Overview of habitat enhancement opportunities on the River Wandle, London

Undertaken on behalf of The Wandle Trust
by Vaughan Lewis, Windrush AEC Ltd

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1.0 Introduction

The River Wandle was a renowned chalkstream, with catches of large brown trout *Salmo trutta* commonly made by anglers. Nelson regularly fished the river, whilst Halford was reputed to have caught his first trout from the Wandle. However, during the period from the late 1800's to the 1990's, the river suffered badly from anthropomorphic impacts, including abstraction, poor water quality and major modification of the channel. As a consequence, fish stocks in the river declined. More positively, during the last 10-15 years, water quality in the river has improved, allowing a partial recovery of fish stocks, particularly coarse fish.

The Wandle Trust was formed to enhance the profile of the River Wandle, and to build on the opportunities provided by improved water quality in order to develop the river's ecological value. The Trust has developed strong links with the community, water undertakers, particularly Thames Water, and local schools. Its 'Trout in the Classroom' initiative has not only raised awareness of the river with school children, but has also provided a stock of brown trout to the river. Small numbers of adult trout have subsequently been captured by recreational anglers.

Further ecological development of the river is currently being limited by poor habitat quality in some sections. This report examines opportunities for habitat enhancement along the length of the river. Throughout the report, normal convention is followed, with Right Bank (RB) and Left Bank (LB) designated when looking downstream.

2.0 Habitat assessment

Reach 1

The effective source of the River Wandle was immediately upstream of Carshalton Ponds. Groundwater recharge to the pond had been significantly affected by abstraction. As a consequence, augmentation flow was provided by Sutton and East Surrey Water Company, using a recirculation system. Water was abstracted from the Wandle immediately upstream of the discharge of the Beddington STW outfall, with water subsequently being discharged into a channel feeding the upper pond in Grove Park. It is understood that under the abstraction licence held by Sutton and East Surrey Water Company, the augmentation should provide a guaranteed minimum flow of 4.5 Ml/d. Contemporaneous records from JetSet (reported to the Environment Agency) show that this condition of the abstraction licence has been breached on a number of occasions, with augmentation flow reduced to zero.

Augmentation flow discharging into upper Carshalton Pond

The ponds themselves had been heavily modified and offered little or no habitat for brown trout. Some coarse fish are believed to be present within the ponds. Recently, it has apparently been discovered that water is being lost from the ponds via imperfectly resettled hydraulic plugs set into the concrete lining to protect it from damage due to the periodically high water table. These losses may exacerbate those resulting from abstraction.

Downstream of the ponds, the old mill had recently been restored. Aspirations to resume operation of the mill would require diversion of a proportion of the flow away from the main channel of the river, with associated detriment to instream habitat likely. The operating head for the mill had been created by the construction of an ornamental cascade in the grounds of The Grove, at the downstream limit of the reach. This structure prevented any upstream migration of fish, resulting in spatial isolation of fish stocks in the two reaches.

Ornamental cascade preventing upstream migration of fish

Downstream of the cascade, there was a small impoundment with a head loss of some 0.5m across it. It is understood that the original impoundment was constructed in order to create cress beds in the upstream reach, although it now functions as a gauging weir. Interruption of migration of fish would be likely at this structure over a range of discharges.

Below this structure, the channel was some 6m wide, with a substrate consisting largely of unsorted coarse gravel and cobbles. Large boulders had been introduced randomly into the channel, presumably either as an aesthetic addition or in order to increase potential habitat for fish. Despite this, the water was very shallow, with a depth of more than 20cm present over most of the channel's area.

The channel was delineated by wooden toe boarding on both banks, with a vertical drop of some 30cm-50cm from the mown lawns of the surrounding park. As a consequence, there was effectively no development of marginal vegetation along either bank of the river, reducing the abundance of cover for juvenile brown trout.

The margins of the channel were heavily shaded in places by riparian trees, including sycamore *Acer pseudoplatanus*, willow *Salix* spp. and elder *Sambucus nigra*. This shading was suppressing the growth of marginal vegetation in these areas. At the downstream end of the section, the mill-channel rejoined the main river.

Reach 2.

Below of the pedestrian footbridge at the downstream limit of The Grove, the channel was some 2m-3m in width, with a relatively steep gradient. The bed of the river was

dominated by coarse, poorly sorted gravel, overlain over much of its area by fine sediment and filamentous algal growth. There was little variation in bed profile, with a distinct lack of deeper water areas suitable for adult trout, chub *Leuciscus cephalus* and other coarse fish. There was some marginal aquatic vegetation, although much of the bank length was covered in ruderal vegetation.

There was a general lack of Large Woody Debris (LWD) in the channel, reducing the beneficial impacts on habitat quality associated with this structural element.

Channel downstream of pedestrian footbridge

The channel was partially shaded by riparian trees on the RB, particularly ash *Fraxinus excelsior* and willow *Salix* spp, with some localised suppression of marginal growth in the shaded areas.

A small impoundment with a head loss of some 0.5m was present adjacent to Paper Mill Close Bridge. This was constructed from engineering bricks and blocks. Its purpose was unclear. Over a range of discharges, it would affect upstream migration of fish adversely.

Impoundment at Paper Mill Close Bridge

Downstream of the weir, the channel had a good gradient, with relatively clean gravel and strong stands of starwort *Callitriche* Spp, providing potentially excellent spawning and juvenile habitat for brown trout, chub, barbel *Barbus barbus* and other rheophilic fish species. The LB had been reinforced with stone filled wire gabion baskets. Some coppicing of riparian willow trees had been recently undertaken by the EA, with the woody arisings chipped on the bank. A short section of water crowfoot was present in this section.

Habitat then became dominated by shallow glide, largely due to the presence of a second small weir, immediately downstream of the footbridge at Butter Hill. Removal of this weir and replacement with shallow gravel riffles at a lower level would reduce the backwater effect, improving upstream habitat as a consequence.

Downstream of the wooden footbridge at Butter Hill, the LB was reveted by vertical concrete walls, with a drop of some three metres from the footpath to the water. There was extensive shading cast by the dense riparian tree fringe on the RB.

Downstream of Butter Hill Footbridge showing vertical concrete revetment and small impounding weir

As a consequence of the concrete wall and tree shading, marginal vegetation growth was restricted.

The downstream limit of Reach 2 was marked by the presence of an old mill impoundment, retaining a head of water of approximately 2m. The backwater effect of this mill was expressed upstream to the small weir at Butter Hill Footbridge. As a consequence, instream habitat was deep/shallow glide, with a substrate dominated by a deep layer of fine sediment. The impoundment comprised of two fixed outer weirs, with a central variable sluice structure. The presence of the mill structure prevented any upstream migration of fish, effectively isolating fish populations in the two adjoining reaches. The construction of a fish pass in the mill would be of great benefit to re-establishing spatial connectivity of these populations.

Old Mill impoundment at Butter Hill

Reach 3:
Downstream of the mill, the river was considerably overwide, with a wetted width of some 8m-10m. This was a consequence of the construction of a wide, shallow retaining weir at Mill Pond Place bridge. Head difference across the weir was some 300mm. As a consequence of its presence, the bed of the river was coated in a thick layer of accumulated fine sediment. Instream vegetation was restricted to some strong stands of starwort. The weir also restricted access of fish migrating upstream during low flow periods.

There was a well-developed fringe of branched bur-reed *Sparganium erectum* on the LB of the channel where tree shading was light. Elsewhere in this section, the riparian tree canopy on both banks was moderately dense, creating enough shade to restrict the growth of marginal vegetation.

Overshaded and overwide channel downstream of Butterhill Mill

The river length downstream was extensively shade by a mixed riparian tree fringe on the RB (sycamore, hazel *Corylus avellana* etc), preventing establishment of marginal vegetation. The bed was gravel dominated with a thin layer of fine sediment present in what was a generally overwide channel.

Reach 4

The Carshalton and Croydon arms of the river joined upstream of an impoundment at the old Shepley Mill site. The weir had a head loss of approximately 2m across it, with the river downstream then flowing through a culvert some 50m in length before exiting into a large mill pool.

Shepley Mill Pool

The combination of the large head loss over the weir, the concrete culvert and associated trash grids effectively prevented upstream and downstream migration through this site, spatially isolating fish populations in the adjoining reaches.

The mill pool was bounded by vertical concrete and stone walls on three sides. Water depth exceeded 2m in the north-west corner of the pool, with the water depth shallowing towards the tail of the pool. Trout, common carp *Cyprinus carpio*, dace and barbel had all been caught in pool during the period 2003-2005, whilst kingfishers *Alcedo atthis* were often seen fishing here.

Downstream of the pool, the channel had a more natural appearance, with a well-developed fringe of emergent marginal vegetation. In places, the river was heavily overshaded by a mix of riparian trees including horse chestnut *Aesculus hippocastanum*, sycamore, ash, and elder, with associated restriction to the growth of the marginal vegetation. Where tree cover was more limited, stands of water crowfoot had become established.

