DRAFT

KNEPP CASTLE ESTATE

River Adur

Options for Restoration and Enhancement

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1. Preamble

The River Restoration Centre is a not-for-profit information and advice centre, providing non-consultancy services to the UK statutory environment agencies, river managers, land owners, practitioners and interest groups. RRC, founded in 1992, has a wealth of experience through staff and its network of Advisors (UK and internationally recognised experts who support the concept of river restoration and an RRC, and who provide services through the Centre's 'teams'. The RRC promotes the concepts of river restoration, sustainable river management and incorporation of multi-functional benefits from single function activities.

As the Centre is reliant upon subscribers, 'clients' will be asked to join for a small annual fee, to be eligible for 'member' rates for site visits, reports, etc. RRC's continued existence and promotion of river restoration depends upon this support.

The following report is based on a one day visit to the Estate, and some follow-up enquiries.

Present:
Charlie Burrell, Owner
Jason Emrich, Estate Manager
Martin Janes, RRC
Jenny Mant, RRC

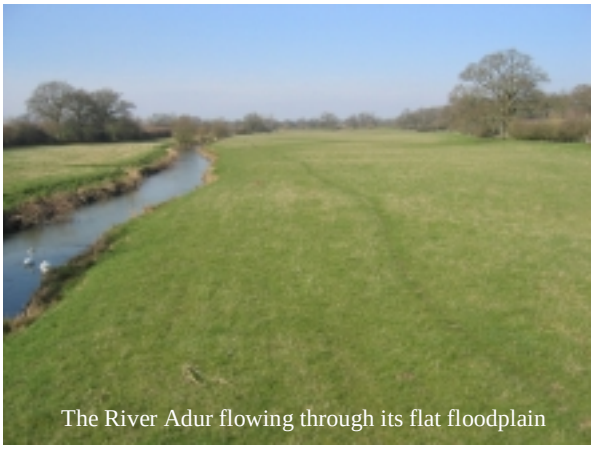
2. Introduction

Knepp Castle Estate is keen to maximise the biodiversity potential of the whole estate. Through discussions with Defra the estate will be entering the Adur and its floodplain into a Countryside Stewardship scheme. The reach to be entrered is approx. 2.2km, with two main tributaries and their floodplains adding to the extent of land to be considered.

Various options for habitat enhancement and increasing biodiversity are apparent, from re-wetting by the use of sluice boards to restoration of the old course of the Adur.

3. Description

The floodplain is very distinct, rolling valley sides meet the flat floodplain lags with a convex slope, one of the practical reasons behind the Estate's hammer ponds found on a number of tributary valleys. The catchment is clay, with much fine sediment being deposited in both the ponds and the main river. Some gravels are apparent within the channel, though these are most probably derived from isolated lenses and have been distributed widely over time.



The River Adur flowing through its flat floodplain

The lowland southern England landscape provides the Adur with very little gradient, thus the river is typical of this part of the county; flat and silty with a naturally steep clay bank, dominated by marginal vegetation established on the silt berms (ledges).

Through the centuries works have been undertaken to 'manage' the river for agriculture, industry, (ore for the hammer pond mills and foundries) flooding and fisheries. On rivers such as the Adur this has taken its toll and the channel is now vastly different to what it once would have been.

The main river through the estate is, at its lower section, approx. 10m top width, 4-6m wide at water level, with 3m high banks. In places the actual flow (on a dry day) passes gently through sections 1.5m wide and 20cm deep.


Siltation and reed growth narrowing the channel

The present course is interrupted with structures to impound water levels for the benefit of fish, such that in summer low flows (reported to be often) they are provided with deeper holding pools along the river. However, the angling club currently renting the fishing rights have indicated their desire not to renew the rights due to poor catch returns.

The downstream border to the estate is bounded by the A24 Worthing to Horsham duel carriageway. The river passes under the road in a semicircular culvert, approx. 8 wide by 4m high. This culvert is the route for the river under the road (a secondary or original culvert is present but was blocked off as part of the duelling of the A24). In flood events (Feb. 2004) the river backs up from the culvert and floods over the lag, sometimes isolating the castle hill. The owner reported that the depth was such that boats could be used on the lag.

It is not known whether the duelled A24 has ever flooded as a result of backing up, but reportedly in the floods of 2000 water was lapping at the road in a low spot by the Kneppmill Pond outlet stream.

