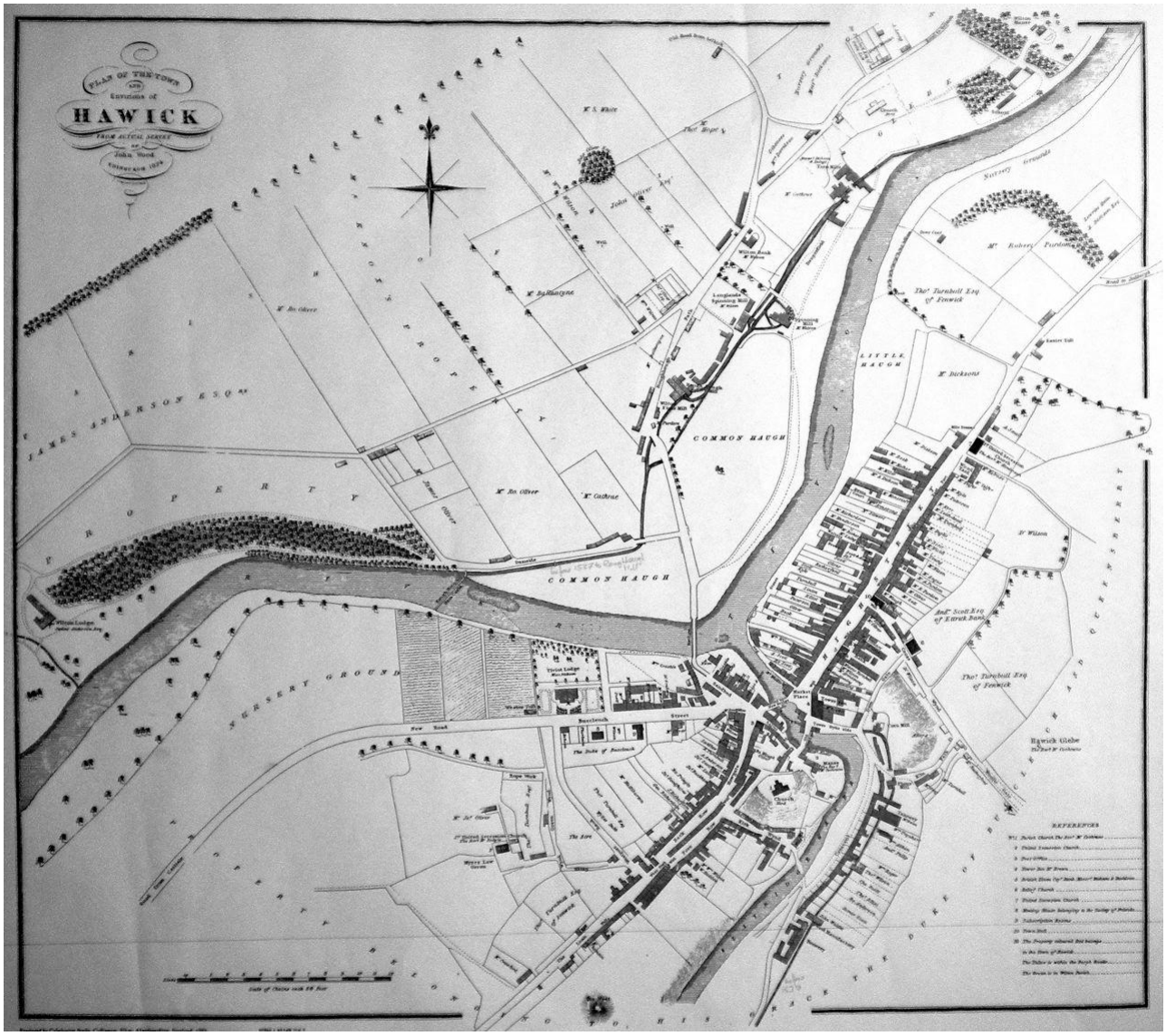
River Tweed catchment



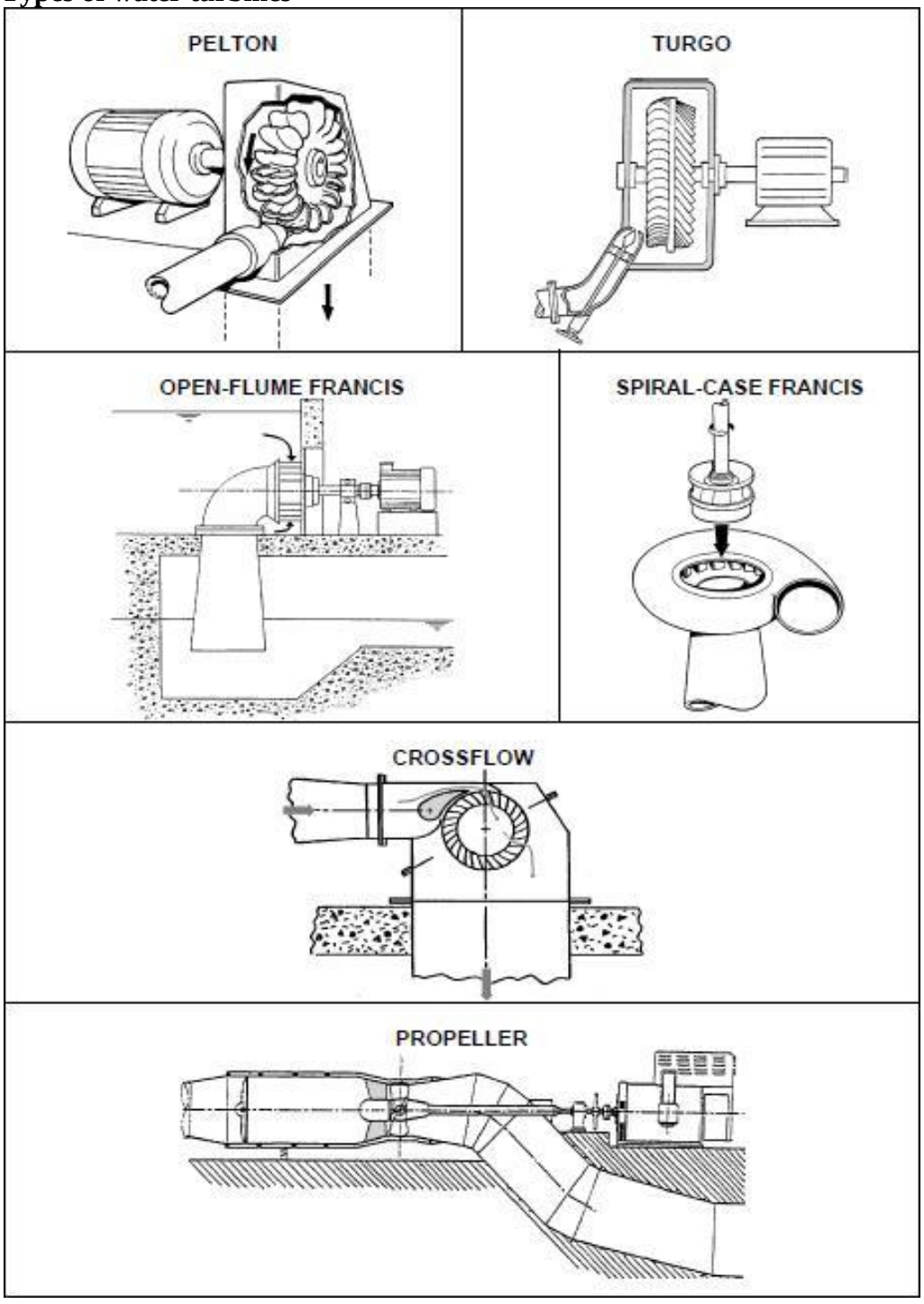
Archimedes Screw

Originally the Archimedes screw was invented and developed for pushing water uphill. To generate electricity you reverse the process so that the weight of the water turns the screw. Furthermore it is fish-friendly. Fish could be carried up and down without getting hurt.

Map of Hawick showing the locations of former mills and the lades that delivered water to drive them.



Types of water turbines



The Pelton and Turgo turbines are so-called impulse turbines. These turbines change the direction of flow of a high velocity fluid jet. The resulting impulse spins the turbine and leaves the fluid flow with diminished kinetic energy. There is no pressure change of the fluid in the turbine rotor blades. Before reaching the turbine the fluid's pressure head is changed to velocity head by accelerating the fluid with a nozzle.
Kaplan and Francis turbines are reaction turbines. These turbines develop torque by reacting to the fluid's pressure or weight. The pressure of the fluid changes as it passes through the turbine rotor blades. A pressure casement is needed to contain the working fluid as it acts on the turbine stage(s) or the turbine must be fully immersed in the fluid flow. The casing contains and directs the fluid and maintains the suction imparted by the draft tube.

Useful links:

http://www.scotborders.gov.uk/pdf/20328.pdf
http://www.british-hydro.org/
http://www.british-hydro.co.uk/
http://www.therenewableenergycentre.co.uk/hydroelectric-power/small-scale-hydroelectric-system-suppliers/
http://www1.eere.energy.gov/windandhydro/hydro_turbine_types.html
http://www.forestry.gov.uk/pdf/HydroBriefingdocumentfinal.pdf/$FILE/HydroBriefingdocumentfinal.pdf
http://www.keepscotlandbeautiful.org/ccf.asp