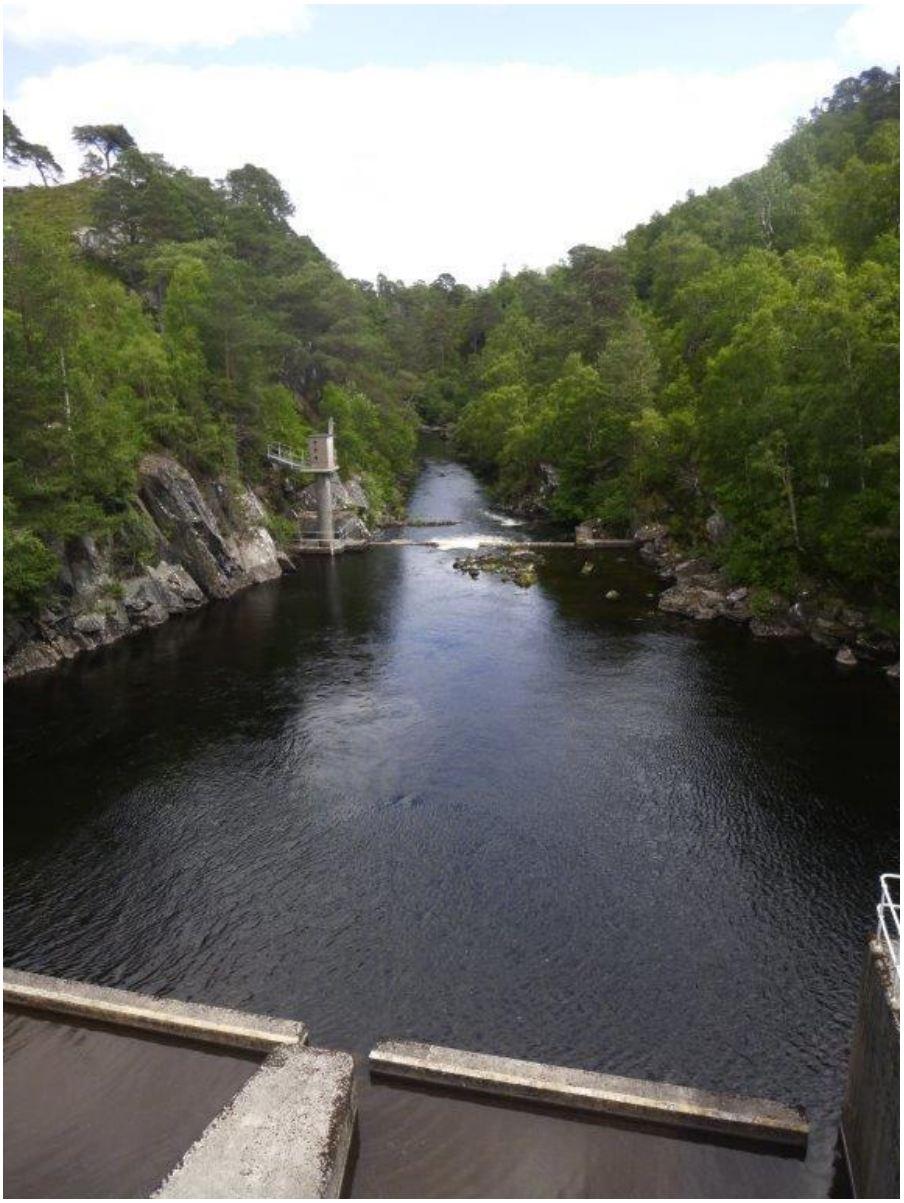
Beauly
Fishery Board

FARRAR HYDROMORPHOLOGY REPORT 2023



Looking downstream from Beannacharan dam, R. Farrar

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1. SUMMARY

The aim of this study was to assess the impact of Beannacharan dam on the substrate and Atlantic salmon spawning habitat on the R. Farrar with a view to informing sediment management.

In summer 2023, walkovers were conducted from the Allt Doire nan Gilean (at the top of the R. Farrar) to the R. Farrar's confluence with the R. Glass.

To further help characterise the impact of hydro on the river, historic photos (pre-dam) have also been reviewed to provide a context for the walkover survey findings.

Assessment of findings show that there is a lack of spawning substrate available to fish below Beannacharan dam, and recommendations for improved sediment management are provided.

2. INTRODUCTION

Hydropower infrastructure is a strong presence in the R. Beauly catchment. The R. Farrar hosts one large hydro dam, Beannacharan dam and two main power stations (Deanie, and Culligran), as well as numerous abstracted tributaries with intakes. This infrastructure has been in place since the late 1950s. See Map 1.

Map 1: SSE infrastructure in the catchment, with the Farrar system highlighted.

Large hydro may impact on natural river processes by influencing the hydrological and sedimentary regimes of the river. This could reduce the availability of salmon spawning habitat through the loss of spawning substrate because hydropower structures impede sediment supply into the river from upstream and managed flow regimes can affect downstream transport of sediment.

The main focus of this report is on assessing the potential impact that Beannacharan dam has on the substrate in the mainstem river Farrar in relation to Atlantic salmon spawning habitat availability, however during the course of the walkovers, it became apparent that the numerous tributaries, abstracted for water were also worth consideration as they are important substrate sources given correct sediment and flow management. **Recommendations for improved sediment management are made at the end of the report**.

No sediment management is currently carried out in relation to Beannacharan dam, although annual maintenance is carried out on the small tributary intakes. This involves intakes being 'turned out' i.e. water and substrate is allowed to pass downstream of the intake. As the Beauly hydro system was one of the last large hydro schemes to be built in Scotland during the 1950s, lessons had been learnt, and a few of the intakes are of a sympathetic design in regard to allowing substrate to pass over them rather than holding up substrate behind them.

In terms of flow regime, this is far from natural with water held up at Loch Monar (large hydro loch at the top of the R. Farrar). The flow regime is typical of many hydroed rivers in Scotland with a relatively stable regulated flow. This includes the U.Misge, the main tributary of the Farrar. This means that there are a lack of extreme flow events currently in place i.e. spate flows (that would normally move substrate about) and low flow events (drought conditions). Freshets from Beannacharan dam (elevated flows to help encourage fish passage at Deanie falls and Beannacharan dam) occur Thursday-Sunday during the fishing season, and in general, river level and flow below Culligran power station is determined by whether there is demand for electricity.

Adult Salmon typically require uncompacted, coarse substrate (a mixture of cobble, pebble and gravel) to spawn, with suitable cold flow (conditions often found at the top of riffles/ tails of pools) and sufficient depth to cover their backs during spawning and enable oxygen delivery to the eggs and alevins in the gravel. Substrate ideally contains minimum fines which could otherwise smother the eggs/ alevins.

3. METHODS

3.1 Walkover surveys

Over ten days between 31 May and 30 June 2023, two surveyors undertook a walkover from the Allt Doire nan Gilean (at the top of the U. Misge, the main tributary of the R. Farrar) to the confluence with the R. Glass to assess the current hydro-morphological conditions along the R. Farrar. Substrate composition and available fish habitat were recorded as well as the presence of tributaries and their contribution to sediment supply.

Where possible, surveyors walked in the channel or on the bank alongside to assess conditions. Where this was not possible (e.g. bedrock gorge sections) data is recorded for as an estimate based on observations above and below the inaccessible sections.

The surveys were undertaken in conditions of good visibility and low to medium flow levels. They were carried out in a downstream direction. Sections were delineated by substantive changes to hydro-morphological conditions as determined by the surveyors; for example, changes in typology, substrate composition or flow type, or the presence of a significant tributary.

A photograph was taken from the top of each section looking downstream. Typology, channel depth, channel width, and surrounding land use were assigned according to the predominant condition observed. Substrate composition of fines, gravel, pebble, cobble, boulder and bedrock were recorded as a percentage of the entire section to total 100%. Where the section was a loch (i.e. too deep to wade in or make an accurate assessment due to vastness), the substrate visible from shore was recorded but has been presented in the substrate graph as 99% fines to make interpretation clearer.

Available salmon habitat for fry, parr, spawning and adults was recorded as a percentage of the entire section based on the Hendry and Cragg-Hine habitat definitions. Fish habitat can fall short of 100% as some in-river areas are not useful for fish or defined under the Hendry and Cragg-Hine habitat definitions (e.g. slack shallow areas not useful for fry, slack areas not deep enough for adult fish or useful for juveniles, and stagnant areas (wetland). Fish habitat can also exceed 100% as spawning habitat can be in areas used by fry, parr and adults.

