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Maraig Micro-Hydro

Preliminary Design Report

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Contents

Brideswell, Cushnie, Alford, Aberdeenshire, AB33 8LD

1. Non-Expert Summary

1.1. System Overview

Details of the system components and layout are available in drawings 13018D001 and 13018D002. In summary it will consist of the following basic components:

- An intake weir and header tank to take water from the burn; because the system is run-of-river there will be no storage reservoir
- A buried pipeline to transfer the water to the turbine
- A turbine house containing a turbine, generator and controller
- A tailrace channel returning water to the burn
- A buried cable from the turbine house to the connection point

1.2. Proposed Turbine

Turbine type	Cross-flow
Turbine maximum power	49.6 kW
Expected annual energy yield	237,912 kWh or 65 average UK households[1]
Expected annual CO2 saving	115 tonnes[2]

1.3. Planning Considerations

All development has an impact on the landscape and local environment. By its nature hydro-power will have little long-term visual impact on the landscape and statutory noise limits are easily achieved through appropriate design of the turbine house.

Scottish Ministers support the development of all forms of renewable energy and wish to see an increase in the production of electricity from the smaller-scale sources as outlined in Scottish Planning Policy 6 [3].

Under the Controlled Activities Regulations (CAR) SEPA are responsible for defining acceptable deviations from the natural flow regime of a watercourse. They also authorise construction activities within water bodies. The planning authorities are responsible for balancing a wider range of social, cultural, economic and environmental issues. Planning Advice Note 51, paragraph 51, states that the water flow regime, passage of fish and modification of the river banks and bed are best addressed by CAR [4].

The general layout of this system has been designed to minimise any impact to local habitats. The risk to protected species can generally be mitigated against through the use of sensitive construction methods. Scottish Natural Heritage (SNH) will be able to advise if further work is required to assess or mitigate the risk to specific species.

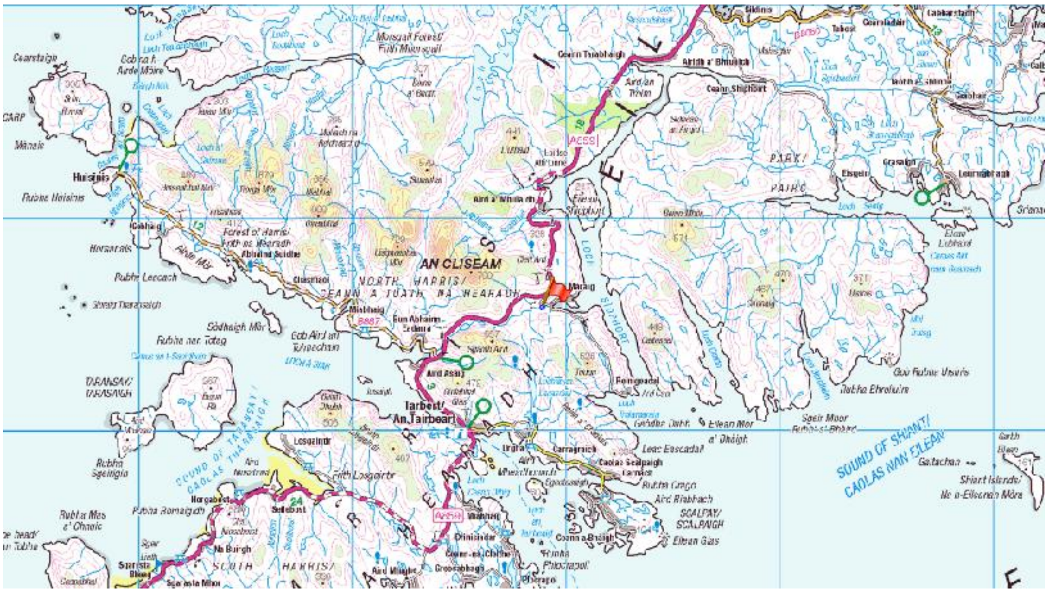
[1] Assuming an average annual electrical demand of 3,638 kWh per household [1]

[2] Based on the UK energy mix in 2005 [2]

2. Property Details

The site is located at NB 1940 0581, around 48 km south west of Stornoway. The Abhainn Mharaig is fed by a small mountainous catchment.

