Glenan Woods
River Restoration Assessment Summary For West Glenan Burn

The Glenan Woods site visit was done on the 17th of May, 2023. Two stream were assessed on the day – West Glenan Burn NR 92122 70540 and an unnamed burn located North of West Glenan Burn NR 91889 70856. Both Burns discharge into Glenan Bay, Loch Fyne.

West Glenan Burn has 1.5m wet width and 3m bank base width average. It is a single-thread channel stream with tidal character. The burn flows through a medium gradient. The geomorphic river typology changes from *active meandering* on the lower reach, changing to *plane riffle* and *plane bed* in the middle reach where the gradient starts to increase, with short sections of *cascade* and *step pool* type of stream, especially on the gorge areas where the gradient is high and the valley adopts a vee-shaped form.

Channel pattern of the West Glenan Burn starts with a meandering planform, soon to become a straight channel with low sinuosity as the gradient increases.

Bed sediment distribution varies from gravel and pebble as a dominant sediment size class, to pebble and cobble and more frequent boulders as the gradient increases. There are short sections of bedrock, especially in the gorge areas. The bed condition is mostly stable along the middle reach, with large stretches of sediments covered with algae. The lower reach bed condition is unstable with deposition of new sediments coming from upstream after each flood event. This is what would be expected naturally in the lower meandering reaches where the gravel is deposited creating point and side bars (sediment depositions) after a rainfall.

The dominant flow type in the lower reach is *smooth*, especially where the riffles (shallow bed areas) and glides (deeper and slower flow type) are present. This is the most common flow type on the assessed area of the West Glenan Burn. *Still* flow type is scarce in the middle system due to lack of pool habitat. Most of the pools are located in the lower reach and on the meandering bends. *Broken* flow type is present where step-pool stream is present as the water falls from a step created from boulders into a plunge pool below it.

The dominant salmonid juvenile fish habitat is fry and mixed juvenile. There are few sections of adult habitat where the water depth is >0.8m but these are limited. Salmon and trout spawn in freshwater systems, where the river is well oxygenated. They like a substrate size range from gravel size to cobble size (pea to golf ball for trout and golf ball to orange for salmon). They make nests called redds where they lay their eggs. Once the eggs hatch, they become alevins and shelter under and in-between the substrate until they have develop to fry and then parr before they leave the freshwater system as smolts to go to sea. Fry and parr are able to swim and feed through the river system. This is their most vulnerable lifecycle stage. At this point their optimal habitat is where there is enough food supply from aquatic and terrestrial invertebrates and woody features (LWS – large woody structures and CWS – coarse woody structures) so they can shelter from predators. In order for them to have this type of habitat, the river system needs to have enough riparian trees on the banks which would fall and become large and coarse woody features (instream and on the riparian area). The branches would create dappled shade and be a source of nourishment in the form of invertebrates for fish and other wildlife to feed upon. The large woody features would increase habitat complexity, creating areas of deeper pools which are necessary for adult fish returning from sea or just sheltering while migrating through the system. LWS increase spawning areas as the sediment deposits where the flow slows down. LWS reduce water temperature fluctuations and create refuge and shelter for fish. In summary, LWS would increase the amount and quality of habitat available for fish and other wildlife to complete their lifecycle.

On the site visit day, it was observed that optimal pool habitat was scarce through the assessed area of the river. The upper catchment was not assessed on the day of the site visit.

The dominant riparian habitat and the surrounding land use is complex with mixed woodland where broadleaved species (birch and oak) are the dominant type. There is also presence of non native conifer species. There is clear sign of natural regeneration occurring in the catchment area. However, the saplings are struggling to develop as browsing pressure is high, most likely deer. Therefore, the woodland is mainly a single age type.

The bank cover for fish species is mainly undercut and draped and it is extensive on both banks. This is a positive factor in the river ecology as fish, birds, mammals and amphibians rely on aquatic and terrestrial invertebrates to feed on. Dead and live wood with branches in the water create the space for the invertebrates to grow and fish need it to shelter in high or low flows. LWS or CWS also provides refuge from predators, cooler temperatures and have improved habitat availability for the different life-stages, so the migratory and resident fish compete less for space and resources.

