



Cyfoeth Naturiol Cymru
Natural Resources Wales

Water Resources LICENCE TO

ABSTRACT

WATER

Environment Act 1995
Water Resources Act 1991 as amended
by the Water Act 2003
Water Resources (Abstraction and
Impounding) Regulations 2006
Natural Resources Body for Wales (Functions)
Order 2012

IMPORTANT NOTES

Need for safekeeping

This licence is an important document. The permission or right to abstract water may be valuable to your landholding. So -

- **Keep the licence safe, preferably with your deeds etc.**
- **Take careful note of the comments below about “transfer and apportionment” and “death and bankruptcy”.**

This is to ensure that the permission and any rights granted by the licence continue if you need to pass it on to someone else.

If you want to:

- **revoke (cancel) the licence;**
- **vary (change/amend) the licence in any way or**
- **change your contact address (but you continue to hold the licence).**

Please write to us at your local Natural Resources Wales office.

Details of this licence are placed on a register, kept by Natural Resources Wales and open for inspection by the public. The public may also obtain further details about it by virtue of the Environmental Information Regulations 2004 (see also Disclosure of Information) except in special cases (for advice please contact us at the address shown on the front page of the licence).

Transfer and apportionment

If you need to pass this licence or any part of it to someone else, you must contact Natural Resources Wales and obtain the appropriate application forms. Temporary licences cannot be transferred or apportioned. The licence holder remains responsible for compliance with the terms of the licence and any charges payable until the licence has been transferred or apportioned.

Death or bankruptcy of the licence holder

If a licence has been ‘vested’ in you, as a result of the death or bankruptcy of the licence holder, please contact Natural Resources Wales in writing, telling us the licence number(s) and the date that the licence vested in you as a personal representative or trustee of the licence holder. This is necessary in order to enable you to subsequently transfer the licence.

‘Vesting’ is the transfer of responsibility and ownership of a licence when an existing licence holder is no longer able to hold the licence either through death or bankruptcy.

You do not have to complete a form, but you must notify us in writing within 15 months of the date of vesting, giving the full names of all personal representatives or trustees and a contact address.

Time limits

Your licence may be subject to a time limit (stated on the front of your licence). All new abstraction licences are legally required to include a time limit. For variations to licences, time limits are added in accordance with our policy.

The duration of a time limit is determined in accordance with our time limiting policy. The time limit is linked to the next or subsequent review of water resources within a Catchment Abstraction Management Strategy (CAMS).

There will be a presumption of renewal providing three tests are met: environmental sustainability is not in question; there is continued justification of need; and water is being used efficiently. Any application for renewal will still be subject to the normal statutory considerations.

If your licence is time limited and you wish to renew it when it expires, you will need to apply for a new licence to replace the existing one. You are advised to submit this application at least three months before it expires. To allow you to give early consideration to this, we will send you a reminder approximately 18 months before the expiry date.

If your licence cannot be renewed, we will endeavour to give at least six years notice. We will also endeavour to give at least six years notice where the licence is likely to be renewed on different terms and will significantly impact upon the use of the licence.

In exceptional circumstances, for example where there are other overriding statutory duties such as the Habitats Regulations, it may not be possible to provide six years notice.

Charges

Unless specifically exempted, we may levy an annual CHARGE for water AUTHORISED to be abstracted by this licence, in accordance with our abstraction charges scheme in force at the time.

The licence may be revoked if charges are not paid.

Quantity and quality of water

You must not abstract more than the quantity specified in the licence.

Natural Resources Wales does not, by issue of this licence or otherwise, in any way guarantee that the source of supply will produce the quantity of water authorised to be abstracted by this licence, nor that the water is fit for its intended use.

The quantity of water authorised for abstraction is given in cubic metres. One cubic metre is approximately 220 gallons.

(The precise conversion is 1 cubic metres = 219.969 gallons).

Source of supply and authorised point of abstraction

You may abstract from the point(s) specified in the licence and from no other points. If you want to add or change the authorised point(s) of abstraction, you must apply to us to vary the licence.

