

**Archimedean Screw
Hydropower scheme at
Staverton**

**ENVIRONMENTAL SUSTAINABILITY
ASSESSMENT**

31st October 2018

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Executive summary

The design of the proposed scheme has taken account of the latest regulatory guidance for best practice hydropower schemes. Consideration is given in turn to those areas of greatest interest in EA licensing. An operating regime is proposed which has been intentionally designed so as to have least environmental impact while still allowing a viable hydropower scheme. The proposed regime is as protective as EA default guidance, or more so, and significantly exceeds guidance in terms of minimum residual flow. This regime seeks to minimise change to the natural environment. Other aspects of scheme layout and technical design are detailed to minimise or mitigate environmental detriment.

Introduction

Renewable energy developments benefit the environment through carbon emissions reduction, but must also demonstrate sustainability in wider environmental terms. The present document summarises how the proposed scheme addresses environmental considerations as noted in the Environment Agency (EA) Good Practice Guidelines (2009) on environmental assessment of low-head hydropower, as modified in guidance to 2016.

Using an Archimedean screw turbine is identified as having low negative impact on fish. This is recognised in latest EA guidance, where the default position is that screws meeting standard criteria are considered for implementation without any fish exclusion screening.

This document is laid out with respect to areas of principal interest to the EA, but serves as a summary of relevant environmental issues and how the project design addresses these.

Scope of this project

Application is made to the EA to grant licence/s to change the status quo, as follows:

- Replace an existing partial obstruction with a new hydropower emplacement at the downstream end of the leat
- Admit agreed amounts of flow - by gravity fall - through the existing intake sluices and into the leat. Manage the sluices to achieve this: repairing as needed, and opening the gates as necessary for normal operation.
- Begin or cease hydropower operation by means of an automatic hydraulic vertical sluice gate at the turbine. The undershot gate will in principle normally operate fully open (drawn up above water level), and will close to exclude all flow when abstraction is not permitted or not required or when there is a fault (failsafe closure: gravity fall when positive signal lost).
- Comply with the agreed flow regime by managing the rotation speed of an Archimedean screw turbine – by means of a variable-speed control system and its software parameters - allowing the water to fall back to the river via the screw and thereby generating electricity.
- Maintain an acceptable residual flow in the main channel at all times. The proposed regime is for (Q95 HOF + 50/50 proportional take) – this is designed to preserve a conservative minimum residual flow to maintain necessary services (fish passage and habitat) and an acceptable degree of flow variation in the main channel.

- Condition these changed flows based on continuous recorded input from a level sensor, and a proportional-take equation to be determined at commissioning.
- Improve fish and eel passage by upgrading an existing breach or easement in the weir to a technical fish and eel pass and by repairing the weir crest to suit this.

EA licensing and consents

The Dart is a main river, therefore Environmental Permits for the works in the river will be required from the EA as Lead Local Flood Authority. Works activities are detailed separately in another document. Planning permission has been sought from South Hams District Council.

An EA licensing pre-application was made in 2015 to which the EA gave full response. The advice remains broadly applicable in that there are no significant changes to the proposal or to the relevant EA guidance. One thing which has since changed is that the Totnes hydropower scheme at the tidal limit of the Dart close downstream of Staverton has produced new monitoring evidence on the activities of salmon in this part of the catchment. This may better inform fisheries questions than the EA's previous assumptions from 2009.

A Full Abstraction Licence 14/46/004/0522 is in existence for flow into the leat, held in the name of the EA. This licence was varied in 2009 by the EA to reduce the abstracted quantity. After discussions with the EA it is understood that the EA agrees in principle that the effect of this licence can be superseded by a licence for the hydropower scheme.

Application is therefore made to the EA for:

- Replacement - or variation - of the existing full abstraction licence, to regulate: the non-consumptive abstraction of an increased quantity of water, for the purpose of hydropower; the non-chargeable, non-consumptive abstraction of water for sweetening flow when the hydro scheme is not operating; ancillary non-consumptive uses of water for agreed fish and eel passage proposals in the main river channel modification of in-channel structures for the purposes of hydropower and for fish and eel passage.
- Consent from the National Fish Pass Panel to approve design of technical fish pass and eel pass (this has already been applied for)
- Bespoke Environmental Permits for the permanent and temporary works-in-river (applied for along with the licence)

- Grant of rights by the EA to the applicant to develop and operate all elements of the scheme as proposed where those elements occupy land owned by the EA and/or fall within other rights as held by the EA (e.g. under a 2011 registered Caution on the leat; under a 1973 conveyance by the EA's predecessor Devon Rivers Authority; and where the EA is the owner of any assets), including rights to operate the intake sluices as needed. It is inferred that the EA can delegate such rights to another licence holder such as the current applicant.

