Hydro Potential of Dighty Water

Preliminary Feasibility Study (with amendments)

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PREAMBLE - HYDROELECTRIC SCHEMES

The following paragraphs provide some general background information regarding the development of a small hydroelectric scheme.

▪ Scheme Description

Typically, most hydroelectric schemes being commercially developed in the UK today are relatively small scale, 'run of river' schemes which do not require a large volume of water stored behind a massive dam.

Typically, 'run of river' schemes draw water directly from the river via an intake built into a simple weir. The weir is built across the stream, diverting some of the water through a screen into a chamber and from here into a pipeline. This carries the water down to the water turbine, through which it passes before returning back into the river.

The turbine is housed in a small powerhouse, along with the generator, transformer and electrical switchgear. From here, the electrical energy is metered and delivered, usually via overhead cable, to the nearest available existing power line.

Most systems are fully automated and controlled remotely. Schemes are designed to last and one can expect a hydro scheme to operate for at least 40 years, if well maintained.

Smaller domestic scale schemes can also be built. Electricity generated by these schemes can be used entirely on-site, however for schemes close to the grid network, it is most cost effective for the system to be connected to the grid, so that 'surplus' electricity can be sold to a power supply company. The components and layout of a domestic scale scheme are very similar to a commercial scale scheme, though usually the control system is less automated.

▪ Planning

All hydro project proposals are subject to scrutiny by local and national regulatory bodies to ensure every scheme built conforms to the required standards. Planning applications for schemes less than 1MW are submitted to the local planning authority.

▪ Government Policy

Hydropower, like other forms of renewable energy, is supported by the UK and Scottish governments through a Feed in Tariff scheme (FITS). FITS are receivable for all new hydro generation, both for commercial grid connected schemes and for smaller 'stand alone' domestic scale schemes. (For sub 50kW schemes, both equipment and installation must be supplied and installed by an accredited company.) The rates that are paid under the FITS scheme are favorable to smaller schemes and these payments now make it possible to develop economically viable hydro projects on suitable sites in Scotland.

Details of the FIT scheme are set out in the government Department for Energy and Climate Change paper published in February 2010. This document can be obtained by clicking on the following link.
http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/policy/feedin_tarriff/feedin_tarriff.aspx

More information on FITS relevant to the hydro scheme assessed in this report can be found on pages 7 and 8.

CONTENTS

AMENDMENTS - Section 4, on page 5 subsection Powerhouse and on page six, subsection Access.

1 INTRODUCTION

Search (Richard Langley) has been commissioned by Ann Lolley on behalf of DightyConnect to carry out a preliminary study to report on the potential for generating hydroelectricity using water flowing in the middle-lower reaches of Dighty Water, Dundee.

The river rises in four head streams in the Sidlaw hills to the north west of the city and flows east-south-east to discharge into the Firth of Tay some 3km beyond Broughty Ferry. This report has looked at sites identified by Ann Lolley in the stretch of river which passes through the northern edge of Dundee, between Trottick and Balmossie. This whole stretch falls generally at a very shallow gradient.

Map 380 of the OS Pathfinder 1:25,000 series shows the full extent of the river.

The following sections of this report are based on a walkover site survey, email correspondence with the client, OS map data and a technical resource assessment using LowFlows and Hydra software, developed by the UK Institute of Hydrology.

2 EXISTING INFRASTRUCTURE

The stretch of river we looked at has a long history of providing power for small industrial mills. Remnants of weirs, leats and channels are shown on the OS maps and were found at several sites along the river during the walkover survey. All were disused and generally in poor condition.

Two sites were identified where renovation may be feasible, see *Fig 1* below.

