babyHydro

Small hydro from idea to operation

# Lochbroom Community Hydropower Scheme
# Allt a' Mhuilinn
# Feasibility Phase 2 & 3 Report

Photo 1: Allt a' Mhuilinn

| Version | Date | Revisions | By | Approved By |
|---|---|---|---|---|
| Draft V0.1 | 17th Aug 2015 | | JH | NF |
| V1.1 | 21st Oct 2015 | Release | JH | CM/NF |

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# Contents

## 1 Background

This document describes the activities and results of Phase 2 & 3 of the Detailed Feasibility Study conducted on the proposed hydro-electric scheme on the Allt a' Mhuilinn, also referred to as the Lochbroom Community Hydro. The report contains the following sections:

- Summary of activities
- Ongoing and outstanding tasks
- Summary of surveys with impacts on the project
- Summary of preferred design and mitigations if required
- Financial analysis summary update

The main outputs so far have been the Supporting statement document (used in Planning and licencing applications) along with drawings, technical appendices and grid connection application.

## 2 Summary of Phase 2 & 3 Activities

- Site meetings with civil contractor and group members.
- Refined design options
- Ecological Phase 1 habitat/NVC, Protected Species
- Topographic surveys including visibility splay information
- Drawing visibility splays
- Geo-technical survey
- Fish habitat survey
- BS5837 tree survey
- Consultation with relevant statutory bodies: Highland Council Planning, SEPA Hydro Team, SNH, Wester Ross Fisheries Trust, Scottish and Southern Electricity Power Distribution
- Consultations with stakeholders Forest Enterprise and site visit with the Forest District liaison officer, FC Planning officer and hand-over to new liaison officer.
- Interim financial analysis
- Development of Supporting information documents (CAR and Planning)
- Mechanical and electrical outline design
- Civils outline design drawings, spec for budget, planning/CAR app
- Budget quotes for turbine and civils received
- Site plans, drawings, printing
- Reports write-up & group meeting

## 3 Summary of Preferred Layout

The currently preferred layout is outlined in red in the site plan (see 006-01-01). (See Phase 1 report Table 1 for definitions of all options previously considered). The principal features are:

- Intake structure at grid ref NH 19378 82155, situated on flat bedrock platform between two large waterfalls. Incorporating Coanda screen (or Tyrolean style bar drop screen if preferred), compensation flow notch, wing walls, header tank, safety railings (timber appearance) and breather pipe.
- Pipeline following the line of least resistance, taking the most suitable and shortest possible route on the south east bank ('intake B2') to the powerhouse site on the north west bank. Pipe route avoids rock outcrops and existing drainage channels where possible as it runs down the open hillside, crosses underneath the FCS road, skirts the far edge of a small group of trees then crosses the river via a covered pipe-bridge and is bunded-over to the powerhouse. Avg gradient on steeper sections of pipe is approx. 1in3, no less than 1in 100.
- Powerhouse at NH 19139 82076 on northwest bank of burn, tailrace adjacent to this 14m upstream from the culvert.
- Electrical connection by buried cable (beneath A835) then across fields to 33kV network. Connection directly to new pole mounted transformer to export all energy to grid.

**Table 1: Preferred Layout Site Parameters**

| *Item* | *Data* |
|---|---|
| Power (kW) | *100* |
| Energy (MWh/year) | *479* |
| Homes equivalent offset[1] | *115* |
| $CO^2$ emissions offset (tonnes/yr)[1] | *213* |
| Annual Mean Flow ($m^3/s$) | *0.153* |
| Design Flow ($m^3/s$) | *0.103* |
| Gross Head, Hg (m) | *134.5* |
| Hands-off flow ($m^3/s$) Q90 | *0.018* |
| Catchment Area ($km^2$) | *3.028* |
| Depleted Reach (m) | *300* |
| Depleted Reach Avg Gradient (%) | *0.44* |
| Intake grid reference | *NH 19378 82155* |
| Powerhouse grid reference | *NH 19139 82076* |

# 4 Specifications of Preferred Layout

## 4.1 Intake

Grid ref: NH 19378 82155 at 157.75m AOD.

The designs approved by SEPA to date include two of 1500mm wide Type E 'quarter height' (400mm in the vertical) Coanda screens. These are the most effective option for screening out

[1] Figures based on latest statistics by Department of Energy and Climate Change

fine debris. However, there will be room to accommodate either the Coanda screen or 'Tyrolean drop screen' depending on client preference. A drop screen may need more frequent checking and will allow more small silt particles into the turbine than a coanda screen, but will be cheaper.

A concrete apron or secondary plunge pool may be required at toe of weir to distribute flow and prevent geomorphological changes further downstream. The river bed at the intake site is bedrock and the channel sides appear to be of sound condition. It is noted that the geotechnical report recorded that the rock did contain lateral and vertical jointing, which unless treated (by e.g. grouting, pinning etc) could allow some seepage into the rock fissures, which in turn could exacerbate geotechnical stability next to the intake works.

- The structure will measure approx. 8m wide by 1.5m high and 1.5m deep. The intake structure should be designed to be capable of passing up to $8m^3/s$. (approximately 50x Annual Mean Flow (Qmean) to contain flows within the bank of the channel in full spate.
- The intake water surface level is estimated to be at 157.75mAOD based on the outline design as approved by SEPA CAR licence. Levels have been defined by topographic survey.

  See Appendix 1 Figure 4 – intake elevations.

### 4.2 Pipeline

The proposed pipe route has been assessed following several walk-over surveys including geo-technical, environmental, topographic and civil engineering surveys. It is deemed viable.
The overall gradient of the penstock route is relatively steep in comparison to other micro hydro schemes in the Highlands, but is by no means the steepest. Risks can be managed by opening short sections of trench and backfilling promptly and easing the gradients where possible by cut or fill. Specialist management of the pipe works will be required near trees and high risk areas identified in the geotechnical report.

- Total measured length is 505m from intake to powerhouse, with an average gradient of 1in3. A downhill gradient of >1in100 should be maintained for approximately the first 30m from the intake.
- A nominal pipe size of 315mm (outside diameter HDPE grade PE100) is recommended based on a design flow of 103l/s, which is the required flow for a rated capacity of 100kW. The hydraulic calculations for pipe sizing are based on assumption of 5% total headloss.
- Penstock trench may be up to 2m deep as it exits the intake, but typical depth elsewhere nominally 1m. It is expected that at least 600-750mm depth of cover on top of the pipe will be possible, although invasive ground investigations have not yet been carried out. For the FC road crossing 900mm min depth of cover is required (or suitable for a 30 tonne vehicle).
- Construction access will be from the existing FCS access points. There will be access created for vehicles to the intake via the existing harvester/quad bike track. An easement will be required along the pipe's length in order to excavate and install. Where it crosses the FC road, easement will not be required. This approach will require suitable area for pipe joining and laying out - the laydown area (marked 'Laydown Area 2') on the site plan would be the most suitable location and allow working uphill and downhill from the FC road.

See Site plan 006-01-01 for details of pipeline route.

### 4.3 Pipe-bridge

The current proposal is to bring the pipe back to the north-west bank because of the more favourable access and powerhouse position. This presents an opportunity to install a safe viewing area for the waterfall in the form of a timber decking with the pipe hidden beneath. See example below.

**Photo 1: example of an (unfinished) pipe-bridge encased within structural beam. Gangway and handrails would be mounted above and the banks landscaped.**

### 4.4 Outfall

The outfall structure will be embedded in the bank of the river adjacent to the powerhouse and could be clad in natural rock to visually blend into the surrounding rocky river channel. The outfall pipe will be submerged to help attenuate noise and will be suitably screened to prevent entry by fauna.

### 4.5 Turbine & powerhouse

NH 19139 82076, floor level 22.5mAOD

The feasibility study identified a Pelton type turbine with 99.9kW installed capacity, operating on 134.5m gross head and rated flow of around 0.103$m^3$/s as the most suitable option. A maximum of 1.3xQmean, equal to 0.199$m^3$/s would likely be permissible under CAR regulations, which could be done by a 'technical variation' in future if required.

We have based the energy output prediction on a quotation received from Gilkes (see '15086GM Allt a' Mhuilinn Offer' for details). This comprises a single jet pelton with automatic spear-valve to vary flow rate in line with river flows. A twin-runner or twin jet machine may allow better match with the 'flashy' flow characteristics likely at this site, and should be investigated with suppliers during tender stage.

### 4.6 Generator & controls

The alternator could be either an induction or synchronous machine, depending on the control system chosen. It would export to grid over 3-phases, at 50Hz and generate at 'Low Voltage' ie. 440V. The generator is normally supplied with a control panel specific to the hydro scheme. The control panel is required to sync to grid and provide fully automated 'run-of-river' control.

The system continually senses the amount of water available using a water level sensor(s) at the intake. It is imperative that the control system is compatible with the turbine type and is often provided by the turbine supplier. Remote monitoring by 3G, landline or satellite connection is recommended for weekly operational checks and diagnostics.