The applicant has already secured the necessary right to access the point of abstraction, being the intake sluice, over land owned by others. (Plan and proof of right are submitted.)

In the event that any time-limited form of licence were to be required, we would agree that the licence review date may be the next CAMS end date (2026); however, if the environmental risk of this proposal is considered to be low, we would welcome the EA instead exercising its discretion (as explained when time-limited licences were introduced) to grant a "long-term" licence to the subsequent CAMS end date.

The EA expressed concern at pre-app that the sweetening flow might be subject to a unit charge if a full abstraction licence was applied for. This is not necessary, as there are various alternatives which may apply, used in EA precedents elsewhere in England. For example, a minimum sweetening flow could be conditioned WITHOUT A UNIT CHARGE:

- In a full abstraction licence for hydropower, as a separate Schedule (B), by a simple condition to maintain an agreed aperture when the turbine was not in operation. During operation, the alternative schedule (A) would then condition flows for the purpose of hydropower (and could – but, in practice, need not necessarily - condition suspending the sweetening flow aperture). A condition on the licence then stipulates that the necessary minimum aperture size and method is to be agreed in writing by the EA prior to operation.
- In an Impoundment licence, by specifying the aperture as above, and/or the flow
- in its own transfer licence, as a transfer "without intervening use", as is routinely done for fish passes and other movements of water for ecological purposes only, with no implication that unit charging need apply. During hydropower operation, a condition could relax the sweetening flow in deference to the full abstraction licence. Transfer licences can be issued alongside full licences, where this is the correct way to implement the legislation in complex circumstances.

The EA will consider whether these proposals meet its definitions to be conditioned as an Impoundment licence or a Full Abstraction Licence for the hydropower system as a whole. The abstracted flow here will be used for hydropower, therefore this does not seem to meet the definition of “without intervening use” which defines a Transfer licence. A unit charge is inapplicable for hydropower abstraction.

EA PLEASE NOTE: If the EA decides to issue an abstraction licence WITHOUT an impoundment licence, or vice versa, **the EA is asked to supply a formal letter stating that whichever licence type is NOT issued is (in the EA’s opinion) formally “NOT required”**. The issue of such a letter in this case is required by OFGEM as a prerequisite (as proof that no further application is outstanding for another type of licence) before it will consider the hydropower scheme as eligible to receive income.

Environmental Impact Assessment (EIA)

For hydropower schemes which are less than 0.5 MW (5 times larger than proposed here), statutory EIA is only invoked where there is also a concern the scheme must demonstrate no significant risk of environmental damage to designated protected sites. On the basis of the evidence submitted, and subject to the regulatory conditions which will be imposed by the EA and planners on any areas of specific concern, the designer considers that the present project will not be found to pose significant risk to designated features.

Water Framework Directive

In considering a proposal for a hydropower scheme, the EA will have regard to the EU Water Framework Directive (WFD). The EA has a legal duty to ensure that all existing and new modifications do not risk preventing the waterbody achieving its status objective, nor causing a deterioration in its current status. The submission is therefore expected to make a case for how this scheme design complies with the intent of the WFD.

A dedicated Water Framework Directive Compliance Assessment has been carried out for this project and is included in the submission documents. The present document defers to that assessment, adding only the observations below.

The relevant waterbody is GB108046008350 – River Dart. Details are available on the EA’s Catchment Data Explorer:

<http://environment.data.gov.uk/catchment-planning/WaterBody/GB108046008350>

The Dart here has Moderate Ecological Status at present, and is targeted to have Good Ecological Status by 2027, were it not for the recognised disproportionate cost burden of improving status for fish. The current proposal will make a substantive improvement to fish passage at the cost of the developer, while evidence is provided to show no detriment on fish habitat or populations. This is a clear benefit towards achieving the WFD status target.

The EA typically considers that the significance of impact on the quality elements should be assessed at a waterbody scale (except for critically sensitive habitats). It is inferred that the EA does not consider the present reach to be a critically sensitive habitat in these terms. The significance of the impact on the quality elements may therefore be assessed at a waterbody scale. Based on the presence of many other such schemes on watercourses in England, over an increasing depth of time, with no evidence of negative impacts on water quality, then no negative impacts on water quality are anticipated from the proposed scheme. As this impact is unlikely to be significant even locally, its significance at a waterbody scale is low or zero.

A specific factor identified as likely to prevent the Dart achieving Good Chemical Status is mercury contamination, because the solutions to this problem are considered technically unfeasible. The current proposal cannot impact this metric, and thus has neutral benefit. Other aspects which inform WFD metrics are set out under the headings in this document.

As the physical implications are similar to those in other on-weir Archimedean screw applications licensed by the EA in all regions, it is anticipated that consideration of these aspects will be sufficient to conclude that this scheme design likewise complies with the intent of the WFD and does not prejudice the attainment of its objectives.

