OXFORD
INTERNATIONAL
AQA EXAMINATIONS

2018/19 CANDIDATE RECORD FORM, PRODUCTION LOG AND ASSESSMENT RECORD

INTERNATIONAL INDEPENDENT PROJECT QUALIFICATION (9690)

Please attach the form to your candidate's work and keep it at the centre or send it to the moderator as required. The declarations should be completed as indicated.

Centre number	**Centre name**
16943	West Bridge College
Candidate number	**Candidate's full name**
94637	Davina Bains

Work submitted for assessment **must** be the candidate's own. If candidates copy work, allow candidates to copy from them, or cheat in any other way, they may be disqualified.

Candidate declaration

Have you received help/information from anyone **other than** your supervisor (include specialist consultant if relevant) to produce this work?

☒ No ☐ Yes (give details below or on a separate sheet if necessary).

Please list below any books, leaflets or other materials (eg DVDs, software packages, internet information) used to complete this work **not** acknowledged in the work itself. Presenting materials copied from other sources **without acknowledgement** is regarded as deliberate deception.

N/a

From time to time we use anonymous examples of candidates' work (in paper form and electronically) within our guidance materials to illustrate particular points. If your work appears in Oxford AQA Exams materials in this context and you object to this, please contact us and we will remove it on reasonable notice.

I have read and understood the above. I confirm I produced the attached work without assistance other than that which is acceptable under the scheme of assessment.

Candidate signature

Date 23rd January 2017

Supervisor declaration

I confirm the candidate's work was conducted under the conditions laid out by the specification. I have authenticated the candidate's work and am satisfied (to the best of my knowledge) that the work produced is solely that of the candidate.

Supervisor signature

Date 23rd January 2017

Candidate number	**Candidate's full name**
94637	Davina Bains

Submission checklist

To be completed by the supervisor

International Independent Project **working** title	Environmental and financial study on the use of a small scale hydrodynamic screw.
International Independent Project **final** title	Study of environmental and economic impact of the use of micro scale HEP (hydroelectric power) schemes.

Please note that failure to complete or submit a compulsory element may result in a mark of zero being awarded.

Select/tick	Items that **must** be included	Notes
☒	1. A signed and completed *Candidate record form, production log and assessment record*	This document. All pages must be completed.
☒	2. Research based written report	Must be 5,000 words in length (+/- 10%).
☒	3. Evidence of a presentation within the *production log*	Presentation on the project process and findings/conclusions.

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The taught skills element

To be completed by the supervisor

Outline details of taught skills

Record here details of relevant skills taught in a class/group and details of relevant skills taught individually to this candidate as described in the specification eg your scheme of work. Continue on a separate sheet if necessary.

All students received a 30 hour taught skills course, delivered by the supervisor in a class-room setting. This course was divided into five sections, based on the guidance in the IPQ specification:

1. Project Planning/Management
2. Research Skills
3. Report Writing
4. Presentation and Oral Communication
5. Evaluation skills

For the part of the course on Research Skills, the school librarians ran several workshops on skills including: selecting relevant resources, evaluating sources, research ethics and the importance of referening and bibligoraphies (in the context of avoiding plagiarism). The librarians also introducted students to the range of paper-based and online/electronic resources available in the school.

Regarding the part of the course on Presentation/Communication skills, students delivered practice presentations (on a separate subject of personal interest), to implement the skills learned.

The taught skills course was based on a number of resources, including the OxfordAQA Scheme of Work (https://oxfordaqaexams.org.uk/subjects/projects/ipq) and some online resources from:

- Southampton University: https://www.southampton.ac.uk/learnwithustransition/epq-support/index.page,
- Manchester University (Resources for Extended Project tutors and assessors): http://www.manchester.ac.uk/connect/teachers/students/post-16/extended-project/resources/
- Birmingham University (Research and Study Skills: Academic Writing): https://www.birmingham.ac.uk/Documents/students/guide-to-academic-writing.pdf

No additional/specific skills were taught to the particular student in question.

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Record of grade

To be completed by the supervisor
Grades must be awarded in accordance with the instructions and criteria in the specification.

Has the student done the following:

Identified and selects an area of interest.	Yes	No
Set a working title.	Yes	No
Undertaken a risk assessment.	Yes	No
Produced a project plan.	Yes	No
Implemented the project plan and documents any changes to it.	Yes	No
Produced a report addressing the selected final title.	Yes	No
Used a referencing method.	Yes	No
Communicated findings in the report and the presentation.	Yes	No
Created a bibliography/reference list.	Yes	No
Evaluated the strengths and weaknesses of the project.	Yes	No

If you answered "No" to any of the above, the student must be awarded a Grade U. If all answers are "Yes" proceed to the Grading section below.

Grading

Which grade descriptor is the project most like? (circle one)

A

If you selected **A**, is the project an **A**,
or is it better (**A***)
or worse (**B**)?
(circle one)

A*	A	B

D

If you selected **D**, is the project a **D**,
or is it better (**C**)
or worse (**E**)?
(circle one)

C	D	E

If you selected **E** above, as a final check,
is the project worthy of a pass (**E**) as
opposed to a fail (**U**)?
(circle one)

E	U

Candidate number	**Candidate's full name**
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Record of grade (continued)

To be completed by the supervisor

Summary information to show how the grades have been awarded should be given in the spaces below in addition to comments in other pages of this document and any supporting information in the form of annotations on the candidate's work.

Assessment objectives	Supervisor's supporting statement
AO1: **Selection of topic**	An initial area of interest is indentified early in the project: An outline aim and project scope is described in Record of Initial Ideas and there is some evidence of preliminary research – though this could have been more explicit. The Part A Candidate Proposal is well formulated.
AO2: **Planning, monitoring and developing**	There is a detailed working plan in Planning Review. The Mid Project Review reports some progress in research but on-site work yet to be attempted. There is some evidence of monitoring and subsequent changes. The project is completed by Project Product Review, including environmental reasons why calculations could be inaccurate. Log lacks detail in places, but does indicate that the project was well managed and developed by the student.
AO3: **Demonstration of research skills**	The report contains a bibliography of 22 websites, all of which were referenced in the report. There is no documented evaluation of sources, other than in answer to a question (Presentation Record Part B). This was a deficiency as many of the sources were from company websites; critical analysis was largely absent. Much of the research involved survey work at the proposed site to attempt to determine the viability of the proposed installation. This was fraught with many difficulties; the impact of these was evaluated and included in the report. Data was carefully analysed and clear links made between primary data and secondary research.
AO4: **Analysis and application of research**	The plan was implemented and the aim achieved; the site was evaluated both technically and economically and a proposal developed based on the potential benefits, but also including the potential flaws. The principles of the hydrodynamic screw were developed and compared to other methods of generating hydro-electricity, to show, with some conviction, the advantages of the HDS for the proposed site. The site was surveyed thoroughly and possible outputs compared to those reported from existing local schemes. Material was relevant and structured in accordance with the component parts of the work. However, the candidate did not appear to consider how best to present the copious data generated during the work. Conclusions were evidence based, but did depend on a number of assumptions, all of which were discussed in the report. There was good analysis throughout, with the caveat that the sources of much of the technical information may not have been evaluated. The candidate achieved synthesis between technical, environmental and financial aspects of the proposed instillation and reached conclusions on potential effectiveness. There was the potential for very significant shortfalls on the predictions; the origins of these were reviewed. Good oral communication (Presentation Record Part B), but the questions asked were largely on process, so did not give the opportunity to expand on understanding of the issues in this work.
AO5: **Evaluation of product, process and self**	The student's reflection on own learning and the process was supplemented by the evaluative sections in the presentation. The student identified clearly that the conclusion was largely based on estimated data. There was a good review of practical, analytical and IT skills developed, but this could have included further recognition of higher-order thinking skills, or how the identified skills could be utilised in future studies.

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Record of grade (continued)

Supervisor's concluding comments

This was a very original and ambitious project, based on careful planning and some good development. The weaknesses include a lack of source scrutiny (particularly pertinent given the nature of many of the sources) and a lack of control over the presentation of the report, which might have benefitted from a simpler design (to manage to amount of information involved).

Internal moderation comments if appropriate

Supervisor declaration

I confirm that no work assessed for the award of the grade above is also to be submitted, or has been submitted, for any other accredited qualification(s).

Supervisor signature

Date 18th January 2017

Candidate number | **Candidate's full name**
94637 | Davina Bains

Record of initial ideas

To be completed by the candidate

This page records initial meeting(s) with your supervisor to agree your project ideas. Additional pages can be submitted if more than one idea has been explored.

My idea(s) for topic/title:

One idea would be to do a topic about global warming but I thought the topic was too broad, impersonal and an obvious choice. Another idea focuses on the hydroelectric renewable energy, but I will have to know what I am aiming to do as it can get quite complicated. Possible title: Environmental and financial study on the use of a small scale hydrodynamic screw.

My preliminary research and development of my project ideas:

I will look into the general reasons for using renewable energy. I will conduct a semi feasbility study on whether I can could successfully install hydroelectic power on my river. There are limitations to doing this as I cannot do a full study because it would involve things like planning permissions and FIT eligibility to consider. I will only look into calculating flow and using the head to calculate as an estimate only, how much electricity I would generate and the costs of installment. I had written out a detailed plan on how my report will be structured and the contents.

My summary of the comments and advice from my supervisor (and specialist consultant if applicable):

We have discussed the structure of the written form of the project. Also which areas need to be researched as soon as possible. Whether I will install my 'own' HEP scheme or not- to be decided and whether I can get enough information to complete a full length project. She said it would be good to investigate actual small scale HEP stations and maybe compare them to big scale HEP stations, to get contrast as the report seems too specific.

Modifications I have made as a result of my discussion with my supervisor (and specialist consultant if applicable):

I changed of wording in the title from financial and economic. I also changed some of the structure and content. For example I used another existing HEP stations. One thing is missing from my plan is case studies of various different small scheme HEP stations such as Sonning Mill Theatre which I will include.

My proposed title, aims and objectives:

Study of environmental and economic impact of the use of small scale HEP (hydroelectric power) schemes.

Date 2nd February 2016

Comment [A1]: AO1 – A well-developed working title.

Comment [A2]: AO1 – An appropriate area of interest and a clear aim.

Comment [A3]: AO2 – Some initial refinement of first idea.

Comment [A4]: AO2 – Evidence of development of project, though justification could be more explicit.

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94637	Davina Bains

Part A: Candidate proposal

To be completed by the candidate

Working title of my International Independent Project.
Present the topic to be researched in the form of a short statement/question/hypothesis with clear focus.
Study of environmental and economic impact of the use of small scale HEP (hydroelectric power) schemes.

My initial resources will be

I will use my own location by a river as a case study for a future instalment of hydronamic screw. I will firstly carry out a survey on the river, this will be my primary data. I will also study environmental and economical impacts of installing the scheme, this will be my secondary data. I will do this by looking mostly into internet sources using government website, official renewable energy websites etc. I will other resources like leaflets and books.

Comment [A5]: AO2 – A clear strategy is evident.

The courses of study or area(s) of personal interest to which the topic relates

As I live by a river in which I own the part of the land that has goes with it and recent up-rise of renewable energy following the reduction of oil in the future. This inspired me to find any means of generating renewable electricity using the river.

My project aims and objectives

Firstly I will carry out my survey on the river. I have done research beforehand on the method and what data I needed to collect and I will pick the location best location to install the hydroscheme, I will measure the head using tape measure, the flow using a method which comprises of using a cork over a stretch of ten metres and timing how long it takes to get from one end to another then dividing that value by ten to give velocity which is metres per second. I will also measure depth and width to work out cross-sectional area of the river and then work out flow/discharge by multiplying cross-sectional area and velocity together to give metres cubed per second. I will measure the flow on one of the bypass river which will mimic the screw channel flow as proportional wise it is quite similar. This survey comprises of estimates not real values.

I will also do other background research to get an idea of what my project will comprise of and formulate a plan. I also need to make a decision of what type of hydropower I will use that is best for my site and explore all options. This will include recording useful websites and printing off documentations to highlight and understand.

Comment [A6]: AO2 – Clear strategy.

Provide details of the courses that you are currently studying

Qualification type	Awarding body and subject
eg A-level, IB, Modern Apprenticeship, BTEC	eg AQA Mathematics, OCR Computing, WJEC English
A-level	Biology
A-level	Chemistry
A-level	Geography

Qualification type	Awarding body and subject

Notice to candidate You must not take part in any unfair practice in the preparation of project work required for assessment and you must understand that to present material copied directly from any book or any other sources without acknowledgement will be regarded as deliberate deception. If you use or attempt to use any unfair practice you will be reported to Oxford AQA Exams and you may be disqualified from **all** subjects.

Candidate declaration

I certify that I have read and understood Oxford AQA Exams Regulations relating to unfair practice as set out in the notice to candidates above.

Candidate signature

Date 10th February 2016

Candidate number	Candidate's full name
94637	Davina Bains

Part B: Supervisor's comments on candidate proposal

To be completed by the supervisor
Please comment below on the validity and feasibility of the candidate proposal (Part A) as an International Independent Project.

	Supervisor's comments
Indicate the relation to, and development/extension outside of, the main course(s) of study or interest.	Personal interest for the candidate as she wishes to investigate the feasibility of implementing a turbine on her land. Candidate studies Geography A-level.
Comment on the suitability of the proposed initial sources and research base.	Very good.
Confirm that the project is feasible in the proposed timescale and/or indicate any potential difficulties that may prevent the candidate from meeting the Assessment objectives.	Yes it is feasible.
Comment on the suitability of the proposed title, aims and objectives.	A good title which is specific with the opportunity to develop a solid response.

