Welcome to **Estuary Edges: Ecological Design Advice.**

This advice shows how you can make a positive contribution to one of our most important environmental and social assets – our estuaries.

CONTENTS

Introduction

Well-planned developments next to our estuaries can create better places to live and work.

When reconstructing or refurbishing the banks of an estuary, your project should include features that support wildlife, improve public access, and educate people about the importance of protecting the environment.

Replacing grey sheet piling with lush colourful plants and swards of reed stems rustling in the wind add significantly to the waterside experience.

The natural habitats of our estuaries are often missing, especially in urban areas. For example, in the Thames Estuary only around 2% of the tidal banks are now natural in profile. The absence of the soft edges – where wildlife is most abundant – impacts on the ecological recovery of our rivers and estuaries.

Improving lengths of estuary habitat can restore nursery areas for commercially sought fish, such as Sea Bass. It can also benefit recreationally important fish such as Dace and Roach. By seeking refuge in the margins during the flooding tide, juvenile freshwater and marine fish are safer from predators and can feed on the aquatic insects that are abundant in the plants and mudflats.

Reed Warbler in reed bed

A Sea Bass

PLEASE NOTE PLANNING POLICY IS UNDER REVIEW & THIS SECTION WILL BE UPDATED BY 2013.

Policy, legal and planning requirements

Government guidance on biodiversity now requires developers to protect and enhance biodiversity in their schemes, particularly priority habitats such as mudflats and saltmarsh. Estuary and river edge design must improve the environment for fish and other wildlife, as well as meet national, regional and local Biodiversity Action Plan targets.

First of all, what is the 'estuary edge'? As a minimum this should be the entire zone set by the byelaws relating to Flood Risk Management (Land Drainage) consent under Schedule 25 of the Water Resources Act (1991). On the tidal Thames, for example, this extends 16 metres from the inland limit of any statutory flood defence.

National policy – The national encroachment policy for tidal rivers and estuaries states that development should not encroach further into the river channel or estuary.

European policy – The European Unions' Water Framework Directive highlights the need for maintaining and improving the ecological value of rivers, estuaries, lakes and coastal waters. It *discourages* actions that would reduce this value.

Further key elements of the main policy and legal framework for estuary edge design in the UK are summarised in *Building a better environment: A guide for developers*. These include:

- *Making Space for Water* – the Government strategy that promotes retreat of estuary edges for environmental gain as well as flood risk management.
- *Technical Advice Notes (Wales) 15: Development and Flood Risk* – this emphasises the environmental drawbacks of over-engineered river and estuary edges.
- *PPS9: Biodiversity and Geological Conservation (Section 2.2.4)* – this emphasises the need to ensure ecological enhancement in UK development projects of all kinds.
- *The Natural Environment and Rural Communities Act 2006* – this has given a duty to all public authorities to conserve biodiversity so far as consistent with carrying out their other functions (this relates fundamentally to the National Biodiversity Action Plan).
- *PPS1 Delivering Sustainable Development and Planning and Climate Change* – these provide policy support for the wider benefits of ecologically designed estuary edges.

A general approach to sustainable development is explained throughout *Building a better environment: A guide for developers*. The policies and licensing requirements of the local Navigation Authority should also be consulted. You should also check whether local policies promote particular estuary edge designs. For example the London Plan requires that new development be set back from the river and estuary edge for reasons of flood risk management and the environment.

Building a better environment: A guide for developers discusses the relevant Environment Agency permissions. Developments concerned with building in, over, under or beside our tidal rivers and estuaries will require flood risk management permission through local byelaws (in addition to planning permission from the local authority). The Environment Agency can recommend approval or refusal of applications or request planning conditions and legal agreements to be attached to any planning permissions granted. Consents issued by others that may be necessary for working on estuary edges may include (but may not be limited to):

1. **Planning Permission** from the Local Authority.
2. **Food and Environment Protection Act (FEPA) Licence** from the Marine and Fisheries Agency/ Welsh Assembly Government. This will be replaced by the Marine Licence following the enactment of the Marine Bill.
3. **Coastal Protection Act Consent** from the Marine and Fisheries Agency. This will be replaced by the Marine Licence following the enactment of the Marine Bill.
4. **Navigation or Harbour Authority Consent**.
5. **A Rights of Way Diversion Order** from the Local Authority or Highways Authority (for example, where a footpath or track follows the river or estuary edge).
6. **Natural England or Countryside Council for Wales Assent** where works may affect a site carrying a statutory designation for nature conservation (for example, Ramsar Site, Special Protection Area, Special Area of Conservation, Site of Special Scientific Interest or Local Nature Reserve) and licences where certain legally protected species might be affected.
7. **Listed Building, Scheduled Monument or Conservation Area Consent** from the consenting body via consultation with English Heritage or Cadw where planning permission is required and works might affect the demolition of buildings that are listed or in conservation areas, or the alteration of nationally important listed buildings or monuments.
8. **Landowner Consent** (for example, Crown Estate, Harbour Authority, etc.).

As legislation can change, you need to keep up to date – we will help you with this when you consult us.

Consulting with the Environment Agency

Call 08708 506 506 (Mon–Fri, 8–6) and ask to be put through to your local planning team.

Building a better environment: A guide for developers sets out the consultative process that we would expect you to follow in presenting any design option to us. In the case of estuary edge works you will involve officers from at least four out of our five main departments (see Section 1.3 of *Building a better environment: A guide for developers*).

You will need to demonstrate that your design is the most ecologically beneficial and locally appropriate solution that will maintain *all* of its functions through its required design life. You should consider further ‘hard’ engineered elements only as absolutely necessary.

Another key point to emphasise is that you should consider flood risk management using the Government’s advice on assessing flood risk (PPS25).

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Design considerations

There are many different considerations, so good forward planning will help you immensely.

Most importantly:

- Softer solutions should be used where possible
- Look to the surrounding area to influence your design

Many other factors will all influence your choice between design options. These will include:

- your key masterplan aims
- the land value of the project site and adjacent areas
- the flood risk assessment and the locations of the first inland constraints at any point.

Also, bear in mind that any designs are site-specific and depend on local circumstances.

Adjacent land use

The estuary edge will normally be just part of a larger development area that will have detailed development proposals or a masterplan of some kind. There may well be opportunities for a landscape design that highlights the interesting estuary character – this can create exciting landscapes that are not common in the wider urban environment. All elements of masterplanning, including water access and transport routes, wider wildlife corridors, and Sustainable Drainage Systems, should be considered in parallel with the estuary edge and waterside design options.

Land drainage

You should also consider your land drainage strategy and how it will interact with any intertidal system. Such an approach can lead to other benefits. For example, you might choose to discharge rainwater above the highest astronomical tide into a waterside habitat sequence – this helps create a variety of edge salinities and habitat variety. It could also avoid 'tidal locking' (this is when drainage outlets may be below low water level and pumping is required to discharge the run-off).

Bad drainage design can lead to problems with estuary habitats. For example, poorly designed outfalls can lead to local erosion damage, possibly increasing flood risk or damaging habitats. In addition, you need to consider land contamination – there are generally ecological solutions even at the most contaminated sites. This is addressed in some detail in the *Building a better environment: A guide for developers*, Section 2.2.7.

Flood risk management

The features of the flood risk management system that need to be considered include:

- Land-based loadings (for example, soil, water, buildings, vehicles, etc.).
- Current flow, waves, boat and propeller wash, and risk of illegal mooring.

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- Anticipated future estuary uses.
- Durations of all forces, especially peak forces.
- Frequency and duration of inundation of the waterside area under consideration (tidal level).
- Ground conditions and geology.
- Gradients of any maximum slopes necessary in the space available and stability of substrates at those gradients.
- The strength and durability of individual components and the elements included in the design.
- Water chemistry and factors affecting growth of plants in the intertidal zone.
- The overall desired lifespan of the design.
- Monitoring and maintenance.

You will need to set out your proposals clearly, both in terms of what you propose to build and how you intend to build it. You will need to specify how both the integrity of the estuary edge structure and flood risk management functions depend on elements other than hard engineering.

Navigational safety

Some engineering designs may create submerged hazards that may be necessary to day-mark for boats. In the case of softer margins, signage to deter unwanted mooring may be necessary both for protection of the edge and public safety. You also need to think about safety features for escaping from the water, such as grab chains.

Archaeology and heritage

We will be keen to hear how your design will both respect and celebrate heritage. It is important to check whether you are likely to affect any features of archaeological or heritage importance (such as those listed on the National Sites and Monuments Record or by local museums). In London, for example, the entire foreshore is considered to be of ‘high archaeological potential’. Along many of our estuaries, historic wharves are protected by specific planning policies.

Wildlife and green space

83.5% of the estuaries in England and Wales carry one or more designations as a Special Area of Conservation, Special Protection Area or Site of Special Scientific Interest. Many estuaries also carry local designations, so it is highly likely that your site will be in, next to, or close to a designated wildlife site. These designations need not, however, be a constraint. On the contrary, soft-engineering solutions are almost always going to improve the local conditions for valued flora and fauna and hence the integrity of the designated areas.

As with any development project in any habitat, you will need to fully assess how you will manage legally protected species.

In order to minimise any adverse effects on wildlife during construction itself, you should have a construction management code. This would, for example, check whether waterfowl feed or roost in the shoreline or on the nearby mud and shingle flats. Your proposals should seek to minimise disturbance, perhaps using various types of temporary and permanent screens or by timing the works around these seasons. You should also be aware of likely movements and behaviour of fish locally (The Environment Agency can often provide these data) and whether your site is close to key spawning areas.

The key zone for the growth of true saltmarsh is between Mean High Water Neap and Mean High Water Spring tide level and in many cases the aim should be to maximise the area of habitat created in this zone. However, the whole zone, from lowest tide mark to highest astronomical tide, is 'foreshore' and considered to be valuable habitat. The zone between 0.5 to 1 metre above highest astronomical tide, especially where there is a splash zone, is also of ecological importance and may support important shingle beach species. When designing areas of significant salt influence, you should note that naturally occurring saltmarsh in the UK is rarely stable at a slope greater than 1:7 and hence you should try to ensure that this slope is not exceeded in any area that you hope to support saltmarsh. Where substrates are made of larger particle sizes (such as shingle beach or boulder), steeper natural slopes supporting at least some vegetation can be stable.

You should always encourage and promote natural colonisation in the design as this will create locally appropriate communities. However, planting may be needed when:

- there appears to be limited scope for such natural colonisation, such as a lack of a seedbank that can reach the site naturally.
- early vegetation establishment is required for slope stability.

Timing of the planting and pre-establishment of species of the correct genetic strain will be important considerations. Use of rhizome or root barriers may be necessary to maintain the integrity and appearance of planted stands and prevent domination by particular species such as Common Reed, which can otherwise become completely dominant and diminish biodiversity. You should obtain specialist ecological advice from a consultant with prior experience of intertidal plantings to ensure that plants are of appropriate species and, wherever possible, of local origin. Plants also need to be selected at the correct size, planted at the correct tidal level, and in appropriate groupings to ensure maximum chance of establishment.

Some invasive species that may be particularly problematic in the intertidal margins include Japanese Knotweed and Chinese Mitten Crab. You should consult us directly for specific advice if such species occur on site or in the local vicinity and we will advise you how to meet design and legal requirements. Wildfowl themselves may be a problem as they feed on intertidal marginal plant growth. This risk needs to be assessed and if necessary protection measures put in place, such as fencing or mesh netting.

Many of our estuaries through urban areas include areas of derelict land that have been colonised naturally by numerous species of plants, invertebrates, birds and other species of notable ecological value. For example, along the urban Thames, the nationally rare breeding bird, the Black Redstart is often associated with tidal fringe habitats and benefits from low-nutrient, flower-rich habitat. Such low-nutrient species-rich swards can very readily be created along the water's edge itself or on nearby roof spaces. In the case of the roof space, creating such habitats will give multiple environmental, architectural and economic benefits.

You should also consider providing artificial refuges and freshwater wetland features for bats, some species of which may focus their feeding activities along the tidal water.

The importance of sustainable urban drainage and its integration with intertidal habitat creation is explained in *Building a better environment: A guide for developers*.

Careful waterside design will complement the ecologically designed flood defences. For example, at Barking Barrier the creekside was developed as wildflower-rich parkland to complement the set back flood defences. In another of our projects, in Essex, excavations from shoreline were used to make the new retreated revetments and create a saltwater lagoon. Behind the revetments the area of the excavation was developed as a freshwater lagoon, creating a sequence of complementary habitats of considerable value to wildlife.

Black Redstart on brownfield substrate

Top of river wall along Deptford Creek, London

Low-nutrient eco-roof in London

Public access

It is a key element of our policy to promote good, safe public access to estuaries. This may be achieved in many ways:

- Highways authorities are obliged by law to produce Local Rights of Way Improvement Plans.
- There may also be opportunities to work in collaboration with Natural England and Countryside Council for Wales to meet the aims of their Coastal Access initiatives.

When improving access, careful consideration should be given both to ensuring public safety and protecting wildlife. It may be appropriate to deter access to certain areas of foreshore where substrates are dangerous. In other areas, protection of waterfowl from disturbance may be a concern.

Education, aesthetics and art

With any project you should take every opportunity to make design references to environmental issues and social history. Extending the landscape design from the intertidal into the water's edge can produce striking landscapes. You should also consider seasonal changes in appearance – for example, Common Reed may remain as attractive stands in winter, whilst other species may die back to root stock or need to re-establish each year from seed. You should, however, avoid creating monocultures. This is both in the interests of biodiversity and of plant protection, as it reduces the risk of pest species reaching 'plague' proportions and damaging the planting severely.

