Archimedean Screw Hydropower installation at Linton Lock

HERITAGE STATEMENT

17 April 2015

Author: Adrian Clayton

Mann Power Consulting Ltd.
Manor Farm
Kirkham
YORK
YO60 7JS
01653 619968
info@mannpower-hydro.co.uk
www.mannpower-hydro.co.uk

Revision history
17/03/2015 first draft release
14/04/2015 updated detail
15/04/2015 updated detail

Background
A proposal is submitted to add a new hydropower turbine and fish pass facility beside the existing hydropower turbine on the Nun Monkton bank of the Ouse at Linton Lock and Weir.

The developer / operator will lease the site from the landowner who has sole ownership of the proposed development site.

Harrogate BC has granted planning consent and Listed Building Consent on previous occasions (2003, 2009) for hydropower at this site, which resulted in construction of the existing scheme in 2012. This site is the largest weir (in terms of head and flow combined) and therefore the largest potential low-head hydropower site in the Harrogate BC area.

The lock, weir and existing fish pass are owned by Canal & River Trust (CRT). As neighbouring landowner and navigation authority, CRT is a stakeholder and has been consulted at all stages, as have English Heritage (now Historic England) and the Environment Agency (EA).

Hydropower schemes are regulated by the EA through the grant of mandatory licences and consents which are a pre-requisite to operation of the scheme. Fundamental design parameters of the proposed scheme are the result of meeting environmental requirements set out in the EA's guidance for hydropower schemes. There is a legal requirement that formal applications for EA licences at this site are made via the navigation authority CRT.

Sources consulted include British Listed Buildings online, Historic England online, historical photographs and OS maps, historical primary and secondary sources online and in City of York Archives and University of York. West Yorkshire Archives Service at Wakefield holds engineers' drawings of the Linton Lock Navigation, the weir and fish pass. An earlier 2003 impact assessment by Lindsay Cowle is reproduced below (Cowle 2003) by permission of David Throup who commissioned that report.

Statement of significance

The proposed site is on the right or south / east bank of the River Ouse north of Nun Monkton, adjacent to the weir which relates to Linton Lock on the opposite bank. The site lies in Harrogate BC area, at its boundary (which lies in mid-river) with Hambleton DC.

The "Weir and Salmon Ladder, Nun Monkton" was listed Grade II* (October 1986, Historic England List #1293712 / English Heritage Building ID# 332108, listing updated 2004). The text describes:

> *Weir and salmon ladder. Of c1767 origin with later repairs. Coursed limestone, part cement-rendered. Weir across most of the river with overflow channel on right and salmon ladder on left* [NB: This usage is the reverse of conventional river usage, which ascribes left and right when facing downstream. The salmon ladder is at the true right bank, which here is the south / east bank]. *The retaining wall on the [r]ight side of the river has herringbone-tooled stones. The top surface above the overflow channel is of large blocks of stone with iron, lead-covered ties. Later paddles with winding gear. The salmon ladder has a series of stepped basins with ramped walls and adjoining it, down river, the remains of a wall and possibly a large pool. The weir and salmon ladder were constructed following an Act of parliament of 1767.*

http://www.britishlistedbuildings.co.uk/en-332108-weir-and-salmon-ladder-nun-monkton-north.

A little distance west of the weir and separated from it by an island, "Linton Lock" has its own listing Grade II (October 1986, Historic England List #1151005, English Heritage Building ID# 332107):

> *Lock. c1767 with later repairs. Coursed limestone. Lock walls of large blocks of stone. Renewed gates. Incised on the south wall at the west end are Roman numerals indicating the water level in feet. The Lock was built following an Act of Parliament of 1767 which specified that the lock should hold vessels 60' x 15'4" drawing 4' of water (Act of 1767, pl4).*

http://www.britishlistedbuildings.co.uk/en-332107-linton-lock-linton-on-ouse-north-yorkshi

On the north bank of the lock channel stands “Lock House Restaurant” with its own listing Grade II (October 1986, Historic England List #1190631, English Heritage Building ID# 332106):

> *Lock keeper's house, now restaurant. Mid-late C18 with C19 addition. Red-brown brick in irregular bond with yellowish brick to addition; pantile roof. 2 storeys, 2 bays with added bay to left. Central C20 double door flanked by C20 canted bay windows. 4-pane sashes in flush wood architraves above. Stepped and dentilled eaves. End stacks. Added bay to left has board door on left, 4-pane window with cambered brick arch above, stepped and dentilled eaves and end stack to left. Lower single-storey hipped-roof bay added to right. Right gable of house has lower courses of tumbling-in. Linton Lock was built following an Act of Parliament of 1767 and the lock keepers house is likely to date from that time.*

http://www.britishlistedbuildings.co.uk/en-332106-lock-house-restaurant-linton-on-ouse-nor

No other listed buildings are within the area of influence of the present proposal, and the site does not lie within a Conservation Area.

On the lock island, between the weir and the lock channel, and facing north downstream, stands the derelict and deteriorating reinforced-concrete shell of the York Corporation hydropower station which operated between 1923 and ~1962.

On the right or south / east bank, demarcating a small island of uneven ground beside the weir, is a bypass channel lined with steel piling, which culminates in an Archimedean screw hydropower system installed in 2012 (under HBC planning ref# 09/00655/FUL). The present proposal is to add a further and larger Archimedean screw hydropower system immediately to the east of this, together with a new fish pass beside it.

The heritage significance of structures is influenced (among other things) by their date, origins, purpose and condition. Heritage descriptions (such as the listings above) and modern secondary sources describing this weir and salmon ladder typically ascribe them a date of 1767, as this was when the Linton Lock Navigation received its founding Act. However, it emerges that the sequence and evolution of the surviving structures were incompletely understood at the time when the listings were written, and that the above assumptions would benefit from revision in the light of available evidence.

Research undertaken for the present document adds to an understanding of the structures. On the basis of evidence set out below, it is concluded that:

- Linton Weir was first built, in its original form, during 1768-71
- the weir has subsequently been substantially repaired or changed, including a substantive alteration of its shape (profile, slope) and appearance in 1922, with further minor change (dismantling) after 1962
- the salmon ladder in its surviving form and position is the result of action after the Salmon Fisheries Acts (1861- onwards) which prioritised making weirs passable to salmon. Under this legislation, a fish pass was built on Linton Weir in 1886, and was replaced by the building of a more effective fish pass in 1894. The pass was modified in 1924 and 1936, and (at that time or later) lost the top of its outer wall.

