Chapter 4.5

Morphological Change and Biodiversity Benefits

4.5.1 Chapter Summary

Morphology is seen in the WFD as supporting the ecological quality of water bodies. At present there are no 'standards' for morphology (although there are proposed morphological 'conditions' which may be used to highlight activities with potential to cause deterioration).

While it is evident this pressure is widespread, data on the extent and cause of the morphological pressure exerted on water bodies in England and Wales is lacking. There is also a science gap in understanding of the relationship between morphological pressures and biological effects, and the costs and effectiveness of measures to deal with it are highly variable depending on the exact site, timing, scale and nature of the measure. This makes morphology a challenging pressure to address.

This is one area of the directive where the imperative to deliver 'no deterioration' is very relevant. Action to avoid or mitigate the effects of new physical modifications will fall to many sectors.

Action to improve status and tackle past morphological changes will also be necessary. This action will be more challenging to deliver because apportionment of responsibility for the changes, and hence for action to tackle them is more difficult, and there are gaps in the current range of delivery mechanisms.

This chapter presents 4 scenarios for dealing with morphological pressures.

1. Higher certainty of achieving outcomes, no phasing
2. Higher certainty of achieving outcomes, which phasing over 3 river basin planning cycles
3. Lower certainty of achieving outcomes, no phasing
4. Lower certainty of achieving outcomes, with phasing over 3 river basin planning cycles

The scenarios developed here are 4 possible scenarios which fit with the descriptions provided for the pCEA but there are many possible variations and alternatives which could be just as valid. Many assumptions have been made when suggesting these possible costs, and there is a high level of uncertainty surrounding them.

The following broad assumptions were made when assessing cost effectiveness analysis of morphology measures:

- That restoration measures will only need to be applied in water bodies which, despite agreed non-WFD measures, are at risk of failing GES (normal WBs) or GEP (HMWBs/AWBs) . This is taken as 18000km; 35% of the extent of all surface water bodies by length, calculated as 45% (the high HMWB outcome for rivers, transitional and coastal waters) reduced by an arbitrary 10% for those water bodies which will not actually be failing. This figure is the same for all scenarios. Although a phased programme with further investigations in

initial cycles would provide more information before action was taken, we do not know whether investigations would reveal an increase or decrease in the number of water bodies in which action is needed.

- That any coastal defence type representing more than 10% of the defended length of the coastline of England or Wales is nationally significant, and any coastal defence type representing less than 10% is not nationally significant (thus seawalls and revetments are the only nationally significant primary coast protection structures).
- That the presence of a pressure can be used to indicate a risk of failure – in other words that a morphological pressure will lead to a corresponding negative impact on biology.
- That action necessary to deliver protected area objectives (especially Habitats and Birds Directive objectives) and the national SSSI target will be taken under those Directives and policies rather than the WFD. There will be costs for all sectors, over and above the costs listed here, to deliver the Habitats and Birds Directive and SSSI requirements.
- That the measures required to achieve good status are broadly similar to those required to achieve good potential. The extent of application of a particular measure could vary significantly depending on whether the target for the water body is GES or GEP but this distinction was not made in this analysis.
- The costs used are the 'best estimates' provided by the working groups for their sector measures. This is a major assumption given the degree of uncertainty about many of the estimates. The navigation sector report gives ranges for costs, For example estimates of annual operating/maintenance costs for mitigating hard bank defences or install soft bank protection in inland waterways in England range from £10 000 to £800 000. But as other sectors did not do similarly, it has not been possible to show ranges for the scenarios as a whole.
- That costs and effectiveness of flood management measures are the same regardless of operator (IDB, Local Authority, landowner or Environment Agency).
- Maintenance costs have been included where these are a significant element of the cost of the measure and there is credibility in the figures available.
- Where it was not clear from the available information whether costs are for England only or England and Wales, it is assumed they are for both England and Wales and that 10% of the costs will fall to Wales and 90% to England.
- That the Priority Substances Daughter Directive requirements for sediment are the same as those in the current proposal (changes to these requirements could limit the amount of sediment available for beneficial use measures).

The main areas of uncertainty relating to cost-effectiveness of measures are:

- Both cost and effectiveness of morphological measures can vary significantly depending on site-specific characteristics in often dynamic physical systems, and the associated availability and adequacy of existing information. There

are therefore a number of areas of uncertainty relating to the *unit cost* estimates derived by all working groups. .

- There are legal and financial difficulties to be overcome in relation to delivery of many of the restoration measures listed here. Although the pressures and impacts can often be associated with a particular sector, it will not always be fair, or possible to require anyone in particular to take action in relation to historic structures (especially where they were put there legally, perhaps even required by Government; and/or the ownership or use of the structure have changed over time). A recent Defra consultation on "Mechanisms to Deliver WFD Requirements on Hydromophology" [reference 6] sought views on what, if any, additional delivery mechanisms might be used to tackle or reduce some of these difficulties.

Taking into account these assumptions and uncertainties, the estimates of the likely costs of implementing the four scenarios are as follows:

ENGLAND

Present Values £bn	**Scenario**			
RBP cycle	**One**	**Two**	**Three**	**Four**
Cycle 1	2.1	0.5	0.6	0.4
Cycle 2	0.3	0.9	0.2	0.3
Cycle 3	0.2	0.7	0.1	0.3
Total	**2.6**	**2.1**	**0.9**	**1.0**
Equivalent annual value (£m)	**153**	**123**	**52**	**55**

WALES

Present Values £bn	**Scenario**			
RBP cycle	**One**	**Two**	**Three**	**Four**
Cycle 1	0.2	0.1	0.1	0.04
Cycle 2	0.04	0.1	0.02	0.03
Cycle 3	0.03	0.1	0.01	0.04
Total	**0.3**	**0.3**	**0.1**	**0.1**
Equivalent annual value (£m)	**17**	**14**	**6**	**7**

The chapter includes sectoral breakdowns of these costs. Full information about the derivation of these costs is included in the spreadsheets in the annexes to this chapter.

Key points of the chapter:

- The overall scale of costs for tackling morphology ranges from £1.1 to 2.9 billion for England and Wales. This is higher than the transposition RIA estimate of £0.5 billion – though that figure was only for river habitat restoration not all morphological pressures
- There is even more uncertainty surrounding this pressure than others. Although we have "more certain" and "less certain" scenarios, all are likely to be less certain than those for some other pressures.
- In all scenarios there are costs for the Environment Agency, inland navigation, marine navigation, agriculture, local authorities and Internal Drainage Boards, industry, private individuals and the water industry.
- There are legal and financial difficulties to be overcome before many of the measures to tackle past morphological changes can be delivered. Although the pressures and impacts can often be associated with a particular sector, it will not always be fair, or possible, to require anyone in particular to take action in relation to historic structures.

4.5.2. Relevant WFD objectives

Morphology is about the physical form of a water body: the width, depth and structure of the river, lake or sea bed, and the structure and condition of bed, banks and shores. The WFD lists morphological aspects which should be considered for each category of water body:

Quality elements relating to morphological conditions for each category of water body [see section 1.1 of Annex V WFD].

Rivers	**Lakes**	**Transitional waters**	**Coastal waters**
Width variation			
Depth variation	Depth variation	Depth variation	Depth variation
Structure and substrate of the river bed	Quantity, structure and substrate of the lake bed	Quantity, structure and substrate of the bed	Structure and substrate of coastal bed
Structure of the riparian zone	Structure of the lake shore	Structure of the intertidal zone	Structure of the intertidal zone

The WFD establishes several types of objective for the water environment, of which the two key default objectives are:

- to aim to reach 'good status' in all water bodies by 2015
- to prevent deterioration in status of water bodies

Status objectives

For a surface water body to reach or maintain **high status**, its hydromorphologicial conditions must be totally (or nearly totally) as they would be in undisturbed conditions.

For a surface water body to reach or maintain **good status**, the hydromorphological conditions must be consistent with the achievement of the relevant biological quality elements.

So, whilst morphological conditions are important in themselves for meeting high status, for meeting good status it is only those changes to morphological conditions which affect the biological quality elements that need to be addressed. However there is scientific uncertainty about what biological impacts are caused by morphological pressures and hence the extent to which these pressures are relevant in terms of achieving WFD objectives.

The forthcoming priority substances daughter directive may also have impacts for morphological conditions, as it is likely to require Member States to take measures aimed at ensuring that concentrations of priority substances in sediment do not significantly increase.

Article 4.3 - Artificial and Heavily Modified Water Bodies and Good Ecological Potential

The provisions for Artificial and Heavily Modified Water Bodies (AWBs and HMWBs). are particularly relevant in the case of morphological changes. For AWBs or HMWBs the objective is to reach good chemical status and Good Ecological Potential (GEP). GEP is a less stringent objective than GES in that it makes allowances for the ecological impacts resulting from the "sustainable human development activity" for which the designation is necessary. Although less stringent than GES, GEP is still a challenging objective and measures will be required to reach it.

Article 4.3 Water Framework Directive

"Member States may designate a body of surface water as artificial or heavily modified, when:

a) the changes to the hydromorphological characteristics of that body of water which would be necessary for achieving good ecological status would have significant adverse effects on

i) the wider environment

ii) navigation, including port facilities or recreation;

iii) activities for the purposes of which water is stored, such as drinking-water supply, power generation or irrigation;

iv) water regulation, flood protection, land drainage, or

v) other equally important sustainable human development activities;

b) the beneficial objectives served by the artificial or modified characteristics of the water body cannot, for reasons of technical feasibility or disproportionate costs, reasonably be achieved by other means, which are a significantly better environmental option.
Such designation and the reasons for it shall be specifically mentioned in the river basin management plans required under Article 13 and reviewed every six years."

This alternative objective makes the link between impact and activity especially important for morphological pressures. It is necessary to know the use being made of a modification, or the activity having an impact, to assess whether the resultant pressure on the environment is supporting an "important sustainable human development activity" and hence whether it may be designated as an HMWB. In HMWBs allowances can be made for the ecological impacts resulting from the "sustainable human development activity", whereas morphological pressures which are causing an ecological impact but which are not supporting an "important sustainable human development activity" (eg situations where the activity causing the pressure/ecological impact has ceased) will need to be addressed.

There is European guidance on "Identification and Designation of Heavily Modified and Artificial Water Bodies" which sets out the approach which Member States should take to identification and designation, and to setting ecological objectives in these water bodies [reference 1]. This European guidance sets out an approach to defining GEP which involves defining GEP based on the biological, chemical and physico-chemical quality elements.