The channel was generally straight and relatively uniform, with limited variation in bed profile. Water depth was between 0.5m - 1m, with an unsorted hard substrate, covered with a layer of fine sediment for much of the reach length. The downstream length of the reach towards Hackbridge had a generally reduced water velocity, as a result of small impoundments downstream of the bridge and the overwide nature of the channel. There was a strong marginal growth of emergent vegetation, with the bed of the river heavily coated with fine sediment.

Overshading of the channel in the middle/lower section of the reach

Reach 5

The upstream limit of Reach 5 was alongside Culver's Island. The river was overshaded by riparian trees including sycamore, horse chestnut *Aesculus hippocastanum* and ash growing along both banks. As a consequence, there was virtually no instream or marginal vegetation present under the tree canopy. The channel was some 6m-8m in width, with a relatively steep gradient, and an unsorted gravel and cobble dominated substrate. The gravel was relatively silt free, although the uniformity of the bed profile was likely to be limiting fish population abundance, with the lack of deeper glide and pool habitat particularly apparent.

Small patches of water crowfoot were present in this section, with a number of adult and juvenile coarse fish noted.

Downstream of Culver's Island. Note the overshaded and overwide channel, with virtually no instream vegetation. Note also the uniform, undifferentiated bed profile

There were extensive stands of Himalayan Balsam *Impatiens glandulifera* present along sections of this reach. The impact of these was evident, with little/no growth of any other plants beneath them. Several kingfishers *Alcedo atthis* were noted in this reach. The gradient of the river flattened at the downstream end of the section, with shallow glide the dominant instream habitat. The channel remained overwide, with small stands of sedge present in the margins and on the bank.

In contrast, habitat in the section downstream was markedly better. The banks of the channel were open, with virtually no shading. As a consequence, the growth of marginal vegetation, largely branched bur-reed, reed sweet grass *Glyceria maxima* and bulrush *Typha arundinacea,* was excellent, narrowing the channel, increasing water velocity and encouraging the growth of water crowfoot, starwort and other submerged vegetation. Locally high water velocity also promoted the scouring and sorting of the substrate. The dimensions of the channel at this point were approximately 5m wide by 0.25m deep. This cross sectional area provides some indication of the sustainable dimensions of flow dependent, self-cleansing channel under the current flow regime experienced in this reach of the Wandle.

Midway along this section, there was a short length of river with extensive growth of alder *Alnus glutinosa* on both banks. Shade cast by these trees had resulted in the suppression of the marginal vegetation, increasing channel width from around 5m to 8m. Associated lower water velocities had reduced the abundance of instream weed.

There was no clearer example of the damaging impact of heavy shade on any reach of the river.

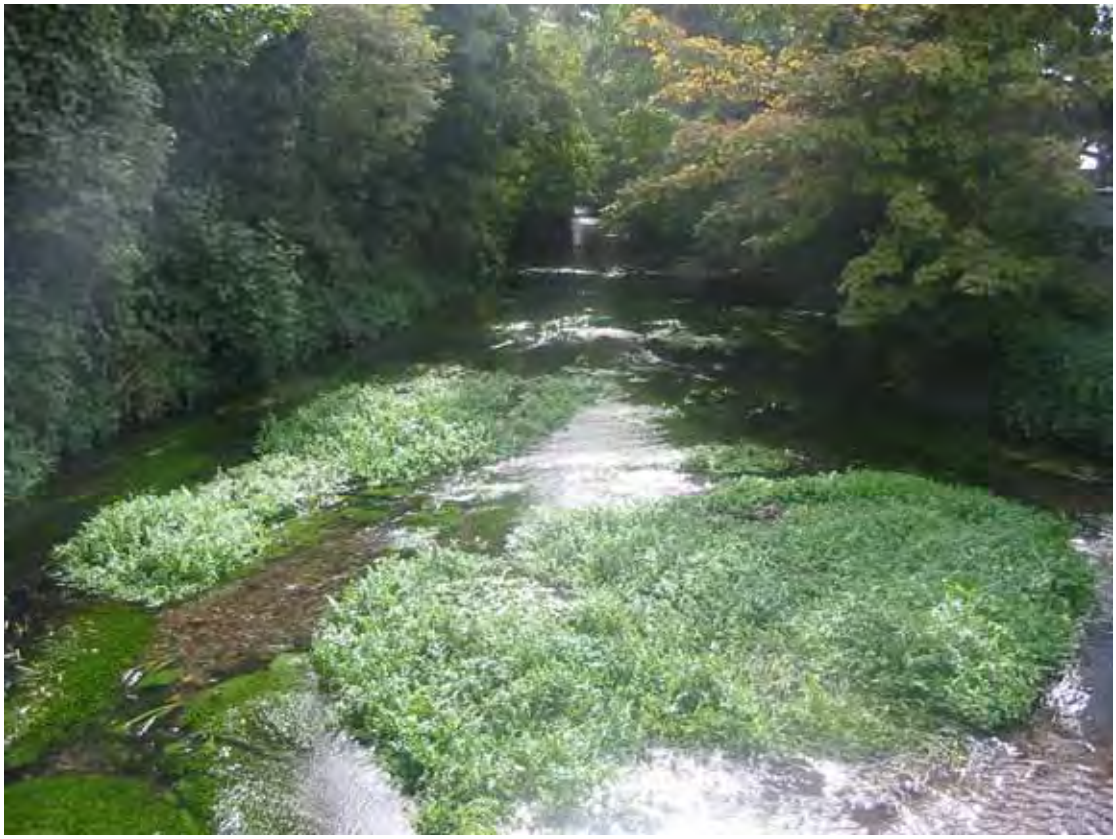
Open section of the river with well-developed margins, high water velocity and extensive instream weed growth.

The impact of shading. Note the suppression of marginal growth and the resultant widened channel at the downstream end of the section

Large stands of floating pennywort *Hydrocotyle ranunculoides* were present from this point downstream in all reaches of the river. This is an alien species those presence within the river is undesirable. Despite this, it did provide sections of floating cover in slow moving reaches of the river otherwise lacking in instream feature.

Upstream of the 'curly footbridge', the channel remained relatively unshaded, with an abundant growth of starwort, Canadian pondweed *Elodea canadensis,* curled pond weed *Potomogeton crispus* and lesser water-parsnip *Berula erecta,* in a generally shallow glide habitat, with a mean water depth of 0.5m. A strong growth of marginal vegetation, mainly reed sweet grass, water cress *Rorippa nasturtium-aquaticum* and fool's water cress *Apium nodiflorum*, reduced the channel width and provided a moderate water velocity. Overall, this section of the reach provided excellent habitat for a range of adult coarse fish and trout.

At the downstream limit of the reach, there was abundant habitat suitable for juvenile trout. Riffles and shallow glides braided by extensive stands of water cress and fool's cress, with submerged weeds dominated by starwort and water crowfoot, provided abundant cover for fry. The weir at McRae's Mill formed a significant barrier to ascending fish, effectively isolating upstream and downstream fish populations.



High quality trout fry habitat downstream of McRae's Mill

Reach 6:
The key feature of this upper section of the river was the discharge from Beddington Sewage Treatment Works (STW). Above Goat Road, some 27 Ml/d of treated effluent was discharged from the works to the Wandle via a concrete lined effluent channel across Mill Green. Within this channel, excellent habitat had developed over time. The gradient was relatively steep, with a strong flow and locally high water velocity. Substrate was dominated by fine gravel and sand, with stands of water crowfoot, horned pondweed *Zannichellia palustris,* opposite leaved pondweed *Groenlandia densa*, curled pondweed and starwort. Water depth ranged between 0.25m and 0.5m, with water velocity estimated to vary locally between 20cmsec^{-1} and 40cmsec^{-1}.

Due to the concrete nature of the channel sides, there was no growth of marginal vegetation within the channel. This was likely to have reduced the habitat quality within the channel for juvenile fish and a range of macroinvertebrate species. Large chub, dace *Leuciscus leuciscus* and barbel were seen within the channel.

Effluent channel carrying discharge from Beddington Sewage Treatment works

Immediately downstream of the confluence of the effluent channel, the river was constrained within concrete banks. Flow within the channel was strong, with a water depth of 0.5m on average. Some turbidity of the water was noted. Substrate was dominated by a mixed gravel and sand mix, with a coating of filamentous algal coating over much of the bed. The presence of the concrete walls and heavy shading on the LB had limited the growth of marginal vegetation to practically zero, leaving the channel overwide. Ruderal species along the bank were hanging over the channel and providing some cover. There were small clumps of water crowfoot and lesser water parsnip present in the channel, with a stand of amphibious bistort *Persicaria amphibia* also noted.

Stands of Japanese knotweed *Polygonum cuspidatum* were present on both banks of the river.