By following latest EA guidance for hydropower schemes, and as detailed in this and supporting documents, the current proposal takes reasonable practical steps to mitigate its negative impact, and will have no detrimental impact on the WFD status of the Dart. The EA typically considers that the significance of impact on WFD quality elements should be assessed at a waterbody scale (except for critically sensitive habitats). As considered below, quality impact is unlikely to be significant even locally, and its significance at a waterbody scale low or zero.

Fluvial geomorphology

A hydromorphology assessment is submitted, which assesses the status quo together with the proposed regime, and predicts no detrimental impact. A fisheries impact assessment was also undertaken which characterises the depleted reach of river between the leat intake and outflow and makes recommendations based on this.

Rivers act as a conduit not only for water, but also for gravels and sediment. The point at which the Dart passes Staverton leat is dynamic, and has evolved in response to a combination of natural and anthropogenous processes. While weirs form an obstruction to natural processes, where a weir has persisted for many years this in itself can contribute locally to the variety of form in a river. The weir at Staverton is such a case, with a slow pool upstream and more turbulent flow downstream adding to other natural riffles.

The proposed scheme is not anticipated to have any significant impact on bedload gravel or sediment movement through the catchment. The proposed abstraction of a minority of the river's flow - this abstraction varying and being at its greatest during medium flow conditions - will not reduce the river's ability to mobilise and propel bedload material along the natural channel during those high flows in which this process occurs. Suspended sediment will continue to move through the natural channel, and in future also through the leat and hydropower system, in proportion to the flow of water in each case. Sediment will not be screened or settled out at the hydropower scheme and will remain within the water column to pass freely through the Archimedean screw turbine. Allowing sediment to transit onwards via the leat will reduce the build-up behind the weir in the existing channel.

A more consistent and habitable water level will be created in the leat, which will encourage, for example, eels and coarse fish to use this new addition to habitat.

Coarse woody debris and leaf material likewise will not be screened out at the leat intake. The smaller elements of all materials that pass into the leat intake with abstracted flows will pass on through the hydropower debris screen and then safely through the screw. Only the largest sticks and branches will be stopped at the screen and will then be fended off to rejoin the natural main channel or withdrawn by the operator at cleaning intervals. Continuance of this maintenance activity is assured by the economic driver of maintaining efficient operation of the hydropower system. The majority of flow stays on the weir crest, where material borne in this flow will pass on down the natural main channel as at present.

Areas where the flow will be altered or excavation will take place are protected either by existing stone/concrete banks, new concrete structures, or piles, thus preventing any increase in sediment transfer downstream, or increased siltation of the river downstream. The outflow channel has large dimensions to keep the water velocity below 0.7m/s, and the channel is oriented to direct the flow downstream back into the main channel, with no potential for erosion on the opposite bank which is distant at this location.

Flow Regime (Hydrology)

See Hydrology and Fisheries assessments for detail.

The project fisheries consultant proposed a minimum residual flow of Q95 and a flow split of 50/50 thereafter. A 50/50 split is what SEPA in Scotland typically licence for a depleted-reach Archimedean screw scheme on a salmon river with a semi-passable weir and no co-located fish pass.

No water will be abstracted before the river reaches its Q95 condition. Above this, 50% of all other flows may be taken, up to a maximum abstraction of 6.00 m³/s. All other flows will remain in the main channel. This proposal has been concluded by the fisheries consultant to create suitable conditions to preserve fish habitat and movement. A 50/50 proportional take on top of a Q95 minimum flow will provide a regime for fish to pass the weir which is more favourable than the EA's default guidance, because it will better conserve low-medium depleted flows, rather than higher depleted flows in which passage up the weir is more likely to be more challenging at present.

Under the proposed regime, an agreed minimum flow of Q95 (1680 l/s in this analysis) will always be maintained at the weir via the new fishpass and a smaller existing notch or side spill at river left, ensuring that the depleted reach remains passable to fish. (The side spill, close to the leat intake sluices, has been characterised and its relative flow capacity measured by spot gauging. For this detail, see submitted document entitled "Flow distribution - side channel flow split".)

In practice, the flow at the weir and hence in the main channel will be larger than Q95. The turbine will be technically unable to run if it cannot pass at least 300 l/s, and due to the 50/50 flow split, the system will not be permitted to take that until and unless a further 300 l/s remains in the river: so the net result is that **there will always be at least 1980 l/s in**

the depleted reach (= Q92 in this analysis). On every rising event, there will be no hydro abstraction until the turbine starts up at 2280 l/s (= Q89 in this analysis), whereafter the main channel will revert to 1980 l/s until levels rise.