There is also an alternative approach to defining Maximum Ecological Potential (MEP) and GEP presented in Annex II of the EU technical paper on hydromorphology [reference 2]. This was developed in recognition that there are some gaps in the scientific understanding of the effects to the ecological quality of water caused by hydromorphological changes, and that this will mean that Member States are likely to have some difficulties determining what the correct biological quality element values are for GEP. The alternative approach is that Member States might define GEP in terms of measures. GEP would be the ecological standard which would be reached by taking all of the possible mitigation measures which would not have an adverse effect on the use of the water body, except for those which would have only a slight ecological benefit.

The HMWB and AWB designation process in underway now in England and Wales but will not be complete until the end of 2007. Environment Agency guidance for the purposes of pCEA was to use the following assumptions for England and Wales:

Water body type	**Low HMWB%**	**High HMWB%**	**Low AWB%**	**High AWB%**

Rivers	30	45	2	5
Lakes	40	55	2	5
Transitional	30	45	2	5
Coastal	30	45	2	5

Preventing deterioration

In addition to achieving good status or potential, it is a requirement for all water bodies that no deterioration in status occurs.

Two WFD alternative objectives are relevant here: Article 4.7 provisions for new physical modifications, and article 4.6 provisions for temporary deterioration.

Article 4.7 - New physical modifications

Article 4.7 is particularly relevant for morphological objectives as it sets out the conditions which Member States must meet in order to proceed with any new physical modifications to surface water bodies which would cause deterioration in water status.

Article 4.7 may be used as either an alternative objective or a defence. In other words it can be used to justify setting an alternative objective in a RBMP, or retrospectively, to justify cases where the objective which was set in a RBMP has not been met. The tests contained within it are similar to those in other Directives. There is further information about Article 4.7 in the EU paper [reference 3]

Article 4.7 Water Framework Directive

"Member States will not be in breach of this Directive when

- failure to achieve good groundwater status, good ecological status or good ecological potential or, where relevant, good ecological potential or to prevent deterioration in the status of a body of surface water or groundwater is the result of new modifications to the physical characteristics of a surface water body, or alterations to the level of bodies of groundwater, or
- failure to prevent deterioration from high status to good status of a body of surface water is the result of new sustainable human development activities

and all the following conditions are met

a) All practicable steps taken to mitigate adverse impact on status of the body of water

b) The reasons for those modifications or alterations are specifically set out and explained in the river basin management plan required under Article 13 and the objectives are reviewed every 6 years;

c) the reasons for modifications or alterations are of over-riding public interest and/or the benefits to environment and to society of achieving the objectives set out in paragraph 1 are outweighed by benefits of new modifications or alterations

to human health, to the maintenance of human safety or to sustainable development; and
d) the beneficial objectives served by those modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option."

Article 4.6 - Temporary deterioration
Article 4.6 sets out a defence which may be used retrospectively, to justify deterioration which has occurred where the objective which was set in the previous RBMP has not been met. It is relevant for morphology because it mentions particularly to extreme floods prolonged droughts.

Article 4.6 Water Framework Directive
" Temporary deterioration in the status of bodies of water shall not be in breach of the requirements of this Directive if this is the result of circumstances of natural cause or *force majeure* which are exceptional or could not reasonably foreseen, in particular extreme floods and prolonged droughts, or the result of circumstances due to accidents which could not reasonably have been foreseen, when all of the following conditions have been met:

a) All practicable steps are taken to prevent further deterioration in status and in order not to compromise the achievement of the objectives of this Directive in other bodies of water not affected by those circumstances;
b) the conditions under which the circumstances that are exceptional or that could not reasonably have been foreseen may be declared including the adoption of the appropriate indicators, are state in the river basin management plan;
c) the measures to be taken under such exceptional circumstances are included in the programme of measures and will not compromise the recovery of the quality of the body of water once the circumstances are over;
d) the effects of the circumstances that are exceptional or that could not reasonably have been foreseen are reviewed annually and, subject to the reasons set out in paragraph 4(a), all practicable measures are taken with the aim of restoring the body of water to its stauts prior to the effects of those circumstances as soon as reasonably practicable; and
e) a summary of the effects of the circumstances and of such measures taken or to be taken in accordance with paragraphs a) and d) are included in the next update of the river basin management plan."

In order to help prevent deterioration in status a screening system for new proposals is being developed by the UK Technical Advisory Group. This uses morphological 'conditions' that may be used to highlight those projects or activities that have potential to cause deterioration to a water body.

The morphological screening conditions are:

- Rivers: a 5% reduction in *capacity* for river channels/banks and riparian zones (high status) and 15% (good). Capacity is dependent on the type of river and type of activity.
- Coastal and estuary waters: conditions are now out to stakeholder review
- Lakes: conditions are now out to stakeholder review

For information on the proposed conditions, see reference 4. [The coastal, estuary and lake conditions were not available when the pCEA working groups completed their analysis.]

4.5.3 Extent and nature of pressure, trends and associated uncertainty

Extent of the pressure, and uncertainties

The sources of morphological pressure which have been considered in this chapter of the pCEA are those resulting from flood risk and land drainage, coastal defence and navigation and agriculture. Information on morphological pressures from agriculture comes from outputs of the Fisheries, Alien Species and Biological Pressures (FAB) working group. There is some information on morphological pressures from fisheries, but little on the nature or extent of these pressures. The only costed fisheries-related measures included here are for abstraction screens and making barriers passable.

Flood defence and land drainage activities typically include construction and maintenance of structures and embankments or barriers, creation and operation of wash lands and storage, managed realignment, beach management and maintenance of water levels. These activities can represent pressures on the environment encompassing alteration of flow and sediment regime, discontinuity in the system, and direct biological pressure.

Coastal defence activities typically comprise cliff stabilisation measures, offshore and shoreline structures, beach management, managed realignment, abandonment and maintenance activities. The main pressure exerted by these activities is the change in the sediment regime (supply, transport and storage of sediment along the coastline). Other changes include wave and/or tidal regime, direct morphological impacts, and effluent water drainage.

Many navigable water bodies have historically been subject to physical modifications
including deepening, straightening, reclamation, flow control, etc. In addition many are subject to ongoing maintenance such as dredging or de-silting, and traffic may also have an effect on the environment. Designation of many of these water bodies as heavily modified or artificial (whether due to navigation activities or other factors such as flood defence) is anticipated.

Agriculture has also caused changes to hydrological and sediment regimes across catchments, through both cultivation and the direct impacts of livestock farming. The extent of cultivation and its impact on the ecological status of waterbodies is highly catchment specific, and to date agriculture has not been assessed as a morphological pressure. However there is evidence that, for example, run-off is a major cause of sedimentation in lakes, as is bank-side erosion caused by livestock. There are management practices which are proven to help reduce the impacts on morphology.

All fishing activities impact to some degree on the environment. The main morphological pressures associated with fishing in marine and estuarine waters result from

- Trawling and dredging, which can have adverse impacts on bottom dwelling organisms/ecosystems and can stir up sediment
- Beam trawling and use of benthic release panels and
- Scallop dredging.

In freshwaters the main fisheries-related morphological pressures result from detrimental management of the riparian zone by riparian owners (and in some cases anglers eg. felling of bankside vegetation).

Most pressures have an effect on most types of water body, although lakes were not widely considered by the pCEA working groups. The initial River Basin Characterisation exercise demonstrated that across England and Wales over 40% of river water bodies, and 75% of coastal and 90% of estuary water bodies (by number) were at risk of failing because of morphological pressures.

2005 initial risk assessment results: Percentage of water bodies "at risk" or "probably at risk" of failing to meet GES by 2015 as a result of morphological pressures

	Wales	**England**
Rivers	23.1	53.5
Lakes	56.2	60.1
Estuaries	90.6	89.4
Coastal Waters	83.3	76.0
Groundwater	Not applicable	

Within this, the Environment Agency has identified approximately 2500 significant obstructions to fish passage (about 250 in Wales and 2250 in England).

This characterisation is being updated but the lack of data on extent and nature of pressures is a cause of major uncertainty. For example

- the National Flood and Coastal Defence Database has been developed for a different reason, and whilst it is a useful data set, is not fully populated so there is no comprehensive source of information on all defences in England and Wales.
- For coast protection, the last survey was undertaken during the late 1990s and while Welsh coverage is good, only 27% of the English coastline was covered and it is not clear what proportion of the remainder is not known, not 'coast protection' or not defended at all.
- While information on barriers to species migration exists, it is incomplete and was collected for a variety of reasons.The 2005 risk assessments assessed the risk from shellfisheries and fishing activity in transitional and coastal waters, focusing on shellfish dredging, beam and otter trawls. But further, more detailed local risk assessment will be necessary to ascertain the true extent of risks.

In addition there is uncertainty resulting from the scientific evidence about whether morphological pressures will have an impact on biology, and hence the extent to which these pressures are relevant in terms of achieving WFD objectives. The evidence about this link is better for some types of morphological pressure than for others but it causes uncertainties when estimating the significance of the morphological pressure and the effectiveness of measures to deal with it.

Trends and associated uncertainty

There is information about policy trends, and the impact which action taken as a result of other policies may have on ability to meet WFD objectives, in the WRC report titled "Information on trends to improve the baseline scenarios" [reference 5]. The overall picture is very complicated with significant uncertainty, but the WRC study was able to draw some conclusions about pressure-activity relationships where the potential impact of trend data was high. They divided these into two groups depending on the level of confidence in the trend information. For morphology, the following pressure-activity relationships were highlighted:

Potential impact of trend data high Confidence in information on trends at least 'reasonable'	**Potential impact of trend data is high Confidence in the information provided on trends low**
Morphology – Flood defence	Morphology – Urbanization
Morphology – Navigation	

Flood Risk Management
Over the next 50-100 years climate change will represent a major challenge to Flood Risk Management. A recent study into future flooding predicted that UK flood losses will increase significantly by the 2080s, by between £1 billion and £27 billion, if flood risk management policies and expenditure do not change (see Foresight report on Future Flooding - reference 7). The number of people at "high" risk of flooding in 2080 could rise from 1.5m to up to 3.5 million. At the same time population growth will drive more development, potentially in areas at risk now or in the future.

While investment in flood risk management in some areas may increase it is likely that these areas will already have some extent of flood defences. This means that investment is more likely to take the form of raised or improved defences, rather than the introduction of a defence to an undisturbed area. The additional pressure on WFD quality parameters is therefore likely to be minimal. In some cases increased developments could lead to new floodplain development and require defence of an area not previously modified. Where this is likely to cause deterioration or lead to non-achievement of GES or GEP then it would need to be justified in WFD terms.

'Making Space for Water', Defra's new flood management strategy for England examines a more holistic approach to flood risk management, taking account of more types of flooding and helping to ensure it supports sustainable development. It adopts a catchment wide and whole shoreline approach that is consistent with and contributes to the implementation of WFD. The strategy is yet to be finalised, and its final scope is to some extent dependent on continued evidence gathering. It is likely that the Environment Agency will adopt similar principles in Wales, as part of delivering the Welsh Assembly Government Environment Strategy.