A small impoundment was present in this reach, with a head loss across it of some 300mm. It had no obvious contemporaneous purpose. Downstream of the weir, the depth of the channel increased to around 1.0m-1.5m, with a width of 10m+ and heavy shading due to the presence of riparian trees.

Impounding weir – purpose unknown

As shading decreased downstream, marginal growth began to establish, with water cress and fool's cress present. Instream, a diverse and abundant mix of weeds including opposite leaved pondweed, horned pondweed, water crowfoot, curled pondweed and lesser water parsnip were noted. Habitat in this reach was ideal for coarse fish species.

The river width continued to increase in width to more than 20m. There was extensive growth of what appeared to be broad leaved pondweed *Potomogeton natans,* with an increasingly well-developed marginal fringe of reed canary grass *Phalaris arundinacea*.

Reach 7:
Downstream of Mitcham road bridge, the Wandle enters the grounds of Morden Hall, a National Trust property. Significant amounts of floating pennywort had accumulated in the backwater created by the old flood arches of the bridge. The main flow of water was passing through the main arch of the bridge and along the RB of the channel.

The channel was overwide, with a substrate of unsorted mixed gravel, cobble, sand and builders waste, overlain in places with a coating of fine sediment. Despite a relatively steep gradient, there was little variation in the bed profile across the channel's width. Mesohabitat was generally riffle or shallow glide. The channel was heavily shaded by mature trees within the grounds of Mordon Hall, restricting instream weed growth to a few small stands of water crowfoot.

Further downstream, there were abundant stands of floating pennywort present in marginal areas, with the relatively high water velocity probably preventing its establishment in the centre of the channel. Some small LWD dams were present. Their impact on habitat was apparent, with locally increased flow velocity resulting in substrate scouring.

LWD covered with floating pennywort on the LB of the river. Note locally increased water velocity

Within the grounds of Morden Hall, the river split into a number of small channels, with potentially high value as recruitment areas for both coarse fish and trout. Typically, these channels had a wetted width of between 2m-4m, with an unsorted fine gravel and sand dominated substrate. The banks of the channels were generally heavily cut, leaving little or no marginal vegetation growth. There were a number of instream structures within the channels. The backwater effect of these channels was having a significantly detrimental impact on upstream habitat quality, due to accumulation of fine sediments.

Sections of the main channel and distributary streams had been reveted using wooden toe boarding. Whilst this treatment of the channel may aesthetically appeal to some, its presence was significantly reducing instream habitat quality by suppressing marginal vegetation growth.

Small channel within the grounds of Mordon Hall. Note heavily cut banks, wooden toe boarding and small impounding weir

Other distributaries had banks reveted with concrete slabs, preventing the development of marginal vegetation and limiting overall habitat quality.

Large numbers of small roach *Rutilus rutilus*, gudgeon *Gobio gobio* and other coarse fish were noted in this section of the reach.

Reach 8:
Instream habitat downstream of Merton Abbey Mills was generally excellent, with a steep gradient, mixed substrate and strong stands of submerge vegetation. However, the banks of the Wandle were reveted with concrete, preventing the development of marginal vegetation.

Downstream of the Merantun Way bridge, the gradient of the river increased dramatically, with a torrential flow. Substrate was mixed boulder, cobble and gravel. Erosion of the bed had created some deep gullies with associated downstream riffles created by the eroded bed material. Water crowfoot was abundant in sections of this reach where high flows and coarse substrate were not limiting. Spawning opportunities for trout and rheophilic coarse fish species were excellent in this reach. Barbel in excess of 5kg in weight had been caught on rod and line.

This section was heavily shaded by riparian trees. Japanese knotweed and Himalayan Balsam were abundant on the banks.

Channel adjacent to Merton Abbey Mill

Downstream of Merton Abbey Mill roadbridge, showing torrential flow

Approximately 200m downstream, the RB of the river was reveted by a 3m+ high palisade of tannalised wooden stakes. There was very little emergent vegetation along this bank, although floating pennywort had begun to form a marginal shelf. Instream weed remained abundant, with starwort and water crowfoot present.

Wooden revetment along RB with floating pennywort in the margins

The lack of marginal vegetation continued further downstream on the LB adjacent to Merton High Street, with vertical concrete revetment preventing its development in this location. Despite this, the instream habitat was good with a gravel dominated bed, with stands of starwort and water crowfoot abundant.

Lack of marginal vegetation at the base of a section of vertical concrete revetment

Downstream of Merton High Street, the channel was some 8m wide, with vertical concrete revetment continuing along the LB, with an associated paucity of marginal vegetation, particularly in the upper length of the section. The RB was heavily tree lined, partially shading much of the channel.

Instream habitat was generally good, with a steep gradient and high water velocity. The substrate was dominated by mixed gravels, cobbles and sand, with a mix of riffle, shallow glide and deep glide habitat. Stands of water crowfoot were present, with some filamentous algae overlaying some of the bed.

Downstream of Connolly Mill, there was a limited development of a LB fringe of marginal vegetation, particularly water cress/fool's cress. Extension of this area would be of great benefit to the river at this location, narrowing the channel and increasing instream water velocity locally.

Reach 9:
The EA had undertaken a major habitat enhancement about 1 km south of Trewint Street. A redundant weir had been removed, with the head difference dissipated by constructing a section of steep, boulder strewn, gravel riffle. The resulting habitat was excellent, with the fast water velocity over the gravel bed and stands of water crowfoot, ideal for spawning fish and a range of macroinvertebrate species. Islands had subsequently formed in the channel due to the establishment of willow and floating pennywort around the boulders. These not only braided the channel, but also provided an element of valuable fringing cover.

Mid-stream island at Trewints Lane

Reach 10:
Upstream of the Arndale shopping centre, the river had a very steep gradient, with cobble and coarse gravel substrate dominant. Water crowfoot was growing in abundance in the fast flow. Bankside spider's webs had captured large numbers of adult olives (Ephemeridae) indicating that habitat and water quality in this reach were of adequate quality for this pollution sensitive family of invertebrates.

Much of the bank length had vertical hard revetment. However, low marginal shelves had been established in some sections as planning gain during recent development adjacent to the river. A particularly good example was present on the RB with strongly growing stands of water forget me not *Myosotis scorpioides*, sedge and water cress. This was an exemplar of the aspirations for creation of this habitat type elsewhere along the river.

Low-level shelf created on RB upstream of the Arndale centre. Note strong growth of water forget me not

Upstream of Mapleton Road, instream habitat was excellent, with a steep gradient, high velocity channel dominated by coarse gravel, and abundant water crowfoot. This reach had excellent potential for spawning and juvenile trout and rheophilic coarse fish species.

The presence of vertical concrete walls and sheet piling along one or both sides of the river had again prevented the establishment of marginal vegetation.

Similar comments apply to the split concrete channel behind the stores alongside Upper Mapleton Road.

Hard vertical revetment preventing establishment of marginal vegetation

3.0 Enhancement opportunities

A number of significant opportunities exist for the restoration and enhancement of instream habitat in the River Wandle. These opportunities are outlined below:

Reach 1

- The river downstream of Carshalton Ponds could be significantly enhanced by the augmentation of flow. Ideally groundwater abstraction would be reduced, allowing more natural recharge of the ponds and hence the river, to take place. Such a reduction in abstraction might be possible under the provisions of the recent Water Act, 2004. It would inevitably require the redistribution of existing potable supplies, or the establishment of a new resource for the water undertaker.

In the absence of such a change being realised, an opportunity exists to augment flows by back pumping effluent from the Thames Water Utilities Limited (TWUL) sewage treatment works at Beddington. At present, the effluent is discharged to the Wandle via an artificial channel downstream of the works. It is understood that the EA has significant concerns regarding the ecological consequences of introducing nutrient rich water to Carshalton Ponds, due to the risk of promoting undesirable algal blooms. This concern is acknowledged, although stripping of phosphate from the effluent prior to its discharge would reduce the likelihood of algal blooms significantly and would indeed also improve the ecological well being of the whole Wandle system. In the event that the EA's objections to discharge of effluent into Carshalton Ponds is sustained, then a closed water recirculation system could be constructed at the ponds, maintaining water levels within them without prejudicing water quality.

Relocation of a percentage of the effluent flow into the river below the outfall at Grove Park would provide a partial and temporary solution to low flows in the upper river until the abstraction regime is modified, without risk of compromising water quality within Carshalton Ponds. The length of river benefiting from additional flow would increase by several kilometres. As a consequence, the availability and quality of flow dependent habitat in the river would be increased, promoting opportunity for the recruitment of rheophilic fish species, and flow dependent macrophytes and macroinvertebrates. In addition, the provision of additional flow to the upper river might provide an opportunity to allow restoration of the operation of the mill.

