Beauly
Fishery Board

RIVER BEAULY HYDRO-MORPHOLOGY REPORT 2023

Looking downstream from Kilmorack dam, R. Beauly

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CONTENTS

1. SUMMARY

The aim of this study was to assess the impact of Aigas and Kilmorack dams on the substrate and Atlantic salmon spawning habitat in the R. Beauly, with a view to informing sediment management.

In summer 2023, substrate and fish habitat walkovers were conducted from the start of the R. Beauly (at the Farrar-Glass confluence) down to Lovat bridge (the normal tidal limit).

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

2. INTRODUCTION

Hydropower infrastructure has been prevalent in the Beauly catchment since the late 1950s. The R. Beauly hosts two large hydro dams (Aigas and Kilmorack) and these have a significant impact on the natural flow and sediment regime further downstream. This could reduce the availability of salmon spawning habitat through the loss of substrate because hydropower structures impede sediment supply into the river from upstream and managed flow regimes can affect downstream transport of sediment. See Map 1.

Map 1: SSE infrastructure in the catchment, with the R. Beauly highlighted.

The main focus of this report is on assessing the potential impact that Aigas and Kilmorack dams have on the substrate in the mainstem river Beauly in relation to Atlantic salmon spawning habitat availability, with recommendations for improved sediment management made at the end of the report. Currently no sediment management is in place in relation to Aigas or Kilmorack dams.

In terms of flow regime, this is far from natural. If generation occurs further up the catchment (at either Culligran or Fasnakyle) then generation has to occur at Aigas and Kilmorack dams to let the water through. Generation (elevated flows) is generally determined by electricity demand from the national grid. The flow regime is typical of many hydroed rivers in Scotland with a regulated flow with a lack of extreme high flow and low flow events.

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.

Hydro-morphologist, Hamish Moir (commissioned by Lower Beauly Fishing Syndicate) wrote a report in 2019 [3] focussing on future possible management options for the Cruives structure on the Lower Beauly, and this provides some useful background information. Amongst other mitigation options he suggests that a sediment management plan could be developed in relation to Kilmorack dam, with translocation of appropriately sized sediments from above the dam to below.

In summary: “Gravel-sized material in the river downstream of Kilmorack dam is steadily being depleted over time”, however the Cruives structure provides some mitigation to this process. The Cruives structure is known to impede sediment movement whilst allowing some sediment to pass downstream in high flow events.

The substrate held up at Cruives along the N side of the channel is well known to be used by spawning salmon in the autumn.

Moir writes that during high flow events the sediment slowly released at Cruives provides important substrate for fish spawning further down the river although useful spawning gravel can end up being deposited out of the active channel on the N side of the river and unutilised.

The Cruives structure may result in a local ‘coarsening’ of the channel bed over time with loss of spawning habitat downstream (especially on the N bank where this has resulted in overly-stable and vegetated conditions with a lack of gravel downstream). The island that has developed downstream of Cruives has developed since the structure was in place and is vegetated by trees and is stable with little evidence of deposition.

3. METHODS

3.1 Walkover surveys (Substrate and Fish habitat assessment)

Over six days between 30 May-12 July 2023 walkovers were undertaken from the top of the R. Beauly (where the rivers Farrar and Glass meet) to the normal tidal limit at Lovat bridge to assess the current hydro-morphological conditions along the R. Beauly. Substrate composition and available fish habitat were recorded as well as the presence of tributaries and their contribution to sediment supply.

Surveyors assessed the river either from the bank or from in the channel where this was possible. For gorge areas where access was limited (i.e. Aigas Gorge) substrate was assessed from vantage points, and an estimate made.

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 loch-like (i.e. too deep to wade in or make an accurate assessment due to depth/ visibility), the substrate visible from shore was recorded and has been assumed to be predominantly fines for presentation in the substrate graph.

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.

3.2 Local Knowledge

Following the walkovers, Gordon Armstrong (current Head ghillie, Lower Beauly Fishing Syndicate) provided his observations of where he had observed salmon spawning on the Lower Beauly.

3.3 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. Beauly, historic photographs, some dating to before Kilmorack dam was installed were obtained from Willie Mathieson (his family have been ghillies on the Lower Beauly for at least three generations), and local resident (and postcard collector in Cannich) Richard Wood. These photos and postcards enable a visual comparison of past river substrate and form with present day.

The locations of the photos were discussed with Willie and Richard ahead of a site visit which was carried out on 19 Oct 2023.

4. RESULTS AND FINDINGS

The annotated maps are presented first, followed by the substrate, fish habitat, local knowledge, and finally the results are put into further context with the 'Review of historic images' section.

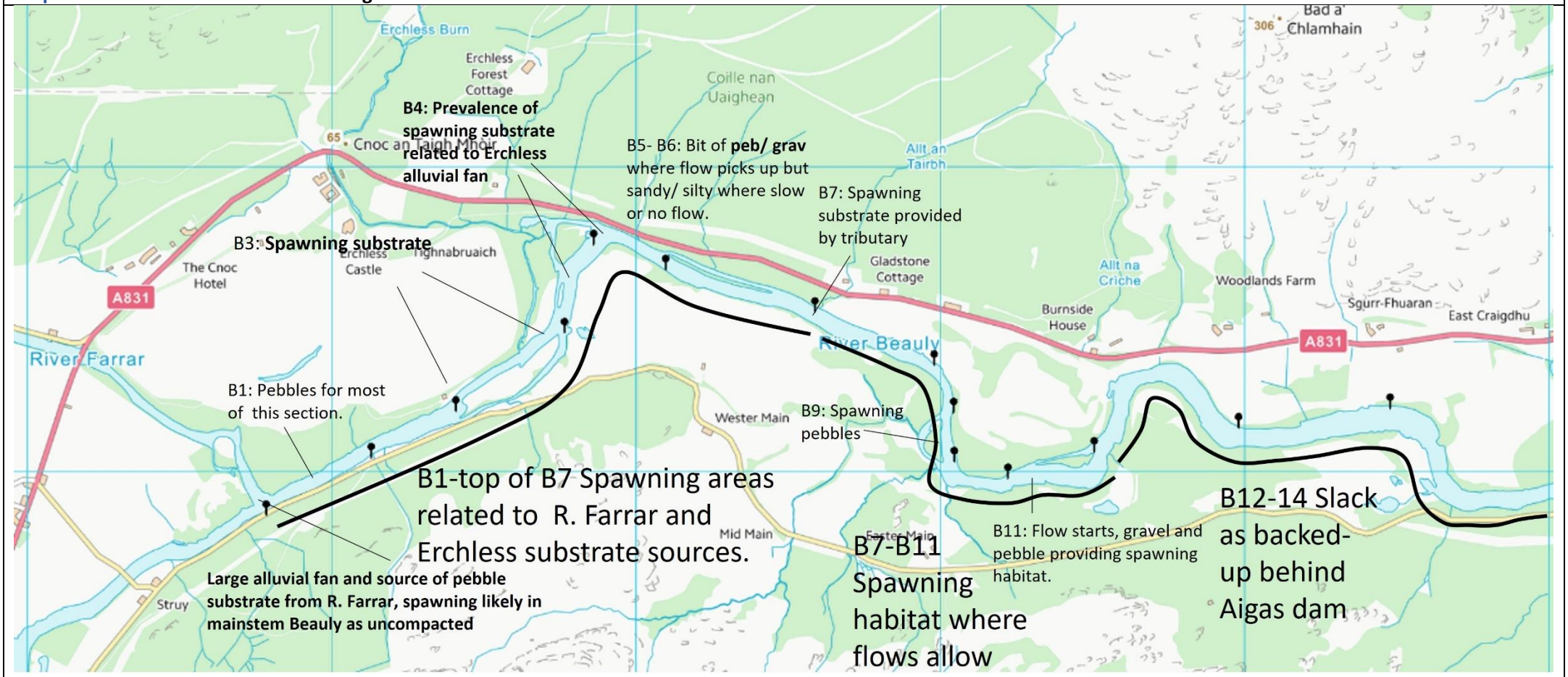
The full walkover results and all photos taken during the walkovers can be found here.