Hydro indicators were recorded as observations to support the substrate and fish habitat assessments for each section. They were recorded as not present (N), present (P) or extensive (E) and their relative location in the channel (i.e. sub littoral (SL), littoral (L) and mid channel (M)) were noted. The most important of these being whether the substrate was **compacted** (i.e. suitable or not for spawning), if recent **erosion** was present (indicating possible substrate sources), and if **point/ side bars** were present (indicating active deposition and typology). The presence of a trashline was also recorded to indicate if flow heights appeared to vary significantly. Other possible indicators of hydro impacts that were recorded, included: presence of diatoms, algae, fines, moss, lichen, and submerged, emergent and terrestrial plants in the channel. **Tributaries** were recorded as being perched (P) or not perched (NP) and whether they supplied a source of substrate (S) or not (NS). Notes and photographs were taken regarding other points of interest such as presence of fish barriers, visible bank alterations and species observations.

Insights relating to the sources and movement of substrate were recorded. **Walkover Guidance notes** are included in Appendix 6.1 to this report. In addition to the walkover survey, **aerial images** of the study area obtained from GoogleEarth were consulted briefly to ascertain the presence or absence of alluvial fans representing sediment in the lochs, these are contained in Appendix 6.2.

3.2 Historic photo comparison

To help provide context for the survey findings and help to build a picture of the processes at work on the R. Farrar historic photographs dating to before Beannacharan dam was installed were obtained from Culligran estate, Struy estate, and local resident (and old postcard collector in Cannich) Richard Wood to enable a visual comparison of past river substrate and form with present day.

A visit to the site of photo 3) in the review occurred on 15 May 2022 with the main site visit occurring on 16 February 2023 with the Struy and Culligran estate owners. They have an intimate knowledge of the river, and this enabled present-day comparison photos to be taken.

4. RESULTS AND FINDINGS

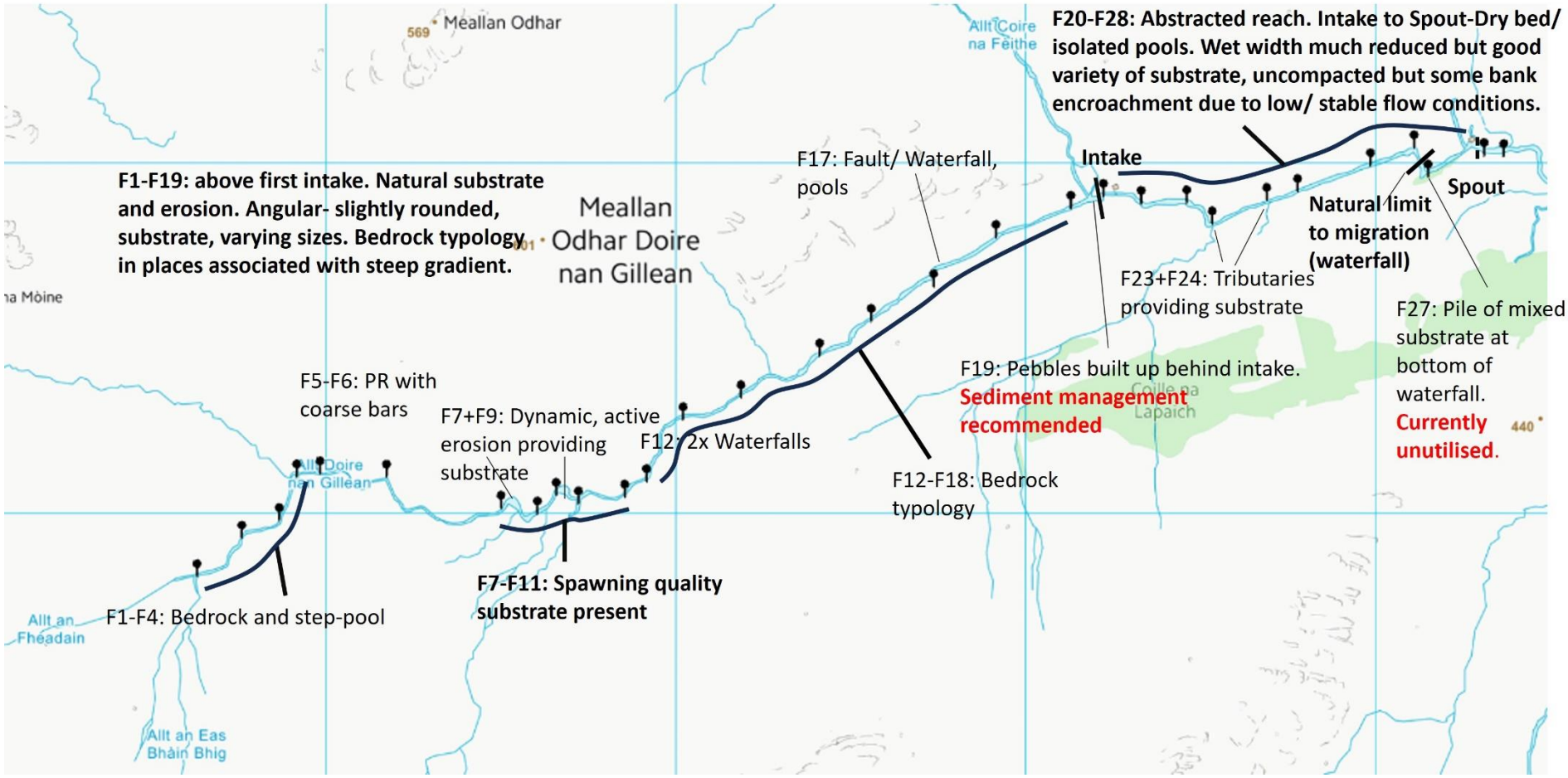
The annotated maps are presented first, followed by the substrate, fish habitat, and finally the historic photo review.

The full walkover results and all photos taken during the walkovers can be found here.

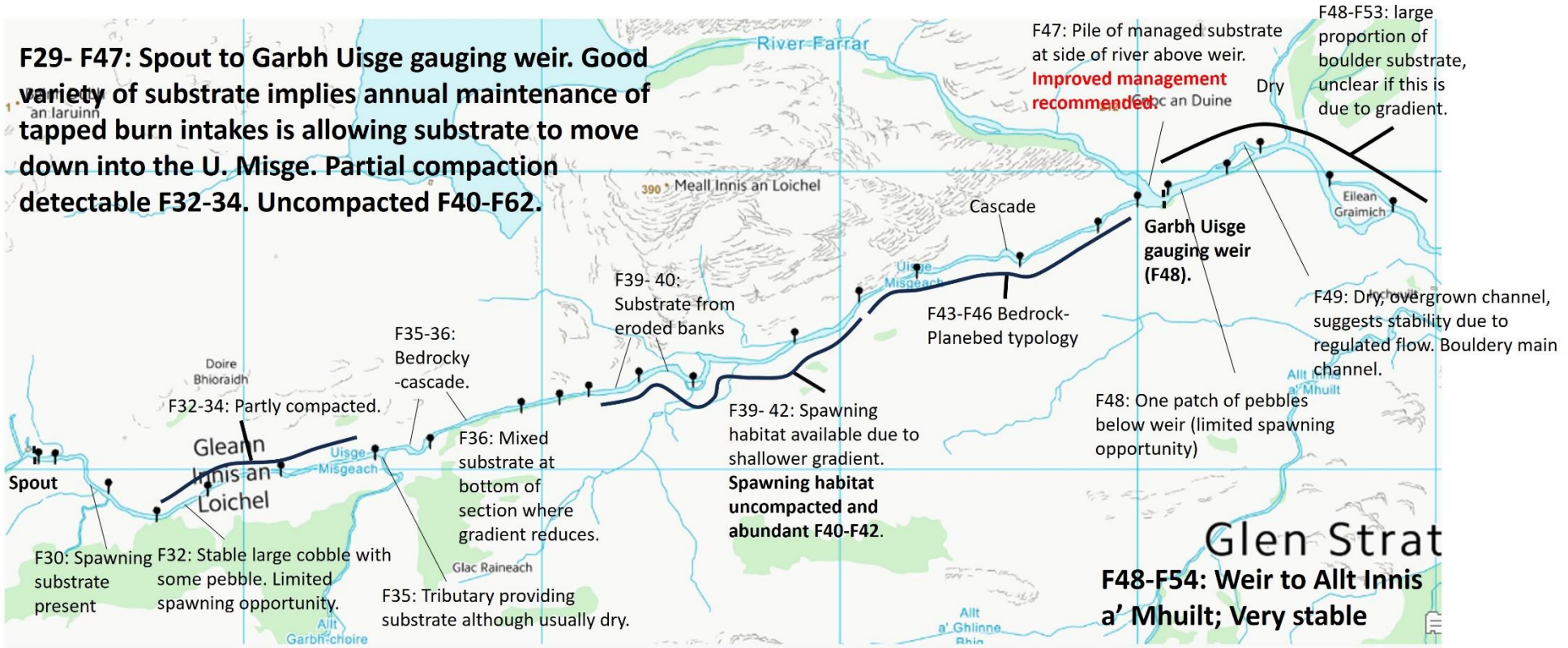
4.1 Annotated maps

Below are the maps summarising the main findings of the walkover surveys for all sections (F1-F127).