Less positively, back pumping a percentage of effluent from Beddington STW to the upper reaches of the Wandle would inevitably change the habitat conditions in the effluent channel, with a reduction in water volume and velocity likely to lead to a more depositing sediment regime, with associated changes in habitat type. Resizing of the channel by the installation of low-level marginal shelves (see below) would compensate for these changes.

The augmentation of flow to the upper reaches of the river using treated effluent would be predicated on the assumption that its quality would be maintained at a high level. This would require continued compliance with the existing discharge consent for the works. Future consents are likely to require tightening in recognition of probable increases in volumetric discharge as a result of further development in the London area. Without this reassurance, there is a real risk that poor water quality could compromise the benefits achieved by higher flow in the upper river.

A similar project is currently ongoing on the River Cherwell, Banbury, Oxfordshire. Under a programme developed as part of an Alleviation of Low Flows (ALF) study and TWUL's third Asset Management Plan (AMP 3), treated effluent will be backpumped some 4km upstream from Spittal Farm Sewage Treatment Works to be discharged into the Cherwell immediately downstream of Grimsbury Waterworks. The augmentation is being made as direct compensation for the acknowledged damage caused to the ecology of the River Cherwell by the TWUL abstraction at Banbury. The potential risks of discharging treated effluent to the upper river have been acknowledged by the Environment Agency, who believe that they are outweighed by the benefits brought to the ecological and recreational value of the reach by increased flow.

- The presence of the wooden toe boarding, was preventing the development of valuable fringing vegetation in the reach below The Grove cascade. In order to redress this habitat deficiency, it is recommended that a meandering two-stage channel should be created within the existing form of the river. 300mm diameter pre-planted coir fibre rolls or faggot bundles should be installed, primarily on the RB of the river, in order to create a two-stage channel. The rolls should be retained by cleft chestnut stakes set at approximately 0.6m centres, with the top of the rolls set some 100mm-150mm above agreed summer water level. The new bank line should be backfilled with spoil derived from localised reprofiling of the existing banks, in order to create a shallow berm some 1m-2m in width. This area would then be planted with a range of native emergent plants species, typically reed sweet grass, sedge, yellow flag *Iris pseudacorus* and reed canary grass. This would not only create a valuable

area of dense marginal vegetation, but would soften the visual impact of the wooden toe boarding.

- In order to encourage sorting of the substrate and heterogeneity of the bed profile in this section of the channel, a number of measures are recommended. A series (say 5 no.) of small, upstream facing 'v' groynes should be installed near to the centre of the channel, in order to scour deeper pools, important as refuge areas for brown trout and other fish. These are simple to construct from timber derived from localised coppicing.

Wooden 'v' groyne. Note deeper hole scoured downstream of the structure

In addition, use should be made of small faggot islands in order to 'braid' the existing single channel into a series of smaller channels. These will increase the abundance of habitat for juvenile brown trout (by increasing visual isolation), increase water velocity locally, encouraging the growth and development of water crowfoot, and will provide an extensive areas of marginal vegetation suitable for juvenile trout.

A total of 10 islands are recommended, with overall dimensions of 2m (w) by 4m (long). The islands should be arranged in a staggered line down the channel, in order to create a mosaic of channels with increased velocity, and optimising conditions for the growth of water crowfoot. The islands should be constructed from deadwood faggot bundles, secured to cleft chestnut stakes, driven at 0.6m centres.

The central core of the islands should be infilled with woody brashings, tied down in order to prevent washout by high discharge events. The upstream 'toe' of the islands

should be protected by stone rip-rap to reduce the risk of erosion. Emergent vegetation including yellow flag and sedge should be planted into the brashings in order to rapidly enhance the structural integrity of the islands. The top level of all islands will be set approximately 100mm-150mm above mean summer water level as defined on site. During high flow periods, the islands will become submerged, reducing the risk of accumulation of debris and minimising their impact on flow conveyance.

- Rotational coppicing of riparian trees should be undertaken in order to reduce shading of the channel and increase marginal vegetation growth. Timber and brash arising from the coppicing could be used in the construction of the faggot islands.

Reach 2:

- The energy of chalkstreams is not generally sufficient to create scour and sorting of the substrate. In natural river systems, fallen trees and branches create increased localised velocity and hence scour. The more managed river systems common to lowland rivers in the UK often lack this Large Woody Debris (LWD) element. The River Wandle is no exception. In many reaches of the Wandle, this lack of sorting has lead to uniform substrate, with significantly reduced habitat quality and availability for all lifestages of a range of fish species.

The introduction of LWD would be of great benefit to this reach. Measures to increase LWD should focus on the provision of cover logs in marginal areas by the simple expedient of trimming small to medium sized trees to an acceptable size and then felling them into the river channel. They can then be pinned into position using driven wooden stakes. Stable LWD of this sort is of particular long term value, allowing the build up of weed/debris rafts and associated beneficial macroinvertebrates that are vital components of the energy cycle of river systems. Sediment accreting within and downstream of LWD will eventually be colonised by emergent vegetation, helping to narrow the river channel. Weed raft/ fallen tree complexes also provides excellent cover for adult fish.

It is also recommended that there should be a presumption against the removal of any naturally fallen timber. Such material can be pinned in place as described above with all the associated advantages stated. Advice relating to the management of LWD in the channel is predicated on the assumption that its retention does not cause any increased risk of damaging flooding. This risk should be assessed in conjunction with the EA's Development Control and Flood Risk Management departments.

- A series (say 10) 'v' shaped groynes could also usefully be constructed in order to create diversity in the bed profile and increase sorting of the substrate.

- Continuation of the localised coppicing by the EA would be of benefit in order to reduce shading of the channel. Timber arising from the coppicing could be utilised in the introduction of LWD and the construction of 'v' shaped groynes. The current EA policy of chipping of the timber should be a last resort, with the materials arising better used in the construction of valuable groynes.

- The apparently redundant weirs upstream and downstream of Paper Mill Bridge could be removed and replaced with a series of (probably two), constructed gravel

riffles. The level and grade of these should be set so as to maintain the existing water level upstream, or could be lowered, effectively increasing the upstream gradient, promoting scour and thus reducing the accumulation of sediment. The creation of gravel-dominated riffles would also increase the availability of this valuable and under-represented habitat type. A range of species is associated with gravel riffles, in particular spawning/juvenile brown trout and water crowfoot. In general, it is recommended that riffles should be constructed to be a minimum of 15m in length.

Each riffle will increase the retained head, probably by between 15cm-30cm, with the extent of this backwater effect being assessed as part of the detailed design process. Optimum conservation benefit is obtained if the depth of gravel in each riffle exceeds 50cm, with a range of macroinvertebrate species requiring a hyporheic zone of this depth to reproduce successfully. In order to optimise spawning conditions for brown trout, water velocity should be between 25cm/sec – 75cm/sec, with a water depth of between 25cm and 60cm. Gravel and stone will need to be imported onto the site from the nearest quarry for construction of the riffles.

- Downstream of Butter Hill Bridge, the combination of RB tree shading and vertical concrete revetment had combined to limit the growth of marginal vegetation. Rotational coppicing (as described above) would reduce shading in this section of channel. In addition, it is recommended that a two-stage channel should be constructed along the LB of the existing channel. This should vary between 0.5m and 2m in width in order to create an element of sinuosity within the river and should be constructed from chestnut stakes and coir fibre rolls/faggots as described for Reach 1.

- The old mill impoundment at Butter Hill isolated fish populations in adjacent reaches, effectively preventing any upstream migration. It is recommended that consideration should be given to the retrofitting of a modular fish pass within the structure in order to afford passage to fish. It is likely that either a Denil or Larinier pass could be fitted within the brick wing walls downstream of the central sluice. Prioritisation of flow through this channel would allow passage of fish over a large range of discharges. Detailed design of such a pass is a specialist undertaking, and beyond the scope of this report. It is recommended that Greg Armstrong, the EA national fish pass officer should be consulted via the local EA fisheries team for further professional input into any project aimed at providing fish passage over this obstruction.

- The mill impoundment had also resulted in the accumulation of up to 1m of fine sediment in the river length upstream. It would be of great benefit if the retained head could be reduced by lowering the central sluice permanently, reducing the retained head and increasing water velocity upstream. This would reduce the volumes of fine sediment retained in the channel over time. Such a change in the retained head would need to be carefully planned in conjunction with the proposed fish pass construction, and the creation of a two-stage channel upstream of the mill. There is some risk that the sediment currently retained behind the impoundment is contaminated with heavy metals and/or organic compounds. As a consequence, it may be necessary to consider

the initial controlled removal of this sediment to an appropriate licensed waste facility. The EA should be consulted for their views with reference to this issue.

Reach 3

- Much of the reach downstream of Butter Hill Mill was overshaded by riparian tree growth. A programme of rotational coppicing should be instigated in order to reduce this shading, promoting the development of a marginal fringe of aquatic vegetation and consequent narrowing of the channel.