## 4.7 Transmission line

The connection to grid requires approximately 200m of LV armoured cable from a new dedicated transformer to a cut-out adjacent to the turbine house. Planning has been approved for an external cut-out kiosk with timber fence screen. The DNO[2] switch-gear and meter cabinet could be housed externally, or within the powerhouse if the meter operator has an access key. The proposed grid connection would join the existing 33kV spur that terminates at NH 190 821.

A grid connection application was submitted June 2015 to SSEPD and an offer of connection was issued to the client on 14th Sept 2015, with connection date of 30th Sept 2017 (subject to negotiation with local depot nearer time of implementation). This has now been accepted since first draft of this report.

See document 'DOCO Allt A Mhuillin Hydro DOCO - EDY 615 14-09-15' for full details of connection agreement.

## 4.8 Construction Access

### *4.8.1 Site access from the trunk road*

The site has access to the lower and mid-tier using the existing FCS roads and bell-mouths from A835. The north and south entrances are herein referred to as Access 1 and Access 2 respectively.

Visibility splays for the accesses have been produced (see drawings 006-08-02 and 006-08-03 for detailed plans). These showed that the Wellingtonia trees are not within the required zone of visibility for either access. Some foliage, an FC sign and embankment needs to be altered to improve visibility.

The planning authority c/o Transport Scotland requested further information regarding visibility distances. A subsequent topographic survey revealed that the view splay south from Access 2 is partially obscured in the vertical and horizontal by the embankment on the road verge, despite attempts to improve this in recent years. Transport Scotland have been consulted directly by babyHydro in conjunction with the planning authority and their response confirmed the proposed embankment works would be sufficient mitigation to proceed with construction; see planning decision notice 15/02527/FUL for relevant planning condition.

### *4.8.2 Access from Forestry road*

The upper tier of the site to the intake area will require, as a minimum, temporary construction access to be made. It is proposed to use the existing route of the forestry harvester track, uphill from the forestry road as shown in the site layout plan 006-01-01. This will require suitable drainage and potentially borrow material. This measures approx. 950m

Although it could be cost and time effective to use alternative methods to transport materials to the upper site (e.g. tracked excavator/dumper, skyline winch, or even helicopter), it is recommended to install the access route to bring it up to a suitable standard for an all-terrain vehicle or quad bike. Material can be won onsite for granular surface metal using a small borrow-pit on site, which has been located and is shown on the plans.

[2] Distribution Network Operator – Scottish and Southern Energy Power Distribution (SSEPD).

The helicopter option could have difficulties while working on steep cross slopes of up to 35deg (1 in 1.8) or near trees but should not be ruled out if permanent access tracks were seen as prohibitive for some reason e.g. cost. Current estimated cost of upgrading 1km of access track is estimated to be £25,000, while helicopter may cost around £21,000 for three days' hire. With the complication of getting machines up to the intake safely and for maintenance in future, this option has been ruled out for now. Along the track route there were no major significant risks found in the geotechnical assessment except the short section adjacent to the intake. This will require careful design and construction methods. The remaining risks along the route are generally localised rock outcrops, which can be managed as per the geotechnical recommendations.


**Photo 2: visibility at access 2 is restricted by foliage, sign and bank**


**Photo 3: looking east from intake site. Large fragmented rock on LHS will need to be removed**

**Photo 4: looking downhill along pipeline from next to intake**

**Photo 5: position of pipe-bridge incorporating footbridge/viewing platform below waterfall**

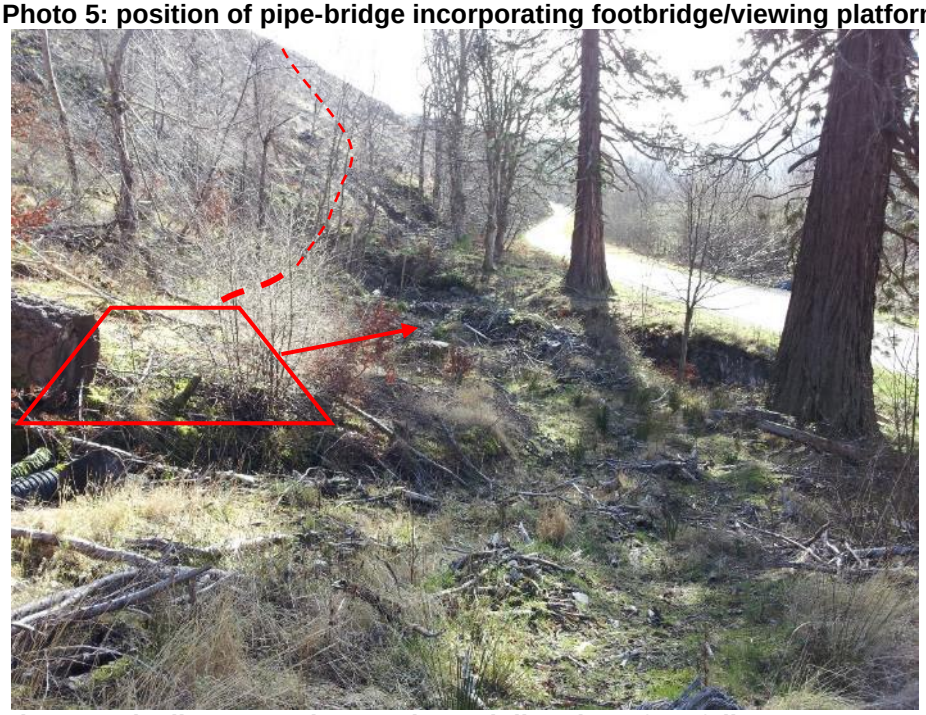

**Photo 6: pipeline, powerhouse site and direction of outfall**

**Photo 7: Looking approx. north adjacent to A835. Yellow line shows access route to Mhuilinn powerhouse site using previous harvester track from existing bell-mouth access to construction yard; slope beyond is on north bank of burn.**

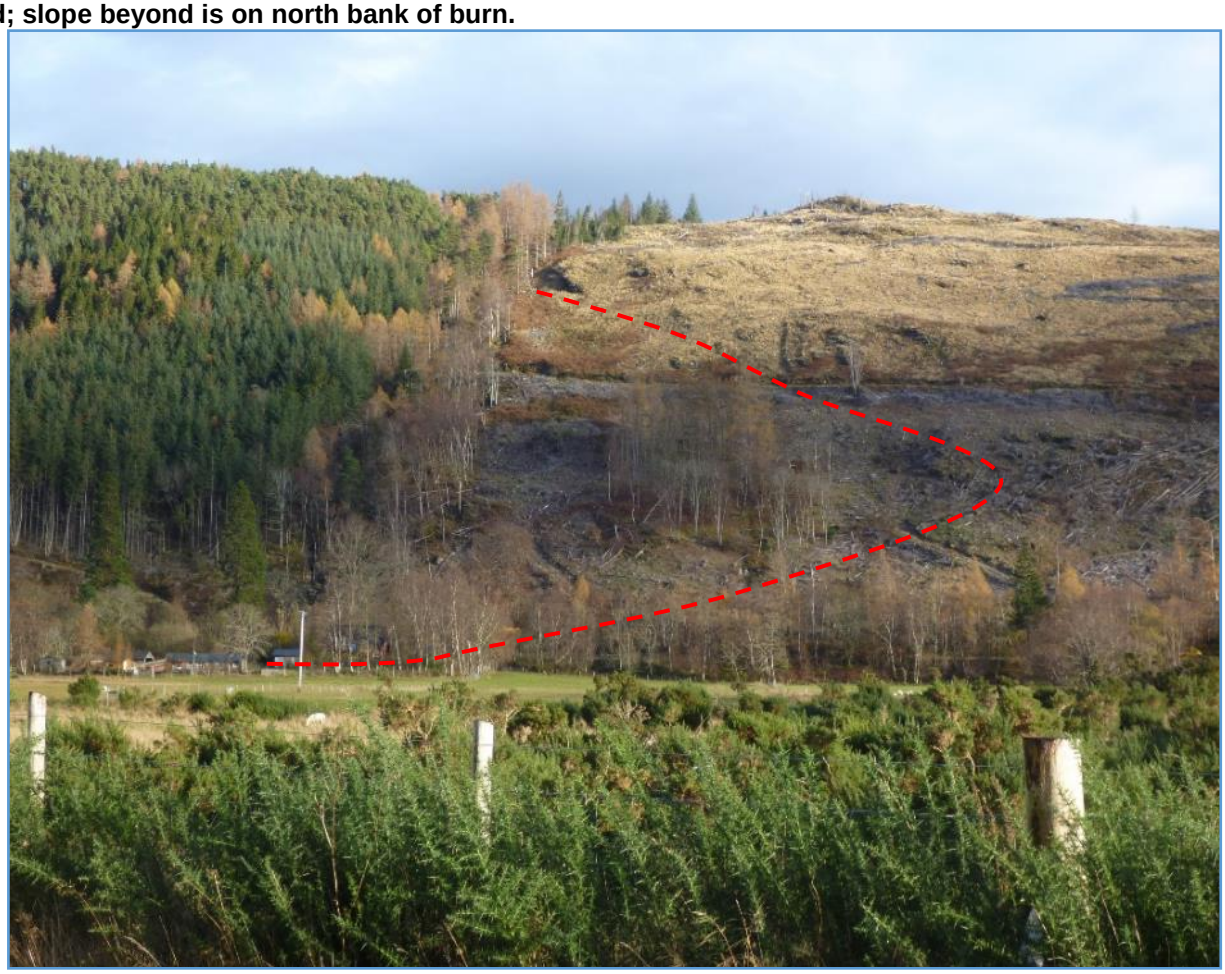

**Photo 8: approximate line of penstock route 1in3 gradient (photo by Paul Copestake)**

# 5 Hydrology

The catchment area modelled is 3.009km$^2$ and the annual mean flow 0.153m$^3$/s. It should be noted that this basin model was conducted at an intake location slightly upstream of the intake site and therefore the actual catchment area will be marginally higher.