The new European Flooding Directive, due to be finalised in 2007 will lead to closer links between river basin planning and flood risk management planning. From 2015 it will be a *requirement* that WFD objectives will also need to take account of flood risk management objectives.

Increasingly investment will be targeted where it can achieve most for society and the environment. This is likely to lead to investment in high risk areas and acceptance of increased risks in less populated areas and those with fewer assets (economic and/or environmental).

Decisions not to maintain structures may remove flood risk management as a justification for continued pressure, and create an opportunity, to restore or enhance the ecological status of the water body. This may start to have an effect within the timescales of WFD implementation – Defra and the Environment Agency have already issued a policy on withdrawal of maintenance from uneconomic sea walls and a similar policy for rivers is likely to follow. Even if this

were the case in only 10-15% of existing defended lengths, this equates to potentially thousands of kilometres of rivers. If the removal of ‘use’ of flood defence structures creates an assumed obligation for restoration, this would need to be supported by a clear view on the cost effectiveness of measures, and a funding source to deliver it, as engineering activity and potential compensation measures would be needed.

These decisions about where defences are no longer justified will be made through the ongoing Catchment Flood Management Plan (CFMP) and Shoreline Management Plan (SMP) development (all catchments) and strategy production (where these are required) and the use of Systems Asset Management Plans. This is a contribution to the process of identifying future measures for reducing morphological pressure, and is already funded. Additional analysis for WFD compliance, and any selection of different policy options to complement or deliver WFD aims will add costs.

Coast Protection
Climate change and changes in coastal behaviour will have a significant effect. Risks of coastal erosion are set to change over the next 100 years due to changes in the climate and sea levels. Whilst the quantum of change in the sea level has been defined by Government for the British coast, and there is some evidence to suggest increased storminess might be an issue, there is uncertainty about the consequences of this change.
The increase in either could allow an increase in the erosion of defences (and cliffs) leading to more frequent failure and greater releases of sediment as a result. What is unclear is where any equilibrium might lie, if sufficient sediment is released and remains as protective morphology (perhaps driven up by larger waves and leading to a coarser sediment) then erosion may reduce or abate following initial releases.

“Making space for water” adopts a whole shoreline approach that looks to adapt to climate change, and aims to integrate strategy with other relevant Government policies. In future there may therefore be more managed cliff retreat or abandonment of defences (as part of an exit strategy). However, in WFD terms, the pace of change is likely to be slow. Shoreline Management Plans are being used to revise management of coastal defences and identify significant increases in defence modification or removal to release sediment into the environment and provide defences that are sustainable in defence terms. The present round of Shoreline Management Plans is working to epochs of change in the coast at 2025, 2050 and 2100. Many plans identify a change in 2025 eg with defences being held up to 2025 and then retreated or modified following that.

What is likely to continue is the priority of protecting urban areas being higher than rural areas. In this respect the trend for increased housing and development (200,000 new homes by 2016) may make some areas that were previously unjustified become justified in defence terms. This will be reliant on effective

planning measures to prevent development in such areas (whilst planning blight remains an issue politically that may prevent this happening).

Ports and Navigation
Many of the major navigation-related physical modifications in both inland and transitional and coastal water bodies took place many years ago. More recently, growth in the sector has been characterised by *locally* significant hydromorphological changes, for example associated with seaport development and/or dredging. This has largely been to accommodate the continuing growth in unitised cargoes (containers).

The restoration of old canals and/or the development of new marinas to support the sustainable growth in recreational boating is foreseen in 'Waterways for Tomorrow'.

There are a number of areas where climate change may increase the requirement to exert some hydromorphological pressures - notably dredging and bank protection.
Whilst these trends may continue to result in locally significant physical changes in the foreseeable future, the navigation Working Group's assessment did not identify any nationally significant trends in navigation-related pressures.

Urbanization
Urbanisation trends, and are addressed in the chapter on planning (chapter 4.10).

Climate change
There is emerging evidence that morphological measures could play a part in adapting biodiversity to climate change. For example, blocking upland drainage systems may help sequester carbon in wetlands and better sustain flow in watercourses during droughts. The protection of the riparian zone can improve morphology and shade rivers from the sun thus reducing stream temperature. In addition, the creation of coastal wetlands could offset the effects of "coastal squeeze" as well as deliver more sustainable flood risk management.

4.5.4 Apportionment and associated uncertainty

Pressures from new and ongoing activities
In order to ensure no deterioration as a result of morphological pressure, measures are needed to control the impact or new and ongoing physical modifications. The costs of measures to avoid or minimize the impact of such modifications will largely be borne by the sectors wishing to carry out the activity, although there will also be administrative costs here for the government organisations with existing licensing and regulatory powers, and advisory remit. More information on administrative costs is provided in Chapter 4.12.

Pressures from historic activities and structures
For restoration measures, apportionment is more difficult because time has elapsed since the morphological change was made, and to some extent it is less relevant because the 'polluter pays' principle is difficult to apply when many of the relevant activities and structures were promoted, paid for, or required by government in the past. The main difficulties are that

- there is little consistent data on the many historical changes to rivers and coasts
- many structures are no longer obviously owned or operated
- uses of structures have changed and/or structures now have multiple uses
- many structures and features are owned privately.

Flood risk management and coastal defence
It is clear from initial analysis that a large proportion of morphological alterations are, and have been, made to prevent or minimise the probability of flooding inland, on estuaries and to a lesser extent at the coast (where coast protection also features). Most of the responsibility for pressure resides with the Environment Agency, Internal Drainage Boards (IDBs) and Local Authorities. The remaining sections of defence are mainly in private ownership such as individual landowners, rail operators, or other private businesses or may be historical in nature (such as military defences under the Ministry of Defence). For the purposes of this assessment, the pressures resulting from all flood management activities (whether carried out by IDB, Local Authority, landowner or Environment Agency) have been considered together, and costs and effectiveness of measures assumed the same regardless of the operator.

Navigation
The navigation sector has provided an initial estimate of its contribution to various pressures in table 1, but caveats its use beyond this exercise.

Table 1: Pressure Apportionment

Pressure or activity affecting water status	Other sources of pressure	Estimated navigation-related contribution to pressure
Flow control structures on inland waterways	Agriculture; flood defence; water resources; industry/mills	30% of pressure on rivers 90% of pressure on canals
Bank protection on inland waterways	Flood defence; riparian landowners; developers; highways authorities	5% of pressure on rivers 95% of pressure on canals
Dredging of inland waterways	Flood defence; conservation; water resources; clean-up dredging; agriculture	30% of pressure on rivers 90% of pressure on canals
Vessel movement on inland waterways	None identified	100% of pressure on rivers 100% of pressure on canals
Structures in TraC waters	Coastal defence; power generation; industry; agriculture	5% of pressure in coastal waters 5% of pressure in estuaries
Dredging in TraC waters	Aggregate extraction*; flood defence; commercial fishing	5% of pressure in coastal waters 90% of pressure in estuaries
Disposal/placement in TraC waters	Coastal defence; flood risk management	10% in coastal waters 100% in estuaries

Multiple pressures

For the purposes of this chapter, morphological pressure is considered separately from others. However, it is rare that a water body will be subject only to morphological pressures – typically other pressures such as diffuse pollution from agriculture or towns, or point source pollution will also be acting to limit ecological status. In cases where morphology is not the limiting pressure, measures for morphological improvement would not necessarily see a corresponding improvement to overall water quality.

Improved estimates of apportionment will be possible once the Environment Agency updates the River Basin Characterisation data later in 2007.

4.5.5 Measures to meet WFD objectives under the four scenarios

Groups of measures

There are three main types of measures needed to meet WFD objectives in relation to morphology. They are:

- *Measures to reduce uncertainty* See section 4.5.8
- *Measures to ensure no deterioration*, including:
  - measures to control and mitigate the effects of new developments and activities
  - maintenance measures, i.e. the continuation of activities on which the current status depends – for example where protected areas are only in existence because of ongoing maintenance regimes, even if these are no longer important in flood risk management terms (the extent of this is unknown at present but could be significant).
- *Measures to achieve the right status* (ie measures to improve), such as on the ground restoration activities that will support biological elements.

On the spreadsheets for each scenario in the annexes to this chapter, measures to reduce uncertainty are shown in yellow rows, no deterioration measures in green, and measures to improve status in orange.

The scenarios in this chapter include measures to address morphological pressures from 4 main sectors

- Flood risk
- Inland and marine navigation
- Coastal defence
- Agriculture

In addition there are some measures for industry, the water industry and private individuals.

Measures have been aggregated into types of measure, such as

- remove effectiveness of structure
- restoring in-stream characteristics
- manage asset differently
- modify navigation management
- naturalise sediment levels.

These aggregated types of measure may be delivered in different ways using different techniques. For example 'make barriers passable' may involve altering weirs, dams, sluices, locks, culverts, urban channels, flap valves, barrages, pip crossings, or pumping stations. The cost-effectiveness of measures to "make barriers passable" may be determined by the length of river or number of water bodies that fish are given access to, the degree of impediment to migration of original obstruction (for example some are completely impassable, others might be passable at high flows, and the ability of the fish species in question to overcome obstructions).

These aggregations are used to incorporate a high number of possible measures, but in recognition that their application is so site specific that to provide cost and effectiveness assessment beyond this high level is not appropriate at this level of analysis.

Assumptions and uncertainties relating to cost effectiveness

The following broad assumptions for cost effectiveness analysis of morphology measures were adopted here:

- That restoration measures will only need to be applied in water bodies which, despite agreed non-WFD measures, are at risk of failing GES (normal WBs) or GEP (HMWBs/AWBs) . This is taken as 18000km; 35% of the extent of all surface water bodies by length, calculated as 45% (the high HMWB outcome for rivers, transitional and coastal waters) reduced by an arbitrary 10% for those water bodies which will not actually be failing. This figure is the same for all scenarios. Although a phased programme with further investigations in initial cycles would provide more information before action was taken, we do

not know whether investigations would reveal an increase or decrease in the number of water bodies in which action is needed.