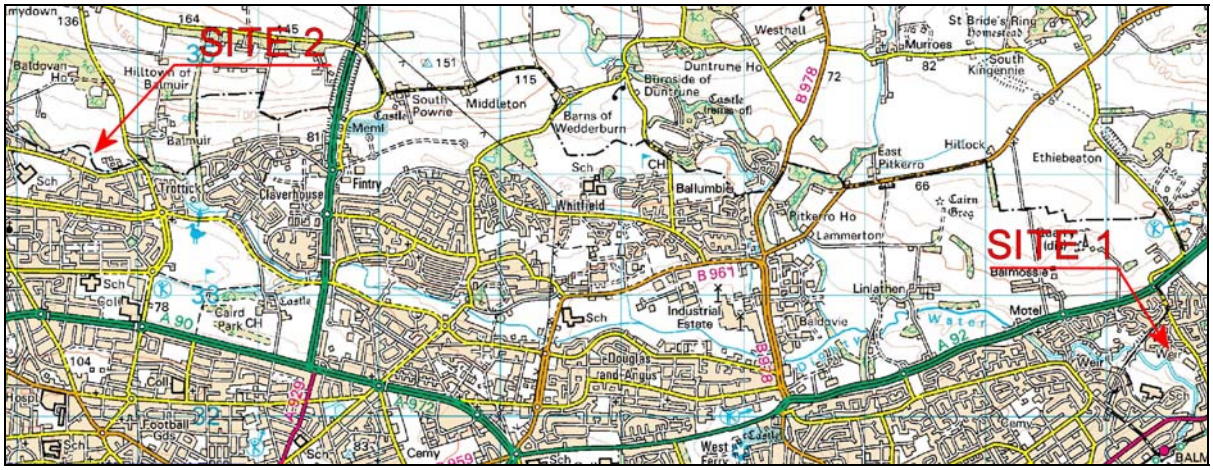

Fig 1. Site locations

Site 1, some 800m upstream from the river outfall into the Tay estuary, where there are remains of a substantial concrete capped stone weir which has been breached. At one side of the weir there is an old stone lined channel leading from it, running downstream along the north river bank. This site is believed to be on council owned land, with well made footpaths accessible to the public, although no access has been made to the river itself, perhaps because of (historic) poor water quality.

Site 2, about 12 km from the river outfall, where there are the remains of another stone/concrete weir and a long overgrown stone channel, leading to an extensive and mostly silted up mill pond, all to the north side of the river. At the far end of the pond there is a forebay tank with the remains of an open flume Francis type turbine and generator. This site is wholly owned by one landowner; however an agreement to re-build the weir will need to be obtained from the landowner of the opposite bank.

3 SCHEME OPTIONS

Both sites make use of steeper sections of river, but even so the falls are shallow and the heads (difference between the upstream water level at the intake and the water level at the outfall) available for power generation are small. Schemes using these sites will be very low head type.

At site 1, the intention would be to renovate/rebuild the weir and channel and install a water turbine at the downstream end, with the water discharging back into the burn.

A level survey was not carried out, but from observation, the head available at site 1 was estimated to be between 3 to 5 metres.

At site 2, the procedure would be similar, but include the restoration of the mill pond. Estimated head at site 2 is between 2 to 3 metres.

Despite these low heads, flows in the river are quite substantial. At site 1, a 'run of river' scheme with capacity up to around 40 kW is theoretically achievable and for site 2, which has the potential for some water storage, up to 15kW.

Schemes with capacities within this range can be grid connected.

A measured survey will be required at each site, to accurately determine the drop between the intake and the proposed powerhouse site, from which actual scheme capacities and electrical outputs can be calculated.

SCHEME COMPONENTS AND CONSTRUCTION

At both sites, the scheme will consist of the following main components:-

- **Intake** Construction of a new weir, on the site of the remains of the old one. The new weir would provide the facility to divert water into the existing stone channel. A new penstock gate to regulate flows into the channel would be required.

Fig 2. Remains of old 2m high weir with channel entry (near side).

- **Channel** Excavation of the existing stone channel. Depending on the condition of the existing structure; if reasonable then renovation; if poor then the channel would be used to carry a low pressure pipeline. N.B. The dimensions and gradient of the channel will determine the maximum flow rate to the turbine.
- **Forebay tank** At the downstream end of the channel:- at site 1, no forebay tank was found, so most likely a new reinforced concrete forebay tank would be required. At site 2, the existing forebay tank is in reasonable condition, so renovation could be carried out. In addition, silt and vegetation in the head pond at site 2 would be cleared out and a second penstock gate will be required, to regulate flows into the forebay tank.
- **Turbine/Generator/Control.** Crossflow or possibly Archimedes screw type turbines would be the most suitable machines for both sites.
- **Powerhouse.** No powerhouse as such would be required if an Archimedes type turbine is installed, however such turbine will need to be mounted on a substantial reinforced concrete foundation which would enclose the generator and control system. A Crossflow type turbine on the other hand will need a powerhouse. The building would be single storey, ‘double garage’ size. A short track will be required for either turbine option, to get access for construction/installation.
- **Transmission** An electrical connection is required, either overhead line or buried cable, to link the generator through system control to the grid.
- **Installation/commissioning** Building the new weirs will be the most challenging part of construction. Otherwise the scale of works is relatively small and with a set of detail drawings and method statements, the civil engineering construction works could be undertaken by a competent local contractor. The work is best carried out over the months April through September. Overall, scheme construction and commissioning is expected to take up to eight months to complete.

