

FISH BARRIER ASSESSMENT OF FAIR-A-FAR MILL AND DOWIES MILL WEIRS, RIVER ALMOND

Kjersti Birkeland & Alistair Duguid

13th July 2015

1. Summary

An assessment of the passability or otherwise of Fair-a-far Mill and Dowies Mill weirs was carried out by SEPA fish ecology using the WFD111 barrier porosity assessment methodology¹. This considered all of the migratory fish species potentially present, i.e. salmon, sea-trout, eel and lampreys. The main aim of this assessment was to clarify the degree to which these two lower catchment weirs impact on fish movement, to update their classification and to help inform what type of action, if any, is required to mitigate any problems they may be causing to fish movements. The survey was conducted on 30th June 2015 during normal summer flows.

Main findings, Fair-a-far Mill

- The weir face is classified as impassable to all species, so only the fish pass was assessed using the full survey methodology;
- The fish pass was classified as **impassable** to lamprey species due to vertical drops and high water velocity. It is likely to remain impassable at higher flows;
- The fish pass was classified as a **high impact barrier** for eels, as climbing substrate was rare. It is likely to remain a problem at higher flows;
- The fish pass was classified as a **high impact barrier** for sea trout and salmon due to insufficient water depth in the upper part of the fish pass. Water velocity and turbulence is also likely to be problematic. The fish pass is expected to remain a high impact barrier, or possibly become completely impassable at higher flows;
- The assessment suggests that the weir and fish pass can be considered as having a **high impact** on fish migration and should therefore be regarded as impassable in terms of WFD classification.

Main findings Dowies Mill

- Three potential sections were identified at Dowies Mill, and all were surveyed using the full methodology.
- The section up the left bank was considered **impassable** to all migratory species under the conditions during the survey due to insufficient water depth up the sloping weir face. It is likely to remain impassable under medium and high flows, mainly due to shallow water at the weir toe.
- The middle section, which carries most of the river flow, requires a vertical leap up the weir face. It was classified as a **high impact barrier** for salmon, sea trout and

¹ SNIFFER (2010). *WFD111: Coarse resolution rapid-assessment methodology to assess obstacles to fish migration*. Available at <http://www.sniffer.org.uk/knowledge-hubs/resilient-catchments/water-framework-directive-and-uktag-co-ordination/fish-obstacles-porosity/>

eels, and impassable for lamprey. This is mainly because of the vertical height of the weir, and the relatively shallow water below which would hamper leaping. The vertical height would be expected to decrease during higher flows and permit migration. Lack of water depth at the toe of the weir is likely to remain a limiting feature however, due to the presence of large armour rocks, so the obstacle is expected to remain a high impact barrier. Moving these rocks to provide a pool below the weir would be expected to ease the barrier for adult salmonids during elevated flows and should be considered further.