- That any coastal defence type representing more than 10% of the defended length of the coastline of England or Wales is nationally significant, and any coastal defence type representing less than 10% is not nationally significant (thus seawalls and revetments are the only nationally significant primary coast protection structures).
- That the presence of a pressure can be used to indicate a risk of failure – in other words that a morphological pressure will lead to a corresponding negative impact on biology.
- That action necessary to deliver protected area objectives (especially Habitats and Birds Directive objectives) and the national SSSI target will be taken under those Directives and policies rather than the WFD. There will be costs for all sectors, over and above the costs listed here, to deliver the Habitats and Birds Directive and SSSI requirements.
- That the measures required to achieve good status are broadly similar to those required to achieve good potential. The extent of application of a particular measure could vary significantly depending on whether the target for the water body is GES or GEP but this distinction was not made in this analysis.
- The costs used are the 'best estimates' provided by the working groups for their sector measures. This is a major assumption given the degree of uncertainty about many of the estimates. The navigation sector report gives ranges for costs, For example estimates of annual operating/maintenance costs for mitigating hard bank defences or install soft bank protection in inland waterways in England range from £10 000 to £800 000. But as other sectors did not do similarly, it has not been possible to show ranges for the scenarios as a whole.
- That costs and effectiveness of flood management measures are the same regardless of operator (IDB, Local Authority, landowner or Environment Agency).
- Maintenance costs have been included where these are a significant element of the cost of the measure and there is credibility in the figures available.
- Where it was not clear from the available information whether costs are for England only or England and Wales, it is assumed they are for both England and Wales and that 10% of the costs will fall to Wales and 90% to England.
- That the Priority Substances Daughter Directive requirements for sediment are the same as those in the current proposal (changes to these requirements could limit the amount of sediment available for beneficial use measures).

There are also many areas of uncertainty relating to cost-effectiveness of measures:

- Both cost and effectiveness of morphological measures can vary significantly depending on site-specific characteristics in often dynamic physical systems, and the associated availability and adequacy of existing

information. There are therefore a number of areas of uncertainty relating to the *unit cost* estimates derived by all working groups. .

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- There are legal and financial difficulties to be overcome in relation to delivery of many of the restoration measures listed here. Although the pressures and impacts can often be associated with a particular sector, it will not always be fair, or possible to require anyone in particular to take action in relation to historic structures (especially where they were put there legally, perhaps even required by Government; and/or the ownership or use of the structure have changed over time). A recent Defra consultation on "Mechanisms to Deliver WFD Requirements on Hydromophology" [reference 6] sought views on what, if any, additional delivery mechanisms might be used to tackle or reduce some of these difficulties.

Measures most likely to be cost effective

It is not easy to generalize about relative cost-effectiveness of measures to tackle morphological pressures because, as mentioned above, both costs and effectiveness vary considerably depending on local circumstances. However, there was general agreement amongst working groups that the following types of measures would often be amongst the most cost-effective

- Measures to reduce uncertainty – including improving understanding of the pressure, the relationship between pressure and impact, and to test other likely cost effective measures (see section 4.5.7)
- Measures delivering significant improvements at no or low cost eg making barriers to migration passable to migratory species, and

reducing maintenance where this allows a degree of natural recovery and does not jeopardise the use.

- Win-wins such as measures which have economic as well as environmental benefits (eg beneficial use of dredged material) and

measures which will deliver improvements in other pressures as well as morphology (eg some of the agriculture measures for morphology will also help tackle water resources, sediment and nutrients pressures).

Spatial and timing considerations affecting cost effectiveness

Morphology of a water body results from the interplay of local and catchment scale pressures, particularly land-use and land management. For example, extensive drainage of the uplands increases run-off rates and the erosive power of the stream. Increased sediment loads are carried downstream (both from the land drained and by increased erosion of the banks) and are deposited, for example, in spawning gravels or on a lake bed. Increased erosion of the banks may lead to engineering works to reduce the erosion and this may cause further problems. These catchment scale pressures problems can generally be tackled most efficiently and effectively at source.

In cases where catchment scale pressures dominate, measures to improve the morphology of a water body will need to be applied upstream of that water body (eg following the example above, by reducing upland drainage). If dominant catchment pressures are not tackled at source, then the effectiveness of local measures further downstream is likely to be reduced.

Strategies for the restoration of the function and form of a river system are likely to inform the scheduling of measure implementation. For example, it may be found that it is most cost-effective to apply some measures starting in low order stream and working downstream, whereas for other measures the opposite might be true. For example, in making obstructions passable by migratory salmonids it would be most cost-effective to start at the mouth of the river and work upstream; to reduce sedimentation on spawning grounds by improving land management practice, it would be most effective to start at the top of the catchment and work downstream.

Cost effectiveness and links with action to tackle other pressures
The scenarios presented here relate only to morphological pressures and do not factor in links with measures which will be taken to tackle other pressures. However, these interlinkages will have significant consequences in terms of cost-effectiveness – those measures which deliver improvements in many pressures are likely to be more cost effective. For example, some of the agriculture measures for morphology will also help tackle water resources, sediment and nutrients pressures.

There are arguments for phasing physical restoration works after other pressures have been resolved. Water chemistry, and hence pollutant levels, whether from point or diffuse sources, is often a determinant of ecological status (i.e. if the chemistry isn't right the population cannot survive). However, morphology is generally less of a critical limiting factor on populations. With the exception of barriers to migration, morphological changes tend to be more subtle – eg altering population numbers or location rather than having an "all or nothing" effect.

4.5.6 Costs of 4 scenarios

Four spreadsheets showing 4 possible scenarios for implementation of WFD morphology measures are presented in Annex 1 of this chapter. The spreadsheets give a summary explanation of each measure, the sector responsible, where cost figures came from and how they were calculated.

On the spreadsheets, measures to reduce uncertainty are shown in yellow rows, no deterioration measures in green, and measures to improve status in orange. There are two versions of each spreadsheet, one with measures grouped into these 3 types, and one with the measures organized by sector.

The scenarios provided here assume we know costs, effectiveness, and the extent of water bodies that require measures. The differences between the

scenarios therefore only relate to disproportionate cost, uncertainty, timing and cost share.

For this pressure it is not possible to identify that these measures are 'tried and tested'. The measures included in the scenarios are those agreed by most to be the likely measures to achieve the likely required improvement and no deterioration. The "higher certainty" and "lower certainty" of achieving WFD objectives therefore relates more to the extent of action taken than the likely success of the measures.

Scenario 1 – Higher certainty of achieving outcomes, no phasing - do all tried and tested technically feasible measures at once.
This scenario involves putting in place all of the measures which have been costed for all sectors in the first River Basin Management Plans (RBP1) using the assumptions stated in section 4.5.5 above.

Some costs are accrued in further rounds of delivery as these are not 'one-off' activities but ongoing requirements, or ongoing additional cost burdens because of a change in management technique.

The overall costs of this scenario are £2.6 billion for England and £0.3 billion for Wales, with equivalent annual values of £153m and £17m respectively.

Present Values £bn	**England**	**Wales**
RBP cycle	**Scenario 1**	**Scenario 1**
Cycle 1	2.1	0.2
Cycle 2	0.3	0.04
Cycle 3	0.2	0.03
Total	2.6	0.3
Equivalent annual value (£m)	153	17

The sectoral breakdown of present value costs for all 3 river basin planning cycles is as follows:

£m	**RBP1-3 England**	**RBP1-3 Wales**
EA	274	28
Inland navigation	63	6
Marine navigation	246	33
Agriculture	643	71
Local Authorities and IDBs	859	95
Industry	106	12
Private individuals	74	8
Water industry	32	4
Sector unknown	341	36
Total	**2639**	**294**

Scenario 2 – Higher certainty of achieving outcomes, some phasing - do what is tried and tested and reasonable as soon as possible.

This scenario includes the same measures as scenario 1 but with implementation of measures phased over 3 river basin planning cycles. The approach to phasing is tailored to the particular measures (for example, ongoing measures are not phased, research to reduce uncertainty phased in the first two cycles, and some measures where further research and investigation is needed do not begin until the second cycle). The phasing is as follows:

- Replacing flood risk assets which are still required with ones which meet WFD requirements is all done in second cycle rather than the first
- EA and local authority and IDB prioritised programme of work to tackle redundant flood defences, and the associated agricultural funding for alternative use of land begins in second cycle rather than first.
- Further research to improve understanding of pressure/response links is split evenly between first and second cycles
- Making barriers passable for fish is split evenly over 3 cycles.
- Provide screens for fish by abstractions and other necessary sites is split evenly over 3 cycles.
- Funding for implementing livestock fencing, buffer strips etc is phased over 3 cycles.
- Mitigate hard bank defences or replace with soft bank protection (for rivers and canals) split between second and third cycles.
- Remove bank protection for inland navigation and reprofile split between second and third cycles

The overall costs of this scenario are £2.1 billion for England and £0.3 billion for Wales, with equivalent annual values of £123m and £14m respectively.

Present Values £bn	**England**	**Wales**
RBP cycle	**Scenario 2**	**Scenario 2**
Cycle 1	0.5	0.1
Cycle 2	0.9	0.1
Cycle 3	0.7	0.1
Total	2.1	0.3
Equivalent annual value (£m)	123	14

The sectoral breakdown of present value costs for all 3 river basin planning cycles is as follows:

£m	**RBP1-3 England**	**RBP1-3 Wales**
EA	256	27
Inland navigation	54	5
Marine navigation	246	33
Agriculture	451	50
Local Authorities and IDBs	649	72.
Industry	88	10

Private individuals	61	20
Water industry	26	3
Sector unknown	291	31
Total	**2122**	**251**

Scenario 3 – Lower certainty of achieving outcomes, no phasing - do all technically feasible measures at once, use innovative measures.
The list of measures included here is more limited, focusing on those considered to be nationally cost effective. As with scenario 1, all of the measures are implemented in the first cycle. There is potentially a lower certainty of achieving outcomes because fewer measures are being applied across fewer water bodies.

The following measures are removed (from those included in Scenarios 1 and 2):

- Replacement of EA flood risk management assets which are still required with ones which meet WFD requirements
- Mitigation of hard bank inland navigation defences or replacing them with soft bank protection - in both rivers and canals
- Restoration of in-stream features
- Characterisation of the coast by Environment Agency and local authorities and IDBs. Rely instead on Shoreline Management Planning to help characterize and deliver change
- specific effort by EA flood management, local authorities and IDBs, and the agriculture sector to tackle redundant defences, instead relying on withdrawal of maintenance to ensure some natural recovery over time.

And the extent to which the following measures are applied is reduced (from what is included in Scenarios 1 and 2):

- piloting monitoring and analysis to reduce uncertainty over cost effectiveness of measures. Costs are halved.
- making barriers passable for fish. Scenario 3 has costs for tackling half rather than all of the relevant barriers
- providing screens for fish at abstractions and other necessary sites. Scenario 3 has costs for providing one third of screens rather than all of them.
- Funding for livestock fencing, buffer strips etc. For scenario 3 the water body length tackled, and hence cost, is halved.

The overall costs of this scenario are £0.9 billion for England and £0.1 billion for Wales, with equivalent annual values of £52m and £6m respectively.