Please note that wet and bed width are the same for a lot of the Beauly owing to the channelised nature of the Beauly.

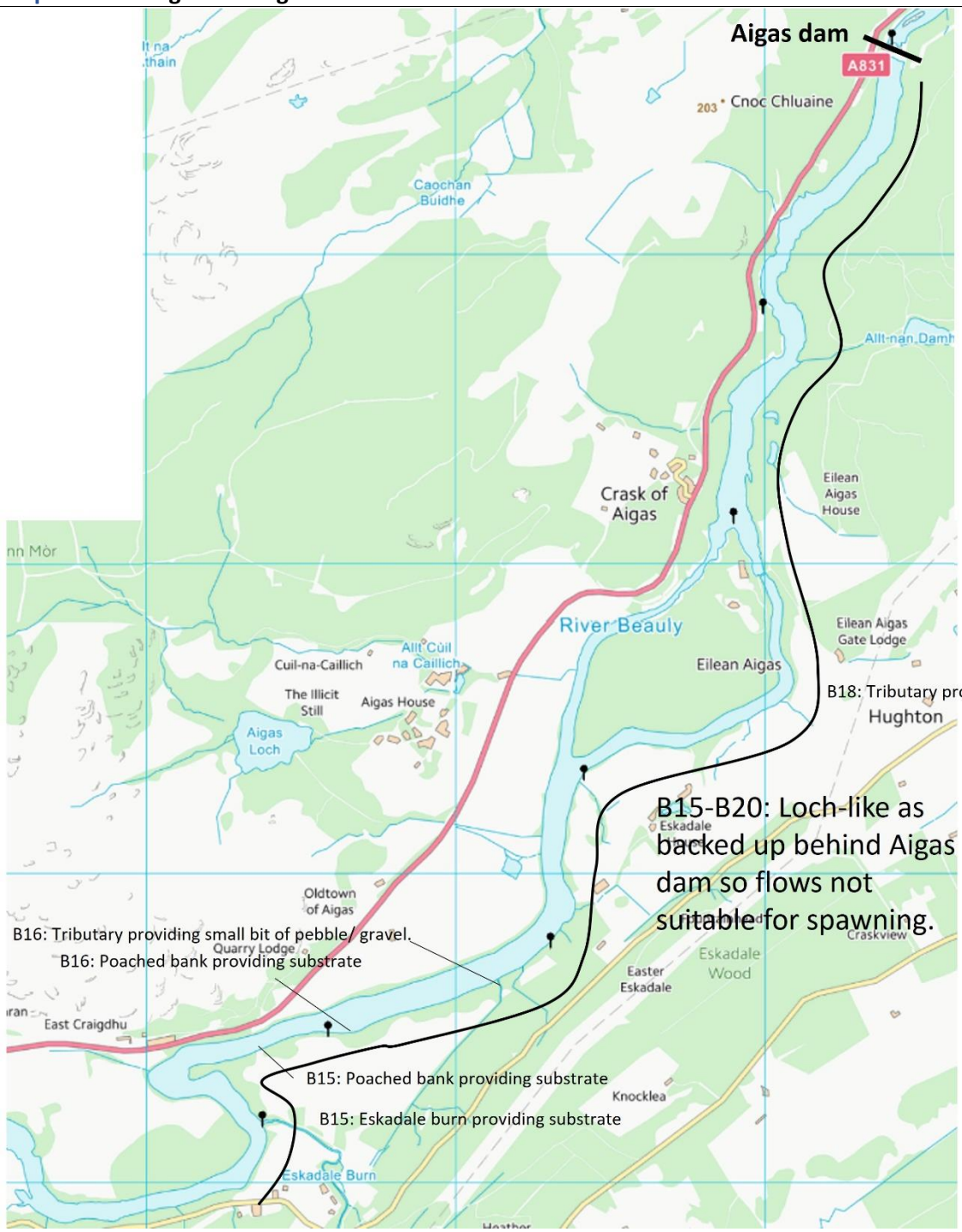
4.1 Annotated maps

Below are annotated maps, summarising the main findings of the walkover for all sections (B1-B33).

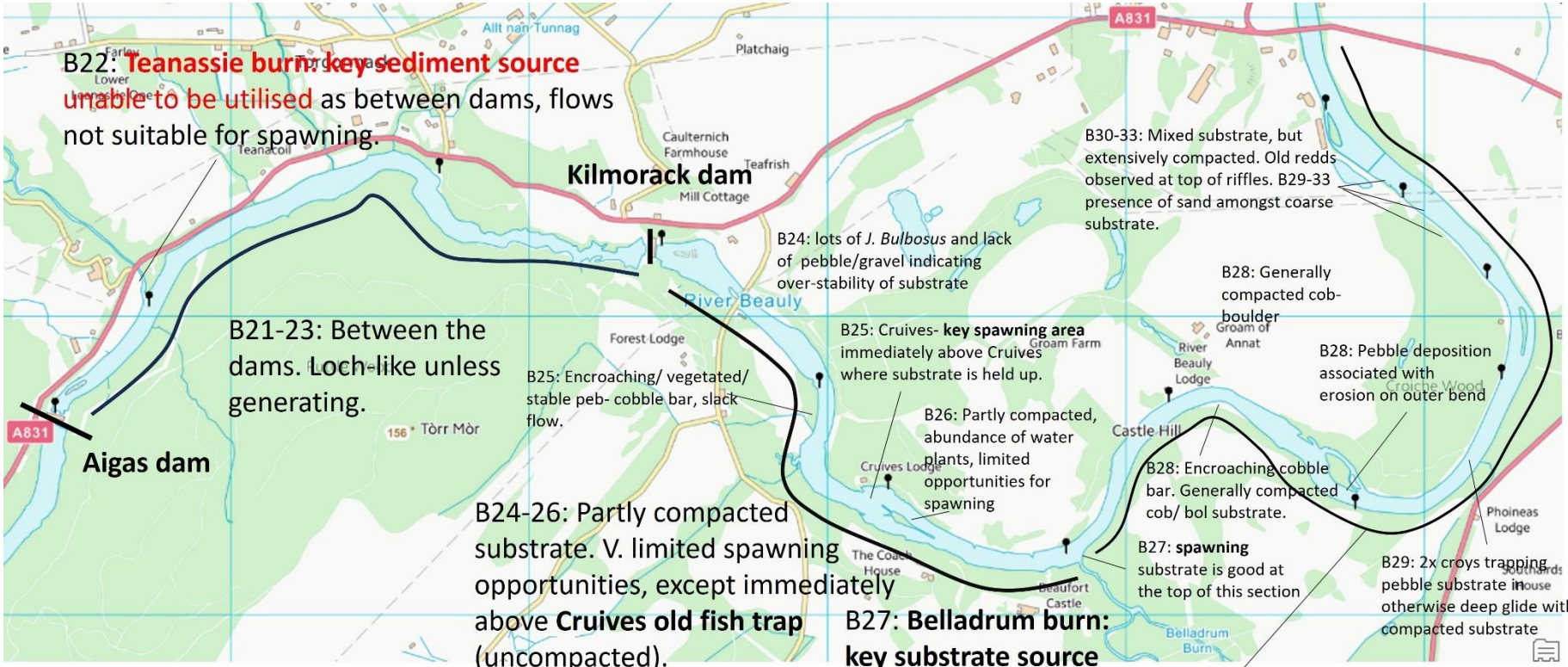
Map 2: R. Farrar confluence to East Craigdhu



Map 3: East Craigdhu to Aigas dam



Map 4: Aigas dam to Lovat bridge



B27-33: Although Belladrum burn is providing substrate to this section and spawning does occur, the lack of spate flows on the Lower Beauly is causing compaction, over-stability and encroachment of the banks. This is limiting the usefulness of potential spawning substrate and limiting spawning opportunity.