For consenting purposes SEPA accept this as a suitable estimate of the hydrological conditions at the site due to the steep topography. As such, a Lowflows river flow estimate report, produced by Wallingford Hydro Solutions (WHS), was supplied to SEPA as supporting information to the CAR licence.

For a project of this scale, it may be considered prudent to conduct some form of in-river flow measurement in order to confirm the desktop model. However, Lowflows is an accepted industry standard and is widely used for investment and environmental decision making purposes. The report quotes the uncertainty and confidence levels expected and notes that results do not take into account unnatural influences, such as abstractions upstream. These are highly unlikely in this upland headwater tributary. Furthermore, a catchment area of more than 1km$^2$ is considered to yield suitably accurate results.

It was decided that flow monitoring for a 12 month period would not improve the confidence in the flow forecast model and so was not undertaken as it was not seen to be cost effective.

Based on the Lowflows2 hydrology model the recommended option to take forward is a 100kW scheme with a maximum design flow of 0.103m$^3$/s

# 6 SEPA - Water Framework Controlled Activities (Scotland) 2011

Water Framework Controlled Activities (Scotland) 2011 or CAR licence has been issued to LCR Ltd, which covers the construction of the intake, outfall and other in-water structures as well as the water abstraction volumes permitted.

See CAR licence CAR/L/1137084 for further details.

# 7 Geotechnical Risk Assessment

## 7.1 Scottish Road Network Landslides Study (2008)

It should be noted that the site was identified as 'High potential hazard' in the GIS based Scottish Road Network Landslides Study 2008.

## 7.2 Coffey Report (2012)

There is an existing geo-technical report by Coffey Geotechnics (2012) for the site, commissioned by FCS as part of their forestry operations risk assessments. This states a High **Hazard** category and a Low/Moderate **Risk** for the river gorges within the Lael Forest. The Mhuilinn gorge has not technically been defined in the Coffey risk assessment as a river gorge, but it has been assumed that it should be included in this category as it is a similarly incised, deep cut cascade. It recommends:

> "No heavy plant should work within 10m of the gorge unless a specific risk assessment is undertaken. Good housekeeping to ensure debris material is removed from the gorges where possible."

This risk level would apply to the intake, pipeline, access, powerhouse and outfall works where these are less than 10m from the burn, as this is considered to be within the main ravine. FCS therefore requested a project specific risk assessment to establish the level of risk and presence of hazards associated specifically with the hydro development.

The layout (as per layout shown in Figure 3) lies within Areas 14 and 15 as defined in the Coffey report, with the Mhuilinn river gorge acting as the boundary between area 15 and 16. There are rock crags, embankment slip and debris flow in the vicinity of the development, but outwith the immediate development boundary. There is potential for block fall and boulders being dislodged, which is considered a Moderate to High category hazard with Low to moderate risk. The main receptors to consider are the forest road users and the public road at the foot of the hill.

Steep gradients are present on site, between 20-33deg uphill of the FCS road and even steeper slopes of 20-40deg on the downhill side.