- The small retaining weir at Mill Pond Place bridge was detrimentally affecting upstream habitat. Its backwater effect had resulted in an overwide channel and ongoing and damaging deposition of fine sediment on the river bed. It is strongly recommended that it is modified, ideally by its total removal, or alternatively, by the removal of a wide central notch, reducing the retained head and damaging upstream impacts, and allowing passage of fish across the structure at all times.

If this option were chosen, then up to 40m of coir fibre or faggot revetment would be required on the RB upstream, in order to promote the development of a strong fringe of marginal vegetation. If adoption of this option were not possible, an alternative approach would be to build up the bed level downstream, by the construction of a gravel riffle. This would have the effect of raising the head level upstream of the riffle by some 20cm-30cm, removing the hydraulic step created by the impounding weir. This would allow access across the weir to fish, and would increase the availability of flow dependent trout spawning habitat. However, it would not address the impacts of the weir on upstream habitat.

- The introduction of LWD and the construction of a series of ‘v’ shaped groynes in the section downstream of Mill Pond Bridge would create increased diversity in the bed profile. In conjunction with channel narrowing as a result of increased marginal weed growth following coppicing, these prescriptions would significantly increase habitat quality and availability for a range of species.

Reach 4:

- Consideration should be given to the development of a fish pass at Shepley Mill. The present impoundment and concrete culvert in combination are currently acting to prevent the migration of fish between reaches 3 and 4. Removal or bypassing of the obstruction would allow the reconnection of the presently isolated fish populations. However, given the scale of the impoundment and the developed nature of the site, the practical and financial difficulties of providing a fish pass facility should not be underestimated. It is likely that the best opportunity for the installation of a pass or bypass channel may be if/when the site is subject to future development. If development of the site was to be proposed, the Wandle Trust should press the local authority to make the provision of a fish pass a condition of planning. Similar

schemes have been successfully implemented on a number of former mills sites on the River Wye, High Wycombe, Bucks and the River Windrush, Witney, Oxon.

- Much of the reach was overshaded by bankside trees. A programme of rotational coppicing should be instigated in order to reduce this shading, promoting the development of a marginal fringe of aquatic vegetation and consequent narrowing of the channel.

- Timber and brushwood from the coppicing should be retained and utilised to locally narrow approximately 200m of the middle/lower reach. Sections of faggot or coir fibre roll revetment should be installed, in order to create a narrower, low flow channel within the existing channel outline. The area behind the new bankline should be packed with dense bundles of brushwood, tied down to prevent their loss during higher flow events. This prescription will slow down water velocity within the woody matrix, encouraging deposition of fine sediment and colonisation with marginal aquatic plants. As an alternative to narrowing the channel from the margins, mid-channel faggot islands could be constructed in order to braid the channel as detailed for reach 1. A total of 25 islands could initially be created in this reach, with results of these monitored over time.

Reach 5:

- The channel was heavily shaded by trees, reducing marginal and instream weed growth. Many of these trees were large, with considerable landscape value. However, some limited coppicing, pollarding or trimming might be possible in order to decrease shading of the channel.

- Following removal of some of the shade, sections of faggot or coir fibre roll revetment should be installed, in order to create a narrower, low flow channel of some 4m-5m width within the existing channel outline. The area behind the new bankline should be packed with dense bundles of brushwood, tied down to prevent their loss during higher flow events. This prescription will slow down water velocity within the woody matrix, encouraging deposition of fine sediment and colonisation with marginal aquatic plants. As an alternative to narrowing the channel from the margins, mid-channel faggot islands could be constructed in order to braid the channel as detailed for reach 1. A total of 20 islands could initially be created in this reach, with results of these monitored over time.

- LWD and ‘v’shaped paired groynes should be utilised in this reach to increase diversity of the bed profile and in order to develop habitat suitable for both adult trout and coarse fish. The groynes could be constructed from timber arising from local coppicing/pollarding, or could be constructed by utilising some of the larger individual stones that existed within this reach.

- The old weir at McRae’s Mill presented an impassable barrier for upstream migrating fish. Ideally it would be removed and replaced with a series of constructed riffles. In the event that this is not possible, then the provision of a fish pass should be considered at the site, in order to re-establish the connectivity of upstream and

downstream fish populations. It is recommended that Greg Armstrong, the EA national fish pass specialist should be consulted via the local EA fisheries team for further professional input to any project aimed at providing fish passage over this obstruction.

Reach 6:

- The lack of marginal vegetation was very noticeable in the Beddington STW effluent channel and was likely to be limiting the value of the channel for juvenile fish and a range of macroinvertebrate species. It is recommended that a shallow marginal berm should be constructed within the channel to address this habitat shortfall. 300mm diameter pre-planted coir fibre rolls should be bedded onto proprietary 300mm diameter rock rolls or stone filled gabion mattresses, in order to create a shelf with a width of between 0.5m and 2m. The coir rolls should be fixed to the rock rolls or gabions using wire or plastic ties, in order to create a firm and stable revetment.

The void behind the newly created bankline should be infilled, either with tied down brush wood bundles or sub-soil or a mix of both. Planting of this area with a mix of emergent and marginal aquatic plants will speed up stabilisation of the berm. By alternating the bank on which the shelf is created, a meandering planform could be established for the new bankline.

- Downstream of the confluence of the effluent channel, LB shading and the concrete banks of the river had severely restricted marginal growth. Development of a strong marginal fringe should be encouraged by judicious LB coppicing/pollarding and creation of a low level 2-stage channel as described above. Alternatively or in addition, a series of faggot bundle islands could be created in order to braid the channel and increase habitat diversity.

- LWD was under-represented in this reach. Some of the larger timber resulting from coppicing and pollarding should be introduced and secured within the channel.

- The small impounding weir in this reach could be removed and replaced with a constructed riffle, approximately 30m in length. This would increase the availability of flow dependent spawning habitat for rheophilic species whilst enhancing oxygenation of residual effluent.

Reach 7:

- The channel was overshaded, with significant suppression of instream and marginal vegetation resulting. It is recommended that this shading be reduced by selective trimming of the canopy. The high landscape value of many of the trees within the Morden Hall Park may limit the amount of trimming possible but does not negate the need for a reduction in the shade cast by them.

- The channel downstream of Mitcham road bridge was overwide and undifferentiated. In order to increase heterogeneity of the bed, it is recommended that LWD be introduced. In addition, 10 paired ‘v’ shaped groynes and 20 mid-stream faggot islands should be created. Timber and brushwood arising from the cutting of the riparian trees should be utilised for these enhancements. Given the abundance of

floating pennywort in this reach, it is very likely that any structures constructed within the channel will become colonised by this alien plant. Although it would be more desirable to promote the development of native plant species, floating pennywort will aid consolidation of the structures, and narrowing of the channel. Its likely presence should not be used as a rationale for not instigating these works.

- The backwater area downstream of the flood arches should be preserved. Areas such as this are of fundamental importance to the survival and subsequent growth of juvenile coarse fish. They provide refuges from spate conditions and are rich in food items eaten by young fish. It is recommended that backwater areas in the form of "dead" arms of channels, old ox-bows and small ponds connected to the main river should be encouraged and developed within the reach. These features need not be extensive; shallow flooded marginal areas and small bankside scrapes can be of great benefit.

- Prior to any works being undertaken on the numerous channels within Morden Hall's grounds, it is essential that the apportionment of flows between the channels should be agreed. Flow should generally be prioritised into the river system rather than the stillwater and wetland areas within the Hall's grounds. The river system is flow dependent whilst the lakes are level dependent, allowing them to flourish with only periodic inputs of water. Indeed, having flow through the stillwaters at all times is poor management practice, resulting in the accumulation of sediment and nutrients within them, promoting the growth of algae and shortening their life as open water areas.

It may also be possible to prioritise flow along the various tributary streams seasonally in order to optimise conditions for spawning fish, gradually reducing flows after emergence of fry. Without an agreed flow regime for each, the installation of appropriately sized enhancements will prove difficult in these channels.

- Where historic landscape considerations permit, the management regime of the channels within the grounds of Mordon Hall should be modified, with the present heavy bank cutting regime reduced in order to allow development of a fringe of marginal vegetation, ideally at least 2m in width.

- The small impoundments located in several of the channels within the Hall's grounds should be removed and replaced by constructed riffles of appropriate dimensions and gradient. This will reduce the accumulation of fine sediment in the channel, whilst increasing the quality and availability of spawning habitat for rheophilic fish species that is currently under-represented in this reach. In the event that removal of these impoundments is not possible, then gravel riffles could be constructed downstream of each impoundment increasing the length of good quality spawning habitat present for trout and rheophilic coarse fish within the reach.

- The toe boarding present over lengths of the distributary streams and main channel should be removed and replaced with 300mm diameter coir fibre rolls,

bedded on proprietary 300mm diameter rock rolls where appropriate. In conjunction with modification of the management regime within the Hall's grounds, this would promote the development of a strong and valuable fringe of marginal vegetation.