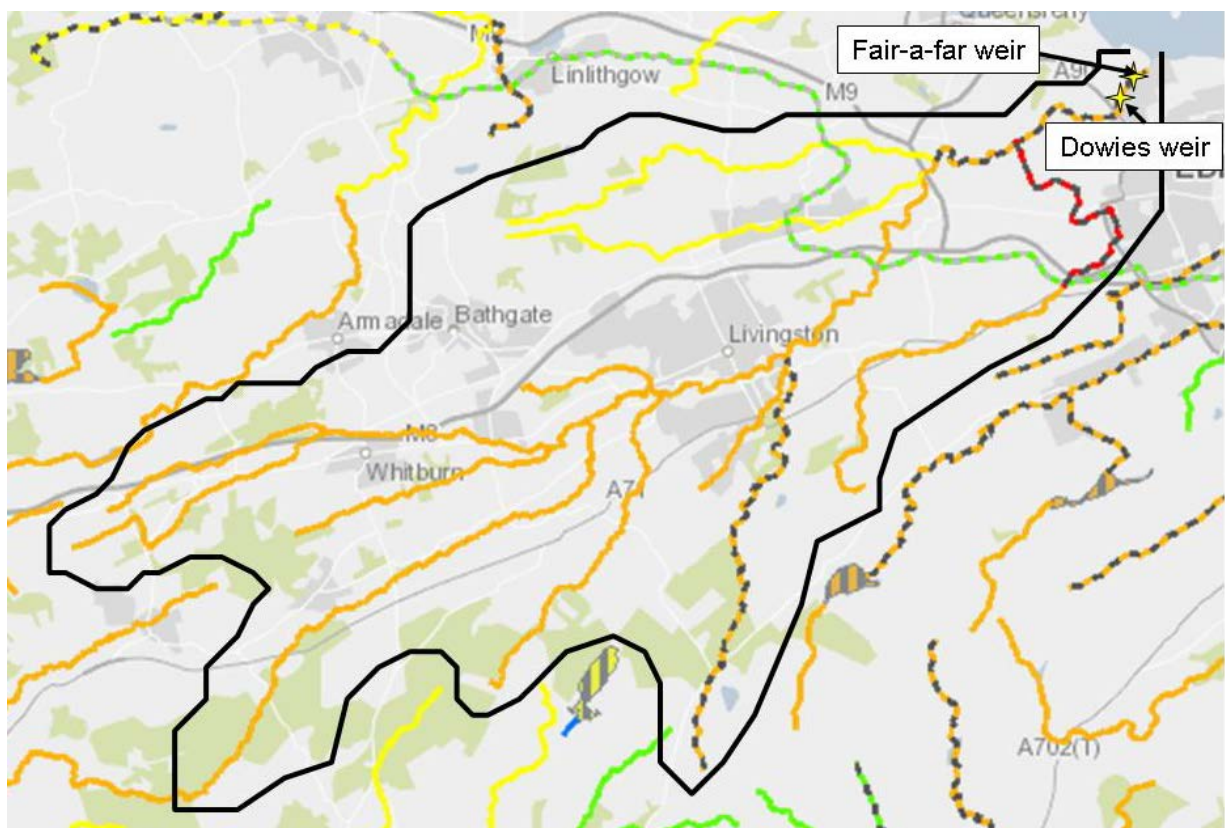
- The existing fish pass was classified as a **high impact barrier** because of excessive turbulence. This is likely to become considerably worse during higher flows, as the small pools in the pass will struggle to dissipate power sufficiently. Turbulence would be improved if flows into the fish pass were reduced to match the size of the pools in the pass pool size, although this may make the entrance too difficult for fish to find.
- The weir is in a noticeably poor state of repair, and would appear likely to further degrade in the future. This is likely to alter passability for fish in unpredictable ways, and could be a risk to the long term success of future improvement works unless it is stabilised.
- The assessment suggests that the weir and fish pass can be considered as having a **high impact** on fish migration and should therefore be regarded as impassable in terms of WFD classification.

2. Introduction

Background

Fish migration in the River Almond is currently compromised due to a number of weirs restricting upstream fish migration. This has caused 12 of the 20 Almond catchment waterbodies to be classified as less than good under the Water Framework Directive (WFD). A catchment wide project is therefore underway to ease the barriers currently causing these downgrades.

Figure 1. A map showing the location of Fair a Far and Dowies weirs in relation to the River Almond catchment, which is outlined in black. The presence of the two weirs at such a critical location close to the river mouth should be noted. The main river and major tributaries are shown, with colours representing their classification under the Water Framework Directive. The effect of impassable weirs means that the majority of these are classified as “Poor” and coloured orange.



These two lower catchment weirs (Fair A Far and Dowies), were not considered entirely impassable to fish but given their location and the sensitivities around action at the weirs more certainty was sought by way of the WFD111 assessment. Individually, these weirs are each currently considered partially passable since salmon have occasionally been recorded upstream of them, despite SEPA's view that they contribute to a cumulative impact on migration by 7 weirs along the Almond. This is based on the presence of a small numbers of juvenile salmon caught in a very restricted range of sites in some, but not all, electric fishing surveys of the catchment during the past 11 years². This is important to

² Atkins. 2011. Assessment of Restoration Options, River Almond. March 2011;
SEPA data, 2009;
Forth Fishery Foundation data, 2002;
Napier University data, 2009, 2010;

note, because the WFD does make an allowance for the inclusion of obstacles which are having a major impact, even if they are not complete barriers to migration.

Prior to this survey, neither barrier had been assessed using the recently developed WFD111 barrier assessment tool. This tool provides a potential method to objectively assess barrier porosity to fish for the WFD. It can also provide information on the key factors at a barrier which are causing an issue for migrating fish of different species³.