The shoreline offers opportunities for artistic and aesthetic expression in the design. Signage for example can be dramatic and multifunctional. Sculptures in the intertidal zone can be particularly spectacular and also educational in terms of our relationship with nature and natural forces. Examples include Anthony Gormley's *Another Place*, at Crosby near Liverpool where 100 statues of men stand looking out across Liverpool Bay. Remember that any installations would have to be compatible with navigational safety requirements.

Intertidal sculpture by Anthony Gormley, Crosby

Last but not least all of these installations need to be explained to the observer, or they will be misunderstood and may even be criticised. Environmental signage should be eye-catching, artistic and robust.

Vertical sign illustrating the tidal range, Greenwich, London

Another key consideration is the trapping of litter, flotsam and jetsam. Litter collection barges could be installed in conjunction with the port authority or estuary clean-up groups. You can consult the Environment Agency and the local navigation authority about such initiatives.

Sustainability of materials

You should use recycled materials wherever appropriate. A recurring issue is the use and re-use of timbers. You should ensure that there is a mechanism for regular checks of the integrity of any intertidal timberwork, as well as a suitable maintenance regime.

Treated timber should be avoided due to their risk to river life from toxic wood preservatives leaching into the river. Timbers with a relatively limited lifespan (such as untreated pine) may also be used but particular attention will need to be given to monitoring their condition for repairs (see the Section 8 on aftercare and monitoring).

Vertical timbers and wood panelling, Deptford Creek, London

Wherever possible, when choosing other construction materials, you should opt for those of the greatest surface roughness for claddings in the intertidal zone. This is to provide stable colonisation by surface-dwelling algae and plants.

Unexploded ordnance

You should take reasonable steps (by desk-based research and, if necessary, remote survey) to assess the likely risk of unexploded ordnance. Deep estuarine silts can harbour dangerous unexploded ordnance that can migrate downstream over time, ending up in unexpected locations and at unexpected depths. In high-risk areas of unexploded ordnance, traditional hard-engineering techniques will be more hazardous.

Indemnity

You need to consider various factors when indemnifying intertidal defences:

- Indemnities applied to component products
- Frequency of repair and maintenance.
- Precedent projects
- Safety and cost implications of worst-case failure.

Sometimes more than one party can be involved in providing the overall indemnification for a design. For example, when timbers were added to a vertical wall for visual and ecological reasons (see Case Study 9 in the section on structurally engineered designs), the Local Authority may accept responsibility for their insurance and maintenance.

The designs

There are four different categories for designing estuary edges:

Bioengineered designs – These designs rely entirely on plants for long-term protection from erosion. Bioengineering techniques can be appropriate in any situation as they mimic natural systems. However, the natural estuary state may have been changed by man to such an extent that bioengineering may be inappropriate.

The ecological value of such designs is generally the closest to that of a natural tidal bank.

Biotechnically engineered designs – plants contribute significantly to the design but harder engineering elements are also provided for stability in the long-term. The permanent man-made elements provide root anchorage for plants, which then raises the protection to an even higher level.

The ecological value of such designs can approach that of a natural bank.

Structurally engineered designs – the engineering provides the structure and any ecological elements are simply added on. These designs include structurally engineered elements that form terraces to hold silts and soils.

The ecological value of such designs varies widely, but can be high.

Hard engineering – these designs are used when there is too much water energy for anything to attach, other than seaweed and very exposure-tolerant invertebrates.

The ecological value of such designs is generally negligible.

Selecting a design

It is difficult to provide a simple set of rules for selecting a design as there are so many variables at any given site. Therefore it is important to create local trial sites to test the suitability of a design.

The table on the next page summarises the environmental variables described in this guidance and how they could influence the selection of a technique.

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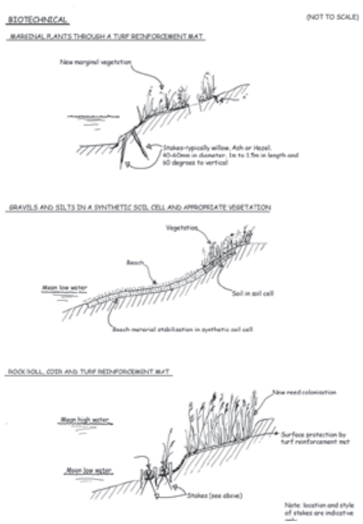
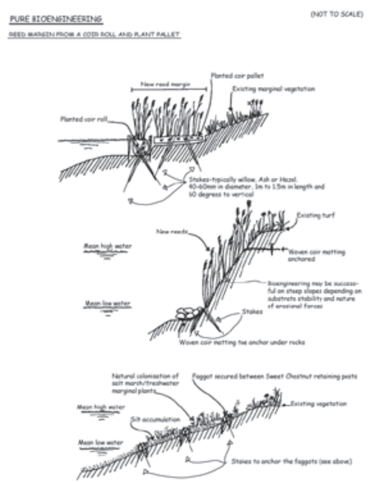
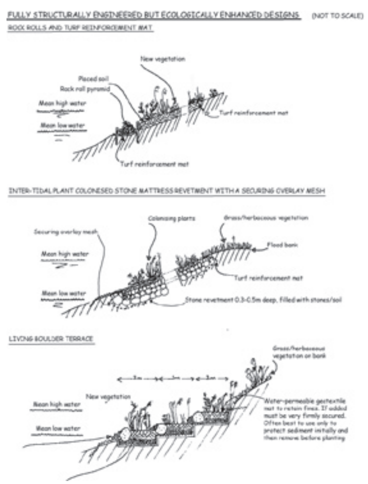
	Bioengineering	Biotechnical engineering	Fully structural engineering	Hard engineering
Techniques	• Reed margin from a Coir Roll or Coir Plant Pallet • Woven Coir Matting and Plug-Planting • Fascines or Brushwood Mattresses to trap silt • Natural colonisation promoted wherever possible	• Marginal plants growing through a Turf Reinforcement Mat • Gravels/ sands in a Synthetic Soil Cell plus appropriate plant regime • Rock rolls and Turf Reinforcement Mat	• Rock rolls or boulder packing and geotextile backing supports plant terrace • Stone Revetment promoting natural colonisation (may also be planted) • Hard engineered terraces to create beds for natural colonisation or planting • All revetments step BACK from existing intertidal not into it.)	• Sheet Piling • Concrete or Brick Walling • 'Block Stone' • Rip-Rap (1-tonne stones) • Concrete Block Systems
Illustrations				Not illustrated.

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	Bioengineering	Biotechnical engineering	Fully structural engineering	Hard engineering
Land-based loadings and land values Loadings of substrate and features that put pressure on the tidal edge from the landward side. This is the factor considered first in combination with ground conditions to see if the tidal edge, at the proposed geometry, is 'intrinsically stable' (when protected from erosion).	Generally 'low' to 'medium' loadings (pedestrian to vehicle). In built-up areas these techniques may still be appropriate where other structures provide secondary line of flood defence.	Generally 'medium' to 'low' loadings (pedestrian to vehicle). In built-up areas these techniques may still be appropriate in a wide range of circumstances, where other structures provide secondary line of flood defence.	Generally 'high' loadings (buildings/heavy vehicles). The flood risk assessment often shows the land value to be high with little or no protection against flooding by secondary structures.	Generally 'high' loadings (buildings/ heavy vehicles). The flood risk assessment often shows the land value to be high with little or no protection against flooding by secondary structures.
Ground conditions (soil/geology) Ground conditions are considered at the outset along with land-based loadings and bank geometry to check for 'intrinsic stability'.	Ground conditions are critical to this technique. Roots of plants can undoubtedly contribute to bank stability and support loadings, but cannot be relied on due to the wide variability of the root penetration profile, root strength at different ages, etc. Accordingly, bioengineering is generally only selected when the erosion-protected estuary edge is 'inherently stable'. Plants can, however, be included to contribute to the resistance of the design. Soil must also be suitable to support the expected plant growth.	Ground conditions are critical to this technique. Biotechnical solutions are designed to prevent erosion rather than address problems of inherent stability in relation to ground-based loadings. Thus the erosion-protected edge must be 'inherently stable' at the geometry proposed. Soil must also be suitable to support the expected plant growth. The substrate will often be inherently weaker than where bioengineered solutions are proposed and plant rhizome/ root systems will often be slower to develop.	The substrate must be capable of being retained with stability. This technique should be used in preference to bioengineering or biotechnical systems only where the estuary edge is inherently unstable.	The substrate must be capable of being retained with stability. This technique should be used in preference to bioengineering or biotechnical systems only where the estuary edge is inherently unstable.

	Bioengineering	Biotechnical engineering	Fully structural engineering	Hard engineering
Bank geometry including maximum slope Bank geometry is considered at the outset along with land-based loadings and ground conditions to check for ‘intrinsic stability’. Steeper slopes are possible with more robust ground conditions and lower land-based loadings.	The slope depends completely on the inherent stability of the bank. This is typically ‹1:7 at freshwater salinities and ‹1:2 at brackish salinities; but such techniques have been used on inherently stable banks at slopes of up to 1:1 (see case studies on the River Severn).	Depends completely on the inherent stability of the bank. Bioengineered erosion protection has been used on inherently stable banks at slopes of up to 1:1, to increase the opportunities for vegetation in the river edge.	Generally slope ›1:7 and in most cases the only option at slopes ›1:1. These techniques can create the framework for plants to survive on the exterior surface.	Any slope.
Duration and return interval Estimated duration of the peak dynamic force is considered to help define the ‘peak dynamic event’. The acceptable duration and return interval are based on a risk assessment that involves considering monitoring and maintenance options and commitments, and the plants’ ability to recover from damage.	Whilst these factors are undoubtedly crucial to the survival of bioengineered erosion protection, there are no reliable data testing the effects of these variables on unprotected vegetation. Accordingly, local decision is based on context and precedent. This type of vegetation is used to being tidally inundated.	Published test data are used to assist in the choice of design to withstand the predicted peak dynamic events. This will vary enormously between sites and can not be defined here.	The range of species that will survive on the engineered edge will vary inversely with increasing duration of event and return frequency of peak dynamic forces.	Not relevant.

	Bioengineering	Biotechnical engineering	Fully structural engineering	Hard engineering
Frequency of inundation Frequency of inundation is considered in relation to the ability of different plant species to survive on the river edge at a given tidal level.	Tidal levels below Mean High Water Neap tide level are typically unlikely to support vegetation. At low salinities however (below c. 10% seawater), planting can survive more often below this tidal level.	As for bioengineering.	As for bioengineering.	Not relevant.
Water chemistry The consideration of water chemistry involves an assessment of the ability of different species to tolerate mainly different salinities but also sediment loads and in some cases pollution.	Most examples of bioengineered tidal solutions are in brackish water. Bioengineering solutions are quite feasible at full marine salinities (see www.intertidalmanagement.co.uk). As the fully marine environment is typically high-energy, bioengineered solutions in such situations involve saltmarsh restoration techniques and shallow slopes (see *The Saltmarsh Creation Handbook* – full details are given in the 'More information and advice' section of this guidance).	Definitely viable at brackish salinities and probably at seawater salinities.	Definitely viable at brackish salinities and probably at seawater salinities.	Not relevant.

	Bioengineering	Biotechnical engineering	Fully structural engineering	Hard engineering
Strength and durability of individual components The selection of man-made materials is based on the ability of the materials to withstand the regime. The abilities of different plant species to consolidate surface sediments are also considered.	Strength and durability of components are not typically measured for plant components but are in relation to biodegradable components that help the plants to become established and then survive on site.	A very wide range of options is available. There are published performance characteristics on the man-made components. Data are also available on the additional erosion resistance that the vegetation gives and the speed of loss of the latter with increasing duration of a peak event.	A very wide range of options is available to suit any conditions.	A very wide range of options is available to suit any conditions.
Required design life The design life is set by the joint consideration of the strength and stability of the individual components and the monitoring and maintenance regime.	If appropriately chosen and properly applied, the design life is indefinite unless there are significant biophysical condition changes.	As for bioengineering.	Such designs are typically installed for a design life of at least 50 years, but this may vary depending on planning constraints and lifetime risk assessment.	Such designs are typically installed for a design life of at least 50 years, but this may vary depending on planning constraints and lifetime risk assessment.
Monitoring and maintenance	Monitoring is an important part of any scheme, especially shortly after construction. This will help identify benefits and areas for improvement. Ecological monitoring may need to be undertaken for several growing seasons . These designs can be self-sustaining, or require much more regular maintenance.	As for bioengineering.	A long interval between maintenance inspections is acceptable (though these are critical). Some areas must be left un-vegetated to allow full inspection of the structural integrity of walls.	Generally a much longer interval between maintenance inspections is acceptable (though these are critical).

Bioengineered designs

In bioengineered designs, plants are essential for the long-term integrity of the water's edge. Certain hard elements may be included, such as driven wooden piles, but their functions are short-term, often to provide initial protection for plants to establish or grow. They do not form part of the design for long-term flood risk management. Unless there are considerations such as development in close proximity, hydrological forces from structures in close proximity, significant erosive wave action, land level changes, then such edges should not need any more reinforcement.

A bioengineered solution is quite likely to be effective if a bank already exists that is fully stabilised by vegetation near the site of interest. Where existing plant cover is failing near the site, purely bioengineered solutions may not be appropriate.