Supervisor signature

Date 14th February 2016

Candidate number 94637

Candidate's full name Davina Bains

Part C: Centre coordinator's approval of candidate proposal

Supervisor's name

Melissa Pearson

To be completed by the centre coordinator
If you are acting as both the centre coordinator and the supervisor, please seek counter signature from a senior colleague.

Centre coordinator's comments on the feasibility and acceptability of the proposal (parts A and B) as an International Independent Project Qualification.

A very good project proposal. The proposal is detailed, specific and one which the student has a personal interest relating to the land and river owned by her family. This will give an opportunity to carry out live field work in the area where the turbine could be situated.

☒ Approved

☐ Approved subject to the implementation of the centre coordinator's recommendations

☐ Resubmission required

Centre coordinator's name

Claire Bevington

Centre coordinator signature

Date 16th February 2016

Candidate number **Candidate's full name**

94637 Davina Bains

Planning review

To be completed by the candidate

This page records your outline plan once your proposal has been approved.

My next steps in planning, researching and deadlines that I will set myself. What I intend to do, by when, what resources I will use and how I will implement the recommendations of the centre coordinator (where appropriate).

I had written out a detailed plan on how my report will be structured and the contents.

Comment [A7]: AO2 – clear evidence of a detailed working plan in this section. The student has clearly thought carefully about how to approach the aim.

Technical

- HEP, use, different types HEP
- turbines, wheels, choose one HEP power suited for my river
- kW, how much is generated

Primary survey

- measure flow
- mark river bypasses, use one to estimate max and min flow
- measure fall/head

Environmental impacts

- fish friendly
- Green energy, renewable, why its good. Future more demand for electricity, non renewable sources running out Future electric cars.
- effects on flow and flooding overall, using own river asses the problems that could occur with flow and head.

Costs

- building costs
- river works on banks and shutting oft river
- sluices (already 1nstalled in Jackpool)
- screw and turbine installation
- cost of screw and turbine
- cost of generator and electrics to hook up to house
- cost of maintenance. may break down which could result in high costs to fix it.

Benefits

- generate free electricity and save buying electricity from grid. Monetary. However may not always generate enough electricity.
- sell excess electricity to grid
- feed in tarrif, government grants and tax free, however in the future could be change in rules for government grants. taxes or permission etc.
- add value to building that comes with HEP

Risks

- changes in weather ,especially rain and flow over years.
- changes in river in summer and winter. I.e frozen or negative changes in head, flow and discharge.
- breakdown, high cost fixing
- change in rules, e.g. gov grants, taxes or permission etc.

- change in weather, flow, rain
- does not afways generate enough electricity

The reasons for my decisions.
It helped to divide my report plan into six distinct sections, beginning with some introductory information and then looking at the practical part of the work. I also thought it was a good idea to put the benefits and risks next to each other, to help me formulate my conclusions.

My summary of the comments and advice from my supervisor (and specialist consultant if applicable).
My supervisor said my plan was good and that I need to start doing a plan of when to write each section.

Modifications I have made as a result of my discussion with my supervisor (and specialist consultant if applicable).
Along with the plan I have formulated the dates which I will complete parts of my project. I will try to stick to the timetable well.

Please append any relevant planning documentation or tools that you have used.

Date 8th March 2016

Candidate number 94637

Candidate's full name Davina Bains

Mid-project review

To be completed by the candidate
This page records your outline plan when you have completed your research.

Is my project following my original plan? How has my plan developed?
I have completed the survey, I initially wanted to measure the distance of the cork travelled over 10 metres however because of access problems I had to do it over 14 metres instead. It was recorded on a slight miander too so the method is a little unreliable.I would like to improve the method by using a stream flow meter instead which had its own equation to work out velocity. It is far more accurate and quicker, it means I could take more readings and average them and work out flow in other locations to get the best idea of the overall flow.

Comment [A8]: AO2 – Good monitoring of progress against the plan.

The difficulties I faced in research is that the screw is so new that there isn't a proper terminology for it set in stone so I had to type in reverse Archimedes screw, hydro-dynamic screw or Archimedes screw to get what I wanted however Archimedes screw also referred to a different mechanism. I found it hard to write in third person in the report, every time I wrote in prose in anything I always wrote in first or second person never third person.

I changed various aspects of the report as I went along. For example I added history of the screw, I had rearranged the plan, to be in more logical sense. I also added a section when describe large scale and small scale schemes and what hydropower is used in those situations. I also added direct advantages of the screw.
The feasibility study was the hardest part of the project so far as it involves various different calculations most which interconnect with each other, it also involved using excel which I had some help on how to use it again. Finding the estimated costs of the screw was difficult and I had to use a general estimated cost of the installation in a website and had to estimate some of the pricing myself. Although I have contacted a hydropower company to look at the site and I will hopefully hear from him soon.

Comment [A9]: AO2 – Evidence of development of the project – decisions are clear though not always justified explicitly.

My summary of the comments and advice from my supervisor (and specialist consultant if applicable).
My supervisor supported my opinion about changing my method to using a stream flow meter, she has managed to provide me the school meter along with instructions on how to use it. She said some parts to my project had some bad grammar which needed correcting.

Modifications I have made as a result of my discussion with my supervisor at this stage (and specialist consultant if applicable).
I will definitely use the stream flow meter to measure flow at different locations. I have also gone through the project and tried correcting some of the grammar mistakes and tenses.

My final title, aims and objectives.
Study of environmental and economic impact of the use of micro scale HEP (hydoelectric power) schemes.

Comment [A10]: Note – further detail regarding the aims/objectives need to be stated here.

My planned next steps to achieve my project's aims and objectives.
I have completed most of the project, what is left is the feasibllity section which is the major part of the project. Doing all the calculations such as flow, power, cost, electricity generated, estimated income and payback time. I will also need to include an introduction regarding the location of the screw. Then based on this section I will write a conclusion regarding whether a hydro-dynamic screw can be installed.

Comment [A11]: Note - this could be clearer...!

Please append any relevant planning documentation or tools that you have used.

Date 4th June 2016

Candidate number	**Candidate's full name**
94637	Davina Bains

Project product review

To be completed by the candidate
This page records the near completion of your project product. Outline the successes, failures, additions and/or changes you made as you followed the plan in your mid-project review.

Did my project follow my revised plan from the mid-project review?
I have completed the whole project. The new improved river flow survey using a stream flow meter proved successful and the results were promising these results replaced my estimates of the river flow in other locations. The only thing was that the main mill stream flow may have been higher as I got backflow from the screens. On the wider rivers I simply measured the flow suspended from the bridge so waders were not needed. Again I have gone through the project and put headings in a more logical order. From the external company about the cost of the screw, I have heard rough estimates but no reply at the moment about the real costs of the project taking in account of repairs etc. A big mishap is that I went above the intended word limit, about 7,500. This was not including bibliography and contents . I then had to cut it down to almost 5500 including bibliography and contents which proved extremely difficult but I had to take out some content that was not directly related to my title.

Comment [A12]: AO2 – Good monitoring of progress and development of project.

My summary of the comments and advice from my supervisor at this final stage (and specialist consultant if applicable).
My supervisor advised that I should include a bibliography, that I must cite the website author and date. And also cross-reference sources and check if it is a valid source.

Modifications I have made as a result of discussion with my supervisor (and specialist consultant if applicable) at this final stage.
Do I need to do anything else to complete my project?
I have added a bibliography, however the referencing was quite difficult as I could not find many authors or dates of when the article was written. A lot of my project was based on PDF files so I could only find the company in which was written for.

Please append any relevant planning documentation or tools that you have used.

Date 3rd October 2016

Candidate number | **Candidate's full name**

94637 | Davina Bains

Presentation record part A

To be completed by the candidate

This page records your presentation and its preparation.

Planned format of my 10 minute presentation (eg audience, use of visual aids, slides, use of notes, etc).

I had done a PowerPoint presentation which included a short video clip of the screw working to gain a better understanding from the audience and also included graphs and tables to clearly represent what I was speaking about. I had handwritten the script then wrote it up on Microsoft Word which encourage me to proof read and make improvements to the script. The script itself was not fully written to what I would say, I left it in various bullet points with points that I will explain in the actual presentation as I think I understand and know my project well. I then rehearsed it to myself and found it took about 15 minutes.

Comment [A13]: AO2 – Good planning of the presentation.

Planned content of my presentation.

- **Project process:**

The main headings for my powerpoint was as followed:

- The purpose of this study
- What is HEP?
- slide showing a graph with differentturbines operating at different heads (m) and flow (m3 / s) with how much power (kW) they generate.
- slide showing graph with the comparison of the general power from the head and flow for a hydrodynamic screw
- slide showing a graph showing efficiencies of different HEP
- How the Hydrodynamic screw works
- Advantages of Hydrodynamic screws
- various case studies
- location
- Survey
- Economic analysis of installing screw
- The Environmental impacts
- Risks
- Conclusion
- Evaluation which included skills developed, research, difficulties, outcome and what I would have changed.

Comment [A14]: Structure of presentation is clearly considered carefully, though the student should take care not to try and include too much…

- **Project findings and conclusions:**
  - In conclusion it is recommended that the hydroelectric screw should be installed. This is all dependent on receiving planning permission from the environmental agency and local council.

Modifications I have made as a result of rehearsal and/or discussion with my supervisor (and specialist consultant if applicable):

Originally I was not going to do a PowerPoint, but my supervisor recommended that I should. I am glad I took this advice as it helped me a lot in my actual presentation as it made it easier for both me and the audience. I did however have a technological fault which resulted in the video not working.

Date 22nd October 2016

Candidate number 94637

Candidate's full name Davina Bains

Presentation record part B

To be completed by the supervisor
Record and comment below on the delivery of the presentation.

	Supervisor's record/comments
The nature of the audience should be a minimum of two adults including supervisor (include numbers of staff, students and others present).	Two members of staff present.
The nature of the presentation (include use of notes, use of display items, and use of presentation software).	Candidate used notes and detailed clear PowerPoint presentation.
Comment on the content and delivery of the presentation (for example clarity of ideas, structure of presentation, pace, engagement with audience).	Clear, confident and very knowledgeable delivery. The candidate has an excellent knowledge of the subject and is clearly invested in the investigation. She talked about the content of the project and the project process, both in details and to a high standard.

Please append any relevant planning documentation or tools that you have used.

Candidate number	Candidate's full name
94637	Davina Bains

Presentation record part B

Comment [A15]: AO4 – The four questions (should be five) are all about the process. Several of the questions should also be about the findings/conclusions/report so that the student has a chance to expand on their understanding of the issues involved.

To be completed by the supervisor
Record and comment below on the delivery of the presentation.

Comment on the response of the candidate to questions that demonstrated understanding and grasp of the project and/or its production. **Give examples of five questions asked and answers given.**	1. How did you manage your time? I tackled large chunks of the practical work and then wrote up the project in small amounts regularly. I made a plan of dates to complete the work by.
	2. How did you check the validity of your sources? I cross referenced sources and didn't discard any as the cross referencing provided enough confidence to use the data.
	3. Why did you use this project title? Personal to me as I want to install a turbine on my family land and wanted to complete a thorough investigation to decide if it would be cost effective.
	4. Were there areas that didn't go so well or you were unable to complete? The costings were more complicated than I thought. I would have liked to have got someone else with specialist knowledge to look at the location to provide guidance. Finding data for the case studies was difficult and I had to learn how to analyse this data. The screw is new and so there are no fixed terms for it making second research harder to do.
	5.

Supervisor signature

Date 2nd November 2016

Candidate number	Candidate's full name
94637	Davina Bains

Summary and reflection

To be completed by the candidate
This page records your summary, reflection and evaluation when you have completed your report and given your presentation.

Some questions you may wish to answer in this section include, what have I learned from completing this project? What new knowledge or expertise have I enjoyed or found valuable? What are the strengths and weaknesses of my project (including planning and organisation)? What skills have I improved? What changes would I make if I undertook such work again? What advice would I give to others undertaking such a project?

The hydrodynamic screw is used mainly for its high efficiencies and ability to generate enough electricity at sites with very low heads and flow. The advantages of Hydrodynamic screws is that it is low maintenance as minimal cleaning is required. There is low installation costs because it involves simple installation. It is durable, wear resistant and made with high grade materials. It has a Ccnstant supply of electricity, up to 95% efficient and self-regulating. The Environmental impacts of the screw are the river levels changing but river levels shouldn't be affected significantly as the flow can be controlled at various points. Fish migration is not a problem as the screw Is 'fish friendly'. Approximately 50-60 tonnes of CO_2 could be saved and it is also green way of generating electricity as it is renewable. Risks of installing the screw are that the capital cost could be more than expected or running costs more than expected. There could be access problems to the site, it could be installed too high or too low and the flow levels could vary. Permission may not be granted and income could be lower than electricity generated, flow, head could be less than expected. Feed in tariff or export tariff could change. Maintenance could be difficult as lifetime of screw could be shorter than expected. There is seasonal risks e.g freezing and flooding or physical damage to screw.

The economic benefits far outweigh the costs. The advantages are that there is a potential estimated annual income of around £15,000 (tax free) for 20 years, assuming an average of 60,000 kWh/year is generated. The anticipated payback period is between 5-7 years with 10 years as the worst case scenario. The property price is likely to increase by at least £150,000, more than the original investment. However, the analysis has not taken into account any costs of borrowing the initial Installation costs.

The environmental benefits far overweigh the impact. The environmental impact is relatively low as it has little effect on the wildlife and although the river levels may change slightly this has no significant environmental impact. However the energy generated is from a renewable source, saving a possible 50-60 tonnes of CO_2 per year.
In conclusion it is recommended that the hydrodynamic screw should be installed. This is all dependent on receiving planning permission from environmental agency and council. A previous planning permission was approved but has lapsed, this means that a resubmission is also likely to be approved.

Comment [A16]: AO4 – good, clear account of the key findings of the project.

