

SEVERN TIDAL POWER

Potential for Compensatory Measures

MAY 2010

Severn Tidal Power Report on Possible Compensatory Measures under Article 6(4) Habitats Directive

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Executive Summary

This report forms part of the environmental studies for the Severn Tidal Power Feasibility Study. It looks at possible compensatory measures under Article 6(4) of the Habitats Directive that might be applied if an STP option was to be developed. A preliminary report published as part of the Phase 1 STP Consultation provided an initial scoping of topic areas which have been further developed in the light of consultation responses.

A number of supporting reports have been developed to inform the assessment of compensatory measures, including a study on the potential for scaling up managed re-alignment to create inter-tidal habitat; a report on the implications of habitat creation options for migratory birds and reporting on possible measures for migratory fish. This report brings together findings from these and other studies and considers a possible toolkit of measures. The adverse effects identified in the Report to Inform an Appropriate Assessment are then compared against the compensation that the toolkit might provide. The consideration of compensatory measures does not pre-judge whether a scheme could meet the other requirements of the Habitats Directive.

This is a strategic study and does not consider compensation for all features of all the Natura 2000 sites that might be adversely affected. The scope is the Natura 2000 features of the Severn Estuary and the migratory fish using the Special Area of Conservation (SAC) rivers that flow into the Severn and Bristol Channel. The study is therefore partial and contains gaps that would need to be filled in as part of the development of a project. It does not cover compensation for changes to a Ramsar site feature that is not also a Natura 2000 feature.

All STP options would be the largest development permitted within a protected site in the UK. They would have unprecedented effects on estuary and inter-tidal habitats, migratory fish and migratory birds all of which are protected under EU statute. Compensation is likely to be required on a scale that is unprecedented. A twin track approach to investigating compensatory measures has been followed. This involved considering the extent to which measures within Commission guidance might be applied and investigating the feasibility of measures outside Commission guidance but within the spirit of the Directive. The Sustainable Development Commission (SDC) was asked to lead an investigation of the possibility of developing measures outside Commission guidance that would be of equal value to the coherence of the Natura 2000 network.

The report is presented in two parts. The first part was developed in parallel with the SEA studies and ahead of the final reporting of the effects of the STP. It describes the findings of the supporting studies and identifies a possible toolkit of measures within Commission guidance. Where possible the potential upper limits for measures are identified. The second part brings together the findings of the Appropriate Assessment and maps them onto the toolkit of measures. It also considers the potential need for measures outside Commission guidance.

There are 14 measures that are either included or conditionally included within the toolkit of measures within Commission guidance. Conditionally included measures are those that might not be developable for 2020 but may have potential, and those

that require further investigation of their workability in terms of effectiveness or effects on other policy. Most of the 14 measures are conditionally included. This reflects the unprecedented challenge of an STP which would require a package of measures of extraordinary scale and complexity. The requirement for inter-tidal habitat compensation for example, could be between 6 and 60 times greater than any previous project.

Few of the compensatory measures looked at are established and none have been used at the scale that a STP would require. As a result there are many gaps and uncertainties in their reporting. Further investigation and study would reduce the associated risk. Assessment of possible compensation measures depends on the accuracy and robustness of all the preceding assessment processes with the potential for uncertainties to become magnified. The findings should therefore be treated as indicative and would require further development in the light of more detailed understanding.

The hyper-tidal range of the estuary gives rise to dynamic conditions that support an extreme and unusual ecology. A loss in the extent of hyper-tidal estuary could not be compensated for on a like for like basis. Compensation would depend on adopting a novel approach to defining coherence.

Managed re-alignment to create inter-tidal habitat is the most established compensation measure considered. This might provide compensation for loss of SAC habitats and partial compensation for loss of supporting habitat for birds. Our studies have been positive in indicating that it may be possible to create very large areas of inter-tidal habitat through managed re-alignment, although this would be challenging and would not be fully 'like for like' compensation for any option. This is potentially least challenging for Bridgwater Bay Lagoon which has the least loss of inter-tidal habitat.

Compensatory measures would be likely to involve unprecedented interventions in terms of the area of land and river affected and the scale of engineering and other works undertaken. There could be significant environmental, social and economic costs associated with compensation on this scale. There would also be the potential for benefits. Communities affected by or benefiting from these measures would be largely outside the area of the Severn. The acceptability of such an approach with stakeholders and the wider public would need to be tested.