Site Location



The site is located in Maraig which is accessed via a single track road off the A859. New access tracks to the intake and turbine house will be required. The turbine house track could follow the route of the existing footpath.

3. System Design

As outlined in the scoping report the potential for this site is far greater than the current 50kW grid restriction will allow. In an attempt to future proof the system, in light of the restriction, the intake and pipeline have been designed to take enough flow to generate 100kW.

We are currently working with Community Energy Scotland on another community hydro project looking at means of using excess power locally. This may be something you wish to consider to maximise the potential of the site.

3.1. Operating Principles

The system will generate clean, renewable electricity in the following way:

- Water is abstracted from the watercourse at the intake weir. The amount of water abstracted is controlled automatically by the turbine.
- A buried pipeline then carries the water, under pressure, to the turbine shed lower down the watercourse
- A turbine and generator are attached to the end of the pipe and convert the energy in the water into electricity. These are housed within the turbine shed.
- A buried, low-voltage electrical cable then carries the electricity to the connection point.

3.2. System Efficiency and Power Output

The maximum power, annual energy yield and expected efficiency of the system are given below [10]:

Overall system efficiency[3]	67.7 %
Maximum Power	49.6 kW
Expected annual energy yield	237,912 kWh
Capacity Factor	54.8 %
Expected annual CO2 saving	115 tonnes

3.3. Flow Regime

It is necessary to balance the environmental impacts of reducing the flow along a section of watercourse against the socio-economic and wider environmental benefits to be gained from the system. To this end the following flow regime is proposed:

Minimum abstracted flow	0 l/s
Maximum abstracted flow (design flow)	241 l/s

[3] Accounting for intake and pipeline losses; turbine, drive-train and generator efficiencies and electrical cable losses

Mitigation flow[4]	Minimum of Q90 (55 l/s), increasing to Q80 (86 l/s) at Q30

Further information on the proposed abstraction regime can be found in Appendix I while the mechanism for ensuring the mitigation flow is maintained is explained in Section 3.4.1

3.4. Component Details

The system will consist of the following components, as illustrated in Appendix II:

- Intake – diverts water from the burn
- Pipeline – carries water to the turbine
- Turbine house – contains the turbine, generator and controller
- Tailrace – returns water to the burn
- Transmission cable – carries electricity to the connection point.

3.4.1. Intake

Location and Design	See drawings 13018D001 and 13018D002
Weir construction	Concrete
Fish pass	No – impassable obstacle downstream,
Mitigation flow mechanism	Passive: profiled plate mounted lower than intake crest
Intake screening	Wedge-wire screen, maximum aperture = 1 mm
Intake head loss	0.7 m
Cleaning mechanism	Passive: self-cleaning by overspill wash
De-watering mechanism	Removal of mitigation plate
Maintenance regime	Monthly inspection, annual de-water and service

[4] The flow to be left running down the depleted reach when the turbine is operating

3.4.2. Pipeline

Route	See drawing 13018D002
Maintenance/emergency shut-off mechanism	Sluice at intake
Maintenance access locations	Intake and turbine manifold
Construction access	Semi-permanent track along trench. Topsoil reinstated on backfill.
Maintenance regime	Annual inspection, swabbing every 5 years
Section 1	
Type	PE100 SDR 26
Length	350 m
Nominal Diameter	560 mm
Pressure Rating	6 Bar
Bedding/trench requirements	Buried with a cover of at least 0.9 m. Pipe bedded and covered with riddled or crushed material with a maximum dimension of 50 mm.
Head loss	0.74 m

3.4.3. Turbine, Generator and Controller

Turbine type	Cross-flow
Design flow	241 l/s
Net head at turbine design flow	29.5 m
Turbine mechanical efficiency (at design flow)	79 %
Generator type	Induction, asynchronous
Generator/drive train efficiency (at design flow)	90 %
Controller type	Electronic generator controller. Intelligent flow control using head level sensor in header tank at intake.
Sensor cable to intake	2 X SWA, 1.5 mm^2, 3-core
Flow control mechanism	Actuator controlled, variable nozzle on turbine.
Maintenance regime	Monthly inspection, annual service