The evidence for this more accurate interpretation is presented in the sections below.

On this basis, the significance of the weir and fish pass at Linton Lock is revealed as that of much-modified structures which have evolved to keep pace with changing purposes. The original forms and materials of the structures have been obscured by these later changes for new purposes, such that the forms and materials which were subject to the listing are rather removed from the appearance and function of the original works. Not least in this is that the evidence dates the surviving salmon ladder to an altogether more recent period making it one of the least original and most recent elements in the group. It was further modified after 1922, which is also the date of the now visible shape of the weir.

Therefore, when considering the impact of the present proposals upon significance:

- Repairs to the upper end of the existing salmon ladder will restore twentieth-century damage, and thereby restore the intended functionality of this fish pass to at least its original state - from its present state of ineffectiveness (caused by former attempts to make it interoperate with 1922 alterations removed in 1962). On the recommendation of the EA, a minor improvement can be made by cutting a notch in the modern wooden boards beside the old pass, to concentrate flow here, while raising the boards sufficiently to ensure no net change in water level.
- Other than this: **the physical form of the listed structures is NOT modified**
- **Significance of the setting is rather different to what is asserted in the listing text, but is in fact influenced much more by twentieth-century hydropower. The proposed changes to setting should be evaluated in this light.**
- **In a setting of existing and longstanding use for water-engineering purposes, and hydropower structures since 1920-23, the proposal adds further similar elements in continuation of this use and in keeping with surviving remains.**

Evidence for the above

a) Development of the lock and weir to 1900

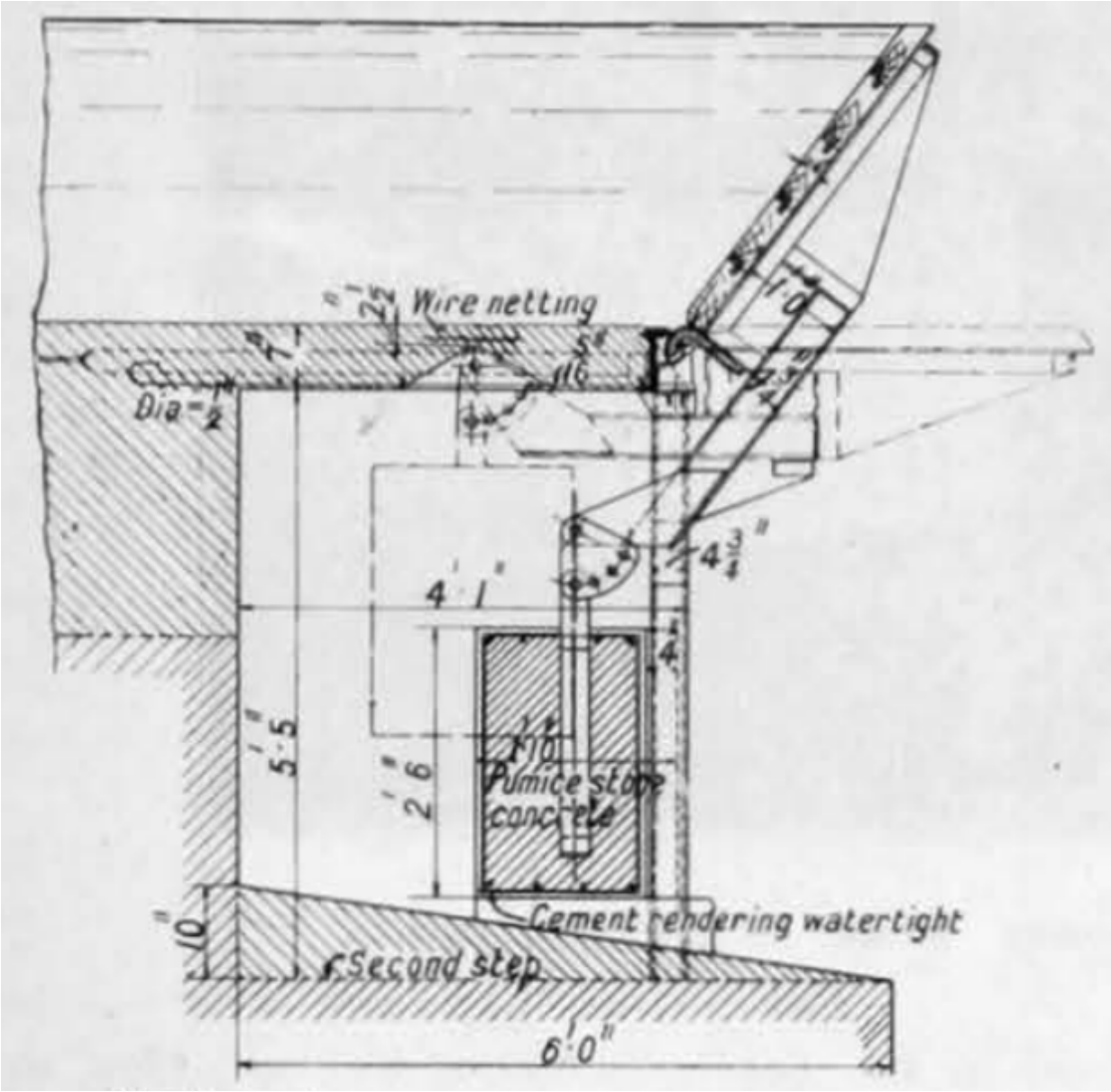
- The Lock was begun in early 1768 and opened in August 1769 [1]
- The weir in its original form was completed by 1771 [2]
- By 1783 the weir "became so dangerous that the river level needed to be lowered and tenders sought for a major repair" [3]
- Further works were done shortly before 1852 to increase the level upstream [4]

b) Development of the lock and weir, post-1900

- The Linton Lock Navigation declined commercially from ~1900 and sharply in 1920 when an employee embezzled the company's funds [5]
- York Corporation leased land and began construction of a hydropower scheme in 1920 which was officially opened in 1923. The lease payments from this scheme enabled Linton Lock Navigation to carry on [6]
- In 1922, as a late change to the planned works for the hydro scheme, the crest and face of the weir were substantially rebuilt. Two tilting steel shutters of length 50' and height 2' were added to the weir crest to enable automatic control of levels. The automation was by concrete counterweights which were hung beneath the shutters. To house this large mechanism, it was necessary to form a gallery below the crest. The formerly stepped or sloping weir apron was therefore altered by casting a 7"-deep concrete slab above the new gallery to create a near-vertical downstream face. This alteration moved the effective crest to a point some distance downstream of the crest of the original stepped or sloping weir.[7] The new elements added to extend the weir are pictured in section view on the next page.[8]
- 1962: At the expiry of its lease, the hydro scheme closed down due to failing viability (like many others at this date, due to competition from nationalised coal industry and the new charges for water abstraction).[9] Thereafter the hydro machinery was removed, including the shutters on the weir crest. This change left the crest in its surviving form and appearance.
- early 1960s: the Lock gates collapsed. With no further hydro lease payments to subsidise restoration, the Lock was abandoned.[10]
- 1967-: a local motorboat club stepped in (and then CRT's predecessor), restored the Lock, and encouraged the growth of the marina. [11]
- In 2012, the new private hydropower scheme was installed on the opposite (true right) bank

