RIVER RESTORATION ASSESSMENT OF THE STREAM PROJECT

EXECUTIVE SUMMARY




Report by

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Project Background

The STREAM project was a £1 million four-year conservation project centred on the River Avon and the Avon Valley in Wiltshire and Hampshire. The River Avon and its main tributaries are designated as a Special Area of Conservation (SAC), and the Avon Valley is designated as a Special Protection Area (SPA) for birds. The STREAM project has undertaken strategic river restoration activities and linked management of the river and valley to benefit the chalk habitat including populations of Atlantic salmon, brook and sea lamprey, bullhead, Desmoulin's whorl snail, gadwall and Bewick's swan.

The approach to the restoration works is to reinstate the physical form and diversity of the river channel, creating dynamic habitats that are sustained by the river's natural flow regime. The aim of the works was to demonstrate novel and appropriate restoration techniques for the chalk river types within the River Avon SAC, but the approach should be applicable to other rivers supporting *Ranunculion fluitantis /Callitricho-Batrachion* communities.

Works included bank re-profiling to a more natural slope, non-native tree felling and native tree planting, reconnecting the river to its floodplain, and enhancing currently poor marginal habitat, which is known to be critical to fish and invertebrates in lowland rivers.

The key objective of the restoration work was to demonstrate restoration techniques suitable for recreating favourable condition for the River Avon SAC species and habitats.

Monitoring

Monitoring the success of the restoration works was undertaken by Royal Haskoning (Haskoning 2009), with the River Restoration Centre (RRC) carrying out a series of River Restoration Assessment surveys. The RRC surveys were planned to be carried out pre, during, just after (as built) and post the restoration works. The projects were divided into physically distinct reaches each of which was assessed separately. The reaches include one or more upstream of the restoration (recording upstream impact) and one or more downstream of the restoration (again recording any subsequent impact). Repeat photography was also carried out and a set of maps showing the location of the photographs was produced.

The RRC pre project assessment includes a précis of the objectives and background information, the reach characteristics including width, depth, bank and bed material, vegetation, land use and quality of ecological habitat along with the short and long term potential impacts of the restoration work.

The 'during construction' pro forma includes information about the contractor and a technical site plan. The form also includes a summary of predicted short and long term impacts (both positive and negative). There are then a number of questions relating to the construction programme and costs and a section related to changes to the original design.

The post and as-built assessment additionally provides an inventory of restoration techniques and an assessment of the number of different aspects of the project including;

- Visual and social elements;
- Physical characteristics;
- Vegetation;
- Fish & Aquatic Invertebrates, and;
- Mammals, terrestrial invertebrates and birds

The potential changes, both short (recovery from the physical works) and long (beyond the lifetime of the project) term, are then identified and an appraisal of the techniques used is carried out. The overall project was then assessed and future improvements and management requirements identified along with the potential for adaptive management and future restoration opportunities.

Restoration Techniques and Lessons Learnt

River Nadder at Fovant

For the Fovant site the most significant action was to raise the hatches which had previously impounded the river through the restoration reaches. In addition 'dragon's teeth' deflectors were built out from the banks to narrow the channel by allowing silts to build up between them which would subsequently become vegetated. Some limited gravel re-working was also carried out.

Dropping the impoundment has completely altered the flow conditions, reduced depth, speeding up the velocity to remove deposited silt and keep the gravels 'clean', and providing for the full range of flow types from low flow to overbank events.

The 'dragons teeth' deflectors generally succeeded in reducing channel width at low to moderate flows, defining different velocity zones (eddies and faster flowing runs) enabling the river to deposit silt load in the slow flowing zones and clear (and subsequently keep clear) the central flow path. The 'dragon's teeth' also provided a source of vegetative material to start the colonisation of these marginal silt berms. Tree removal to reduce shading has had a considerable effect on opening up the river and should aid the colonisation and establishment of a *Ranunculus* type habitat.