Inter-tidal habitats are designated features of the SAC and are supporting habitats for the bird populations that are the reason for the designation of the Severn Estuary as a Special Protection Area (SPA). An STP scheme reduces the extent of inter-tidal habitats (saltmarsh and mudflat and sandflat). The options also reduce the potential for habitat creation through managed re-alignment adjoining the Severn Estuary. This ranges between virtually none in the case of a Cardiff-Weston scheme to a couple of thousand hectares for the other options. The potential for habitat creation within the Severn is principally for saltmarsh. This has major implications for compensation, since the loss of inter-tidal mudflat is many times greater than the loss of saltmarsh and is an important habitat for birds.

The options could result in the loss of between 7 and 13 migratory fish populations that are SAC features and there is the potential for UK extinction of twaite shad. Compensation for the loss of entire SAC fish populations has never been attempted before. Most of the compensation measures that have been identified are thought to be unfeasible for a 2020 scheme but may be feasible for a later project. Only two compensation measures for migratory fish might be achievable by 2020 subject to further study. It is reported that the fish compensation measures are unlikely to completely offset all negative effects. Fish compensation is likely to require measures outside Commission guidance for any option.

The inter-relationship between Habitats Directive and Water Framework Directive legislation would require further consideration. Compensatory measures for fish might duplicate actions already required by environmental legislation. The scale of measures that are additional to existing requirements and could practically delivered would need to be determined.

The loss of mudflat is a key issue for birds particularly dunlin and redshank which specialise in feeding on mudflat. It would not be possible to compensate within the area of the Severn Estuary for these birds for all options. This finding is sensitive to assumptions about the amount of topographic modification that might be possible, and to the assessment of bird impacts. If the amount of topographic modification could be substantially increased and/or additional development of bird modelling was able to demonstrate a lower impact than our findings, then it might become feasible.

Switching to a strategy involving compensation for birds at distance to the Severn Estuary could require revisiting the Report to Inform an Appropriate Assessment as the risk of negative effects on flyway sites might not be discounted. Consideration of what level of displacement of a population of birds from the Severn might give rise to a *significant* effect on another site within the flyway might be used to set a threshold that was able to discount significant effect for some species.

Habitat creation for birds at distance to the Severn might have benefits for climate change adaptation. However developing compensation against a possible future baseline would be outside guidance and involve greater risk. Developing compensation as a contribution to a climate change adaptation strategy for waterbirds might have environmental benefits. However it would need to be backed with fundamental studies and modelling of bird flyway populations. Even if successful there would be a risk of interim declines in species such as dunlin and redshank which are very site faithful. The significance of these effects on a flyway population and the risk that they might be permanent rather than temporary and reversible would also need to be assessed.

The potential to develop novel approaches to compensation outside Commission guidance has been investigated by the Sustainable Development Commission. They have identified a number of principles and tests backed by technical studies and believe that it could be feasible to develop a new methodology for compensation outside EU guidance but compliant with the Directives themselves.

It is reasonably clear that compensation would require novel approaches that are outside current practice and Commission guidance for all schemes. In the case of a

B3 Cardiff-Weston scheme, unconventional and riskier measures would be needed for inter-tidal habitats, migratory fish and migratory birds.

The overall contribution to the coherence of the Natura 2000 network would comprise a modified Severn Estuary SAC and SPA (which would still be internationally designated) together with the range of measures adopted as compensation whether within or outside Commission guidance. This is a novel and unprecedented situation.

Alternative ways of considering equivalence and a new way of defining the overall coherence of the network would be required. Different approaches to coherence might be justifiable in the context of the potential changes to Natura 2000 features that might arise from climate change. Alternative approaches possibly based on the SDC's study findings might be developed. In conclusion it is not impossible that compensation might be achievable for an STP but this would require unprecedented measures including some measures which rely on an interpretation of the requirements of the directive that varies from the Commission's interpretation in its guidance.