Land on which water is authorised to be used

Where this condition applies, you may only use the water you abstract on the area specified in the licence. You must apply to us to vary the licence if you wish to extend or alter this area or remove it.

Purpose for which water is authorised to be used

You may only use the water for the purpose(s) specified in the licence. You must apply to us to vary the licence if you wish to add to or change the purpose(s).

Offences

Under the Water Resources Act 1991 it is an offence:-

- to abstract water, or cause or permit any other person to abstract water, unless the abstraction is authorised by and in accordance with an abstraction licence, or is subject to an exemption;
- to do anything to enable abstraction, or to increase abstraction, except in accordance with an abstraction licence or exemption;
- to fail to comply with the conditions of an abstraction licence.
Note in particular that it may be a condition of the licence to maintain the meter or other measuring device etc. and failure to do so will be an offence;
- to interfere with a meter or other device which measures quantities of water abstracted so as to prevent it from measuring correctly;
- to fail to provide information which we have reasonably required for the purpose of carrying out any of the Natural Resources Wales water resources functions;
- to knowingly make false statements for the purpose of obtaining a licence or consent or in giving required information.

The requirement for a licence is subject to some exemptions, set out in the Water Resources Act 1991 as amended. If in any doubt as to whether you need a licence, contact us at the address shown at the bottom of the front page of the licence.

Right of appeal

If you are dissatisfied with our decision on your licence application, you may appeal.

If you are in England, you should write to the Secretary of State for the Environment, Food and Rural Affairs, care of The Planning Inspectorate at:
Room 4/19 Eagle Wing,
Temple Quay House,
2 The Square,
Temple Quay,
Bristol,
BS1 6PN.

If you are in Wales, you should write to Welsh Government care of The Planning Inspectorate at:
Crown Buildings,
Cathays Park,
Cardiff,
CF10 3NQ.

You must serve notice of appeal within 28 days of the date of receipt of this licence (although the Secretary of State and The Welsh Government have power to allow a longer period for serving notice of appeal). See Water Resources Act 1991, section 43.

Disclosure of information

Information about this licence is available in the public Register held by Natural Resources Wales. Members of the public are also entitled to ask us for other “environmental information” it holds, including any activities likely to affect “the state of any water” or any “activities or other measures designed to protect it”. That would include the information additional to the licence document e.g. any related agreement or abstraction returns. In certain restricted circumstances it is possible to claim that information should be kept confidential. If you require more information about keeping this information off the public register because it is confidential, please contact us by writing to the address shown on the front page of the licence within 28 days of receiving this licence.



FULL LICENCE TO ABSTRACT WATER

The Natural Resources Body for Wales (hereafter referred to as “NRW”) grants this licence to:-

J.W.Greaves & Sons, Limited (“the Licence Holder”)

Llechwedd Slate Mines
Blaenau Ffestiniog
Gwynedd
LL41 3NB

Company Registration Number: 00067876

This licence authorises the Licence Holder to abstract water from the source of supply described in the Schedule of Conditions to this licence and subject to the provisions of that Schedule. The licence commences from the effective date shown below and shall remain in force until the date of expiry shown below.

Signed:

Ashley Lansdown
Permitting Team Leader
Permitting Service
Natural Resources Wales
Welsh Government Offices
Cathays Park
King Edward VII Avenue
Cardiff
CF10 3NQ

Date of issue.....05 June 2025

Date effective..... 01 April 2025

Date of expiry.....31 March 2037

Date of original issue.....01 September 2005

This licence should be kept safe and its existence disclosed on any sale of the property to which it relates. Please read the ‘important notes’ on the cover to this licence.

Note: References to “the map” are to the map which forms part of this licence.
References to “NRW” are to the Natural Resources Body for Wales or any successor body.