---

[1] Hadfield, Charles (1972), *The Canals of Yorkshire and North East England, Volume 1*, p.104.
[2] Ibid.
[3] Hadfield, Charles (1972), The Canals of Yorkshire and North East England, Volume 1, pp.107-110.
[4] Broadhead, Ivan E. (1982), *Portrait of the Yorkshire Ouse*, p.35.
[5] Ibid.
[6] Ibid.
[7] *The Engineer* (1923), pp.148-150. Tyson, S. (1972) "The Linton Lock Hydro-Electric Power Station." *Industrial Archaeology: The Journal of the History of Industry and Technology*, Vol 9 No 1, Feb 1972, pp.48-57. Procurement of automatic shutters: York Corporation: Electricity and Tramways Committee, minutes Vol.5. York Archives, Y/COU/5/11/1, 14/3/1922, 16/5/1922.
[8] *The Engineer* (1923), p.150.
[9] Ibid.
[10] Broadhead, Ivan E. (1982), *Portrait of the Yorkshire Ouse*, p.35.
[11] Ibid.



This section drawing (published 1923) [12] *shows the modifications to the weir crest which were made in 1922. At the centre is a gallery in which the concrete counterweights hang. Above this is a reinforced concrete slab upon which the automatic shutters are hinged. The shutters were removed after 1962. Close inspection at site in summer 2014 confirmed that the top slab and gallery are still present as shown above, but that the mechanisms have been removed.*

The "second step" may or may not be part of the pre-existing structure of the weir. However, the vertical upstream wall of the gallery shown here does not match the sloping form of the weir fall seen in the 1880s-90s photograph, and must be inferred to be new foundation work for the 1922 gallery.

[12] *The Engineer* (1923), p.150.

c) Development of the fish pass

- ~1864: A wooden ladder for salmon was built near the navigation sluices (i.e. at the true left end / west end of the weir), which proved inadequate by ~1877 (had either fallen into disrepair, washed away, or was otherwise unsuitable).[13]
- ~1877: A fish pass was built on the opposite bank (true right bank / east bank), consisting of sanitary pipes (i.e. glazed clay pipe) buried in the ground outside the wing wall with opening/s through the wall to the river. This was too steep for fish and the tunnel was infilled around 1878.[14]
- 1885: HM Inspector of Salmon Fisheries inherited a design which his predecessor had approved for a new salmon pass at Linton Dam (Yorkshire Ouse). He "thought it my duty" to criticise shortcomings in the design, but was constrained by his Board to confirm approval.[15]
- 1886: The inspector confirmed that this sub-optimal "fish pass at Linton, on the Ouse, has now been erected. If this great dam could be made easily passable for salmon, a large extent of river would be benefitted." [16]
- 1890: "The fish pass at Linton being wholly inefficient, I have strongly pressed my view that its improvement should be carried out before any money is spent on the weirs above it; and, although the difficulties are considerable, I have roughly suggested a plan which I believe would be successful". The pool pass at Boroughbridge was considered a good example to follow. - "there now seems to be a good prospect that the much-needed opening up of Linton Dam, the key of the Ure, may shortly be carried out." – "The Conservators of the Yorkshire Fishery District have been successful in securing the assistance of riparian proprietors, and others… in their efforts to improve the fish pass at Linton." The Marquis of Ripon was engaged and a public meeting held in the autumn to raise subscriptions for the replacement pass. [17]
- 1894: "A new fish pass was erected on the site of an old one at Linton Dam, and has proved most successful." (Further detail omitted: inspector was excused from submitting his customary full report on account of grave illness.) [18]
- 1902: "There used to be a serious obstruction [to salmon on the Yorkshire Ouse] until some six or seven years ago" - when a new pass was built by the Fishery Board. Previously Linton Dam "never had a fish pass that was any use or much use". [19]
- 1924: The fish pass needed modification to correct its interaction with the weir shutters added to the hydro scheme. 2 top steps (pool walls) changed. Request from Yorkshire Fishery Board that other steps (pool walls) to be "dished" to maintain a min water depth of 4" (8" at top step).[20]
- 1936: Fish pass needed further modification to correct interaction with the hydro scheme. A gap was notched out of the lower wall of the pass to improve attraction of fish. [21]
- "Solutions for fish passage change over time as knowledge and technology move on. Frequently, fish passes may prove to be effective but not necessarily efficient. Lessons

[13] Ward, R.W. (1946). History and report on fish passes and migratory fish in the Yorkshire Fishery Board's area. The Yorkshire Fishery Board. February 1946. pp.16-17. Ward's dates are sometimes at odds with primary sources (may have been misread from notes) and may be treated with caution.
[14] Ibid.
[15] HM Inspectors of Salmon Fisheries Annual Reports, 1886 (for year 1885).
[16] HM Inspectors of Salmon Fisheries Annual Reports, 1887 (for year 1886).
[17] HM Inspectors of Salmon Fisheries Annual Reports, 1891 (for year 1890), pp.5, 11, 22.
[18] HM Inspectors of Salmon Fisheries Annual Reports, 1895 (11th Jan, for 1894), p.67.
[19] Commission of Enquiry on Salmon Fisheries, 1902. Minutes of evidence, p.121.
[20] York Corporation: Electricity and Tramways Committee, minutes Vol.5. York Archives, Y/COU/5/11/1. 11/6/1924, 9/9/1924, 14/12/1924. Other sources assert 1921, but as the developer only considered automatic shutters until 1922, earlier discussions were not a response to these.

need to be continually learnt from their failings and improvements made to try to maintain the most effective and efficient passes. For example, one of the first recorded fish passes in the UK was a wooden fish ladder that was constructed in 1864 on the River Ouse at Linton-on-Ouse. Either because it perished or else did not work, it was replaced with a 'tunnel' in 1877. However, the tunnel was rapidly scrapped in 1878 because it proved too steep for the fish to use. It was then replaced with a Home Office (government) approved pass in 1886 (approval first became required by law in 1883), but was once again reconstructed in 1899 *[1894 above]* at a cost of £547 because the previous one was considered to be of poor design. In 1921 *[1924 above]* it had to be further modified when a hydropower plant was constructed at the site, resulting in raised upstream water level. It was then modified again in 1936 to improve the location and attraction of the downstream entrance, which had been compromised by the conflicting lead caused by flow from the turbine draughts on the opposite bank of the river. Clearly there were problems at this site and [indeed] the existing pool & traverse pass no longer meets current design guidelines." [22]

c) Photographic evidence

The photos on the next page illustrate the development stages raised above.