3.4.4. Turbine Housing

Location	See drawings 13018D001 and 13018D002
Foundation	Reinforced concrete
Construction	Steel portal frame
Roofing	Box profile metal sheet
Cladding	Box profile metal sheet
Lighting	Corrugated plastic roof-lights and low-energy internal lighting
Lifting provision	Portable gantry required

3.4.5. Tailrace

Location	See drawing 13018D002
Type	Piped
Screening	Maximum 20 mm bar spacing on exit of turbine house

3.5. Electrical Connection

Connection type	2-Phase
Maximum current per-phase	103.3 A
Connected under engineering recommendation	G59/2
Witness testing required?	Yes
Electrical protection	All electrical equipment to be protected to IP55 specifications
Earthing arrangement	All equipment bonded to mains earth. Additional local earth spike at turbine house if required.
Production metering	Ofgem approved kWh meter within turbine house
Export metering	To be arranged with power supplier
Length of cable to connection point	50 m
Cable specification	SWA Copper conductor, 70 mm^2, 3-core
Losses in cable at peak power	1.12 %

4. Design Constraints

The system as detailed in Section 3 had been designed to account for the following constraints.

4.1. Key Parameters

The scale and type of hydro-electric turbine that can be installed at this site is determined by the following parameters:

Average flow in watercourse	560 l/s [8]
Gross head	31 m
Distance between intake and tailrace exit to achieve this head[5]	375 m

4.2. Hydrology

Information on the flow characteristics of the watercourse can be found in Appendix I

To verify the computer flow prediction used in this analysis it is strongly recommended that the client takes regular digital photographs of a reference point on the watercourse between the intake and tailrace exit locations, noting the date and time that the photograph was taken. A scale staff (meter stick) should be visible within the photos to allow qualitative assessment of the flow.

4.3. Terrain and Habitat

Details of the terrain along with observations on the aquatic and riparian habitat are available in Appendix II.

[5] Measured down the centre of the watercourse

4.4. Designations

Landscape and habitat designations as detailed by SNH [7] are detailed below:

Designation	Yes	No
SSSI		X
RAMSAR		X
Special Protection Area		X
Special Area of Conservation		X
National Nature Reserve		X
National Scenic Area	X	

4.5. Protected Species

There are a number of key species which, if present, could be affected by the development. SNH and SEPA will be able to advise on the likelihood of their presence and additional survey requirements.

The species that are most likely to be present will vary from site to site but the primary species that can be affected by a micro-hydro installation are otter, water vole, badger, red squirrel, nesting birds, salmon, sea trout, lamprey and fresh-water pearl mussel.

The potential risks to these species arise from disturbance during construction, injury from passing through the turbine and loss of habitat. These risks can be mitigated against through implementation of suitable precautions during construction and have been addressed by the design and layout of the system as a whole.

Different species are at risk at different times of the year. For example salmon and trout are more sensitive during the migration and spawning season (generally autumn to early winter) while nesting birds are more sensitive in spring and early summer. As a result it is impossible to define a construction window to suit all species. Instead some general principals should be followed:

- In-river works should not be undertaken during the Salmonid spawning season
- General construction should take place during the driest months to minimise damage to ground-cover and avoid the risk of sediment pollution
- If extensive areas of the site are suitable for ground nesting birds (not heavily grazed or cropped) then a breeding bird survey should be undertaken immediately prior to construction if it is due to begin within the bird nesting season (1st March to 31st July).

To minimise the risk of disturbance of protected species during construction the method statement contained in Appendix III has been compiled with precautionary procedures in place.

4.6. SEPA Guidance

This scheme would appear to be "potentially acceptable" according to SEPA's published guidance [5]. However, a detailed fish habitat survey will be required as the gradient of the watercourse is less than 10%. The table below shows the key criteria [6], while Appendix IV shows how this conclusion was reached.

Waterbody or Tributary	Tributary
Waterbody name	n/a
Waterbody status	n/a
Catchment area upstream of tailrace	8.69km^2
Length of proposed depleted reach	375m

SEPA should be approached for a scoping opinion at the earliest opportunity to refine additional survey requirements.