It was considered important to reassess the existing classification of the barriers based on current methodologies, since SEPA may take action where a partially passable barrier is having a high impact on fish passage i.e. is likely to prevent a significant proportion of fish from successfully passing up or downstream. To this end, there are specific provisions in the WFD barrier classification method to consider an obstacle that is partly passable to be causing a downgrade if it is considered to “severely impair” fish movements. A “severe impairment” is considered to be blocking more than 80% of fish that would otherwise be able to migrate had the barrier not been present. The classification method also specifically states that a barrier which is defined as “High Impact” by a WFD111 survey may also be considered to meet the definition of severe impairment for WFD classification⁴.

3. Aims

The aims of this survey were to carry out WFD111 barrier assessment on Fair-a-far Mill and Dowies Mill weirs, to determine the extent to which these two weirs are affecting movements of the main migratory fish species potentially present.

4. Methodology

The survey was carried out on the 30th of June 2015 by SEPA fish ecologists, using the WFD111 methodology. The river was running at normal summer level, and discharge at the time of survey was gauged at the nearby SEPA station at Almondell at approximately a Q₈₀ flow.

The WFD111 barrier porosity assessment has been designed to provide a procedure for assessing at a coarse level the likely passability of a potential fish barrier to key migratory fish species. Field measurements of physical parameters such as barrier length, height, water depth and water velocity, combined with a subjective expert assessment of barrier porosity for target species and life history stage(s), are used to assess passability of natural and artificial barriers.

Based on the assessments carried out, a passability score is generated for each fish species and life stage assessed. It is considered that the barrier will have a severe impact on fish populations when the WFD111 assessment results in the barrier being classified as either “impassable” (passability score 0) or “passable high impact” (passability score 0.3).

Forth Fishery Trust data, 2001, 2014.

³ SNIFFER (2010). Op cit.

⁴ UKTAG (2015). Barriers to fish migration (Scotland). Available at <http://www.wfduk.org/resources/barrier-fish-migration-scotland>

5. Results

5.1 Fair-a-far Mill weir

Fair-a-far weir is located approximately 400m upstream of the normal tidal limit (NT 1840 7643) and is the first major barrier encountered by fish as they ascend the River Almond. The weir is approximately 30 metres wide with an estimated vertical drop of approximately 3.5 metres. The water-depth at the base of the weir was shallow (<1m) and the weir was therefore considered to be entirely impassable to all upstream migrating fish (WFD111).

There is a fish pass structure situated at the left bank (looking downstream) of the weir. The entrance is at right angles to the main flow, in a back eddy some 14 metres downstream from the weir face. There seems to be little attraction flow to the fish pass entrance and even during the relatively low flow conditions prevailing during the site visit it would be expected that fish would be attracted to the impassable weir face instead of the fish pass. At best this will delay the time it will take for fish to find the fish pass entrance, but it may result in some fish completely failing to find the fish pass.

Figure 2: General view of Fair-a-far weir showing the weir height, and fish pass on the far bank. Note the lack of a clear attraction flow towards the fish pass entrance, and the leap needed to enter the first pool.



As the fish pass is the only feasible migration route for fish ascending the river, a WFD111 assessment was only carried out on this section. The fish pass is a pool and traverse design with two large pools at the downstream end and a series of four baulks further upstream. Any fish wanting to use the fish pass will have to undertake three vertical jumps,

the largest of which is at the fish pass entrance and is 80cm high. There are also two sloping areas, each of which, although separated by baulks, represents a challenging swim section.

Physical measurements of the fish pass, including hydraulic height of vertical drops, slope, water depth and velocity was carried out along the length of the fish pass to assess likely passability of the fish pass to key fish species. The key dimensions are given in Figure 3, while Figures 4 and 5 show annotated photos of the key sections of the fish pass.

Figure 3. Rough plan of the Fair-a-far fish pass. This is not drawn to scale, but key dimensions are shown. Vertical drops requiring fish to leap are shown with arrows. Water depth is given at spot locations in orange boxes. Note the lack of suitable depth in the uppermost section of the pass, which is also shown clearly in the photograph in Figure 5.