The proposed abstraction would create reductions in flow in the main channel as follows:

Flow Data in m ³ /s BEFORE AFTER						Proposed regime:		
Q%	Gauging station flow	Total site flow	Depleted site flow	Minimum residual flow	Permissible abstraction	Actual abstraction	% abstracted	% left in river
1	62.86	65.55	59.55	33.61	31.93	6.00	9%	91%
5	35.20	36.70	30.70	19.19	17.51	6.00	16%	84%
10	25.50	26.59	20.59	14.13	12.46	6.00	23%	77%
15	20.20	21.06	15.06	11.37	9.69	6.00	28%	72%
20	16.60	17.31	11.31	9.49	7.82	6.00	35%	65%
25	13.90	14.49	8.49	8.09	6.41	6.00	41%	59%
30	11.80	12.30	6.99	6.99	5.31	5.31	43%	57%
35	10.20	10.64	6.16	6.16	4.48	4.48	42%	58%
40	8.96	9.34	5.51	5.51	3.83	3.83	41%	59%
45	7.90	8.24	4.96	4.96	3.28	3.28	40%	60%
50	6.96	7.26	4.47	4.47	2.79	2.79	38%	62%
55	6.14	6.40	4.04	4.04	2.36	2.36	37%	63%
60	5.41	5.64	3.66	3.66	1.98	1.98	35%	65%
65	4.76	4.96	3.32	3.32	1.64	1.64	33%	67%
70	4.16	4.34	3.01	3.01	1.33	1.33	31%	69%
75	3.60	3.75	2.72	2.72	1.04	1.04	28%	72%
80	3.05	3.18	2.43	2.43	0.75	0.75	24%	76%
85	2.52	2.63	2.15	2.15	0.47	0.47	18%	82%
90	2.07	2.16	2.16	1.92	0.24	0.00	0%	100%
95	1.61	1.68	1.68	1.68	0.00	0.00	0%	100%

This has been designed as the most favourable regime for the river that can be proposed for a viable hydropower scheme at this site.

Status quo flows in the leat are small and are ignored as negligible in this analysis. If an allowance was made for this, the main channel flow (in the status quo condition) would be slightly smaller than the total site flow above,

Effect on the depleted reach

A hydromorphology assessment is submitted, which assesses the status quo together with the proposed regime, and predicts no detrimental impact. A fisheries impact assessment was also undertaken which characterises the depleted reach of river between the leat intake and outflow and makes recommendations based on this.

The reach which would be depleted by the proposal is a length of some 660m, following a roughly west-east course between Staverton Weir and the confluence with the

downstream end of Staverton Leat. The weir crest features a breach or fish easement not far from the right bank; the line of the crest then curves downstream towards the left bank, for some distance has become naturalised into an island of often-dry ground, but then terminates in a length of side crest parallel to the riverbank which features a chute suitable for use by smolts (see Hydrology above). The left bank and the side crest together demarcate a channel which is designed to supply the intake sluices into Staverton Leat. The proposed point of abstraction is considered to be these intake sluices at the left bank at the downstream end of the weir. The abstracted water is returned where the leat rejoins the left bank of the river, having passed through the new turbine at that location. No part of the Dart will suffer from reduced flows other than in this depleted reach at Staverton itself.

The Fisheries Impact Assessment characterises the depleted reach of river between the leat intake and outflow and makes recommendations based on this. At pre-app the EA suggested that there could be merit in restricting abstraction at flows between 200% and 400% of Q95. A separate report entitled Staverton Fish Migration Flows is submitted which specifically addresses this, adducing the latest evidence of fish migration versus flow in the lower Dart to demonstrate that the proposed regime and new fish pass give more benefit.

The proposed abstraction regime has been designed to have the least impact on flow variation while allowing abstraction for a viable hydropower scheme. Specifically this means having allowed for the highest levels of non-abstraction while still viable, leaving the most possible water in the depleted reach, having particular regard to lower flows where the free movement of fish may become most difficult. Difficulty for fish movement, in particular at low flows, is principally due to the weir which present the key obstruction to free passage. This project proposes to upgrade an opportunistic easement of uncertain performance with proven forms of technical fish and eel passage at the same location.

Water quality

As noted above, quality is among elements assessed for compliance with the Water Framework Directive (WFD). Present information should be sufficient to conclude that this scheme design does not threaten the chemical and ecological quality status of the waterbody (see WFD, above) nor prejudice the attainment of water quality objectives.

The proposal will redistribute some flows away from the depleted reach as described, this being subject to a licensed regime derived specifically to protect rivers from abstractions of this sort based on best-available knowledge of impacts. Upstream or downstream of the

scheme itself, the proposal will not reduce flows as against the status quo: all water will remain available in the catchment. Oxygenation continues to take place, now at the screw as well as the weir. Sediment is not screened out, so is allowed to move freely with flows through the system.