4.7. Built Heritage

The scheme will not affect any known built heritage or archaeological sites [9].

4.8. Landscape

By its nature hydro-power will have little long-term visual impact on the landscape. The pipeline will be buried and will regenerate in a few years. The intake and turbine house have been sympathetically designed

4.9. Recreational Use

The watercourse may be used for angling but appears to be unsuitable for navigation.

4.10. Noise

Statutory noise limits are easily achieved through appropriate design of the turbine house.

4.11. Land Ownership and Tenancies

The watercourse is entirely contained within the local crofters land. Initial discussions with regard to the development have been undertaken.

4.12. Terrain and Access

Observations on the terrain around the watercourse are detailed in Appendix II.

Temporary access will be required to all of the works during construction. During normal operation vehicular access to the turbine house will be required while safe access to the intake will be by required for ATV and foot only.

4.13. Lay-down Area

During construction it is necessary to stage materials and equipment close to the main access. For smaller schemes the “lay-down” area may just be a designated patch of field, for larger schemes this is likely to be a temporary hard-standing.

At this site a suitable location for the lay-down area would be adjacent to the turbine house.

5. Permissions

Planning permission, a CAR license and an electricity network connection will all be required. It is recommended that planning and abstraction are applied for simultaneously to allow construction to commence as early as possible. The application for connection to the electricity network can throw up significant up-front (although refundable) costs and so it is recommended that you approach the local Distribution Network Operator (DNO) to discuss the scheme.

We have provided most of the information necessary for the client to pursue the appropriate permissions although some refinement of the design will be required upon consultation with the authorities. Dealing with the regulatory bodies has historically been a laborious and complex process. We would strongly recommend that Highland Eco-Design be commissioned to act as an agent in applying for permissions.

5.1. Abstraction Licence

An abstraction license will be required for this installation; the information required for the abstraction licence application form has been refined in Appendix IV. The application should be submitted along with this report to the SEPA regional office.

The regional SEPA office for this site is:

Dingwall Office
Fodderty Way
Dingwall Business Park
Dingwall
IV15 9XB
Tel: 01349 862021
Fax: 01349 863987

5.2. Planning Permission

Planning permission is required for micro-hydro installations. Additional design work may be required for a planning application depending on the local authority.

Planning applications can now be submitted and tracked through a central internet portal:

https://eplanning.scotland.gov.uk/WAM/

It is possible that further environmental surveys will be required to satisfy the statutory consultees such as the Scottish Environment Protection Agency, Scottish Natural Heritage, and the relevant fisheries board.

5.3. Electricity Network Connection

An application for connection to the electricity network should be submitted as early as possible to the District Network Operator:

SSE Power Distribution
10 Henderson Road
Inverness
IV1 1SN

6. Finance, Risk and Delivery

6.1. Costs and Returns

A breakdown of costs and returns is given in Appendix V.

6.2. Financial Risk and Mitigation

As with all development investments there is an element of financial risk associated with developing a hydro project. A sensitivity analysis of some of these risk factors is also included in Appendix V.

The uncertainties associated with a hydro scheme can be characterised into the following categories:

6.2.1. Development

This is the outlay required to assess and design a scheme prior to being granted planning, abstraction and grid connection permission. There is no guarantee that all permissions will be granted and so this stage of a project represents the highest risk.

6.2.2. Construction

This represents the possibility of overspend inherent in any large civil engineering project. Overspend can occur for any number of reasons but with a hydro scheme the primary causes are likely to be ground conditions and the potential for flooding events during near-river operations.

Ground conditions can be assessed through an appropriate site investigation prior to tendering. However there is always a chance that this investigation will miss something requiring extra work, for example an area of solid rock.

Flood risks should be minimised by careful timetabling of certain works, this is generally good practice for pollution avoidance.

6.2.3. Operational

This covers two areas: Single, unforeseeable events and the accuracy of the prediction of available water resource. Unforeseeable events can be mitigated against through appropriate insurance and designing redundancy into the system so that it can cope if something unexpected happens.