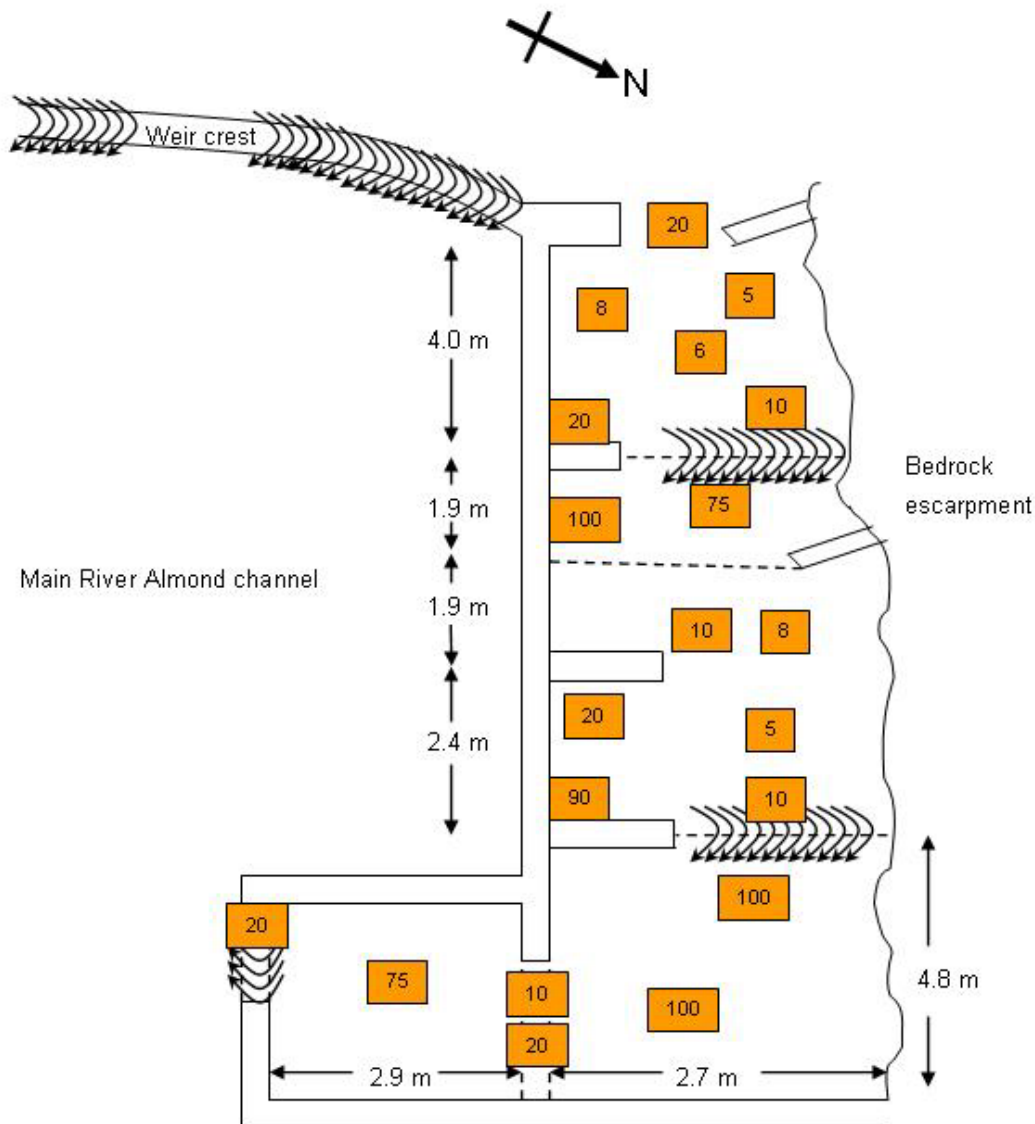


Figure 4: The upper part of the fish pass at Fair-a-far. The challenges presented by different sections are indicated.