I have learnt that feasibility tests involve a lot of calculations and estimates. It really annoys me not knowing the full correct answer as most of my calculations are based on estimates. This makes me curious as to whether actually installing the Hydro-Dynamic screw would work, showing whether my calculations and presumptions are correct.

Comment [A17]: AO5 – Evaluation of final report – insightful.

I started to do research last year in September, then I took measurements in October. I did little snippits of research, printed out sources and highlighted relevant information and added websites to the bibliography. In February I realised I needed to start writing the EPQ up. So I did little sections each week with an organised table showing when a section needed to be due. Over time this made me lose my motivation as it was difficult to see the outcome of the project I had a free weekend and did most of the write up. This was better as it encouraged and motivated rne better as I could see the project as a whole and the outcome better. I have learnt that it is better doing big chunks of the project at a time as it helps keep my focus.

I am faced with a small technical problem of using 2003 word and I'm worried that the conversion to the recent version will mess my format up.

I thought my primary research was very through, I have recorded many variables and also improved upon my method by using more reliable and technical equipment. I think my secondary research is detailed too. I have used many different resources. However some of the sources may have bias as some of the information has come from a screw manufacture. But I have made sure I looked at many websites to check the major source and cross referenced some of the websites.

Carrying out primary research, I have developed my fieldwork techniques, making sure I took many readings to get an average. I also learnt using equations to calculate using my results different variables like velocity and discharge. And further developing the data by calculating kW and money generated from the turbine.

I also developed my ICT skills. For example using Excel to create tables, graphs and to plug in difficult formulas. Also learnt how to put videos in PowerPoint's. Carrying out secondary research using leaflets and websites, I have also developed my skills in research ,referencing and evaluating sources.

Comment [A18]: AO5 – Good review of practical, analytical and IT skills development (but lacking in review of higher-order skills).

I have managed to keep my project relevant to the title and have managed to get good results. Although I have changed the content of my initial plan and changed the order to a more logical sense and also took out big chunks of the project which was extremely hard to do.

I have learnt a lot doing this project and if I did it again I would improve my primary research by measuring all the variables every month. Although this year was an exception as there were extreme flooding between December and march so measurements taken in that time would have to be taken out as is thought as an anomaly. I would have better time management by lengthening the content I write at various times. I would try and be more concise in my writing and improve my basic grammar such as plural = are and singular = is. Also if I did it again I would have done the project sooner and not in the time when I am most busiest in my A Levels and close to my exams, it gave me lots pressure completing it when I could have done it sooner in the year.

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Study of environmental and economic impact of the use of micro scale HEP (hydroelectric power) schemes.

- The plan was implemented and the aim achieved (AO4)
- Material was relevant and structured in accordance with the component parts of the work, however to some extent the material might have been structured in a more effective way... (AO4)
- Conclusions were evidence-based but did depend on a number of assumptions (all of which were discussed in the report) and therefore, to an extent, evidence was lacking... (AO4)
- Good analysis throughout and synthesis was achieved between technical, environmental and financial aspects (AO4)
- The report contains a bibliography of 22 websites, all referenced in the report (AO3). However, there is no documented evaluation of sources, which is a weakness of the project (AO3)

Written by

Table of Contents

Introduction

The purpose of this study is to find out the economic feasibility and environmental impact of a small hydroelectric power (HEP) installation to generate electricity at a particular location.

What are Hydro-Electric Power stations?

Nearly 18% of electrical energy worldwide is generated from Hydro-Electric Power (HEP) stations; it is currently the only renewable energy source to make a big contribution to the population the majority being large scale schemes. Hydroelectric power stations generate electricity converting the weight of water by a using a turbine and generator to produce electricity.

There are many different methods of generating electricity from water sources; these include using waterwheels, Hydro-Dynamic Screws and various types of turbines to convert the potential energy in water to turn a generator. The method chosen usually depends on the location and the available flow and the head of water.

Large Scale Schemes

Large scale schemes are usually based around dams or reservoirs where large quantities of water with a high head can provide huge quantities of electricity either continuously or over short periods (pumped storage).

Pumped storage

Pumped storage uses two reservoirs, one elevated much higher than the other. It is not a continuous way of generating electricity. When there is off-peak small demand for electricity, water is pumped from the lower reservoir to the higher reservoir using electricity at low-cost. At peak times when there is a higher demand for electricity the water is then allowed to flow back to the low reservoir which drives the turbines at high pressure. This generates electricity which is sold back to the grid at higher prices during peak demand for electricity. The problem with this is that it can use more electricity than it generates and is generally used only to top up the grid during peak periods.[i]There aren't many pumped storage stations, one example is Bath county station in Virginia, USA. It has a generation capacity of 3,003 MW and the station has two reservoirs separated by about 1,260 feet (380 m) in elevation. It is the largest pumped-storage power station in the world.[ii]

Dams

A dam is a man-made barrier built to hold back large masses of water creating a deep reservoir or lake. Generally dams provide a continuous supply of electricity but could generate less during the summer. The power station is usually at the base of the dam, but is sometimes at a much lower level and connected via pipes called penstocks. There are small numbers of large scale dams providing huge amounts of electricity. [iii]For example there is the Hoover Dam in the USA built in 1936. It has a maximum hydraulic head of 180 m and a flow rate of up to 85 m^3 / s. The dam has an annual generation of 4.2 billion KWh. [iv] [v]

Small scale schemes in high relief areas.

By far the majority of hydro schemes are in high relief areas where small dams can deliver high head but generally have smaller flow. Historically overshot water wheels have been used to convert the power of water into motion to drive machinery but as these are generally difficult to generate electricity from as it relies solely on the weight of the water and the revolutions are very low. A much more efficient method is by using turbines such as in Culbone, Devon where a Pelton turbine is used which jets water onto the turbine causing it to turn at very high revs. It has a very high head of 50 metres and low flow rate of 0.016 m3/s. It generates 4.5 kW and about 24,000 kWh per annum. [vi]

Small scale schemes in lowland areas

Undershot water wheels are traditionally used in medium flow and low head situation but they are usually not appropriate for generating electricity as they are inefficient and the revs per minute are low so high gearing is required. For example a waterwheel in Lowna Mill, Kirbymoorside, North Yorkshire which has a head of two metres and a flow of 0.305 m^3 / s, the maximum power output of 2.6 kW and the estimated annual output is 15,968 kWh.[vii]

Cross-flow turbines and Hydrodynamic screws use low head situations (HDS). HDS use the same principle behind the Archimedes Screw which turns using the potential energy of the water (see below for more detail). Recently Hydrodynamic Screws have been developed to be used efficiently in very low head and low flow locations. [viii] This means many more locations are now suitable for generating electricity efficiently. See figure 2.5 for case studies of hydrodynamic screws in the UK.

Options for the proposed site

The proposed location for this study has a low head (<2 metres) and low flow (<1 m^3/s) so there are only two options available, a water wheel and a hydrodynamic screw. As a waterwheel based solution is impractical and inefficient, the feasibility report below looks at the potential use of a Hydro Dynamic Screw.

Hydro-Dynamic Screws

History

A Hydro-Dynamic Screw otherwise known as the Archimedes Screw or reverse Archimedes Screw. The idea originated from the original Archimedes Screw which was used to raise water up for irrigation, it was invented by Archimedes of Syracuse in 200-250BC. [ix] But this was wrongly attributed as these screws existed in Egypt many years before then, Archimedes merely adapted the design.

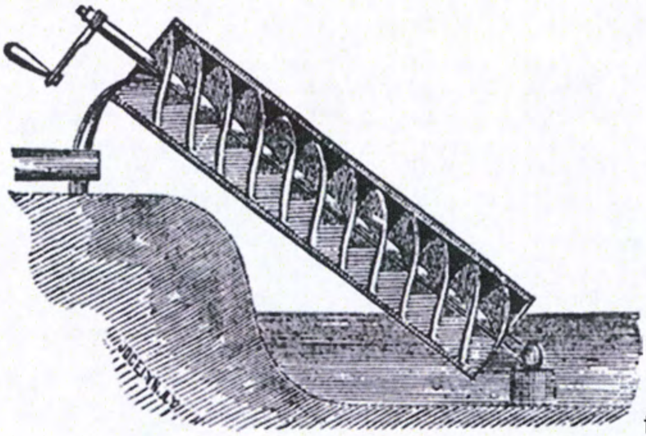


figure 1

Archimedes screw (figure 1) consists of a screw inside a hollow pipe. The screw is turned usually by a windmill or by manual labour. As the shaft rotates in an anticlockwise direction, the bottom end scoops up a volume of water. This water will slide up in the spiral tube, until it finally pours out from the top of the tube. It was used for irrigation or extracting water from low-lying lands and mines. Now it is still used to drain lowlands in Netherlands and sewage systems. [x]

Design

The Hydro-Dynamic screw works on exactly the same principles as the original Archimedes screw but acts in reverse. Using a Hydro-Dynamic Screw to generate electricity is a very recent concept, it has only been refined and commercially available in the last decade, so it is a very new way generating electricity using water and is particularly suited to low flow and low head situations.

The hydrodynamic screw works by the weight of the water turning the screw, as the water flows down the screw this action turns the shaft and in turn drives the gearbox and electric generator. The flow of the water is controlled by a sluice gate. Unlike the Archimedes Screw it does not need to be in a pipe, the screw can exist on a half-pipe with the other half exposed.

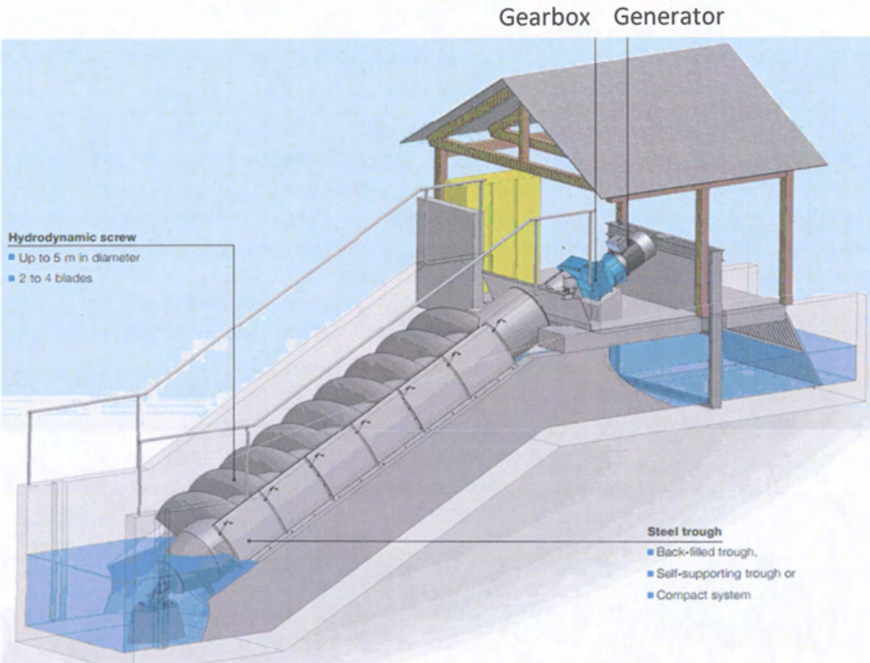


Figure 1.2 [xi]

The diagram above shows a 3-D drawing of a Hydro-Dynamic Screw. It includes the screw, support for the screw, a protective cover for the gearbox and generator. Instead of the turbine directly driving the generator like most hydroelectric stations, the screw drives the gearbox which then drives the generator. A gearbox is essential for the screw as the revolutions per minute are quite low in comparison to traditional turbines.

There are many factors to consider when installing a HDS on a river. For example flow, head, height of river, type of generator, gearbox and the effect on the environment.

Suitability of Hydro-Dynamic Screws for low head sites

Below is a diagram that shows the various types of turbines and their efficient ranges of heads and flows. From this it is clear that with a very low head and flow only Hydro-Dynamic Screws are suitable (labelled Landy Screw in the diagram below). The area shaded in green shows that a HDS can work down to a head of 1 Metre and a flow of 0.5 m3/s which is smaller than at the location.

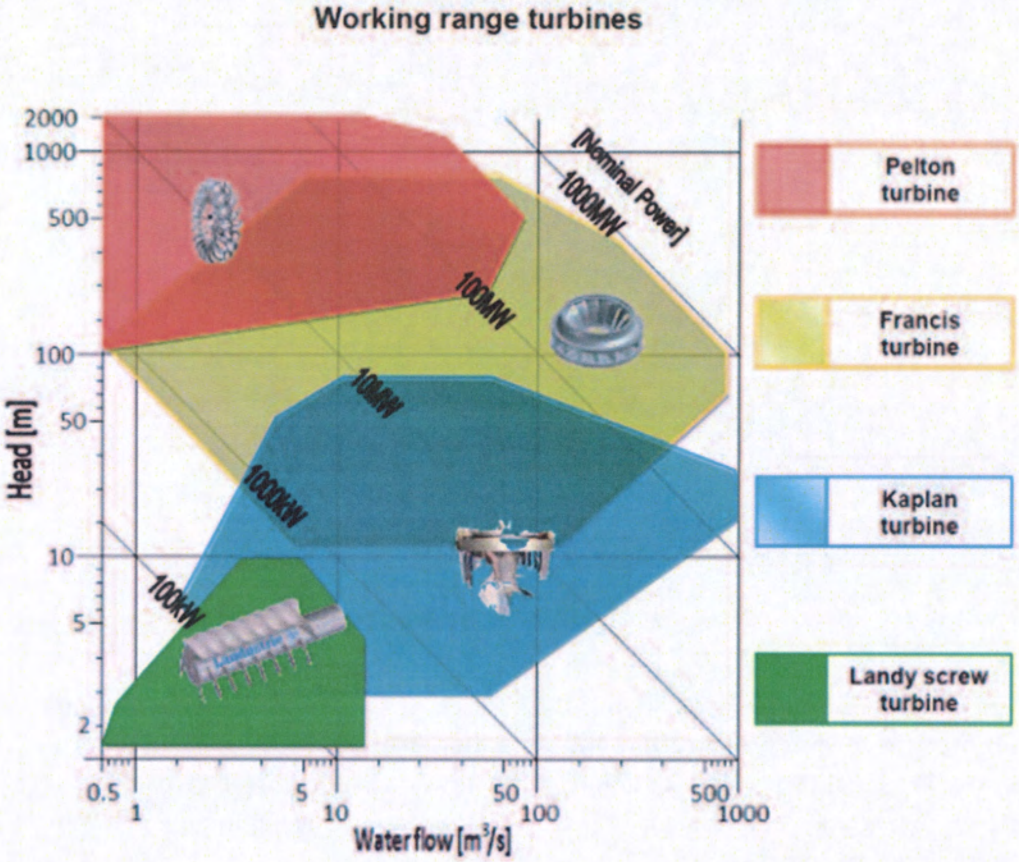


Figure 3 [xii]

Looking at the HDS section only (the green area) in more detail the figure below shows the possible power generated from various heads and flows.