SCHEDULE OF CONDITIONS

1. SOURCES OF SUPPLY

- 1.1 Inland water (reservoir) known as Llyn Newydd at Llechwedd Quarry, Blaenau Ffestiniog, Gwynedd.
- 1.2 Inland water (reservoir) known as Llyn Bowydd at Llechwedd Quarry, Blaenau Ffestiniog, Gwynedd.
- 1.3 Inland water (reservoir) known as Llynnau Barlwyd at Llechwedd Quarry, Blaenau Ffestiniog, Gwynedd.
- 1.4 Inland water (river) known as Afon Barlwyd at Llechwedd Quarry, Blaenau Ffestiniog, Gwynedd.
- 1.5 Inland water (stream) known as an unnamed tributary to Afon Barlwyd at Llechwedd Quarry, Blaenau Ffestiniog, Gwynedd.
- 1.6 Inland water (stream) known as an unnamed tributary to Afon Barlwyd at Llechwedd Quarry, Blaenau Ffestiniog, Gwynedd.
- 1.7 Inland water (stream) known as an unnamed tributary to Afon Barlwyd at Llechwedd Quarry, Blaenau Ffestiniog, Gwynedd.

2. POINTS OF ABSTRACTION

- 2.1 At National Grid Reference SH 72192 46940 marked 'Point A' on the map.
- 2.2 At National Grid Reference SH 72327 46709 marked 'Point B' on the map.
- 2.3 At National Grid Reference SH 70960 48290 marked 'Point C' on the map.
- 2.4 At National Grid Reference SH 71021 48068 marked 'Point D' on the map.
- 2.5 At National Grid Reference SH 71026 47930 marked 'Point E' on the map.
- 2.6 At National Grid Reference SH 71038 47860 marked 'Point F' on the map.
- 2.7 At National Grid Reference SH 70916 47550 marked 'Point G' on the map.

3. MEANS OF ABSTRACTION

- 3.1 Gravity flow into an open channel.

4. PURPOSE OF ABSTRACTION

- 4.1 Power production.

5. PERIOD OF ABSTRACTION

- 5.1 All Year.

6. MAXIMUM QUANTITIES OF WATER TO BE ABSTRACTED

6.1 From Point A:

25,920 cubic metres per day
4,450,000 cubic metres per year

At a maximum instantaneous rate not exceeding 300 litres per second.

6.2 From Point B:

25,920 cubic metres per day
2,750,000 cubic metres per year

At a maximum instantaneous rate not exceeding 300 litres per second.

6.3 The aggregate quantity of water authorised to be abstracted under this licence from Point A and Point B shall not exceed:

400 litres per second.

6.4 From Point C:

25,920 cubic metres per day
1,300,000 cubic metres per year

At a maximum instantaneous rate not exceeding 300 litres per second.

6.5 From Point D:

2,073.6 cubic metres per day
380,000 cubic metres per year

At a maximum instantaneous rate not exceeding 24 litres per second.

6.6 From Point E:

2,246.4 cubic metres per day
420,000 cubic metres per year

At a maximum instantaneous rate not exceeding 26 litres per second.

6.7 From Point F:

6,652.8 cubic metres per day
1,260,000 cubic metres per year

At a maximum instantaneous rate not exceeding 77 litres per second.

6.8 From Point G:

6,480 cubic metres per day
1,220,000 cubic metres per year

At a maximum instantaneous rate not exceeding 75 litres per second.

6.9 The aggregate quantity of water authorised to be abstracted under this licence from Points C, D , E, F & G together shall not exceed:

400 litres per second at any time.

6.10 The aggregate quantity of water authorised to be abstracted under this licence from Points A to G, as specified in conditions 6.1, 6.2, 6.4, 6.5, 6.6 6.7 and 6.8 above, for the purpose of power production shall not exceed:

34,560 cubic metres per day

11,780,000 cubic metres per year

At a maximum instantaneous rate not exceeding 400 litres per second.

Note: A day means any period of 24 consecutive hours and a year means the 12 month period beginning on 1 April and ending on 31 March.

7. MEANS OF MEASUREMENT OF WATER ABSTRACTED

7.1 (i) The Licence Holder shall determine the quantity of water abstracted by reference to the kilowatt-hours generated at each turbine, as measured by the kilowatt-hours meters multiplied by the conversion factors determined using the calculation checklists attached to this licence.

(ii) The Licence Holder shall retain supporting documentation relating to details of the methodology and calculations used to convert electricity generated at each turbine to the quantities abstracted and make them available to NRW on request.