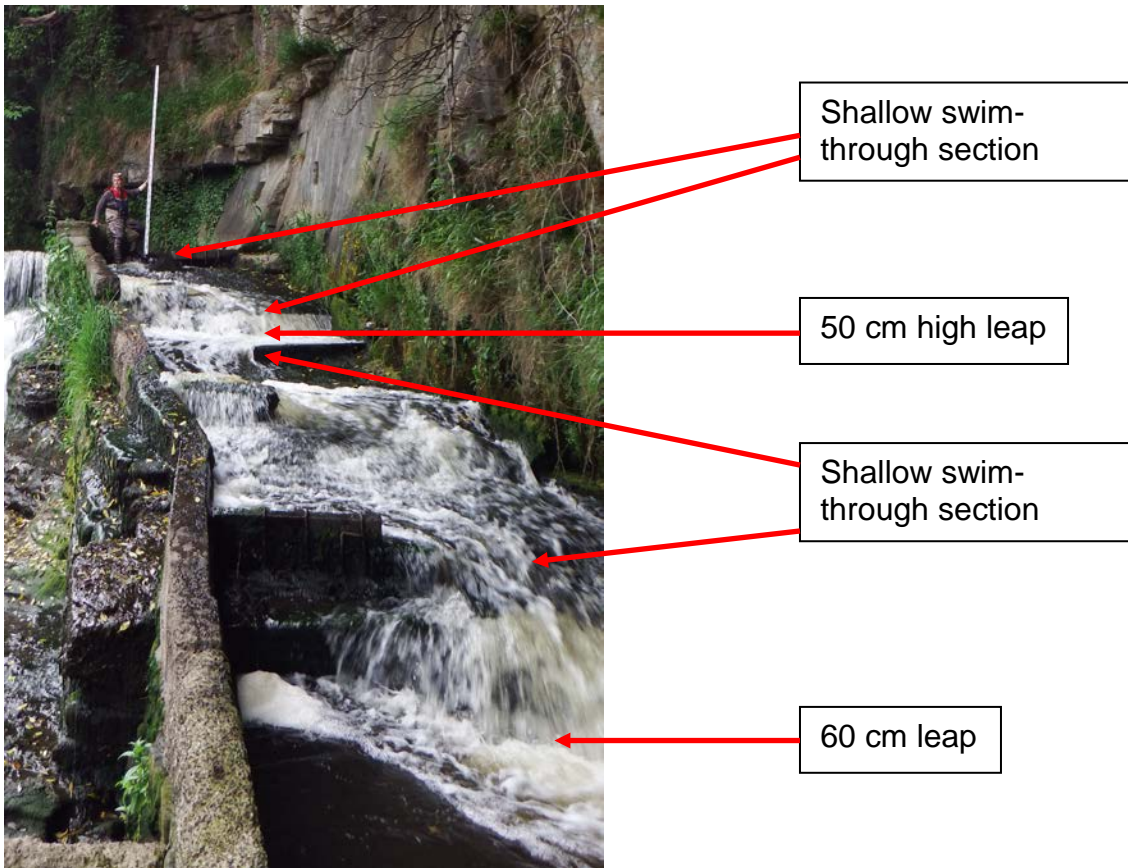
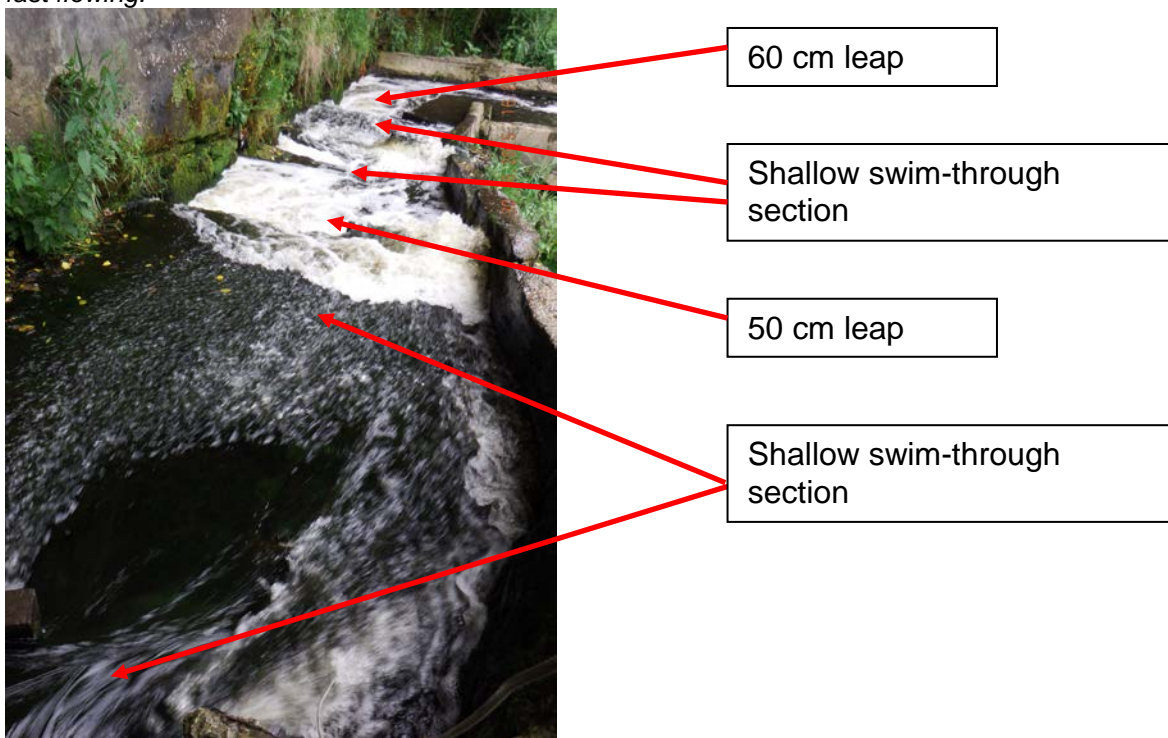