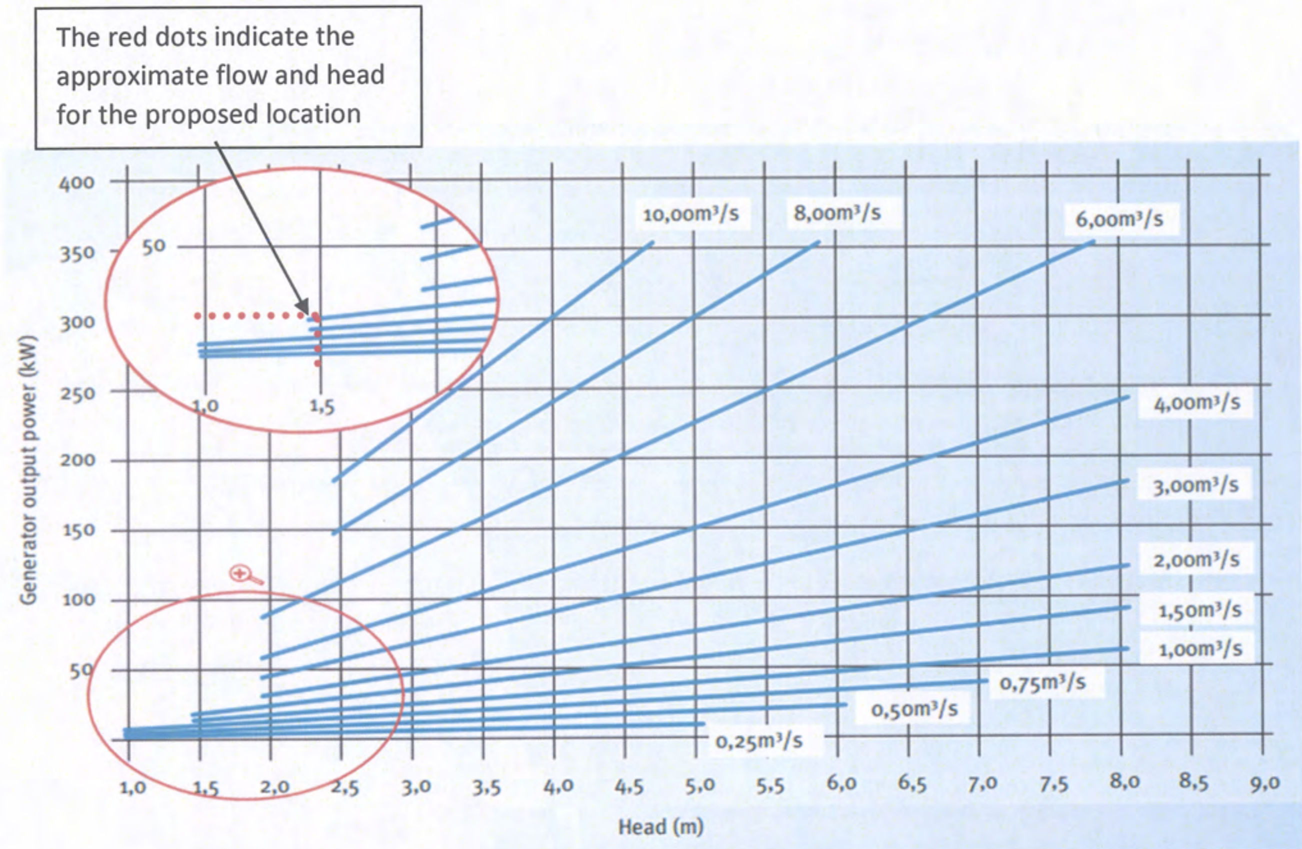


Figure 4 [xiii]

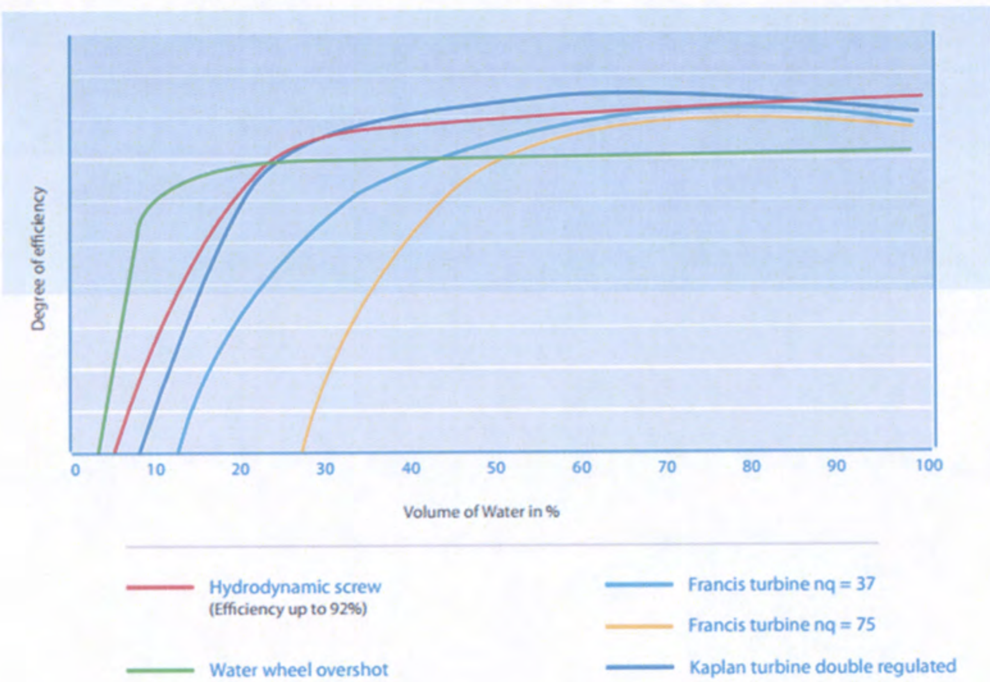


Figure 5 [xiv]

Figure 5 shows that the Hydro-Dynamic Screw has the highest efficiency of 92% with almost 100% volume of water in the screw. It not only has a very high efficiency it is also efficient across a wider range of flows from 20% to 100% of designed flow.

Advantages of hydrodynamic screws

They require very low maintenance as minimal cleaning is required. They can operate with a coarse screen (not a fine screen) so things like small twigs and leaves can pass easily

The screw has lower installation cost compared to other methods because it involves simple installation with less civil construction and can often be constructed into existing mill locations.

They also have low maintenance costs and are wear resistant because of the low revolutions per minute. They are made of high grade, durable materials therefore have a very long life cycle.

They have reliable and efficient operations at both high and low flow rates which means they can work efficiently with a wide variety of flow in the same location.

The screw is very efficient at up to 92%. It is efficient even with very low power output of 1 kW and with fluctuating water volume and levels.

Hydrodynamic screws improve water quality because of aeration of the water. The screws are fish friendly as fish can pass through the screws unaffected. This is more economic as no extra money is needed to build a separate fish pass. [xv]

Feasibility Study

Introduction

To estimate how much power can be generated from the stream the main factors to be considered are the flow through the screw and the head of water. The head is the difference between the height of the water above the screw and the height of the water at the lower side. Hydrodynamic Screws work best at low head locations, but the river needs a good flow. The power generated also depends upon the efficiency (conversion of the potential energy in the water to electrical energy). Archimedes Screws are one of the most efficient ways of converting this energy and can be up to 92% efficient.

Proposed location

The proposed location is at Calcot Mill, Mill Lane, Reading and is situated on the Holybrook which is a distributary off the Kennet. The Holybrook splits from the River Kennet at Arrowhead close to Theale, about 2 miles up-stream from the Mill. Historically Arrowhead split the Kennet two thirds of river discharge for the Kennet and one third for the Holybrook. Since the original division was made some silting and narrowing of the entrance to the Holybrook has meant that the division is closer to three quarters to the Kennet and one quarter to the Holybrook.

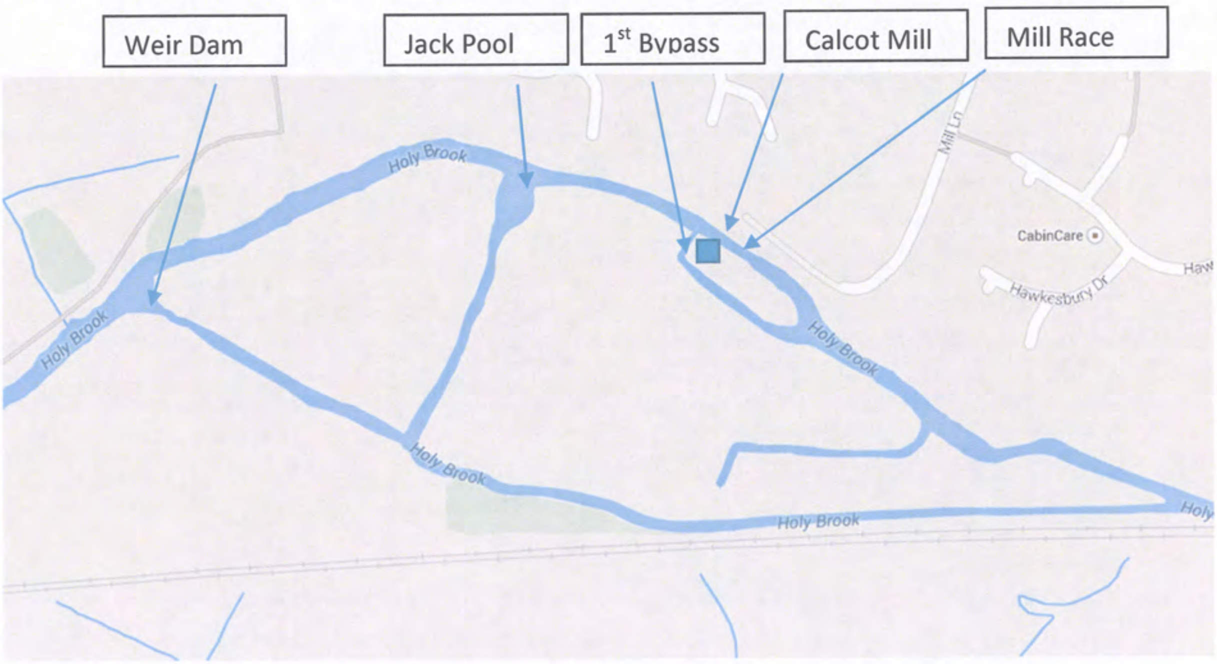


Figure 6

Calcot Mill is no longer a working Mill but still has the main river passing under the Mill and into the main mill race along with three bypass streams of different sizes shown above. The first bypass stream has a partially working sluice. It splits from the main river just above the Mill and joins back into the main Mill race about 70 metres downstream. The second, main bypass stream has two working sluices and discharges into a large pool called the "Jack Pool" and is about 100 metres upstream of the Mill. This main bypass stream is the primary method of controlling the flow and levels of the Holybrook River. There is a final bypass stream about 200 metres upstream of the Mill. It is constructed of a concrete dam with the top level of the dam at a level where the river flows over when the river is in flood. This stream should only allow a very small amount of water to pass, but at the moment the concrete dam has been eroded and is leaking allowing a large amount of water into the bypass stream, both during the summer and winter. This weir dam needs to be fixed to keep the water in the main river.

The proposed project is to install a new Hydrodynamic Screw, turbine and associated sluice and feed channel on the western side of the Jack Pool slightly upstream of the existing sluice. The feed channel will be cut across the existing access track at a slight angle. It will be covered over to enable tractor access to the rear field. The channel will feed directly across to the edge of the existing Jack Pool bank to where a new sluice will be constructed to regulate the flow into the screw. The screw will be installed at the appropriate descent angle and flowing the same angle as the feed channel to reduce possible loss of energy. New piles will be installed into the bed of the jack Pool to support the lower end of the screw. The sluice on the feeder channel will be used to maintain an agreed river level on the upper stream. A large trash screen will be installed on the upper entrance to the feeder channel.

Other building work is required including steel support and concrete behind to stop the leak in the weir dam and also the small leak developing to the side of the Jack Pool sluices.