- Where banks of the distributaries were lined with concrete slabs, coir fibre rolls and faggot bundles should be used to create a low level marginal shelf and mid-channel islands within the existing channel as described for previous reaches.

Reach 8:

- The concrete lined channel adjacent to Merton Abbey Mills would benefit from the creation of a low-level marginal shelf. Pre-planted coir fibre rolls, with a gabion or rock roll footing, should be used to create a 1m-2m wide shelf as described for previous sections. By alternating the shelf along the LB and RB, a meandering planform to the river could be created.

- A similar coir fibre shelf should be installed at the base of the wooden revetment on the RB downstream of the Merantun Way roadbridge, and for the length of vertical concrete walls alongside Merton High Street and the downstream Wandle Bank. A sub-surface concrete shelf was present along some of the latter length of bank. This could be used as a footing for the coir fibre, probably removing the necessity for gabion mattresses or rock rolls over some of the length of the enhancement.

- Downstream of Connolly Mill, 50m of coir fibre and faggot revetment should be installed in order to extend the existing length of LB marginal shelf. Reprofiling of the existing bank could be used to create backfill behind the revetment (so-called 'cut and fill'). This technique should ensure like for like flood risk compensation for the creation of the shelf. Maximum benefits would be realised if the RB trees (mainly crack willows) were pollarded. Arisings from this management could be utilised to create the faggot bundles for the revetment.

Reach 10:

- The creation of marginal or midstream cover would be of great value in this reach. The lack of this habitat type is likely to be limiting the survival of trout and coarse fish fry. Its absence also renders the unsightly hard revetments more prominent. If flood risk considerations permit, the installation of pre-planted coir fibre rolls on a gabion or rock roll footing along one or both banks of this length would be of huge benefit. Alternatively, or in addition, mid-stream islands could be constructed using faggots and stakes as described previously.

Overall:

- The final dimensions of any enhancements installed upstream of the present discharge from Beddington STW will need to be defined with respect to an agreed flow regime. This will be dependent on the volumes of re-circulated augmentation

flow agreed. Clearly, any increase in the present volumes will require less narrowing of the channel than would be the case if the status quo were maintained.

- Floating pennywort is found throughout the middle and lower reaches of the River Wandle. The presence of this invasive alien plant species has been cited by the EA as a reason to avoid some forms of habitat enhancement on other rivers in the Thames Region. What was apparent in the reaches of the Wandle visited was that floating pennywort was less abundant in shallow, free-flowing reaches with a relatively high water velocity, exactly the conditions that brown trout, chub and barbel require for spawning. Given this, the development of this mesohabitat type by the implementation of enhancements detailed in this report may perhaps reduce the incidence of pennywort in some reaches.

- It is likely that at present, there is a 'bottleneck' for trout at the spawning lifestage, perhaps due to the direct and indirect impact of the low flows often experienced during key periods. The introduction of fed trout fry via the 'Trout in the Classroom' project has proved the viable survival of these fish to maturity, with a number of fish averaging 250g caught on rod and line.

A practical way to overcome this apparent spawning bottleneck is through the use of a deep substrate incubation box. In essence, these are gravel filled boxes, approximately 0.6m in each dimension, which are filled with suitably sized gravel and seeded with 10,000 - 20,000 trout eggs. A water feed at the bottom of the box allows the eggs to incubate and hatch. Once they reach the swim-up fry stage, they leave the box via the overspill pipes, stocking themselves into the river or are caught in outfall traps and distributed into suitable juvenile habitat elsewhere in the river. In effect, these are naturally reared fish without the unhelpful behavioural modifications associated with hatcheries. Such a system could be established on one or more of the impoundments within the river, using the head loss across them to drive the boxes. Particularly useful sites might include Butter Hill Mill, McRae's Mill and one or more of the minor channels within Morden Hall More details on incubation boxes can be found on the Wild Trout Trust web site www.wildtrout.org or in Volume 2 of the Trust's magazine, *Salmo trutta.*

In addition to their recorded success in enhancing numbers of trout in rivers with spawning bottlenecks, deep substrate incubation boxes are a powerful educational and social tool, providing a focus for groups with an interest in river conservation and a tangible benefit that reinforces the efforts of volunteers. Information from the hatched fry could also provide a useful data source for schools participating in the project. Degree days to hatching, number of fry emerging from the trap each day and survivorship of eggs to swim up fry stage are all examples of data that could be used in maths and science classes.

The fact that the Trust has stocked numbers of hatchery reared fish (from the 'Trout in the Classroom' project) into the river should permit the use of viable hatchery origin eggs in the incubator under the guidelines for stocking in the EA's 'Trout and Grayling' strategy.

- The quality of suitable spawning gravel within the river may be limiting the abundance of trout. The quality of the gravel can be improved by establishing a

regime of cleaning spawning gravels each September. This can be achieved by either manual raking, or by the use of high-pressure water jets. Care must be taken to clean riffles rotationally, with only short sections being treated annually. It is important that the EA are contacted prior to any cleaning of gravel, due to the possible discoloration of water in the river resulting from the operation. The same concerns dictate that downstream neighbours should also be forewarned of the operation.

- The creation of low-level marginal berms where specified will not only improve the ecological value of the Wandle, but will in many cases help to hide unsightly hard bank revetment in what are often very public areas. For the Wandle to flourish, it is vital that both its place in the visual landscape and standing with the local community are enhanced. Softening of the hard edges of the river is one positive mechanism for achievement of these goals.

- The Environment Agency should be contacted with a view to reviewing the need for and manner in which maintenance work is undertaken, in particular maintenance dredging and the need to remove LWD from the Wandle channels. It is essential that agreement be reached regarding these practices if benefit from the enhancements proposed in this report is to be optimised.

- The development of the Wandle's fish stocks is predicated on the assumption that water quality within the river is maintained or improved from its current level. The source of the majority of flow within the middle and lower river is Beddington Sewage Treatment works. Given the high volumetric output of the works, it is imperative that discharge standards, in particular that for ammonia, remain tight. Any significant slippage in the present standard or compliance with it, would seriously compromise the benefits to riverine ecology that would arise from the habitat enhancements proposed on this report. It is strongly recommended that the Wandle Trust obtains regular data on water quality within the River Wandle, including information on macroinvertebrate sampling undertaken by the EA, collated in the Biological Monitoring Working Party (BMWP) and Average Score Per Taxa (ASPT) score. In addition, data on effluent quality from key discharges, in particular that from Beddington STW should be obtained and checked for compliance against statutory consent conditions. Only in this way can any long-term diminution in water quality be monitored and pro-active steps taken to improve it.

Placing eyed ova into a deep substrate incubation box

- The presence of Himalayan Balsam and Japanese knotweed are undesirable. They are classified as alien invasive weed species. It is understood that there is no policy for their control on a catchment basis, with no authority having a remit to undertake this work. Given the urban nature of the river, their control cannot be given a high priority. However, should the Wandle Trust, the local authority or the EA decide to tackle the issue on a local or river wide basis, chemical control with the herbicide glyphosate when the plants are actively growing in early spring should prove to be the most effective strategy. Himalayan Balsam can also be cut at ground level before the flowering stage (June) or can be pulled up by the roots and disposed of by composting or burning unless seeds are present.

Note that the use of glyphosate or any other herbicide on or near water requires the consent in writing of the EA.

4.0 Legal and other considerations.

A range of legal requirements must be considered as part of the detailed planning for any enhancements. The list below highlights some of the likely key requirements. However, this should not be considered a comprehensive list, with the Wandle Trust and the enhancement designer/contractor liable for ensuring that all necessary consents and permissions are obtained:

- All works to the bed or banks of the river or within 8m of its banks may require the written consent from the Environment Agency under the Land Drainage legislation. It is imperative that all relevant consents are obtained by the club prior to the commencement of any works.

- A Flood Risk Assessment may be required as part of any Land Drainage consent application. No Flood Risk Assessment has been undertaken as part of this design package. Accordingly, no liability or responsibility for any loss or damage due to consequent flooding can be accepted by Windrush AEC Ltd as a result of any person, company or other organisation acting, or refraining from acting, upon comments made in this report

- Planning permission for some of the works proposed may be required under the terms of the Town and Country Planning Act. Accordingly, the local authority should be contacted for their advice regarding necessary consents at the detailed planning stage of any scheme.

- The introduction of any fish or eggs into any inland water requires the consent of the EA under the Salmon and Freshwater Fisheries Act, 1975. It is imperative that all relevant consents are obtained by the club.