Figure 5: The upper part of the fish pass at Fair-a-far, viewed from the upstream end. Challenging sections are indicated, as in Plate 2. Note particularly the upper swim through section, which is extremely shallow and fast flowing.



Swim-through sections

Shallow water depths and high velocities were recorded through the sloping section of the fish pass making these sections of the fish pass a major issue (Table 1). Water levels recorded on the day were moderately low (approximately Q80) and the maximum water depth recorded through the sloping section was 10cm, but in places the water depth was as low as 5 cm, and was commonly around 8 cm. These values are at the minimum limit required for a salmon to swim effectively, and result in a high impact barrier score to salmon and sea trout.

The water velocities observed throughout most of the fish pass would be expected to be manageable for salmon and trout, although they would be challenging in the upper section, where speeds approached 2.5 m/s. This is on the boundary between Low and High Impact barrier, and within the value of 3m/s used to define a passable obstacle for salmon and sea trout (Table 1).

The turbulence in the fish pass was also relatively high, despite the survey being carried out when flows in the river were low. This turbulence also results in an assessment of High Impact (Table 1). As water velocities and turbulence are likely to increase with increasing river discharge it is considered this will become a limiting factor to upstream migration during higher flows.

Vertical leap

The highest vertical drop recorded in the fish pass was at the fish pass entrance, measured at 80cm (Table 1). The pool depth below the entrance was 50cm, i.e. 0.63% of the drop. These measurements represent a low impact obstacle for salmon but a high impact barrier to trout and an impassable obstacle for lamprey.

Eels

Eels behave quite differently to other migratory species, and have a different mode of ascending obstacles, using climbing substrate like moss, rather than swimming or leaping. The WFD111 methodology requires a subjective assessment to be made of the overall presence of routes with suitable rough surfaces for climbing, and an absence of vertical drops requiring a leap to be made. Given the presence of vertical drops into the fish pass, and the rarity of suitable climbing substrate around the weir, Fair-a-far weir is expected to act as a significant, high impact, obstruction to eels as well.

Table 1: Overall passability of the Fair-a-far weir fish pass. The first row gives the survey result for each type of measurement, and the individual cell values explain what this represents for each species from the WFD 111 method.

	Slope =20%	Max hydraulic head = 0.8m	Minimum water depth through swim section = 0.08m	Max Velocity = 2.47m/sec	Turbulence = HIGH	Overall passability assesment
Salmon	Low Impact barrier (0.6)	Low Impact barrier (0.6)	High Impact barrier (0.3)	Low Impact barrier (0.6)	High Impact barrier (0.3)	High Impact barrier (0.3)
Adult trout	Low Impact barrier (0.6)	High Impact barrier (0.3)	Low Impact barrier (0.6)	Low Impact barrier (0.6)	High Impact barrier (0.3)	High Impact barrier (0.3)
Adult lamprey	Impassable	Impassable	Low Impact barrier (0.6)	Impassable	Complete barrier (0.0)	Complete barrier (0.0)
Juvenile eel	Vertical drops and high turbulence considered too high for juvenile eels. However some limited climbing substrate was available					High Impact barrier (0.3)

Summary

Based on the WFD survey carried out during prevailing flow conditions the fish pass is considered suboptimal to upstream salmon and trout migration and should, at best, be considered a **high impact barrier** for salmon, trout and eel and impassable to lamprey (Table 1). It is considered the fish pass may become impassable during lower flows due to lack of adequate water depth through the sloping section of the fish pass; depth was borderline passable on the day of the survey. Under high flows the fish pass is likely to become impassable to all species due to high turbulence and water velocity.