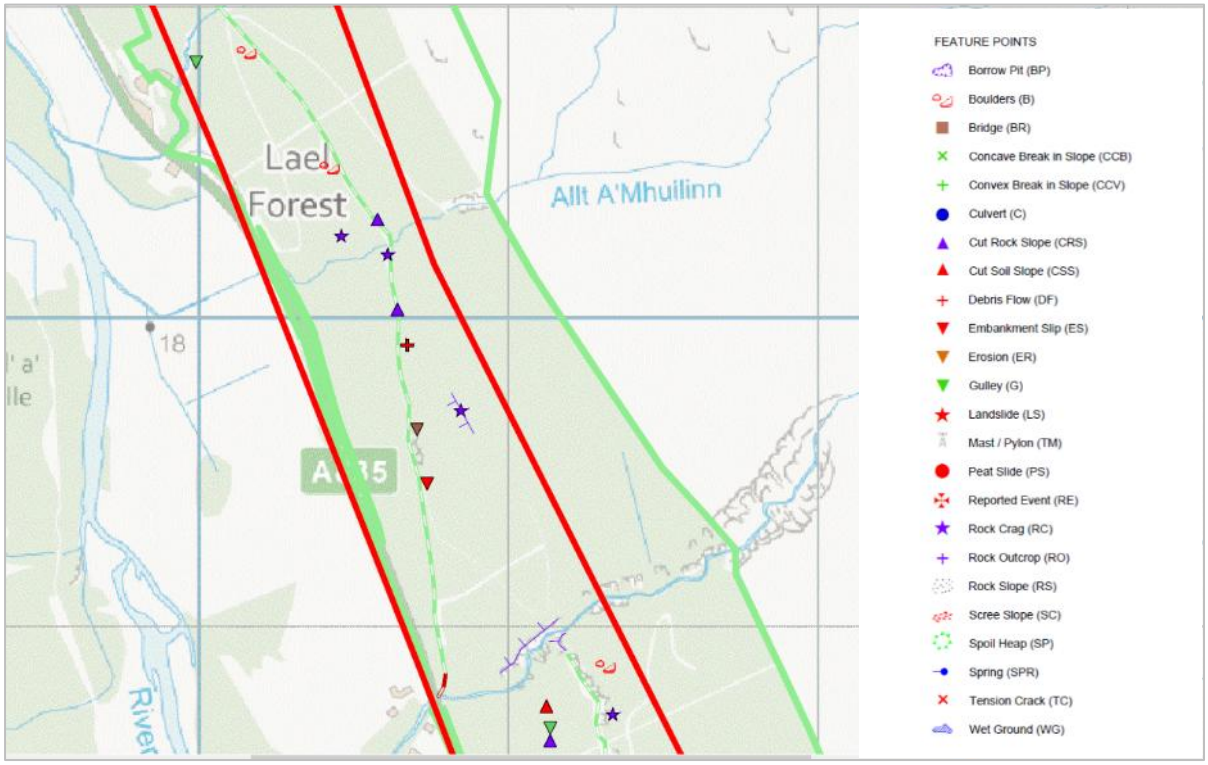


**Figure 1: Geo-technical point hazards (Coffey, 2012)**

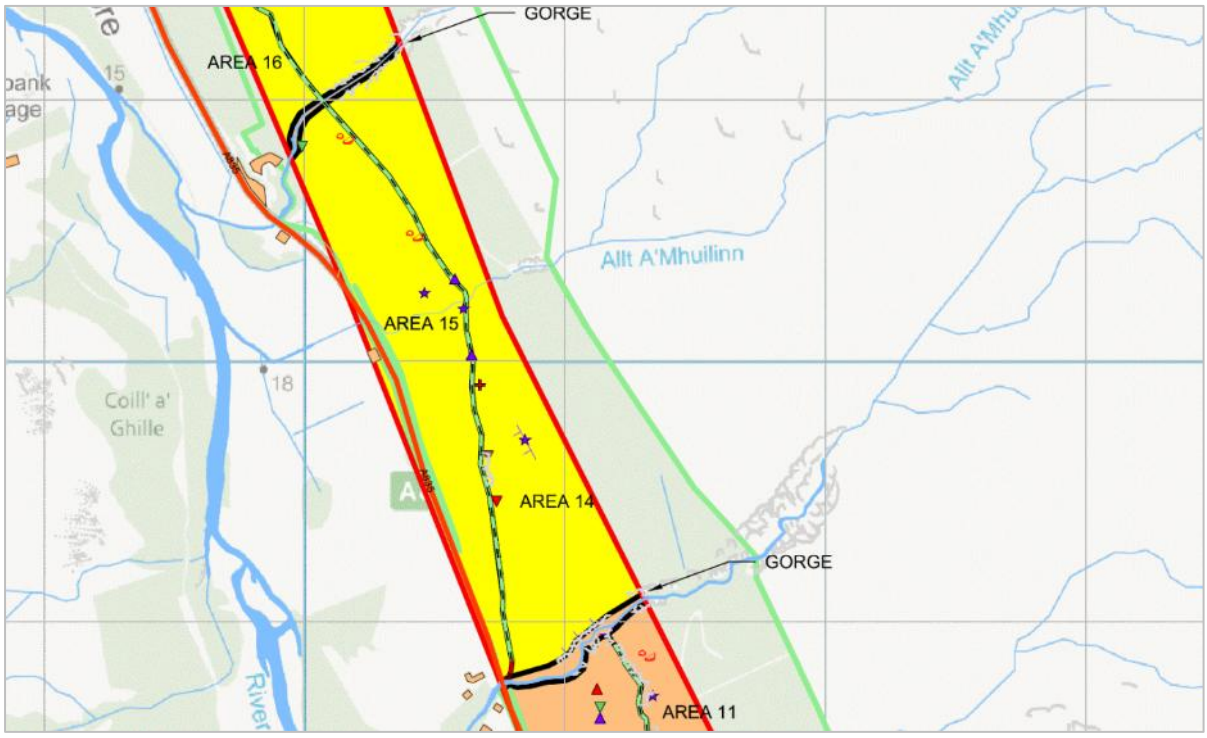


**Figure 2: Geo-technical area boundaries (Coffey, 2012)**

### 7.3 Dalgleish Associates Report (2015)

Dalgleish Associates were commissioned to carry out a detailed assessment relating to the hydro scheme development at Allt a' Mhuilinn. It comprised a desk based study, site walkover, hazard ranking matrix, discussions and recommendations. See their report dated 24th June 2015 for full details.

The findings confirm that there are four 'serious' locations (01, 02, 14 and 15) and several 'significant' locations (03, 04, 07, 09 and 29 outcrops/boulders) (08 and 29, steep slopes) that fall close to, or within, the development area. The report states that, through appropriate management and remediation, risks can be brought down to an acceptable level. The recommendations are that mitigation and further investigation work will be required. It has been suggested that either a broad brushed approach to the mitigation or a more specific assessment plus mitigation could be adopted. The latter is considered the most suitable in this case, because of the number of hazards on site. Either would be feasible in terms of safe working and cost. Detailed budget quotes should be sought from specialist contractors for specific engineering works to manage geo-technical risks prior to construction e.g. cleaning loose blocks from rock faces or installing catch netting, stand-off fencing. These have been estimated by civil contractor at this stage at £25,000 and are included in the financial budget in section 14, but could amount to more depending on ground investigations.

Contractor's construction method statements (CMS) will need to detail appropriate mitigation for the high risk areas identified in the report. For example, on the steep, potentially loose sloping ground, the pipe trench should not cut across slope at 90deg to the slope, nor straight down, but diagonally and be open for short lengths only (<50m) with clay/sandbag 'plugs' within the trench at regular intervals, or where working on the slopes directly above the public road.

The conclusion of the assessment is that further investigation is required and that mitigation will be required to construct to the required level of safety.

# 8 Ecological Surveys

## 8.1 FC Baseline Data

FC provided baseline, historic and management data relating to the Lael forest site. Summary of the significant points is provided below:

1. The upper section of the pipe route above the FC road is within what is called a Planted Ancient Woodland Site (PAWS). This area and the rest of the development are defined as part of a Low Impact Silviculture System (LISS) as part of FC's management plan.
2. The site has been clear felled and is currently rejuvenating.
3. There were recorded signs of hawks within 2km of the site, however none in the immediate development area.

## 8.2 Ecology Report - Direct Ecology (June 2015)

### Phase 1 Habitat, NVC and Protected Species

See section 9 with regard to surveys for aquatic species.

See section 10.2 for discussion about SNH's opinion on required protected species surveys as requested in the scoping phase.

Ecologists, Direct Ecology Ltd, carried out Phase 1 habitat, NVC and protected species surveys in April 2015. Their report dated 25th June 2015 provides a full discussion and conclusions to the findings.

#### *8.2.1 Habitats*

The majority of the site is harvested plantation woodland, but as this is recovering, is transitioning could be classed as plantation on ancient woodland. Indeed there are patches of riparian upland oak/birch woodland.

The NVC assessment found that some areas of woodland fall within priority habitat categories, however, due to their 'impoverished' conditions i.e. no mature trees, limited extent, they are not considered of significant value. They will however have a local value, and so through our design will be largely avoided where possible apart from several trees near the pipeline, where absolutely necessary. The individual and heritage value of the trees themselves is discussed further in the arboriculture survey schedule and Tree Protection Plan (SAS Ltd, 2015). Ground Water Dependent Terrestrial Ecosystems (GWDTE) or peat were not considered to be a prominent feature on this site due to its steep nature.

An Ecological Clerk of Works (ECoW) must be appointed and the construction corridor restricted during the works. Habitats should be restored as works proceed.

#### *8.2.2 Protected species*

Protected species surveys were carried out for badger, bats, otter, water vole, red squirrel, pine marten, wildcat and birds as well as other species.

Anecdotal evidence of badger (roadkill) in the vicinity were provided by a local farmer who lives near the site, but no signs were found in the survey area. The site doesn't offer optimal badger habitat due to its steep, rocky terrain, which is unsuitable for sett building. No mitigation is required.

Seven bat roost potential sites were recorded during the survey, with further potential possible along the trees lining the gorges. Most likely species present are common pipistrelle but Direct Ecology do have records of small brown eared roosts 3.5km north of the site. Accordingly, further pre-construction/felling surveys of trees required.

Otter activity across the site is low. No resting up sites were found on the Alt a' Mhuilinn within 30m of the development and a single spraint was found downstream, near the confluence with the Broom about 200m away. Two resting sites were recorded on the Allt a' Bhraighe, but these will not be disturbed and should not require a licence so long as >30m buffer is maintained.

**Photo 9: wellingtonia with woodpecker holes offering bat roost and bird nesting potential. These trees will be protected during the development and are included in the Tree Protection Plan.**

Red squirrel and pine marten are present on site and therefore pre-commencement surveys should be carried out, particularly where trees are to be removed and tool-box talks issued by the Ecow. Rocky areas that may offer potential resting up sites for pine marten should also be checked. If a den is discovered a licence from SNH would be required to continue with construction. It is unlikely that wild cats are present, but if signs are found then specialist licences and ecologists must be brought in.

SNH and RSPB do not consider it likely that there are either peregrine or golden eagle breeding sites within 1km of the site.

### *8.2.3 General Mitigations & Recommendations*

1. Ecological Clerk of Works (ECoW) should be appointed prior to construction
2. Restrict construction corridor as much as possible (planning red line boundary is a maximum – only disturb what is absolutely necessary) and restore habitat as work progresses.

3. Pre-construction checks for all species mentioned in report, especially bats and red squirrel in any trees that are proposed to be felled that could have bat roost potential (BRP) i.e. those near the burn that were not surveyed. Consider bat roost provision in powerhouse roof.
4. Breeding birds surveys should be carried out prior to build. Ecologists suggest discouraging nesting by carrying out vegetation clearing prior to build from Sept to April (i.e. outside summer breeding season) and ticker tape/markers on trees within the development site that are to be felled as part of the development.

There were **no significant impacts** predicted, provided the recommended mitigations are applied.

### 8.3 Woodlands & Tree Protection

Tree surveys have been conducted by Scottish Arboriculture Services (SAS), focusing on trees adjacent to the powerhouse and roadside as well as riparian trees around the intake. A total of around 40 stems are proposed to be removed in total across the site. These have been marked up on site and are included in the Tree Protection Plan and Tree Schedule submitted to planning. The planning conditions require that a scope of works is agreed for an Arboriculture consultant to provide supervision (especially felling and setting up the TPP measures) and written certificates of compliance are submitted and approved by planning (woodlands officer).

## 9 Aquatic Species (Wester Ross Fisheries Trust)

As described in correspondence with WRFT, their concern was any potential good fish habitat between the outfall and the first upstream natural barrier and any impacts downstream during construction or as a result of increased erosion/sedimentation. It's noted that the channel downstream of the road culvert was straightened in the past, and that efforts were made to improve riparian vegetation cover by WRFT and the Landowner with a grant from SNH, which was designed to encourage fish to use the lower reaches of the burn.

A qualitative fish habitat survey assessed the habitat in the depleted reach as well as downstream of the road. The road culvert on the Mhuillinn could be acting as a barrier to species moving upstream, especially in low flows, and furthermore the river channel generally consists of large boulders and stepped bed rock.

There is a reasonable level of vegetation cover from the confluence up to the main waterfall 60m upstream of the road.

It is unlikely that, in the wider context of the river catchment management, there will be any significant impact on aquatic species, assuming environmental good practice guidelines are followed by the civils contractor.