Even in highly built-up urban locations with high land values, bioengineered solutions can be used. For example, if the land rises steeply away from the river or there are washlands/floodplain on the estuary to take some of the velocity from the flood waters, or the underlying geology provides support.

In some cases there may be fast tidal currents, but vegetation can thrive and contribute significantly to the overall flood risk management function if initially helped to take root. In such cases the approach can be to stabilise the substrate only as long as it takes strong estuarine plant species such as Common Reed or Sea Aster to become established. This approach is illustrated in Case Study 1 where an anchored biodegradable coir (coconut fibre) erosion control blanket was used, which was planted with pre-grown estuary grown Common Reed. This technique may also be appropriate on infrequently inundated upper slopes where there is a risk of erosion eddies (see Case Study 3).

In other cases, the environment may be considerably more saline and the water more silt-laden. Where there is not a high risk of major wave action, the main aim here may be to ensure that the river edge achieves net balance between accretion and erosion, by initially favouring the deposition of sediment. Techniques designed to achieve this are illustrated in Case Study 2 where 300mm diameter bundles of cut branches (generally Hazel) were laid on the substratum to a depth of some 300–500mm. This 'brushpacking' technique promotes rapid sedimentation.

Case Study 2 also illustrates the technique of 'brushwood fascine' (or 'brushwood faggot)' installation on steeper upper slopes less frequently inundated by the tide. Brushwood fascines are bundles of cut branches, tied with cord and entrenched in a woven pattern between closely placed driven poles to create quite robust low 'fences'. Again, sediment rapidly accumulates between the fascines where the technique has been correctly selected.

Coir rolls, coir matting, synthetic soil cells, turf reinforcement mats, even gabion mattresses need to be adequately anchored to the bank. Depending on the river flow (that is, whether the flow speed is fast or slow, whether the slope of the bank is steep or shallow and whether there is boat wash from passing vessels), the required number of stakes and their lengths will vary. The faster the flow, steeper the bank and greater the height and frequency of the wash, the longer the stakes that will be required. Willows, Hazel, Sweet Chestnut or Ash can be used for stakes. The length will vary from 1–1.5m and the diameter from 40–60mm. It is common practice to incline the stakes at about 60 degrees to the vertical. The mat or roll manufacturer's guidance should be sought where necessary. Consideration should also be given to possible erosion of the bank and any resulting bank slip leading to collapse of the bioengineering elements. In addition to anchoring these elements, scour protection of the bank – either using horizontal timber planks and vertical timber

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uprights/stakes or some other installation – may need to be put in place where the high flow and boat wash is known to erode the banks.

The success of, and need for, planting or seeding varies strongly between sites. In the example in Case Study 1, the pre-grown reeds were expected to establish rapidly and within the lifespan of the protection matting and hence planting was essential. Where there is likely to be considerable sediment accretion, as in the case illustrated in Case Study 2, early planting can fail due to smothering, and there is a strong case for waiting to see whether natural colonisation can be sufficient. The example shown in Case Study 3 shows that where seeding is undertaken it may be advantageous to install an enriched starting substrate for the seeds.

One important point illustrated by the examples in Case Studies 2 and 3 is that the use of bioengineering techniques can be applied close to or adjacent to river barriers or bridges where traditional concerns regarding erosion eddies and backwash has led to the almost universal application of hard engineering techniques to prevent damage to bridge or structure foundations.

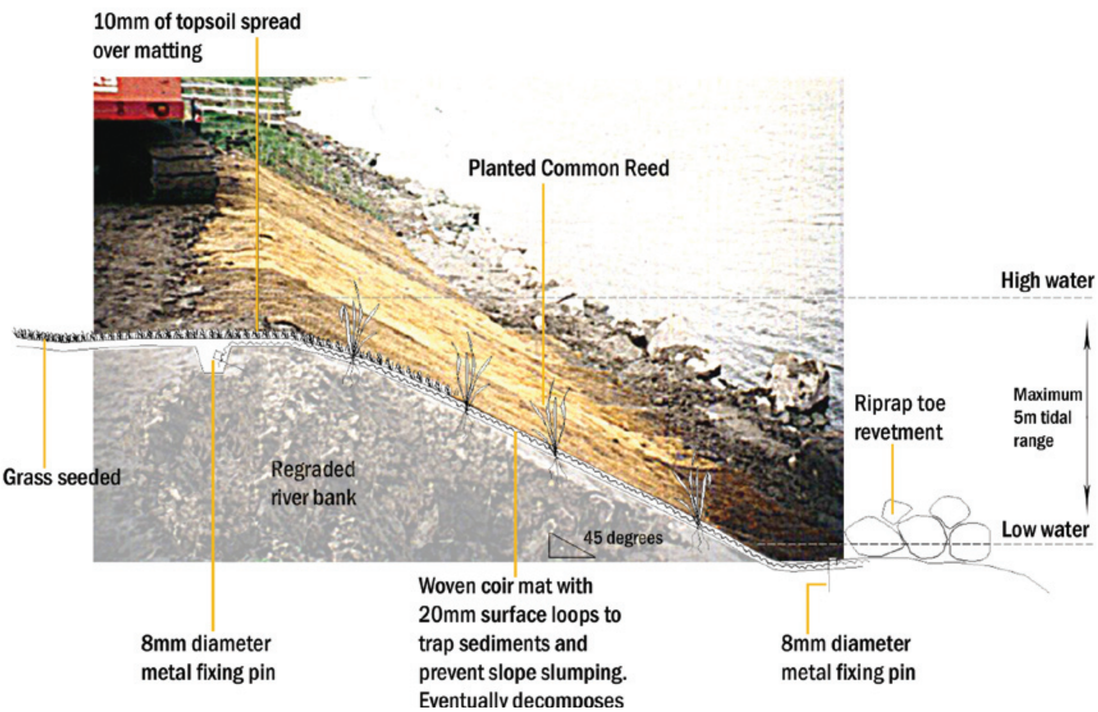
Case Study 1: River Severn, Longney, Gloucestershire (completed 1997)
Grid Reference: SO 756 106

The site

- Around 50m section of river bank, 45 degree slope and 5m maximum tidal range. River 230m wide locally.
- Subject to the erosive forces of the Severn Bore, with maximum current speeds in excess of 3 m/s.
- Salinity brackish.
- Active erosion zone with little vegetation, unlike the adjacent areas.

What the developers did

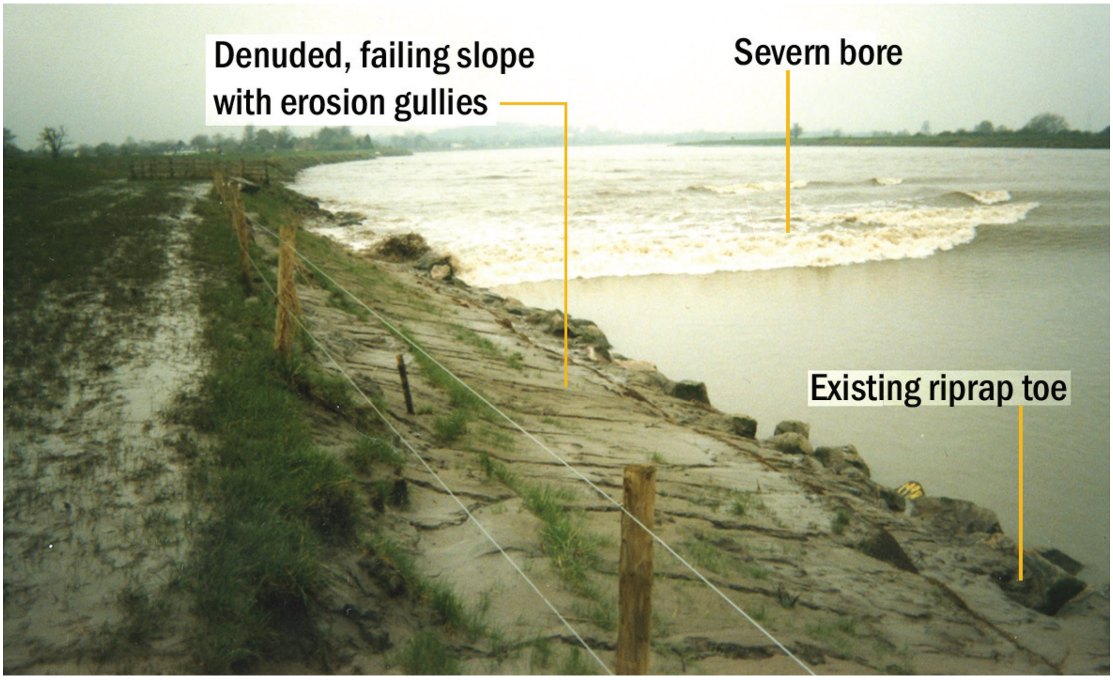
- Three-dimensional woven coir matting with an initial 9 kN tensile strength applied to the re-profiled slope and anchored top and bottom.
- Toe revetment of riprap retained as hard engineering element, but main slope completely bioengineered.
- Locally collected Common Reed rhizomes planted through the matting.



River Severn, Longney: Installation of loop mat planted through with pre-grown Common Reed

The result

- Common Reed established well, continuing to stabilise the substrate after the decomposition of the coir matting.
- Design considered highly successful, cost-effective and appropriate to location.



River Severn, Longney: The slope above the riprap toe several months after installation showing sediment accretion

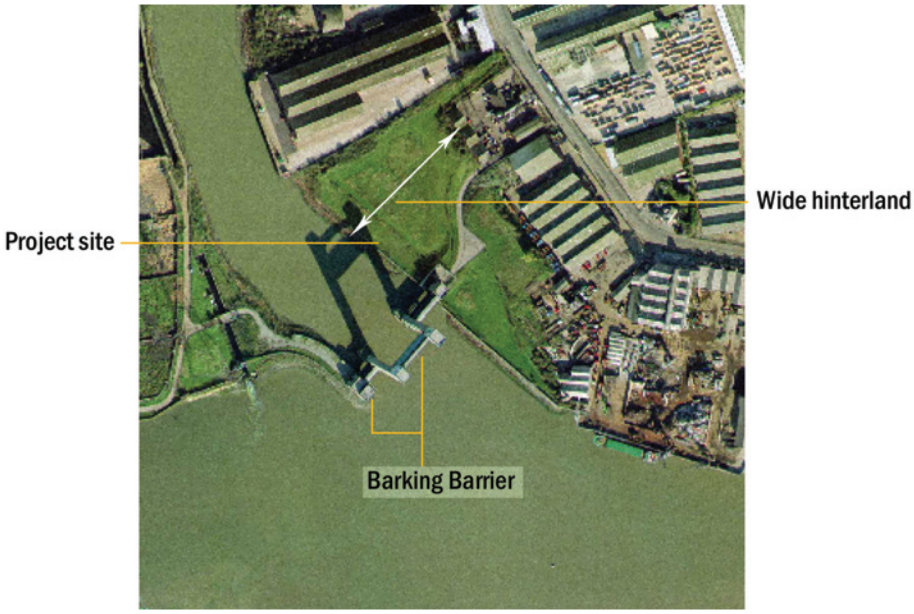
River Severn, Longney: Successful restoration

Case Study 2: Barking Creek at Barking Barrier (completed March 2006)

Grid Reference: TQ 455 818

The site

- Scheme to create an ecologically rich, attractive new intertidal embayment and educational area on Barking Creek, 100m upstream of Barking Barrier on the north bank of the Thames.
- River over 50m wide and subject to 7m tidal range.
- Low risk of wave-wash from vessels.
- High sediment load in water column.
- Large area of riverside available.
- Relatively low flood risk in the event of loss of integrity of the design.