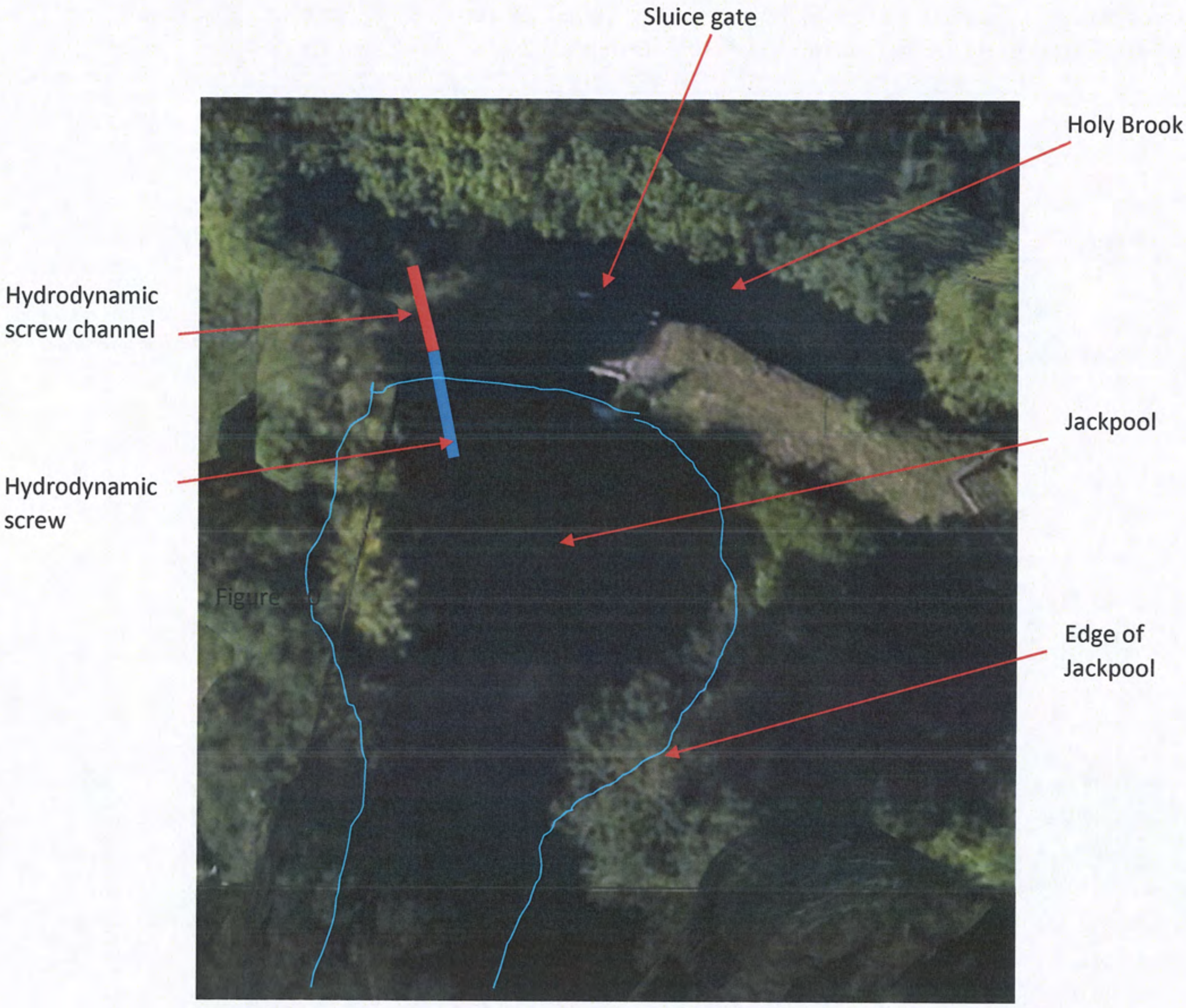


Figure 7- Plan of Installation of the screw (Google Maps)

Figure 8

Figure 9

Figure 10

Figure 11

The pictures were taken in the Jack Pool where the Hydrodynamic screw will be located. The red lines are estimated guidelines so where the hydrodynamic screw will be installed. Figure 8 shows the side profile of the position of the screw and feeder channel. Figure 9 is exactly the same but on the opposite side. Figure 10 is showing the location of the feed channel. And figure 11 is the down facing perspective of the screw. The screw and channel is positioned at approximately 45 degree angle (as shown in figure 2.0) from the Holybrook to ensure maximum flow into the turbine.

River flow estimates

It is necessary to estimate the overall flow of the Holybrook and in turn each of the bypass streams both during maximum and minimum flow situations (winter and summer).

To work out the flow of the Holybrook and then the various flows through the main mill stream and associated bypass streams to ensure enough water can go through the turbine and also ensure that enough flow continues in the other streams so that the water level does not change too much.

To estimate how much flow there is in the Holybrook over the year I have looked at the flow of the Kennet at Crump Weir at Theale, where there is an Environment Agency flow gauging station. This has been measuring the flow since 1961 and has full records until 2012.

Crump Weir details

Grid Reference:	SU649708	**Catchment Area**:	1033.4 km^2
Measuring Authority:	Environment Agency - South East	**Station Level**:	43.4 m AOD
Hydrometric Area:	39 - Thames	**Station Type**:	Crump weir
Period of Record:	1961 - 2012	**Sensitivity**:	6.5 %

Crump Weir location

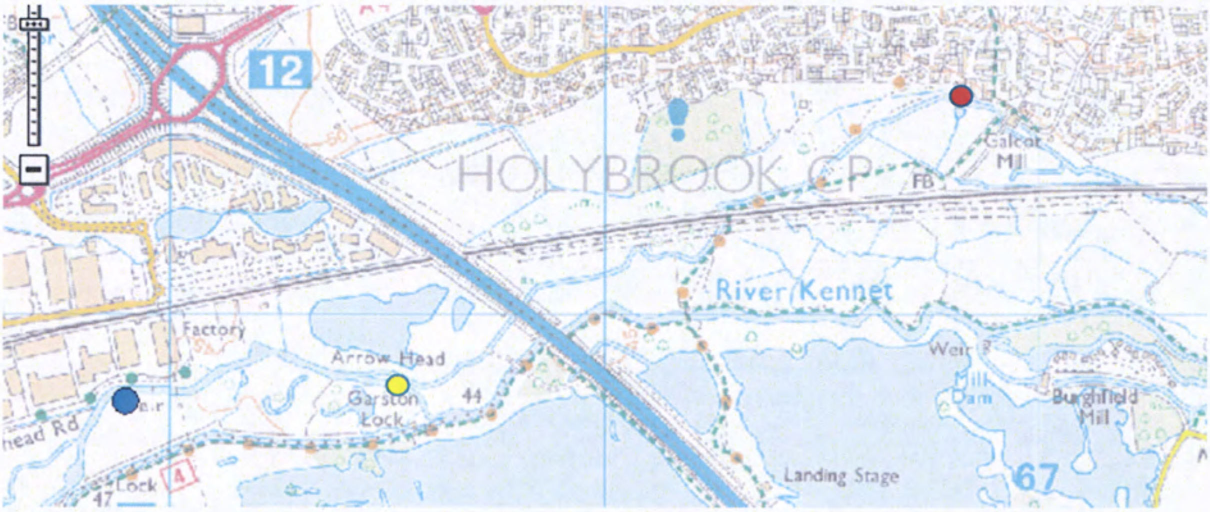
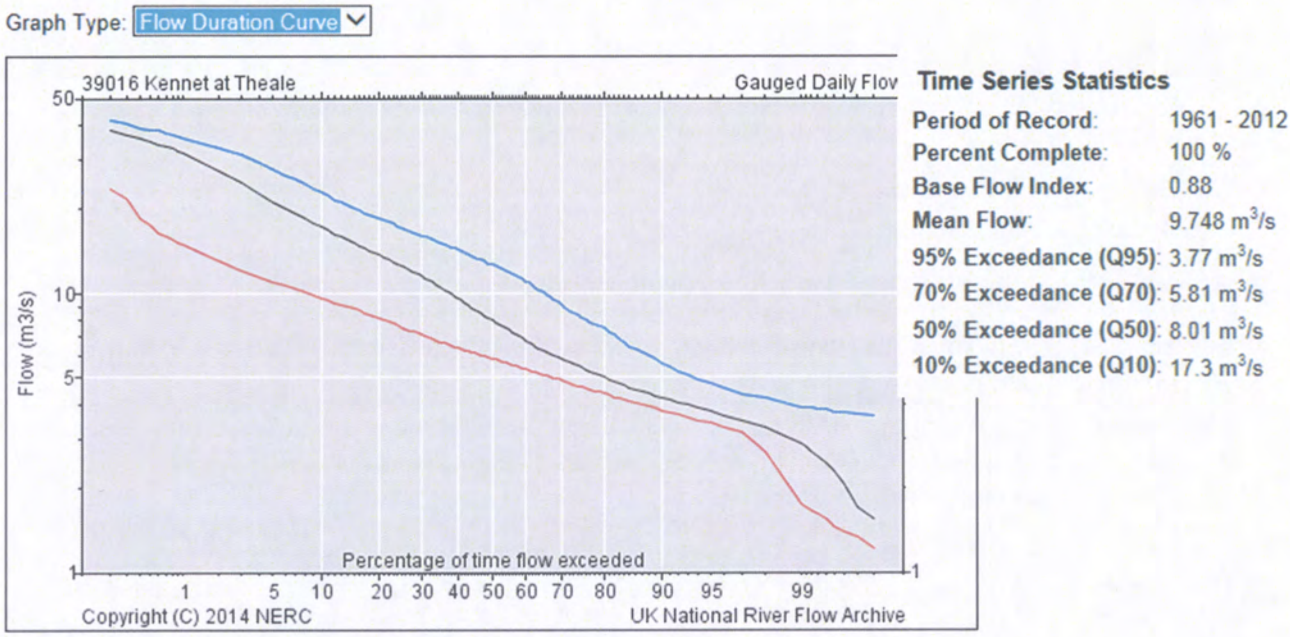


Figure 12

The purple dot shows the location of Theale gauging station, the red dot shows the location of the Jack Pool and the yellow dot is the source of the Holybrook River.



Key: Black line - annual; blue line - December to March; red line - June to September.

Underlying data supplied by the Environment Agency

Figure 13 Flow duration graph for Crump Weir [xvi]

On the assumption that about one quarter of the flow goes down the Holybrook and the average flow of the Kennet is 9.7 m3/s, the estimated mean flow down the Holybrook would be 2.4 m3/s.

Flow calculations for each bypass stream

In March 2014 during quite high river conditions the flow was estimated in each of the bypass streams by using a stream flow meter. In the summer of 2013 estimates were also taken of the furthest bypass stream during drought conditions. The aim is to fix the dam so that this "leaking" water can be used in the main Jack Pool.

The flow through the weir dam was measured during the summer of 2013 when flows were at their lowest. The flow was calculated by measuring the speed of a floating object over a distance of 14 metres. There was a slight bend in the stream but the banks were quite clear from obstructions and a fairly consistent width and depth. Calculations to work out the flow are as below:

A	Length of river between X and Y	14	m
B	Average width of river	2.2	m
C	Average depth of river	0.5	m
D	Time taken between X and Y 1st	42	Secs
E	Time taken between X and Y 2nd	42	Secs
F	Time taken between X and Y 3rd	45	Secs
G	Time taken between X and Y 4th	41	Secs
H	Time taken between X and Y 5th	42	Secs

I	Average Time (Sum of D to H / 5)	42.4	Secs
J	Average velocity (B / I)	0.330189	m/sec
K	Adjustment factor (J x0.8)	0.264151	m/sec
L	Cross sectional area of river (B x C)	1.1	m2
M	Volume of water, discharge (L x K)	0.290566	m3/s

The flow was recorded on a slight meander and flow would be lower because of surface friction so the method was unreliable so I improved the method in March by using a stream flow meter (MFP51, MJP stream flow meter) instead which had its own equation to work out velocity. It is far more accurate and quicker, it also meant I could take more readings and average them and more locations which are shown below

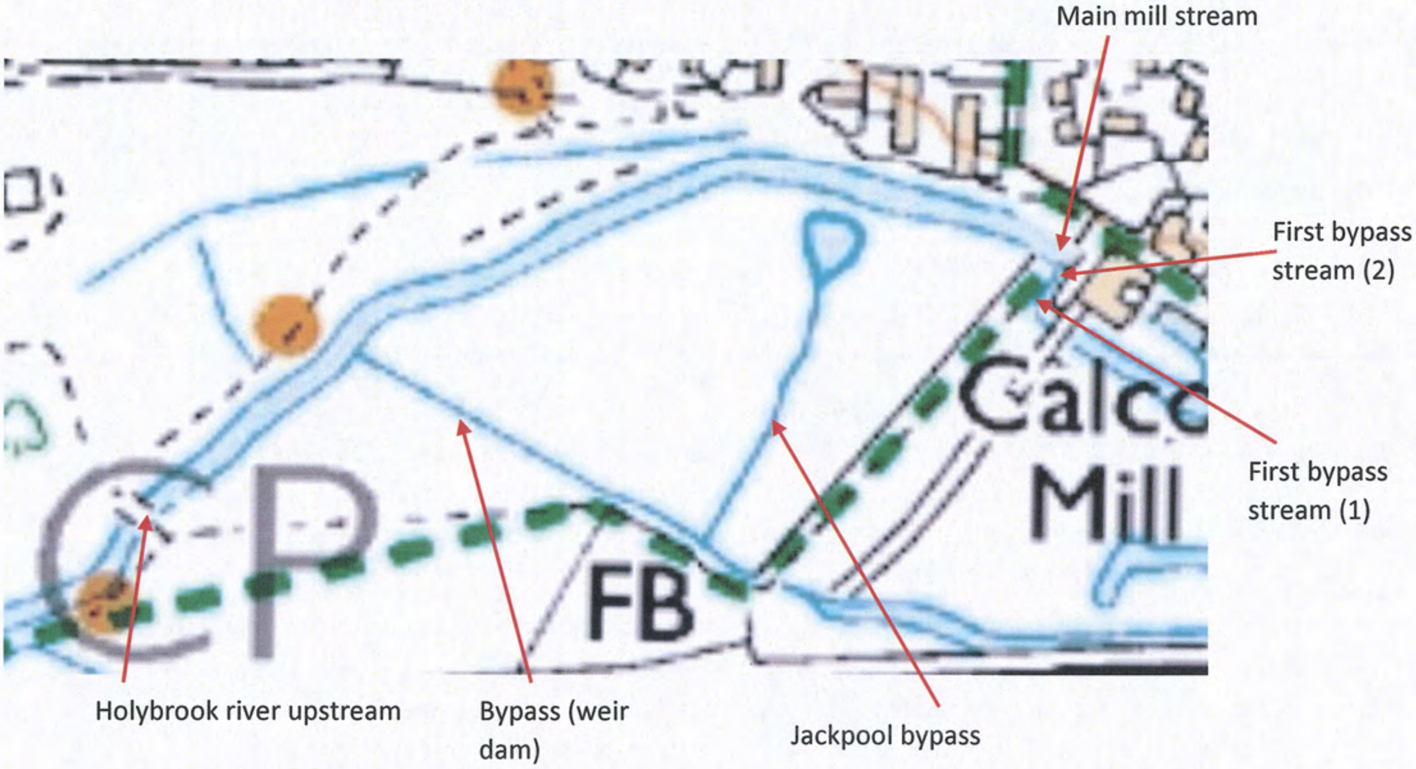


Figure 14 – locations measured by flow meter (OS map)

In the survey, the flow meter, depth and width of the river was used to calculate the flow. Depth (m) was measured using a pole with marked measurements every 0.1 of a metre. It was measured at five equal points across the river then the values were averaged and a 20m tape was used to measure the width (m) of the stream. The stream flow meter was used in the middle of the stream which measured rounds per minute. This was repeated three times from which the values were averaged. The width multiplied by the depth was the cross-sectional area (m^2). The velocity (cm/s) was calculated from the given equation in the manual with the flow meter so additional conversion had to be done from (cm/s) to (m/s). The cross-sectional area (m^2) multiplied by the velocity gave the flow (m3/s).