The gravel redistribution has also worked to speed up the physical process of transportation of gravel and deposition in the lee of the deflectors. Such minor reworking of a mobile gravel bed has been undertaken elsewhere where physical or hydraulic modifications have previously reduced the ability of the river channel to develop appropriate features on its own. The wood deflectors install in the reach just above the hatches demonstrated that larger deflectors were more effective. In addition alternating the deflectors on the left and right banks would have created a much more sinuous flow.

Many of the deflectors were protruding out of the water too far, so at high flows they were not drowned out and scouring was occurring resulting in the cross logs getting exposed and in some instances the matting was rolled up.

The sill of the hatches continued to act as an impoundment and ideally the entire structure should be removed to allow the free passage of water. The originally planned ditch works would create ideal habitat for Desmoulin's whorl snail and other wetland aquatic species. It is therefore suggested that when appropriate conditions prevail the works should be carried out.

For this site potential for major restoration was always limited by the presence and need for continued existence of the Iron Hatches structure. Its removal and subsequent bed re-grading could have further improved the success of the restoration work, allowing clearer fish passage to the upper reach, but only as far as Teffont Mill. However, this work would have been significantly more costly and the benefit in relation to the cost to the SAC interest more difficult to quantify.

At Fovant, flood flows are likely to be less dramatic than on other non-chalk stream river types and this deflector installation was perhaps more involved and costly than was necessary. It also required more accuracy in terms of locating its surface height in relation to summer flows. Some of the deflectors are obviously set too high and there has been erosion of the top surface

and may eventually lead to disintegration of the structure (though the presence of a river keeper ensures that periodic repairs can be carried out before the structure becomes too unstable).

Some deflectors were located in inappropriate locations: heavily shaded thus negating the ability of macrophytes to colonise the deflector and silt berms which would lead to their stabilisation. Here the deflector may eventually fall apart and any collected silt will then wash away without vegetation to prevent this.

The two deflectors (the final two to be installed), just above the hatch, are perhaps the most appropriately sized of all the deflectors and provide a significant reduction in flow width (approx. one third reduction). Practically, the workforce are always likely to get better at installing the same structure at each subsequent attempt, so the fact that the last two were the best sized is not surprising. This really just highlights the benefit of using experienced contractors to implement technical works.

River Avon at Upper Woodford

At this site new mid-channel islands were created to narrow the channel and create flow variability. In addition 'D' shaped deflectors and marginal brushwood ledge were installed to narrow the channel and a causeway was built to create slack water areas to act as refuge areas for fish fry.

The upstream causeway has narrowed the channel from it's significantly over-wide state. The thin strip of made land now separates an area of slow flowing to still water (beneficial for fry and ammocoetes). The islands act to split flows, add woody material to the river (as a habitat for invertebrates and fry) and this in turn will accrete silt and provide a good growing medium for further vegetation growth. The establishment of tall willows on the islands may need to be managed by the river keeper, or they could be left to establish and provide much needed shade and cooling to river in summer months, improving resilience to climatic warming.

The 'D' shape brushwood deflectors are similar to the islands in their make-up and intended purpose. They have vegetated well with a mix of marginal and emergent plants and shrubby willows. The deflectors still have shallow areas of open water within them providing fry habitat. The marginal brushwood ledge also provides additional edge habitat for smaller fish and lamprey young.

As with Seven Hatches the implementation of a suitable hatch operating protocol should ideally occur before design of any restoration works such that the altered conditions are then used as a baseline for the planned work. This was not possible here as the operating protocol was developed in parallel with the demonstration projects

For this site potential for major restoration was always limited by the impoundment of the weir downstream. There removal of the weir would have a considerable benefit for all the upstream reaches.

The initial design specified additional deflectors at the lower end of the site however it became apparent on the initial pre-works assessment visit that these structures would have very little impact if implemented as flow velocities were so low. Subsequently the hatch operating protocol has been proposed which should reduce the adverse impact of the impoundment.