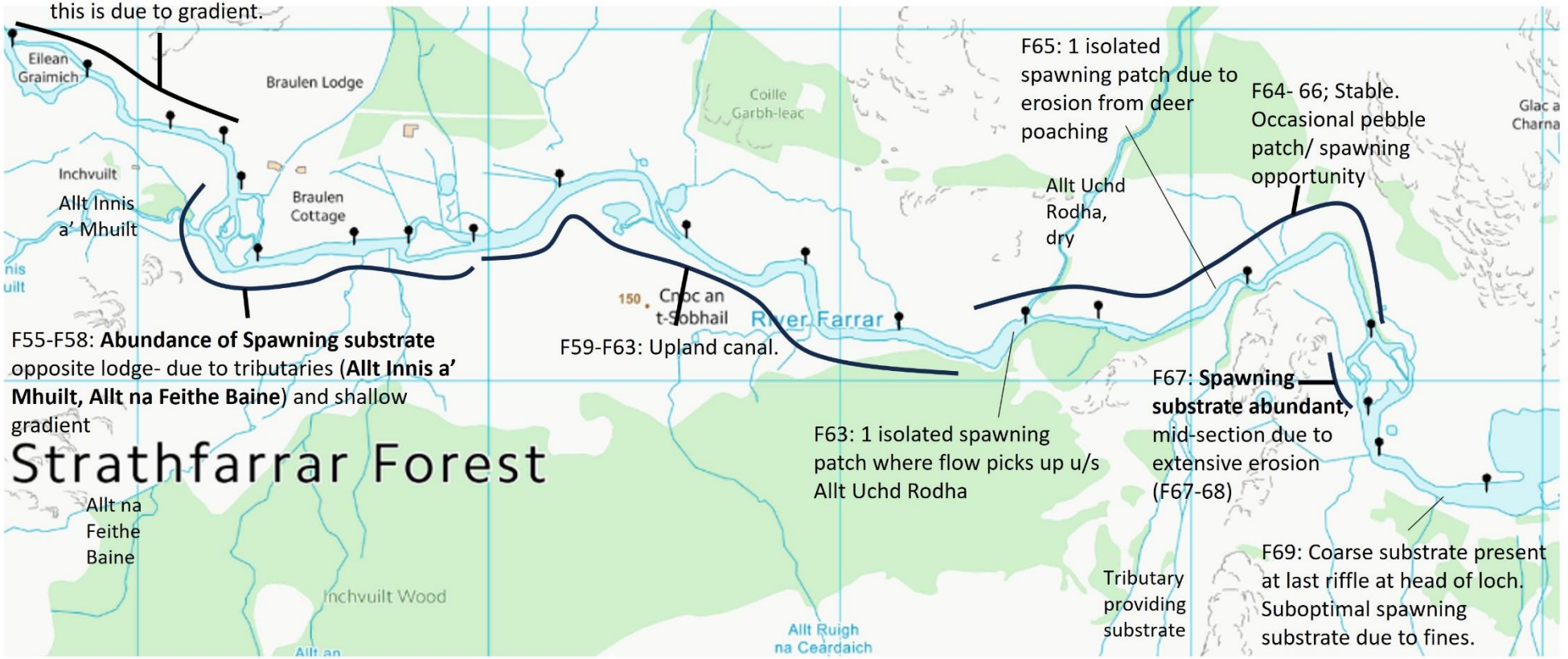
Map 2: Allt Doire nan Gilean to the Spout



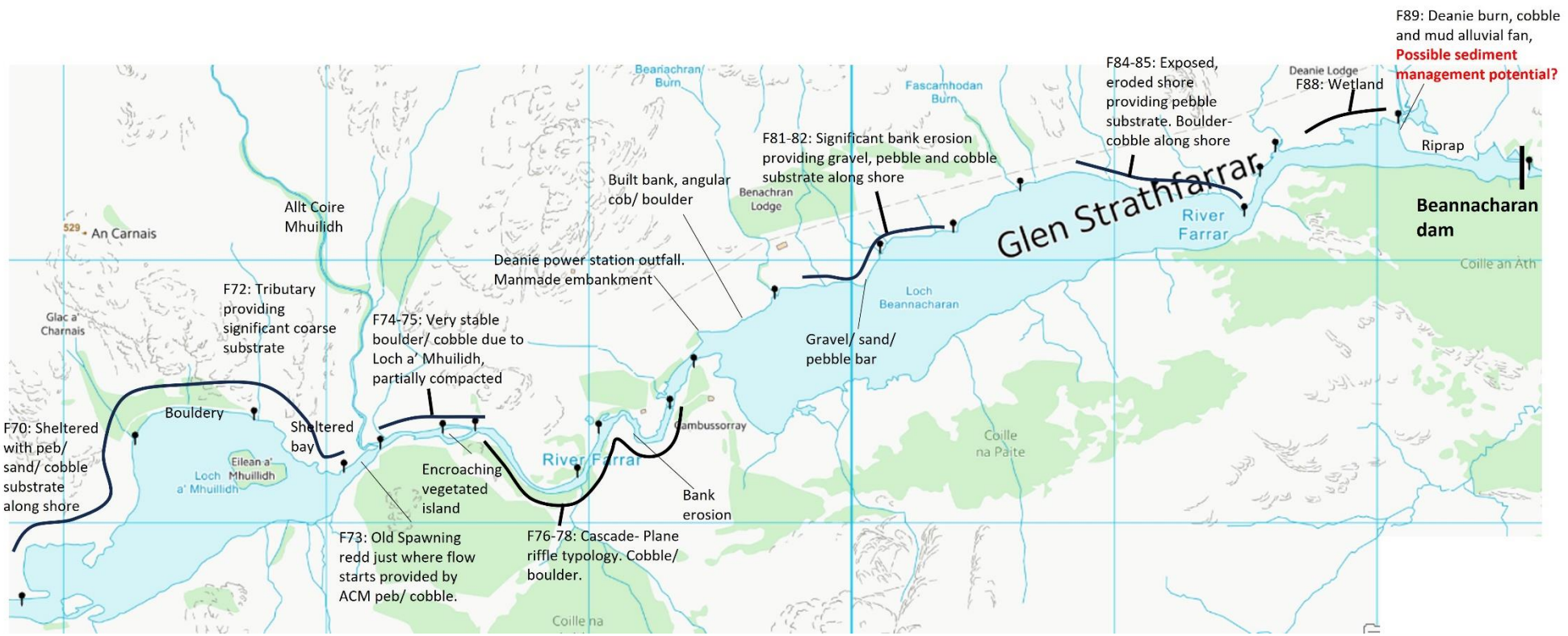
Map 3: Spout to Farrar weir



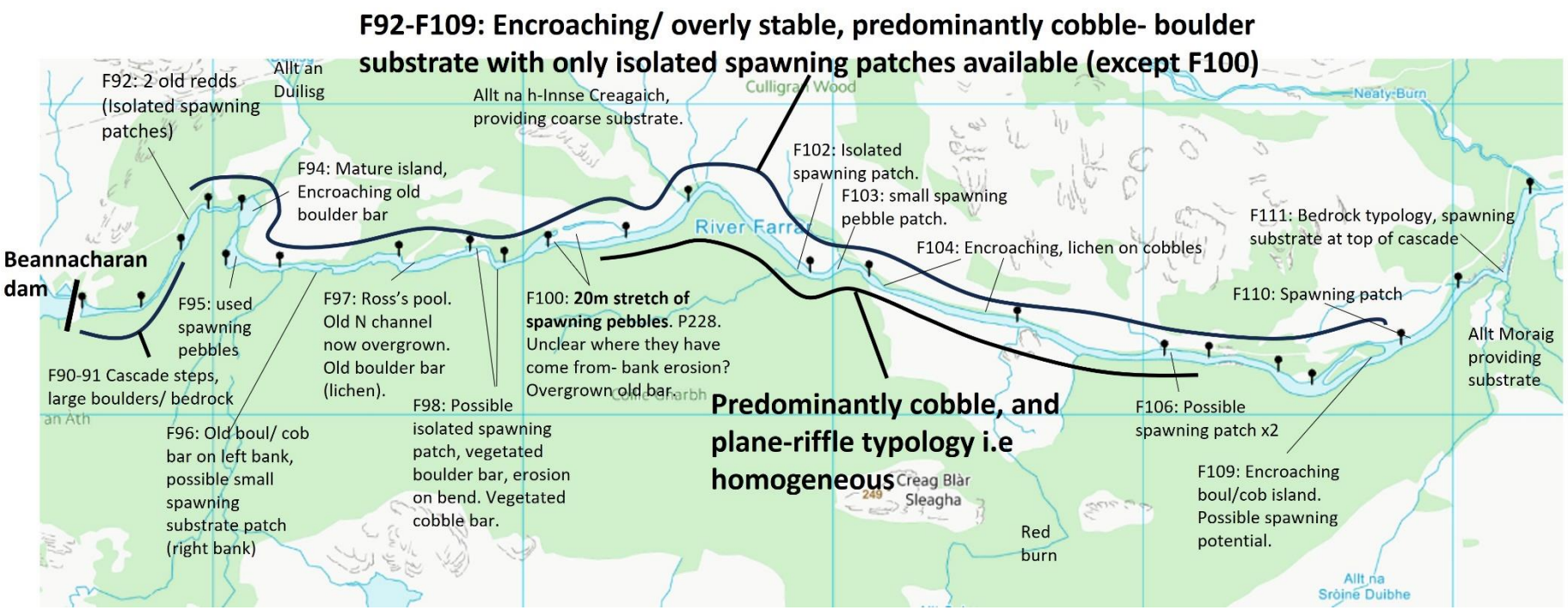
Map 4: Allt Innis a' Mhuilt to Loch a' Mhuilldh