- Some of trees along the length of the river may be covered by a Tree Protection Order. Details of such trees are held by the local authority, whose records should be checked prior to the commencement of any felling. In addition, a felling licence may be required from the Forestry Commission if more than 5 m^3 of timber is to be felled in any calendar quarter. More detailed information on felling licences can be obtained from www.forestry.gov.uk

- Water vole survey. This is an essential pre-requisite of any enhancement work where water voles are suspected to live. It is an offence under the Wildlife and Countryside Act (1981, as amended) and the Countryside and Rights of Way Act 2000, to intentionally or recklessly damage, destroy or obstruct access to any structure or place a water vole uses for shelter or protection, or to disturb a water vole whilst it occupies such a place.

5.0 Design Package

The design package outlined below is based on a single visit to each site. As such, no detailed measurements have been taken for the enhancements proposed; all quantities and dimensions are thus estimates for use in discussions with statutory bodies and potential project partners. As such, no liability or responsibility for any loss or damage can be accepted by Windrush AEC Ltd as a result of any person, company or other organisation acting, or refraining from acting, upon comments made in this report.

Design Package

5.1. Scope of Works
5.2 Specification
5.3 Indicative Quantities
5.4 Design Drawings

5.1. Scope of Works

Reach 1:

i) Modify existing impoundment within The Grove to allow fish passage

ii) Narrow 100m of channel using pre-planted coir fibre rolls and faggot bundles. Backfill with excavated bank material to create low-level marginal berm.

iii) Construct 5 no. paired ‘v’ shaped groynes

iv) Construct 10 no. midstream faggot islands

v) Selectively coppice/pollard riparian trees to reduce shading and increase marginal plant growth

Reach 2:

i) Construct 10 no. paired ‘v’ shaped groynes

ii) Selectively coppice/pollard riparian trees to reduce shading and increase marginal plant growth

iii) Introduce LWD elements into marginal areas of the channel

iv) Remove 2 no. existing weirs and replace with 4 no. constructed riffles

v) Narrow 100m of channel using pre-planted coir fibre rolls and faggot bundles. Backfill with locally derived sub-soil or timber brashings in order to create low-level marginal berm.

Reach 3:

i) Selectively coppice/pollard riparian trees to reduce shading and increase marginal plant growth

ii) Remove or modify the weir apron at Mill Pond Place bridge in order to allow fish passage

iii) Narrow 40m of channel using pre-planted coir fibre rolls and faggot bundles. Backfill with locally derived sub-soil or timber brashings in order to create low-level marginal berm.

iv) Introduce LWD elements into marginal areas of the channel

v) Construct 5 no. paired ‘v’ shaped groynes

Reach 4:

i) Selectively coppice/pollard riparian trees to reduce shading and increase marginal plant growth

ii) Narrow 150m of channel using pre-planted coir fibre rolls and faggot bundles. Backfill with locally derived sub-soil or timber brashings in order to create low-level marginal berm

Reach 5:

i) Selectively coppice/pollard riparian trees to reduce shading and increase marginal plant growth

ii) Narrow 50m of channel using pre-planted coir fibre rolls and faggot bundles. Backfill with locally derived sub-soil or timber brashings in order to create low-level marginal berm.

iii) Construct 5 no. paired 'v' shaped groynes

iv) Introduce LWD elements into marginal areas of the channel

Reach 6:

i) Narrow 300m of the effluent channel using pre-planted coir fibre rolls set on gabion mattresses or proprietary rock rolls. Backfill with locally derived sub-soil or timber brashings in order to create low-level marginal berm.

ii) Narrow 200m of the main river channel using pre-planted coir fibre rolls set on gabion mattresses or proprietary rock rolls. Backfill with locally derived sub-soil or timber brashings in order to create low-level marginal berm.

iii) Construct 30 no. midstream faggot islands

iv) Remove small weir and replace with a 30m length of constructed riffle

v) Introduce LWD elements into marginal areas of the channel

Reach 7:

i) Introduce LWD elements into marginal areas of the channel

ii) Construct 20 no. midstream faggot islands

iii) Construct 10 no. paired 'v' shaped groynes

iv) Remove wooden toe boarding and replace with pre-planted coir fibre rolls over an unspecified length of river

v) Remove impounding weirs (unspecified no.) and replace with appropriate

length of constructed riffle

Reach 8:

i**)** Narrow 590m of the channel using pre-planted coir fibre rolls set on gabion mattresses or proprietary rock rolls. Backfill with locally derived sub-soil or timber brashings in order to create low-level marginal berm.

ii) Narrow 50m of channel using pre-planted coir fibre rolls and faggot bundles. Backfill with locally derived sub-soil or timber brashings in order to create low-level marginal berm

Reach 10:

i) Narrow 590m of the channel using pre-planted coir fibre rolls set on gabion mattresses or proprietary rock rolls. Backfill with locally derived sub-soil or timber brashings in order to create low-level marginal berm.

ii) Construct 20 no. midstream faggot islands

All as per attached Drawings, Specifications and Bill of Quantities.

5.2 Specification.

As on enclosed Drawings and herein:

i) <u>Modify existing impoundment to allow fish passage</u>

Modify the existing weir at the Grove, by cutting a low flow notch in the centre of weir to allow fish passage. Detailed design to be agreed with the Environment Agency.

ii) <u>Narrow channel using pre-planted coir fibre rolls and faggot bundles at locations marked on site</u>

Narrowing to comprise of deadwood faggots woven between cleft chestnut stakes driven upright to a minimum depth of 500m at centres of 600m at a distance of between 1m – 2m from the bank (as specified on site). Faggots to be compacted vertically to ensure a dense weave between the stakes. Top level of installed faggots to be 100mm-200mm below agreed summer water level. Proprietary 300mm diameter pre-planted coir fibre rolls to be attached to the stakes above the faggots. Stakes and top level of the coir fibre rolls to finish between 100mm and 200mm above mean summer water level (to be agreed on site). Upstream and downstream limits of the revetment to be returned into the bank and adequately keyed to prevent erosion at these nick points. Void space between new and existing banklines to be backfilled with sub-soil obtained from local regrading of banks (as specified on site) or timber brashings from on site coppicing

Coir fibre:	300mm x 2m proprietary pre-planted coir fibre rolls. Plant mix to be specified at detailed design stage

Faggots:	1.5m x 0.5m. Constructed of brushwood tied with Polypropylene string. Wired to posts at 0.5m centres.
Stakes:	Untreated softwood or cleft chestnut stakes (purchased) or hardwood stakes (from on site coppicing) of nominal 100mm diameter at 0.6 m centres. Driven to depth to ensure retention of backfill, with tops cut to 100mm above mean summer water level following installation.

iii) Narrow channel using pre-planted coir fibre rolls set on stone filled gabions or rock rolls at locations marked on site

Narrowing to comprise of 2m x 1m x 0.5m stone filled gabion mattresses or 300m diameter proprietary rock rolls laid on the existing bed of the river so as to form a stable base 1m –2m (as advised) from the bank. 300mm diameter pre-planted proprietary coir fibre rolls should be tied to the gabion mattress or rock roll using wire or plastic ties. Top level of installed coir fibre rolls to finish between 100mm and 200mm above mean summer water level (to be agreed on site). Upstream and downstream limits of the revetment to be returned into the bank and adequately keyed to prevent erosion at these nick points. Void space between new and existing banklines to be backfilled with sub-soil obtained from local regrading of banks (as specified on site) or timber brashings from on site coppicing.

iv) Construct paired 'v' shaped groynes at locations marked on site

Paired groynes to be constructed from local timber derived from on site coppicing. Individual timbers to be sized to ensure that the invert of the installed groynes is no more than 50mm above agreed summer water level. Timbers to be located approximately centrally within the channel, and paired approximately perpendicular in order to form an upstream facing 'v'. Timbers to be retained by untreated softwood or cleft chestnut stakes (purchased) or hardwood stakes (from on site coppicing) of nominal 100mm diameter set at 0.6 m centres. Stakes to be driven to depth to ensure retention of timbers, with tops cut to 100mm above mean summer water level following installation. The void between the lower edge of the timbers and the existing bed should be filled with locally derived large stone/gravel in order to prevent under scour of the timbers.

v) Construct midstream islands at locations marked on site

Islands to be installed in a staggered fashion as shown in Drawing 1 and as marked on site. Each island to be approximately 2m wide, and 4m long. Individual islands to be constructed from deadwood faggot bundles, woven between cleft chestnut stakes at 600mm centres. Each stake to be driven vertically to a minimum depth of 500mm. Faggot bundles to be compacted vertically to ensure a dense weave between the stakes. Stakes and faggots to finish at between 100mm and 150mm above mean summer water level (to be agreed on site)

Centres of the islands to be infilled with woody arisings, obtained locally or imported. Arisings to be well compressed to ensure a dense fill to the island, and securely fastened to prevent washing out during high flow events.