The current issues with insufficient depth, excessive turbulence and possible high flow velocity would be best solved by modifications to the fish pass. It is doubtful that small scale works to repair or upgrade the existing baffles will be sufficient given the gradient and length of the channel. The site would seem to lend itself to the use of a technical baffled pass however, either a bottom baffled, Larinier type, or, if that can not be fitted into the available space, then an Alaskan type side baffled pass. A double-flight pass may be needed given the length involved, and the existing large deep pool halfway up the fish pass could be used as an effective resting area between flights. If the lowermost flight were to double back towards the weir toe, this would appear likely to improve attraction to the fish pass entrance, as it would be discharging into the main weir pool, as well as reducing the height of the vertical leap required to enter the fish pass.

5.2 Dowies Mill weir

Dowies Mill weir is located approximately 1 km upstream from Fair-a-far Mill weir (NT 1792 7566). The weir is a broad, gently curving structure with a total width of approximately 50 m and a head difference across the structure of approximately 1.5m. The weir is in a poor state of repair and is severely undercut in places. Sections of the concrete weir apron have been broken off so water is now seeping in to the stonework underneath the concrete. The channel immediately downstream of the structure is characterised by large boulders, most of which appear to have come from the collapsed sections of the weir, or have been brought into the site recently to help stabilise the weir.

The main attraction flow for salmonid fish is to the right side of the channel, where there is a potential migration route through the large stone blocks below the weir, leading into turbulent water immediately below the weir face. There is also a fish pass structure on the far right of the channel which is a notch type pool-and-traverse design.

On the day of the survey hardly any water was running over the weir at the left side of the channel, although it is possible that this may become a migration route in higher flows. Consequently it was decided to carry out a WFD111 barrier assessment of each of the three potential migration routes identified, i.e. fish pass, right and left channel.

Fish pass assessment:

The fish pass structure is a pool and traverse structure with two sections where a leap will be required, the highest of these is 0.6m high. Depth measurements on the fish pass showed water depths were generally sufficient to provide resting space for salmonids and there was adequate depth (50-70cm) below the vertical drops to allow the required leaps to be carried out. Water velocities through the fish pass were moderately high, ranging from 0.29 to 1.89m/sec but are not expected to pose a significant problem for upstream migrating salmon and trout during low to medium flows. Extremely high turbulence was observed in the upper parts of the fish pass however, as a result of the small dimensions of the individual fish pass pools. It is likely the high turbulence will reduce migration success through the fish pass, and resulting in an assessment of High Impact barrier. The levels of turbulence will become worse during higher flows as power increases, and it is possible that the fish pass will become entirely impassable during flow rises when the majority of fish are likely to be attempting to migrate.

Table 2: Overall passability assessment Dowies Mill fish pass

	Min hydraulic head = 0.6m	Pool depth = 0.5m	Max Velocity = 1.89m/sec	Turbulence HIGH	Overall passability assessment
Salmon	No barrier (1.0)	Low impact barrier (0.6)	No barrier (1.0)	High impact barrier (0.3)	High impact barrier (0.3)
Adult trout	Low impact barrier (0.6)	Low impact barrier (0.6)	No barrier (1.0)	High impact barrier (0.3)	High impact barrier (0.3)
Adult lamprey	Complete barrier (0.0)	-	Complete barrier (0.0)	Complete barrier (0.0)	Complete barrier (0.0)
Juvenile eel	No wetted substrate at day of survey		Complete barrier (0.0)	Complete barrier (0.0)	Complete barrier (0.0)

The fish pass is also partially blocked by debris from the collapsing weir, which has also trapped large woody debris in the channel. Although this would appear to not cause a significant problem at present it may dissuade some fish from entering the main fish pass. As it is also likely to continue to trap further debris in the future, eventually blocking the fish pass completely, this will require attention, and highlights the need for continual monitoring of a deteriorating weir like this, where sudden changes to the structure are likely and may alter passability for fish in unpredictable ways.

Middle channel assessment:

This channel area contains the best attraction flow for salmonids where water was spilling over a 10m wide section of the weir. Two main migration routes though large boulders below the weir lead into turbulent water immediately below the weir face.