The results are shown below

Location	velocity (m/s)	cross-sectional area (m^3)	flow (m^3/s)
First bypass stream (1)	1.76	0.90	1.58
First bypass stream (2)	0.72	1.84	1.32
Main mill stream	0.36	9.60	3.46
Jack Pool bypass	0.84	4.50	3.76
Holybrook river upstream	0.83	13.26	11.07
bypass stream (weir dam)	0.66	0.90	0.60

Figure 15 Flow calculations at various locations

The figure below shows the approximate percentages that flow down each stream based on the flow meter calculations. Also it takes into account the proposed changes to the flow by adjusting the sluices and by fixing the weir dam.

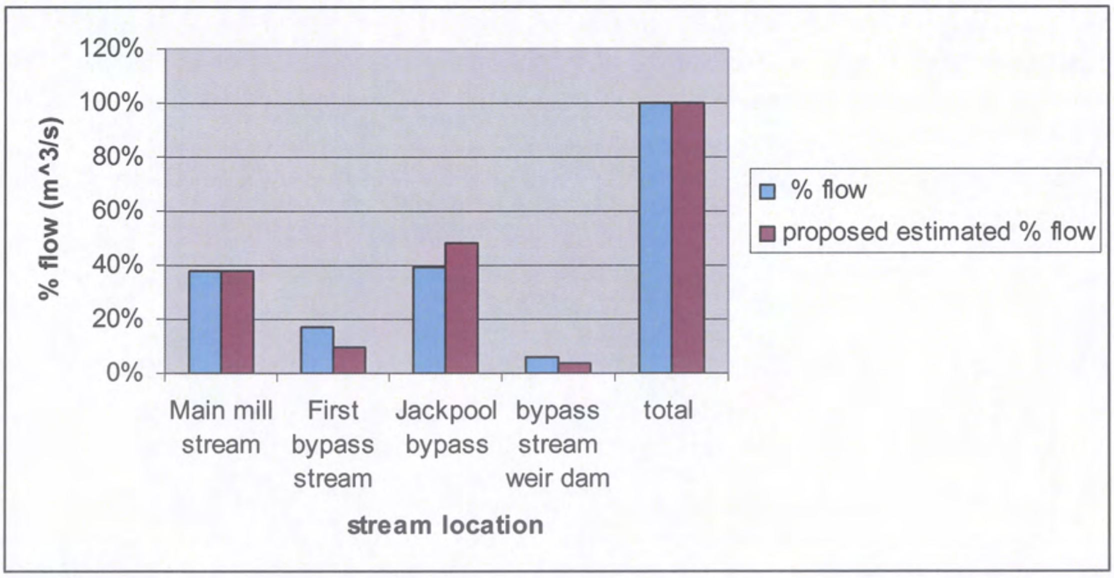


Figure 16 Approximate percentage of flow down each stream before and after works

On the basis that on average the total average flow in the Holybrook is 2.4 m3/s (data from Theale gauging station) and that approximately 40-50% of the flow is diverted through the Jackpool the predicted available flow during the summer and winter is shown in figure 17

Predicted summer and winter flows through Jack Pool

Month	Predicted Flow
Jan	1
Feb	1
Mar	0.9
Apr	0.8
May	0.7
Jun	0.5
Jul	0.5
Aug	0.5
Sep	0.7
Oct	0.8
Nov	0.9
Dec	1
Average	0.775

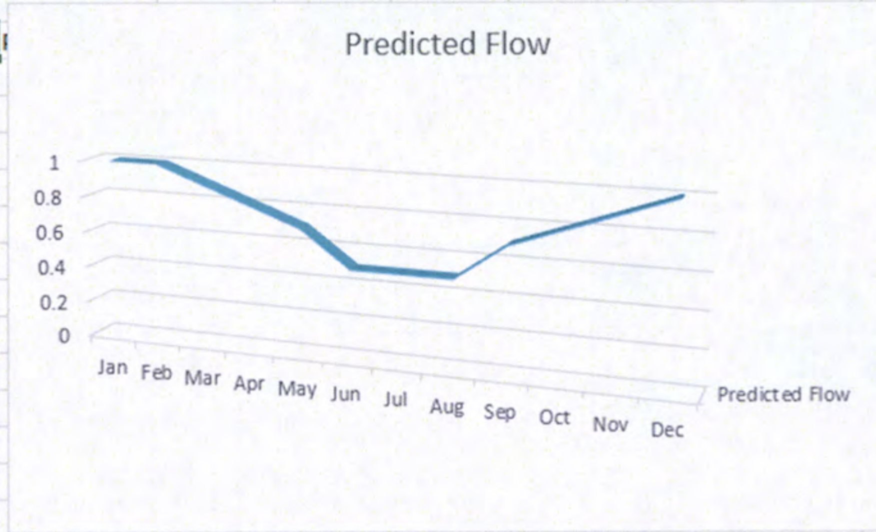


Figure 17

In summer conditions the main river should probably take 40% of the flow and the first bypass stream 10% of the flow. This leaves 50% for the Jack Pool. So even in Q95 situation (0.95 m3/s) approximately 0.5m3/s could be expected. In peak flow, conditions are likely to be too big for just the turbine and would have to be let through the sluice gates as well or reduce flow into turbine using manual sluice inside the screw channel. Even taking the average flow of nearly 0.8 m3/s of this would mean approximately 1.0 m3/s should be achievable.

River head

Upper river level

The river level upstream of the Mill varies between summer and winter, but not massively. This is mainly as the sluice gates are shut down to reduce the flow and keep the level up stream at a reasonable level. There is a river level measure installed just above the main mill building next to the first bypass stream.

Figure 18 - Winter height = 7 (extreme)

Figure 19 - Summer min = 3.5

Difference is 350 mm between the min and max. The average is probably around the 5.0 mark.

Lower river level.

The lower level does vary widely according to season as when in flood the lower river backs up and therefore reduces the available head. Even though the upper river level in the summer was lower as the lower level was much lower, so the available head was close to 1.8m. In the winter the head reduced to around 1.4m in normal conditions, but in extreme flood conditions (winter 2013/14) reduced to around 1.2m, however the flow has increased.

Month	Predicted Flow	Predicted Head
Jan	1	1.3
Feb	1	1.3
Mar	0.9	1.4
Apr	0.8	1.4
May	0.7	1.5
Jun	0.5	1.6
Jul	0.5	1.6
Aug	0.5	1.6
Sep	0.7	1.5
Oct	0.8	1.4
Nov	0.9	1.4
Dec	1	1.3
Average	0.775	

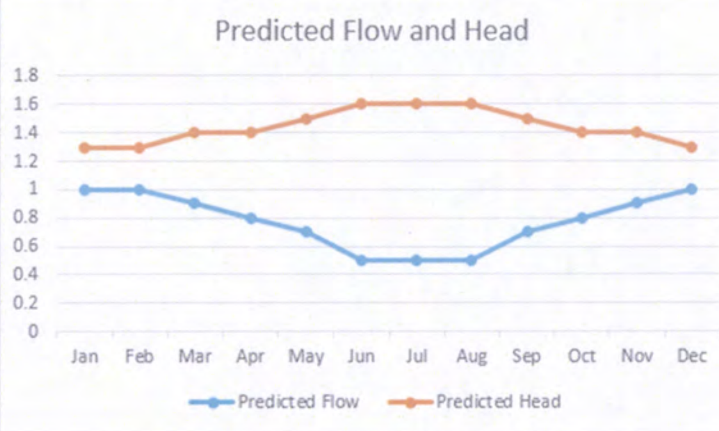


Figure 20 Predicted flow and head for the summer and winter

Efficiency of the installation

The figure below shows various case studies in the UK which has installed hydrodynamic screws. It is shown in the order of power (kW) generated from lowest to highest. The results clearly show that head and flow influence each other and that the higher the head and flow, the more power generated. The average efficiency works out at just over 70% so this is the efficiency used in the power estimates below.

Site	Head	Flow	Power	efficiency
Bonfield Ghyll, North Yorkshire	2.00	0.10	1.00	51%
Dandridge's Mill, Wantage, Oxfordshire	1.70	0.36	4.60	77%
Marsden Manor, Gloucestershire	1.30	0.60	6.00	78%
Thurgoland, Sheffield, South Yorkshire	3.30	0.43	8.00	57%
Frensham, Surrey	1.50	1.10	11.00	68%
Flatford Mill, East Bergholt, Suffolk	1.10	1.56	11.00	65%
Dauntsey Park, Wiltshire	1.25	1.55	12.50	66%
Haddo Estate, Aberdeenshire	5.00	0.48	14.50	62%
Hainbury Mill, Ilchester, Somerset	1.40	1.94	20.00	75%
Howsham Mill, North Yorkshire	1.70	2.00	24.00	72%
JCB Academy, Uttoxeter, Staffordshire	2.30	2.00	27.00	60%
Osney Mill, Oxfordshire	1.90	3.20	45.00	75%

Bridge End Mill, Settle, North Yorkshire	2.00	2.86	45.00	80%
New Mills, High Peak, Derbyshire	3.00	2.86	63.00	75%
River Dart Country Park, Ashburton, Devon	4.50	1.97	65.00	75%
Strathdon, Aberdeenshire	3.80	2.60	70.00	72%
Newby Hall, Ripon, North Yorkshire	2.05	5.44	90.00	82%
Bealey's Weir, Bury, Greater Manchester	4.62	2.91	96.00	73%
Mapledurham, Reading	2.05	5.00	99.95	99%
Linton Lock, North Yorkshire	3.30	4.50	100.00	69%
Omagh, County Tyrone, N Ireland	2.70	6.00	121.00	76%
Osbaston, Monmouthshire	3.60	5.72	150.00	74%
average				72%

Figure 21 – comparison of HDS power and efficiencies at various locations [xvii]

Anticipated power generation

To work out the likely power generated the calculation is used below.

Flow (m3/s) x Head (m) x Gravity (9.81) x Efficiency (0.7) = power (kW)

Then to work out how much power can be generated per year, multiply the above figure by 24 hours and then 365 days.

To assess the impact of changes in the head and flow during the year the table below shows the expected range of flow and head and the resulting yearly kWh produced. The upper and lower quartiles are 42,000 and 63,000 kWh. This gives a power range between 5-8 kW.

	Flow (m3/s)					
Head (m)	0.5	0.6	0.7	0.8	0.9	1.0
1.0	27,392	32,870	38,349	43,827	49,306	54,784
1.1	30,131	36,157	42,184	48,210	54,236	60,262
1.2	32,870	39,444	46,019	52,593	59,167	65,741
1.3	35,610	42,731	49,853	56,975	64,097	71,219
1.4	38,349	46,019	53,688	61,358	69,028	76,698
1.5	41,088	49,306	57,523	65,741	73,958	82,176
1.6	43,827	52,593	61,358	70,123	78,889	87,654

Figure 22 – Anticipated annual power generated with various heads and flows

Financial Analysis

Building work

There is extra construction work that is needed before the screw is installed such as Weir dam repair works, Sluice works on first bypass stream and building works at Jack Pool. Then the screw would be installed and connected to grid also other required electrical works.

Costs

Relative costs per kW for small scale hydro can be higher than for larger scale schemes mainly due to the fact that even though the scheme is small, much of the installation has fixed costs such as the turbine, the control equipment and connection to the grid. The overall cost will also depend on the location, accessibility and type of installation. Below is a rough estimate based on based on a source from BHA (British Hydropower Association) of capital and running costs.

Lower Limit (kW)	Upper Limit (kW)	Capex		Opex
		Fixed Cost per Site (£)	Cost per Installed kW Output (£/kW)	Annual Maintenance (£)
0	15	8,000	8,000	2,500
15	50	12,000	6,000	5,000
50	150	–	4,000	15,000
150	500	–	3,750	35,000

Figure 23 – Estimated construction costs for HDS installations [xviii]

From the calculations of flow and head above it can be seen that the possible range of power produced is between 5-8 kW. Using the table above this would give possible costs between

Low end = £8,000 + (5 x £8,000) = £50,000

High end = £8,000 + (8 x £8,000) = £72,000

Estimated costs for the works at Calcot Mill are below, which is slightly higher than the figures above. This is mainly because of some of the other building works associated with fixing the weir dam and adding additional sluice to the first bypass stream. These estimates have been confirmed by an external company.