The top photo (undated) shows the weir and fish pass in the 1880s-90s in high flow conditions. [23] While the form of the weir is masked by high flows, it is clear that:

- the fall of the weir is set back some distance upstream of the downstream face of the washout sluice chamber, on which the gentleman is standing at the railing, at true left bank (this is no longer the case)
- the weir has a stepped or sloping upper face (this is no longer the case)
- the effective weir crest is topped by boards set back from the edge. These govern flow into a fish pass (at the true right bank).
- the fish pass walls appear to form a convoluted side-to-side chicane (no longer the case)
- the fish pass upper wall does not extend significantly above water level (it did so in 1923)
- the right-bank retaining wall has recently been rebuilt in new concrete

It is therefore inferred that this photo represents the fish pass in its pre-1894 form.

The centre photo shows the weir and fish pass in moderate to high flow conditions when the hydro scheme was formally opened on 1st August 1923. [24] It is clear that:

- the fall of the weir is no longer set back some distance upstream of the downstream face of the sluice chamber (at railing), nor is it clearly stepped or sloping. The weir has been extended downstream and made steeper to accommodate automatic shutters at the crest.
- the fish pass walls have been modified - extended downstream, and apparently having been altered to give the pool-and-traverse format which survives today.
- the fish pass upper wall has been built up to extend significantly above water level
- (the tents of a school summer camp are visible on the right bank)

The lower photo shows the current state of the fish pass. Its high upper wall has been broken away. The shutters have been removed from the weir edge, and boards reinstated set back from the edge.

---

[21] Ward, R.W. (1946). History and report on fish passes and migratory fish in the Yorkshire Fishery Board's area. The Yorkshire Fishery Board. February 1946. pp.16-17.
[22] Kroes M.J., Gough P., Schollema P. P. & Wanningen H. (2006). *From sea to source; Practical guidance for restoration of fish migration in European rivers*. p.49. Some dates here appear to derive from Ward (1946) and, as above, are not necessarily reliable.
[23] York Archives, image y_11125 © City of York Council, licensed for use 14/4/15.
[24] York Archives, image y352_79 © City of York Council, licensed for use 14/4/15.

(black and white images © City of York Council, licensed 14/4/15 for use in this application only)

The proposed development

It is proposed to install an additional Archimedean screw generating system in a new channel bypassing the weir, adjacent and east of the existing system, together with a nature-like fishway (of pools and glides) adjacent further to the east. A lifting bridge is proposed for access across the new channel. At its upper end, the new turbine would have a flood-proof concrete enclosure around the generator. It is proposed that this enclosure is crowned by a railed viewing deck, with the wall finishes designed to replicate the superstructure of a boat giving it a sense of place in a navigation setting alongside the River Ouse.

Please refer to design drawings. In addition, the images below show before and as-proposed views of the upstream panorama, giving an indication of the intended visual form and finish of the altered intake channel and new fishway.

Advice received from English Heritage

At the time of original application for a new hydropower scheme on this site in 2003, English Heritage commented that the proposal for a new hydropower scheme should be viewed as part of the history of developing water use for hydropower on the River Ouse.

Subsequent discussion with Diane Green of English Heritage in early 2015 on the basis of outline designs has raised no issues in principle. Diane was also consulted on the proposals for repairs to the existing salmon ladder, and considers these to be compliant with the original design (based on surveys and historical photos).

Impact assessment

An assessment for an earlier hydropower proposal at this site (Cowle 2003) is reproduced further below for information. The general content of that assessment still stands, but should be read with the present updates of detail on the structures and significance (above) and latest specifics of the design now proposed. The latter are set out below under headings of most interest to the setting of heritage structures.

1. The only viable location

This site is the only viable low-head hydropower site on the River Ouse in Harrogate BC area (and indeed throughout the main stem of the Ouse with the exception of Naburn south of York). It is the largest low-head hydropower opportunity within Harrogate BC area.

2. Design most appropriate for the historic context

a) Hydropower is already an important use and purpose of this site, and the historic significance of the listed structures in terms of their dating, appearance, and purpose has been shown to have been fundamentally influenced by hydropower prior to their listing.

b) Among hydropower options, an Archimedean screw rotates at a slow speed which can be followed by the human eye, allowing the eye to follow the descent of water. This is in keeping with the engineering of the early industrial age which built Linton Lock and the original weir. A slow-moving semi-submerged water device of painted cylindrical metalwork, in a muted green or grey, is not the most incongruous or modernistic of additions among the greys and greens of the water landscape, the sinuous path of the Ouse, the navigation and its varied boats, its bankside furniture, fencing, and clutter of use.

c) Alternative technologies would be high-speed, highly-engineered modernistic industrial technology such as Kaplan turbines, whose works have nothing of historic sensitivity about them. They would not confer the environmental benefits of an Archimedean screw in terms of visual interest or of retaining the use of all the water for the free movement of fish.