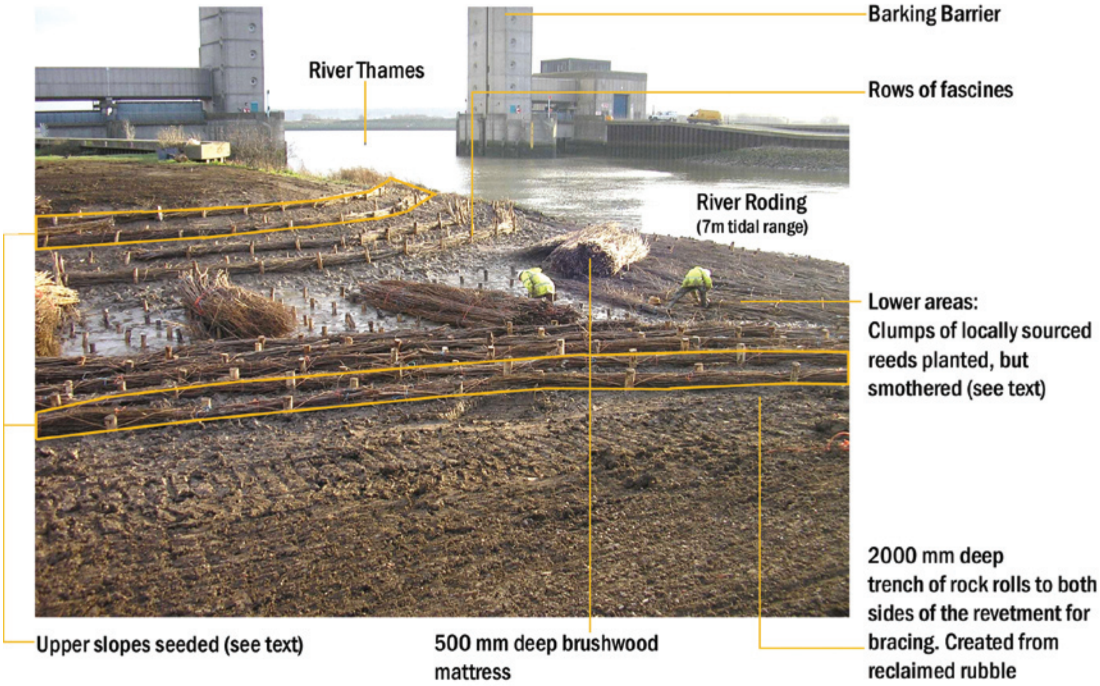
Barking Creek at Barking Barrier: Before creation of intertidal embayment

What the developers did

- Existing land profile excavated away to slopes less than 1:7 and clay capped.
- Sweet Chestnut posts installed and brushwood bundles delivered.
- 'Brushpacking' (500mm brushwood fascines packed over whole mud surface) installed between 2500mm long Sweet Chestnut posts (installed at 600mm centres) retained by biodegradable tensioned coir twine on slopes up to Mean High Water Neaps. Fascine diameter graded down to 200mm at low tide mark.
- Clumps of locally sourced cell-grown Common Reeds introduced on lower slopes smothered with some 40cm of sediment in just six months.
- Steeper upper slopes retained by brushwood bundles installed as fascines between Sweet Chestnut posts on alternate sides at 600mm centres. Diameter of faggot bundles used increasing from 200mm to 500mm down the slope. Retained by biodegradable tensioned coir twine.
- Upper fascine-stabilised slopes seeded with proprietary seed mix at 2 g/m^2 augmented with locally collected seed of Red Fescue, Sea Aster and Sea Arrow-grass.
- Trench of rock rolls at top of each side of revetment slopes for bracing, but still essentially a bioengineered design.
- Wider site includes subsoil-based wildflower meadow, eco-centre and interpretation boards for visitors.

Barking Creek at Barking Barrier: After creation of intertidal embayment

Barking Creek at Barking Barrier: Delivery of brushwood bundles



Barking Creek at Barking Barrier: Brushwood fascines installed on upper slopes and brushpacking being installed on lower slopes

Barking Creek at Barking Barrier: Fixing detail of brushpacking

The result

- Natural colonisation of Sea Club-rush extensive on the upper slopes, stabilising the substrate but overwhelming the planting.
- After 16 months, a wide variety of plants present, with abundant self-sown Sea Aster and strongly spreading Common Reed at higher tidal levels.
- Plentiful supply of fine sediment and net accretion/erosion balance achieved at lower tidal levels.
- Stable vegetation establishment anticipated in the long term, the lowest fringe being colonised by Sea Club-rush.
- Extensive use of the embayment by juvenile fish, especially Sea Bass.
- Considered highly successful and beneficial in ecological, social and economic terms.

Lower slopes of Barking Creek bank at Barking Barrier showing 40cm of sediment accretion on six months

Upper slopes of Barking Creek at Barking Barrier showing rapid establishment of Sea Club-rush

Case Study 3 : Barking Creek at A13 - Frogmore (completed May 2006)
Grid Reference: TQ 444 830

The site

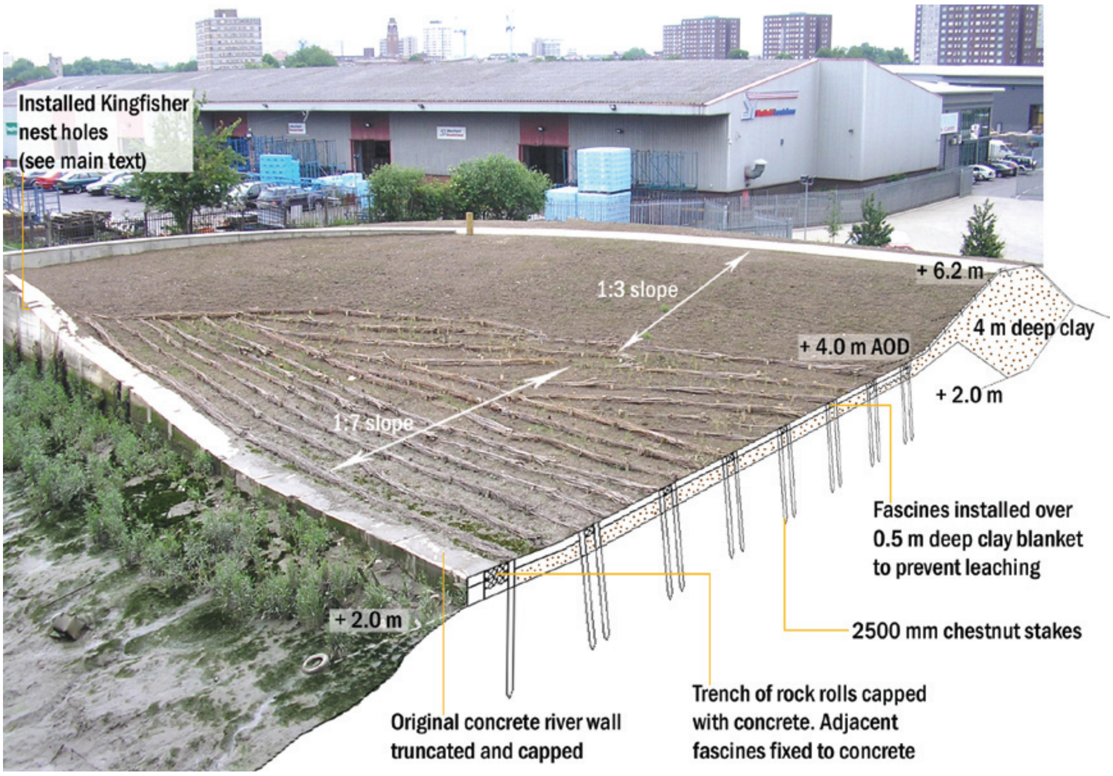
- Site adjacent to the A13 road bridge on the tidal River Roding.
- The channel here over 50m wide with a 3m tidal range at the site.
- Surrounding bridge walls, etc. provide second line of flood risk management.
- Bank loadings and flood risk were assessed as 'medium'.

Barking Creek at A13: View of river edge before and after scheme implementation

What the developers did

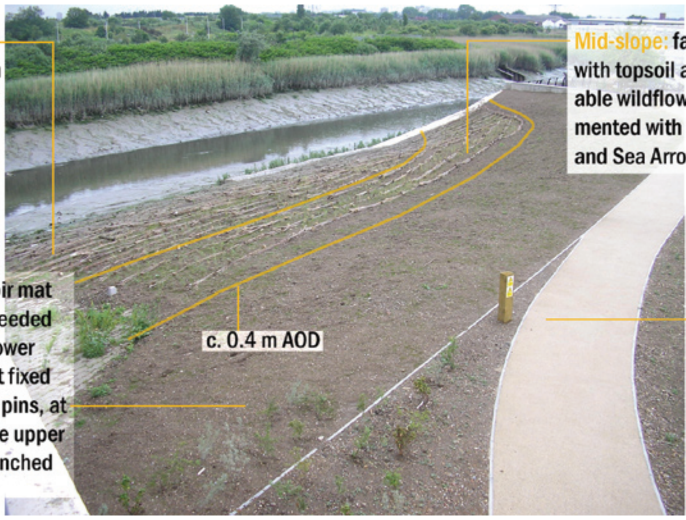
- Existing wall broken out and/or truncated and capped with concrete.
- Slopes re-graded and clay capped and fascine revetment installed.
- Coir erosion control blanket installed over upper slope to prevent sediment loss for up to two years during plant establishment – covered with 'blinding layer' of soil and seeded with wildflower mix. Additional saltmarsh seed added in zone between mean high Neap and Spring Tides.
- Biodegradable Hazel/brushwood fascines placed in rows 1m apart to promote sedimentation at low- to mid-tidal levels.
- New rock rolls in trenches to anchor fascine rows at each end but revetment still essentially bioengineered.
- Kingfisher burrows installed in the truncated concrete river wall.

Barking Creek at A13: Demolition of river wall



Barking Creek at A13: Newly regraded and protected slopes with toe detail

Barking Creek at A13: Details of fascine installation near bridge



Barking Creek at A13: Indicating different planting proposals and surface treatments

The result

- In the first 12 months no erosion occurred on the slope and the coir matting and brushwood fascines had not been damaged.
- Cell-grown Common Reed planted on the lower slope largely unsuccessful but subsequently started to colonise naturally.
- Grassland vegetation establishment from seeding the upper slopes successful despite limited sedimentation.
- Introduced growing medium on the upper slopes considered to have helped establishment.
- Close proximity of a bridge did not prevent a bioengineered design.
- Greatly improved local visual amenity, with far better relationship to nearby semi-natural habitats.
- Considered very successful in ecological, social and economic terms.

Barking Creek at A13: Vegetation establishment after 14 months

Environment Agency

Biotechnically engineered designs

In biotechnically engineered designs, plant material alone is not predicted to withstand the peak forces for the anticipated severe event. So the planting needs to be reinforced with structurally engineered components.

Plants still contribute significantly to the maintenance of bank stability but structurally engineered elements are included to ensure that the flood risk management function of the structure is not compromised during a severe flood/weather event. The role of plants in a biotechnically engineered solution is best understood by considering the progression of a severe event over time. Initially, as a severe event begins, the plant material protects the substrate quite adequately. Then, as forces increase or continue to apply, the engineered element helps the plants to remain rooted in the bank edge and continue contributing to erosion protection. Some or all of the plants may subsequently be washed out. The specification of the engineered element should be adequate to maintain bank integrity from this point to the end of the event. To specify engineered elements that could function adequately without the vegetation at all in a 'severe event' would be an over-engineered solution and not the best ecological option.

In some cases, the decision to include such reinforcement may lead to unforeseen difficulties later. This is illustrated in the example in Case Study 4. The strong erosion forces and durations gave cause for the designers to be concerned that brushwood revetments should be both layered (brushwood fascine layering) and then retained with a wire 'rocknet'. In this situation, if the sediment is not deposited as expected, then the brushwood can be exposed to the air and rapidly decay, exposing the mesh and potentially creating a hazard.

Another application of biotechnical engineering to tidal river edge design is shown in Case Study 5. In this case it was concluded that plants could contribute to the integrity of the bank, but only when provided with significant root stabilisation. In this case gabion mattresses were lined with soil fines infill to the stone first and then a thick coir loop mat was laid under the lid of the basket to prevent wash out of content. The importance of careful installation of substrates and matting and the contribution of the vegetation to the integrity of a steel gabion are illustrated by this example of bioengineering. Poor installation leading to vegetation loss and associated loss of some fine substrate material from such a mattress may permit the remaining larger material within the mattress to move around. This moving material may then damage the mattress well before the term of its intended design life.

Case Study 4: Monk Bretton, River Rother, East Sussex (completed 2004)
Grid Reference: TQ 925 206

The site

- East bank of River Rother, East Sussex was in poor condition, especially at Monk Bretton bridge (A259 road crossing).
- Around 70m of bank of the outer side of the bend undermined by scour caused by design of bridge abutments.
- At this site the river edge structure helps protect various parts of the town of Rye from flooding including 120 properties and a school.
- Channel locally around 35m wide, 6m tidal range.
- Slow current speeds, high sediment loading and low risk of wave wash, but high occasional fluvial flows.

What the developers did

- Some reprofiling of clay embankment was carried out to ensure overall final smooth edge profile.
- Hardwood posts (125mm) were piled using long-reach excavator with modified hydraulic rammer typically to 1.5m depth.
- Posts created framework at 600mm centres to support a brushwood 'fascine' layering revetment.
- Hazel fascines were installed in 30-40cm layers at 90 degrees to each other to create a 'brushwood mattress'.
- Initially retained under a wire 'rocknet' fixed over piled wooden posts and looped under at the edge nearest the river centre.

Monk Bretton site near bridge: Installation of posts for fascines

Monk Bretton site near bridge: Rocknet and fascine detail showing drainage pattern

Monk Bretton site near bridge: Rocknet and fascine installation showing size of drainage rivulet

The result

- Installation construction process had major health and safety benefits over traditional hard engineering due to both the heavy tidal flows and risk of unexploded ordnance.
- Sedimentation rapidly effective on the lower half of the slope but slow in the upper parts of the slope.
- Settlement of the brushwood and sediment resulted in the exposure of the surface rocknet risking rapid exposure and decay of the brushwood and posts causing a potential maintenance, visual and health and safety issue.
- Possibly would have been preferable to attach the fascines directly to the driven posts and omit the 'rocknet', or remove it post-settlement.
- Low deposition rates of fine sediment could be improved by installing an imported growing medium on the upper slopes, for example pre-established coir pallets or erosion control geotextiles. These would provide protection and encourage re-vegetation.
- Considered to be broadly successful, but may need some modification as a technique.