8. RECORDS

8.1 (i) The Licence Holder shall record readings of the electrical output and the corresponding quantity of water abstracted at each turbine at the same time each week, as determined using the calculation checklists attached to this licence or at such other intervals as may be approved by NRW in writing.

(ii) The Licence Holder shall send to NRW summary data from the records required by (i) above within 28 days after 31 March in each year, and also within 28 days of being so requested in writing by NRW.

(iii) The Licence Holder shall keep all records for at least 6 years, and shall allow NRW to inspect them during all reasonable hours.

9. FURTHER CONDITIONS

9.1 No abstraction shall take place from the authorised point of abstraction, marked as 'Point A' as specified in condition 2.1, when the level in the Llyn Newydd is equal to or greater than 2.0 metres below the spillway level of Llyn Newydd, and the abstraction shall not cause the level to fall below 2.0 metres below the spillway level.

9.2 No abstraction shall take place from the authorised point of abstraction, marked as 'Point B' as specified in condition 2.2, when the level in the Llyn Bowydd is equal to or greater than 2.0 metres below the spillway level of Llyn Bowydd and the abstraction shall not cause the level to fall below 2.0 metres below the spillway level.

- 9.3 (i) The Licence Holder shall install a staff gauge board at the sources of supply, as specified in conditions 1.1 and 1.2 to the satisfaction of NRW.
- (ii) The gauge boards shall be installed in such a way that they may be accessed and read in a safe manner to the satisfaction of NRW.
- 9.4 No abstraction of water shall take place unless the rate of flow in the Afon Barlwyd immediately downstream of the authorised point of abstraction, marked as 'Point D' as specified in condition 2.4, is equal to or greater than 0.6 litres per second and the abstraction shall not cause the flow immediately downstream of said abstraction point to fall below that rate.
- 9.5 No abstraction of water shall take place unless the rate of flow in the unnamed tributary to Afon Barlwyd immediately downstream of the authorised point of abstraction, marked as 'Point E' as specified in condition 2.5, is equal to or greater than 0.7 litres per second and the abstraction shall not cause the flow immediately downstream of said abstraction point to fall below that rate.
- 9.6 No abstraction of water shall take place unless the rate of flow in the unnamed tributary to Afon Barlwyd immediately downstream of the authorised point of abstraction, marked as 'Point F' as specified in condition 2.6, is equal to or greater than 2.0 litres per second and the abstraction shall not cause the flow immediately downstream of said abstraction point to fall below that rate.
- 9.7 No abstraction of water shall take place unless the rate of flow in the unnamed tributary to Afon Barlwyd immediately downstream of the authorised point of abstraction, marked as 'Point G' as specified in condition 2.7, is equal to or greater than 1.9 litres per second and the abstraction shall not cause the flow immediately downstream of said abstraction point to fall below that rate.
- 9.8 The Licence Holder shall, as far as is reasonably practicable, ensure that no water flows through each turbine if the Licence Holder is unable to generate power.
- 9.9 The Licence Holder shall make a continuous release of compensation water of no less than 10 litres per second from 'Point D' as specified in condition 2.4.
- 9.10 No abstraction of water shall take place unless the rate of flow from the Maenofferen Turbine header tank, at National Grid Reference SH 71232 46959 marked 'Point P' on the map is equal to or greater than 2 litres per second and the abstraction shall not cause the flow immediately downstream of said abstraction point to fall below that rate.
- 9.11 (i) The Licence Holder shall return all of the water abstracted in pursuance of this licence for power production at the Maenofferen Turbine House to the Pant yr Afon Header Tank at National Grid Reference SH 70713 46993 marked 'Point Q' on the map.
- (ii) The Licence Holder shall return all of the water abstracted in pursuance of this licence for power production at the Pant yr Afon Turbine House to the Afon Barlwyd at National Grid Reference SH 69755 46915 marked 'Point R' on the map.

ADDITIONAL INFORMATION

Note: the following information is provided for information only. It does not form part of the licence.

REASONS FOR CONDITIONS

The licence is time-limited to a date to reflect the timing of a future review of the catchment resources availability.