3. Design must minimize adverse impact on visual setting and structure

a) Adverse impact relates to the assessment of the significance of the structures. The sequence and significance of the weir and salmon ladder have to date not been fully understood (see above). Throughout the history of its occupation since 1768, the site has had almost continuous use as a water management structure and river traffic corridor, and has also provided a resource for hydropower stations between 1923-1962 and 2012-present. The weir's form and appearance have changed since its construction, most

recently with a change of its visible shape for hydroelectric power in 1922. The setting is flanked by the large mass of the derelict concrete former hydropower station, and the setting has been brought back to life by the introduction in 2012 of an active new scheme serving the same purpose. The listed structures and their setting are thus shaped by hydropower. In this light, it is appropriate to continue to develop efficient use of the weir for the provision of power, to meet the modern priorities of the communities who live and work around it and to whom its visual amenity is greatest. This impact upon setting may therefore be regarded as positive rather than adverse.

b) The design now proposed has no structural impact on the historic structures. Design has actively sought to maintain the maximum distance between the new works and the physical structure of the weir while delivering the desired ecological and amenity benefits. The “training wall” within the river downstream of the weir, one of the older elements of the site which was adjacent to works in 2012, was secured against further deterioration by piling at that time, and is not in contact with or affected by the area of works now proposed.

c) The provision of fish passage was an important add-on to the original purposes of the weir. While carried out to the best available standards in previous ages, the existing pass to date has not yet achieved its intent. This intent is now progressed by the proposed design, which achieves a significant improvement in fish passage with a low-profile fish route alongside an efficient hydropower system, without detriment to the historic fabric.

d) Beneficial repairs to the existing listed fish pass are facilitated by the proposed development, at reduced cost to the charitable owner of the listed structure. These repairs will rectify evidently broken parts of the concrete fish pass which now impair its operation.

e) While in recent years the east bank site has been set to farmland, it was not always an unpopulated scene, with the large tepees of annual school camps providing a regular backdrop to views of the weir between the wars. A positive change of appearance imparts optimistic and dynamic purpose to this location, to which the potential canoe use of the new fishway would attract canoeists as active and motivated leisure users of the amenity.

e) Due to the proposed size of the new hydropower system, this requires a flood-proof generator enclosure built up to a certain elevation. This is styled to reflect the texture and features of the superstructure of boats, which are abundant at this location, crowned by an accessible viewing deck. This celebrates the continuity of hydropower at the site, which at present is poorly revealed by the sombre shell of the 1920s station on the lock island. The superstructure and viewing platform will not obstruct, and will have limited presence in, views of the lock and the weir itself, from which it stands at some distance away to the side and distant from the viewer. It will not appear in elevation views of Lock House.

Ground conditions and archaeological potential

Identical conditions are anticipated to the construction of the previous scheme in 2012, which revealed no earlier structures in the same area of works. An archaeological watching brief during the new works may be considered; but as this was not required for the similar operation in 2012, in the absence of any new records it is also likely to be disproportionate for the new works which lie yet farther away from the heritage structures.

Mitigation & Benefits

The proposal offers the opportunity for the weir to be developed in a way which further improves the sustainability of future fish populations, by adding a new supplementary fish pass. This has been designed in line with latest expertise on improving the mobility of coarse fish species, eels, and lampreys as well as salmonids, and thus promotes statutory requirements not only with regard to impact on protected species and their habitats but also to the EU Water Framework Directive objective of restoring river continuity. In addition, the proposed pass is designed expressly to allow a potential dual function as a canoe route and play feature around what is at present an impassable and dangerous weir. This new amenity complements the original purpose of the historic features of the weir and lock as a navigation facility, which since the demise of river transport in the 1960s has revived and evolved in modern times into the amenity of leisure boating.

The proposed design increases access and reduces risk when enjoying the visual amenity of the weir site. By creating a new channel with a lifting bridge which isolates the island at the right bank of the weir, the proposal introduces a safety cordon which for the first time keeps leisure visitors at a distance from uneven ground and a dangerous fall at the weir, while still avoiding a need to add the visual clutter of safety railings at the weir bank. This demarcation also deters unauthorised anglers and poachers from accessing the upper exit of the salmon ladder and weir where angling is not permitted. Security access will remain available to EA and CRT staff. At the same time, a railed viewing platform is provided, giving a better panorama of the site, accessed via a wheelchair accessible ramp.

As the weir site does not explain itself at this bank, suitable interpretative signage might also be included if desirable to enhance this location.

Supporting info: Earlier impact assessment (Cowle 2003)

To avoid duplication in the body of the text, the earlier assessment is reproduced in full below. New evidence above, new applicant details, and the subsequent construction of the 2012 scheme, supersede some of the description; but otherwise the text remains valid.

LINTON LOCK - PROPOSED HYDROPOWER INSTALLATION
Impact Assessment on Listed Structures, September 2003
Prepared by Lindsay Cowle (Conservation Consultant)
on behalf of JR & K Throup and Sons

1.0 Background

This Assessment has been prepared by Lindsay Cowle (Historic Building Conservation Consultant) on behalf of J R & K Throup and Sons, who are proposing to install a hydropower system adjacent to the weir at Linton Lock, on land in their ownership. Several structures in the vicinity of the proposed system (and owned by British Waterways) are Listed Buildings of Architectural or Historic Interest, as described below, and this report assesses the impact on the structures.

2.0 Context (see Fig 1)

Linton Lock is situated on the River Ouse, a short distance upstream of the village of Newton on Ouse. The general context is flat pasture or arable land, relieved by hedges and occasional patches of woodland. The land is low-lying and vulnerable to flooding by the river but protected by low earth bunds.

The area is not designated as an Area of Outstanding Natural Beauty, a Site of Special Scientific Interest or a Conservation Area, and it has no informal designations in the Local Plan.

The river is broad and relatively shallow and flows in gentle curves between sandy banks. At Linton Lock it passes over a masonry weir, built in the mid 18th century, which produces a step in water level of roughly 2 metres and which river traffic can by-pass via a stone-built lock and short man-made channel on the west bank, of the same date. A lock–keeper's house (now a licensed restaurant) of the same date faces onto the lock.

The weir has a large stone and concrete salmon ladder at its east end, projecting into the river, again originating from the mid-18th century. A short distance upstream of the weir a

modern barrier of orange plastic floats across the river prevents river traffic from approaching too close.

To the north-west of the weir, on what is effectively an island between the upper part of the river and the channel, is a reinforced concrete building (now disused) built in the early 20th century and originally used for hydro-electricity generation utilising the drop in river level.

The west bank of the river is lined with floating decks and moorings both above and below the weir, together with permanent caravans and parking for river users and patrons of the restaurant. The east bank is undeveloped below and around the weir, but further upstream is lined with floating decks and moorings.

The weir and fish ladder, the lock and the lock-keeper's house are all Listed individually as Buildings of Special Architectural or Historic Interest (Grade II) and for their Group Value

3.0 History and General Description

Linton Lock is an industrial complex of considerable historic interest. In recent years it has become a focus for pleasure craft on the River Ouse, and has been restored to working order by British Waterways, but it remains essentially a feat of engineering, related solely to the control of the river and river traffic, and therefore of strictly functional design.