## 10 Planning - Highland Council (HC)

The site on which this development is proposed was once a working sawmill until the recent past and some signs of the old pipework are visible on the surface today. The predominant land-use now is turned over to forestry, but it will once again be harnessing power from the water, albeit with 21st century technology and incentives.

Stakeholder consultations were conducted and the planning application was submitted by babyHydro in July 2015.

Highland Council planning department raised concerns about several aspects to the scheme during the scoping phases. These have been addressed through iterative design process. The

archaeological or heritage aspects were not generally of concern, the focus mainly on environmental, safety, local disturbance and general appearance and landscape.

The expected 2 month determination was extended into late Sept due to several exchanges of further information and requests from statutory consultees.

For example, 1 ½ months after the planning application was validated, HC responded with a request for further information regarding the following:

1. Visibility splays from both access points (which required further topographic surveys)
2. Tree information including full scale tree protection plans, tree schedules of removal (also requiring further topographic information)
3. Borrow-pit sections (required further topographic data)

These were all actioned as soon as reasonably possible by babyHydro, the topo surveyor and SAS, but under significant time pressure. There was a significant delay to the consultations to HC and therefore the decision date was pushed back as a result. However, by working closely with the relevant parties, a decision was reached and planning permission granted on 29th Sept 2015. This remains valid for three years from this date, by which point works must have commenced.

### 10.1 SEPA

For further details See CAR licence CAR/L/1137084, effective from 21st July 2015.

SEPA have included their standard advice about the information required with the planning application. This includes details and assessments for all tracks, excavations, buildings, borrow pits, pipelines, cabling, site compounds, laydown areas, storage areas and any other built elements. BabyHydro anticipate that additional maps (with buffers) and assessments will be required for the site, showing all in-river works, peat (confirmation of zero peat), forest removal, borrow-pits and pollution prevention plans e.g. silt management. SEPA confirmed that because the site is within recently felled forestry, GWDTE assessment is not required. Laydown areas and compounds (for fuel storage etc) need to be considered, especially in the upper site. Specific consideration should be given to the material used for track upgrades, especially where borrow pits are proposed. It may be possible to construct a borrow pit in the upper site and subsequently use as a compound storage area if practical.

A good quality CMS and site management from civils contractors will discharge many of the conditions required by SEPA.

### 10.2 Scottish Natural Heritage (SNH)

SNH recommend that species specific surveys would be required for badger (there is a record of the species 8km north at Leckmelm), otters and where trees would be felled e.g. adjacent to intake and pipeline, bats and red squirrels.

It was confirmed that although the online SNH website suggested a bryophytes survey may be required for oceanic species, the aspect and nature of the river gorge is such that it is considered unlikely to yield nationally or internally rare species, and was recommended that no survey is required. This was also verified by expert bryologist, Gordon Rothero. (email correspondence)

The Beinn Dearg SSSI/SAC would only become a concern if the site boundary extended beyond the upper boundary of the FCS, which is now very unlikely given the discussions with the neighbouring estate didn't come to fruition.

SNH have responded to the planning application and have recommended implementing the mitigation measured as outlined in the ecology report and note that control of these measured should be managed by a suitably qualified ECoW.

## 11 Forestry Commission (Scotland) (FCS)

Kick-off meeting and site induction and risk assessment was carried out with the Forest Liaison Officer for the site. Information held by FCS on the site was provided, including geo-technical report, background environmental surveys and forest design plans. A site visit was conducted on 12th Nov 2014 once the options for layouts had been proposed and following this meeting, timber crop compensation figures were produced for the potential corridors requiring felling. This ranged from about £1,500 to £28,000 depending on the pipe route chosen. The current proposed layout, as shown in the site plan (drawing 006-01-01), should avoid compensation costs altogether as the pipe runs through the clear-felled area. It was generally agreed that the proposed layout was acceptable and no major issues or constraints were raised by the foresters.

The land lease agreement heads of terms, including rental rates are agreed and, at the time of writing, being agreed between LCR's and FC's lawyers. An agreed lease is imminent and will be entered in due course.

## 12 Grid Connection - Scottish and Southern Energy (SSE)

babyHydro consulted with SSEPD early in the process and they provided information on the planned upgrades to the local distribution and transmission line network. It was known (at time of correspondence Aug 2014) that the scheme would be likely to receive a connection date to the Distribution Network in 2017. However, the scheme was first thought likely to be 'Transmission Constrained' and thereby limited to 50kW export. It was estimated that this constraint would be alleviated in 2020. It was agreed to proceed with a grid connection application on this basis.

Although it was agreed that the grid connection application should be made as soon as possible in order to secure a place in the 'queue' for grid capacity, because the maximum installed power could have changed as a result of the environmental or topo surveys, it was prudent to wait until these were received before committing to a grid connection application. A time scale of around 4 months had to be allowed from making the grid application and waiting for an offer to be sent before accepting the offer.

The application was made for 100kW of capacity and we requested that staged payments offered, including the minimum deposit to secure the offer.

This has been paid, thereby entering the agreed terms of the offer. See offer document "Allt A Mhuillin Hydro DOCO - EDY 615 14-09-15" for full details with an estimated grid connection date of 30th Sept 2017.

## 13 Project Risks

The main risks to the project have been updated in the project 'Risk Register'. The primary concerns to highlight are:

- Constraint on the electrical distribution or transmission network - this has been confirmed by SSEPD that this line would be subject to transmission constraints until approximately Oct 2016. SSE will allow up to 50kW to be connected in such circumstances without triggering the need for what is called a 'Transmission Statement of Works'. It is recommended to proceed with infrastructure sufficient for the 100kW

scheme as the current project Gantt chart estimates a completion date of Sept 2017, by which time 'T-constraints' will no longer be an issue.

- Risk of larger than anticipated reductions to the Feed-in Tariff by The Department of Energy and Climate Change leading to the project becoming financially less attractive for any future investors: since phase 1 of the feasibility study, a 10% reduction in Oct 2014 and 10% in April 2015 have taken place. This risk is no longer an unknown as the FIT rate is now locked in by successful pre-accreditation on 29th Sept 2015.
- Encountering steep, unsafe ground during the installation of the intake or penstock leading to unexpected difficulties and requiring redesign of engineering works or land slippage and hence cost increases, especially at intake location and on the steeper sections of the penstock. Geo-technical report's mitigation measures must be appropriately implemented to sufficiently reduce this risk to project cost and to health and safety.
- The presence, volume and hardness of rock being underestimated; British Geological Survey record shows the solid bedrock over the majority of the site is underlain with Morar Group (Psammite) and shists, with superficial glacial deposits on lower gradient slopes. The geo-technical risk assessment includes details of rock types and site measurements of planes of weakness and fissure directions. Both vertical and horizontal weaknesses can be observed at weathered outcrops across the site. It is recommended to conduct ground investigations (e.g. trial pits, rock breaking or pecking) prior to the main construction.
- Risk of being unable to finalise financial or leasing agreements with funders and landowning stakeholders. The lease has been discussed at length with FCS, and neighbouring land-owners if applicable e.g. for grid connection wayleaves. FCS have standard set of lease terms for renewable energy projects now and wayleaves are a relatively straight forward task that the DNO deal with on a day to day basis. The neighbouring estate and residents have been consulted early in the project to avoid any unpleasant surprises. Scottish Investment bank have been consulted and a share offer strategy is being planned and implements by members of LCR, who have experience of similar fund raising projects.
- Risks associated with environmental constraints have been dealt with through the thorough and robust scoping, surveying and licensing process that has taken place. These shall be managed by constructing according to the planning conditions, for example employing specialist ECoW and Arborist and implementing good practice guidelines.

None of these risks are judged to be barriers to the development but some could cause costs to increases. Contingencies are included in the financial summary below, which aim to reduce the risk of such unforeseen increases.

## 14 Financial Analysis

The Financial Analysis gives a breakdown of the likely costs and revenues for the project. A table of predicted expenditure up to the completion of construction and commissioning is provided, and predicted annual cashflow over 35 years is also tabulated below in Appendix 2 cashflow.

### 14.1 Budget Costs

- Budgetary costs have been obtained from the leading turbine manufacturer in the UK, Gilkes, Gilbert and Gordon. This includes the turbine, generator, controls system, sensors, telemetry, building services, and mechanical & electrical installation. Details have been provided separately.
- Budget estimates have been compiled by civil engineering contractors RJ MacLeod, covering all aspect of the civils construction. It is noted that an allowance of £10,000 has been made for geo-technical mitigation works, but that the scope of these works required some further investigation. Details have been provided separately.
- The cost of grid connection is based on SSE carrying out all works and is subject to the conditions set out in SSE's offer EDY 615 14-09-15 (now agreed)
- No allowance has been made for compensating FCS for tree felling and timber due to the proposed pipe route. No reimbursement for loss of plantation ground is included, although it is acknowledged this may be required and is yet to be agreed with FC.
- The previous adjustment of £10,000 of CARES grant funding has been discounted from the financial analysis.
- The Capex figure includes cost of feasibility study (£37,419) and planning/CAR licence fees (£14,273), which will be sunk costs at the time of raising the remaining capital.
- A budget of circa £14,000 and £25,000 has been included for design and project management respectively, which are based on babyHydro estimates. Additional budget for the cost of environmental ecological clerk of works have now been included within the project management estimate, which is now confirmed to be a condition of planning permission.
- Contingency of 20% of the total Capex has been included.