Conditions 7 and 8: the Licence Holder is required to record readings of the electrical output and the corresponding quantity of water abstracted to demonstrate compliance with the conditions of this licence and to provide information on actual water usage for water planning purposes.

Conditions 9.1, 9.2 and 9.3: to ensure a flow is maintained in the reservoirs in order to maintain the riverine habitat for the conservation of the flora and fauna.

Conditions 9.4 to 9.7 and 9.10: to ensure a flow is maintained in the watercourse in order i) to maintain the riverine habitat for the conservation of the flora and fauna and ii) to protect the interests of existing downstream lawful users of water.

Condition 9.8: to secure the proper and efficient use of water resources.

Condition 9.9: to ensure a flow is maintained in the watercourse in order to maintain the riverine habitat for the conservation of the flora and fauna.

Condition 9.11: to ensure the abstraction can be classed as non-consumptive.

IMPORTANT NOTES

No impoundment licence is required to facilitate the abstraction of water for the hydropower scheme authorised by this abstraction licence.

For the purpose of condition 9.3, the Licence Holder shall contact:

Senior Officer
People and Places Team
Maes Y Ffynnon
Penrhosgarnedd
Bangor
Gwynedd
LL57 2DW

Telephone: 0300 065 3000

Email: NorthWestPeopleandPlacesTeam@cyfoethnaturiolcymru.gov.uk

Regarding condition 8.1:

The Hydropower scheme has 2 turbines. Water abstracted from points A and B, flows through a turbine known as the Maenofferen turbine and is discharged to the Pant yr Afon lake. Water abstracted from points C, D, E, F and G also goes to the Pant yr Afon lake. All water taken from from the Pant yr Afon lake flows through a turbine known as the Pant yr Afon turbine. Condition 8.1 (i) requires the Licence Holder to calculate the amount of water

taken by each turbine each week using the calculation checklists attached to this licence and to retain these records on site.

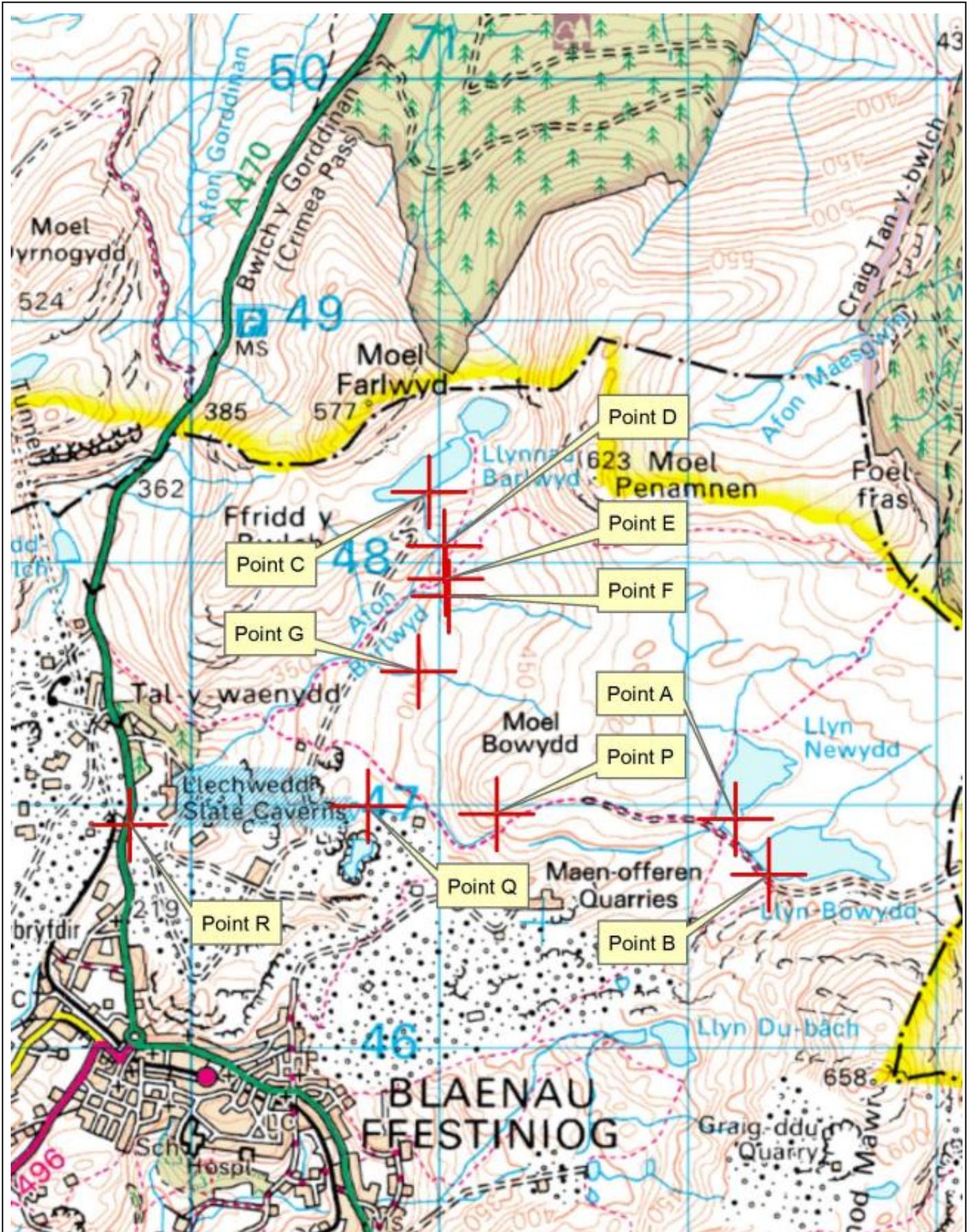
For the purpose of condition 8.1 (ii), the summary data the Licence Holder shall submit to NRW each year shall show the highest quantity of water abstracted from the two records required by condition 8.1 (i) each week, unless otherwise agreed in writing with NRW.