The formal Listing entries show that the weir was constructed shortly after 1767 following an Act of Parliament of that year for '…Making Navigable the River Ouse'. The purpose was undoubtedly to extend navigation up to Boroughbridge and Ripon, for strictly commercial reasons. The complex is therefore simple and purposeful, designed for its function rather than its appearance.

The **weir** itself is difficult to see because of the flow of water over it, but is presumably of stone masonry, with possible later repairs. At the west end there is an overflow channel, and a retaining wall of herring-bone tooled masonry capped with large stones held together with iron cramps. A shallow boarded barrier set slightly upstream of the vertical face (and of modern date) ensures a slightly greater depth of water in low water conditions.

The **fish ladder** is dated in the Listing description as having been built at the same time as the weir but seems to have undergone radical repair or alteration. The stepped watercourse itself and the containing walls separating the ladder from the river appear to

be of mass concrete, presumably cast in the late 19th or very early 20th century, so that the only surviving fabric appears to be the retaining wall of the bank and a low masonry wall standing in the river below (- these are described in detail later). Map evidence suggests that the present ladder still reflects the shape of the original ladder, but very little survives from the 1767 work.

The land bordering the fish ladder has been backfilled in recent years with tipped stone and concrete to combat flood erosion and is unfinished.

The **lock** (and by implication the man-made channel, labelled on the 1848 OS Map as 'The Cut') is also dated in the Listing description as being constructed shortly after 1767. It is of coursed ashlar, and was designed to hold vessels up to 60 feet long and 15 feet 4 inches wide, drawing 4 feet of water.

The **lock-keeper's house** is dated as mid-late 18th century (presumably shortly after 1767) and seems to have consisted originally of a three-bay house, with an additional bay (- probably the 'Smithy' marked on the 1848 OS Map -) added to the west end in the19th century. Further single storey extensions have been made at each end at unknown dates. The materials are local clamp bricks and red roof pantiles. It is of simple design, traditional in the locality, but is of special importance due to its function and physical relationship with the lock.

The early 20th century hydro-electricity generating building is a rather gaunt and unattractive structure, set lengthways on the west side of the river and commanding the view downstream. The bank downstream of the building consists of sheet piling with a concrete capping. The building is not Listed.

4.0 Planning Proposals (see Fig 2)

The proposed hydropower system would be situated on the east bank of the river, and is illustrated on the Consulting Engineer's drawings Nos H20083/1/201, 204 and 205 dated September 2003.

The system would draw water from the river via a new open cutting just above the weir and discharge it through a covered culvert just below the fish ladder. The turbine and generator chamber would be below ground, and the only features above ground level related to this water course and generation plant would be the safety railings round the open channel and

the machinery to control and clean the channel. No vegetation would be disturbed other than some small willow bushes at the water's edge.

The drawings also show a transformer house located a short distance away from the channel. It is understood that the location of this building is flexible, and that it could if necessary be positioned further to the east, on the other side of the flood bund. The building would be of concrete to resist flooding but clad in local clamp bricks, and with a sheet metal and steel frame roof capable of being removed for major repair or replacement of the transformer.

5.0 Impact Assessment – General Overview

A material consideration in determining the Planning Application for the hydro-power plant will be its direct or indirect impact on the Listed features. Specifically, the Planning (Listed Buildings and Conservation Areas) Act 1990 requires that Listed Building consent be obtained for any work which would directly **affect the character of a Listed building** as an historic building (ie by direct intervention), and any work which would **affect the setting of a Listed building**.

In either case the legislation is not necessarily intended to prevent development but to ensure that it is properly designed and controlled. The question of 'effect' is a matter of judgement and degree.

Effect on character

It is clear that the work will have no direct impact on the lock and the lock-keeper's house, as these are on the opposite side of the river.

The work will have no direct impact on the weir apart from two minor issues. The first is that the volume of water passing over the weir will be reduced, but only up to a minimum set by British Waterways and the Environment Agency to ensure the health of the river and its wildlife. The second is that the existing weir boards at the top of the weir to provide extra height would be raised by 150 mm to ensure that the depth of water above the weir is maintained in low water conditions. Neither of these can be said to materially affect the character of the weir.

The work would be in close proximity to the fish ladder and this is discussed in more detail in Section 6.0 below.

Effect on setting

As stated earlier, Linton Lock is essentially a functional work of mid 18th century engineering, perhaps more appropriately regarded as a piece of industrial archaeology. It has been designed to suit the local hydrology but has not been designed to suit the wider landscape and was not conceived with a wider setting in mind. The step in the river level later presented the opportunity for another piece of commercial engineering to be added, in the form of the early 20th century hydro-electricity building. The addition of a 21st century hydropower system to this assemblage would be entirely appropriate and could add interest to the group.

It should be borne in mind that although the various structures are listed for their group value they do not stand in a Conservation Area. Under planning law the requirement to protect the 'setting' therefore only applies to the structures individually and not to the group as a whole.

It is clear that the work would not impact on the setting of the lock and the lock-keeper's house, as these are some distance away on the opposite side of the river. The new machinery and transformer house would be visible from the lock and lock-keeper's house, but under Planning legislation that is a matter of amenity and the wider landscape rather than historic building conservation.

It is also clear that the work would not impact on the setting of the weir itself. By definition the weir is set down in the bed of the river and the new structures would be some distance away on the bank. The mouth of the water channel taking water from the river to the turbine chamber would be close to the top of the weir but would be cut into the ground and apart from the safety railings would be invisible from most viewpoints.

The work would be in close proximity to the fish ladder and this is discussed in more detail below.

6.0 Impact Assessment – the Fish Ladder

As described above, the only fabric to survive from the fish ladder is the masonry wall on the east bank and the low wall in the river below.

The wall can be subdivided into several sections (shown on the attached plan) which are described in south-north (downstream) sequence as follows:

A. At the top end of the ladder a short length of stone wall emerges from the sandy river bank. It is not known how long or how high this wall is, but it is built of relatively small pieces of coursed stone clearly not designed to withstand exposure to the river. It may be a later addition, built part way up the bank to retain the ground above. This wall may have to be removed to make way for the feeder channel, but its loss would be insignificant.