Present Values £bn	**England**	**Wales**
RBP cycle	**Scenario 3**	**Scenario 3**
Cycle 1	0.6	0.1
Cycle 2	0.2	0.02
Cycle 3	0.1	0.01

Total	0.9	0.1
Equivalent annual value (£m)	£52	£6

The sectoral breakdown of present value costs for all 3 river basin planning cycles is as follows:

£m	**RBP1-3 England**	**RBP1-3 Wales**
EA	223	23
Inland navigation	28	2
Marine navigation	243	33
Agriculture	123	13
Local Authorities and IDBs	69	8
Industry	35	4
Private individuals	25	3
Water industry	11	1
Sector unknown	148	16
Total	**905**	**102**

Scenario 4 – Lower certainty of achieving outcomes, with phasing - do what is reasonable as soon as possible. Implement innovative measures over a longer timescale.

Like scenario 3, scenario 4 includes a more limited list of measures and as for scenario 2, the costs are spread over 3 river basin planning cycles..

The list of measures is the same as the list used for scenario 3 except that scenario 4 includes Environment Agency flood management, local authority and IDB and agriculture sector measures to remove the effectiveness of flood defences. Scenario 4 assumes that action to reduce uncertainty in the first planning cycle will show this to be a cost effective measure, and so re-introduces it in the third planning cycle.

The phasing is the same as for scenario 2, plus

- Piloting monitoring and analysis to reduce uncertainty over cost effectiveness of measures are split evenly between cycles 1 and 2 (it is not phased in scenario 2)
- Further characterise the coast is done in cycle 2 rather than cycle 1, and costs are halved on the assumption that work done for the Shoreline Management Plans will have improved data and understanding by that time

The overall costs for this scenario are £1 billion for England and £0.1 billion for Wales, with equivalent annual values of £55m and £7m respectively.

Present Values £bn	**England**	**Wales**
RBP cycle	**Scenario 4**	**Scenario 4**
Cycle 1	0.4	0.04
Cycle 2	0.3	0.03

Cycle 3	0.3	0.04
Total	1.0	0.1
Equivalent annual value (£m)	55	7

The sectoral breakdown of present value costs for all 3 river basin planning cycles is as follows:

£m	**RBP1-3 England**	**RBP1-3 Wales**
EA	234	24
Inland navigation	28	2
Marine navigation	243	33
Agriculture	195	22
Local Authorities and IDBs	74	8
Industry	29	3
Private individuals	20	7
Water industry	9	1
Sector unknown	123	13
Total	**955**	**113**

4.5.7 Measures not considered: assumptions and justification

Measures to deliver other directives and obligations
These morphology scenarios do not consider all measures needed to deliver other directives and obligations, which may help to achieve WFD targets, in particular
those necessary for implementation of the Habitats and Birds Directives and Government SSSI target. These should go ahead irrespective of the WFD. There are some more details on costings for these measures in the Fisheries, Alien Species and Biodiversity working group output report. These issues are discussed more widely in chapter 2 on context.

Fiscal measures
The Working Groups did not consider many wider fiscal options such as

- introducing a navigation tax
- (increasing) harbour or river dues to meet the costs of WFD measures
- wider financial mechanisms for future funding of flood risk management [Though these were considered as part of making Space for Water in England.]

Highly site specific navigation measures
Measures which were not assessed by the navigation sector because their applicability was felt to be highly site specific included:

- the removal of impounding structures on inland waterways
- modifications to vessel traffic management on inland waters
- changes to vessel/hull design

- works to manipulate the flow regime or to modify existing structures in TraC waters

Hull design or other modifications to vessels can be appropriate in especially sensitive environmental areas, this was not included in the pCEA as being a 'nationally relevant' measure. However, the concept of 'fitting the boat to the river rather than the river to the boat' is under close scrutiny as a potential measure elsewhere in Europe. A recent British Waterways study put the cost of retrofitting an existing canal vessel with an 'eco-hull' (ie. to reduce bank and bed disturbance) at between £10,000 and £30,000 per vessel.

Voluntary navigation measures
Many voluntary initiatives exist, examples of good practice being the recreational boating industry Environmental Code of Practice and the 'Green-Blue' initiative; and the recent development of the 'Maintenance Dredging Protocol'. Quantification of their contribution is difficult to assess but may improve with monitoring of uptake and impact.

Coastal protection measures
The scenarios include measures to reduce uncertainty about what action is needed in relation to coastal protection, and a preliminary indication of some aspects of the costs associated to direct coastal defence measures which might be required. However this is based on limited data and further assessment work is needed to enable selection and use of appropriate measures.

Lake morphology measures
The following were identified as possible measures but no information on costs could be provided and the number of cases assumed were low, so they have not been included in assessment at this national preliminary assessment stage:
- schemes to reduce sediment input from eg road drains, will require diversion of the drains or creation of settlement ponds.
- schemes to reduce sediment input from point sources: many of the point-source discharges have been addressed because of nutrient enrichment, but a few remain, mostly from sewage.

Agricultural measures
Whilst some agricultural measures have been considered here, this has been as part of the synthesis process and through the work of the Fisheries, Alien Species and Biodiversity group and not the agriculture working group, which did not examine morphological measures. However members of the agriculture working group have provided comments on a draft of the chapter as well as some additional costings.

Fisheries measures
This chapter mentions some of the morphological pressures caused by fisheries but does not include measures to address them, as the Fisheries, Alien Species

and Biodiversity group did not provide costings for these. However, morphological measures to benefit fish (i.e. fish passes and screens) are included.

4.5.8 Measures to reduce uncertainty

There is a high degree of uncertainty in relation to the nature and scale of action which will be required to meet WFD objectives in relation to morphology. Measures to reduce uncertainty are therefore included in all scenarios.

Evidence of the extent and nature of morphological pressures.
A common measure required is to improve available data. For example to populate the National Flood and Coastal Defence Database with full coast protection data.

Understanding the pressure/impact relationship and therefore the effectiveness of measures.
Common amongst the sector groups is the view that research and analysis to improve understanding of the pressure/impact relationship is likely to be cost-effective. A widely supported way of achieving this is to test and monitor the likely cost-effective measures and measures which are not proven but may be cost effective. Such measures could include:

- the effects of livestock fencing, grip blocking, tree planting
- learning from the strategic documents produced under the 'maintenance dredging protocol' by navigation authorities
- piloting and researching river restoration techniques which do not at present have demonstrable impact on the relevant WFD quality parameters. This could be carried out where Habitats Directive remedies are being delivered.

4.5.9 Further considerations; costs, distributional trade-offs, uncertainty

Measures likely to be disproportionately costly
The working groups considered the following measures likely to be disproportionately costly:

- Wholesale restoration or removal of flood and coastal defences, and other engineered or reinforced channels
- Removal of major infrastructure, bridges and culverts under buildings

Distributional trade offs - between sectors
When considering proposals for future morphological changes, it will be important to look across sectors at the full range of existing and proposed morphological pressures acting on a water body.

There may be some potential for trade offs between sectors here – for allowing an increase in morphological pressure from navigation activity if there is going to be a decrease morphological pressures from flood risk management. However,

the scope and impact of this is difficult to assess, because of uncertainty about sectoral apportionment and both costs and effectiveness of measures.

There is less room for trade-offs between sectors in relation to restoration measures as it is largely a matter of dealing with morphological changes that have already taken place. In addition, the difficulties in relation to apportionment and delivery of action in relation to historical changes currently limit the situations in which restoration action can be taken (see recent Defra/WAG consultation, reference 6). However there will be some trade offs

- removing the effectiveness of flood defences will have costs for agriculture if the land can no longer be used for agricultural purposes, and
- where are multiple structures present in a water body but only some of them need to be tackled in order to meet WFD objectives, there may be some potential for trade offs.

There may be potential to deliver 'win-win' solutions in some situations. For example,

- the beneficial use of dredged sediment by the ports industry may also be of potential relevance to flood risk management.
- removing the effectiveness of flood defences may have benefits for navigation if it creates intertidal land which will help them to achieve Habitats Directive requirements
- measures to decrease the damage caused by cattle poaching river banks may also be those most cost-effective to reduce diffuse pollution from agriculture.

Only when the mapping of multiple pressures within a water body is available will the true overall 'effectiveness' of a measure be determined.

Distributional trade offs - affordability over time

Many navigation organisations, such as the Broads Authority and British Waterways, effectively operate to a fixed budget. If the unit cost of an activity such as dredging increases without a proportionate increase in budget, the consequence will probably be that less dredging will be carried out overall. As a result, users may suffer. Particularly in the case of recreational users, less dredging could mean a reduction in the area of water space available for safe navigation and potentially more congestion in those areas which remain available for use (or a reduction in the number of participants if the value of the experience reduces).

Measures which depend on the acquisition of land adjacent to the water body are particularly sensitive to affordability considerations. As most navigation authorities do not have compulsory purchase powers for habitat creation works, the market price of land can make the difference between the same measure being disproportionately costly or not.

Any WFD-induced requirement to replace a structure before the end of its residual life will have affordability implications (ie. provision would not normally be made in a budget to replace the structure until it has reached the end of its useful life).

For commercial operators such as ports, competition (both within and, importantly, outside of the UK) is critical to survival. If a port raises its charges above a certain level, trade will be lost. Costs may therefore not always be passed on. There is obviously a limit to which a commercial organisation can continue to bear this type of cost.

Organisations delivering flood risk reduction, including the Environment Agency, local authorities and IDBs, also operate within strict budgets and pressure on these will inherently increase as flood risk increases as a result of climate change and development pressure. Any increased requirement for delivery of restoration measures without accompanying funding could compromise delivery of FRM outcomes. Some measures such as those required to mitigate the impact of FRM activities would be seen as ‘must do’. Others (such as reducing maintenance) are likely to be supported by both FRM and WFD objectives in some water bodies. The extent to which this is the case will depend on the co-location of those where flood risk is lower and the need for morphological improvement has been identified.

For the agricultural sector, there are many measures that could be delivered through changed land management for different pressures. Morphology is only one in a series. However, some of these measures deliver multiple benefits and may therefore prove particularly cost effective. Funding mechanisms to support them must be examined in order to ensure delivery is achieved, as reliance on voluntary implementation may rule them out for reasons of affordability.