Introduction to the Two Part Report

This report forms part of the environmental studies for the Severn Tidal Power Feasibility Study. A preliminary review of possible mitigation and compensation requirements under the Habitats Directive (1) was published in January 2009 as part of the STP Phase 1 consultation. That report considered the requirements of the Habitats Directive, the likely effectiveness of mitigation and compensation measures and their possible cost. It also recommended areas for further investigation including the viability of large scale habitat creation, the potential for new notifications and measures for migratory fish.

Within the second phase of the STP study, mitigation measures have been considered within the Strategic Environmental Assessment (SEA) and the Options Definition Report. This reflects established practice that mitigation measures can be included within the SEA and environmental effects described after the application of mitigation as in effect the residual or outstanding effect of the scheme. Further investigation of possible compensatory measures was taken forward in parallel with the SEA and the Report to Inform an Appropriate Assessment (2). The scope of these studies was strategic and concentrated on issues that had been identified as possible barriers to compensation for an STP. This reflects concerns received in the response to the phase 1 consultation that it might not be possible to compensate for the scale and range of adverse effects of an STP scheme. Compensation for a Severn Tidal Power scheme would be very challenging and require measures that were of unprecedented scale and type.

The purpose of the compensatory measures studies is to inform consideration of the feasibility of providing compensatory measures as required by the Habitats Directive in the eventuality that there was a strategic case to progress with a scheme and that the other requirements within Article 6(4) of the Habitats Directive (alternatives and Imperative Reasons of Overriding Public Importance) could be met. Compensation under the Habitats Directive would only apply if the other tests had been met.

The Habitats Directive does not go into detail about how compensation should be achieved but sets out the general requirement that measures must be taken to protect the overall coherence of the network of Natura 2000 sites. To assist Member States, the European Commission has issued two guidance documents, most recently in 2007 (3). Approaches which are not covered by the guidance and would still be compliant with the Directive are thought to be possible. It was recognised by the STP Project Board that compensation of all adverse effects on integrity of a Natura 2000 site for an STP might not be possible within the Commission guidance. Hence a twin track approach to investigating compensatory measures was agreed. This involved considering the extent to which measures within Commission guidance might be applied and investigating the feasibility of measures outside Commission guidance.

The structure of this report reflects the twin track approach. Part 1 considers measures that might contribute to compensation for an STP and are thought to be

within Commission guidance. This is referred to in part 1 as the ‘toolkit’ of measures within Commission guidance. Part 1 also describes the supporting studies that were commissioned to provide evidence on issues that were identified as priorities for more detailed investigation. These include a study on managed re-alignment and a report on the implications of mitigation and compensation options for SPA bird populations.

Part 2 notes the findings on possible measures outside Commission guidance, considers selected results from the Report to Inform an Appropriate Assessment and the extent to which measures might address the requirement for compensation.

The division of the report into two parts also reflects the point that the quantitative effect of a scheme can only be defined at the conclusion of the assessment of impacts and the assessment of the effects of mitigation. Compensation is the most downstream element of the assessment process. Part 1 of the study was developed in parallel with the mitigation and assessment studies and for that reason is concerned with identifying possible measures and their potential limitations, rather than applying them to options.

The approach taken within this strategic study is not comprehensive and could not consider all possible compensation for all features and sub-features that might be affected. Not least, because the range of possible effects requiring compensation could not be known with certainty at the outset of the study, particularly those that are indirect or acting at distance to the Severn. It was also anticipated that the strategic assessment would be uncertain or not quantifiable for some adverse effects.

The study focused on features where it was most likely that measures within Commission guidance would be insufficient to meet the possible compensation requirement. Particular attention was given to inter-tidal habitat losses, effects on migratory birds and migratory fish. The findings are therefore indicative of possible approaches to compensating for some of the most significant effects. Additional work would be needed to develop a scheme.

Areas that are not covered or fully covered in this report would require investigation as part of the development of a scheme are listed below:

- Sub-features of Natura 2000 features. eg Areas of eelgrass are a sub-feature of the Estuary feature of the Severn Estuary SAC.
- Freshwater features within the SAC Rivers joining the Severn Estuary that might be indirectly affected. eg otter could be affected by the decline or loss of migratory fish such as salmon
- Possible effects on certain Natura 2000 sites at distance to the Severn Estuary due to possible changes in water levels.
- Possible effects on other sites used by SPA migratory bird populations visiting the Severn Estuary. (Flyway sites.)
- Ramsar site features that are not features of Natura 2000 sites.