B. A short length of retaining wall approximately 2 metres high strikes out from the bank at an angle to start the 'lead in' to the ladder. It appears to be of mass concrete therefore dating from the late 19th or early 20th century and is of little intrinsic value; it may replace an earlier wall or it may have been added later. This length of wall would be retained.

C. The main part of the wall is built of stone ashlar with large, slightly over-hanging capping stones forming the top edge, fastened together on their top faces with iron cramps. A later capping of concrete has been applied at some date (presumably the early 20th century) but has been largely eroded away. The wall descends halfway down the ladder and then stops at a massive concrete buttress. This wall is the most important remnant of the original fish ladder and it would not be directly affected by the work, the new channel being generally 8m or so to the east.

D. At the concrete buttress a low and severely eroded masonry wall partly obscured by vegetation strikes off at 90 degrees into the bank for a distance of 6-7 metres. It is built of roughly coursed stone and it appears to have been added later to stabilise the sloping ground, in association with back-filling of the main retaining wall with tipped stone and concrete, probably to combat erosion due to the river overflowing the sides of the fish ladder in flood. Most of the wall has collapsed, leaving only a short stretch at the east end and the stone and concrete backfill to the remainder.

This wall would be removed to make way for the new water channel, but it appears to be a later addition of no intrinsic value of no significance to the design and appearance of the fish ladder as a whole

E. Below the fish ladder a broad and severely decayed masonry wall (-now referred to as a 'training wall'-) runs from the bank into the river. It is built of massive ashlar and the broad

cappings are held together with joggle stones. It appears to have finished about 1 metre above normal river level and the 1848 OS Map suggests that it was built as a retaining wall for the river bank, as the Map shows vegetation on the east side. Most of the cappings and top courses of stone have fallen off and the wall has keeled over to the east.

The outflow channel would be located immediately upstream of the wall, in the space between the wall and the fish ladder. The wall would not be directly affected by the work, and the outflow channel would be angled and designed so as to avoid stressing the wall and its foundations with the volume or speed of water. The river bed would be deepened at the outflow but the footings of the wall would be protected by sheet piling into the river bed. The wall disappears just short of the bank but if the footings continue below ground level and are exposed by the works they can be recorded archaeologically.

It is therefore clear that the proposal would have no **direct impact** on the fish ladder, other than the removal of the retaining wall half way up the bank (section **D**), which is a later addition of very little historic interest.

In respect of the **setting** of the fish ladder it should be borne in mind that nearly all the existing structure is of relatively modern concrete construction, reflecting the original arrangement to an unknown extent. It is therefore of limited architectural or archaeological sensitivity, and it is unnecessary to preserve a large area of its context in order to protect its historic value.

The new water channel etc would generally be located 7-8 metres clear of the surviving historic fabric and the only evidence above ground would be the railings and the water control and cleaning machinery, which would be entirely compatible with the character of the area as a water engineering (and later power-generation) complex. Below ground level, the sides of the channel and tailrace would be of sheet metal piling capped with concrete, similar to the bank on the opposite side of the river, below the hydro-electric building.

The proposed transformer house is discreetly designed and would be located more than 20 metres from the ladder, with the possibility of its relocation more than 50 metres away on the other side of the flood bund if required for practical or visual reasons.

7.0 Summary

Linton Lock is important historically as a work of civil engineering carried out for practical and commercial reasons. Apart from the individual Listed components it has no special conservation or amenity designations and it relates purely to the functioning of the river and not to the wider landscape.

In principle, a hydropower installation would be entirely in keeping with the industrial nature of the complex, and with previous attempts to generate power from the fall in river level, and could add engineering and archaeological interest to the site.

The design of the new hydropower installation has had regard for the need under planning law to preserve the Listed structures and their setting. With regard to the lock and the lock-keeper's house these would not be affected directly or indirectly, due to their distance from the proposed site. Likewise the weir would not be affected in any way other than the amount of water flowing over it.

Examination of the fish ladder indicates that it was virtually all rebuilt in concrete at the end of the 19th or early 20th century and that the only pieces of fabric to survive are the east retaining wall and the training wall in the river below. Both of these would be preserved, and the only loss would be a short and relatively insignificant section of flank wall, probably built at a later date to combat flood erosion.

Neither the fish ladder, the weir or the group as a whole has a sensitive setting. The site of the proposed work consists of rough ground and tipped stone of no historic or aesthetic value. Above ground level, the only evidence would be the railings and the water control and cleaning machinery, which would be entirely compatible with the character of the area as a water engineering (and later power-generation) complex.

Below ground level the water channel and tailrace would be formed with sheet piling capped with concrete, similar to the river bank opposite. The transformer house would be discreetly designed and could be located further away, on the other side of the bund.

It is therefore submitted that the proposed scheme has no material impact on the Listed structures or their setting.

Lindsay Cowle B Arch RIBA Dip Cons (Dist) IHBC AABC, September 2003.