### 14.2 Operating Costs

- Operating costs of a hydro scheme are relatively low compared to other forms of energy generation, but as with any mechanical equipment, regular maintenance is required. We have budgeted approximately £3,900 for annual turbine maintenance fees and an equal amount £3,900 for spares (though this is a generous estimate). Insurance, labour for other general maintenance and fees for meter operators make up the other operational costs. In the cashflow model (appendix 2) turbine overhaul at year 20
- An estimate of land rent payable to FCS at 3% of gross annual revenue. This is the latest estimate based on FC guideline figures, and considering the predicted scheme cost/kW is currently £7,500/kW, according to the guidance would require a rent of 2% - 3%.
- Contingency of 10% of the total Opex has been included.

### 14.3 Revenue

The main source of income for this scale of hydro is the 'generation' feed-in tariff, which is guaranteed by the government for a period of 20years and an 'export' tariff, which can be negotiated tariff in a Power Purchase Agreement (PPA). The predicted rates of tariffs used in the model are provided below in table 2 and 3. A small additional revenue stream of £5.3/MWh has been included from 'use of system charges' (bonuses) and triad payments, which may be secured through a PPA, but depend on the PPA supplier. Note: often the PPA export tariff is higher than the Ofgem 'floor price' - currently£48.5/MWH - so entering into a PPA is recommended; babyHydro can help negotiate this in the next stages of the process.

**Table 2: FIT Rate History Tracking and Degression Rate Assumptions Used**

| **Size band (kW)** | **Feed-In Tariff (£/MWh) Oct 2014- Mar 2015 (previous models)** | **Feed-In Tariff (£/MWh) Pre-acc by 30th Sept 2015 (best case - achieved)** | **Feed-In Tariff (£/MWh) Full acc byOct 2017 (worst case modelled)** |
|---|---|---|---|
| **Hydro** | **A** | **B** | **C** |
| <15 | 190.08 | 171.7 | 121.9 |
| 15-100 | 177.48 | **160.3** | **104.3** |
| 100-500 | 140.31 | 126.7 | 90.0 |
| 500-2MW | 109.62 | 99 | 70.3 |
| >2MW | 29.88 | 27 | 19.2 |

### 14.4 Financial Summary

Table 1 in section 3 presents the basic design figures for the proposed scheme layout:

Table 4 summarises the simple financial parameters based on the following assumptions:

- Simple payback ignores inflation applied to FIT and export tariffs, whereas the cashflow assessment (Appendix 2) assumes 2.0% inflation applied to FIT and exports tariffs.
- The simple payback also ignores the cost of interest on financial loans. In the cashflow model this is assumed to be 9.0% per annum.

Note that Table 3 in the Phase 1 report allocated an option number to each layout considered, proceeding in order of analysis revisions carried out. The preferred option carried forward was option 'no 21', using intake 'B2' and powerhouse site north-west of the burn.

**Table 3: Options Parameters (using Lowflows River Estimation figures)**

| Option | Name | Rated power (kW) | Annual energy (kWh) | Gross head (m) | Mean flow ($m^3/s$) | Qdes/Qm ($m^3/s$) | Q des ($m^3/s$) | Hands-off flow ($m^3/s$) | Capacity Factor % |
|---|---|---|---|---|---|---|---|---|---|
| 21 | Int B2 upper, Ph NW, | 100 | 479,000 | 134.5 | 0.153 | 0.673 | 0.103 | 0.018 | 55 |

**Table 4: Simple payback & 20yr Profit Scenarios**

| Option No. | | Rated power (kW) | FIT gen tariff (£/MWh) | FIT export tariff (£/MWh) | Total FIT (£/MWh) | Initial cost | Annual cost | Annual gross revenue | Simple payback (years) | 20 year simple profit |
|---|---|---|---|---|---|---|---|---|---|---|
| A – best* | Pre-acc by 30th Sept 2015 | 100 | 160.3 | 48.5 | 208.8 | £782,826 | £13,530 | £102,554 | 8.8 | £997,651 |
| B - mid | Fully accredit after Oct 2016 | 100 | 105.6 | 48.5 | 154.1 | £782,826 | £12,665 | £76,353 | 12.3 | £490,918 |
| C – mid | Fully accredit after Jan 2017 | 100 | 105.3 | 48.5 | 153.8 | £782,826 | £12,661 | £76,209 | 12.3 | £488,139 |
| D - worst | Fully accredit after Oct 2017 | 100 | 104.3 | 48.5 | 152.8 | £782,826 | £12,645 | £75,730 | 12.4 | £478,875 |

*NB: this is the tariff rate for which the scheme has now been pre-accredited with Ofgem on 29th Sept 2015

### *14.4.1 Discussion*

The projected rate of return on the project has decreased slightly since the Phase 1 report, but the project remains commercially viable. Proposed changes to the feed-in tariff framework remains a small risk, especially in light of the unexpected announcement to remove the pre-accreditation process as of 1st Oct 2015. Consultation on the full FIT review was still open at time of writing.

Some of the key points and changes are:

- The top-end estimated costs of electro-mechanical equipment has risen following budget quotation from leading UK turbine manufacturer Gilkes. Other suppliers are likely to be able to offer competitive quotes, so this should be viewed as the 'top end' of the market. babyHydro would facilitate a competitive tender with recommended suppliers as part of project management of the next stages.
- Annual energy output estimated in conjunction with Gilkes is marginally higher than previously modelled in phase 1 and is based on their system efficiency profile. There is clearly a premium to pay for their high system efficiency. Cost benefit analysis of other suppliers should be carried out at tender stage.
- There were some increases in the estimated costs for civil engineering works following geo-technical and topographic surveys and this was reflected in the higher budget estimation from civils contractors (RJ MacLeod c/o S. Osborne). The civil engineering works makes up the largest portion of the costs and is relatively high compared to some other sites due the steep and difficult terrain at Lael forest.
- Electrical distribution works to export to the 33kV grid network has been revised down significantly since phase 1 but is now 'locked in'. The cost has been revised down to just over £45.5K from £91K. This is based on SSEPD's offer (sept 2015). This includes an apportioned cost of £14.5K for wider network reinforcement that would be shared with other similar connection applicants in the area and SSE. The cost risk is reduced somewhat by splitting the grid reinforcement cost between all applicants at the time of writing. Revenue is not likely to be curtailed by transmission constraints as these are now estimated to be alleviated by 31st Oct 2016. Estimated grid connection date is end of Sept 2017.
- The total annual operating costs (especially insurance) are derived partly from the total capital cost, so the estimated annual costs have risen as a result of net Capex increase.
- Given the longevity of hydro power schemes (50years +) and the likelihood of increased wholesale energy prices into the foreseeable future, the scheme remains a financially viable prospect, with a predicted IRR of around 7.6% going by current budget costs.
- Capex and Opex figures presented here is in fact conservative (i.e. budgeting at the high end of those anticipated to avoid a short fall)
- The risk of missing the FIT pre-accreditation deadline on 30th Sept 2015 was highlighted by the figures in Table 5, which shows in the best and worst case scenarios which would have reduced IRR to 2.5% and virtually half the potential benefit to the community over the first 20 year period. Thankfully, this is not an issue as the scheme has secured pre-accreditation on the FIT as offered at 29th Sept 2015.