The accuracy of the prediction of the water resource is a key issue. Long term measured data at the site will improve the accuracy of a prediction. However climate change, evolving land use and natural variations in rainfall mean that there will always be an element of uncertainty in the predicted flow and thus in the energy yield.

We use the LowFlows 2000 model as the basis for the majority of our analysis. This software has a stated uncertainty of ±11% at 68% confidence, equating to ±22% at 95% confidence. This means that there is a 95% probability that the predicted mean flow will be no more than 22% different to the actual flow at the site.

6.3. Project Structures

Regardless of the output, micro-hydro schemes tend to represent a significant capital investment. How individuals and organizations approach such an investment will vary but the majority of projects fall into one of the classifications below.

We have working relationships with development partners ranging from private investment consortia to professional renewable energy developers and so are well placed to pull schemes forward if a private development is unattractive. Our long-term involvement in a scheme will also give investors confidence as we will have a vested interest in keeping the scheme running at peak efficiency.

6.3.1. Private Development

Under this structure the landowner shoulders all of the risks associated with the development and we simply provide design, supply, installation and maintenance services under contract.

6.3.2. Lease Rental (Professional Developer)

A lease rental insulates the landowner from all of the risks associated with developing and operating a hydro scheme. Payment normally takes the form of a small fixed rate rent plus a percentage of the net revenue of the system.

If this arrangement is appropriate and desirable to both parties we would start by refunding all fees paid to date and signing a simple exclusivity agreement. This would allow us to undertake further investigations of the site and explore the options with our development partners. We would then negotiate a lease rental of the site that provides the best value for both sides.

6.3.3. Joint Venture

A joint venture allows the landowner to invest a certain amount of capital into the project to secure a greater reward than a lease rental but with less risk than a private development.

If this arrangement is appropriate and desirable to both parties we would start by signing a simple exclusivity agreement. This would allow us to undertake further investigations of the site and explore the options with our development partners.

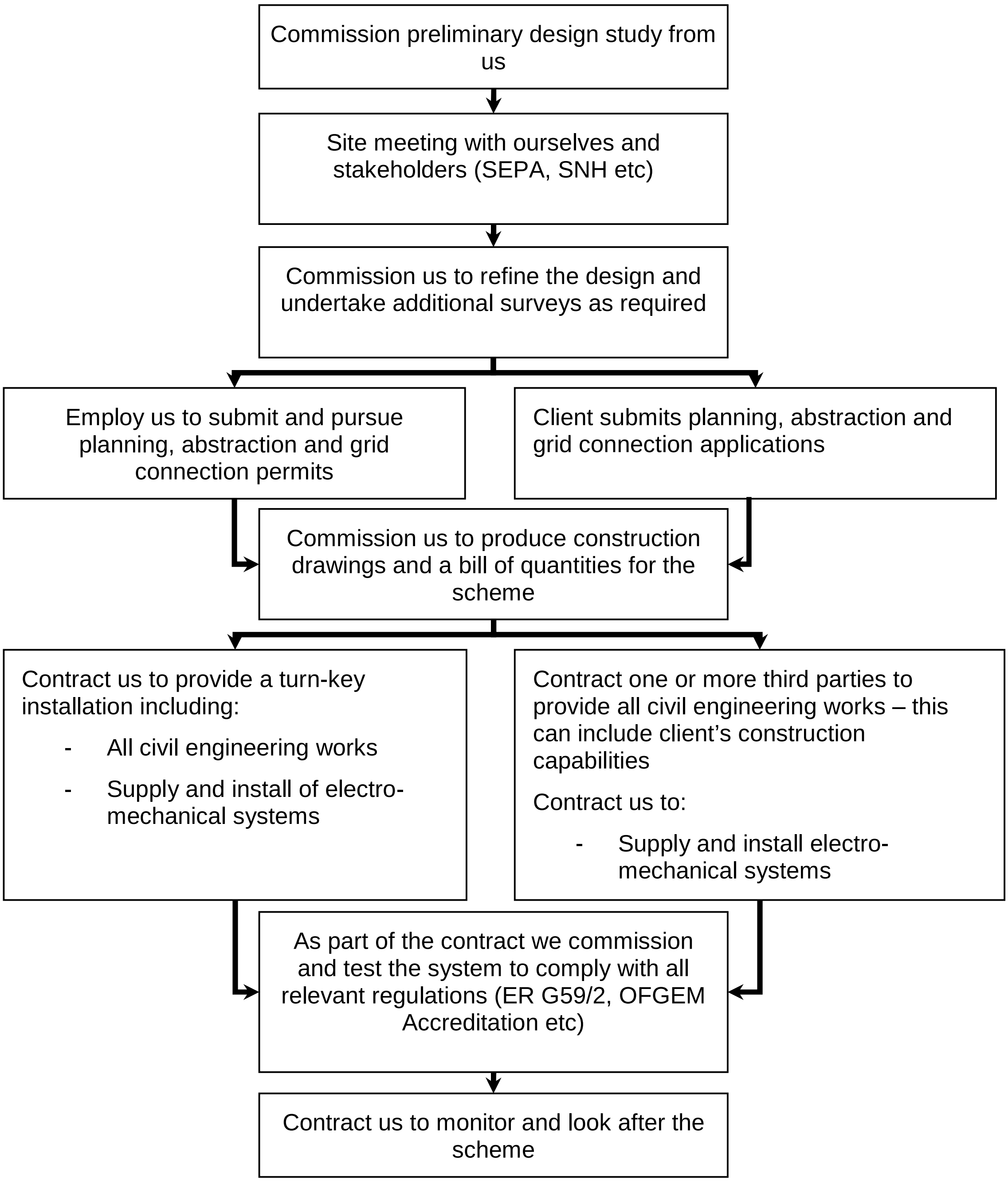
A Limited Liability Partnership (LLP) would then be formed with the sole purpose of developing the site. The members of this LLP would share the initial development risk between them. In this scenario the landowner(s) would either enter into a standard lease with the LLP or be given a small % stake instead of a rent.