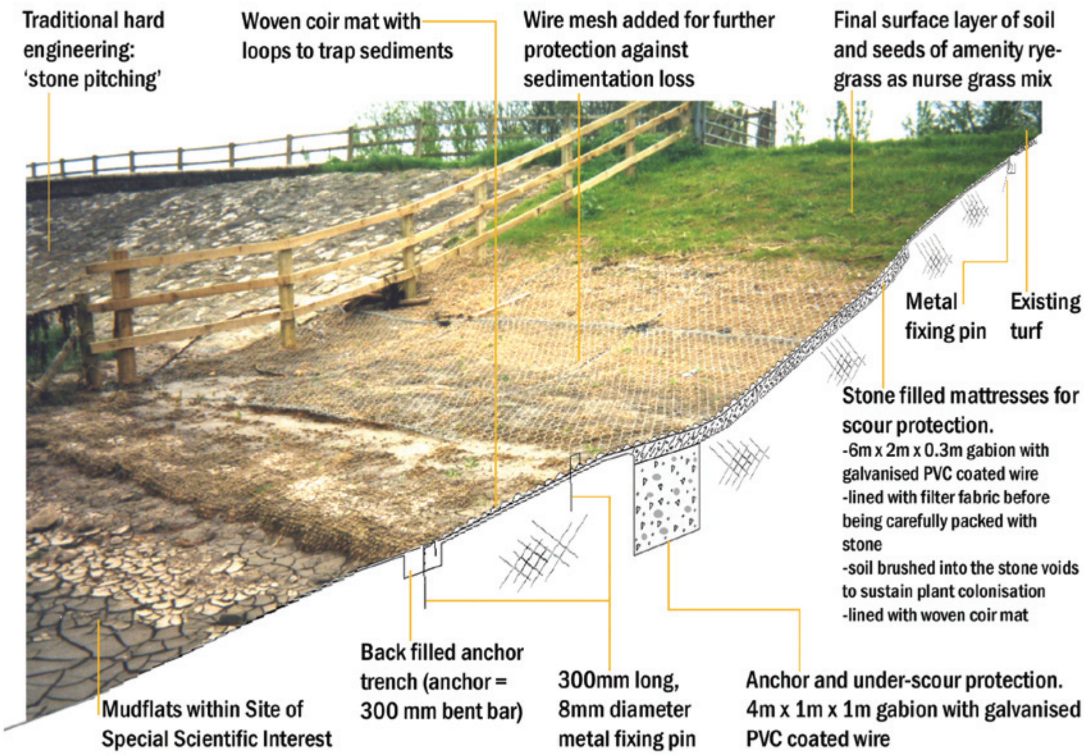
Case Study 5: River Severn, Purton, Gloucestershire (completed 1998)
Grid Reference: ST978 632

The site

- Lower reaches of the River Severn Site of Special Scientific Interest, south bank, 7km upstream of the original Severn Bridge.
- River here is around 3km wide downstream of a stone-pitched section, 10m tidal range.
- Erosion scar was appearing along the high tide line for a length of around 80m.

What the developers did

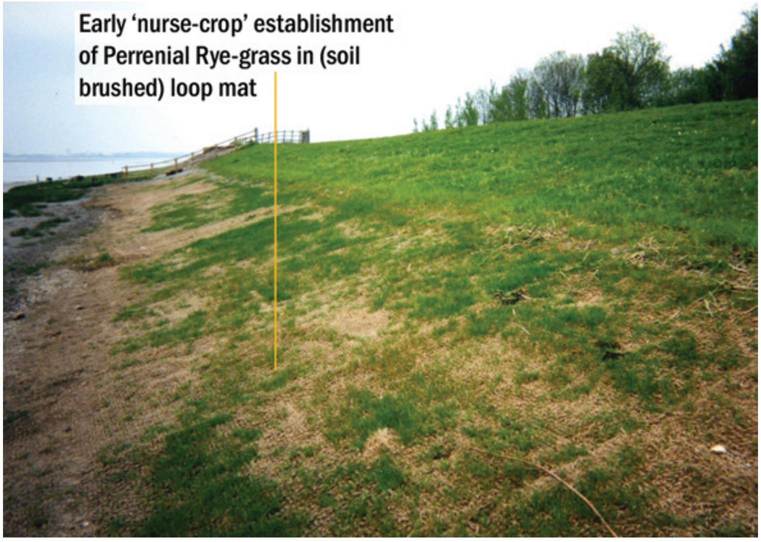
- The scoured area was excavated to accommodate 30cm deep gabion mattresses installed flush to surface level.
- The gabions were of woven wire, galvanised and PVC-coated for increased durability.
- The mattress was lined with a filter fabric before being carefully packed with stone.
- Seeded soil was brushed into the voids, which made up 30 per cent by volume.
- Before closing the lid, a loop-piled woven coir matting was laid over the surface and extended beyond the mattress both up and down the slope.
- At the river-wards edge, the matting was laid over the mudflat and anchored in a trench.



Gabion mattresses installed in SSSI bank

The result

- Initially the coir loop matting was incorrectly attached to the upper surface of some mattresses. This resulted in loss of soil infill and stone movement in the gabions. These were repaired.
- Local vegetation soon colonised the properly installed stone mattresses and no subsequent significant erosion problem was noticed.
- Overall considered to be a highly successful design appropriate to the SSSI.



Gabion mattresses installed in SSSI bank: Early colonisation at high tidal levels

Gabion mattresses installed in SSSI bank with full successful colonisation by species characteristic of the SSSI

Structurally engineered designs

Where there is not room for a more gentle slope, so a steep or near-vertical solution is required, habitat can still be created by establishing plant communities on steps, terraces or 'ledges' on hard engineered walls. This may also be the solution where storm forces are such that bioengineered solutions could not be relied on. In these designs, plant material does not contribute appreciably to flood risk management but does add considerable value in other respects.

Vegetated terraces

The first option is to create some form of terrace between hard engineered elements. The nature of this will depend on many factors:

- The more limited the space available, the steeper the terrace will need to be.
- The steeper the terrace and the greater the erosion forces, the larger the particle size distribution required for a slope that does not have additional biotechnically engineered reinforcement.

Such steep slopes with cobbles and large gravel may not be suitable for growing intertidal plants, but may still provide many refuges for invertebrates... In brackish and saline environments, where slopes of around 1:7 or less are achievable, terraces in which the substrate is stabilised solely by saltmarsh vegetation may be established fairly readily in the intertidal zone.

Examples of this are shown in Case Study 6, which illustrates different types of terrace arrangement on the Greenwich Peninsula in London (these terraces having been first established 1999).

The design of terraces will differ depending on their location or position within an estuary. The aim is to promote successful establishment of vegetation through providing a revetment that will trap and hold silt and water at the optimum tidal levels for plant growth, but not become waterlogged. Wherever possible the aim should be to install at least 1m depth of gravel and growing medium, generally above a geotextile liner.

A typical specification for a retained substrate might be:

Lower 50cm	100% gravels from 25–10mm with a geotextile mat above to prevent rapid loss of fines.
Upper 50cm	95% gravels from 25mm to dust with an additional 5% sand, topsoil and silt.

Where space permits, a continuous sloping beach profile at a stable angle of repose between the new retreated flood defence wall and the truncated, capped remnant of the former wall can be considered. Such installations may have considerable value for intertidal and littoral fringe invertebrates. This is illustrated in Case Study 6, Site 1, which also shows how dense natural colonisation (in this case of Sea Aster) can occur as long as finished levels are correct. However, where plants did not establish well it was found that finished levels were lower than in the design drawing and outside the optimal saltmarsh growth zone. This example clearly illustrates the critical importance of finished levels matching the design to within a few centimetres.

In Case Study 6, Site 2, simple stepped terraces were created with gabions. Locally, at the highest tidal levels, wooden palisade was used to create the terrace, a technique also illustrated in Case Study 8 at the River Roding Mill Pool in a more protected location. Case Study 6, Site 2, also illustrates some of the issues relating to terrace substrate stabilisation using coir matting before planting. It is possible that the coir

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matting may help to retain the material in severe storms prior to natural sorting and packing of infill material. If, however, the matting is not firmly installed, it may lift. Any plants planted early through the matting may be ripped out of location and lost, and require replanting. It may be appropriate to allow the substrate in the terraces to reach a stable equilibrium under such matting, and then remove the matting (if there is no accretion above it) and plant the terrace. Planting, however, through exposed protection matting is not recommended in an intertidal environment.

One drawback with a stepped terrace form is that flat fish such as Flounder and some other fish such as adult Common Goby appear reluctant to cross up and over submerged terrace steps, and hence cannot access this valuable habitat in any number. A possible solution is to ensure that terraces are sloping in two planes so that there is some point along the profile where the terrace height falls to zero to permit such species of fish to move onto the terrace. This type of design is illustrated in Case Study 6, Site 3.

Plants are best installed in the early spring when they are growing, and from pre-grown stock so that they can survive the tidal forces. Case Study 6 (Sites 1 and 3) demonstrate the value of using estuarine two-year-old container-grown Common Reed.

In some cases it may be considered valuable to install a pre-planted coir pallet as in the example in Case Study 7. This can help promote good early establishment of appropriate plant species especially at higher tidal levels. It should be noted that the quality and handling of the pallet and plant establishment within it can be very important in ensuring success. Case Study 6 also illustrates the problem of over-dominance by one species (for example, Common Reed). If this is not desired, then rhizome barriers should be included in the substrate and/or the reed should be regularly cut.

Case Study 7 also illustrates the problems that may arise. In this example, problems arose due to the very limited fine sediment deposition as the site was on the outer bank of a meander. As a precaution against erosion of the substrate, the decision was taken to contain the terrace growth and habitat substrate within sturdy gabion mattresses closed over the pre-planted coir pallets. It is now considered that this solution was probably over-engineered and terraces, as in Case Study 6, would probably have been more appropriate.

When gabion mattresses are used the installation of a substrate of a smaller particle size than the gabion mesh is not recommended as washout may occur, even if the substrate is covered by a planted coir matting. Also coir may break down too rapidly if exposed to the air and hence its use in areas of limited sediment availability is not recommended.

Case Study 6: Greenwich Peninsula Terraces (completed 1997)
Grid References: (1) TQ 399 794 (2) TQ 390 805 (3) TQ 391 803

The site

- Tidal range 7m.
- Over 1300m of sheet piling was in poor condition and needed to be replaced.
- Peninsula being redeveloped for high-density, high-value housing and facilities.

What the developers did

- In all locations, the existing sheet pile wall was cut down to near beach level and capped.
- Approximately 7–15m inland, either sheet pile or an L-shaped concrete wall were installed.
- Site 1: infill material was installed over wide area at stable angle of repose and allowed to colonise naturally.
- Sites 2 and 3: terraces were created between the new wall and the foreshore using gabions and wooden piles, maximising the area between Mean High Water Neap and Mean High Water Spring tide levels wherever possible at slopes of 1:7 or less. Growing medium initially protected under coir matting.
- Sites 2 and 3 were planted with a variety of saltmarsh plants through coir matting. Substrate particle size distribution was a close match to foreshore for both stability in local area and habitat value.

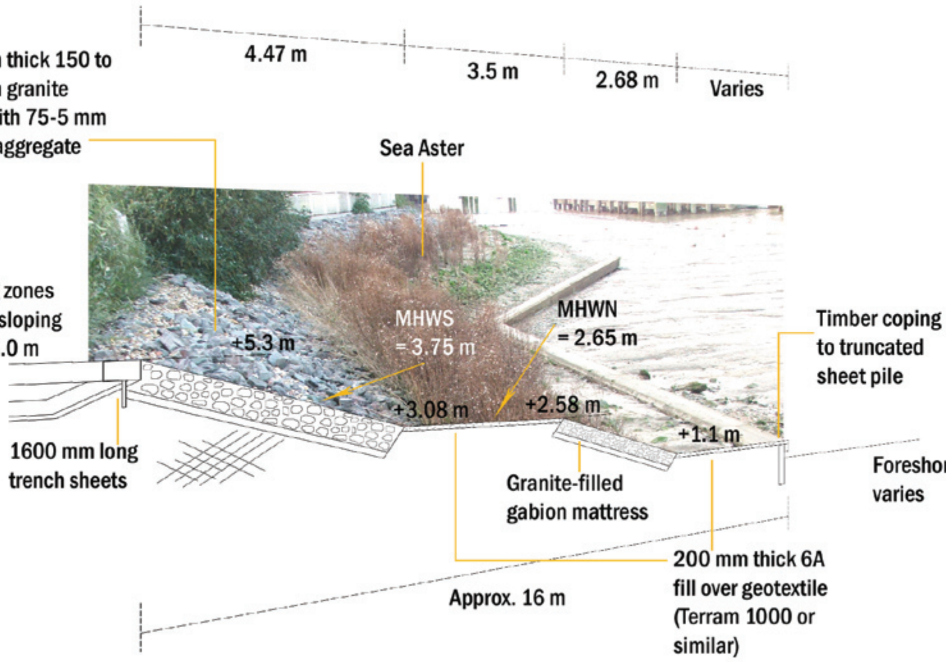
Eastern wall, Greenwich Peninsula, London: Site 2 during construction

The result

- Wave action led to lifting of the matting and extraction of many young plants, necessitating some replanting, though there was also considerable natural colonisation.
- Re-planting of Sites 2 and 3 directly into substrate without erosion matting was most successful with Common Reed, Grey Club-rush Sea Club-rush and Sea Aster, several species surviving well below or above the main ‘saltmarsh zone’.
- Failure to install rhizome breaks has led to excessive dominance by Common Reed, which may need to be corrected.
- Freshwater outfall locations became areas bare of much vegetation, and reinforced geotextile mat used at these locations eventually looked unsightly.
- Extensive monitoring has shown intense use of the terraces by Sea Bass and other species.
- Flounder and adult Common Goby did not appear to ascend submerged terrace steps. One solution