Construction methods and installation of components will be similar at both sites, but the river is wider and runs in a shallow gorge at site 1 and the river banks and surrounding land are accessible to the public, so construction presents more of a challenge at this site. One of the main issues will be gaining access to the site.

- **Access** There is no vehicular access to any part of site 1, although there is access to the wide public footpaths along the north riverbank, fairly close by the old weir site. The old channel runs along this side of the river too, so access to build the scheme is most suitable from the north bank. However the bank is high and steep here, so making an access road through to the river will require excavation, removal and landscaping of considerable amounts of material. (Access ways to the old weir site, along the channel and to the turbine site are all required). During construction some parts of an existing public amenity would have to be fenced off and made secure.

  At site 2, access to the site would be through the driveway to the landowner's house.

5 HYDROLOGY

Method

The generating capacity of a site depends on the amount of water (rainfall/runoff) available from the river catchment area upstream of the intake site. Predicting the availability of water from a catchment requires a hydrological assessment. The assessment in this report is made using HydrA software with figures checked using LowFlows 2000 and actual long term flow records at SEPA gauging station . Both methods use long term average annual rainfall and evaporation databases and soil characteristics, to estimate the mean flow and low flow statistics for the catchment and to derive the flow duration curve. The results of this assessment are detailed later in this section. As it happens, there is a SEPA gauging station at Balmossie and river flows have been recorded here over many years.

Abstraction

Building and operating a hydro scheme on these sites will require a license from SEPA in accordance with the Water Environment (Controlled Activities) Scotland Regulations 2004.

Amongst other things, the license will set out permitted abstraction and compensation flow rates and define flow monitoring requirements. The regulations do not permit the abstraction of the entire stream flow, but require a proportion of the flow (compensation flow) to remain in the river, to safeguard the aquatic environment within the stream. In general, SEPA sets minimum compensation flows of between Q90 and Q95 for hydro schemes. (These flow rates can be visualised as the flows seen during the drier summer months).

Catchment characteristics

The catchment boundaries of the burn for site 1 have been plotted on the OS map shown in *Fig. 2* below. Catchment boundaries for site 2 are not shown.