Item	Estimate
Weir dam repair works	£8,000.00
Sluice works on first bypass stream	£2,000.00
Connection to grid & electrical works	£5,000.00
Building works at Jack Pool	£12,000.00
Controls	£5,000.00
Turbine cost	£40,000.00
Installation	£5,000.00
Permissions	£2,000.00
Consultancy	£5,000.00
Total	£84,000.00

Figure 24 – estimated construction costs

Income

There are a number of ways of getting income from a Hydro Dynamic Screw. All of these can be used together. The main income source that provides long term security is the Feed-in-Tariff (FiT). This is a scheme where the Government pays generators of electricity using alternative methods per kWh for a guaranteed period of 20 years at a fixed rate. The second source of income, is by making savings on the electricity bills of the property. The third source is available if the amount used by the property is less than the amount generated, so the surplus electricity can be sold back to the Grid at an agreed rate per kWh which is called the export rate.

Feed-in-Tariff

The amount that a provider gets for generating renewable electricity varies according to the technology used. Below is an extract of the Hydro document from OfGem. The amount changes depending on how much is likely to be generated and in this proposal it is within the 15kW or less section. This would mean that the rate per kWh would be 21.12p. Some of the big advantages with this scheme are that it is guaranteed for 20 years, Tariffs are index-linked and also the income is free from tax. [xix]

Table 2: Hydro

Description	Period in which Tariff Date falls	Tariff (p/kWh)
Hydro generating station with total installed capacity of 15kW or less	1 April 2010 to 30 November 2012	23.19
	1 December 2012 to 31 March 2014	22.23
	1 April 2014 to 31 March 2015	21.12*
Hydro generating station with total installed capacity greater than 15kW but not exceeding 100kW	1 April 2010 to 31 March 2014	20.76
	1 April 2014 to 31 March 2015	19.72*
Hydro generating station with total installed capacity greater than 100kW but not exceeding 500kW	1 April 2010 to 14 March 2013	12.82
	15 March 2013 to 31 March 2014	16.41
	1 April 2014 to 31 March 2015	15.59*
Hydro generating station with total installed capacity greater than 500kW but not exceeding 2MW	1 April 2010 to 31 March 2014	12.82
	1 April 2014 to 31 March 2015	12.18*

Figure 25 – Feed In Tariff for small scale Hydro schemes [xx]

Export Tariff

Table 6: Export Tariff

Description	Period in which Tariff Date falls	Tariff (p/kWh)
All Eligible Installations	1 April 2010 to 30 November 2012	3.39
	on or after 1 December 2012	4.77

Figure 27 – Export Tariff [xxi]

Any extra electricity can be sold back to the grid for 4.77pence.

Electricity savings at Calcot Mill

Below is a table of the electricity usage at Calcot Mill for the period of 2013 from previous electricity bills. This shows that from January to December 8230 kWh were used at a cost of 11.653p per kWh. The total charge for the year for electricity was £959. So with the electricity from the turbine being used firstly in the house this will be an immediate saving. Any remaining power will be exported to the National Grid.

Month	2013 Use (kWh)
Jan	874
Feb	722
Mar	537
Apr	450
May	441
Jun	726
Jul	662
Aug	696
Sep	716
Oct	635
Nov	851
Dec	920
Total	8230

Cost (pence)	11.653
Total cost	£959.09

Figure 26 – Electricity costs at Calcot Mill

Total estimated income

Using an estimate of 59,257 kWh from the figure 28 below generated the possible income is shown below.

	kWh	£/kWH	Amount
Generated (Feed in Tariff)	59,257	0.2112	£12,515
Used (electricity saved)	8,230	0.11653	£959
Exported (export tariff)	51,027	0.0477	£2,434
Total estimated Income per year			£15,908

Figure 27 – Estimated income

Benefits

Month	Predicted Flow	Predicted Head	Predicted Power
Jan	1	1.3	5854 kwh
Feb	1	1.3	5854 kwh
Mar	0.9	1.4	5674 kwh
Apr	0.8	1.4	5043 kwh
May	0.7	1.5	4728 kwh
Jun	0.5	1.6	3602 kwh
Jul	0.5	1.6	3602 kwh
Aug	0.5	1.6	3602 kwh
Sep	0.7	1.5	4728 kwh
Oct	0.8	1.4	5043 kwh
Nov	0.9	1.4	5674 kwh
Dec	1	1.3	5854 kwh
Average	0.775	Total	59257 kwh

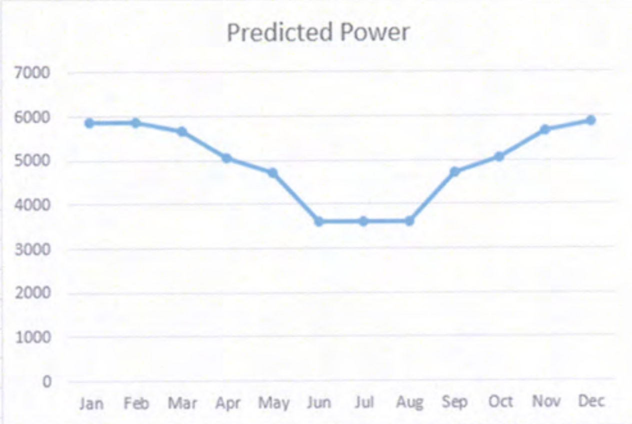


Figure 28 – Anticipated power generated.

The figure below shows the payback period for various capital costs compared with the possible amount of power generated each year. From this it can be seen that in the worst case scenario where the cost of the project is £100,000 and the amount generated per year is as low as 30,000 kWh the payback is 10 years. However at the other end of the scale with lower capital costs at £60,000 and power generated of 70,000 kWh at around 4 years. These figures are worked on an efficiency of 0.6. Also it is calculated on net income and so doesn't take into account that much of the income is tax free. So in reality the estimated payback period is likely to be between 5 to 7 years.

	Generated power per annum (Kwh/Yr)				
Cost	30000	40000	50000	60000	70000
£100,000	10.3	8.4	7.2	6.2	5.5
£90,000	9.3	7.6	6.5	5.6	5.0
£80,000	8.2	6.8	5.7	5.0	4.4
£70,000	7.2	5.9	5.0	4.4	3.9
£60,000	6.2	5.1	4.3	3.7	3.3

Other possible benefits

In the future the property would be immune from any increases in electricity costs. Hot water and central heating costs could be reduced by changing to use electricity rather than gas. It could be possible swap to using an electrical car for short journeys. The property could sell surplus electricity to neighbours at a higher rate than the Export tariff. The value of the house will be increased significantly. And with a possible income per year of £15k with a return of 8% gives a value of £187k, so it would not be unreasonable to expect the value of the house to be increased by at least £150k

Risks

Costs

Capital cost could be more than expected. The capital cost is likely to be between £60k and £100k. The Running costs and maintenance costs could be more than expected.

Installation issues

There could be access problems to the site. The screw may be Installed too high (in summer top level of river drops too low) or Installed too low (river backing up obstructs the outflow of the screw).

Flow levels varying

Changes to the river flow by the Environment Agency, Thames Water or other external parties extracting too much water upstream

Permissions not granted

There may be objections from local residents or Environment agency refuses planning permission.

Income

There are several factors such as efficiency, flow or head are less than expect so the electricity generated is less than expected. There could be changes in Feed-in-Tariff however the FITs are guaranteed for 20 years. However there is a possibility that the export tariff goes down. This means payback for the installation and maintenance will take longer.

Ongoing risks

Maintenance of the screw, labour or the cost could be higher than expected. The seasonal risks like low flow, freezing, flooding could damage the screw or stop it from working completely or there can be physical damage to kit which means no or less electricity is generated so there is less income therefore longer payback with added costs of fixing the screw.

Environmental Analysis

River flow

The current flow that is leaking through the weir dam will be diverted to the Jack Pool. This will provide a minimum of 0.3 m3/s. There is the existing flow through the jack pool and some of the existing flow through the first bypass stream will be diverted through the jack Pool. To enable easy adjustments of the flow a full sluice will be re-instated into the split of the first bypass stream. The flow through the main mill race will remain as is.

Fish migration

One often cited problem with hydro schemes is that they block the passage of fish migration. However one of the key advantages of an Archimedes Screw scheme is that it does not affect the migration of fish. It is found that nearly 100% of fish pass through safety, few having minor scale damage that are easily recoverable. The reason for this is that the blades are relatively slow moving and allow the fish to pass freely through the screw. [xxii]

All existing sluices will remain in-place and most will be used as now. The only change will be that the current leaking weir dam will be fixed and probably during the summer all flow that is currently going through the jack Pool sluices will be diverted through the Screw into the same out flow (Jack Pool). During Winter the jack Pool sluices will be opened to control the upper river level.

Recreation

All land affected by this project is private and the closest public area is on the North side of the river at Linear Park. No public footpaths or rights of way will be affected

Flood defences

During the winter of 2013/14 exceptional flooding was experienced in many places around Reading and the wider vicinity and indeed the flood levels were the highest recorded at Calcot Mill with the river backing up significantly, however the level of the main higher river didn't vary massively and there was very little overflow from the top stream into the flood plain. The introduction of this scheme will not affect the flooding at Calcot Mill or indeed anywhere else.

Renewable energy

The screw does not use any fossil fuels to generate electricity except for manufacturing and transporting it. The screw is also emission free so for every kilowatt-hour generated by a hydro-dynamic screw means around 1 kg less CO_2 polluting the environment, so with an estimated annual production of between 50-60,000 kWh so that means approximately 50-60 tonnes of CO_2 saved, therefore the screw is eco-friendly.

Conclusion

The economic benefits far outweigh the costs. The advantages are that there is a potential estimated annual income of around £15,000 (tax free) for 20 years, assuming an average of 60,000 kWh/year is generated. The anticipated payback period is between 5-7 years with 10 years as the worst case scenario. The property price is likely to increase by at least £150,000, more than the original investment. However, the analysis has not taken into account any costs of borrowing the initial installation costs.

The environmental benefits far overweigh the impact. The environmental impact is relatively low as it has little effect on the wildlife and although the river levels may change slightly this has no significant environmental impact. However the energy generated is from a renewable source, saving a possible 50-60 tonnes of CO_2 per year.

In conclusion it is recommended that the hydrodynamic screw should be installed. This is all dependant on receiving planning permission from environmental agency and council. A previous planning permission was approved but has lapsed, this means that a resubmission is also likely to be approved.

Bibliography

If no information is provided it means that date and/or author is not provided.

[i] http://thinkprogress.org/climate/2013/08/27/2524501/hydro-pumped-storage-climate-change/
By Ryan Koronowski, August 27, 2013

[ii] https://www.dom.com/about/stations/hydro/bath-county-pumped-storage-station.jsp

Company, Dominion, date and author unavailable

[iii] http://britishdams.org/visit-a-dam.htm

Company, British dam society

[iv] http://en.wikipedia.org/wiki/Hoover_Dam

24 April 2014

[v] http://www.nps.gov/nr/travel/ReclamationDamsAndWaterProjects/Hoover_Dam.html

From government, National park service

[vi] http://www.picoenergy.co.uk/culbone
Pico Energy -services for hydro scheme design and installation

[vii] http://www.mannpower-hydro.co.uk/attachments/casestudies/lowna-job-sheet-updated-0909.pdf
Mann power-installation company

[viii] http://info.cat.org.uk/sites/default/files/documents/MicroHydroSystems.pdf
Company-Centre for Alternative Technology

[ix] http://www.renewablesfirst.co.uk/hydro-learning-centre/archimedean-screw/
Renewables first- The Hydro and Wind Company

[x] http://en.wikipedia.org/wiki/Archimedes'_screw

14 April 2014

[xi] http://greenbugenergy.com/shop-hydro/shop-hydro-products-services/grid-tied-screw-generators

Company-GreenBug Energy Inc

[xii] http://www.landustrie.nl/fileadmin/files/Folders/Screw%20Pumps-Hydropower%20screws%202012.pdf

Company-Landustrie

[xiii] http://www.andritz.com/oi-atro-hydrodynamic-screws-en.pdf

Company- Andritz-Atro

[xiv] http://www.andritz.com/oi-atro-hydrodynamic-screws-en.pdf

Company- Andritz-Atro

[xv] http://www.andritz.com/products-and-services/pf-detail.htm?productid=8775
Company- Andritz-Atro

[xvi] http://www.ceh.ac.uk/data/nrfa/data/station.html?39016
Company-Centre for ecology and hydrology

[xvii] http://www.mannpower-hydro.co.uk/casestudy.php
Company- Mannpower

[xviii] http://www.westernrenew.co.uk/wre/hydro_basics/financial

Company- Western Renewable Energy

[xix] http://www.recc.org.uk/pdf/feed-in-tariff-scheme-guidance-for-consumers.pdf
Company- Renewable Energy Consumer Code, date 2014

[xx] https://www.ofgem.gov.uk/ofgem-publications/86011/rpiadjustedtariffsnon-pvconditionaldaterpiadjusted.pdf

Company-Ofgem

[xxi] https://www.ofgem.gov.uk/ofgem-publications/86011/rpiadjustedtariffsnon-pvconditionaldaterpiadjusted.pdf

Company-Ofgem

[xxii] http://www.fishtek.co.uk/downloads/Fishtek-screw-risk-assessment-example-report.pdf
Company-Fishtek, date September 2011

- Evidence for AO5 (in the Reflection) for evaluation of the strengths and weaknesses of the process and the student's own learning is supplemented by evidence from the presentation below.