REFERENCES

1. Common Implementation Strategy Guidance Document No 4: Identification and Designation of Heavily Modified and Artificial Water Bodies http://forum.europa.eu.int/Public/irc/env/wfd/library?l=/framework_directive
2. WFD and Hydromorphological Pressures Technical Report: Good practice in managing the ecological impacts of hydropower schemes; flood protection works; and works designed to facilitate navigation under the Water Framework Directive http://forum.europa.eu.int/Public/irc/env/wfd/library?l=/framework_directive
3. Exemptions to the Environmental Objectives under the Water Framework Directive Allowed for new modifications or new sustainable human development activities (WFD Article 4.7): Policy Paper http://forum.europa.eu.int/Public/irc/env/wfd/library?l=/framework_directive
4. Stakeholder review of proposed morphological conditions for lakes, coastal and estuary waters http://www.wfduk.org./stakeholder_reviews/
5. WRC report for WFD Collaborative Research Programme “Information on trends to improve the baseline scenarios”
6. Defra and Welsh Assembly Government “Consultation on Mechanisms to Deliver WFD Requirements on Hydromophology2 http://www.defra.gov.uk/corporate/consult/nadwp-hydromorphology/index.htm/
7. Office for Science and Technology “Foresight: Future Flooding” http://www.foresight.gov.uk/Previous_Projects/Flood_and_Coastal_Defence/Reports_and_Publications/Project_Outputs/Outputs.htm

Annex A

Scenario 1 – Higher certainty, no phasing.							
Sector	**Cycle 1**	**Source of cost estin**	**Cost England**	**Cost Wales**	**Cycle 2**	**Cost England**	**Cost Wales**
EA other (and/or other regulators)	Put in place and operate new delivery mechanism for no deterioration consenting (introduction of MIMAS or simlar tool, additional costs for consenting, low estimate, capital costs £0.4m, annual costs £1.6m).	EA	10000000		Ongoing process	9600000	
EA (FRM)	Change FRM appraisal and delivery to ensure it is WFD proofed (taken as 10% of ongoing expenditure, = £12m + £1.3m per year England and Wales)	EA	72000000	7800000	Ongoing costs	72000000	7800000
EA (FRM)	Manage flood risk management assets differently, including reducing maintenance where appropriate (assumed 3% of maintenance budget = £3.8m England and £0.5m Wales per year).	EA	22800000	3000000	Ongoing costs	22800000	3000000
EA (FRM)	Replace those assets which are still required with ones that meet WFD requirements (likely disproportionately costly in vast majority of cases), assume 90% England 10% Wales	EA	13500000	1500000			
EA (FRM)	Further research to improve understanding of pressure/response links (costs over 4 years, in addition to already funded)	EA	800000				
EA other (and/or other regulators)	Piloting monitoring and analysis to reduce uncertainty over cost effectiveness of measures	EA	1000000				
EA other (and/or other regulators)	Further characterise the coast - further discrimination on nature of coast (morphology and ecology) to determine "types" that might be compared for objective setting purposes.	Coastal protection report	150000				
EA other (and/or other regulators)	Put in place new delivery mechanism for restoration measures	EA	200000				
EA (FRM)	Begin prioritised programme of work to tackle redundant flood defences (removing effectiveness likely to be more cost effective that complete removal)- can only tackle those identified, not all FRM strategies will be completed by 2015 - NB see also agricu	EA	18000000	2000000	Ongoing programme	18000000	2000000
	Total		138450000	14300000		122400000	12800000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		118790100	12269400		85435200	8934400
RBP1-3 England	273748500	EA					
RBP1-3 Wales	28474200	EA					
Inland navigation	Mitigate hard bank defences or replace with soft bank protection (rivers) (£145,000/km over 20km England and 2km Wales)	Navigation sector report	2900000	290000			
Inland navigation	Mitigate hard bank defences or replace with soft bank protection (canals) (£260k/km over 100km England and 10km Wales)	Navigation sector report	26000000	2600000			
Inland navigation	Modify dredging techniques or disposal options £5/cubic metre for 165,000 England, and 5000 Wales, per year for 6 year cycle)	Navigation sector report	5000000	125000	Ongoing costs	5000000	125000
Inland navigation	Ensure proposals for new development (waterways and new marinas) meet requirements of Article 4(7) of WFD. Assume % of total value of new development required which is £26m per year on waterways and £13m on marinas - £29m per annum total - £174m over 6 ye	British Waterways estimate	7830000	870000	Ongoing costs	7830000	870000
Inland navigation	Hydromorphological evaluation to assess need for protection (£400/km, over 2000km England, 20km Wales)	Navigation sector report	800000	8000			
	Remove bank protection and reprofile (£600k/km over 30km England, 2km	Navigation sector					

Marine navigation	Modify navigation management measures (£50k initial cost then £50k per year per site over 5 (England) and 1 (Wales) approach channels)	Navigation sector report	1750000	350000	Ongoing costs	1500000	300000
Marine navigation	Sediment management (beneficial use) £1/ cubic metre, for 900,000 England and 100,000 Wales, per year for 6 year cycle.	Navigation sector report	5400000	600000	Ongoing costs	5400000	600000
Marine navigation	Development of (£50k) or augment (£10k) dredging strategy	Navigation sector report	1400000	230000			
Marine navigation	Constraints on dredging or disposal, one-off site assesment of £800k per site, assumed 5 sites England 1 site Wales, then ongoing £2/ cubic metre, for 5.4m cumecs England and 0.8m cumecs Wales per year for 6 year cycle	Navigation sector report	68800000	10400000	Some ongoing costs	64800000	9600000
Marine navigation	Remove navigation related structures (£630k/structure, 6 England 1 Wales)	Navigation sector report	3780000	630000			
	Total		121630000	16710000		112200000	15000000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		104358540	14337180		78315600	10470000
RBP1-3 England	246403740	Marine navigation					
RBP1-3 Wales	33327180	Marine navigation					
Agriculture	Control inputs of silt through land management eg. Better farming practice and block gripping. Natural England estimate of £40m to address all the needs for block gripping in England. Halved to reflect that some already going ahead, and only a proportion of gripping will be for WFD purposes. Assume 10% appropriate cost for Wales.	Natural England and Defra	20000000	2000000			
Agriculture	Funding for implementing livestock fencing, buffer strips etc. £10k / km x 4500km x 2, assuming 90% England and 10% Wales.	EA	81000000	9000000			
Agriculture	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, may need 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group and Defra fisheries	247500000	27500000			
Agriculture	Funding for alternative use of land (via agri-environment, purchase etc) necessary as a result of removal of redundant flood defences. Potentially £15k / ha for land use purposely changed, assuming 20 ha per 1km flood defence rendered ineffective, 500km E	EA, amended after stakeholder comments on extent of coastal defences	162000000	18000000	Ongoing programme	162000000	18000000
	Total		510500000	56500000		162000000	18000000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		438009000	48477000		113076000	12564000
RBP1-3 England	643101000	Agriculture					
RBP1-3 Wales	71265000	Agriculture					
Local Authorities and IDBs	Manage assets differently / increased costs to capital investment, estimated at approx 7% of overall spend per year = £6m per annum, assume 90% England 10% Wales	EA	32400000	3600000	Ongoing costs	32400000	3600000
Local Authorities	Characterise the coastal defences -update and improve information on National Flood and Coastal Defence Database, add morphology descriptors, increase coverage, consistency between England and Wales	Coastal protection report	2000000				
Local Authorities	Assess the interactions between coastal defences and coastal morphology to determine likely consequences for ecology, and hence nature and extent of mitigation costs	Coastal protection report	175000				
Local Authorities and IDBs	Piloting and monitoring to improve understanding of possible measures and their effectiveness	Coastal protection report	300000				

	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		806110565	89331890.1		28897200	3210800
RBP1-3 England	858522965	Local authorities and IDBs					
RBP1-3 Wales	95155490.08	Local authorities and IDBs					
Industry	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, may need 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group	123750000	13750000			
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		106177500	11797500		0	0
Private individuals	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, may need 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group	86625000	9625000			
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		74324250	8258250		0	0
Water Industry	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, may need 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group	37125000	4125000			
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		31853250	3539250		0	0
Sector unknown	Restore in-stream features in half of at risk network, assume 90% England 10% Wales, £7/km, 9000km	EA	56700000	6300000			
Sector unknown	Make barriers passable - do all now for fish. Costed as £150k each, 240 in Wales, 2250 in England.	FAB group	337500000	36000000			
Sector unknown	Make barriers passable - do 30 per year for eels. Costed as £10k each, 25 in England 5 in Wales.	FAB group	1500000	30000	Ongoing process	1500000	30000
	Total		395700000	42330000		1500000	30000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		339510600	36319140		1047000	20940

Scenario 2 – Higher certainty, some phasing								
Sector	**Cycle 1**	**Source of cost est**	**Cost England**	**Cost Wales**	**Cycle 2**	**Cost England**	**Cost Wales**	**Cycle 3**
EA other (and/or other regulators)	Put in place and operate new delivery mechanism for no deterioration consenting (introduction of MIMAS or simlar tool, additional costs for consenting, low estimate, capital costs £0.4m, annual costs £1.6m).	EA	10000000		Ongoing process	9600000		Ongoing process
EA (FRM)	Change FRM appraisal and delivery to ensure it is WFD proofed (taken as 10% of ongoing expenditure, = £12m + £1.3m per year England and Wales)	EA	72000000	7800000	Ongoing costs	72000000	7800000	Ongoing costs
EA (FRM)	Manage flood risk management assets differently, including reducing maintenance where appropriate (assumed 3% of maintenance budget = £3.8m England and £0.5m Wales per year).	EA	22800000	3000000	Ongoing costs	22800000	3000000	Ongoing costs
EA (FRM)	Replace those assets which are still required with ones that meet WFD requirements (likely disproportionately costly in vast majority of cases), assume 90% England 10% Wales	EA				13500000	1500000	
EA (FRM)	Further research to improve understanding of pressure/response links (costs over 4 years, in addition to already funded)	EA	400000			400000		
EA other (and/or other regulators)	Piloting monitoring and analysis to reduce uncertainty over cost effectiveness of measures	EA	1000000					
EA other (and/or other regulators)	Further characterise the coast - further discrimination on nature of coast (morphology and ecology) to determine "types" that might be compared for objective setting purposes.	Coastal protection report	150000					
EA other (and/or other regulators)	Put in place new delivery mechanism for restoration measures	EA	200000					
EA (FRM)	Begin prioritised programme of work to tackle redundant flood defences (removing effectiveness likely to be more cost effective that complete removal)- can only tackle those identified, not all FRM strategies will be completed by 2015 - NB see also agricu	EA			Phased delivery	18000000	2000000	Phased delivery
	Total		106550000	10800000		136300000	14300000	
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		91419900	9266400		95137400	9981400	
RBP1-3 England	256080500							
RBP1-3 Wales	26518200							
Inland navigation	Hydromorphological evaluation to assess need for protection (£400/km, over 2000km England, 20km Wales)	Navigation sector report	800000	8000				
Inland navigation	Mitigate hard bank defences or replace with soft bank protection (rivers) (£145,000/km over 20km England and 2km Wales)	Navigation sector report			Phased delivery	1500000	150000	Phased delivery
Inland navigation	Mitigate hard bank defences or replace with soft bank protection (canals) (£260k/km over 100km England and 10km Wales)	Navigation sector report			Phased delivery	13000000	1300000	Phased delivery
Inland navigation	Modify dredging techniques or disposal options £5/cubic metre for 165,000 England, and 5000 Wales, per year for 6 year cycle)	Navigation sector report	5000000	125000	Ongoing costs	5000000	125000	Ongoing costs