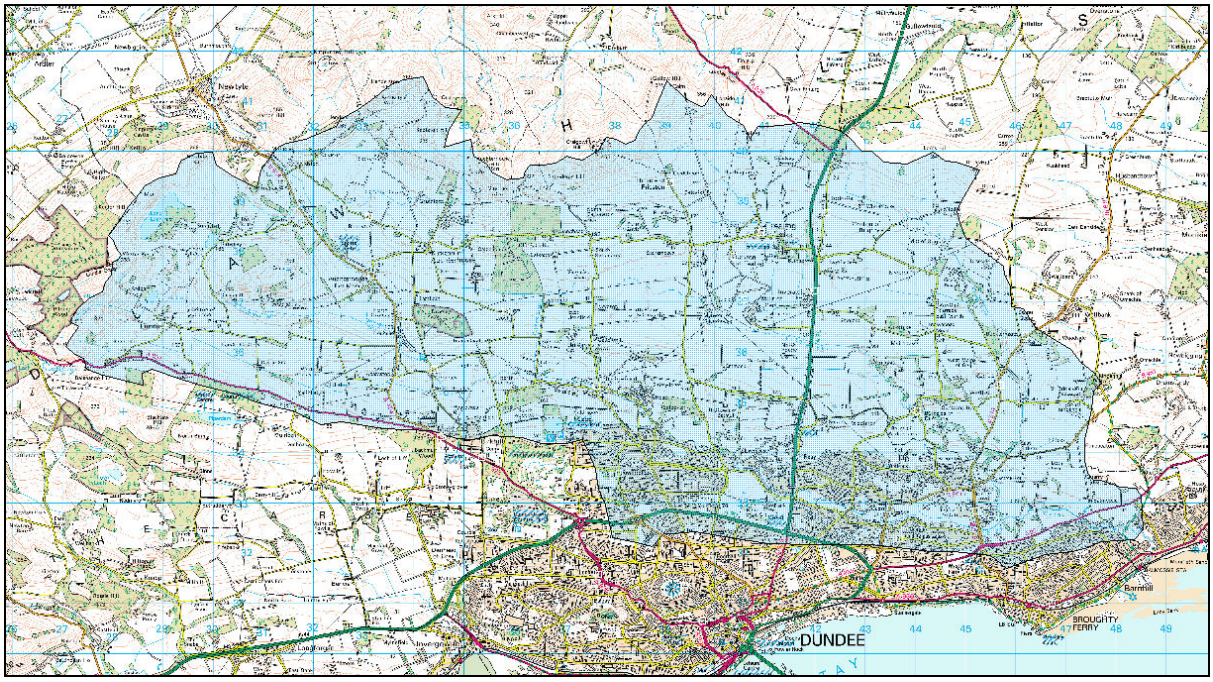

Fig. 2 Catchment boundaries for intake at site 1

The catchment coordinates input to HydrA and LowFlows provide the catchment characteristics shown below in *Table 1*. The recorded figures from the SEPA gauging station very close to site 1 are also included in the table. HydrA figures for site 2 are also tabulated.

Catchment Characteristics	Dighty Water - Site 1			Site 2
Method	HydrA	LowFlows	SEPA	HydrA
Catchment area	126.0 km2	126.0 km2	126.9 km2	60.2 km2
Rainfall (average annual)	825 mm	n/a	798 mm	853 mm
Potential evaporation (avan)	450mm	n/a	n/a	448 mm
Mean flow estimate Qm	1.54 m3/sec	1.52 m3/sec	1.56 m3/sec	0.77 m3/sec
Q95 (absolute)	0.23 m3/sec	0.22 m3/sec	0.24 m3/sec	0.14 m3/sec

Table 1

Both prediction methods for site 1 agree well with the actual flows measured at the SEPA gauging station known as:-

DIGHTY WATER AT BALMOSSIE MILL, STATION NO. 14002 - GRID REF: NO 477 324

6 SCHEME CAPACITIES AND ENERGY OUTPUTS

Performance figures for the schemes have been calculated using the hydrological data generated from the catchment analysis. HydrA output figures assume 'run of river' schemes, variable compensation flows ranging from Q85 to Q95 and no seepage past the intake weir. Performance figures are shown in Table 2 below.

Scheme Capacities and Energy Outputs					
Scheme	Estimated Gross Head m **	Rated Flow l/s	Turbine Type	Rated Capacity kW	Net Annual Output MWh
1	4m	1500 l/sec	Crossflow	40	170
2	3m	700 l/sec	Crossflow	14	58

Table 2

** Estimated gross heads need to be confirmed by level survey.

7 SCHEME COSTS

Detailed scheme costs are outwith the scope of this report. In general low head schemes of this capacity range, where existing infrastructure is in poor condition, are expensive to re-build and very unlikely to be of interest to commercial developers. Costs could be as high as £10k/installed kW. i.e. up to £400,000 for the biggest scheme at site 1, perhaps more if the scheme is built to provide accessibility. It is considered unlikely that either scheme proposed will be cost effective. Building smaller capacity schemes would reduce capital costs, but cost/kW installed would go up and cost effectiveness would almost certainly be less.

More detailed cost estimates would be drawn up in stage 1 of the development plan, see Section 10 below, on page 11.

Whilst cost effectiveness is poor, developing these schemes would bring benefit:- a contribution to reducing CO_2 emissions (albeit small); additional value to local assets and the scheme at site 1 could also be made accessible and a focus of interest to the local community.

8 VALUE OF ELECTRICITY GENERATED

The schemes would qualify for FITs. The FITs payments will consist of two parts:-

- For the scheme at site 1 a generation tariff of 17.8p for every kWh of electricity generated; for site 2 19.9p/kWh. These payments will be made for a period of 20 years (index linked) from the date of commissioning.
- For both schemes an export tariff, paid for all electricity exported to the grid. The export tariff can be either 3p/kWh guaranteed, or generators can opt to sell their electricity on the open market. These payments continue for the lifetime of the scheme (50 years +). Whilst this option has some degree of risk attached, the medium term market value of electricity is around 5p/kWh, so selling into the market is recommended.

Annual Revenues/Costs						
Scheme	Capacity kW	Annual Output MWh	Generation revenue £k	Electricity * revenue £k	Annual Running Costs £k	Annual Net revenue £k
1	40	170	30.3	8.5	6	32.8
2	14	58	11.5	2.9	3	11.4

Table 3

* Figures based on electricity value of 5p/Kwh

All the above figures are indicative only and subject to more detailed analysis.

9 CONSENTS/ENVIRONMENT

Currently any hydro development requires a CAR licence from SEPA, authorizing the impoundment (intake weir) and the abstraction of water for the scheme. The cost of making a licence application for schemes of this size is just under £600.