The purpose of the hammer ponds, such as Kneppmill, was to provide mill power for ironworks. The ore, and presumably goods produced, would have been transported up the Adur which was navigable almost up to the estate. A complex series of locks and structures (a derelict examples remains east of the A24) must have been installed along the river to enable this and the river would have been regularly managed (deepened then dredged) to ensure adequate depth for the barges. This management would have significantly altered the natural planform (shape), size and character of the river.

Above the House, the importance of agriculture would most probably have been the driver for works to the river. Above Tenchford bridge the river turns north/south and curiously hugs the western edge of the lag, tight against the valley slope. Though not uncommon, or even unnatural, this could indicate re-alignment of the river to avoid the difficulties of farming on both sides of the flat floodplain. From historical maps (Crow map of 1754) it can be seen that the river is positioned here at that time, so any re-alignment would have been before then, when the river was a much smaller and (in terms of moving it) a more manageable size.


The river hugs the bank to the left of the lag

From aerial photos (c. 1960's) evidence of possible meander routes is visible, though how old these are cannot be verified at this stage. A further study of historical archives may indicate further previous channels. As mentioned above the course may have been moved centuries before, but the bulk of the dredging and deepening would probably have been more recent.

4. Problems and Issues

- Channel over-sized compared to the normal flows it carries;
- Route realigned for a variety of reasons, original planform lost;
- Large fisheries weir structures impacting on the landscape;
- Low lying estate buildings located within the floodplain (flooded as often as every 10 years);
- High maintenance for Environment Agency Operations staff (desilting and structures);
- The historically damp lags now shed water quickly via ditches into the main Adur;
- Lack of in-channel, marginal, bankside and floodplain habitat diversity;

5. Key interests in the Adur at Knepp Castle

i) Flooding already occurs on the lags, as a result of impoundments and flashy peak discharges. This flooding provides benefits in the form of;

- flood storage for downstream;
- nutrient and sediment recycling, utilised by the grass and benefiting grazing;
- shallow flooding of the grassland for wading birds;
- wetting of the floodplain and retention of temporary pools for invertebrates and wet meadow plant species.

Fisheries weirs help impound low flows in summer

ii) Fisheries improvements have been made in the recent past to protect the populations from low flows. This work has involved the construction of several large weir structures in the river, the most recent being in the 1990's, when a meander was cut-off to construct to weir structure in the dry. Thought the weirs do provide a backwater effect and a 'pool' within the channel at low flows, they still do not address the inherent problem of a massively oversized channel. A more appropriate answer may be to simply restore (or recreate) a more appropriate channel size along the old (or an approximation of the old) route.

iii) General biodiversity and wildlife friendly management practices are being implemented by the Estate (Countryside Stewardship; changing the surrounding valley side agriculture to grassland; improvements to the hammer ponds to provide refuge and support for wintering wildfowl; etc). These estate instigated changes are consistent with the policies of Defra and the statutory environmental agencies (English Nature, Environment Agency).

As well as recognising the past damage done by some 'improvement' works, the Environment Agency's approach to river management is changing to look at sympathetic management of the system and more sustainable 'restoration' of natural form and processes. Knepp Estate is well

placed to demonstrate how to achieve this over a reasonable length of main river which has been harshly managed in the past.

6. Opportunities for restoration and enhancement

Opportunities exist throughout the low lying lags and further up the tributary streams, though funding will need prioritisation of these, based on technical feasibility and value for money.

The key areas are:

- Main river;
- Tributary streams;
- Ditches.

These areas of opportunity will also compliment the ongoing/planned works to the hammer ponds and the estate's changing agricultural practices.

7. Main River Adur

Options exist for enhancing the river right through to restoring its former course. Techniques used on other river systems are equally applicable here, and each will have an impact on the funding required. The main options are:

1. Enhance the present course between weir structures:
    a. Re-profile banks;
    b. Create berms to narrow the low flow channel;
    c. Allow vegetation growth to further narrow the channel;
    d. Restrict weed cutting and desilting operations.
2. Raise the bed of the present course to promote increased frequency of flooding of the lags, and to reconnect the river with its floodplain. This may necessitate redundancy or removal of some/all of the fisheries structures;
3. Recreate a more natural channel planform and cross-sectional profile in the surrounding floodplain, bypassing the present river course;
4. Restore the 'original' course of the River Adur and its original dimensions.

Each of the above have advantages and disadvantages, which can be discussed briefly, but with enough certainty to rule some out as low VFM and/or impractical.