Study of environmental and economic impact of the use of micro scale HEP (hydroelectric power) schemes.

The purpose of this study

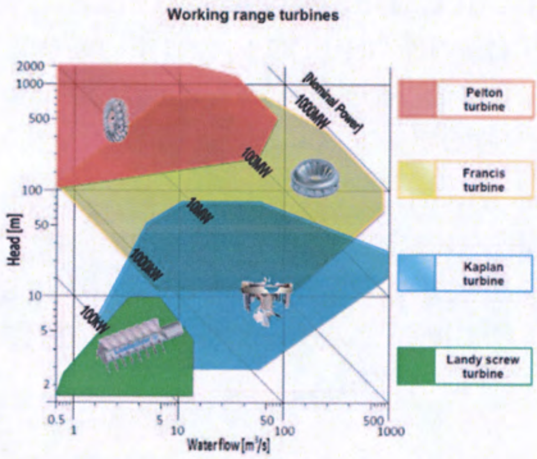
- Find economic and environmental impacts of installing and having a small micro hydroelectric power (HEP) station used to generates electricity for a property.
- Using this information I will apply it to the possibilities of installing my own HEP station and carrying out feasibility test to see if the project would work economically and environmentally.

What is HEP?

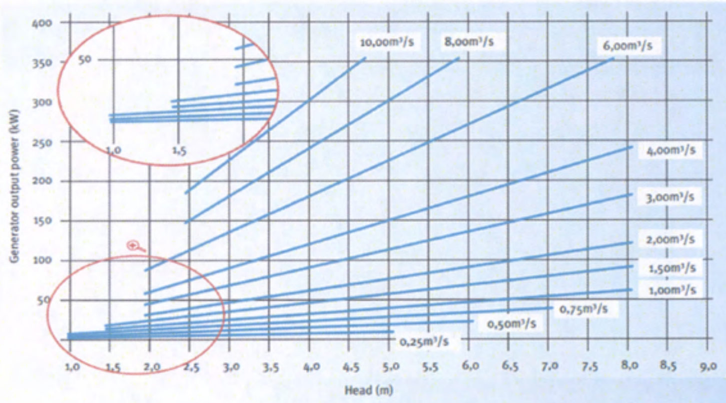
- Hydroelectric power stations generate electricity using the weight of water which is power that comes from water being pulled by gravitational force which then turns the turbine, then the generator in which kinetic energy is transferred to electricity.

High head	Low head	High flow	Low flow	Typical use cases	Technologies
✓		✓		Pumped storage	Uses electricity to pump water to high place and runs it down through a turbine.
✓		✓		Large scale dams (Impoundment)	A big dam with turbines at the bottom where water runs through the turbines.
✓			✓	Small scale schemes in high relief areas. (Diversion)	Small streams which may use overshot water wheel and various impulse turbines.
	✓	✓		Tidal Power	Stores water at high tide then runs through turbines at low tide as water flows out.
	✓		✓	Small scale schemes in lowland areas. (diversion)	Small rivers using undershot water wheel turbines and screw turbines and other reactive turbines.

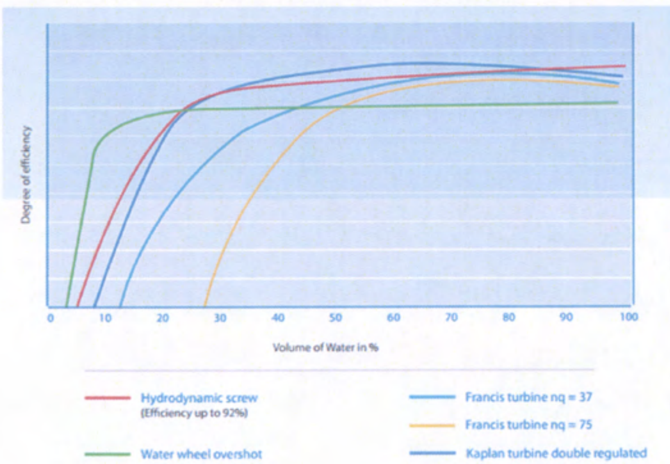
Turbines operating in different heads (m) and flow (m3 / s) with how much power (kW) they generate.



The comparison of the general power from the head and flow for a hydrodynamic screw



Graph showing efficiencies of different HEP.



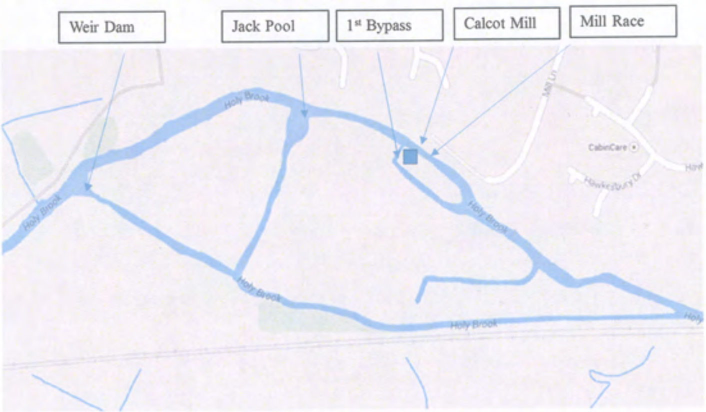
Hydrodynamic screw

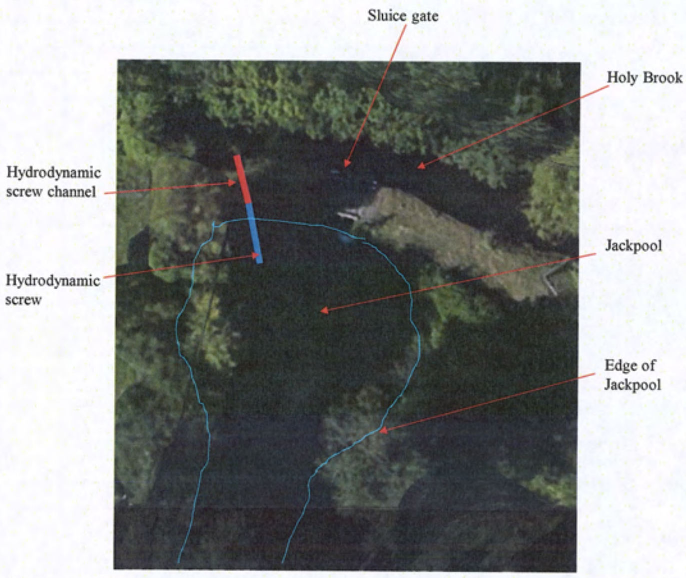
Advantages

- Low maintenance
- Low installation costs
- Durable
- Constant supply of electricity
- Up to 95% efficient
- Self-regulating
- Fish friendly

Site	Head	Flow	Power	efficiency
Bonfield Ghyll, North Yorkshire	2.00	0.10	1.00	51%
Dandridge's Mill, Wantage, Oxfordshire	1.70	0.36	4.60	77%
Marsden Manor, Gloucestershire	1.30	0.60	6.00	78%
Thurgoland, Sheffield, South Yorkshire	3.30	0.43	8.00	57%
Frensham, Surrey	1.50	1.10	11.00	68%
Flatford Mill, East Bergholt, Suffolk	1.10	1.56	11.00	65%
Dauntsey Park, Wiltshire	1.25	1.55	12.50	66%
Haddo Estate, Aberdeenshire	5.00	0.48	14.50	62%
Hainbury Mill, Ilchester, Somerset	1.40	1.94	20.00	75%
Howsham Mill, North Yorkshire	1.70	2.00	24.00	72%
JCB Academy, Uttoxeter, Staffordshire	2.30	2.00	27.00	60%
Osney Mill, Oxfordshire	1.90	3.20	45.00	75%
Bridge End Mill, Settle, North Yorkshire	2.00	2.86	45.00	80%
New Mills, High Peak, Derbyshire	3.00	2.86	63.00	75%
River Dart Country Park, Ashburton, Devon	4.50	1.97	65.00	75%
Strathdon, Aberdeenshire	3.80	2.60	70.00	72%
Newby Hall, Ripon, North Yorkshire	2.05	5.44	90.00	82%
Bealey's Weir, Bury, Greater Manchester	4.62	2.91	96.00	73%
Mapledurham, Reading	2.05	5.00	99.95	99%
Linton Lock, North Yorkshire	3.30	4.50	100.00	69%
Omagh, County Tyrone, N Ireland	2.70	6.00	121.00	76%
Osbaston, Monmouthshire	3.60	5.72	150.00	74%
average				72%

My location

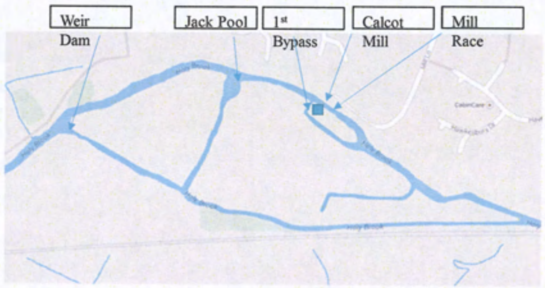




Survey

Carried out my own survey on the Holybrook river and also bypasses measuring the:

- Head (m)
- Velocity (m/s)
- Cross-sectional area (m²)
- Flow rate or river discharge (m3/s)



Economic analysis of installing screw

Using the results from the survey, I worked out the amount of power (kW) the screw generated. Converted it to kWh showing how much electricity it would generate. Then worked out how much money per kWh it can generate in a year based on FIT which is tax free. Based on my household energy price in a year presuming a good power output is generated all year round, I can take that as income and export income when excess electricity generated is sold back to the grid.

	kW/H	£/kWH	Amount
Generated (Feed in Tariff)	59257	0.2112	£12,515
Used (electricity saved)	8230	0.11653	£959
Exported (export tariff)	51027	0.0477	£2,434
Total estimated Income per year			£15,908

	Generated power per annum (KwH/Yr)				
Cost	30000	40000	50000	60000	70000
£100,000	10.3	8.4	7.2	6.2	5.5
£90,000	9.3	7.6	6.5	5.6	5.0
£80,000	8.2	6.8	5.7	5.0	4.4
£70,000	7.2	5.9	5.0	4.4	3.9
£60,000	6.2	5.1	4.3	3.7	3.3

Environmental impact

- River flow
- River levels
- Fish migration
- Flooding
- Save carbon dioxide
- Renewable

Risks

- Costs
- Installation issues
- Permission not granted
- Income
- Maintenance

Conclusion

At the moment the moment it seems the economic and environmental benefits outweigh the economic and environmental risks in installing hydrodynamic screw on Holybrook river presuming all my calculations are correct therefore it is possible to install the hydrodynamic screw.

Evaluation

- Time management
- Difficulties
- Detailed Research?

Evaluation

Skills developed

Carrying out **primary research**, I have developed my fieldwork techniques, making sure I took many readings to get an average. I also learnt using equations to calculate using my results different variables like velocity and discharge. And further developing the data by calculating kW and money generated from the turbine.

I also developed my ICT skills. For example using Excel to create tables, graphs and to plug in difficult formulas. Also learnt how to put videos in PowerPoint's. Carrying out **secondary research** using leaflets and websites, I have also developed my skills in research ,referencing and evaluating sources.

outcome

I have managed to keep my project relevant to the title and have managed to get good results. Although I have changed the content of my initial plan and changed the order to a more logical sense.

What I would have changed?

To improve my primary research by measuring all the variables every month. I would have better time management by lengthening the content I write at various times.

Content	Due time	Have I done it?
Technical	30/02/14	I have managed to reach this target on time but I have changed various aspects and included new additions to this section afterwards.
Environmental impacts	15/03/14	This section was easy to complete. I had no difficulties as I already conducted research and found sources.
Costs/feasibility study	30/02/14 30/04/14	I decided to skip this section as I think it will be better done towards the end of the report. The highlighted date is the amended time in which I will complete my project. I have completed the feasibility section a week before due date.
Benefits	15/03/14 30/03/14	I had a whole free weekend and decided to write both the benefits and risks at once as writing little sections each week was not right for me so I decided to write the whole two sections which was much better as I got a big chunk of the project underway.
Risks	30/03/14 15/04/14	" " " "
Conclusion	15/04/14 30/04/14	I have took the rest of the time checking my work and taking down the amount of words. This took a long time but I have managed to reach my timescale in writing the conclusion too.

Appendix

Risk assessment for primary research on using hydroelectric power

Risk	Who could be affected?	Severity	Likelihood	Risk rating	Control measures
Falling in the river whilst working along the bank of the river.	Me.	High	Low	Low	I am able to swim! Assess the bank of the river for stability before investigating. Have another person with me in case of emergency.
Corks harming wildlife.	Wildlife in the river.	Low	Low	Low	Try and get the corks out of the river at the end of the flow test. I will use natural cork without plastic in it.
Becoming incapacitated in deep parts of the river with strong currents whilst using the stream flow meter in the river.	Me.	High	Low	Medium	I will take someone with me when I do this testing so they can monitor my safety. I also could use a life jacket when I am working in the river. I will try and use bridges where I can rather than wading into the river.
River users being harmed by my presence in the river.	People using the river, for example in boats and canoeing etc.	High	Low	Low	I will use my friend as a lookout along the river bank to alert me to any users of the river travelling my way. I will try and use bridges where I can rather than wading into the river.
Me being harmed by boats etc on the river.	Me if I am struck by a board or similar on the river.	High	Low	Low	My friend will act as look out to make sure there are no boats travelling my way and that I get out of the way in time I will try and use bridges where I can rather than wading into the river.
River users getting tangled up in the stream flow meter.	People using the river on boards and canoes etc.	Medium	Low	Low	I will take care to look out for river user before I conduct data collection from the bridges.