The main findings of the walkover are included in the maps above.

Above Aigas dam:

-Outwith the influence of Aigas dam, spawning substrate was generally abundant where flows allowed and five main spawning areas were identified. These were at the confluence with R. Farrar (B1), downstream of Erchless hut (B3), at the confluence with Erchless burn (B4), and Knocknashalavaig (B9 and B11). See Photos 1 and 2 below.

Photo 1: p464 Just in front of Erchless fishing hut (B3)	**Photo 2 p479 Erchless burn confluence (B4)**
	

-The rivers Glass and Farrar appear to provide the top of the R. Beauly with a key substrate supply and resultant spawning habitat where flows allow in sections B1-7.

-Erchless burn is also a key supplier of substrate to the river (B4) and good spawning habitat was observed where the Erchless meets the R. Beauly.

-Further downstream, spawning habitat was generally determined by flows with good spawning areas identified in sections B9 and B11. B9 spawning substrate was associated with two tributaries and the presence of an island. B11 spawning habitat was good due to erosion providing a pebble source in B10 (p691) and probably tributaries (unassessed from LB).

-A predominantly Meandering typology was present in sections B1-B12, with extensive erosion recorded in sections B6-B11 indicating that the river still retains some of its dynamic nature despite the presence of partially regulated flow.

-**From section B12-B20, the impact of Aigas dam was evident, in that flow was backed-up behind the dam**, and was slack, and deep. Therefore substrate was made up of predominantly fines, with no spawning opportunities observed. As a result of the slack nature of the river, a significant amount of marginal vegetation was present (B12, B13, B14, B16,) and submerged loch macrophytes were also apparent (B15), wetlands had formed in sections B12, B14, and B16. This area was only suitable as adult fish holding habitat and adult fish activity was observed in B14 and B16.

-It is not clear where river substrate ends up being deposited above Aigas dam as a large pile of coarse substrate was not observed, but it is likely that it is deposited in B11 (the last section to have flow) or just below here.

-Several tributaries flow into the slack section above Aigas dam, and were observed to provide a relatively small contribution of substrate to the river (Eskadale burn B15, plus a tributary in B18). This substrate is currently unutilised by spawning salmon due to the flows on the mainstem and would not be easily accessible for potential sediment management purposes.

-From Eilean Aigas to Aigas dam (B18-B20), the river became gorgey and B19 and 20 were surveyed from vantage points.

Between the dams (B21-B23):

Due to the slack nature of the river in this section, there was a high proportion of fines recorded in these sections with no spawning habitat identified due to the slack nature of these sections.

-Teannassie burn alluvial fan should be considered as a potential, currently unutilised substrate source. During the drawdown in 2020 the Teanassie alluvial fan (currently sat under slack water) was measured at 1,600m^2 and so could be a good source of substrate for use downstream of Kilmorack dam if necessary. Provision of a short section of access track would be required.

Draw down 16 December 2020	
Photo 3: Teannassie burn alluvial fan (>1,600m2)	**Photo 4: General view of substrate, looking downstream from Teanassie.**
	

Below Kilmorack dam (B24-B33):

Spawning habitat was limited below Kilmorack dam and generally substrate was partly compacted in sections B24-B29 (Kilmorack dam-above Downie hut) and extensively compacted B30-B33 (Above Downie hut- Lovat bridge).

The main spawning habitat identified was associated with deposition of pebbles on the upstream side of the **Cruives** structure, above the **Belladrum burn** confluence (the key substrate source for the Lower Beauly) and in B28 at the bottom of the island (Fly pool). Apart from this, spawning opportunities appeared very limited to discrete patches of pebbles (e.g. B26 far side of Cruives island, and associated with old croys B29 where flow allowed). Further down in sections B29-33 a few old redds were observed amongst compacted substrate that did not seem very suitable for spawning due to the significant presence of fines amongst coarse substrate.

Although in general the typology of the Lower Beauly appears to be constrained to plane-riffle (from what may have naturally been meandering if compared to that seen above the dams) active erosion (and a potential substrate source) was observed at the bottom of section B28 and is associated with the outer bend of the island at Fly pool.

In relation to sediment management, the walkover highlighted how the pebble substrate held up immediately above the Cruives structure is important (uncompacted and utilised) spawning substrate, as there was limited availability of uncompacted substrate on the rest of the Lower Beauly. **Any sediment management on the Lower Beauly (at Kilmorack dam) would also have to include sediment management at Cruives** to deliver potential benefit to the river downstream between Cruives and Belladrum burn (the most significant source of substrate further downstream). It is not clear where the pebbles held up at Cruives have originated. Two burns flow into B25 on the right bank but these were no assessed from the right bank. Wetland had developed at the confluence with one of them, indicating that this would be unlikely to be a source of substrate. There may be erosion occurring downstream of the dam (outer bend of B25) that was not observed during the walkover.

During the walkovers, empty Fresh Water Pearl Mussel shells were observed in sections B25 and B29. With consultation with NatureScot, their presence on the Lower Beauly may be of use. In conjunction with better sediment management, **grant funding could be applied for to install large woody structures on the Lower Beauly to help hold useful pebble/ gravel substrate in the river for longer**. Currently it is clear that man-made structures on the Lower Beauly are playing their part in holding up some of this valuable substrate (e.g. Cruives, and old croys).

The addition of structures into the river may also be useful as there is significant urbanisation downstream of the dam (i.e. Beauly village) so the scope for introducing a more natural flow regime (i.e. spate flows) is likely to be limited. See Shin restoration project [2] as an example of habitat benefit whilst working within the original flow regime.

4.2 Substrate

Figure 1 summarises the substrate recorded for each section during the walkover. Please note substrate was not visible for sections 8, 12 and 14 but due to the slack nature of these areas substrate has been assumed to be predominantly made up of fines.

Figure 1: Graph of substrate recorded in each section. T= tributary providing substrate.