An obvious lesson learnt from this project is the issue of designing works based on only a short term data set. The designs were carried out based on preceding years flow records being below long term average. Subsequent to the restoration work being undertaken flows switched to being above long term average. This change, coupled with a successful increase in *Ranunculus* growth, raised water levels significantly. These two elements should be borne in mind at other sites, especially on chalk streams where wet years and summer submerged macrophyte growth can have a large effect on water height.

River Avon at Hale

The main opportunities for restoration work at this site were bed-raising by introducing gravels and the introduction of large woody debris to create localised slower flowing water which would act as refuge areas for fish fry. The open aspect of the river bank could further be enhanced by the planting of native trees which would afford some additional shade to the channel and increase the habitat for birds.

The restoration work has had a significant effect locally. The new riffle site in has created variable flow regime locally. The riffle site where the gravels were re-worked has also created flow variability but it is less pronounced. Generally the river is still over-wide and over-deep. The proposed tree planting does not seem to have been carried out and both banks, particularly in the upper reaches are devoid of tree cover and therefore the opportunity for woody debris to develop is limited. More gravel riffles and larger wood debris and tree kickers need to be installed to create more flow variability and potentially create areas of slack water suitable for fish fry to take refuge in

The new riffle was performing well and fish are now using it to spawn. However, the river is still over widened here and more flow variability would create a more varied habitat. There are no pools in this reach and generally a lack of areas of refuge. The re-arranged gravel riffle is performing well creating flow diversity. This reach generally has uniform flow and a lack of pools which would act as refuge areas.

The tree kicker which was installed was not large enough. It was creating flow variability but only on a very local scale. Deflectors were only creating much localised flow variability. They probably needed to be larger and protrude out into the river more. At the time of the post works site visits flows were high. A follow up visit at low flows might reveal the effect of the deflectors.

River Wylye at Seven Hatches

Part of the original aims for the Seven Hatches site included setting a new hatch operation protocol whereby the radial gates would be raised in order to lower the water levels upstream of the hatches. However, the local fishing club expressed their reservations about lowering water levels in this reach because of concern over the reduction of flow entering Butchers Stream. Thus the main restoration works at this site consisted of installing berms created from large woody debris which protruded into the river out towards the centre of the channel with brushwood wired in between the deflectors. These were then planted up with native emergent vegetation species. Downstream of the hatches gravel riffles were installed with woody debris pinned to the substrate within the riffles to create flow variability.

The introduction of gravels and the creation of riffles were largely successful in that increased heterogeneity in flow types was achieved. Additionally, the riffles had large woody debris pinned into the substrate. This increased the flow variability locally and there was evidence of scour taking place on the downstream side of the structures. In the long term it is predicted that the turbulence at moderate to high flows generated by the woody debris will help to ensure that the riffles remain free of excessive siltation.

The channel narrowing techniques (berms) were successful in terms of providing marginal vegetation features. The system of brashings and log deflectors upstream of the hatches trapped silt and sediment. The deflectors have improved the heterogeneity of the habitat, providing shallow well vegetated margins close to the existing deeper water. Larger structures would have had a more significant narrowing effect; however this would likely have had an adverse impact on flood flow conveyance.

For this site potential for major restoration was always limited by the existence of the structures, however many such structures exist all along the Avon where they cannot as yet be removed, so demonstrating approaches to best improve the adjacent habitat was necessary.

Changes resulting from this restoration work were further limited by sub-optimal operation of hatches in that the hatches could not be lowered and therefore the upstream impounding effect remained the same as before. The planned changes to the hatch operation which would have lowered water levels in this reach were not carried out because of the concerns about reduced flows and the potential effect on salmon in Butchers Stream and flooding downstream in Wilton. This project demonstrates the need to be certain of the ability to be able to influence flow management through structures and be aware of all possible concerns that may otherwise arise, but without the hatch operating protocol also developed through this four year project this is unlikely to have been more easily achievable.