Inland navigation	Ensure proposals for new development (waterways and new marinas) meet requirements of Article 4(7) of WFD. Assume % of total value of new development required which is £26m per year on waterways and £13m on marinas - £29m per annum total - £174m over 6 ye	British Waterways estimate	7830000	870000	Ongoing costs	7830000	870000	Ongoing costs
Inland navigation	Remove bank protection and reprofile (£600k/km over 20km England, 2km Wales)	Navigation sector report			Phased delivery	6000000	600000	Phased delivery
	Total		13630000	1003000		33330000	3045000	
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		11694540	860574		23264340	2125410	
RBP1-3 England	53890320							
RBP1-3 Wales	4715544							
Marine navigation	Ensure proposals for new development meet requirements of Article 4(7) of WFD. Assume 5% of total value of capital costs of port and navigation related projects in TraC waters , which are £150m per year = £7.5m per year. Assume 10% Wales, 90% England	Navigation sector report	40500000	4500000	Ongoing costs	40500000	4500000	Ongoing costs
Marine navigation	Modify navigation management measures (£50k initial cost then £50k per year per site over 5 (England) and 1 (Wales) approach channels)	Navigation sector report	1750000	350000	Ongoing costs	1500000	300000	Ongoing costs
Marine navigation	Sediment management (beneficial use) £1/ cubic metre, for 900,000 England and 100,000 Wales, per year for 6 year cycle.	Navigation sector report	5400000	600000	Ongoing costs	5400000	600000	Ongoing costs
Marine navigation	Development of (£50k) or augment (£10k) dredging strategy	Navigation sector report	1400000	230000				
Marine navigation	Constraints on dredging or disposal, one-off site assesment of £800k per site, assumed 5 sites England 1 site Wales, then ongoing £2/ cubic metre, for 5.4m cumecs England and 0.8m cumecs Wales per year for 6 year cycle	Navigation sector report	68800000	10400000	Some ongoing costs	64800000	9600000	Some ongoing costs
Marine navigation	Remove navigation related structures (£630k/structure, 6 England 1 Wales)	Navigation sector report	3780000	630000				
	Total		121630000	16710000		112200000	15000000	
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		104358540	14337180		78315600	10470000	
RBP1-3 England	246403740							
RBP1-3 Wales	33327180							
Agriculture	Control inputs of silt through land management eg. Better farming practice and block gripping. Natural England estimate of £40m to address all the needs for block gripping in England. Halved to reflect that some already going ahead, and only a proportion of gripping will be for WFD purposes. Assume 10% appropriate cost for Wales.	Natural England and Defra	7000000	700000	Phased delivery	7000000	700000	Phased delivery
Agriculture	Funding for implementing livestock fencing, buffer strips etc. £10k / km x 4500km x 2, assuming 90% England and 10% Wales.	EA	21000000	3000000	Phased delivery	30000000	3000000	Phased delivery
Agriculture	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, may need 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group report and Defra fisheries	82500000	9170000	Phased delivery	82500000	9170000	Phased delivery

Agriculture	Funding for alternative use of land (via agri-environment etc) necessary as a result of removal of redundant flood defences. Potentially £15k / ha for land use purposely changed, assuming 20 ha per 1km flood defence rendered ineffective, 500km EA flood de	EA, amended after stakeholder comments on extent of coastal defences			Phased delivery	162000000	18000000	Phased delivery
	Total		110500000	12870000		281500000	30870000	
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		94809000	11042460		196487000	21547260	
RBP1-3 England	450620000							
RBP1-3 Wales	50067080							
Local Authorities and IDBs	Manage assets differently / increased costs to capital investment, estimated at approx 7% of overall spend per year = £6m per annum, assume 90% England 10% Wales	EA	32400000	3600000	Ongoing costs	32400000	3600000	Ongoing costs
Local Authorities	National Flood and Coastal Defence Database, add morphology descriptors, increase coverage, consistency between England and	Coastal protection report	2000000					
Local Authorities	Assess the interactions between coastal defences and coastal morphology to determine likely consequences for ecology, and hence nature and extent of mitigation costs	Coastal protection report	175000					
Local Authorities and IDBs	Piloting and monitoring to improve understanding of possible measures and their effectiveness	Coastal protection report	300000					
Local Authorities and IDBs	Tackle redundant defences (with EA as above) Assumes 500km inland defences at average £20k per km =£10m. Assumes 90% England and 10% Wales.	EA			Ongoing programme	9000000	1000000	Ongoing programme
Local Authorities	Removal of coastal defences - assume £2200/m for revetment and £4400/m for sea wall, 10% of defences removed	Coastal protection report			Phased delivery	157212000	17468000	Phased delivery
Local Authorities	Modification of coastal defences - assume £1316/m reventment and £2614/m sea wall, 10% of defences modified	Coastal protection report			Phased delivery	93469241	10385471	Phased delivery
Local Authorities	Replenish coastal defences - Beach recharge, assume £2442/m, 20% of frontages	Coastal protection report			Phased delivery	197142660	21904740	Phased delivery
	Total		34875000	3600000		489223901	54358211	
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		29922750	3088800		341478282.9	37942031.3	
RBP1-3 England	649280208.7							
RBP1-3 Wales	71906295.13							
Industry	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, may need 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group report and Defra fisheries	41250000	4580000	Phased delivery	41250000	4580000	Phased delivery
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		35392500	3929640		28792500	3196840	

Private individuals	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, may need 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group report and Defra fisheries	28875000	9625000	Phased delivery	28875000	9625000	Phased delivery
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		24774750	8258250		20154750	6718250	
Water Industry	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, may need 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group report and Defra fisheries	12375000	1375000	Phased delivery	12375000	1375000	Phased delivery
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		10617750	1179750		8637750	959750	
Sector unknown	Restore in-stream features in half of at risk network, assume 90% England 10% Wales, £7/km, 9000km	EA	56700000	6300000				
Sector unknown	Make barriers passable for fish. Phased delivery split evenly over 3 cycles. Costed as £150k each, 240 in Wales, 2250 in England.	FAB group and Defra fisheries	112500000	12000000	Phased delivery	112500000	12000000	Phased delivery
Sector unknown	Make barriers passable - do 30 per year for eels. Costed as £10k each, 25 in England 5 in Wales.	FAB group and Defra fisheries	1500000	30000	Ongoing process	1500000	30000	Ongoing process
	Total		170700000	18330000		114000000	12030000	
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		146460600	15727140		79572000	8396940	

Scenario 3 – Lower certainty, no phasing							
Sector	**Cycle 1**	**Source of cost estimates**	**Cost England**	**Cost Wales**	**Cycle 2**	**Cost Englan**	**Cost Wales**
EA other (and/or other regulators)	Put in place and operate new delivery mechanism for no deterioration consenting (introduction of MIMAS or simlar tool, additional costs for consenting, low estimate, capital costs £0.4m, annual costs £1.6m).	EA	10000000		Ongoing process	9600000	
EA (FRM)	Change FRM appraisal and delivery to ensure it is WFD proofed (taken as 10% of ongoing expenditure, = £12m + £1.3m per year England and Wales)	EA	72000000	7800000	Ongoing costs	72000000	7800000
EA (FRM)	Manage flood risk management assets differently, including reducing maintenance where appropriate (assumed 3% of maintenance budget = £3.8m England and £0.5m Wales per year).	EA	22800000	3000000	Ongoing costs	22800000	3000000
EA (FRM)	Further research to improve understanding of pressure/response links (costs over 4 years, in addition to already funded)	EA	800000				
EA other (and/or other regulators)	Piloting monitoring and analysis to reduce uncertainty over cost effectiveness of measures	EA	500000				
EA other (and/or other regulators)	Put in place new delivery mechanism for restoration measures	EA	200000				
	Total		106300000	10800000		104400000	10800000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		91205400	9266400		72871200	7538400
RBP1-3 England	223375800						
RBP1-3 Wales	22939200						
Local Authorities and IDBs	Manage assets differently / increased costs to capital investment, estimated at approx 7% of overall spend per year = £6m per annum, assume 90% England 10% Wales	EA	32400000	3600000	Ongoing costs	32400000	3600000
Local Authorities and IDBs	Assess the interactions between coastal defences and coastal morphology to determine likely consequences for ecology, and hence nature and extent of mitigation costs	Coastal protection report	175000				
Local Authorities and IDBs	Piloting and monitoring to improve understanding of possible measures and their effectiveness	Coastal protection report	300000				
	Total		32875000	3600000		32400000	3600000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		28206750	3088800		22615200	2512800
RBP1-3 England	69225150						
RBP1-3 Wales	7646400						

Inland navigation	Modify dredging techniques or disposal options £5/cubic metre for 165,000 England, and 5000 Wales, per year for 6 year cycle)	Navigation sector report	5000000	125000	Ongoing costs	5000000	125000
Inland navigation	marinas) meet requirements of Article 4(7) of WFD. Assume % of total value of new development required which is £26m per year on waterways and £13m on marinas - £29m per annum total - £174m over 6 years	British Waterways estimate	7830000	870000	Ongoing costs	7830000	870000
Inland navigation	Hydromorphological evaluation to assess need for protection (£400/km, over 2000km England, 20km Wales)	Navigation sector report	800000	8000			
	Total		13630000	1003000		12830000	995000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		11694540	860574		8955340	694510
RBP1-3 England	27937320						
RBP1-3 Wales	2120244						
Marine navigation	Ensure proposals for new development meet requirements of Article 4(7) of WFD. Assume 5% of total value of capital costs of port and navigation related projects in TraC waters , which are £150m per year = £7.5m per year. Assume 10% Wales, 90% England	Navigation sector report	40500000	4500000	Ongoing costs	40500000	4500000
Marine navigation	Modify navigation management measures (£50k initial cost then £50k per year per site over 5 (England) and 1 (Wales) approach channels)	Navigation sector report	1750000	350000	Ongoing costs	1500000	300000
Marine navigation	Sediment management (beneficial use) £1/ cubic metre, for 900,000 England and 100,000 Wales, per year for 6 year cycle.	Navigation sector report	5400000	600000	Ongoing costs	5400000	600000
Marine navigation	Development of (£50k) or augment (£10k) dredging strategy	Navigation sector report	1400000	230000			
Marine navigation	Constraints on dredging or disposal, one-off site assesment of £800k per site, assumed 5 sites England 1 site Wales, then ongoing £2/ cubic metre, for 5.4m cumecs England and 0.8m cumecs Wales per year for 6 year cycle	Navigation sector report	68800000	10400000	Some ongoing costs	64800000	9600000
	Total		117850000	16080000		112200000	15000000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		101115300	13796640		78315600	10470000
RBP1-3 England	243160500						
RBP1-3 Wales	32786640						
Agriculture	Control inputs of silt through land management eg. Better farming practice and block gripping. Natural England estimate of £40m to address all the needs for block gripping in England. Halved to reflect that some already going ahead, and only a proportion of gripping will be for WFD purposes. Assume 10% appropriate cost for Wales.	Natural England and Defra	20000000	2000000			
Agriculture	Funding for more selective livestock fencing, buffer strips etc. £10k / km x 2250km x 2, assuming 90% England and 10% Wales.	EA	40500000	4500000			
Agriculture	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, may need 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group and Defra fisheries	82500000	9170000			
	Total		143000000	15670000		0	0
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		122694000	13444860		0	0
RBP1-3 England	122694000						
RBP1-3 Wales	13444860						