Re-profiling the River Rhee to a shallow slope (60^o to 20^o)

8. Discussion

In the case of Knepp Castle estate, works to the present channel to achieve a worthwhile degree of enhancement are likely to be as, or more, expensive as restoring the original, or a more natural channel alignment and size through the floodplain. Given the height and depth of the river, any bank re-profiling would need to be a major undertaking to create a secondary floodplain within the canal that exists at present. Narrowing to form pinch points would have to be significant, and the whole works would need to be protected from possible damaging high flows for the 1st few years as the vegetation establishes to cover bare soils. The technical difficulty of such an approach is quite high, and would need to involve a

lot of detailed design works and engineering to achieve a stable result. Even if the resulting works is successfully completed within budget, the overall result will only be partially successful in terms of the potential for the site. This will not address the planform, the impact of the structures, the depth of the channel bed, the lack of connectivity with the surrounding floodplain or the desire of the landowner to do something 'exciting'.


River Cole. A smaller channel is cut across.

The 2nd option, does in part address the issues of the present channel, however the technical works needed to infill a watercourse (whilst it is flowing) to a degree where the material will not simply be washed away would be considerable. This has been achieved before, but on chalk streams where infilling with gravel is the natural choice and can be stabilised, and only to a achieve bed raising of a small increase in height. This is a costly option, necessarily using non-native substrate. A conservative estimate would be approx. 10m^2 over 2.2km, giving a volume of granular fill of 22,000m^2. At a cost of say £10 per m^3 this would be in the order of £220,000 just for the material. Once again this option does not address the straightened channel course, and the risk is that the material could be conveyed downstream and lost, or worse still, become a flood risk were it to be deposited near bridges and flood prone urban areas.


Re-meandering the River Cole with a higher bed level

Option 3 removes the constraints of working within a flowing channel. It provides time and dry working conditions to excavate an appropriately sized channel, and establish bank side vegetation cover to prevent bare earth banks being eroded by the first high flows. Importantly, however, it would not be possible to recreate the original course of the river, as this we know would have crossed the present course at several points.


The Gaywood Stream, re-meandering over 1km, Kings

Option 4, restoration of the original course, is the preferred option from a purist approach, and one that the RRC aims to promote *where practical*. In the case of the Adur at Knepp Castle, the historical records concede a long history of management, with some glimpses of the previous course(s?). It is likely that a significant element of the old course is followed by the present channel (especially as the present watercourse's

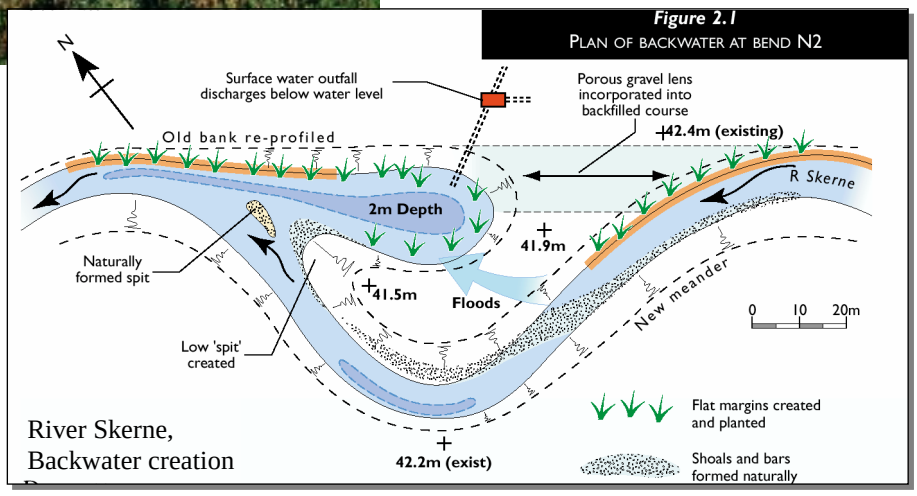
'footprint' is massively wider than the original would have been). For this reason the works would need to involve significant elements of option 1, already argued to be costly and difficult.

Potential option

Perhaps the best 'design' approach (at this early stage) for consideration of the most achievable way forward would be a compromise between the relative ease and flexibility of option 3, and the desire to restore the original course of option 4. The re-meandering would simply entail carving the 'new' Adur through dry ground, away from problems of flowing water and fluctuating levels. The course could, where appropriate, follow the old visible meanders (subject to confirming their authenticity) crossing the present course, rather than incorporating significant lengths of it. Figure 1 shows an annotated map of the lower 1+km of the river, with suggestions of the type of works that may be achievable. Assuming a cost per m3 for bulk earthmoving of £8, the cost of cutting the new course would be around £32K. Crossing the old course is a more technically difficult procedure, and might cost an additional £50K. Landscaping and planting should be budgeted as an additional £20K, suggesting a (very crude) budget of ~£100,000. At this stage it should be noted that monitoring of the site, works and results is a very valuable exercise and should ideally be assigned its own budget. Funding for this is available through government and university research bids, though often fiercely contested!