Water efficiency note

The Licence Holder should use water abstracted under the terms of this licence in an efficient manner. NRW may refer to its guidance on water efficiency (or equivalent guidance) in determining whether water is being used efficiently and may offer advice on any measures considered necessary to meet particular recommendations.

Licence history

Licence Serial Number	Issue and Effective Date	Expiry Date	Summary of Changes
23/65/1/0036	01 September 2005	31 March 2013	Original Licence Issued
23/65/1/0036	10 November 2006	31 March 2013	Variation 1
WA/065/0001/011	31 October 2013	31 March 2015	Single year renewal in order for monitoring to be completed
WA/065/0001/011/R001	24 April 2015	31 March 2025	Issued renewal with monitoring conditions removed
WA/065/0001/011/R002	Issue date : 05/06/2025 Effective date: 01 April 2025	31 March 2037	Issued renewal with amended measurement and records conditions



MAP ACCOMPANYING LICENCE NUMBER / MAP I GYFEILIO TRWYDDED RHIF
WA/065/0001/011/R002
Scale | Graddfa 1:25,000



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© Hawlfraint y Goron a hawl cronfa ddata Arolwg Ordnans. Cyfoeth Naturiol Cymru, 100019741, 2015.

Maenofferen Turbine Calculation Checklist

This checklist shall be used to record the site data and calculate the Hydro Abstraction Factor for the site (HAF_{site}) to allow conversion of electrical output to quantities abstracted. The HAF_{site} is the amount of water used in m^3 per kWh generated for any period.

Site Data	
Site name	
Address	
Licence serial No.	
Contact name	
Contact telephone	
Contact email	
Turbine manufacturer	
Turbine type	
Turbine serial no.	
Number of jets (where relevant)	

Performance Data		
Parameter	Value	How was the parameter determined?
Net operating head of the system at maximum power output ($H_n(P_{max})$) in metres		
Turbine/water wheel efficiency at maximum power output ($e_{turbine/water\ wheel}(P_{max})$)		
Transmission system efficiency at maximum power output ($e_{transmission}(P_{max})$)		
Generator efficiency at maximum power output ($e_{generator}(P_{max})$)		