Where there are existing wastewater discharges into a depleted reach, there is potential for a new abstraction to reduce the dilution of these discharges. Here this affects only the existing consented discharge NRA-SW0257 for small quantities into the leat. Both this discharge and any runoff from bank fields will be better diluted by the proposed increased flow in the leat. Therefore negative impacts on the dilution of discharges are unlikely.

No detrimental impacts on water quality have been reported by the EA from around a hundred similar micro-hydropower sites operating under the EA's regulatory guidance for Archimedean screws. Several hundred other small hydropower schemes have been in operation on watercourses in England, over an increasing depth of time, with no evidence of negative impacts on water quality. Impact of the present scheme is unlikely to be significant even locally, and its significance at a waterbody scale is low or zero.

Water resources

There are no competing licensed abstractions in this area that will be derogated or otherwise disadvantaged by this proposal. The proposal poses no detriment to wells or boreholes. No flow gauging sites or flow measuring structures are present within the area affected. A requirement to maintain main-channel flow is satisfactorily met by the proposed Hands-Off Level and proportional-take regime. On distribution of flow in the wider catchment, beyond the intake and outflow, this scheme has no effect.

There is a residual or intermittently wetted side channel on the left-hand bank of the leat (at NGR SX7930763750). The scheme proposes to allow leat levels to return to their previous values, which could potentially increase flow into this area. If preferred, this can be prevented by bank improvement. If not, this channel will carry at least the same flows as at present. The landowner has been engaged in discussions and is amenable to the project.

If the leat intake sluices are considered to be an EA asset, the applicant will depend upon an agreement being made with the EA to allow the applicant to operate these.

The applicant is confident that the other riparian landlord at the weir has no intention of proposing a competing application for this reach such as might complicate EA licensing.

The volumes of water licensed for use by the system will be measured as per EA WR standard conditions for hydro schemes, by calculation from generation output using a conversion factor which is derived at commissioning and advised to the EA.

For national water management purposes, under an abstraction licence the EA seeks to apply a maximum limit to the quantity of water that may be abstracted per year – the “annual quantity” - as well as the instantaneous flow. At this site there is no particular reason to cap the annual quantity to less than 365 days’ equivalent of maximum design flow, but any reasonable amount will be acceptable. The key result is that any proposed arbitrary administrative cap on the annual quantity must not prevent the scheme from using its agreed daily quantity if that agreed quantity happens to be available on any day. EA Hydropower specialists have previously assured us that this is not the intention of the annual quantity, and the value of annual quantity should not be set so as to cause a conflict. (If the scheme is to be licensed with an impoundment licence only, it is not necessary to specify this notional limit at all.)

Environmental Management

Responsibility for running the scheme on a day-to-day basis, and any maintenance program for the site, will lie with the applicant. Their personnel or contractor will maintain the system on a regular basis in the interests of maintaining their income to recoup their capital investment. This scheme does not have unusual technical complexity – i.e. its operation does not necessitate integration with other sluice gates or channel controls - therefore a formal management plan does not seem to be a proportionate requirement, with all relevant conditions simply being included in the licence.

Whatever residual flow is agreed will be calibrated and set by an equation in the control software, which takes as its input the river level at the sensor. This is the method successfully used at other proportional-take screw sites such as those regulated by SEPA in Scotland. The software will control the turbine speed to govern abstraction to be no more than the agreed proportion of river flow, using an agreed lookup table of field measurements of level vs gauged flow. The contents of this lookup table and equation can be calibrated during works, and written approval of the method can be a condition on the licence as a prerequisite to operation.

Where the EA is willing, the hydropower control system can be configured to receive a data feed from the local EA gauging station via a telemetry link as a basis for its flow management decisions. This method is now operating at several lock sites on the EA's Thames navigation, where the applicant provides a Modbus-enabled GSM router at the EA's equipment and another at the hydro scheme, and receives agreed parameters as a basis for operation. If the Austins Bridge flow gauge is able to send flow data in this way, and if the EA is agreeable to using this proven method at Staverton, development of such a method to be approved in writing by the EA can be a condition on the licence.

In all cases: the hydropower system “fails safe” – i.e. when the relevant level threshold cannot be maintained, or on loss-of-signal in a fault condition, the hydropower sluice closes passively and abstraction to the turbine ceases.

If the scheme is to be licensed with a full Abstraction licence, the standard EA hydropower conversion sheet will be completed to ensure correct reporting of abstracted flows; even with an Impoundment licence - where the legislation itself does not require annual reporting - the same effect can be achieved via licence a condition, if there is a particular concern to monitor this. Equipment calibration documents, efficiency specifications, etc can be supplied upon installation. If the EA wishes to make visual inspections of compliance with a minimum water level, installing a visible staff gauge close to the the relevant level sensor is often conditioned in the licence. The foregoing standard provisions are typically deemed adequate to meet requirements of EA Environmental Management.