Supporting info: overview of the Archimedean screw turbine

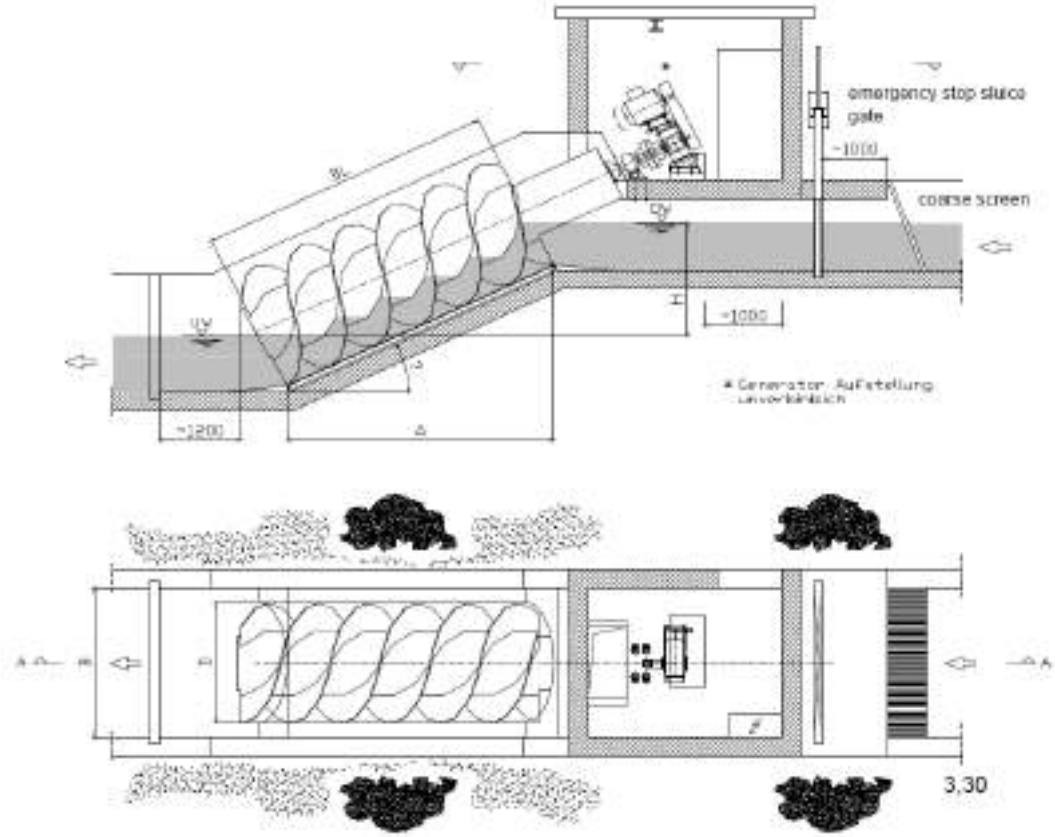


Figure 1: Archimedean screw hydropower system – generic layout sketch

Figure 2: Floodproof screw installed at Goldsborough, North Yorkshire

The concept of the Archimedean screw has been known since ancient times, when it was first used as a water pump, with the screw rotating to lift water uphill. The potential of inverting this process has now been realised, by allowing water to fall by gravity into the chambers of the screw. The system then rotates, allowing potential energy to be extracted from the water and fed through a gearbox to power a generator to export electricity.

The turbine structure is similar to an extremely large hardware screw, which commonly consists of a single blade rotating round a central core (single helix). The modern hydrodynamic turbine consists of a triple or quadruple helix, combining large open water chambers with a slow speed of rotation, which avoids any pressure change in the water. Fish can therefore simply enter the screw at the top, and pass through the screw unharmed at the bottom. Extensive testing has been carried out to prove just how fish-friendly the machine is, with over 1000 successful passages of live fish of various species and sizes. These tests were carried out and fully documented by independent experts Fishtek Consulting Ltd.[25] .[1]. As there is no need to exclude fish, only a very coarse screen is required, which allows leaves, sticks and other debris to pass through without causing blockages and the subsequent loss of output that other turbines would suffer.

The top of the screw is connected via a flexible coupling to a gearbox, to increase the speed to close to 1500rpm, and then through a final drive to the generator. An electrical control system controls the flow of water to the screw via a sluice gate, monitors the output of the generator, and ensures that the correct frequency and voltage are maintained at all times.

Efficiency comparison

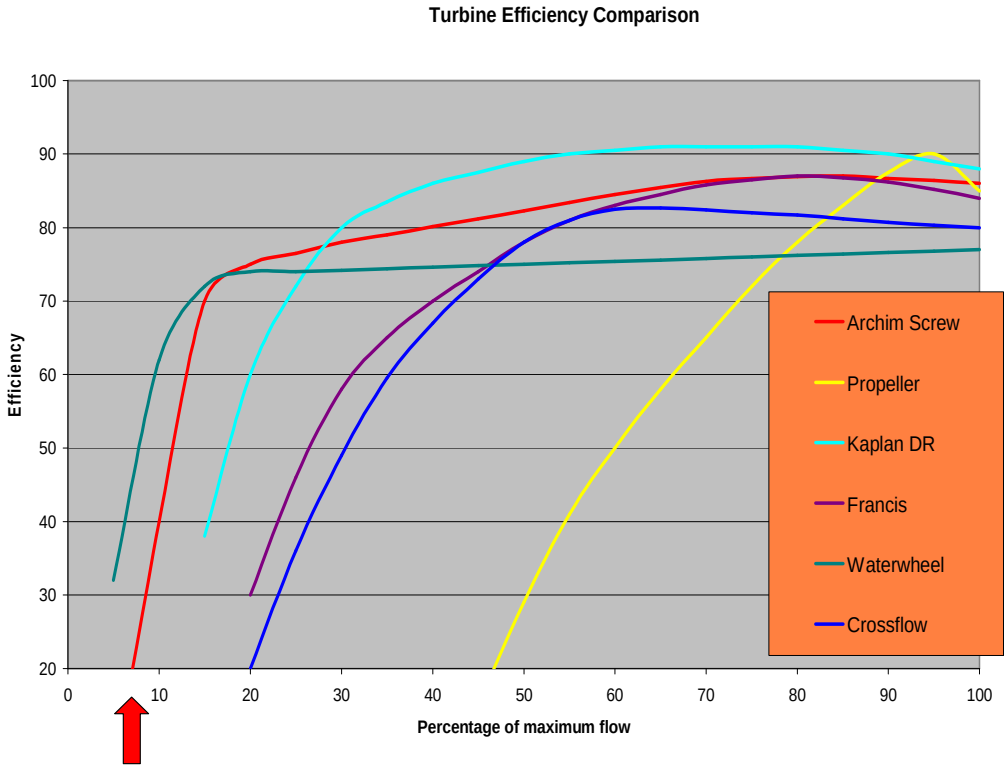
The Archimedean screw is recognised not only for its potentially fish-friendly design, but for its performance among competing designs as increasing flow affects efficiency (below). These are reasons why the Archimedean screw is preferred to less visible turbine types.

The Archimedean screw reaches efficiencies of up to 86%, providing a comparable electrical output to alternative systems, but with a lower capital cost and maintenance overhead. The omission of fine screening, together with a low water velocity and low pressure throughout the system, means that the net head available for generation is very

[25] Archimedean Screw Fish Passage Test Results, Fishtek, Sept 2007 et seq.

close to the gross head at the site. In addition, full flow capacity is maintained through the screw even when the gross head is reduced during times of high water. These factors can all have a significant impact on the actual annual generation possible from a particular site. A thorough assessment of the actual performance of an operating system was carried out by independent consultants Nick Bard Hydro Systems, which proved that the performance matched that predicted by the manufacturer.[26]

When estimating the energy delivered over the course of the year, it is most important to consider the effect of changing head and flow on efficiency. Favourable performance of the screw in this respect is reflected in the energy capture calculations provided to the client.



[26] River Dart Hydro Performance Assessment, Nick Bard Hydro Services, June 2007. http://www.mannpower-hydro.co.uk/research.php