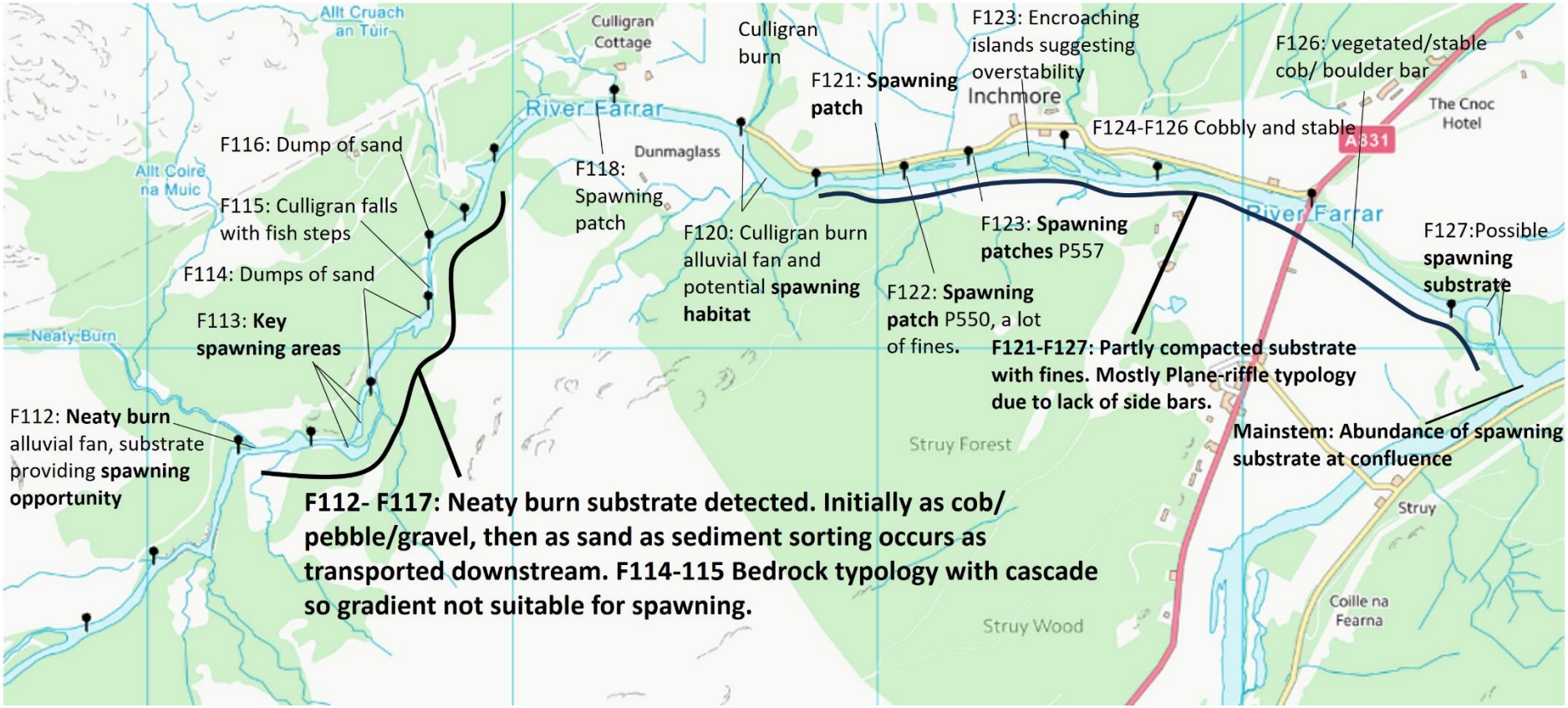
Map 5: Locha Mhuillidh to Beannacharan dam



Map 6: Beannacharan dam to Neaty burn



Map 7: Neaty burn to confluence with R. Glass



The main points to take away pertinent to sediment management on the R. Farrar and it's tributaries are that:

Several sediment management opportunities are not being taken or executed effectively to provide the best habitat for invertebrates and fish in the R. Farrar, and opportunities appear to be being missed. These include:

- **at the first Intake**. Suitable spawning sized substrate is held up here, whereas it could be introduced below the spout to become useful spawning substrate in the U. Misge). See Photo 1.

- **at and above the spout weir**. Suitable spawning sized substrate is held up here with limited high flow events to move it over the weir. There is also a pile of suitably sized spawning substrate c160m above the spout at the bottom of the waterfall which is thought to be the natural limit to migration (Photo 2). This substrate is currently unlikely to be utilised due to the consistently low flows of the abstracted reach immediately above the spout. If more actively managed, and moved downstream of the weir it could be used by fish on the U. Misge. Patches of uncompacted spawning substrate were found in the first 250m downstream of the spout (F30), however partial compaction was observed below there (F32-F34, F39) which may indicate that **the introduction of occasional extreme flood events (in addition to the annual maintenance regime) could help keep substrate uncompacted at the top of the U. Misge**.

-**above the Farrar weir** (Garbh Usige gauging weir). Historical sediment management appeared to have taken place, however the suitably sized spawning substrate appeared to have been left above the weir on the bank rather than been placed downstream of the weir where it could have been useful (Photo 3). Over-stability, a predominance of boulders and a lack of spawning substrate defined F48-F53 and these sections could clearly benefit from a better sediment supply. The precise effectiveness will depend on the gradient of these sections which is not assessed in this report. The proportion of spawning substrate picked up from F55-F58 (from the islands at Braulen cottage where the Allt Innis a' Mhuilt comes in, to in front of Braulen lodge, with some active erosion occurring and a change of typology from Plane bed and Plane-riffle to Meandering). The Allt Innis a' Mhuilt and Allt Feithe Baine are providing important spawning substrate to the mainstem river.

Photo 1: Mixed substrate, unutilised, at the 'first intake' NH17222 37900

Photo 2: Mixed substrate, unutilised at the Natural limit to migration, 160m upstream of the spout. NH18150 37955.

Photo 3: Pile of managed substrate placed out of the active channel, upstream of the Farrar weir. NH22102 38915

Photo 4: Alluvial fan of the Allt Toll a' Mhuic. NH22500 39102

-Several tapped tributaries were observed to be dry during the course of the walkover and were observed to provide some but overall limited substrate to the mainstem. E.g. the **Allt Toll a'Mhuic** (F50, Photo 4) and **the Allt Uchd Rodha** (F64).

The Allt Toll a' Mhuic is within sections F48-F53 highlighted as having stable conditions with predominantly cobble-boulder substrate, therefore any improvement to the flows and sediment management on this burn could prove beneficial to the mainstem, by increasing the amount of pebble-gravel in these sections.

The Allt Uchd Rodha, given it's significant location downstream of the upland canal (in front of Braulen lodge F59-63) which does not provide the hydraulic conditions or substrate conditions for fish

spawning, this tributary should be helping provide important substrate and flows for spawning opportunity in the mainstem for sections F64-66 but this did not appear to be the case. The mainstem river would likely benefit from improved sediment management and flows on this tributary. Please see below for comments on the Allt Coire Mhuilidh.

-possibly at the **Deanie burn alluvial fan** (immediately above Beannacharan dam). The alluvial fan here is under still water (unsuitable conditions for salmon spawning) and so might lend itself to being used in sediment management downstream of Beannacharan dam, however it may be better management practice overall to encourage more flow down this burn to create an attraction flow where the burn meets the loch to encourage fish to spawn in the lower burn instead, as past fish surveys have highlighted a lack of salmon fry in the burn.

Also:

-It was noted that sections F59-63 contain upland canal (Low Gradient Passive Meandering typology) opposite from Braulen lodge. It was unclear if this was a natural feature of the river profile or not, however a quick look at a historic map on the National Library of Scotland appears to show that the river has taken this form at least since 1875 (Appendix 6.3).