Ecology

Refer to Ecology technical report.

The scheme is designed with features and a proposed flow regime which are intended to minimise detriment to local ecology and nearby designations and their features of interest. The River Dart is the route by which salmon and eel reach the Dartmoor SAC. The scheme has no significant detrimental impact on fish, as discussed in the Fisheries Impact Assessment.

As part of the Habitats Directive Review of Consents to determine their impact on salmon migration between the sea and their spawning grounds in the Dartmoor SAC, the existing abstraction licence (14/46/004/0522) held by the EA, to abstract from the River Dart into

the leat, was subject in 2009 to downwards modification of abstracted flow. The EA is still engaged in amending or affirming licences in line with the site action plan (SAP) for the Dartmoor SAC, and the present licensing variation will need to be assessed to give a comparable level of protection to that applied in assessing the licences in the SAP for the Dartmoor SAC. As other hydropower licences in the catchment allow significantly larger proportions of river flow than applied for here, and as the present proposal includes mitigations and benefits, this proposal should be achievable without detriment to the SAC. Details relating to SAC species of interest are found in the Fisheries Impact Assessment.

The ecology survey covers areas of interest. The proposed installation in the leat close downstream of the mill would result in temporary disturbance of adjacent small areas of agriculturally-improved pasture or garden of low nature-conservation. Access to the sluices for repairs will be from an existing trackway/route used in the past for maintenance by the EA. This route runs amid areas of local or unconfirmed wildlife interest, noted in the ecology survey.

The EA noted that multi-fruited river moss (*Cryptophaea Lamyana*) has been attested at Riverford Bridge at SX77006300 some distance upstream, on a different reach of the Dart, separated from the proposed site by another intervening weir. The proposed scheme cannot cause any impacts to flows, levels or bryophytes in that reach. The species is an inundation specialist which grows in the flood zone and copes well with intermittent changes in water levels. If this species does spread to Staverton, the likelihood of impacts being caused by the proposed changes is low.

The potential presence of protected species is not only seasonally-determined but can change from year to year. Ecology assessment identifies a need to check for specific species prior to construction, and provide mitigation measures as appropriate. Due consideration will be given to the protection of wildlife during works and to the appropriate eradication of any undesirable invasive flora and fauna discovered.

Specific aspects of potential interest including those which the ecologist has highlighted are as follows:

- Fish, including salmon, trout and eels: see Fisheries section, below. Proposed changed flow regime is designed with specific regard to mitigating impact for fish and their habitat, with concomitant similar mitigated impact (via limited flow reductions) on other species.

- crayfish: no impact anticipated, outside range, habitat unsuitable.
- invertebrates: no significant impact anticipated – habitats common and widespread. Regarding benthic macroinvertebrates, bed conditions will be unchanged (except for small works footprints at weir and outflow). Standard silt and pollution control conditions for river works to be followed during construction.
- aquatic macrophytes: no impact anticipated – depths and flows are not being modified to such an extent that local aquatic plant assemblages likely to be deprived.
- otters:
 - o no direct evidence found in site survey, but likely to be present or passing locally in this riverbank environment
 - o potential for transit – small areas of riverbank are implicated, passage around these changed areas remains open for transit, opposite banks are not affected
 - o holts and lay-up areas – site can be checked immediately before works, any new holts to be fenced off and contractors made aware
 - o risk to individuals during works – all open excavations will be provided with exit ramp or slope
 - o risk to individuals during operation – intake screens minimum 100mm spacing, sufficient to prevent entrainment
- water vole (if confirmed present):
 - o no direct evidence found in site survey, but could be present locally in this riverbank environment
 - o Leat banks mainly hard and unsuitable for habitat.
 - o Main channel water level variation will be slightly moderated during scheme operation, but will continue to vary, so no net detrimental impact on potential habitat here.
- nesting birds: Impact will be avoided by a seasonal condition for relevant tree/habitat clearance to be conducted between September and February (inclusive) only, or inspection for active nests prior to tree work outside this season.
- bats: low roost potential in site of works, other than in specific noted tree/s. Aerial roost feature survey prior to works on Tree 8. Conditions for daytime working / lighting during works would avoid any detriment to foraging.
- badgers: little evidence found, no setts on site, no specific measures proposed.
- trees: refer to Arboricultural technical report.
- invasive species: contractors follow standard guidance for dealing with the most common invasives, and will be informed of Himalayan Balsam noted by ecologist.

Fisheries

Refer to Fisheries technical assessment and to Hydrology assessment for flow regime. The scheme is designed with features and a proposed flow regime (Q95 HOF plus 50/50 flow split) which are intended to minimise detriment to fisheries in the Dart.