RBP1-3 England	122694000						
RBP1-3 Wales	13444860						
Industry	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, may need 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group and Defra fisheries	41250000	4580000			
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		35392500	3929640		0	0
Private individuals	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, may need 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group and Defra fisheries	28875000	3208000			
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		24774750	2752464		0	0
Water Industry	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, may need 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group and Defra fisheries	12375000	1375000			
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		10617750	1179750		0	0
Sector unknown	Make barriers passable - do half now for fish. Costed as £150k each, 120 in Wales, 1125 in England.	FAB and Defra fisheries	168750000	18000000			
Sector unknown	Make barriers passable - do 30 per year for eels. Costed as £10k each, 25 in England 5 in Wales.	FAB and Defra fisheries	1500000	30000	Ongoing process	1500000	30000
	Total		170250000	18030000		1500000	30000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		146074500	15469740		1047000	20940
RBP1-3 England	147973500						
RBP1-3 Wales	15507720						

Scenario 4 – Lower certainty, phased									
Sector	**Cycle 1**	**Source of cost**	**Cost England**	**Cost Wales**	**Cycle 2**	**Cost Englan**	**Cost Wales**	**Cycle 3**	**Cost Englan**
EA other (and/or other regulators)	Put in place and operate new delivery mechanism for no deterioration consenting (introduction of MIMAS or simlar tool, additional costs for consenting, low estimate, capital costs £0.4m, annual costs £1.6m).	EA	10000000		Ongoing process	9600000		Ongoing process	9600000
EA (FRM)	Change FRM appraisal and delivery to ensure it is WFD proofed (taken as 10% of ongoing expenditure, = £12m + £1.3m per year England and Wales)	EA	72000000	7800000	Ongoing costs	72000000	7800000	Ongoing costs	72000000
EA (FRM)	Manage flood risk management assets differently, including reducing maintenance where appropriate (assumed 3% of maintenance budget = £3.8m England and £0.5m Wales per year).	EA	22800000	3000000	Ongoing costs	22800000	3000000	Ongoing costs	22800000
EA (FRM)	Further research to improve understanding of pressure/response links (costs over 4 years, in addition to already funded)	EA	400000			400000			
EA other (and/or other regulators)	Piloting monitoring and analysis to reduce uncertainty over cost effectiveness of measures	EA	500000			500000			
EA other (and/or other regulators)	Further characterise the coast - further discrimination on nature of coast (morphology and ecology) to determine "types" that might be compared for objective setting purposes.	Coastal protection report	150000						
EA other (and/or other regulators)	Put in place new delivery mechanism for restoration measures	EA	200000						
EA (FRM)	Begin prioritised programme of work to tackle redundant flood defences (removing effectiveness likely to be more cost effective that complete removal)- can only tackle those identified, not all FRM strategies will be completed by 2015 - NB see also agriculture costs below. (Costs = £40k / km X 500m in first cycle). 90% England 10% Wales.	EA						Start programme after further investigations locate where its cost	18000000
			106050000	10800000		105300000	10800000		122400000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		90990900	9266400		73499400	7538400		69523200
RBP1-3 England	234013500								
RBP1-3 Wales	24075200								
Local Authorities and IDBs	Manage assets differently / increased costs to capital investment, estimated at approx 7% of overall spend per year = £6m per annum, assume 90% England 10% Wales	EA	32400000	3600000	Ongoing costs	32400000	3600000	Ongoing costs	32400000
Local Authorities	Assess the interactions between coastal defences and coastal morphology to determine likely consequences for ecology, and hence nature and extent of mitigation costs	Coastal protection report	175000						
Local Authorities and IDBs	Piloting and monitoring to improve understanding of possible measures and their effectiveness	protection report	300000						
Local Authorities and IDBs	Tackle redundant defences (with EA as above) Assumes 500km inland defences at average £20k per km =£10m. Assumes 90% England and 10% Wales.	EA						Start programme after further investigations locate where	9000000
			32875000	3600000		32400000	3600000		41400000

	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		28206750	3088800		22615200	2512800		23515200
RBP1-3 England	74337150								
RBP1-3 Wales	8214400								
Inland navigation	Modify dredging techniques or disposal options £5/cubic metre for 165,000 England, and 5000 Wales, per year for 6 year cycle)	Navigation sector report	5000000	125000	Ongoing costs	5000000	125000	Ongoing costs	5000000
Inland navigation	marinas) meet requirements of Article 4(7) of WFD. Assume % of total value of new development required which is £26m per year on waterways and £13m on marinas - £29m per annum total - £174m over 6 years	British Waterways estimate	7830000	870000	Ongoing costs	7830000	870000	Ongoing costs	7830000
Inland navigation	Hydromorphological evaluation to assess need for protection (£400/km, over 2000km England, 20km Wales)	Navigation sector report	800000	8000					
			13630000	1003000		12830000	995000		12830000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		11694540	860574		8955340	694510		7287440
RBP1-3 England	27937320								
RBP1-3 Wales	2120244								
Marine navigation	Ensure proposals for new development meet requirements of Article 4(7) of WFD. Assume 5% of total value of capital costs of port and navigation related projects in TraC waters , which are £150m per year = £7.5m per year. Assume 10% Wales, 90% England	Navigation sector report	40500000	4500000	Ongoing costs	40500000	4500000	Ongoing costs	40500000
Marine navigation	Modify navigation management measures (£50k initial cost then £50k per year per site over 5 (England) and 1 (Wales) approach channels)	Navigation sector report	1750000	350000	Ongoing costs	1500000	300000	Ongoing costs	1500000
Marine navigation	Sediment management (beneficial use) £1/ cubic metre, for 900,000 England and 100,000 Wales, per year for 6 year cycle.	Navigation sector report	5400000	600000	Ongoing costs	5400000	600000	Ongoing costs	5400000
Marine navigation	Development of (£50k) or augment (£10k) dredging strategy	Navigation sector report	1400000	230000					
Marine navigation	Constraints on dredging or disposal, one-off site assesment of £800k per site, assumed 5 sites England 1 site Wales, then ongoing £2/ cubic metre, for 5.4m cumecs England and 0.8m cumecs Wales per year for 6 year cycle	Navigation sector report	68800000	10400000	Some ongoing costs	64800000	9600000	Some ongoing costs	64800000
			117850000	16080000		112200000	15000000		112200000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		101115300	13796640		78315600	10470000		63729600
RBP1-3 England	243160500								
RBP1-3 Wales	32786640								

Agriculture	Control inputs of silt through land management eg. Better farming practice and block gripping. Natural England estimate of £40m to address all the needs for block gripping in England. Halved to reflect that some already going ahead, and only a proportion of gripping will be for WFD purposes. Assume 10% appropriate cost for Wales.	Natural England and Defra	7000000	700000	Phased delivery	7000000	700000	Phased delivery	6000000
Agriculture	Funding for implementing livestock fencing, buffer strips etc. £10k / km x 4500km x 2, phased delivery, assuming 90% England and 10% Wales.	EA	20500000	2500000	Phased delivery	10000000	1000000	Phased delivery	10000000
Agriculture	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, deliver one third of 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group report and Defra fisheries	27500000	3057000	Phased delivery	27500000	3057000	Phased delivery	27500000
Agriculture	Funding for alternative use of land (via agri-environment etc) necessary as a result of removal of redundant flood defences. Potentially £15k / ha for land use purposely changed, assuming 20 ha per 1km flood defence rendered ineffective, 500km EA flood defences and 100km IDB / LA defences is 15000x20x600. Assume 90% England 10% Wales.	after stakeholder comments on extent of coastal defences						programme after further investigations locate where its cost effective	162000000
			55000000	6257000		44500000	4757000		205500000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		47190000	5368506		31061000	3320386		116724000
RBP1-3 England	194975000								
RBP1-3 Wales	21558068								
Industry	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, deliver one third of 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group report and Defra fisheries	13750000	1530000	Phased delivery	13750000	1530000	Phased delivery	13750000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		11797500	1312740		9597500	1067940		7810000
Private individuals	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, deliver one third of 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group report and Defra fisheries	9625000	3208000	Phased delivery	9625000	3208000	Phased delivery	9625000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		8258250	2752464		6718250	2239184		5467000
Water Industry	Provide screens for fish by abstractions and other necessary sites. Assume £50k average cost, deliver one third of 11000 in total, assuming 90% England and 10% Wales. Assume 50% agriculture, 25% industry, 17.5% private, 7.5% water industry	FAB group report and Defra fisheries	4125000	458000	Phased delivery	4125000	458000	Phased delivery	4125000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		3539250	392964		2879250	319684		2343000
Sector unknown	Make barriers passable - do 30 per year for eels. Costed as £150k each, 120 in Wales, 1125 in England.	FAB group and Defra fisheries	56250000	6000000	Phased delivery	56250000	6000000	Phased delivery	56250000
Sector unknown	Make barriers passable - do 30 per year for eels. Costed as £10k each, 25 in England 5 in Wales.	FAB group and Defra fisheries	1500000	30000	Ongoing process	1500000	30000	Ongoing process	1500000
			57750000	6030000		57750000	6030000		57750000
	Present value (multiplied by 0.858 for cycle 1, 0.698 for cycle 2 andd 0.568 for cycle 3)		49549500	5173740		40309500	4208940		32802000
RBP1-3 England	122661000								
RBP1-3 Wales	12807720								