The weir face is near vertical and requires a leap of just over one metre (Table 8). Several “take off” pools of various depths are present below the weir, the deepest of which was 0.5m deep. These are too shallow to allow efficient leaping at the weir face, and, together with the substantial vertical height, suggest that this is a high impact barrier. The vertical height of the weir face is likely to be reduced at higher flows, but the depth in the take off pool is likely to remain an issue, because of the large armour rock boulders placed along the toe of the weir. If these could be safely moved and reconfigured, this would make the weir more passable, particularly if they could be arranged to form a pre-weir, to both increase depth and reduce the vertical height over a wider range of flows.

Table 3: Passability assessment Middle channel

	Min hydraulic head = 1.05m	Pool depth = 0.5m	Max Velocity = 1.02m/s	Turbulence = High	Overall passability assessment
Salmon	High impact barrier (0.3)	High impact barrier (0.3)	No barrier (1.0)	High impact barrier (0.3)	High impact barrier (0.3)
Adult trout	Complete barrier (0.0)	High impact barrier (0.3)	No barrier (1.0)	High impact barrier (0.3)	Complete barrier (0.0)
Adult lamprey	Complete barrier (0.0)	-	High impact barrier (0.3)	Complete barrier (0.0)	Complete barrier (0.0)
Juvenile eel	Vertical drops and high turbulence considered too high for juvenile eels. However some limited climbing substrate was available				High impact barrier (0.3)

Left channel assessment:

The weir on this side of the river channel is badly eroded and undercut. Very little water was running over the weir and down the left channel on the day of survey and it is considered this channel will only be used for upstream passage during much higher water flows.

This potential route is complex, and would require a vertical jump onto the weir, followed by a swim up the sloping weir face. These two aspects are surveyed separately in the WFD111 methodology.

The hydraulic head difference from the river bed to the weir face ranged between 0.9m and 1.2m. Water depth at the weir toe was shallow, being a maximum of 30 cm. These figures represent a complete barrier to all species (Table 4).

The slope of the weir face was calculated to be between 14.5 and 18.6% with an effective length (from downstream to upstream) of between 5 and 6 metres. Water depth on the weir face was extremely low, being less than 5 cm in most places. Overall, this part of the weir would be impassable to salmon and trout because of the lack of suitable water depth (see Table 4). It would potentially become passable to salmon and trout at higher flows, if water velocity remains manageable once water depth increases to more than 10 cm.

Table 4: Passability assessment Left channel

	Min hydraulic head = 0.9m	Pool depth = 0.3m	Max Velocity = 1.02m/sec	Turbulence = Low	Slope=18%; effective length =5m	Depth =4cm	Overall passability assesement
Salmon	Low impact barrier (0.6)	Complete barrier (0.0)	No barrier (1.0)	No barrier (1.0)	Low impact barrier (0.6)	Complete barrier (0.0)	Complete barrier (0.0)
Adult trout	High impact barrier (0.3)	Complete barrier (0.0)	No barrier (1.0)	No barrier (1.0)	Low impact barrier (0.6)	Complete barrier (0.0)	Complete barrier (0.0)
Adult lamprey	Complete barrier (0.0)	Complete barrier (0.0)	Complete barrier (0.0)	No barrier (1.0)	High impact barrier (0.3)	High impact barrier (0.0)	Complete barrier (0.0)
Juvenile Eel	Climbing substrate potentially available to left of section, but dry at the time of survey. Likely to become wetted during high flows						Complete barrier (0.0)

Summary

Downies Mill weir is a complex structure, in poor repair. Three potential routes are present, but based on the WFD survey carried out during prevailing flow conditions, these are all considered to severely impair upstream migration of salmon and trout migration. Overall, the weir should be considered a **high impact barrier** for salmon, trout and eel and impassable to lamprey (Table 4). The fish pass section is considered a problem due to excessive turbulence and this is likely to become progressively worse during rising flows. Consideration could be given to reducing flow down the fish pass to reduce this effect, but this would also have the risk of reducing the attraction of fish to the pass entrance.

The middle section is a high impact barrier because of the shallow water at the weir toe, and the vertical height of the weir. This is likely to be improved at higher water flows, although depth and turbulence may still be limiting. If the large boulders at the weir toe can be safely rearranged, then constructing a pre-weir structure could help reduce the impact at this section. The section towards the left bank is completely impassable to all species, and likely to remain so due to insufficient depth at the weir toe. The overhanging and unstable weir edge will also cause difficulties for upstream migrants.