Downstream passage / Intake screening

The proposed proportional-take flow regime maintains downstream passage over the weir and through the depleted reach. It causes a proportional (minority) reduction at higher flows than Q95, and causes no reduction in weir flow or main channel flow in conditions below Q95, in which condition the fisheries assessment indicates that the weir and channel contain sufficient water to maintain downstream passage for all fish species.

The new fish pass and the existing side spill or smolt chute (near the leat sluices: see Hydrology above) are located distant from each other at different points on the weir crest, which provides for fish near both banks to pass downstream over the weir and into the main channel. Other fish will follow the minority flow which is abstracted into the leat.

Safe downstream passage is provided via the leat and thence via the large chambers formed by the Archimedean screw turbine blades. The large body of water entrained by the passing of each blade is open to natural light and air, avoiding any pressure change. EA guidance allows that it is not necessary to exclude fish from an Archimedean screw turbine, provided that the screw complies with a guidance matrix based on research evidence, which sets limits on blade tip speed (a function of rotation speed, number of blades, and diameter) and on minimum diameter; and which requires that it is equipped with correctly affixed and maintained compressible rubber bumpers on the leading edges. Because it is not necessary to exclude fish, the screw is equipped only with a debris exclusion screen (of e.g. vertical 25mm round bars or vertical 12mm flat bars) at 100mm spacings.

Larger-diameter screws such as proposed here comply with EA guidance thresholds. Where – as proposed here - larger-diameter screws are implemented with steel troughs (rather than rough or erodible concrete troughs) and are operated under a variable-speed control system (which keeps all chambers full of water at all times), the risk of damage to fish is logically less likely than in other cases (where smaller quantities of water are injected into screws at higher fixed speeds and/or with more irregular trough surfaces).

Research has been carried out regarding potential damage to fish passing through Archimedean screw turbines. Most of this research has considered salmonid smolts which move downstream through the screw. Potential differences in the implementation of different screws, such as those above, may help to explain the variation in the low incidence of scale loss which is attested in some research on live smolts passing through screw turbines. The system proposed for this site adopts all the above known measures to minimise this impact while still permitting that smolts may pass through the screw. This remains in keeping with EA national licensing practice at the present time.

The proposed proportional-take flow regime is designed such that the hydropower intake will never admit more than a minority of river flow and will therefore not be predominantly attractive as the downstream route. This represents the best available mitigation which the flow regime can be made to provide while still accommodating a hydropower scheme.

Fish taking the leat route and passing through the screw will thus avoid the risk of swimming through shallow flows on the face of a weir with an increased risk of stranding and predation, and any risk of physical damage from passing the weir itself.

Seasonal suspension of operations is not normally proposed in assessing screw schemes, and it is unlikely that this would be a viable option for this scheme, as it has proposed a conservative flow regime which is already very conservative. Seasonal screening may also prove difficult to agree in this location.

If regulators in this case depart from established EA regulatory precedent and are able in this case to cite compelling reasons why they must instead propose an unusual condition which permanently excludes smolts from the intake, then regulators will present specifications of evidence required to demonstrate that the scheme as proposed poses no unacceptable risk. Any such further evidence may form a condition on a licence or planning consent. Typically, where there is such residual concern, there is regulatory precedent for a suspended condition to require retrospective exclusion screening in the event of future developments emerging from monitoring, wider research, or in forthcoming changes to regulation or legislation.

Upstream fish passage

There is currently no fish pass at the site, only a rudimentary easement on the face of the main weir. The weir therefore represents a semi-passable barrier to fish. There is an opportunity to improve fish passage when building the hydro scheme which would result in an improvement to the existing situation. The Fisheries Impact Assessment makes a proportionate recommendation for improving the easement with a pass of Larinier baffles. Planning this work to take place alongside installation of the hydropower scheme provides the only likely near-future opportunity and budget for such an improvement at this site. Doing so will benefit salmon transiting to the upstream Dart catchment and Dartmoor SAC. The detailed design of the fish and eel passage measures have been submitted to the EA National Fish Pass Panel for approval prior to construction.

The Fisheries Impact Assessment identifies the benefit of installing such a fish pass, and also concludes that no adverse impact will be caused by the installation of the hydropower scheme. The proposed proportional-take flow regime causes no reduction in weir flow or main channel flow in conditions below Q95, at which the fish pass will be passable to migrating salmonids and eels, and all other parts of the depleted reach are passable in general. At flows above Q95, the proposed regime marginally reduces flows in the depleted reach, which assessment indicated was unlikely to cause detriment to passage. Specifically this also marginally reduces flow in the fish pass, delaying the onset of overcharging, making it less challenging to ascend for those fish which attempt this, especially in higher flows. At pre-app, EA Fisheries suggested that there could be merit in additionally restricting abstraction at flows above Q95. While this would disproportionately affect viability of the hydro scheme, it would not accurately target the key conditions for salmon migration at Staverton. Having analysed 2017 data on fish migration versus flow in the lower Dart, a report is submitted entitled Staverton Fish Migration Flows which demonstrates that the proposed regime and new fish pass together give a better solution to migration past the obstruction at Staverton.