This model is particularly useful for multiple-owner sites.

6.4. Project Delivery

Highland Eco-Design Ltd provides a flexible service from concept to commissioning and beyond. We can assess, design, secure permissions, supply, project manage, install and commission the scheme as a turn-key installation or we can provide individual elements on a contract basis.

The flow-chart below outlines the primary development route for a client-funded small-scale hydro-electric project. Typically the whole process takes between 2 and 3 years to complete.



7. Disclaimer

The energy production, income and capital cost estimates contained within this report are based on the best available information. However, as they are subject to uncertainty arising from a wide range of sources, they are given as guidance only and should not be considered as a guarantee. The conceptual designs outlined in this report have been presented to provide as much information as possible. However, Highland Eco-Design Ltd can not accept liability for damage or loss resulting from the implementation of these preliminary designs.

The designs outlined in this report remain the property of Highland Eco-Design Ltd and may not be reproduced for purposes other than developing the site to which this report refers without express written permission.

8. Glossary

Capacity factor - Also known as the Load factor, this is the % of a single year that the turbine would have to operate at full power in order to generate the energy it is expected to produce in a full average year.

Depleted reach – The section of watercourse between the intake and the tailrace where a reduced flow is experienced

Design flow – The optimum flow through the turbine, often the maximum flow the turbine can handle

Generator – A device for converting rotational kinetic energy into electrical energy

Gross head – The overall height available between the intake and the turbine

Header tank – A tank at the top of the penstock, contains the head level sensor and allows maintenance access. The purpose is not to store water

Intake weir – A low dam across the watercourse to ensure that the mitigation and turbine flows can be accurately controlled

Mitigation flow – The flow left running down the depleted reach when the turbine is operating

Net head – The head of water experienced by the turbine, equal to the gross head minus intake and pipe losses

Renewable electricity – Electricity that has been produced from an unlimited energy supply. In the modern context this also refers to energy that is produced with no release of pollutants into the environment.

Run-of-river – A hydro system that abstracts water depending on the flow available within the watercourse at any given time. No storage reservoir

Tailrace – An open channel or pipe returning the spent flow from the turbine to the watercourse

Turbine – A device for converting the gravitational potential energy of a flow of water into rotational kinetic energy

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