-It was observed that Loch a' Mhuillidh appeared to be a substrate sink overall despite there being a tributary on the N shore providing a significant amount of coarse substrate (F72). The presence of the loch appears to be keeping the river below here (F73-75) very stable. This is to the point that encroachment is occurring and the cobble/boulder substrate in F74 is partially compacted. The **Allt Coire Mhuillidh** is potentially a significant substrate source in this section despite it being tapped but there is a lack of spawning habitat downstream of it. The intake is specially designed to allow substrate to pass over it, and the flow regime has apparently been improved to allow more water down the burn but it is unclear how often the burn spates. There could be improvements made here.

-The north shore of Loch Beannacharan (F81-82) appeared to be actively eroding and pebble substrate was being liberated from the banks into the loch. It is unclear where this useful substrate ends up.

-Overall there seemed to be a **distinct lack of spawning habitat between Beannacharan dam and Neaty burn** with just an occasional old redd or spawning patch observed (except in F100 where a 20m stretch of spawning pebbles occurred). This conclusion was reinforced with consistent observations of encroachment/ and lack of side/ point bars in sections F90-111. Typology was predominantly plane-riffle with low sinuosity. Gradient in the plane-riffle typology sections was seemingly suitable for spawning if the substrate had been present. Despite the homogeneous nature of the channel in the plane-riffle sections, and a relative lack of the gravel/ pebble component, substrate was uncompacted in these sections. **As gradient has not been calculated as part of this report this could be useful to check. This stretch would likely benefit significantly from improved sediment management at Beannacharan dam.**

-**Neaty burn** (F112) was found to supply important mixed substrate to the main stem (despite being host to a run-of-the river hydro scheme and being abstracted by SSE). This results in **significant spawning areas being present downstream in F112-113**. Whilst being a key coarse substrate source, it is also the source of a significant amount of fines which appear present all the way to the confluence with the Glass. With a lack of spate flows to shift/ move substrate around this appears to be causing partial compaction in the lower Farrar (F121-F127). **Consequently it is recommended that spate flows**

are introduced into the flow regime to improve the quality and abundance of spawning habitat on the Lower Farrar.

-**Culligran burn** (F120) was found to be another key source of substrate on the Lower Farrar, evidenced by the large alluvial fan present at its confluence with the mainstem.

4.2 Substrate

Figure 1: Percentage of substrate for each section, with annotation. T= Tributary providing substrate to the mainstem.

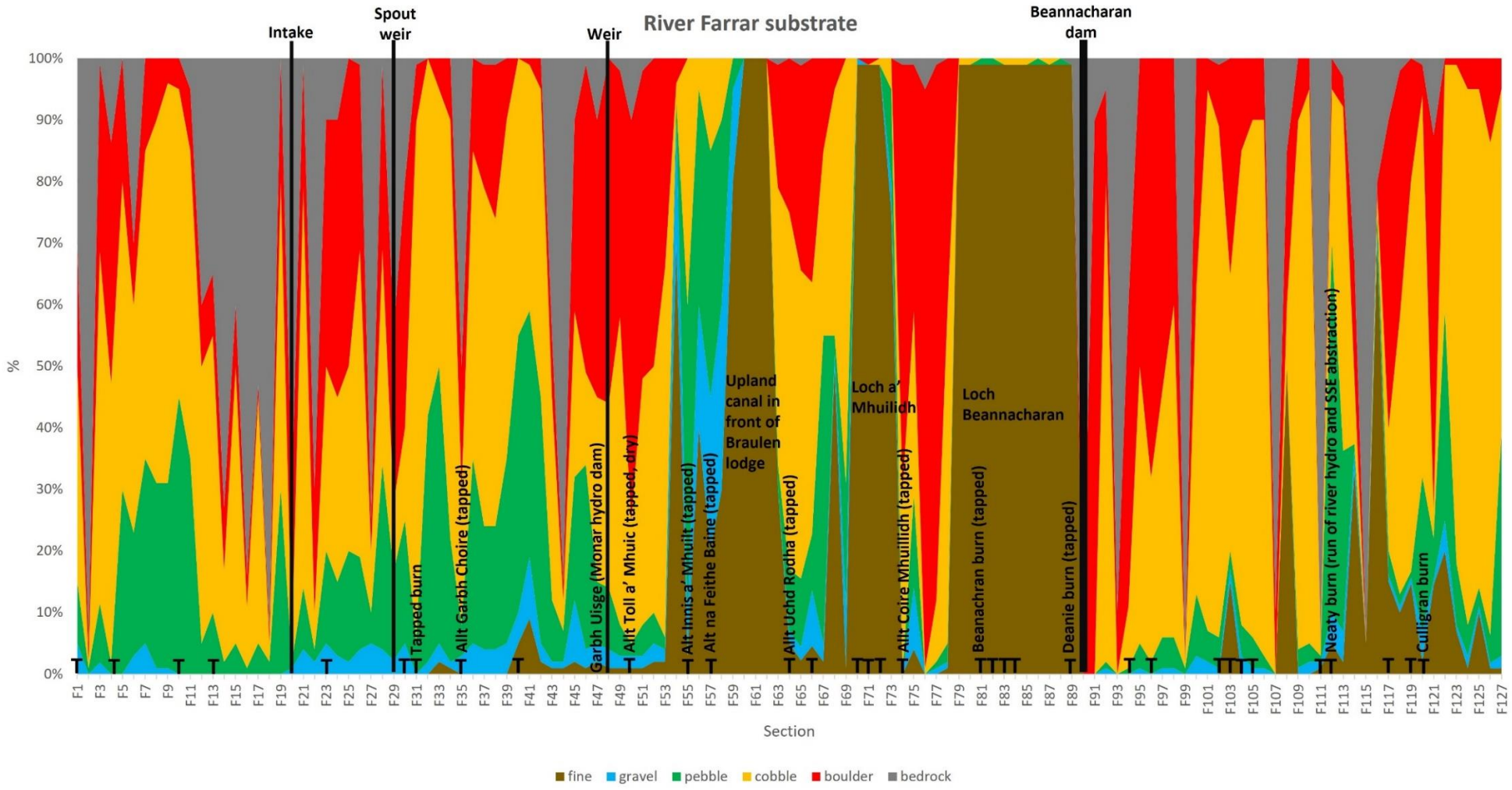


Figure 1 above summarises how substrate composition varies in each section, relative to Beannacharan dam and other key infrastructure on the river. Tributaries providing substrate are also shown, some of which have intakes on them (are 'tapped'). A few 'tapped' burns may have been missed as we did not receive this information at the time of the survey.

The main finding from Figure 1 above is that:
There is clearly a lack of gravel and pebble substrate below the dam when compared to above the dam. The proportion of cobble substrate is similar above and below.

The substrate survey findings displayed in Figure 1 also support the previous findings highlighted in 4.1. Specifically that:

Despite being 'tapped', the intake burns above Beannacharan dam appear to be providing gravel and pebble substrate to the mainstem, so it would appear that annual maintenance at the intakes is allowing substrate to move down the tributaries, however it is not clear what the current regime is and if this could be refined further to increase the amount of spawning substrate available to adult salmon.

Neaty and Culligran burns appear to be key substrate providers below Beannacharan dam.

Surveyors recorded the substrate seen along the edge of Loch a' Mhuilidh and Loch Beannacharan, however the majority of loch substrate was not visible due to depth and vastness. A look on google earth (Appendix 6.2) does not yield clarification on whether the majority of the loch beds were made up of fine or coarse substrate. For the sake of Figure 1 above, 99% fines have been assumed for the loch substrate sections, however the original recorded substrate observed along the shore is retained in the Walkover notes.

From the google earth images and walkover findings, substrate appears to be deposited above Loch a' Mhuilidh in F69 (coarse substrate where it can be utilised by spawning fish), and at the E end as sand, F72-73. In Loch Beannacharan, substrate is visible from the GoogleEarth images at the E end of the loch (as fines) and also around the Deanie outflow/ alluvial fan (as a mixture of fines and cobble).

During the walkover, rounded pebble was observed being eroded from the banks of Loch Beannacharan and longitudinal drift processes seemed to be at work (Photo 5). This would imply that the final resting place for substrate above the dam is in loch Beannacharan itself but a large pile of pebble/ gravel substrate was not directly observed due to the depth of the loch.

Photo 5: Active erosion providing substrate along the N bank of Loch Beannacharan (F81) Photo IMG_20230621_161728602_HDR

4.3 Fish habitat

Figure 2: Fish habitat recorded in each section. T= tributary providing substrate.