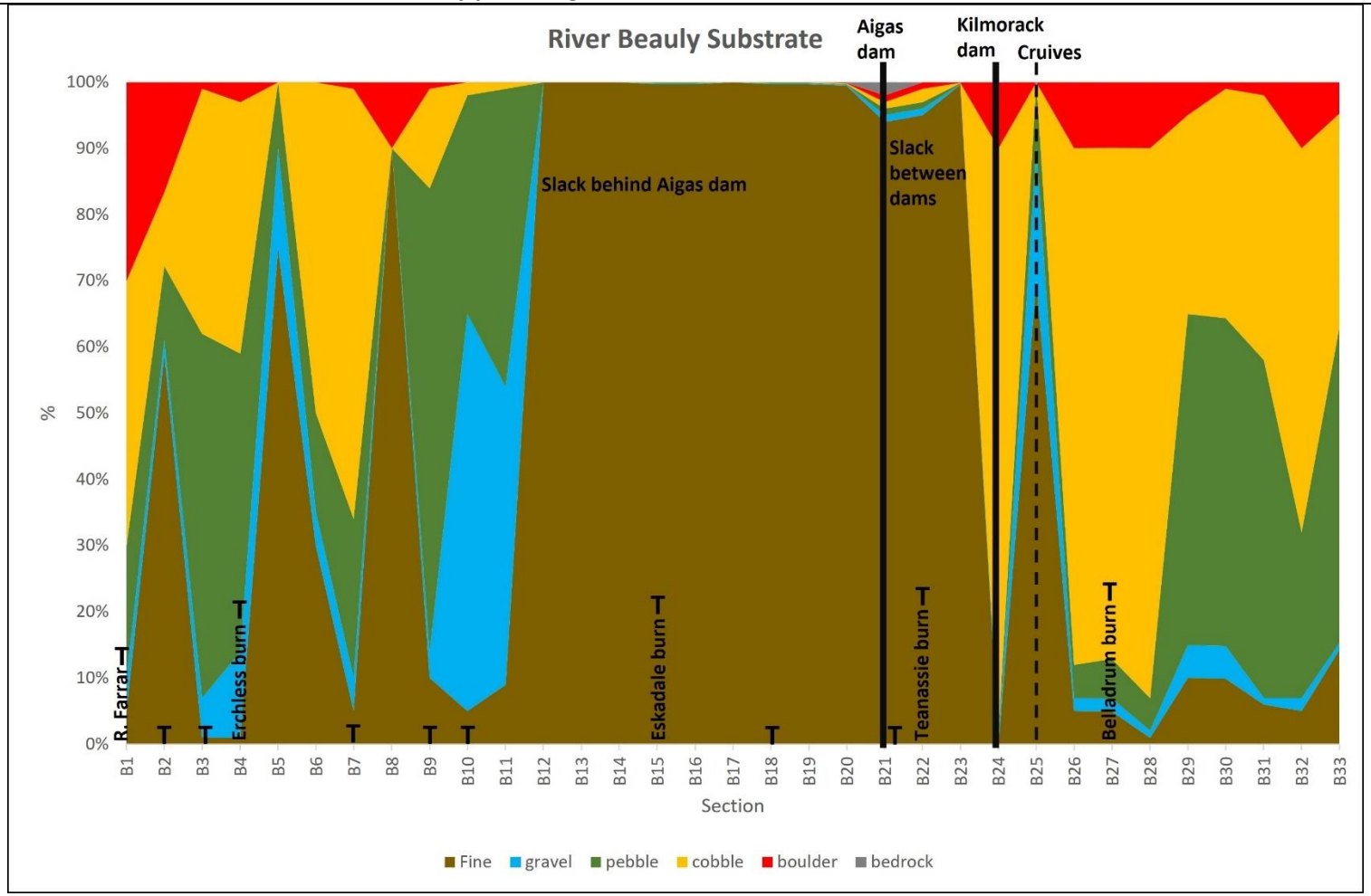


Figure 1 above summarises how substrate composition varies in each section relative to Aigas and Kilmorack dams and Cruives. Tributaries providing substrate are also shown. A few tributaries may have been missed if not clearly visible during the walkover.

Figure 1 may show that **there is a lack of gravel substrate below Kilmorack compared to above the dams. There is also a predominance of cobble below the dams when compared to above which may suggest a coarsening of substrate in sections B24-B29.**

The areas of majority fines are in slack areas e.g. behind the dams or in sections that contained a significant stretch of still water. The sections behind the dams are annotated on the graph (B12-B20, B21-B23). Additionally: Section **B2** is majority pool above Erchless hut, **B5** is the slack area below Erchless burn, **B8** was slow flow along the left bank to slack and deep for the majority of the channel width, B9 includes a deep slack area at top of section, B10 was mostly slack, B11 included a sandy back-channel and was partially slack at the bottom of the section. Downstream of the dams: **B25** above Cruives is slow flow (possibly due to the presence of the structure itself), B29 contained slack at the bottom of the section.

Figure 1 does not tell a very clear story until taken in the context of other findings (already highlighted in 4.1 and) in the following report section (4.3 Fish habitat). This is due to the size of the sections, with sections containing different flow types/ depths etc.

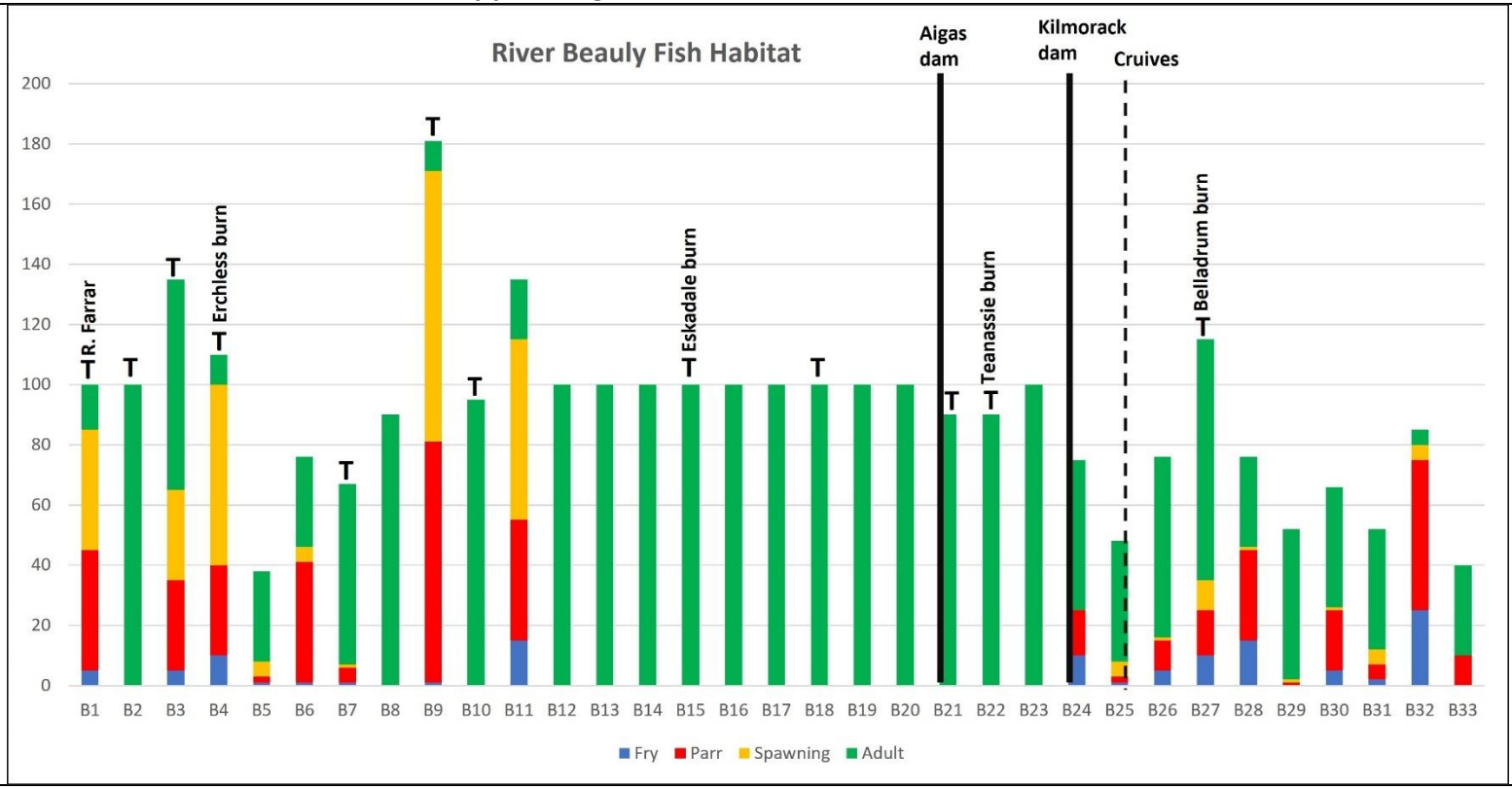
The contribution of Belladrum and Teannassie burns to the substrate composition is visible from Figure 1. However the significance of the pebbles built up behind Cruives is lost in the size of the section (B25). It would be possible to re-calculate the area of each substrate type in each section and display these instead to replace Figure 1 (based on the width and length of each section) however this may lead to misleading results as '1%' was used to imply 'present' during the walkovers and any literal taking of m^2s would have to be avoided. Instead, please see the next section of this report (4.3 Fish habitat), as the results are clearer.