Conversely, EA Fisheries have favoured not attracting fish into the leat. It is unlikely that a new fish pass co-located at the turbine would be agreed acceptable at this site, as it would bring upstream migrants out of the designated main natural channel and instead into the leat. The proposed scheme therefore prevents fish entering the leat, retaining them in the preferred habitat of the main channel. With no pass near the turbine, a deep pool at the discharge will be provided so that screw discharge flow loses its velocity sufficiently that it

does not predominate as at attraction to fish. The proposed flow regime will permanently provide significant attraction in the adjacent onward river channel.

Consultation by the project clients with the EA, local fisheries groups and the local parish council has yielded support for the proposals, and the local community stakeholders look forward to the benefits the hydropower scheme will bring.

Habitat

Fish habitat quality impacts are anticipated to be low. Changes to oxygenation or temperature are negligible. The proposed flow regime deducts only an agreed proportion from medium flows, maintaining an occurrence of relative peaks, and not modifying spate events which move vegetation and bedload and which thus refresh bed habitats. Limited modification of the flow regime to an extent which does not greatly reduce natural variation likewise minimises the potential for impacts on channel depths, widths and form. If this flow regime is agreed it will not significantly impact habitat in terms of passage, residence or spawning. Sediment release from the construction works is minimised by working within the cofferdam and filtering all pumped water back to the river.

Timing of works

The EA prefers that works within the river should if possible be carried out outside of the main migratory period for relevant fish populations. Construction works will take place within dewatered cofferdams and/or behind a closed sluice. The EA is invited to indicate any ecological “best season” to minimise river impacts in the Dart, so contractors can consider how works might be scheduled around this.

Trees

A tree report has been carried out and is submitted. This considers tree protection and the cable route, as the footprint of the main works does not contain or require removal of trees. Some smaller self-set trees may need to be removed from the leat walls when conducting stabilisation works and during periodic maintenance. The program will be monitored by the ecologist in case prior checking for nesting birds or for signs of use by otters is required.

Noise

Noise is generated in the turbine housing due to the rotation of the gearbox and generator. This noise is similar to other rotating machinery such as motors or fans. A generator such as is to be used here has a noise rating of 69dB. Housing the equipment within an

enclosure dramatically reduces the external noise, and to keep any impact to a minimum, it is recommended that the gearbox and generator are covered with such a sound-proofed structure. Lesser noise arises from the electronic components of the control system, which in any case must be housed within a weatherproof shed or outbuilding. Studies of noise impact for similar schemes in close proximity to residences have revealed no concerns.

Noise monitoring and assessment was carried out for this project and has been submitted for planning permission. This concluded that the proposed scheme as designed will not cause significant noise at nearest receptors.

Recreation and amenity

Third-party recreational or amenity interests are affected only insofar as the development will reduce river flow, within that reach of the river only, during some parts of the flow regime as described.

Dart Angling Association has been made aware of the proposal. Any impact on angling will be restricted only to the redistribution of medium flows between main channel and the leat, subject to the licensing requirements.

The proposal will have no impact on access to the river, moorings, slipways, navigation rights or canoeing. The proposed changes to in-river structures do not pose any negative impact on amenity uses. Riverbank rights-of-way will where necessary be diverted during construction and reopened afterwards.

The top end of the screw is screened against debris and ingress. The discharge point is in deep water. As is typical for Archimedean screw hydropower schemes, the discharge is not screened against ingress: when the screw is operating, the release of large volumes of water repels swimmers or canoeists from the immediate vicinity of the screw.

Potential environmental risks in construction

Ecological risk from pollution of the watercourse is managed by precautions during works. The following risk factors have been identified and clear prevention and mitigation measures are contained in the project construction method statement.

- Fuel/Oil Spillage resulting in soil contamination
- Fuel/Oil Spillage resulting in contamination of water course

- Contamination of watercourse with cementitious material
- Contamination of watercourse with chemicals
- Contamination of watercourse with sediments due to run off from excavations

These risks are familiar to construction contractors using construction materials and manual or mechanical plant in rivers. Clear prevention and mitigation measures compliant with EA guidance are put forward in a project outline Construction Method Statement (CMS) which will be the model for Method Statements (MSs) required from contractors.

Works in the river will if possible be scheduled in the appropriate season to minimise river impacts. The EA is invited to advise when the preferred period is considered to fall here. During works, water flow through the works will be excluded by piled or bagged cofferdamming below, and by closing off the intake above, removing connection to the watercourse. Where oils are required for operation, PANOLIN environmentally low-impact products are used.