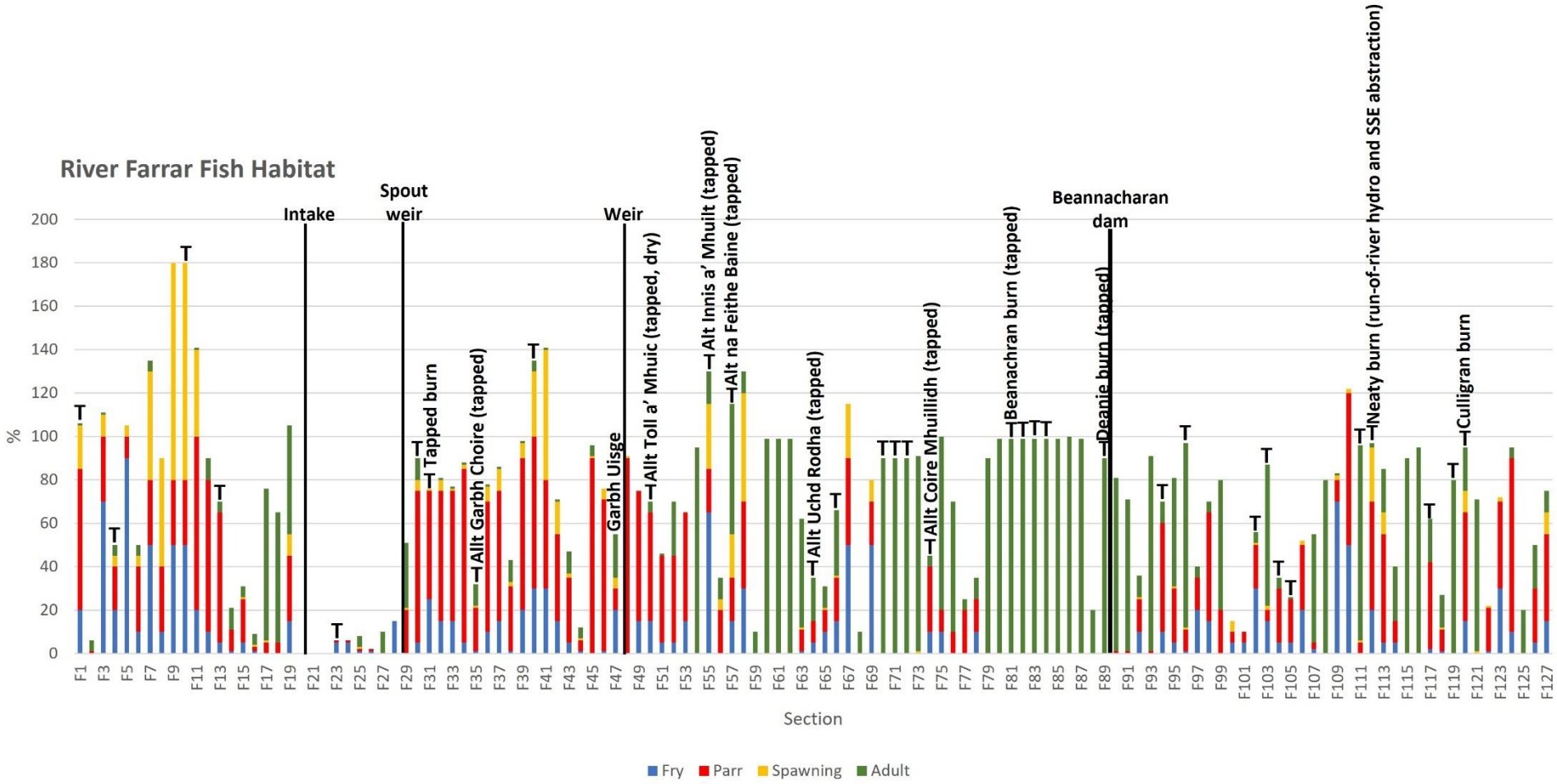


Figure 2 above summarises how fish habitat varied between sections.

The main finding from Figure 2 above is that:
There appears to be relatively less spawning habitat available to adult salmon downstream of Beannacharan dam compared to above.

The natural limit to migration for adult salmon is thought to be a waterfall c160m upstream of the spout intake (in F27), however habitat was assessed from a salmon eye's view in sections above here to provide a comparison for downstream of Beannacharan dam.

Please note that F20-22 shows no fish habitat as this was the abstracted reach below the first intake and was shallow, with no flow, not useful to fish on the day of survey.

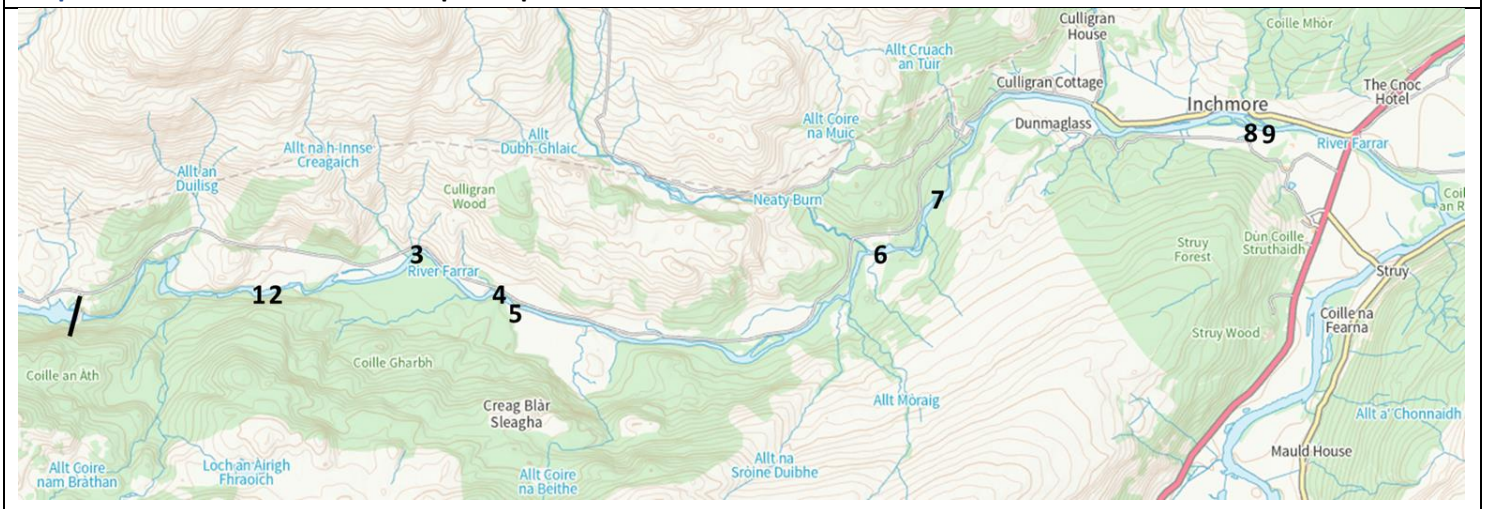
Figure 2 supports the findings highlighted in 4.1, specifically:
-That there is a relative lack of spawning habitat in sections F91-F111 (Beannacharan dam-Neaty burn), despite the typologies in most of these sections suggesting that the gradient could host spawning habitat.

-A lack of spate flows and compaction on the lower Farrar is likely to be limiting the quality of spawning habitat.

4.4 Review of historic images

From the previous sections of this report it is clear that there is a lack of mixed substrate providing spawning habitat in the mainstem river below Beannacharan dam when compared to above. To investigate if this is a natural occurrence or due to morphological changes seen since the installation of Beannacharan dam, old photographs taken pre-dam were gathered and re-constructed to see what changes have occurred (see Map 8). As the main focus of this report is to assess the impact that Beannacharan dam and the resulting flow and sediment regime may be having on spawning habitat distribution downstream of the dam, photos from above the dam have not been gathered or assessed. **Analysis of these (from Braulen estate) could prove useful in the future when assessing if further refinements to sediment and flow management on the tapped burns is necessary.**

Map 8: Locations of reconstructed photo points



1) NH33613 39494 Ross's pool PRE. Mobile substrate bar at top of island. Rock face visible.

1) NH33613 39494 Ross's pool POST. Stable vegetated island, no mobile substate. Channel on right of photo now dry/ vegetated (F97).

2) NH33648 39476 Ross's pool PRE. Pebble-gravel substrate present along left bank.

2) NH33648 39476 Ross's pool POST. Higher water level, encroaching bank, cobble-boulder (F97).

3) NH34573 39725 Little Bridges, FAR2 efish site PRE. Richard Wood's postcard. Mobile gravel and pebble side bars along both banks.

3) NH34573 39725 Little Bridges, Far2 efish site POST. Higher water level. Predominantly cobble substrate and encroaching banks with trees due to stable flow regime (F102).

4) NH35072 39479 Fir tree PRE. Gravel bars.