Planning consent is also required - the cost of an application depends on the size and extent of the particular scheme. Dundee City and Angus Council's current fee structures charge £319 per 0.1 hectare of site development area. Negotiations are usually required to determine the fee; given the small scale of these projects the fee is not expected to exceed £500.

In addition to the application charges, the Authorities can require the proposed development to be advertised in the press and this can add to costs.

For hydro schemes, the consenting bodies' primary concerns will be to ensure that the visual and environmental impacts of the development are within acceptable limits. Both schemes are renovations of previously used sites and this may favour a re-development.

Given both schemes are in an urban setting, so getting general approval from neighbours/local community is recommended for a smooth consenting process, particularly for the scheme at site 1, where construction operations will require barring access to part of a locally important amenity for up to 8 months. However, once built, most parts of this scheme could be made accessible to the public, opening up what is now an area almost impenetrable because of it's steepness and thick vegetation.

Environmental Concerns

Recent guidelines for 'run of river' hydro schemes issued by SEPA state that in general, shallow gradient rivers (such as Dighty Water) are not considered suitable for the development of small (<100kW) schemes. However a web search has shown that (the lower reaches of) Dighty Water is classified as having less than 'good' river status, so the above guideline may not apply.

If there are any fishing interests, SEPA may require the developer to carry out surveys to inform the CAR licence application.

A search on the Scottish Natural Heritage web site shows there are no designated sites of national or international importance in the vicinity of the hydro sites. Whilst this suggests that SNH are unlikely to object to the scheme, this will depend on the local importance of the sites. At site 1 the river banks are wooded and some trees would need to be felled to get access to build the scheme. At scheme 2 the silted up mill pond is now full of bog-loving plants - these may have some local importance. At both sites surveys for protected species such as otter may be requested.

10 PROJECT DEVELOPMENT

The procedure for developing the hydro scheme up to the point of build is split into two stages. Stage 1 covers those items required for obtaining consents and Stage 2 covers detailed scheme design.

Stage 1

1. Full feasibility study, including measured site survey
2. Grid connection application (Scottish Power).
3. Consulting with Planners, SEPA, SNH & Historic Scotland. **N.B.** Depending on the sensitivities at the site, consultees may require expert surveys/reports to be carried out, as part of the consenting process.
4. Draw up and submit planning application and CAR licence application.

The Stage 1 process will take at least 12 months to work through, once a decision to go ahead has been made. Completing stage 1 will incur considerable costs.

Stage 2

Assuming successful completion of stage 1 and once consents are in place, the following steps are required (not necessarily in order shown)

1. Preparation of detailed design, drawings, specification and bills of quantities.
2. Finalise construction method statement, environmental management and CDM plans
3. Obtain quotations from civil engineering contractors.
4. Draw up supply and construction contracts and engage suppliers and contractors.

Stage 2 is likely to take at least six months to complete.

Given the above timescales and allowing for inevitable delays I would not expect construction to start before spring 2013.

11 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

- Two pre-existing sites were identified that could be redeveloped to support low head ‘run of river’ hydro schemes up to around 40kW capacity at site 1 and 15kW at site 2.
- A SEPA operated gauging station on Dighty Water has long term records of flows, providing a very good basis for calculating power and energy potential; however level surveys at both sites are required to accurately measure available head, required to do the calculations.
- Remaining structures at the sites are in poor condition, but parts may be possible to renovate and re-use.
- Crossflow or Archimedes screw type turbines are considered most suitable for these sites.
- The scale of works is relatively small and with a set of detail drawings and method statements, the civil works could be undertaken by a competent local contractor.
- Access to the river to build at site 1 is through ‘public’ ground and will require excavation, removal and landscaping of considerable amounts of material. Part of the public space will need to be fenced off and made secure during construction.
- Both schemes will make a contribution towards reducing carbon emissions, but neither is considered cost effective.
- Both schemes, particularly the scheme at site 1, would need consistent strong support from the local community and public bodies to be successful.

Recommendations

If cost effectiveness is not the overriding issue, then Stage 1 of project development can be initiated. To start the process, the next steps are recommended to proceed as priority:-

- Check out responses to proposal from local community and public bodies (site 1)
- For both sites, request scoping opinion from SEPA and local planning office
- Check out land ownership.
- Carry out level surveys to measure available head to calculate capacities and outputs
- Make enquiries to S&SE regards grid connection

END