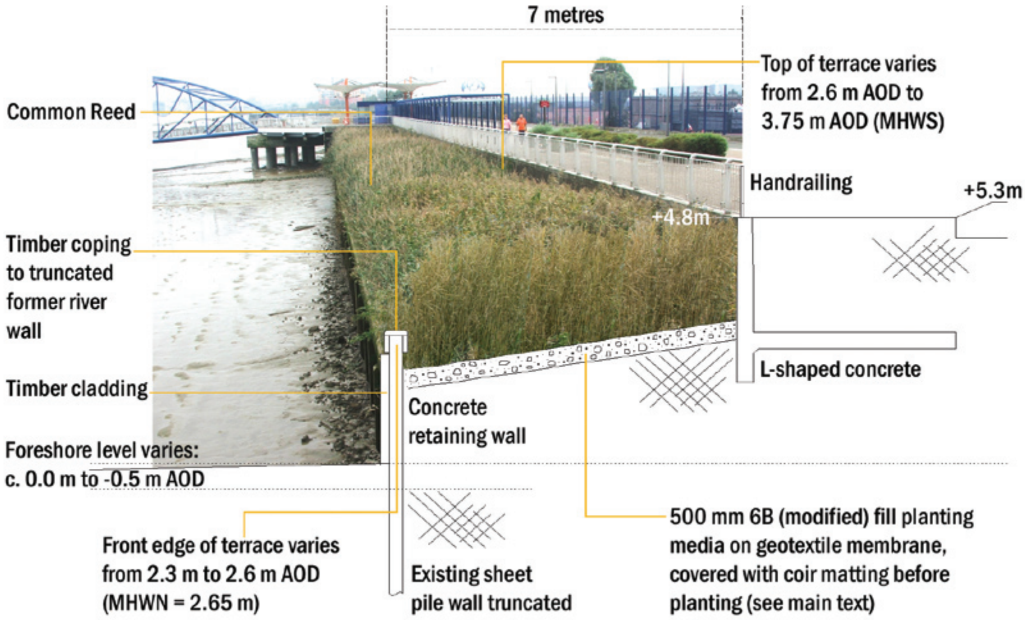
to this is shown in the design for the terracing at Site 3, where a series of terraces sloping in three dimensions was created in the form of an 'ecological sculpture'. (In future schemes, cutting down of the old sheet pile to beach level should be considered to avoid the creation of barriers to certain fish species).

- Limited scope for human access, which might be addressed in future schemes by a variety of slipways or floating pontoons (where ecological and safety constraints permit).
- Overall considered to be a highly successful, benchmark design, though a few gabions appear to be breaking down after ten years (probably due to use of welded gabions) and repairs/renewals may be necessary to retain certain terraces (woven and plastic-coated gabions are always the preferred option if gabions are to be used).

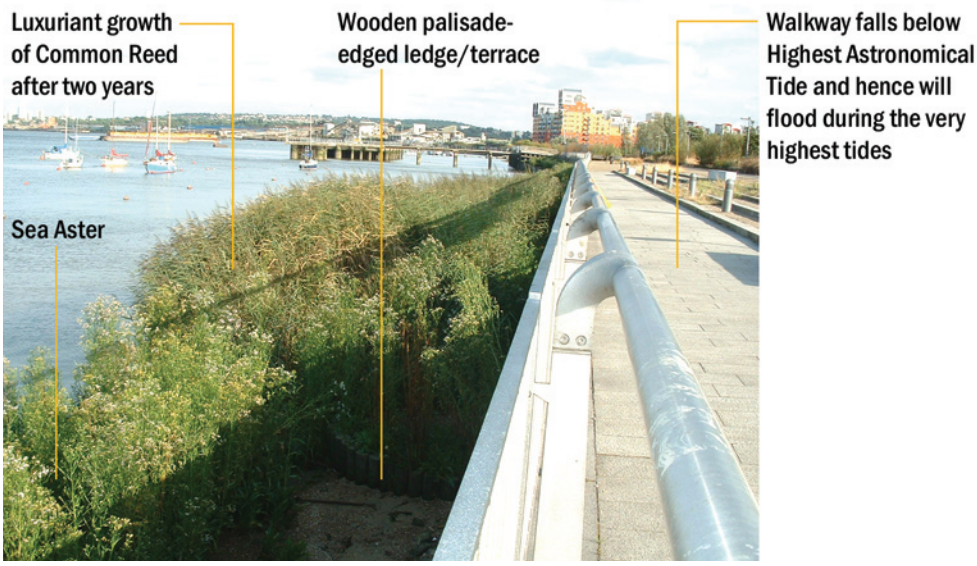


Greenwich Peninsula, London: Site 1 from south, eight years after implementation (winter)

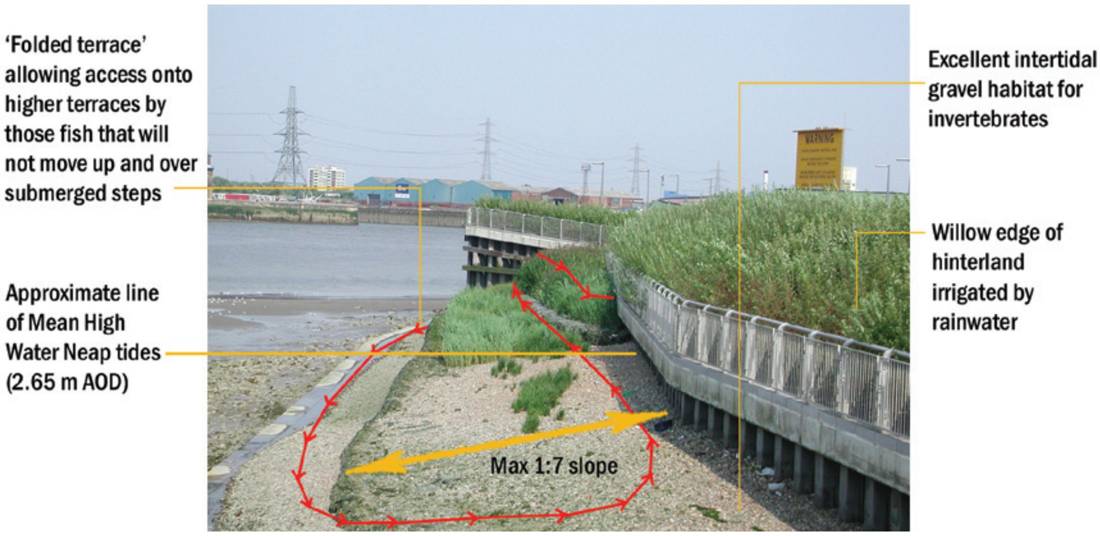
Greenwich Peninsula, London: Site 1 from north, eight years after implementation (winter)



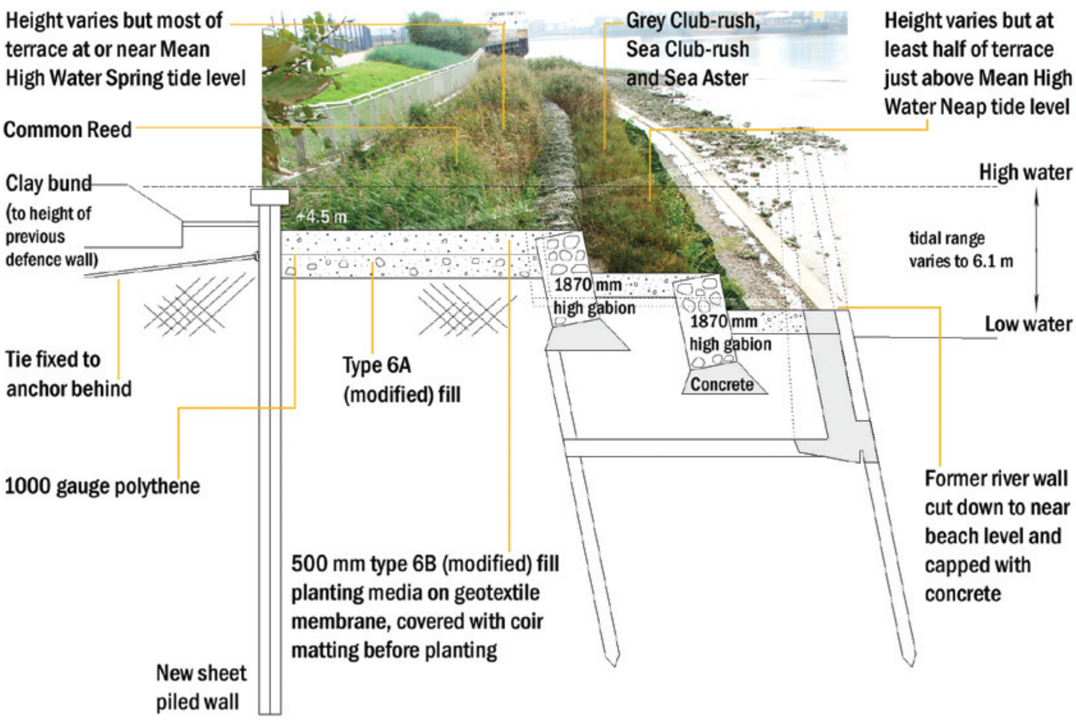
Eastern wall, Greenwich Peninsula, London: Site 2 north end, six years after implementation (autumn)



Eastern wall, Greenwich Peninsula, London: Site 2, south end, three years after implementation



Eastern wall, Greenwich Peninsula, London: Site 3 from west, two years after implementation (summer)



Eastern wall, Greenwich Peninsula, London: Site 3 from east, six years after implementation (autumn)

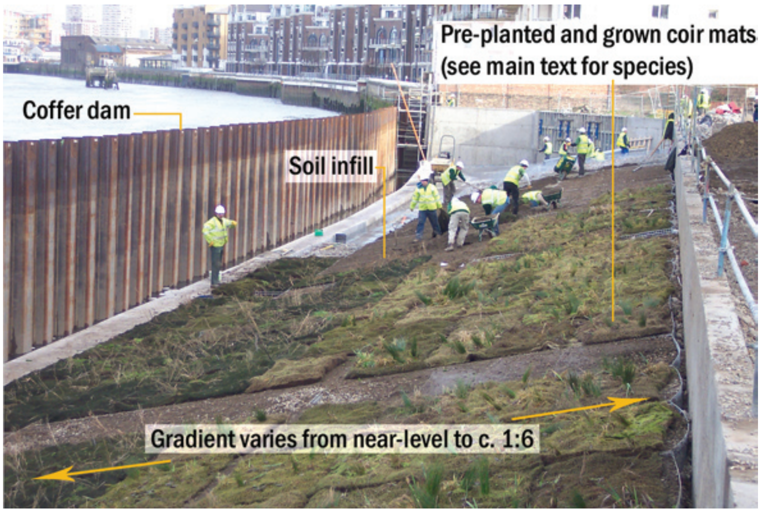
Case Study 7: Battersea Reach Terracing (completed February 2005)
Grid Reference: TQ 261 755

The site

- South bank of Thames just north of Wandsworth Bridge on the outer bend of a meander with little obvious fine sediment deposition on the shingle foreshore.
- Here the estuary is typically less than 1% of the salinity of seawater, but true saltmarsh plant species do still occur in patches.

What the developers did

- The design was similar to that of the Greenwich terraces, but due to perceived erosion risk a gabion mattress slope was built with pre-established coir pallets placed inside the lid.
- The lower slope was planted with inter-tidal species and the upper slope with more general freshwater bankside species.