River Skerne, Backwater creation

This compromise between 3 and 4 also has benefits that each would not necessarily deliver on their own. The old channel could be utilised to continue to provide refuge for fish in low flows, as well as acting as a sheltering backwater in floods. Backwaters also provide habitat for invertebrates, plants and mammals, and protection for fish fry, and have historically disappeared from many river reaches (convenient dredging spoil tips). These are now commonly introduced into river systems by the Environment Agency, sometimes called ORSU's (off-river support units). The extent of backwaters depends upon cut and fill budgeting, but clearly there would be a deficit of fill material (possibly as much as 60%) if it is intended to dig the new channel significantly smaller than the present one (figure 2). The old channel that remains could include temporary ponds (with no direct connections to the river), ponds linked by pipes to ensure river dependant levels, and backwaters



River Skerne, Backwater creation

connected at one end only. All of the above provide for different communities and species, and add to the diversity of habitat available.

Works to the main river should be able to be carried out on the lower west-east section, prior to Lancing Brook joining the river (the gradient is thought to be approx. 1:1000). Above this the Adur flows north-south, and the gradient of the river here will be the deciding factor for design of river works.

9. Tributary Brooks

Two main tributaries join the Adur within the estate grounds, the Lancing Brook and a smaller one just downstream of Capps Bridge. Lancing Brook contributes significantly to the flow of the Adur. On these two smaller watercourses the impact of management, and in particular dredging, is visible but to a lesser degree than on the main river. Here, options for enhancement of the channel, much of which is likely to still follow its original course, are more viable. This should be in conjunction with limited and sympathetic ditch management, allowing the watercourses to develop an appropriate vegetation structure and allowing the build-up of silt where the present course is over-sized.


Narrowing of the upper reaches through deposition

Once again flood defence issues must be considered and any design must not be to the detriment of people or property.

10. Ditch Network

Throughout the lags within the estate grounds, ditches convey surface water to the river and brooks, draining the grazing land. One of the goals of the estate is to increase surface water, both from flooding and retention of precipitation. The ditch (or possible meander route) in the four acre field by Tenchford Bridge shows the possibilities for retaining surface water, encouraging Rush dominated pasture and providing feeding habitat for wading birds. This 'ditch' is blocked at the downstream end and retains rainfall until it evaporates. Infiltration through the soil is likely to be minimal due to the heavy clay nature of the catchment.


Damming the ditches will create wader habitat

This approach could be copied across the remaining floodplain, such that every ditch, instead of draining the lags, is actively re-wetting the surface. This approach is more beneficial than completely filling in the ditches, as it is less labour intensive (so less costly), and provides temporary shallow open water for birds and invertebrates. Studies have shown that the increase in habitat and biodiversity achieved through adding shallow temporary wet scraps to floodplains can be far greater than that achieved by in-channel river habitat enhancement/restoration. In part this is due to the greater potential for colonisation by wetland, terrestrial and semi terrestrial plants and invertebrates, but shows the potential increase in biodiversity available by very simple techniques.

As well as blocking the drains, opening out the linear shape of them to provide shallower slopes will provide more shallow margins, as will gradual poaching by sheep, horses and cattle.

11. Additional works

With the shift from arable practices to grassland reversion over the estate, a strategy of blocking field drains should also be considered. Early drainage in the 1800's and later in the 1950's and 60's has dramatically increased the 'time to peak' of rivers. On clay catchments this is particularly noticeable, as the field drains would have been spaced only a few meters apart, to make the fields workable for longer. By cutting out and plugging the drains, siltation, nutrient transport and excessive runoff will all be countered to some degree. By employing this approach over much of the estate, the effect could be quite considerable, and a programme of monitoring should be encouraged to assess the benefits. This same approach was used to aid reversion from arable farming to hay meadow, as part of a Countryside Stewardship scheme adjacent to the River Cole (river restoration demonstration site, Oxon/Wilts)