The narrowing above the hatches could have been bolder than was actually carried out. The log deflectors could have protruded much further into the channel and the brushwood infill and log staked wet ledge could have then been wider. However, what was installed is developing well.

The result of the planting scheme was not as varied as was originally planned because many of the plants did not survive as a result of water levels being higher than expected due to wet winters and wet summers. However, often planted vegetation takes a number of seasons to establish well, and any 'gaps' are usually colonised by spread from other planted species or through silt and seed deposition of upstream macrophytes. It could be a number of years before the ledge vegetation reaches its full potential, something that is often outside the reporting phase of a 4 year project.

The combination of gravel introduction and log deflectors improved the flow variability. The combination of the two techniques (gravel augmentation and log deflectors) has improved their individual effectiveness. Between the riffle sections the water is still deep and substrate is silty. Due to the depth of the channel, cost of material and the resulting short distance of overall length of the riffles the majority of the river remains over-deep and over-wide. Significant benefit could be accrued by this approach but only with a much larger investment of funding.

The tree deflectors needed to be much bigger and protrude into the river much more to have desired more visible and immediate effect. Felling and securing large willows directly in to the river could have been more effective. Localised flow variability has been achieved, and this signifies that the deflectors are likely to have the desired effect, but could take a further 5+ years to gradually begin to re shape the channel through year-on-year deposition and vegetation growth. This has been observed in other silt laden channels where very minor changes in flow velocity by submerged log deflectors have slowly accreted significant vegetated marginal ledges.

River Avon at Amesbury

The restoration works aimed to create variability of flow types and encourage vegetation growth and siltation to narrow the channel. Some limited gravel shoal introduction was undertaken. In addition, in the reach downstream of the A303 road bridge the bank was pushed into the channel to give an instant narrowing effect. Deflectors were also installed which consisted of upstream facing large woody debris, also willow saplings were partially cut through and bent over to lie on top of marginal reed beds.

The marginal riparian fringe laid onto the reedy marginal edge should over time aid the continued development and stabilisation of this area, acting to narrow the channel. The tree deflectors have worked very well where placed in series and where they were larger and extended further into the channel. Currently they simply disrupt the flow pattern, but have already begun to accrete silt and allow vegetation colonisation. In addition the deflectors have been collecting cut weed forming rafts providing cover for fish.

Pushing forwards the stable marginal edge had only been carried out successfully on a couple of river systems in the UK. The intact root system is continuing to provide structure to the mass that has been moved, especially the leading edge. The narrowing achieved here is immediate but

does not involve placing additional material into the channel and therefore does not reduce the capacity of the river to convey floods. This technique is simple and very cost effective as it requires no additional material and only one long reach excavator operator, and generates no waste material. The bank re-profiling could have extended further into the river which would have made it even more effective.

The successful use of gravel to introduce greater sinuosity was tempered by the depth of the channel and the limited gravel content within the on-site raised bank (originally planned to be removed and stripped of gravels but found to be uneconomical). The considerable volume of gravel imported was only sufficient to install three shoals and had only reduced the width slightly and the river bed was still silted. A further 10 similar shoals could have had a more significant beneficial impact, but would have been impossible at this location due to the impact on water levels.

The Amesbury works were the final works undertaken by the project team, thus any lessons learned over the previous four projects could be incorporated into the design. This was particularly relevant for the large trees deflectors, where those at Hale and Seven Hatches were seen to have been undersized for the river, due mainly to the considerable length of trunk that is needed to be buried into the bank.

For this site potential for major restoration was always limited by the fixed crest weir acting to split the flows into the second (bypass) channel. A concept originally looked at was to create a bypass channel around this weir to provide improved access for fish species. This could also have reduced the impoundment behind the structure where the narrowing and tree deflectors have been installed in deep water. Due to restrictions on the application of LIFE Nature funding to achieve benefit for SAC interests by targeting area outside of the immediate SAC boundary (the river bank) this was not possible and severely reduced the potential for restoration.