There is presence of bank erosion along both banks, especially present in the low reach of the system. The river is incising too at this point and unable to connect to the floodplain.

On the day of the site visit, there is presence of invasive non native species, such as *Rhododendrum ponticum* along the riparian banks. Currently, the amount of it is limited but if not eradicated soon, it would expand fast and impact negatively on the local habitat and initiate biodiversity loss on the local area.

RESTORATION RECOMMENDATIONS

The recommendations are based on purely natural processes of the land and the fluvial system. It is taking into account what would be the best for nature and no other private interests where included. The areas benefitting from enhancement from the estuary to the upper sections, avoiding the areas of gorge and bedrock and focusing on stream types such as meandering (low reach of the catchment), plane riffle and plane bed (middle reach). These are the areas where the techniques recommended would be most effective.

1. The first recommendations and the most effective one for creating a natural river system and the adjacent land is to reduce the deer population to numbers that allow for natural regeneration. A rough gauge of sustainable numbers is 3 to 5 deer/km2. The most effective way of doing so it would be through active deer culling. Another way of managing the deer population it would be through erecting a fence and excluding the deer from the area. However, this is not the most beneficial way of dealing with high deer population as they would be pushed to the surrounding areas and having more impact on the adjacent land. It is also important to mention that deer are woodland animals and they should be part of the native woods. Deer, currently, do not have predators. In natural circumstances predators would be part of the natural equilibrium of a river and land system, thus the population numbers should be managed by a cull as any other option would be a temporary solution.

2. The second recommendation is to control the INNS, such as *Rhododendrum ponticum*. It is clear that this species has travelled into the area, mainly on the riparian corridor. Its areas are not extensive at present, however, as by its nature, it will propagate fast and it would be much more difficult to get on top of it in the near future.

3. The third recommendation is to enhance the river system through introducing large woody structures and creating beaver dam analogues mimicking what it would happen naturally. In natural conditions, rivers would connect to its floodplain wherever there is a floodplain area. From the

confluence and the low reach, the West Glenan Burn cannot connect to its floodplain naturally as features such as large wood and log jams are not present in high densities. There are signs of natural dams starting to form in the stream as well as LWS, nevertheless they are present in limited numbers. Abundance of this type of features in the West Glenan Burn would increase the availability of habitat complexity and therefore, the biodiversity of the whole area.

3.1. LARGE WOODY STRUCTURES (LWS)

The installation of large woody structures can be done in different ways, such as:

- Tree hinging. There is an optimal amount of trees on the banks for carrying out this type of action, where the tree is cut partially and left on the hinge and the rest of the branch is directed into the water.

- Tree kickers: This is a technique where a large tree is cut completely (or on part of the trunk it is multi-branched) and secured on site so it does not travel downstream in high flow events. This is a very effective way of creating complex instream habitat.

3.2. BEAVER DAM ANALOGUES (BDA)

This type of woody structure mimics the type of dam that beavers would make if they were present in the system. Beavers would have been present in the majority of streams across Scotland but they were hunted to extinction.

BDAs bring numerous benefits to the river processes and ecology, such as connecting the river to its floodplain; increasing the height of the water-table and water storage (hugely important for the future water availability); they can also create abundant habitat complexity for a wide range of wildlife and overall make the whole fluvial system more resilient to the rapidly changing climate.

For the dams to be the most effective, it is recommended that six of them are installed in close proximity as the burn is less than 3m wide average, especially on the lower reaches of the catchment where the burn is experiencing floodplain disconnection and the burn is incising.

Quite recent studies show that beavers are not only freshwater engineers but also play an important role in coastal areas. They have been found making dams in brackish water and restoring estuary habitats.

'Greg Hood, senior research scientist at the Skagit River System Cooperative in Washington. Hood's research suggests beavers are equally indispensable along the coast, engineering deep pools for fish, including juvenile salmon, in estuaries plagued by habitat loss'.

West Glenan Burn is a small stream that discharges into Loch Fyne. At the estuary, on the lower reach, the burn meanders through brackish water. This is the area where the dams could be installed.