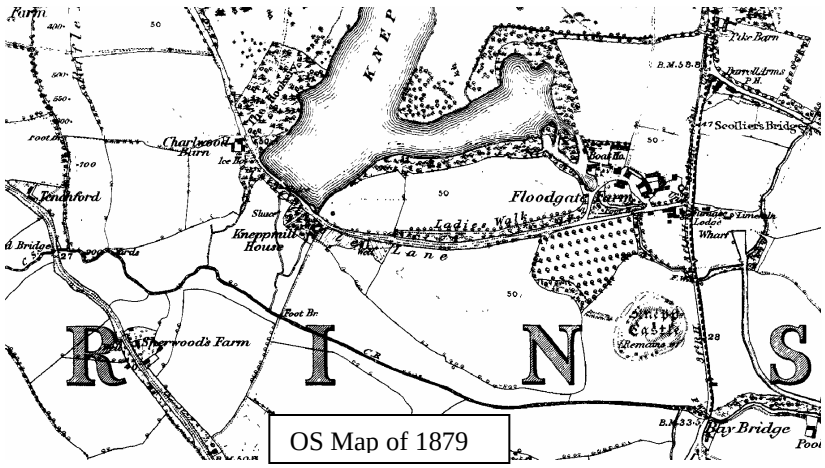
It is unlikely that such field drainage blocking works will unduly affect the rewetting of the lower floodplain, it will merely slow the passage of surface runoff to the lags and river.

12. Pre-feasibility works

Stage 1. Necessary works and surveys required to propose detailed options for consideration
Various unknowns exist at present;

- *Topographic level survey of the river and floodplain, its features and extent between the A24 and Pound Lane*
  This is the most important element of the pre-feasibility works. It will inform the applicability of the options for the main river and help define the realistic options for consideration. The effects of any proposed works on river levels would need to be analysed to ensure that the backwater effect of the new channel will not adversely affect the upper limit of Pound lane bridge. Gradient is known to be limited, but accurate levels are needed to ensure no worsening of flooding potential for property and communication links. Pound Land and Swallows lane both flood at present, though this is thought to be due to inadequate capacity of the bridge structures. Tenchford and Kneppmill cottages will need to be protected from increased flood risk, perhaps by bunding. This will also require accurate floodplain level information and potentially, hydraulic modelling at the later feasibility stage. The survey brief will depend on the scale and extent of the scheme envisaged, however it is always worthwhile having a more (rather than less) detailed study done at the outset.

- *Brief overview of historical data*
  A search of county archives, Estate archives, etc. should quickly indicate whether there is any further evidence of previous routes across the floodplain. This information will feed into the proposed option for works to the River Adur. This



OS Map of 1879

could be carried out by the Estate.

- *Geomorphological comparison with surrounding catchments*
  Defining the accurate and most appropriate size and sinuosity of the 'restored' river is a careful balance between historic information, overviews of the surrounding catchments and an assessment of the current hydrological information for the river. Though shallow flooding of the lags is desirable, prolonged deep flooding resulting in the deterioration of the meadows is not. Too small a cross-section could result in the above whilst too large could equate to a waste of time, effort and funds. Understanding, designing and prediction how 'natural processes' will behave requires and experienced fluvial geomorphologist.

- *Fisheries input*
  The river supports a Sea Trout run, as well as a variety of coarse fish. As a fishery the river is known to be poor through the estate, but as a fisheries resource it may be valuable for salmonids. This may explain the large and costly structures installed by the water board, NRA and Environment Agency. This information needs to feed into any outline design options at an early stage.

Stage 2. Following the successful completion of the topographic survey, RRC could (if required) field a small team of its 'Advisors' to work up the outline options for the estate, Defra and other potential partners to consider. This stage would produce a reasonably detailed justification for the various options, based on the information available and that proposed above. It would give rough costings and suggestions of techniques to be used and examples from elsewhere. This report could form the basis of a brief for consultant engineers to carry out a technical feasibility study of the favoured option(s).

Stage 3. Further 'technical feasibility' would:

- provide the required assurances for the Environment Agency flood defence team, to enable consent to be gained;
- calculate accurate material quantities timescales and costings involved;
- provide the tender drawings and documentation (bill of quantities, etc. needed to let the contract to contractors.

RRC normally suggests it be involved at the design and implementation stages to ensure that the design produced by the consultants is true to the client's original perception of the project output, as this is not always the case! The Centre has a formal written framework agreement with the Environment Agency covering all of the above, and considerable experience in advising on large scale innovative river restoration demonstration projects.

Further Reading;

- Manual of River Restoration Techniques 2002 Update (2002), published by RRC, May 2002.

- Manual of River Restoration Techniques (1999), published by RRC, February 1999.

[Both can be found as pdf's at: http://www.therrc.co.uk/manual.php]