Not shown by Figure 1 is that the main difference in substrate composition above and below the dams is compaction (generally uncompacted above, compacted below) and also how the fines are distributed amongst coarse sediment. Where high levels of fines were recorded above the dams this was generally deposited in discrete areas associated with slow/ no flow rather than occurring in amongst useful coarse substrate. 'Fines' as an indicator were recorded in the lower sections B28-B33 (below Beauly Lodge- Lovat bridge) and may be part of the natural partitioning out of Belladrum burn substrate.

4.3 Fish habitat

Figure 2 summarises the Fish habitat recorded for each section. Fish habitat will not always add up to 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 i.e. wetland). Fish habitat can also add up to over 100% as spawning habitat can be in areas used by fry, parr and adults.

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



The main finding from the fish habitat walkover is that:
There is relatively less spawning habitat available to adult salmon downstream of the influence of Aigas dam compared with above.

This is despite the contribution of Belladrum burn and is partly due to the lack of gravel but mostly down to the compacted nature of the substrate and presence of fines (as previously highlighted in 4.1). Substrate was partly compacted in sections B24-B29 (Kilmorack dam-above Downie hut) and extensively compacted B30-B33 (Above Downie hut- Lovat bridge). The presence of fines interfering with spawning substrate quality was recorded in the lowest sections (B29-33).

The positive influence of Belladrum burn providing spawning substrate is clear from Figure 2.

Isolated old redds were observed during the walkover on the Lower Beauly. Although substrate is available for salmon spawning (albeit with a seeming reduction in gravel composition compared with upstream of the dams), spawning is occurring in areas of **compacted** substrate, where there are often lacustrine plants growing (e.g. *Litorella uniflora*). This was observed during the walkovers where worn (used spawning) depressions amongst *Litorella* and compacted substrate were found. See photo 5 below.

Photo 5: Spawning depression amongst *Litorella* in section B31. P1040956.

This suggests that fish are using sub-optimal habitat to spawn in due to a lack of abundant, suitable, uncompacted substrate. **Substrate quality is likely to continue to deteriorate in the future without improved sediment management**/ recharge from further upstream.

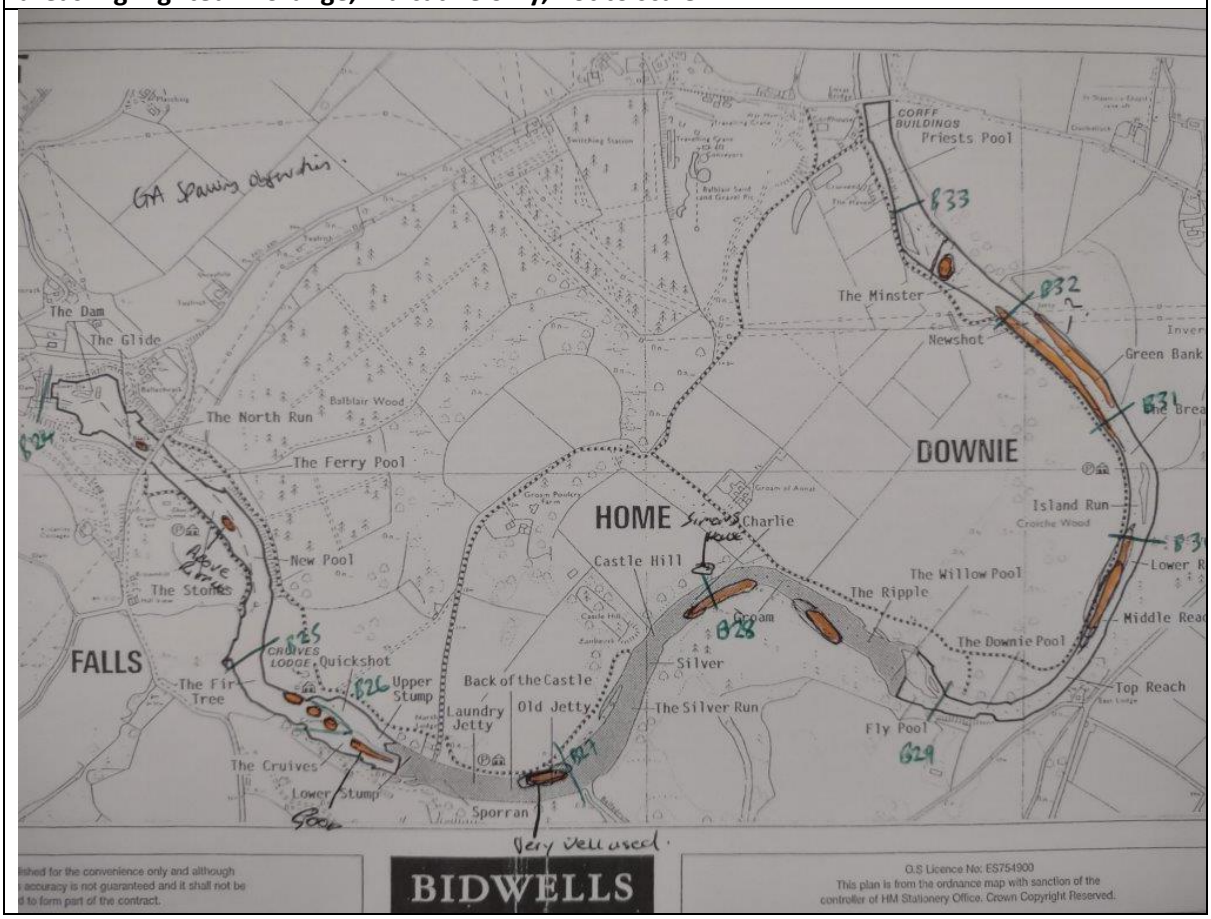
Evidence of spawning occurring downstream of the dam also exists in the form of fish survey data but this is not provided in this report due to time constraints.