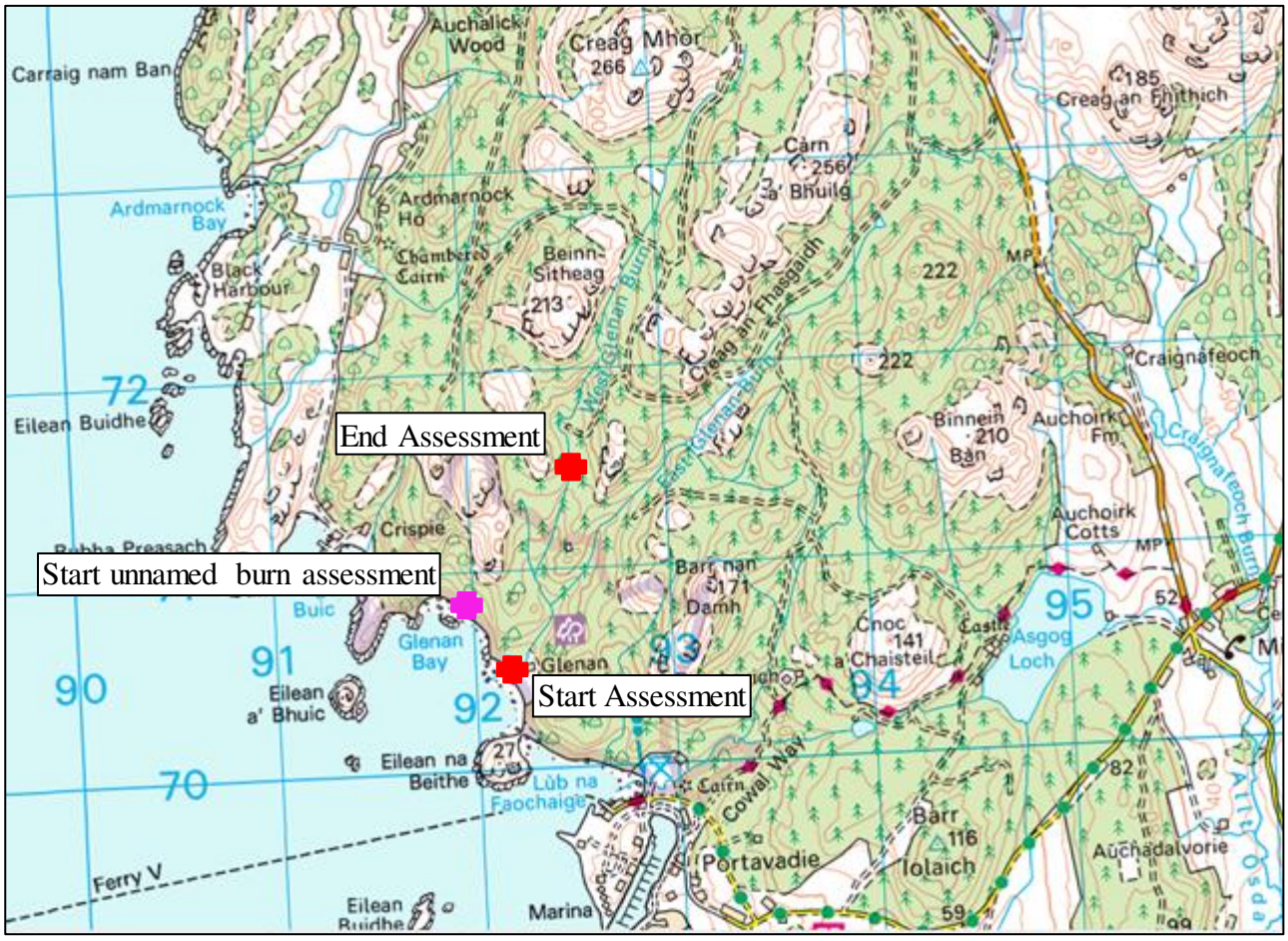

Fig. 1: West Glenan Burn site overview. Red crosses show the start and end points of the visited area. Purple cross shows the start of the unnamed Burn.