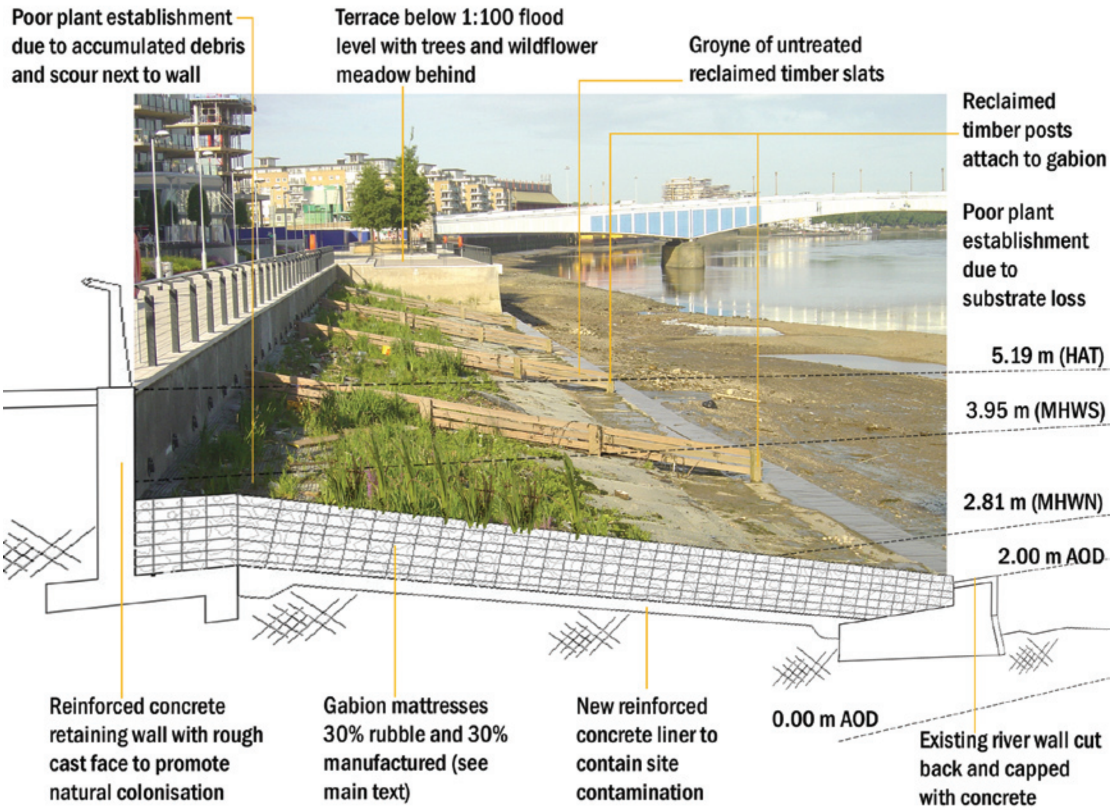
Battersea reach, Thames, London: During construction

The result

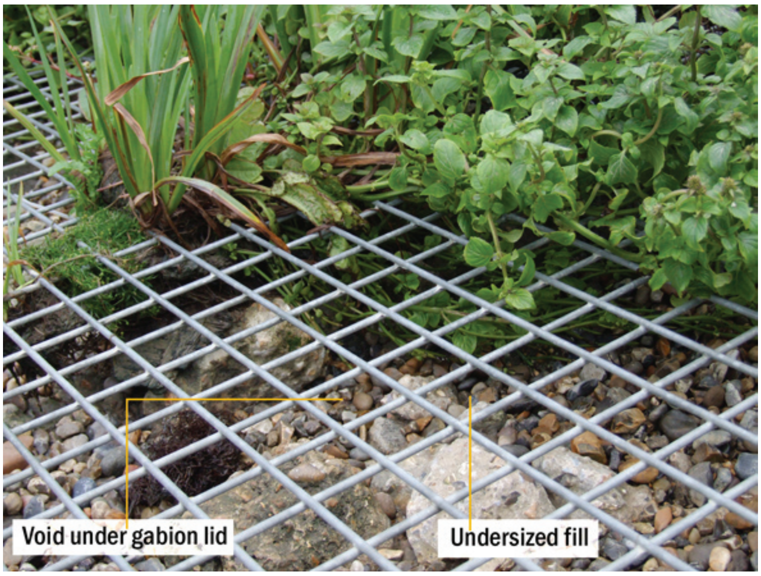
- As with most of the Greenwich Peninsula terraces, the presence of a major 'step' at the waterside edge of the terrace and another at the edge of the gabions prevents access by bottom-dwelling fish.
- After two growing seasons the upper half of the terrace had established well. The coir pallets used in the upper terrace were more mature than those used in the lower areas and this may have affected their establishment.
- However, significant loss of fine sediment from within the gabion mattresses in the lower part of the slope occurred and few plants established. Little new sediment was deposited over the monitoring period. This sediment loss below the matting then led to movement of the matting and the plants were then pulled against the gabion mattress lids and damaged or severed. Fine substrate loss then continued up the terrace leading to failure of most of the planting.
- Grazing of plants by waterfowl and smothering of plants with tidal rubbish may also have also had adverse impacts on establishment.
- After two-and-a-half years there was sediment loss throughout the revetment, though significant natural colonisation by a variety of bankside species including Great Willow-herb, Gypsywort and a wide variety of ruderals.

- Fine sediment was beginning to accumulate in the lower parts of the terrace with reasonable growth of Sea Club-rush and Grey Club-rush.
- Alternatives here might have been to follow the Greenwich Peninsula technique more closely, not using gabion mattresses, ensure all coir pallets were better grown, and add further fine sediment trap features such as brushwood fascines and to remove flotsam and jetsam promptly.
- Having said this, it is difficult to predict how the design will develop in the longer term, and the fine sediment accumulation and plant establishment at lower levels might eventually permit further accretion at higher levels.

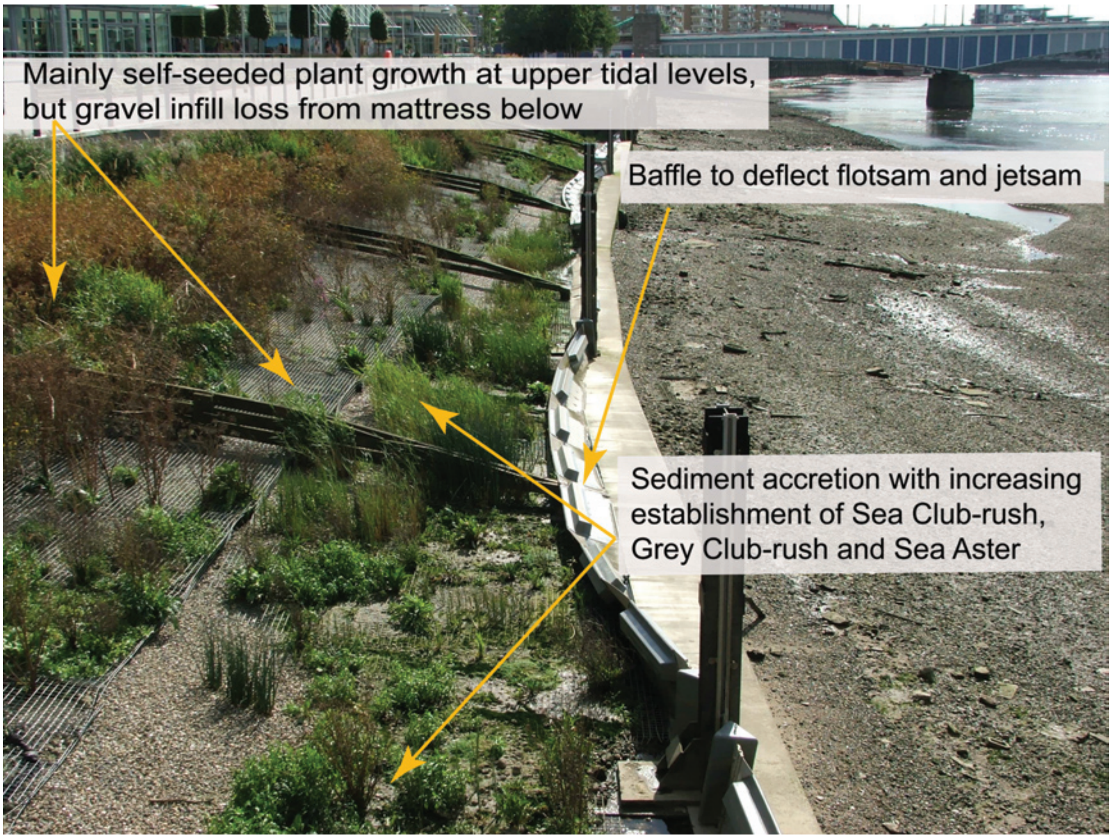
Battersea Reach, Thames, London: Top of slope after one year



Battersea Reach, Thames, London: Poor colonisation at toe after one year



Battersea Reach, Thames, London: Loss of infill after one year



Battersea Reach: Lower slope after two-and-a-half years

Case Study 8: Mill Pool, River Roding (completed March 2006)
Grid Reference: TQ 439 837

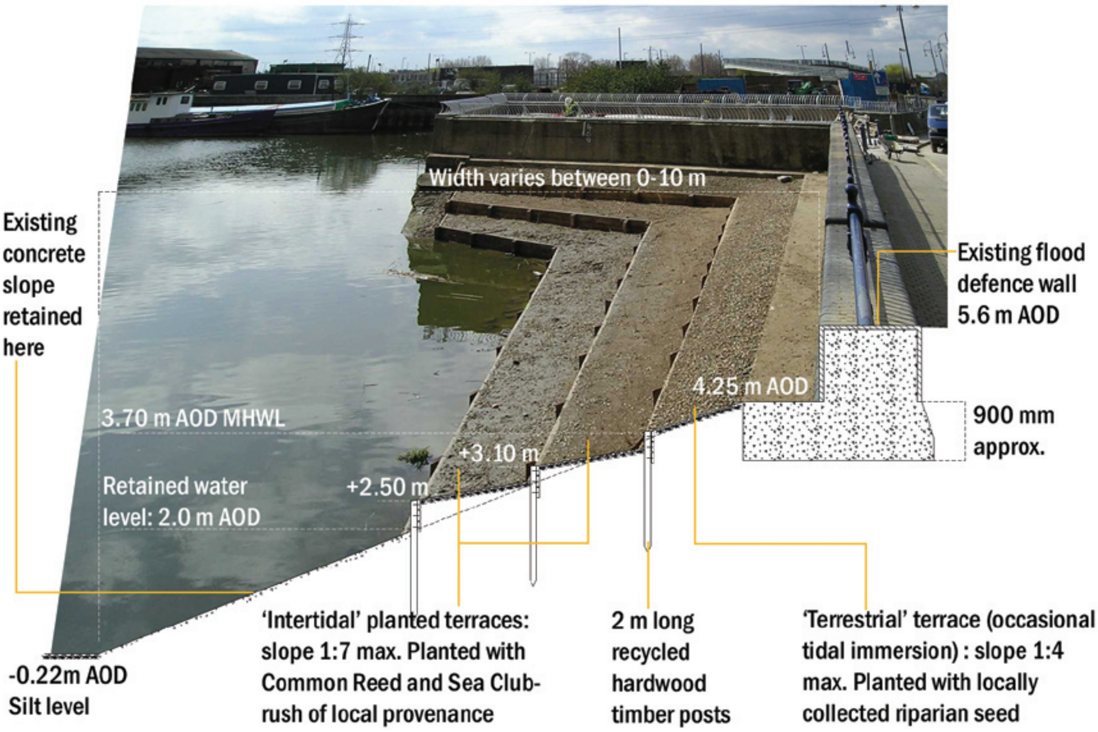
The site

- River Roding opposite the town quay in Barking.
- Decaying concrete slope with invasion of common weeds and relatively low ecological value.

River Roding, London: Mill pool before enhancement

What the developers did

- Works involved the breaking out of the existing concrete revetment and construction of terraces using wooden palisade.
- Upper two terraces were planted with locally collected riparian seed.
- Bottom terrace was planted with Sea Club-rush and Common Reed.



River Roding, London: Mill pool after terracing

The result

- Very poor establishment of Sea Club-rush and Common Reed after 16 months, but dense vegetation of tall species of London brownfield sites. Lowest tidal level dominated by Amphibious Bistort.
- Nearby ledges on the river supported good stands of Branched Bur-reed and Common Reed.
- Not clear why intended planting was unsuccessful.
- Final design with reasonable ecological value, but relatively poor aesthetic value for its setting and planting strategy with pot-grown riparian stock may have produced better results.

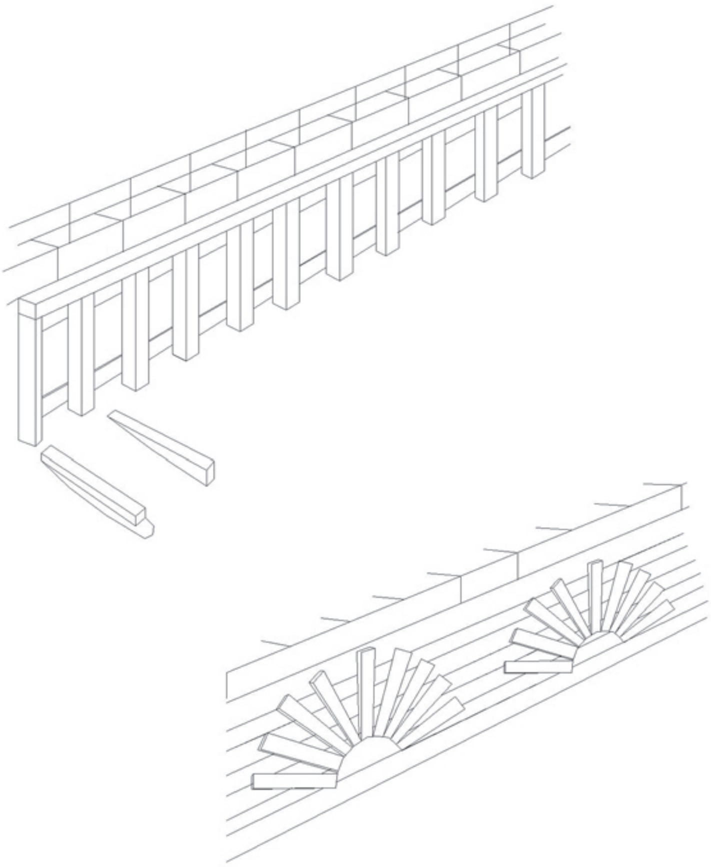
River Roding, London: Mill pool 16 months after vegetation establishment

Ecologically enhanced vertical or near-vertical walls

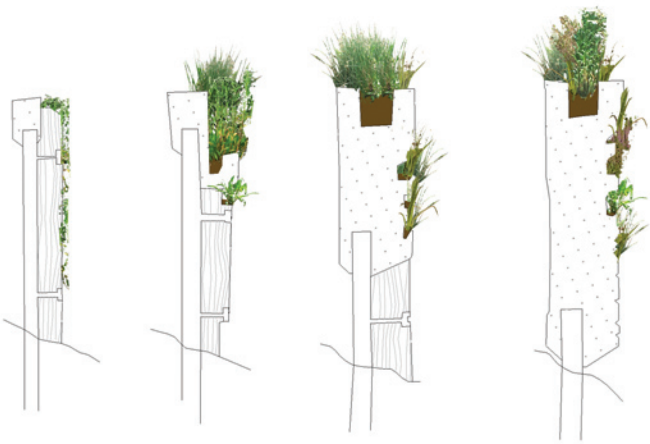
In this category we include any type of vertical or near-vertical, single elevation hard intertidal wall, made of any material, whether new or refurbished. When vertical or near-vertical walls are really the only option, techniques exist for enhancing the ecological and visual interest of such walls. Most methods involve the use of wood coverings of one form or another on the tidal side of the structure.