Fish appear to be using limited areas and sub-optimal habitat for spawning, which may imply that adults are competing over small areas. There is a potential for a genetic bottleneck as a result of too much competition/ overcutting of redds. Given that the current availability of spawning substrate is only going to get worse, **it is highly recommended that sediment management be implemented in relation to Kimorack dam.**

4.4 Local knowledge

To compare how the fish habitat walkover findings compare to the known spawning locations of adult Atlantic salmon on the Lower Beauly, spawning observations were discussed with the Lower Beauly head ghillie in July 2023. Map 5 below shows known spawning locations of Atlantic salmon on the Lower Beauly below Kilmorack dam.

Map 5: Spawning observations of the Lower Beauly Fishing Syndicate Head ghillie. Spawning areas highlighted in orange, indicative only, not to scale.



These spawning observations confirm spawning to be occurring downstream of the dam, and the areas highlighted are broadly compatible with the walkover findings. The walkover survey identified less areas suitable for spawning compared to the areas actually utilised by adult fish shown here. This is because the Hendry and Cragg-Hine definition of 'Spawning habitat' is defined as "stable but **not compacted**, easily workable with a boot without generating excessive silt release"'. By contrast **adult fish are clearly using compacted areas of substrate to spawn**.

It is also possible that the walkover survey did not identify all of the suitable spawning habitat present due to the width of the Lower River Beauly, however sections B30 and B31 were surveyed from the

the left bank which is where spawning is reported to take place. Additionally, the top of riffles (often providing ideal hydraulic conditions for redds) were carefully inspected to ensure the preferential areas for salmon spawning had been assessed.

4.5 Review of historic images

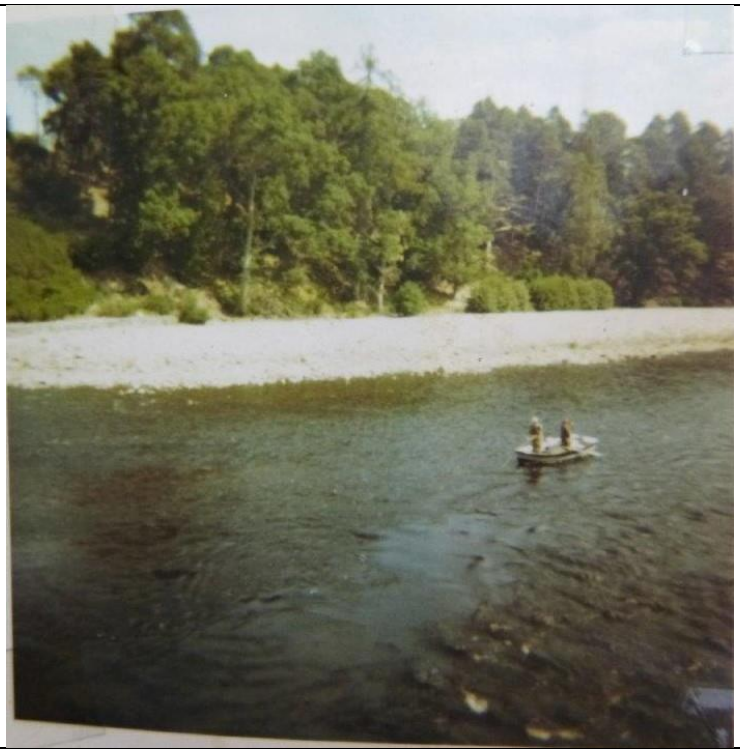
From the previous sections of this report it is clear that there is a lack of spawning habitat in the mainstem river below Kilmorack dam when compared to above the influence of Aigas dam. To investigate if this is a natural occurrence or due to morphological changes seen since the installation of the dams, old photographs were gathered and re-constructed to see what changes have occurred (see Map 6). Summer and autumn 2023 was wetter than previous years and unfortunately most of the present-day photos were taken during medium generation conditions on the river, so it is not always possible to see the changes to substrate in the following photos. However, it would be very rare to be able to see the substrate on normal generation days due to the channelised nature of the river and elevated flow compared to the natural flow regime pre-dams.

Map 6: Locations of re-constructed photo points

1)Immediately below Kilmorack dam; NH49549 44106. Willie's grandfather, shortly after dam was built. A mixture of substrate sizes visible.

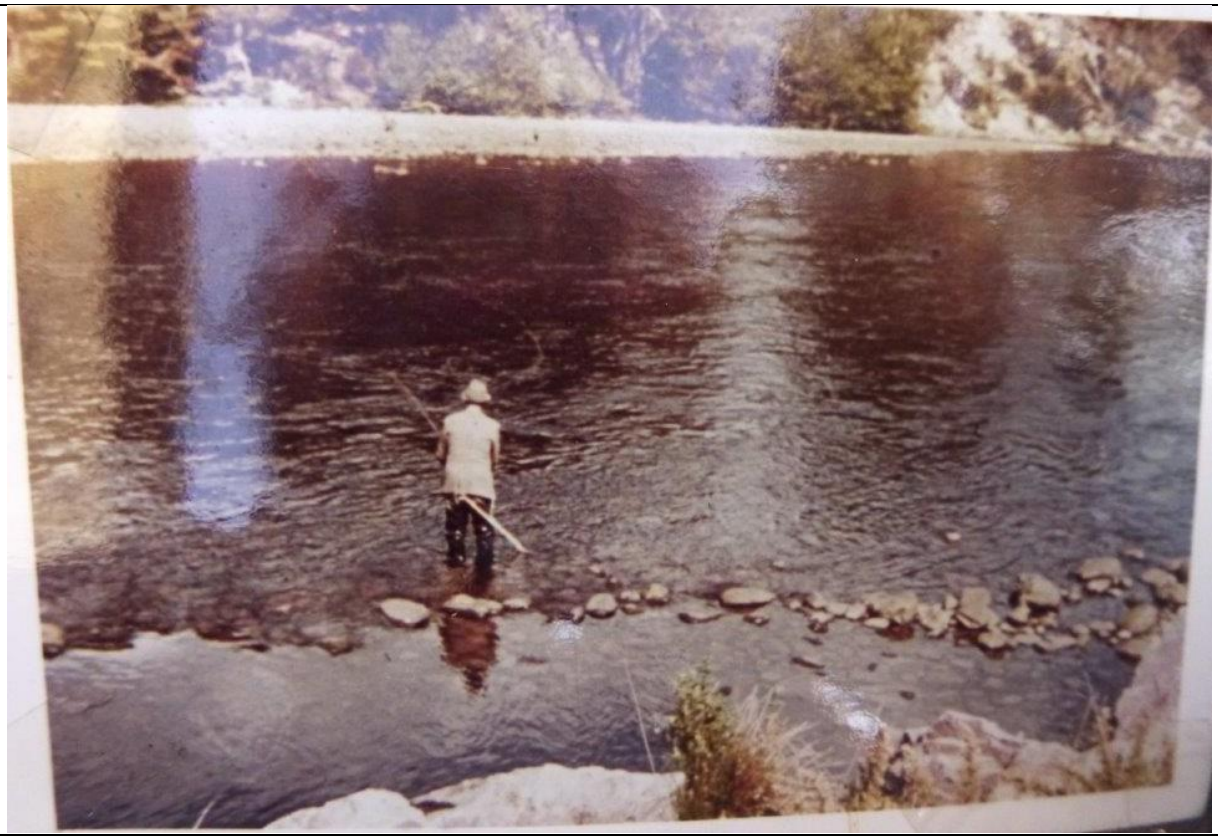
1)Immediately below Kilmorack dam; NH49449 44106, 19/10/23. Water level higher so substrate not visible, encroaching bank. Walkover (section B24) shows substrate to be predominantly cobble-boulder now.