Fig. 2: Aerial imagery of the lower reach West Glenan Burn. The yellow lines represent the recommended areas for installation of beaver dam analogues (BDA).

PHOTOGRAPHIC REPORT WEST GLENAN BURN

Fig. WGB1.1: View downstream at the estuary.

Fig. WGB1.2: View upstream. Pool-riffle sequence.

Fig.WGB1.3: View downstream. Beaver dam analogue (BDA1) proposal site. Grid reference - NR 92183 70556

Fig. WGB1.4: Overview of the floodplain/wetland area. The burn is currently disconnected from the floodplain.

Fig. WGB1.5: BDA2 site proposal. The tree and the accumulation of coarse wood are starting to form a log jam. The accumulation of coarse woody structures should be encouraged enhancing the already existing features by

Fig. WGB1.6: View of the channel and both banks. The process of sediment aggradation is starting to develop naturally but more coarse and large woody structures are needed to connect the burn to the floodplain at much lower bank height

creating a BDA. The blue arrow indicates the flow direction. There is a depositional bar forming upstream of the woody feature. In the future the aggradation of sediments will enable the channel to connect to the floodplain at a lower bankfull height. This is process is desirable. The BDA would encourage it even more.

that occurs in an incised channel at present. Yellow line indicates the BDA2 installation proposal. Grid reference - NR 92214 70521

Fig. WGB1.7: *Rhododendrum ponticum* on the right hand bank. This INNS is present in upper reaches too. The eradication of this species should be a priority action.

Fig. WGB1.8: View downstream of the third site for installation of BDA (BDA3). Grid ref. - NR 92250 70540.

Fig. WGB1.9: View upstream. Proposed BDA site installation (BDA4). Grid ref.- NR 92250 70551

Fig. WGB1.10: Sediment type on the lower reach – gravel, pebble and cobble sizes are the dominant size type. There is algae formation on the sediments indicating that sections of the burn have stable bed.

Fig. WGB1.11: Active meandering geomorphic type of stream. Location of the proposed installation of BDA5. Grid ref. - NR 92242 70566.

Fig. WGB1.12: location of the proposed installation of BDA6. Grid ref. - NR 92245 70575.

Fig. WGB1.13: Plane bed geomorphic type of stream characterised by boulders jotting through the surface with limited sediment depositions (barrs) and quite uniform flow type.

Fig. WGB1.14: Plane riffle type of stream with a short sequence of riffle-glide-riffle (shallow and faster water and deeper and slower flow sequence).

Fig. WGB1.15: Bedrock and cascade type of stream.

Fig. WGB1.16: Deer tracks are present in the whole lower and middle reach.

Fig. WGB1.17: Naturally occurring large and course woody structures in stream beneficial to the river processes and creating complex habitat for a wide range of wildlife.

Fig. WGB1.18: Vee-shaped valley form where the river flows through a gorge. The dominant tree species at this location is oak. However, the young saplings (observed on the site on the day of the site visit), get grazed by the presence of high deer numbers impeding the successional formation of a mixed woodland with various tree ages.

Fig. WGB1.19: *Rhododendron ponticum* on the middle reach, expanding rapidly.

Fig. WGB1.20: Birch woodland area on the middle reach. Natural regeneration present with young saplings that do not develop further as deer feed on them. Thus, the woodland has no a mix of ages.

BDAs INSTALLATION EXAMPLES

Below are the examples of the planform, cross section and profile view of a beaver dam analogue installation method using, in this case, posts and brash. BDA could be installed using different techniques depending on the river typology and each case scenario should be considered prior to installation. It is highly recommended to contact an experienced person for advice on how to install these structures correctly as otherwise, the river can start destabilising the bed and/or banks at undesirable sites.

For more information regarding BDAs and installation methods, could be found on the Utah State University website. It shows detailed design examples. However, the understanding of the rivers and its processes is vital in order to carry out river restoration.