Calculation of overall system efficiency of the rotating parts of the hydro system, at maximum power output ($e_{system}(P_{max})$)

$$e_{system}(P_{max}) = e_{turbine/water\ wheel}(P_{max}) \times e_{transmission}(P_{max}) \times e_{generator}(P_{max})$$

$$= \boxed{} \times \boxed{} \times \boxed{}$$

$$e_{system}(P_{max}) = \boxed{}$$

Calculation of HAF_{site}

HAF_{site} = Hydro Abstraction Factor for the site in question

$$= 366.972 / (H_n(P_{max}) \times e_{system}(P_{max}))$$

$$= 366.972 / (\boxed{} \times \boxed{})$$

$$= \boxed{} \text{ (m3/kWh)}$$

Where:

$H_n(P_{max})$ = net head at max. power.

366.972 = a constant in order to bring the final HAF into the correct unit of m^3/kWh (it is arrived at by dividing the number of seconds in an hour (3600) by gravity ($9.81\ m/s^2$))

The volume of water abstracted for any period (V_{period}) can then be calculated by simply multiplying the HAF_{site} by the number of kiloWatt hours generated thus:

$$V_{period} \text{ (m3)} = kWh_{period} \text{ (kWh)} \times HAF_{site} \text{ (m3/kWh)}$$

See example:

(kWh is a measure of energy, whilst kW is a measure of power: at full efficiency, a 50 kW turbine will produce 50 kWh of energy in one hour, 100 kWh in two hours, 150 kWh in three hours etc.).

Performance Data		
Parameter	Value	How was the parameter determined?
Net operating head of the system at maximum power output ($H_n (P_{max})$) in metres	150	Site survey
Turbine/water wheel efficiency at maximum power output ($e_{\text{turbine/water wheel } (P_{max})}$)	0.9	From manufacturer
Transmission system efficiency at maximum power output ($e_{\text{transmission } (P_{max})}$)	0.85	From manufacturer
Generator efficiency at maximum power output ($e_{\text{generator } (P_{max})}$)	0.85	From manufacturer

Calculation of overall system efficiency of the rotating parts of the hydro system, at maximum power output ($e_{\text{system } (P_{max})}$)

$$\begin{aligned} e_{\text{system } (P_{max})} &= e_{\text{turbine/water wheel } (P_{max})} \times e_{\text{transmission } (P_{max})} \times e_{\text{generator } (P_{max})} \\ &= \boxed{0.9} \times \boxed{0.85} \times \boxed{0.85} \\ e_{\text{system } (P_{max})} &= \boxed{0.65} \end{aligned}$$

Calculation of HAF_{site}

HAF_{site} = Hydro Abstraction Factor for the site in question

$$\begin{aligned} &= 366.972 / (H_n (P_{max}) \times e_{\text{system } (P_{max})}) \\ &= 366.972 / (\boxed{150} \times \boxed{0.65}) \\ &= \boxed{3.764} \quad (\text{m}^3/\text{kWh}) \end{aligned}$$

The volume of water abstracted for any period (V_{period}) can then be calculated by simply multiplying the HAF_{site} by the number of kiloWatt hours generated thus:

$$V_{\text{period}} (\text{m}^3) = \text{kWh}_{\text{period}} (\text{kWh}) \times HAF_{\text{site}} (\text{m}^3/\text{kWh})$$

If, for example your total export of electricity for the period was 68400 kWh, then you would have abstracted a total volume of water of:

$$V_{\text{period}} (\text{m}^3) = 68400 \text{ kWh} \times 3.764 \text{ m}^3/\text{kWh} = 257457.6 \text{ m}^3$$

Pant yr Afon Turbine Calculation Checklist

This checklist shall be used to record the site data and calculate the Hydro Abstraction Factor for the site (HAF_{site}) to allow conversion of electrical output to quantities abstracted. The HAF_{site} is the amount of water used in m^3 per kWhr generated for any period.