2)Taken from downstream Black bridge shortly after dam was built. NH49741 43975. Gravel bar on far side of channel.



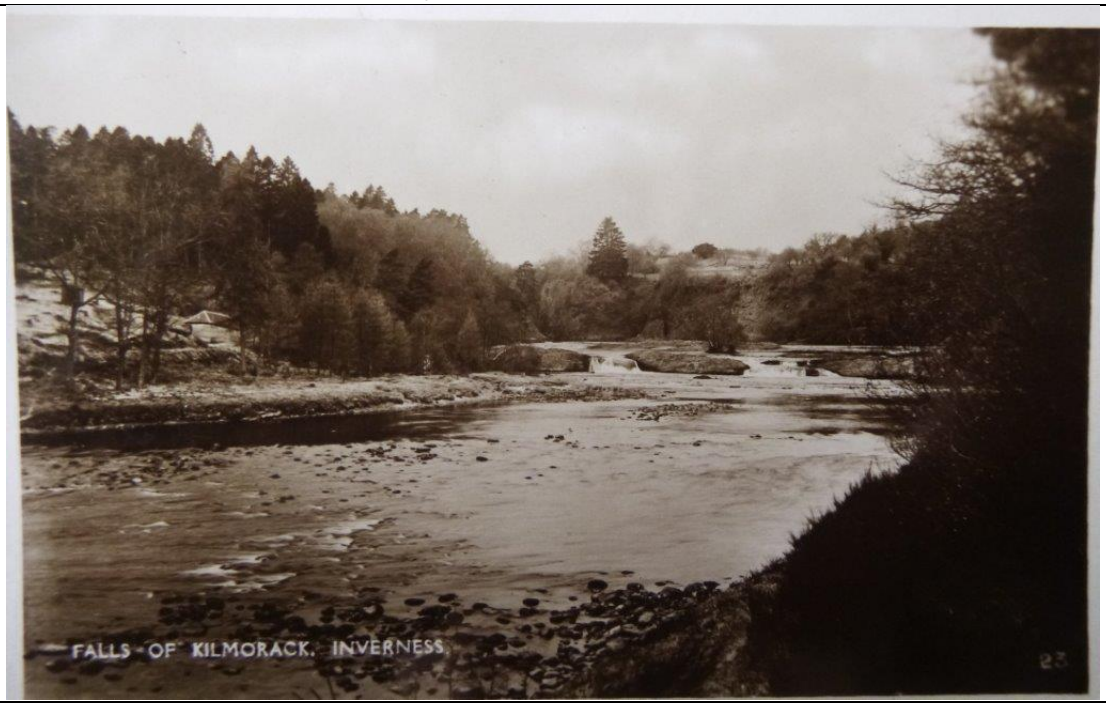
2)Taken from downstream Black bridge. NH49741 43975, 19/10/23. Gravel bar overgrown with trees i.e. stable and undynamic. Also abundance of macrophytes highlighted during walkover (B24).

3)Taken from Falls hut shortly after dam was built. NH49806 43924. Active gravel bar on far side. Cobbles along near bank.



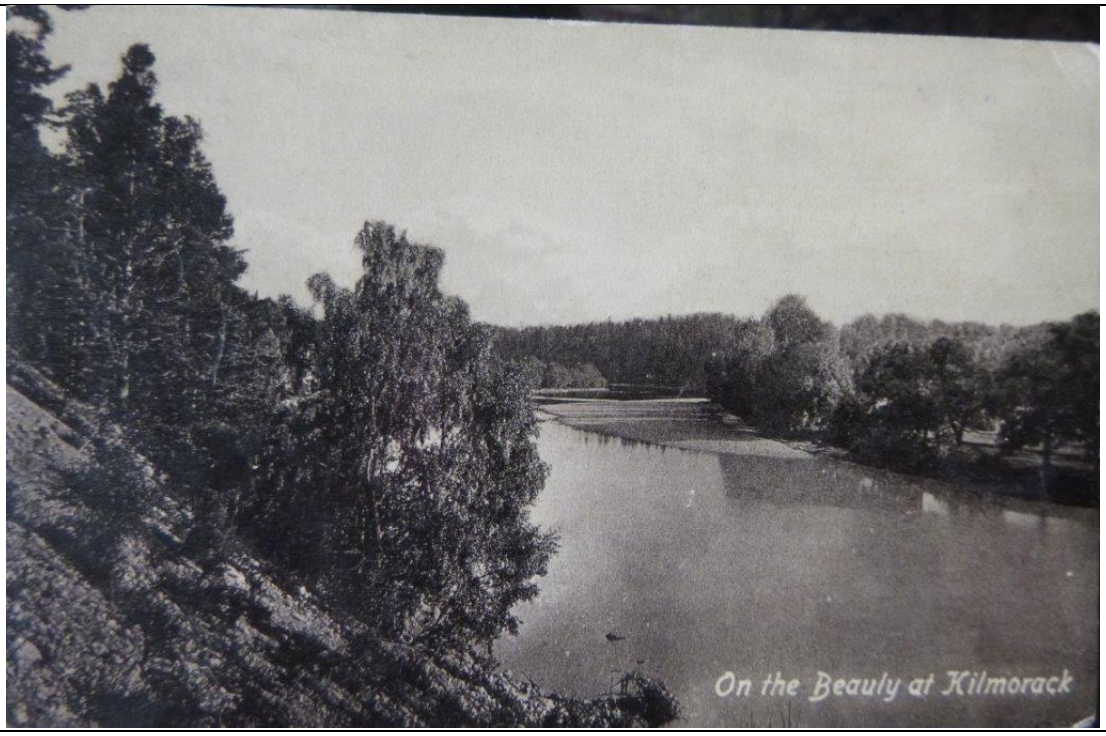
3)Taken from Falls hut. NH49806 43924, 19/10/23. Bar stable and overgrown. Also flows higher but cobble substrate now boulders. Walkover section B24.

4)Looking up to Kilmorack Falls NH49725 44074, 1920s



4)Looking up to Kilmorack dam (where falls used to be) from Black bridge. NH49725 44074, 19/10/23. Island has appeared where cobble riffle used to be, showing stability. (Walkover section B24).

5)Downstream of Black bridge, Kilmorack. 1920s NH49994 43859. Active gravel bar on right bank.



5)Downstream of Black bridge, Kilmorack, New Pool. NH49961 43726. 12/07/2023. Unfortunately the view from the same vantage point is now blocked by trees, however this bar is in walkover section B25 so walkover photo p875 included (taken further downstream, from right bank along bar). Now vegetated.

6)Downstream of Cruives, looking to Beaufort castle and old Red bridge. 1920s or 30s, NH50134 43430.

6)Downstream of Cruives, looking to Beaufort castle, Red bridge washed away. NH50134 43430. Higher flow. Pebble/gravel bars not present during walkover (section B26), now predominantly compacted cobble with macrophytes.

7)Downstream of Cruives, looking to Beaufort castle and old Red bridge. 1930s. NH50202 43422. Gravel bars clearly visible.

7)Downstream of Cruives, looking to Beaufort castle and where Red bridge used to be. NH50202 43422. 19/10/23. Higher flow. Walkover shows this substrate is no-longer there (B26).

8)Downstream of Beaufort castle, looking up to Belladrum burn, shortly after Kilmorack dam was built. NH50868 43273. Vegetated substrate bar.