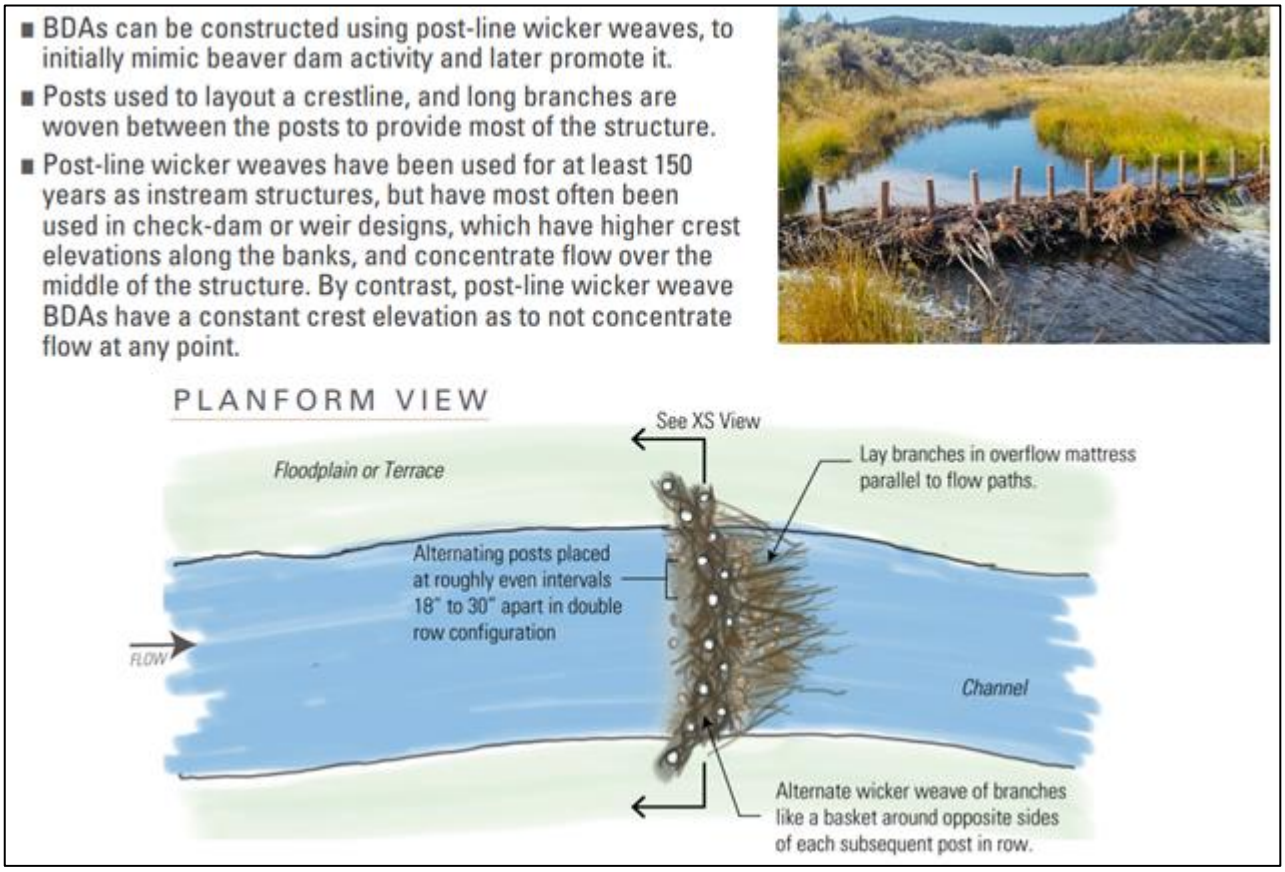

Fig. BDA1: Planform view of an example of a beaver dam analogue (BDA) using posts and brash. Utah State University.