The upstream toe of each island shall be protected by hand or machine laid rip-rap, Rip-rap to be of a minimum diameter of 100mm and to be laid to form a stable revetment around the whole of upstream base of each island of a minimum height of 300mm.

vi) Selectively coppice/pollard riparian trees to reduce shading

Selectively coppice or pollard trees as marked on site. Timber and brushwood arisings to be used elsewhere on site as directed, or disposed of on site or elsewhere as directed.

vii) Introduce LWD elements into marginal areas of the channel as specified on site

Selected limbs from riparian trees as marked on site should be felled into the channel. The limbs should be secured in the channel facing downstream at an angle of approximately 30^0 to the bank, using cleft chestnut stakes and wire were necessary. The limbs should be trimmed so that they extend over no more than 25 % of the total width of the channel (or for a distance agree with the EA under the Land Drainage consenting process)

viii) Remove existing weirs and replace with constructed riffles

Existing weirs (as specified on site) should be removed. Any stone or concrete from the weirs should be re-used in the construction of the riffles, subject to the Waste Licensing Regulations.

Riffles should be constructed from limestone (or similar local stone), with a maximum individual weight of 25 kg. The stone should be laid in an open mosaic on the riverbed at locations specified on site in order to leave a finished water depth of 350mm. The stone should be overlaid by a 50:50 mix (by weight) of flint (or pebble) reject gravel and 20mm-40mm diameter flint or pebble gravel to a mean depth of 150mm at locations specified in drawings. Individual riffles should be between 15m and 20m in length.

5.3 Quantities.

Reach 1:

Description.	**Unit.**	**Quantity.**
Coir fibre rolls	m	100
Faggot bundles	m	350
Untreated stakes	no.	600

Backfill/brashings	m^3	250
Timber for groynes	m	30
Coppice/pollard	Man days	10

Reach 2:

Description.	**Unit.**	**Quantity.**
Timber for groynes	m	60
Coppice/pollard	Man days	10
LWB	m	80
Stone for riffles	tonnes	150
Mixed flint/pebble gravel for riffles	tonnes	65
Coir fibre rolls	m	100
Faggot bundles	m	100
Backfill/brashings	m^3	150
Untreated stakes	no.	250

Reach 3:

Description.	**Unit.**	**Quantity.**
Coppice/pollard	Man days	10
Coir fibre rolls	m	40
Faggot bundles	m	40
Untreated stakes	no.	75
Backfill/brashings	m^3	60
LWB	m	100
Timber	m	30

Reach 4:

Description.	**Unit.**	**Quantity.**
Coppice/pollard	Man days	10
Coir fibre rolls	m	120
Faggot bundles	m	120
Untreated stakes	no.	225
Backfill/brashings	m^3	180

Reach 5:

Description.	**Unit.**	**Quantity.**
Timber	m	30
Coir fibre rolls	m	50
Untreated stakes	no.	50
LWB	m	80

Reach 6:

Description.	**Unit.**	**Quantity.**
Coir fibre rolls	m	500
Faggot bundles	m	250
Untreated stakes	no.	575
Gabion mattress/rock roll	m	300
Backfill/brashings	m^3	1,000
Stone for riffles	tonnes	120
Mixed flint/pebble gravel	tonnes	50
LWB	m	100

Reach 7:

Description.	**Unit.**	**Quantity.**
LWB	m	100
Faggot bundles	m	480
Untreated stakes	no.	480
Backfill/brashings	m^3	160
Timber	m	60
Coir fibre	m	??
Constructed riffle	m	??

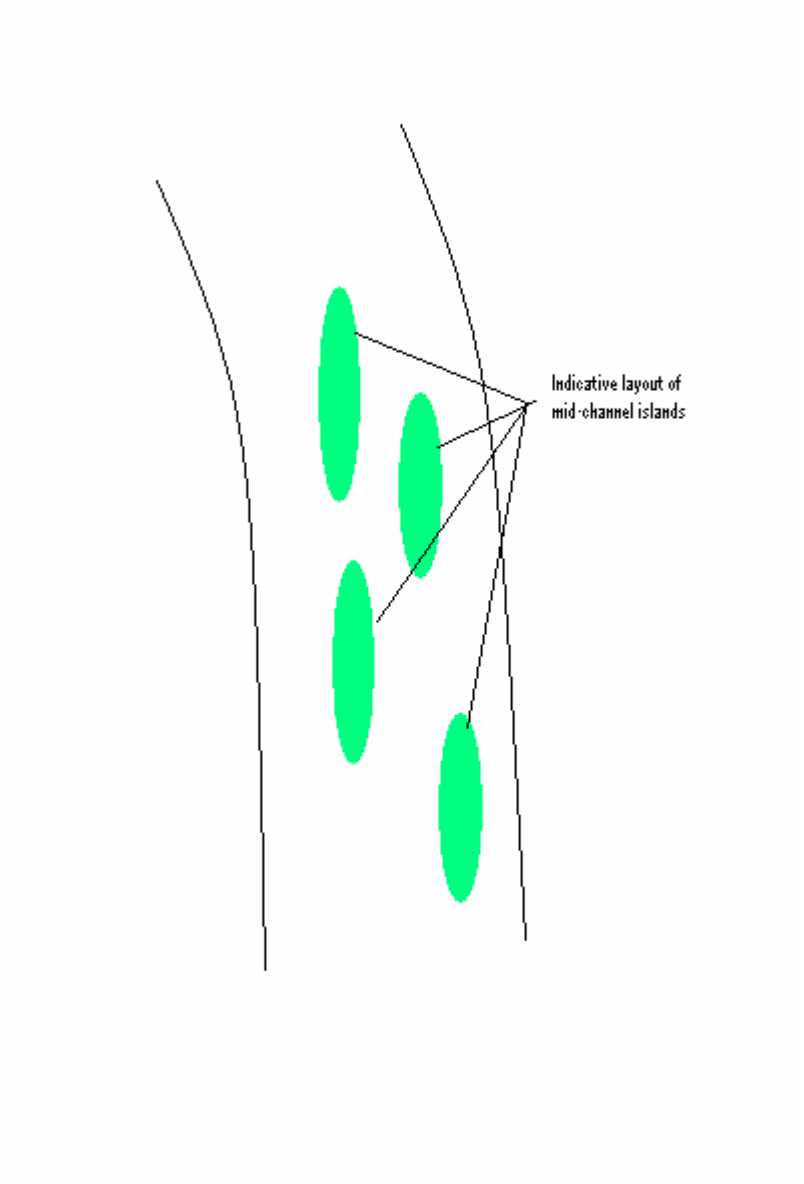
Reach 8:

Description.	**Unit.**	**Quantity.**
Faggot bundles	m	50
Untreated stakes	no.	85
Backfill/brashings	m^3	960
Coir fibre	m	640
Gabion mattress/rock roll	m	590

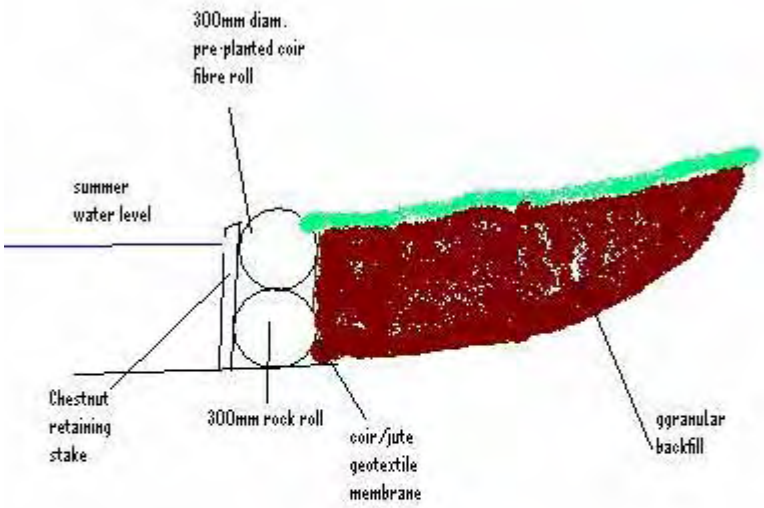
Reach 10:

Description.	**Unit.**	**Quantity.**
Faggot bundles	m	530
Untreated stakes	no.	485
Backfill/brashings	m^3	1,200
Coir fibre	m	640
Gabion mattress/rock roll	m	590

5.4 Drawings



Drawing 1: Layout of mid-channel islands



Drawing 2: Cross section of bank narrowing using rock roll and coir fibre (alternative narrowing uses faggot bundles to replace rock roll)

6.0 Potential funding streams and partners

The following sources of finance and potential partners could be considered for implementation of some or all of the recommended enhancements:

Landfill Tax: Details from www.ltcs.org.uk

Aggregates Levy: Details from http://www.defra.gov.uk/funding/schemes/alsf.htm

Environment Agency 'Cinderella chalkstream' project. Contact Lawrence Talks 08708 506506

The National Trust (for Mordon Hall). Contact Katherine Hearn or Mark Walsingham 01793 817737

WTT. Contact the Director, Simon Johnson 01692 409032