Overall Benefits and Lessons Learnt

The restoration works will have benefited several of the SAC species. Greater flow diversity will have been created for salmonids. Silty margins which are developing in the deflectors will provide for habitat for lamprey ammocoetes and the shallow margins will provide refuge areas for salmonid fry. By increasing flow velocity over a narrowed width, this will aid the mobilisation and self cleaning of silt from spawning gravels. These exposed gravels are now suitable spawning areas for salmon, lamprey and bullhead, and habitat for bullhead juveniles. The emergent vegetation cover now developing in the silty margins has created additional habitat suitable for Desmoulin's whorl snail. The riffles have created new spawning areas for both salmonids and cyprinids. Bullhead juveniles inhabit shallow stony riffles whilst the adults prefer sheltered sections created by large woody debris, tree roots, leaf litter, macrophyte cover and large stones. The additional silty marginal areas and large woody debris have created habitat for the bullhead adults.

For all the sites the qualitative monitoring cannot conclude success or failure as the timeframe is too short. This assessment shows that the changes to the river are only just beginning to be visible, and in some case will take many more years to reach the desired end result. The STREAM project has aimed to work with natural riverine processes, altering the channels in small ways rather than large scale engineering works (which are more costly and increase ecological disturbance). This approach is going to require more 'vision' in terms of immediate works versus long term results.

Landowner and angling club concerns may be perceived as minor in relation to the overall goal, however, as the custodians of the river thereafter these groups need to be informed, listened to and buy into the process of river restoration from the very early discussions of what the river should look like. Otherwise they are able to severely compromise a budget if compensatory

works are required, and longer term may even be tempted to undo the work achieved if it is perceived to be problematic and not what they expected.

The approaches adopted by the project have largely been appropriate for the river type, objectives set or the desired outcomes.

Conclusions

Overall the range of restoration methods used have worked and the project aims of reinstating the physical form and diversity of the river channel, creating sustainable dynamic habitats and demonstrating novel and appropriate restoration techniques for the chalk river types within the River Avon SAC have been achieved. Throughout the project and adaptive management protocol was adopted so that the lessons learnt from one site could be applied to the next.

In the short term the deflectors have reduced channel width, created flow variability and allowed the development of emergent vegetation in the newly developed silty berms. In the long term the silty margins will become completely vegetated over reducing the channel width significantly. Those installed at the start of the works would have had more effect if they had been larger, a lesson which was taken forward in later works.

Changes to the hatch operation, where it occurred, had the biggest immediate impact in the short term by reducing water depth, increasing velocities with the resulting removal of silt from the gravel substrate. The gravel riffles also help to reduce water depth on over-deepened reaches and created potential spawning areas for salmon, trout and lamprey. Pinning logs to the substrate within the riffles created flow variability and increased velocities over the riffles ensuring they remained free from silt. The tree kickers only had an effect locally and again would have benefited from being larger.

LIFE Nature project funders need to be aware that the strict interpretation of SAC boundaries is not always the most beneficial for the SAC interest species/habitat. Often elements of work that could be achieved within the adjacent floodplain area could be far more effective and cost-effective than simply limiting the works to a tightly defined river corridor. This should also be passed on to Natural England when considering the extent of an area which is to be proposed as an SAC or SPA.

The RRC's River Restoration Assessment methods proved useful in assessing the restoration works at each site. From the assessments which were made it was possible to determine the success or failure of each of the methods and give a long term prognosis of the works in terms of how they are likely to adapt and develop.

Note

This document is supported by five more detailed documents, one for each of the sites (Fovant, Upper Woodford, Amesbury, Hale and Seven Hatches). These detailed reports can be found on the STREAM website http://www.streamlife.org.uk/resources/publications under technical reports.