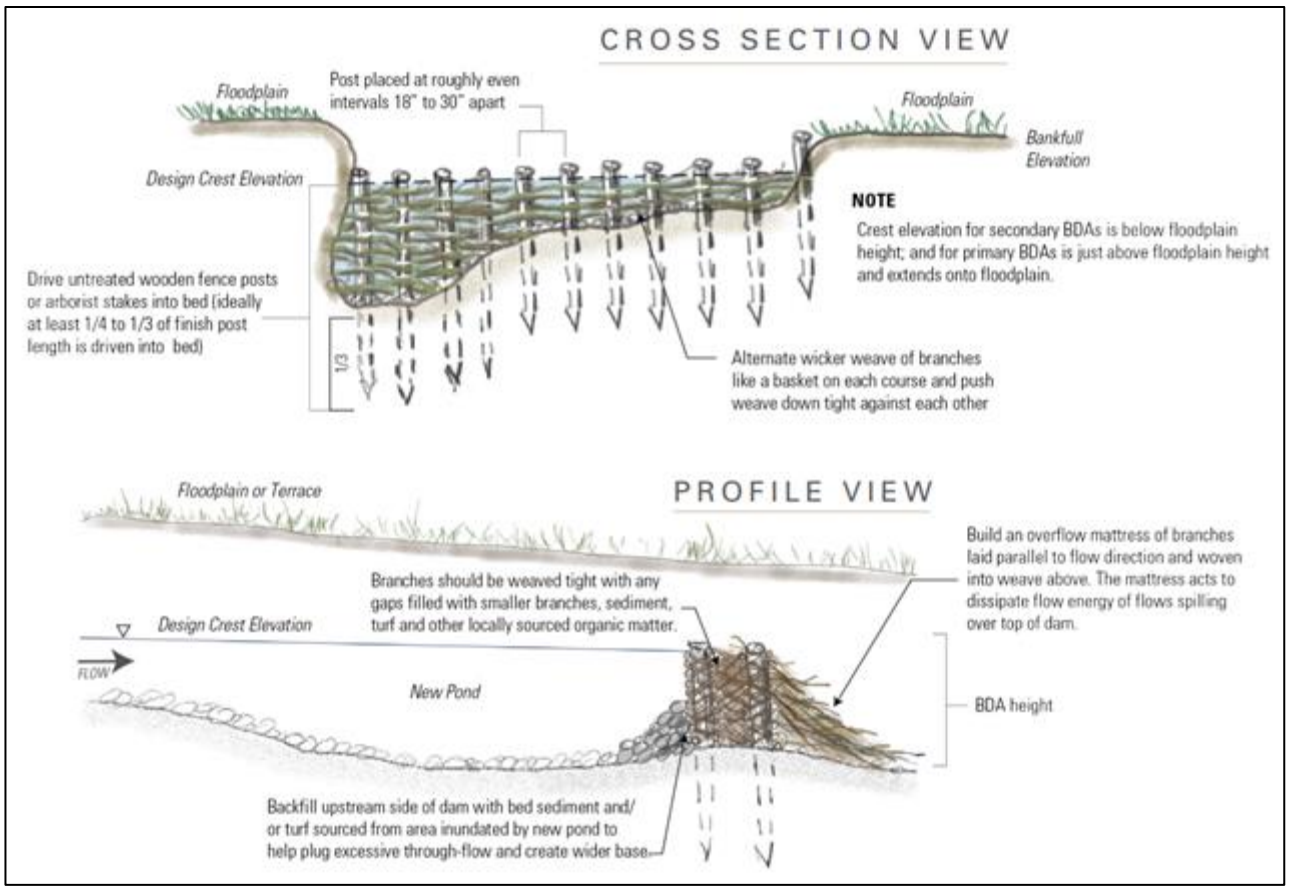

Fig. BDA2: Example of a cross section & profile view of a BDA. Utah State University.

REFERENCES

J.M. Wheaton, S.N. Bennett, N. Bouwes, J.D. Maestas and S.M. Shahverdian (Editors), Low-Tech Process-Based Restoration of Riverscapes: Design Manual. Utah State University Wheaton Restoration Consortium, Logan, Utah.

Rosgen, David L. 1994. "A Classification of Natural Rivers." *CATENA* 22 (3): 169–99.

SEPA geomorphic river typology. https://www.sepa.org.uk/media/152194/wat_sg_21.pdf

Wheaton J.M., Bennett S.N., Bouwes, N., Maestas J.D. and Shahverdian S.M. (Editors). 2019. Low-Tech Process-Based Restoration of Riverscapes: Design Manual. Version 1.0. Utah State University Restoration Consortium. Logan, UT. 286 pp.