**Table 5: Financial Summary Breakdown**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | **babyHydro** | | | | | |
| **Summary of Costs and Returns** | | **Solution 1** | | **Pre-acc by 30th Sept 2015** | | | 22/09/2015 |
| | | | | | | | |
| **1. Capital Costs** | | **(£)** | | **3. Revenue (£/year)** | | | |
| | | | | | | | |
| Feasibility study | | 37,419 | | Installed capacity (power) | | 99.95 | kW |
| Design | | 14,021 | | Annual energy generation | | 479 | MWh |
| Devlpmt (proj mgmt, ecow etc) | | 32,997 | | Generation bonus (FITs or ROCs | | 79,322 | £/year |
| SEPA license/planning fees | | 14,273 | | Offset energy | | 0 | MWh |
| Lade/low pressure piping | | 313 | | Export revenue | | 23,232 | £/year |
| Penstock, bends and valves | | 22,500 | | Annual offset saving | | 0 | £/year |
| Penstock installation | | 22,500 | | **Projected Revenue** | | **102,554** | **£/year** |
| Civil works | | 314,000 | | Simple payback (total capital) | | 8.8 | years |
| Turbine | | 157,440 | | Simple payback (with grant) | | 8.8 | years |
| Generator | | inc. | | | | | |
| Turb & gen installation | | inc. | | **4. Financing Details** | | | |
| Transmission line & install | | 45,508 | | | | | |
| Transformer & connection | | 0 | | Cost of borrowing | | 9.00 | % |
| Extras | | n/a | | Percentage borrowed | | 100.00 | |
| Contingency 20% | | 121,856 | | Tax Rate | | 9.00 | % |
| **Total Capital Cost** | | **782,826** | | Capital Allowance for Tax | | 10.00 | % Ave |
| Less grant | | 0 | | Depreciation Rate | | 15.00 | Years |
| **Total Capital Cost less grant** | | **782,826** | | | | | |
| | | | | **5. Other Inputs** | | | |
| **2. Annual Costs** | | **(£/pa)** | | | | | |
| | | | | Year of Capital Cost | | | |
| Half-hourly metering | | 400 | | First year of Annual Cost | | | |
| Rent | | 3,077 | | First Year of Revenue | | | |
| Rates | | 0 | | | | | |
| Insurance | | 3,914 | | **6. Periodic costs** | | **(£)** | |
| Spares | | 3,914 | | Turbine overhaul yr 20 | | 31,488 | |
| O&M Labour | | 995 | | | | | |
| SEPA subsistence | | 0 | | **7. Results** | | **(£)** | |
| Contingency 10% | | 1,230 | | Accumulated profit yr 15 | | | |
| **Total Annual Cost** | | **13,530** | | Accumulated profit yr 25 | | | |
| | | | | Accumulated profit yr 35 | | | |
| **Gross head (m)** | | 134.5 | | | | | |
| **Design flow (m3/s)** | | 0.103 | | **SRDP grant?** | | N | |
| **Low-pressure pipe length (m)** | | 12 | | **New feed-in tariff?** | | Y | |
| **Penstock length (m)** | | 505 | | | | | |
| **Penstock internal diameter (m)** | | 0.254 | | | | | |

### 14.5 50kW Grid Constraint Discussion

It was originally thought that the scheme would be subject to transmission network constraints, which would have meant restricting generation export levels during its first year(s) of operation.

However, the latest information is that constraints at the Grid Supply Point (GSP) at Grudie Bridge are scheduled to be alleviated 31st Oct 2016, and if so would not affect the project timetable and therefore cashflow given the connection date for the low voltage 'Distribution' works is nearly 2 years from the grid offer date, 30th Sept 2017. As a community scheme, the timeframe to get installed is 30 months so this allows time.

It should be noted that there remains a requirement to demonstrate to Ofgem that the scheme is fully commissioned at the rated 'Total Installed Capacity' (TIC) of 99.9kW in order to qualify for the FIT.

The issue of grid constraint is therefore not of such significant impact as previously predicted.

## 15 Conclusion

Several options have been considered during the feasibility study and the pros and cons discussed. The preferred option taken forward for the Allt a' Mhuilinn scheme was a high-head scheme rated at 100kW, with a pipe routed down the south east side of the burn and powerhouse building on the north west bank, making use of the existing access from the main road.

In Phase 2 surveyors were commissioned to undertake the topographic, arboriculture, ecology and geo-technical work. BabyHydro conducted further environmental surveys, including noise and fish habitat, and gathered all other required supporting information in order to compile design and access statements, drawings and site plans.

The recommendation from the geo-technical investigation was that further detailed examination and mitigation plans on the specific high-risk outcrops and highlighted zones across the site should be undertaken. This should be completed pre-construction by specialist contractors with experience of vertical rock faces and steep slopes. The final method statements must translate into construction methods used by contractors on site in order to ensure the work is completed safely.

The layout as shown has been agreed with FC and is in the final stages of the lease agreement. The plans are being agreed based on the designs to date and will be as close as possible to the final design, with some micro-siting allowed within in the development boundary defined in the planning application.

The community benefit company has been registered with the FCA and board elected. The company are deciding on a marketing strategy for issuing a share offer and plan raising of funds.

CAR licence has been issued. There were no significant issues.

Planning permission has also been granted. There are some conditions of planning that involve slightly more ground works and management during construction e.g. arboriculture supervision at key stages.

The grid application was successfully lodged for the proposed 100kW scheme and has been accepted, with the minimum deposit paid.

The scheme was pre-accredited to the Feed-in Tariff on the 29th Sept 2015 and granted 'community' status allowing an additional 6 months to construct the scheme and convert to full accreditation.

The project has thus far not hit any unsurmountable environmental or technical obstacles following the phase 2 survey work and phase 3 financial stages.

Feedback has been generally positive from the nearby neighbours and the wider local community, which is a key hurdle in making this a successful project for the Lochbroom and Ullapool area. It will be an asset to the local economy and it is recommended to put the Allt a' Mhuilinn back to work, producing sustainable energy once again.

**Next Steps**

The next stages following successful pre-accreditation should focus on working on:

- finalising the lease agreement with FC
- financial share offer marketing strategy and prospectus and/or other project finance options
- preparing a team for the pre-construction and construction phases; deciding on the roles and the team going forward into the financing and construction phases including, project manager, principal designer (engineer for the works), site supervisor, construction contract manager, quantity surveyor and clerks of works (ecological and arboriculture).