4) NH35072 39479 Fir Tree POST. Higher water level. Missing gravel bars (photo taken stood on overgrown bar). F103.

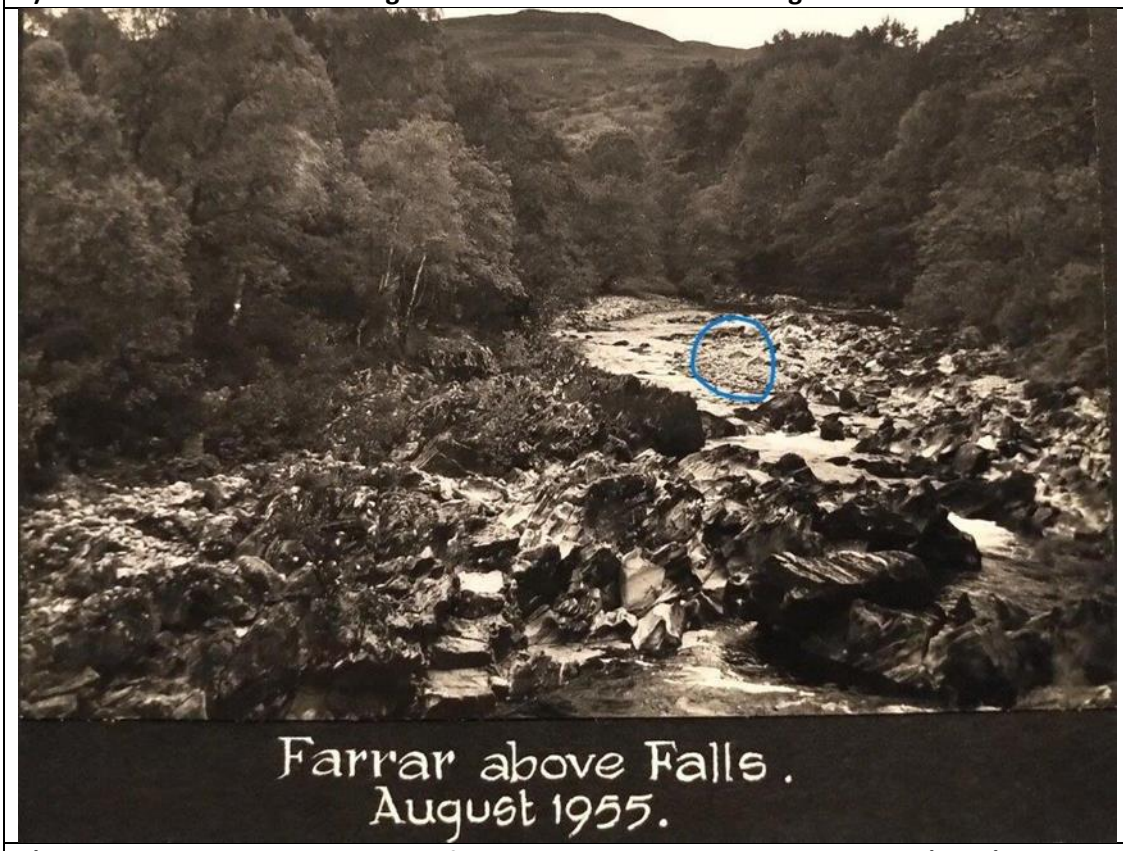
5) NH35306 39363 Cooper's bridge PRE. Exposed mixed substrate sidebar.

5) NH35306 39363 Cooper's bridge POST. Now vegetated cobble bar. (F104).

6) NH37307 39724 Neaty alluvial fan PRE. A mix of substrate.

6) NH37307 39724 Neaty alluvial fan POST. Similar then as now (F112).

7) NH37701 40050 Above Culligran falls PRE. Cobble bar in background.



7) NH37701 40050 Above Culligran falls POST. Now a vegetated, stable bar (F115).

8) NH39649 40434 Looking upstream from above Lodge Pool PRE. Abundance of mobile substrate bars (Meandering-braided typology)

8) NH39649 40434 Looking upstream from above Lodge Pool POST. Mobile gravel bars now treed, stable islands, Plane-riffle typology (F24).

9) NH39574 40468 Above Lodge Pool PRE. Mobile substrate bars.

9) NH39574 40468 Above Lodge Pool POST. Gravel bar now vegetated and stable (F24).

Post-dam, the water level is generally maintained at a higher-than natural flow during the summer months which means that the comparisons are not perfect, however the story of missing gravel bars and a constrained typology (from what was predominantly Meandering to what is now Plane-riffle) is consistent, especially when combined with the walkover findings/ substrate assessment. The exception to this is the Neaty burn alluvial fan (6) which appears to be similar to the previous photo.

The main findings from the photo review are that:
-Consistently there appears to be a lack of mobile gravel bars that were originally present before Beannacharan dam was constructed.

-A lot of the substrate visible in the old photos is of spawning grade potential.

-The impression is that there used to be an abundance of this substrate along the river (including the stretch between Beannacharan dam and Neaty burn) highlighted by the walkovers as currently lacking suitable spawning habitat. Also it would appear that there used to be more mobile substrate available for spawning downstream of Neaty burn too, which implies that the whole river downstream of the dam is impacted.

-This would imply that the isolated spawning patches currently seen on the R. Farrar in areas of sub-optimal spawning habitat are in fact a sign that fish have much less choice than they used to have on how and where to spawn downstream of the dam. The consequences of this could be overcutting of redds due to the limited prevalence of spawning substrate and a vulnerability to environmental change due to the restricted distribution of spawning substrate. In the context of Atlantic salmon decline, it is imperative that fish habitat is as good as it can be so that Atlantic salmon have the best chance at completing their life-cycle.

-These photos put the walkover findings into context and strongly lends support for the need for sediment management in relation to Beannacharan dam, over and above the need for just using the unutilised substrate currently above the dam. i.e. it is recommended that suitable grade substrate is won from local borrow pits and introduced into the river below the dam.

-The discrepancy in substrate abundance past to present appears to be the result of a lack of sediment management and associated natural flows in relation to Beannacharan dam as opposed to the tapped burns below the dam, however further clarification should be sought from SSE as to the layout of their infrastructure below the dam, to check that this is the case.

-From the photos it does not appear that land-use has changed significantly, which would suggest that the changes observed from past to present are due to the presence of hydro in the catchment as opposed to other factors.

5. CONCLUSIONS AND RECOMMENDATIONS

This report has highlighted that there is less spawning grade substrate below Beannacharan dam than above it, and also significantly less spawning grade substrate present currently compared to before Beannacharan dam was installed. This has been demonstrated through the walkover survey and comparison of pre-dam and current day photos. Specifically:

-There is a lack of spawning substrate between the dam and Neaty burn in gradients usually associated with fish spawning activity.

-A lack of spate flows to shift/ move substrate around appears to be causing partial compaction in the lower Farrar.

-At the bottom of the R. Farrar, typology appeared to be constrained to predominantly Plane-Riffle compared to the pre-dam Meandering typology. This illustrates a reduced dynamism since the dam was installed.

-The results of the walkover and photo comparison implies that the isolated spawning patches currently seen on the R. Farrar in areas of sub-optimal spawning habitat are in fact a sign that fish have much less choice than they used to have on how and where to spawn downstream of the dam. The consequences of this could be overcutting of redds due to the limited prevalence of spawning substrate and a vulnerability to environmental change due to the restricted distribution of spawning substrate.

This is likely due to a lack of sediment management and spate flows at Beannacharan dam rather than other land-use factors.

Some sediment management appears to be taking place on the intake tributaries above Beannacharan dam as part of the annual maintenance regime when substrate is flushed through the intakes, but more frequent management could be done to improve fish habitat on the mainstem further.

Some existing sediment management appears to be taking place at various structures on the river, and this could be improved further to help improve fish and invertebrate habitat in the active channel downstream.

RECOMMENDATIONS:

-The introduction of sediment management and improved flow regime at Beannacharan dam (and Culligran power station) to halt or reverse the decline in spawning substrate availability downstream of the dam is strongly recommended. As useful substrate is likely being held up in Loch Beannacharan above the dam (precise location unclear), it is recommended that suitable alluvium deposits are won from borrow-pits on either Braulen or Culligran estates (or the nearby Breedon aggregates quarry) and introduced into the river downstream of the dam. This would be in consultation with SEPA, SSE and in line with best practice sediment management guidance. During the walkover rounded pebble was observed being eroded from the banks of Loch Beannacharan and so appears to be locally available.

-Seek information from SSE as to the location of their infrastructure, especially on the lower Farrar (i.e. tapped burns).

-Improved sediment management (with introduction of more frequent high flow events) at intake tributaries particularly at the top of the U. Misge, the Allt Toll a' Mhuic, Allt Uchd Rodha. and Allt Coire Mhuilidh to enable transport of pebble-gravel substrate down to the mainstem.