8)Downstream of Beaufort castle, looking up to Belladrum burn and Beaufort. Photo taken during walkover from further downstream at NH50921 43384 (B27) 12/07/23. Higher flow. Bank is now fully vegetated, and in a defined channel.

Although the higher (artificial, post-dam) water level has resulted in the current substrate being less visible when compared to the historic photos, what clearly comes across is the stability that has developed since the dams were installed.

More photos would ideally be found that cover the lower half of the Lower Beauly below Belladrum burn (from River Beauly Lodge- Lovat bridge). These might be available through the local historical society, St Andrews university, The National Collection of Aerial photography, SSE themselves (as pre-dam photos were taken), or elsewhere.

The main findings from the photo review are that:
-There appear to be a lack of mobile gravel bars that were originally present before the dams were constructed. This is confirmed through the walkover surveys.

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

-The impression is that gravel bars present before the dams were made up of a greater proportion of gravel, whereas now they are composed of predominantly cobble or are absent altogether. This would imply that the isolated spawning patches currently seen on the Lower R. Beauly 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 typology of the river has changed from meandering to plane-riffle.

Anglers who have fished Falls beat for years comment that it is getting more hazardous to fish there due to the now bouldery nature of this beat.

The photos lend support to the walkover findings and help confirm that gravel (an important component of spawning substrate) is indeed missing from the Lower Beauly. This is likely due to a combination of a lack of supply of substrate at the dams and a more stable flow regime.

5. CONCLUSIONS AND RECOMMENDATIONS

-Upstream of the influence of Aigas dam, spawning substrate was generally abundant where flows allowed and five main spawning areas were identified. Key substrate sources identified were the mainstem R. Glass, R. Farrar and Erchless burn.

-Flow was backed-up behind Aigas dam to 7.2km upstream of the dam. **It was not clear where coarse river substrate ends up being deposited above the dam** but it is presumed to be in the last section to have flow or just below here.

-Between the dams, Teannassie burn alluvial fan (1,600m^2) was identified as a currently unutilised substrate source and could be a good source of substrate for use downstream of Kilmorack dam. Provision of a short section of access track would be required.

-The walkover survey and review of historic photos suggest that **there is a lack of gravel substrate below Kilmorack compared to before the dams were installed. This is due to the lack of sediment management at the dams.**

-The main difference in substrate attributes above and below the dams was compaction (generally uncompacted above, compacted below) and also how fines were distributed. Where high levels of fines were recorded above the dams they were generally deposited in discrete areas associated with slow/ no flow whereas 'Fines' as an unnatural occurrence/ indicator were recorded in the lower sections of the surveyed area and occurred in and amongst otherwise useful coarse substrate. **This is likely to be down to a lack of spate flows that would otherwise shift substrate around.**

-Spawning habitat was limited below Kilmorack dam and generally substrate was compacted despite the contribution of substrate from Belladrum burn. The main spawning habitat identified was associated with deposition of pebbles on the upstream side of the **Cruives** structure (uncompacted), above the **Belladrum burn** confluence (the key substrate source for the Lower Beauly) and at the bottom of the island at Fly pool. Apart from this, spawning opportunities appeared very limited to discrete patches of pebbles. In the most downstream sections, a few old redds were observed amongst compacted substrate that were not optimal for spawning due to the significant presence of fines. From the walkover, and information received from the local head ghillie, **it is apparent that fish are using sub-optimal habitat to spawn** in due to a lack of abundant, suitable, uncompacted substrate. **The limited spawning habitat available may be resulting in increased competition by adult salmon and overcutting of redds. A limited prevalence of spawning substrate increases the Atlantic salmon's vulnerability to environmental change. Substrate quality is likely to continue to deteriorate in the future without improved sediment management**/ recharge from further upstream.

-The typology of the Lower Beauly appears to be constrained to predominantly plane-riffle from what was likely to have been meandering before the dams were installed.

RECOMMENDATIONS

-The introduction of sediment management at Kilmorack dam is highly recommended to halt or reverse the decline in spawning substrate availability downstream of the dam. This would be in consultation with SEPA, SSE and in line with best practice sediment management guidance.

-Given the large area of active channel downstream of Kilmorack dam lacking suitable spawning habitat, the one unutilised substrate source identified between the dams (Teanassie burn alluvial fan) would unlikely be enough to provide the level of sediment management/ introduction required below Kilmorack dam. Therefore **it is recommended that suitable alluvium deposits are also won from borrow pits or the existing Breedon aggregate quarry adjacent to the Lower Beauly.** Initial observations show rounded material (past substrate) to be present at the quarry, although further investigation as to the suitability of using this aggregate would be required. Apart from SSE, it may be the case that Breedon have their own green targets and could (in partnership with SSE) help contribute aggregate for sediment management.

-Winning sediment at the Teannassie burn alluvial fan could occur every few years during draw down maintenance activities. A short extension to the existing track would have to be installed in consultation with the land owner (SSE or Lovat estate) and the tennant proprietor.

-Any sediment management in relation to Kilmorack dam would also have to take into account sediment management at the Cruives structure. In his report, Moir observes redundant gravel material deposited on the downstream, N arm of the Cruives structure, however this material was not observed to be present during the walkover survey. Fine sediment release would have to be considered when managing sediment at Cruives structure to avoid silting of spawning habitat downstream.

-It would also be recommended to **assess if any changes to the flow regime downstream of Kilmorack dam could be implemented to help move any introduced substrate about and reduce the potential for substrate compaction.** Any changes to flow regime using the building block approach would have to take into account the urbanisation downstream of Kilmorack dam and **there is likely limited scope for introducing full spate flows to the Lower Beauly**. With this in mind it is recommended that in conjunction with improved sediment management at Kilmorack dam, **the introduction of large woody structures into the mainstem Beauly may help hold substrate up** and increase the time it is retained in the river with potential use for fish and invertebrates. See River Shin final report [2] where restoration work for FWPM (and salmon spawning potential) was achieved within the original hydro flow regime using large woody structures.

-The presence of Fresh Water Pearl Mussel on the Lower Beauly may provide an opportunity to access grant funding. In conjunction with better sediment management, grant funding could be applied for to install large woody structures on the Lower Beauly to help hold useful pebble/ gravel substrate in the river for longer. The precise locations of live FWPM should be sought through a request of survey data to NatureScot.

-Any changes to sediment management or flows will have implications for the form of the river downstream of the dam. This may have direct benefits to anglers (e.g. making Falls beat easier/ safer to fish) but also may result in changes to the location of historic fishing pools, with new adult fish

holding areas appearing elsewhere. The Lower Beauly Fishing Syndicate, Lovat estates, other local stakeholders would have to be fully consulted.

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

-Fish survey data (although limited for this stretch of river due to river width) this could be analysed to provide further insight into how fish are using the Lower Beauly. Time constraints limited this data from being included in this report.

-Old photos downstream of Belladrum burn are likely to exist and would complete the picture of how the river was pre-dam.

-Please note the gradient for each section was not calculated for this report, however the typologies present (outwith the now slack areas above and between the dams) imply that fish spawning could occur along the entire reach surveyed where flow is present.

REFERENCES

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

[2] Kyle of Sutherland Fisheries Trust (2022). Biodiversity Challenge Fund, project 501679: Restoring Freshwater Pearl Mussel Habitat on the River Shin - End of Progress Report.

[3] Moir (2019). River Beauly Cruives Structure: implications for Atlantic salmon habitats and options for management. CBEC Report.

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