-End-

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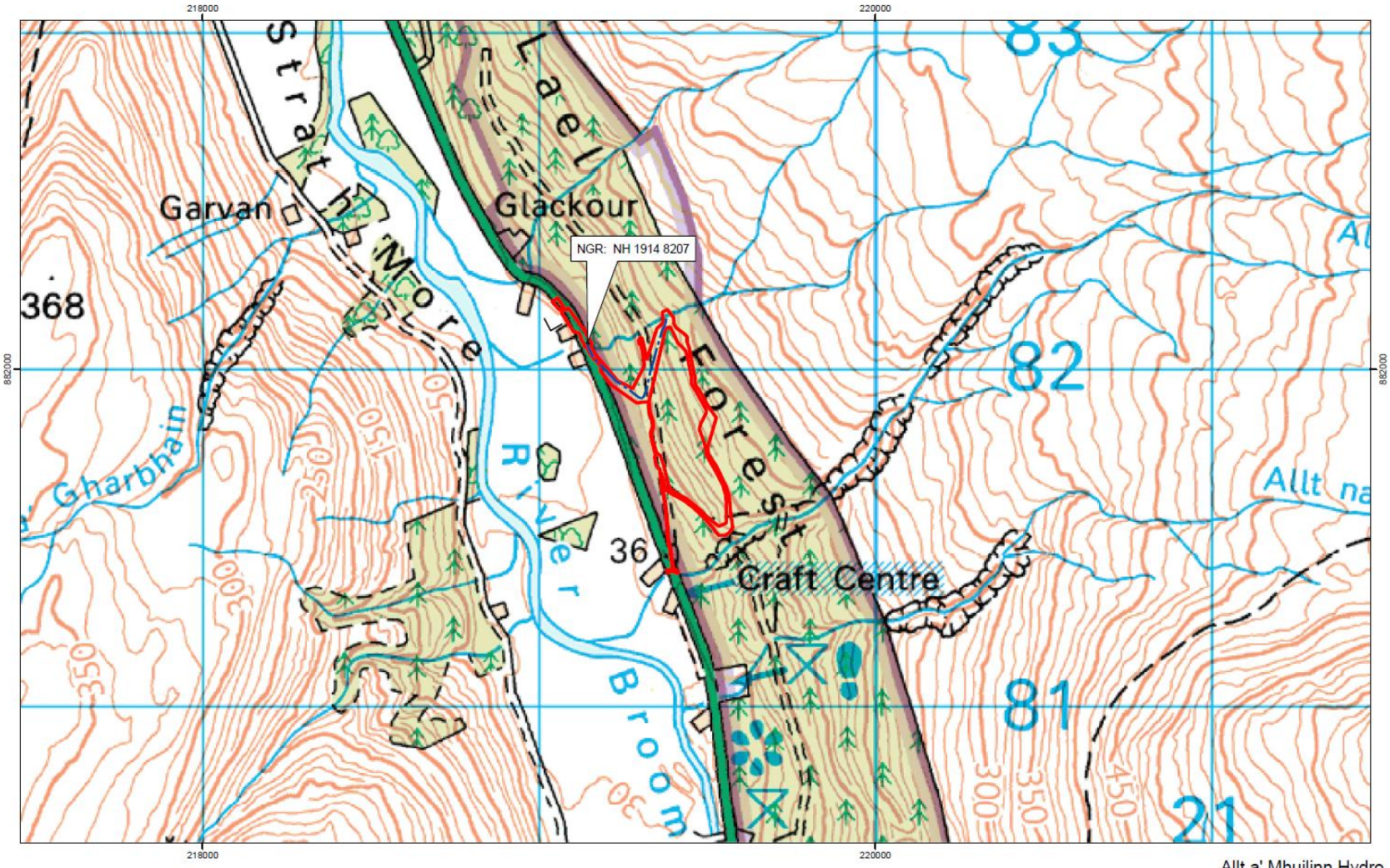
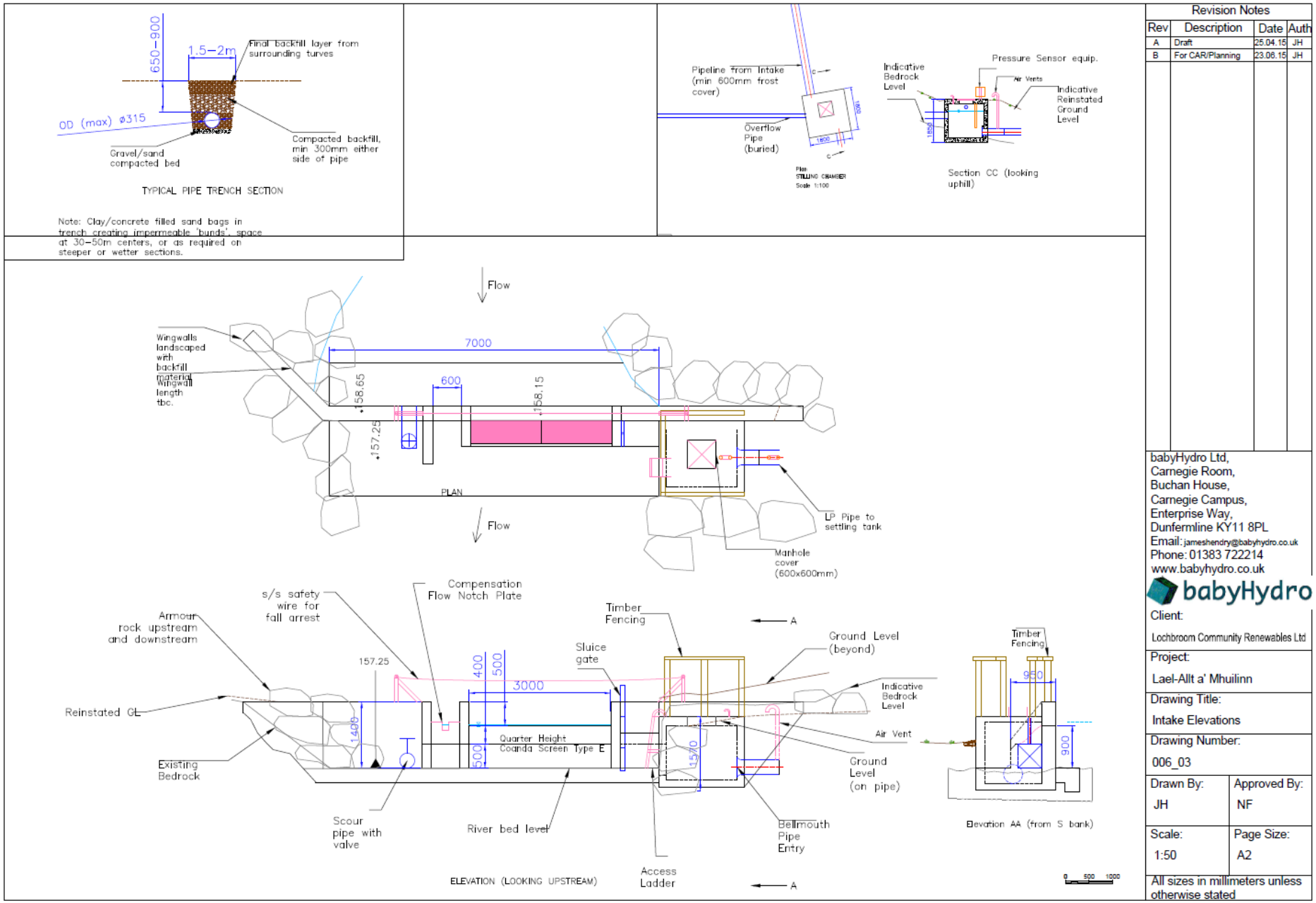
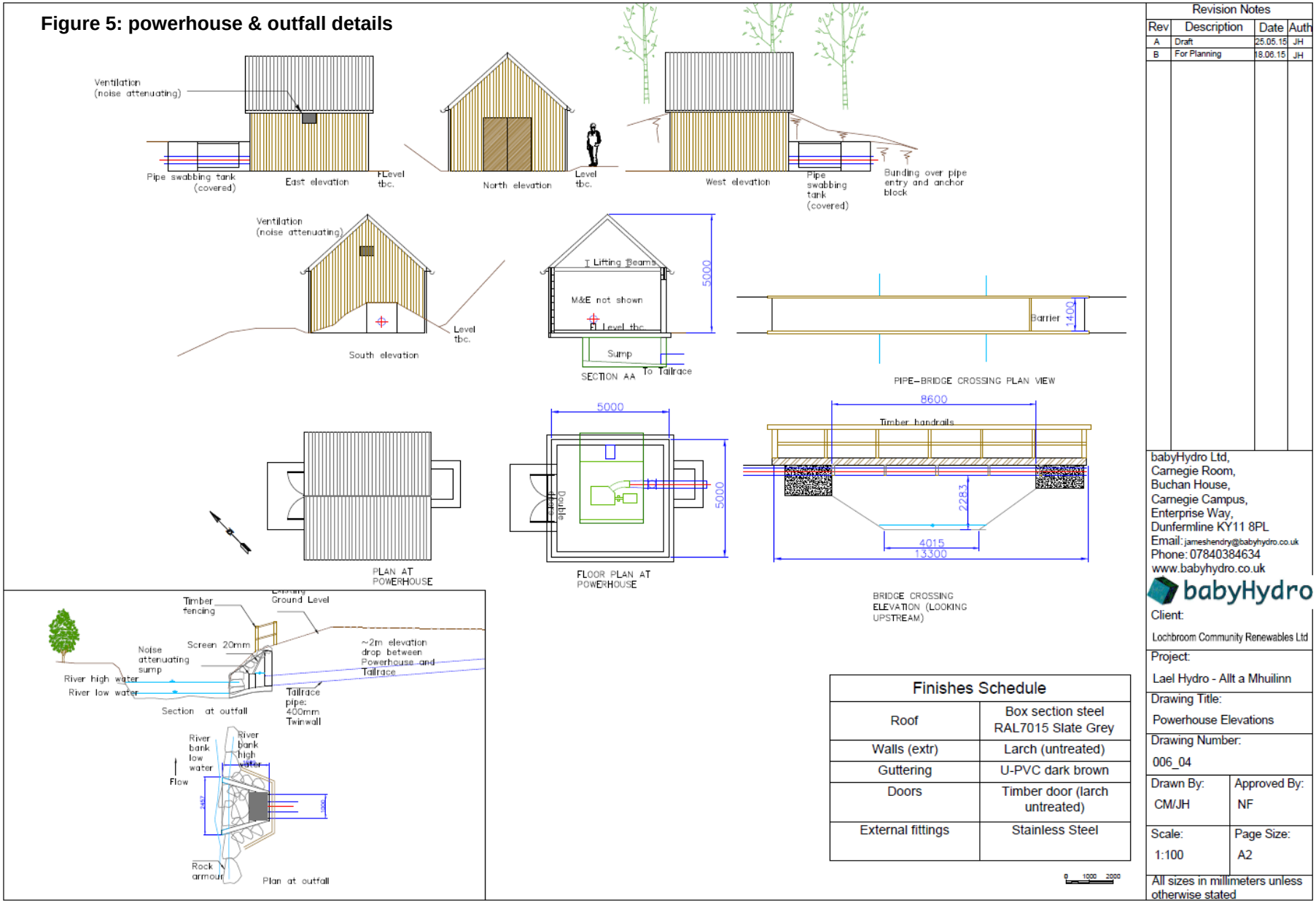
**Figure 3: Mhuilinn scheme location**



## Figure 4 – intake elevations



## Figure 5: powerhouse & outfall details




| Finishes Schedule | |
|---|---|
| Roof | Box section steel RAL7015 Slate Grey |
| Walls (extr) | Larch (untreated) |
| Guttering | U-PVC dark brown |
| Doors | Timber door (larch untreated) |
| External fittings | Stainless Steel |

0 1000 2000

| Revision Notes | | | |
|---|---|---|---|
| Rev | Description | Date | Auth |
| A | Draft | 25.05.15 | JH |
| B | For Planning | 18.06.15 | JH |

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Client: Lochbroom Community Renewables Ltd

Project: Lael Hydro - Allt a Mhuilinn

Drawing Title: Powerhouse Elevations

Drawing Number: 006_04

| Drawn By: | Approved By: |
|---|---|
| CM/JH | NF |

| Scale: | Page Size: |
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All sizes in millimeters unless otherwise stated