-Improved sediment management of unutilised substrate at various structures and locations above Beannacharan dam for the benefit of fish habitat above Beannacharan dam including; At the topmost intake, at the bottom of the waterfall 160m above the spout, at the spout weir, at the Farrar weir.

-Consideration of sediment management of Deanie burn alluvial fan for the benefit of the R. Farrar downstream of Beannacharan dam (although better management practice would be to alter flows on the burn to increase attraction flow and fish spawning activity in the burn itself).

-Any changes to sediment management or flow regime would have to be consulted on with the local landowners and fishery proprietors, as changes to river form to a more natural state may alter the location of adult holding pools etc.

-Any changes to river management should be made in the context of the most up to date information available. The Farrar genetics project and improvements to fish counters could prove to be useful sources of information.

If it is deemed that the observations contained in this report are not sufficient to merit improved sediment management in relation to Beannacharan dam (or the intake tributaries) then further information could be provided through:

-Comparison of the Farrar substrate profile with the R. Glass- the other main tributary of the R. Beauly with no large hydro dam. General observations suggest a much more abundant pebble substrate on the mainstem R. Glass. A brief comparison could be made using habitat data collected at fish survey sites. Juvenile fish survey data (NEPs benchmark) may also provide a useful comparison once the 2023 data has been processed.

-A closer look at the gradients associated with the walkover sections. In general, the typology recorded for each section indicates gradient but this may not be sufficient for the regulator or operator.

- A review of photos above Beannacharan dam (Braulen estate) could be made to help further assess the effectiveness of sediment management at the intakes above the dam and to highlight any other natural changes that may have occurred in the Glen.

REFERENCES

Hendry K, Cragg-Hine D. (1997) Restoration of Riverine Salmon Habitats, A Guidance Manual. Environment Agency (fisheries Technical Manual 4).

Moir, H. (2017) Draft Report on Issues Relating to the Availability of Atlantic Salmon Spawning Habitat on the River Shin. CBEC.

SEPA (2020) draft Sediment Management Plan guidance

SEPA (2012) WFD122 Ecological indicators APEM project trial.

SFCC (2007) Habitat Surveys Training Course Manual.

SNIFFER WFD21d Ecological indicators of the effects of abstraction and flow regulation; and optimisation of flow releases from water storage reservoirs

6. APPENDIX

6.1 Walkover Guidance notes

Hydromorphology walkover guidance notes RW June 2023

Walk the river where possible/practical. Section ends either where typology changes, tributary comes in, another key feature (e.g. island) stop/ starts. If a large reach is the same typology (e.g. the lower reaches of a river) then split section after about 300m.

Assess fish habitat for wet width only. Record flow conditions (med-low) at start of survey.

FISH

From Hendry and Cragg-Hine 'Restoration of Riverine Salmon Habitats':

Table 8.1 Habitat type classification system.

HABITAT TYPE	DESCRIPTION
Spawning Habitat & Silted Spawning Habitat	Ideally stable but not compacted, easily workable with a boot without generating excessive silt release, a mean grain size of up to 80 mm for salmon. 'Fines' (< 2 mm grain size) to be less than 20% by weight.
Fry Habitat	Shallow, = or < 20 cm deep, fast-flowing (50 - 65 cm/s), with surface turbulence and a gravel (size range 16 - 64 mm) and cobble (size range 64 - 256 mm) substrate.
Parr Habitat	20 - 40 cm deep, fast-flowing (60 - 75 cm/s), surface turbulent, with gravel/cobble/boulder (size > 256 mm) substrate.
Glides	= or > 30 cm deep, moderate velocity in range 10 - 30 cm/sec, surface smooth and unbroken, relatively even substrate of cobbles with finer material.
Pools	= or > 40 cm deep, no visible flow, surface unbroken, substrate with a high proportion of sand and silt.
Bankside/Tunnel Vegetation	Riparian vegetation ideally providing a mixture of open and closed canopy throughout the reach. Tunnel vegetation forms a complete closed canopy for extensive lengths.
Macrophyte Beds	Submerged and emergent macrophytes providing localised hydraulic diversity.
Flow Constrictions	Physical features providing a narrowing of the channel resulting in increased velocity and depth.
Obstructions to Migration	Impassable falls, weirs, bridge sills etc., shallow braided river sections preventing upstream migration during low flows

Spawning hab- defined as above with flow. The fry/ parr/ spawning/ adult habs can add to more than 100% as these can overlap.

-Adult cover defined as sufficient refuge areas for adults, deep pools or overhanging veg.

-No perceptible flow

Hydro-indicators (Draft SEPA protocol 2012):

Recorded as: Extensive >33%, P=present, N=none

Diatom scum: Extensive (>33%), Present (1-33%), Not present (E, P or N). Littoral, Sublittoral, Mid-channel (L, SL, M).

Filamentous algae

Fines- dusting/ layer of substrate on existing substrate.

'Lower plant cover' Moss/ lichen on exposed boulders/ cobbles.

Submerged Aquatic Plants? Emergent plants in channel? Terrestrial plants in channel?

Compacted? Record: (Armoured [A], Y, No, Partly); also E, P, N.

Tributary perched, point bar at confluence? Flow estimate (low, average, high)? Record: S (substrate source), NS (No substrate), P (perched), NP (not perched). Score out if no tributary in section.

Evidence of flood/ Trashline? Record: Extensive along at least one bank, P, N.

Recent erosion evident? E.g. undercut, collapsed, eroded. Record E,P, N. Obvious.

Active point or side bars? Record E, P, N plus UV (UnVeg) or V (Vegetated).

Comments: include Fish barrier, natural flow restrictions e.g. log jam, exposed tree roots above river level? Phot IDs.

SUBSTRATE

Landuse

Code	Type
MH	Moorland heath
RP	Rough pasture
BL	Broadleaf
CP	Conifer plantation
MW	Mixed woodland
IG	Improved grassland

Typology as defined by SEPA

Code	Type	Description	Additional info
BDRK	Bedrock	Substrate predominantly bedrock.	Steep and confined; floodplain absent. Variable flow types, often high energy. Few bars, little sediment storage.
CASC	Cascade	Flow type mainly chute flow or broken standing waves over very coarse substrate such as boulders or large cobbles.	Boulders common; disorganized bed; fast flow types.
SP	Step-pool	Steep steps across channel (bed gradient >5%), over which water chutes or falls, separated by distinct pools.	The front of each pool is constructed from boulders/cobbles.
PB	Plane bed	Not more than one kind of bed form or flow type (i.e. the channel is not morphologically diverse).	Uniform bed, fairly straight. Bars infrequent/absent. Bed armoured, hard to kick sample. Cobbles often jutting through water surface.
B	Braided	The main channel braids into two or more channels across mobile gravel bars that are bare or dominated by pioneer species.	Multiple channels.
WGB	Wandering gravel bed	Irregular meanders with long sections of severe erosion and extensive gravel deposits, or river has moved naturally to leave channels abandoned on the floodplain.	Highly dynamic.
PR	Plane-riffle	River stable, with a regular sequence of other flow types (e.g. run-riffle-run-riffle or run-glide-run-glide) with no classic pools.	Low sinuosity and lack of bars.
M	Meandering	River has a sinuous planform, with a roughly regular sequence of pools, riffles and point bars, with erosion on outer bank and deposition on point bars on inner bank.	Well developed flood plain.
LGPM	Low-gradient passive meandering	River has a sinuous, meandering planform but very little or no erosion or deposition.	Deep channel; stable vegetated banks.

Typology might be difficult to categorise in impacted reaches (e.g. where the reach is over abstracted) so you may have to record current typology and also typology if flow was natural.

Substrate sizes based on SFCC EFish protocol

Assess whole bed width.

Code	Type	Description
FI	Fines	V. fine org. matter (HO)
		Inorg. indiv. part. Invisible (SI)
		Inorg. part. <=2mm (SA)
GR	Gravel	Inorg. part 2-16mm (GR)
PE	Pebble	Inorg. part 16-64mm (PE)
CO	Cobble	Inorg. part 64-256mm (CO)
BO	Boulder	Inorg. part >256mm (BO)
BE	Bedrock	Cont. rock surface (BE)
OB	Obstruction	Wood barrels etc; cannot move (OB)

Depth: most common for section, not average.

Width: record both representative wetted and bed width for section

6.2 Google Earth images

Loch a’ Mhuilidh Google Earth images

Loch Beannacharan Google Earth images

6.3 National Library of Scotland map showing a similar river route to currently observed in front of Braulen lodge.

National Library of Scotland. Inverness-shire (Mainland), Sheet XV. Survey date: 1872-75, **Publication date:** 1876-81.
https://maps.nls.uk/geo/find/#zoom=9.9&lat=57.45422&lon=-5.11494&layers=102&b=1&z=0&point=57.40041,-4.94357&i=74427039