Site Data	
Site name	
Address	
Licence serial No.	
Contact name	
Contact telephone	
Contact email	
Turbine manufacturer	
Turbine type	
Turbine serial no.	
Number of jets <small>(where relevant)</small>	

Performance Data		
Parameter	Value	How was the parameter determined?
Net operating head of the system at maximum power output ($H_n (P_{max})$) in metres		
Turbine/water wheel efficiency at maximum power output ($e_{turbine/water\ wheel (P_{max})}$)		
Transmission system efficiency at maximum power output ($e_{transmission (P_{max})}$)		
Generator efficiency at maximum power output ($e_{generator (P_{max})}$)		

Calculation of overall system efficiency of the rotating parts of the hydro system, at maximum power output ($e_{system (P_{max})}$)

$$e_{system (P_{max})} = e_{turbine/water\ wheel (P_{max})} \times e_{transmission (P_{max})} \times e_{generator (P_{max})}$$

$$= \boxed{} \times \boxed{} \times \boxed{}$$

$$e_{system (P_{max})} = \boxed{}$$

Calculation of HAF_{site}

HAF_{site} = Hydro Abstraction Factor for the site in question

$$= 366.972 / (H_n (P_{max}) \times e_{system (P_{max})})$$

$$= 366.972 / (\boxed{} \times \boxed{})$$

$$= \boxed{} \text{ (m3/kWh)}$$

Where:

$H_n (P_{max})$ = net head at max. power.

366.972 = a constant in order to bring the final HAF into the correct unit of $m^3/kWhr$ (it is arrived at by dividing the number of seconds in an hour (3600) by gravity (9.81 m/s^2))

The volume of water abstracted for any period (V_{period}) can then be calculated by simply multiplying the HAF_{site} by the number of kiloWatt hours generated thus:

$$V_{period} (m3) = kWh_{period} (kWh) \times HAF_{site} (m3/kWh)$$

See example:

(kWh is a measure of energy, whilst kW is a measure of power: at full efficiency, a 50 kW turbine will produce 50 kWh of energy in one hour, 100 kWh in two hours, 150 kWh in three hours etc.).

Performance Data		
Parameter	Value	How was the parameter determined?
Net operating head of the system at maximum power output ($H_n (P_{max})$) in metres	150	Site survey
Turbine/water wheel efficiency at maximum power output ($e_{\text{turbine/water wheel } (P_{max})}$)	0.9	From manufacturer
Transmission system efficiency at maximum power output ($e_{\text{transmission } (P_{max})}$)	0.85	From manufacturer
Generator efficiency at maximum power output ($e_{\text{generator } (P_{max})}$)	0.85	From manufacturer

Calculation of overall system efficiency of the rotating parts of the hydro system, at maximum power output ($e_{\text{system } (P_{max})}$)

$$e_{\text{system } (P_{max})} = e_{\text{turbine/water wheel } (P_{max})} \times e_{\text{transmission } (P_{max})} \times e_{\text{generator } (P_{max})}$$

$$= \boxed{0.9} \times \boxed{0.85} \times \boxed{0.85}$$

$$e_{\text{system } (P_{max})} = \boxed{0.65}$$

Calculation of HAF_{site}

HAF_{site} = Hydro Abstraction Factor for the site in question

$$= 366.972 / (H_n (P_{max}) \times e_{\text{system } (P_{max})})$$

$$= 366.972 / (\boxed{150} \times \boxed{0.65})$$

$$= \boxed{3.764} \quad (\text{m}^3/\text{kWh})$$

The volume of water abstracted for any period (V_{period}) can then be calculated by simply multiplying the HAF_{site} by the number of kiloWatt hours generated thus:

$$V_{\text{period}} (\text{m}^3) = \text{kWh}_{\text{period}} (\text{kWh}) \times HAF_{\text{site}} (\text{m}^3/\text{kWh})$$

If, for example your total export of electricity for the period was 68400 kWh, then you would have abstracted a total volume of water of:

$$V_{\text{period}} (\text{m}^3) = 68400 \text{ kWh} \times 3.764 \text{ m}^3/\text{kWh} = 257457.6 \text{ m}^3$$

**Would you like to find out more about us,
or about your environment?**

**Then call us on
0300 065 3000 (Mon-Fri 9-5)**

**email
enquiries@naturalresourceswales.gov.uk**

**or visit our website
www.naturalresourceswales.gov.uk**

**incident hotline 0300 065 3000 (24hrs)
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