At one extreme, the whole wall may be panelled, as in the example in Case Study 9. The wooden panelling forms a relatively soft substrate for the colonisation of algae and invertebrates. Ideally (as in the example in Case Study 9) a gap should be left between the wall and the timbers that can be back-filled with material of fairly similar particle size distribution as the adjacent foreshore to form a vertical beach habitat. Complete covering with wood panelling may cause problems for inspection of estuary walls, and hence partial panelling solutions are recommended. In places, a full height section of the wall should be left exposed for inspection and anchor bolt locations should be left uncovered. The space allowed between exposed sections will depend on the precise nature and construction of the intertidal wall.

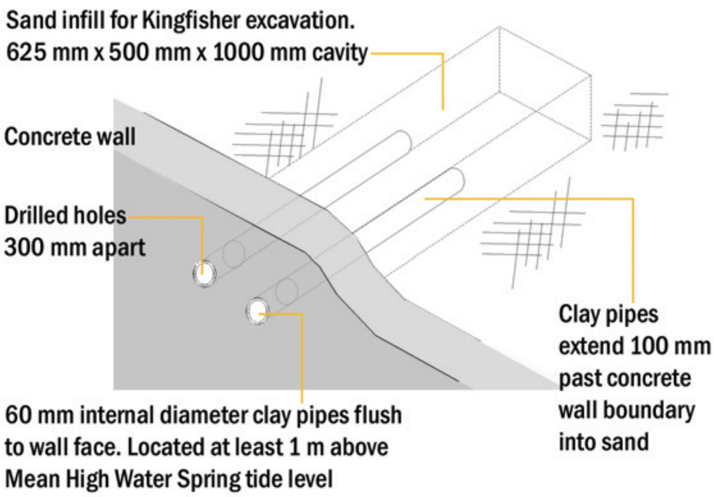
If considerations such as inspection requirements, aesthetics or other functional requirements preclude panelling, it may still be possible to install wooden timbering. This is generally vertical and/or horizontal as shown in Case Study 9 where the timbering was actually designed as intertidal planters that were filled with rubble. Horizontal timbers will be most beneficial when located in the main intertidal plant growth zone. Timbers need not, however, be placed only in vertical and horizontal directions. Other features that may be added included grab ropes and chains and also plastic fronds or ‘brushes’ as substrates for egg laying by fish. As long as the time that these ‘fish egg brushes’ are exposed to the air is limited to a few hours each day, no harm comes to several species of fish egg laid on them.



Different concepts for timbering arrangements for ecological and visual enhancement of near-vertical intertidal walls



Different concepts for modified timbers to promote silt accumulation and plant growth



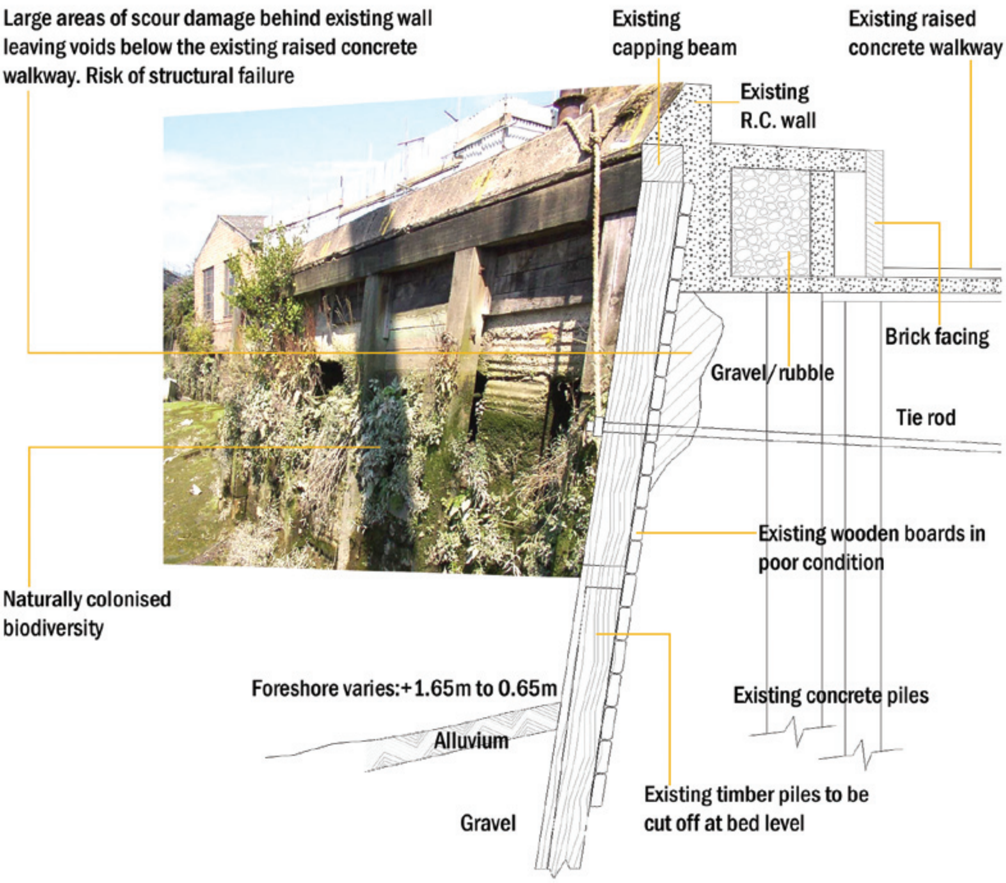
Kingfisher burrow detail

Other installations may include proprietary holes for hole-nesting birds (above the level of Highest Astronomical Tide). Even when Kingfishers do not immediately (or ever) take up the holes, such features can provide a useful habitat for uncommon invertebrates (such as burrowing bees and wasps). Other species that may use proprietary nesting holes in river edge designs include Sand Martins and Wagtails. Holes or other forms of refuge may be added for roosting bats. Specialist ecological advice should always be obtained when installing such nesting or roosting holes.

Case Study 9: Deptford Creek - Vertical Wall Renewal (completed 1997)
Grid Reference: TQ 377 775

The site

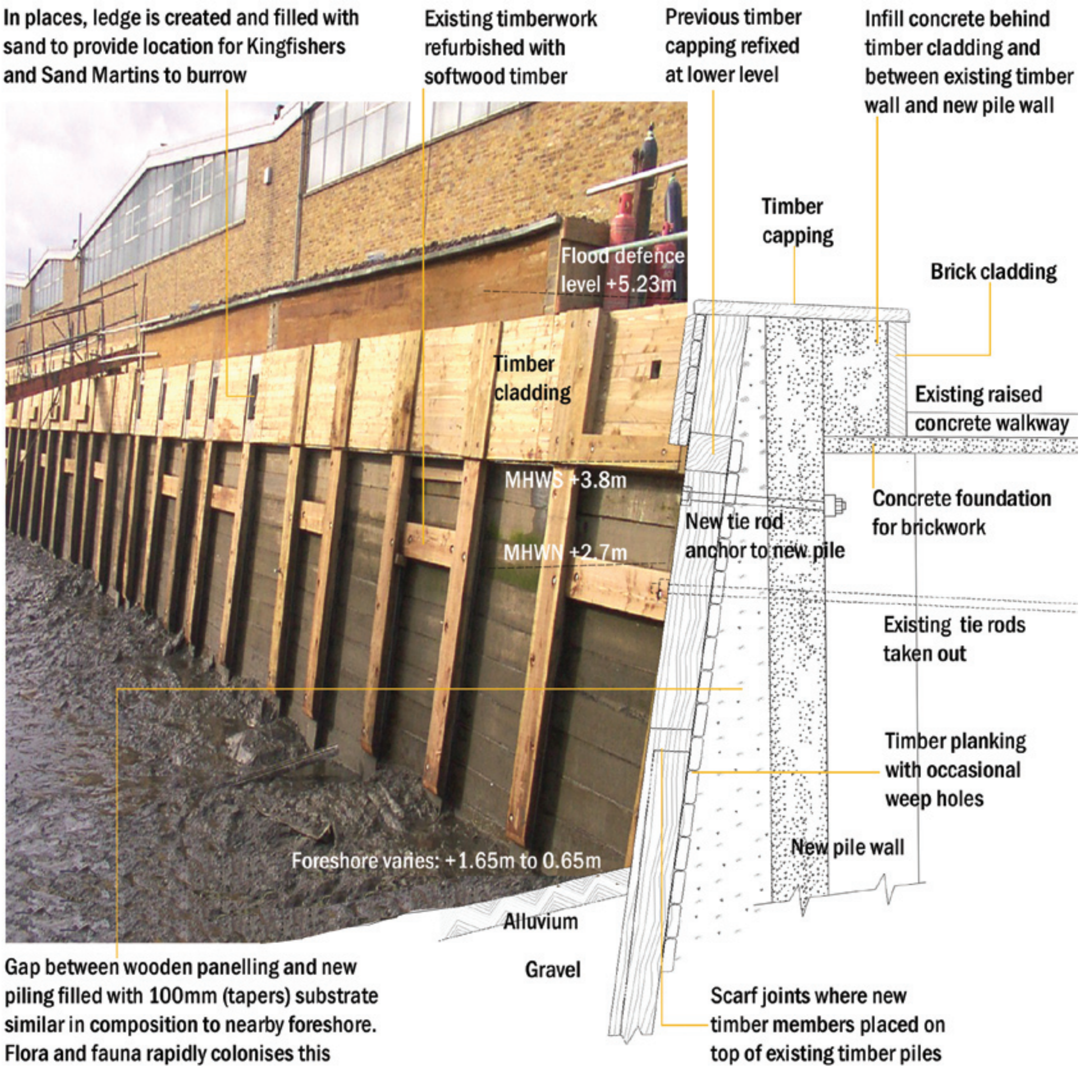
- Deptford Creek is on south bank of the Thames where the salinity regime is semi-maritime.
- Tidal range 7m.
- Old creek walls of wooden construction deteriorated to the extent that in many places only plant roots were holding the wall in place. The economic and social cost of failure of these features assessed as ‘high’.



Deptford Creek, London: River wall before renovation

The result

- New sheet piling was installed and clad with wooden panelling, a variable void created between the panels and the sheet pile. This gap was filled with a substrate similar in composition to the nearby foreshore.
- Artificial burrows for Kingfisher were also installed 50cm below the top of the wall.



Deptford Creek, London: Refurbished defences with full panelling and vertical beach

Deptford Creek, London: Timbering to river wall

The result

- The ‘vertical beach’ rapidly colonised with a fauna and flora similar to that which had colonised behind the old boards.
- Kingfishers have been seen investigating the bank but no breeding has occurred. This may be the result of people using the river edge or the height of the water.
- A good range of sizes in fish species have been seen.
- The scheme has been considered a success in ecological, social and economic terms.

Aftercare and monitoring

If properly designed and implemented, softer estuary edges should require no more monitoring and maintenance than traditional hard engineering solutions.

During establishment with any other landscape design project, there is a defects liability period for any planting, and monitoring of the design by a suitably qualified bioengineer/ecologist should be carried out two to three times a year for at least three years. If certain planting fails, this does not necessarily mean that the design has also failed, as natural colonisation may replace it, and it may be best to wait another growing season or two to see how the vegetated elements evolve naturally (assuming there is no obvious threat to flood risk management).

Monitoring of intertidal areas in the first three or so years should seek to assess whether flotsam and jetsam, grazing animals or vandalism are in evidence, and appropriate steps taken if so. Day-to-day management of vegetation will generally not be required. In the longer term (five to ten years post-establishment) further management intervention may be needed to reduce the dominance of certain species (such as Common Reed) to promote the greatest possible biodiversity.

Where timbers are used in the intertidal zone, annual monitoring of their condition (and any necessary replacement or repair) should be incorporated in the management regime. In severe weather/river flow events, parts of the design may begin to fail and/or erode and require local repair, but as long as the required design functionality is not compromised, the design may still be acceptable. If the designed bank is likely to undergo one or more cycles of major refurbishment of renewal during its design life, The Environment Agency will want full details of how you propose that this be achieved. The Environment Agency will need to be reassured that clear access to the flood defences and foreshore for people and appropriate machinery has been carefully considered and will be as straightforward as possible.

Shoreline landscape will require maintenance as with any other designed habitat, but there will be a particular need to ensure that such maintenance is informed by ecological expertise.

In all cases, it is good practice to record the results of monitoring and share them with the Environment Agency so that any advice can be improved to inform future projects.

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Further information

Please contact our experts for further advice on any aspect of this guidance. The references below will provide much more detail on particular issues. Published environmental assessments by other developers are often good sources of technical detail on particular examples and should be consulted if possible.

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Website

www.intertidalmanagement.co.uk

www.creeksidecentre.org.uk

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