While it is considered appropriate within this strategic study not to cover all of these a more detailed assessment covering all of the above would be required for a scheme to be developed.

The Severn Estuary is also classified as a Ramsar site (under the Ramsar Convention). Planning policy states that listed Ramsar sites should receive the same protection as designated SPAs and SACs. The Ramsar features have been considered within the Report to Inform an Appropriate Assessment so that they benefit from a similar type of assessment as the Natura 2000 sites. However, those Ramsar features that are not also selected as Natura 2000 features would not be included within compensatory measures under Article 6(4) of the Habitats Directive which is the focus of this report. Possible offsetting measures for Ramsar features are covered in the Strategic Environmental Assessment.

Uncertainty in assessing the size of some adverse effects also means that reporting is qualitative rather than quantitative for some Severn Estuary features including the SPA assemblage of overwintering birds.

PART 1 Potential for measures within Commission guidance

1 Background

This part of the report considers measures that might be possible as part of a ‘toolkit’ of measures within Commission guidance. It also describes the supporting studies and reports that were commissioned to provide evidence on those issues that were looked at in more detail. The studies described in this part of the report were scoped and undertaken in parallel with the SEA environmental report and the Report to Inform an Appropriate Assessment. This section of the reporting had to take account of high levels of uncertainty about the possible effects of the five STP options being studied and of the extent of mitigation that might be achievable. Additional factors affecting uncertainty include the number of Natura 2000 sites that might require compensation because of indirect effects or effects at distance.

The approach was to consider the total range of possible impacts arising from the five STP options and the feasibility of compensating for different possible amounts of compensation need. A key objective was to find out whether there was an upper limit for measures within Commission guidance for any of the features considered. This is a significant point because developing measures outside Commission guidance would be unprecedented. It would involve novel environmental and delivery risks the acceptability of which would need to be further considered.

With a few exceptions, this approach is ‘option neutral’ and the findings might be applied to other schemes – for examples those investigated under the Severn Embryonic Technologies Scheme.

The main output of part 1 is a partial toolkit of compensatory measures which are considered to be within Commission guidance and which might be applied to compensate for the effect of an STP option. As noted in the introduction the study could not consider all possible compensation measures for all features of all sites that might be adversely affected. This would require further iteration in the light of the final conclusions from the SEA and Report to Inform an Appropriate Assessment.

Many of the compensatory measures considered would be novel either as types of measure or in the scale at which they might be applied and would require further development to show how they would be delivered. This study has had to balance looking in greater detail at some key measures with looking across a wider range of possible approaches. Three areas have been looked at in greater detail: inter-tidal habitat creation; migratory birds and migratory fish. Inter-tidal habitat was seen as a key issue because it is important as a SAC habitat in its own right and is a supporting habitat for the SPA bird populations.

2 Compensation principles

2.1 Mitigation and compensation hierarchy

A hierarchical approach to managing adverse environmental effect is well established within Sustainable Development principles and within nature conservation practice. Expressions of this principle vary but the general intent is to

place emphasis on avoiding or reducing a negative effect before moving to compensate for any residual effects. For example Planning Policy Statement 9 in England (4) sets out a requirement to work through alternatives to avoid or reduce harm, apply mitigation where this is not possible, and seek appropriate compensation where harm cannot be prevented or adequately mitigated. The same approach is adopted in the Welsh Assembly Government's Technical Advice Note 5 (TAN5) on Nature Conservation and Planning.

2.2 Adverse effect on integrity

Compensatory measures are required to protect the coherence of the Natura 2000 network (Article 6(4) Habitats Directive) if a plan or project is adopted that has an adverse effect on the integrity of a Natura 2000 site and a plan or project must be carried out for imperative reasons of overriding public interest and there are no alternative solutions. Adverse effect on integrity is assessed in relation to the conservation objectives that have been identified for the site (Article 6(3) Habitats Directive) through an Appropriate Assessment. The conservation objectives therefore help define the adverse effect on integrity.

Mitigation measures (referred to as prevent and reduce measures in the SEA) may be taken into account in an Appropriate Assessment, in which case the adverse effect on integrity would be the outstanding effect after the application of the mitigation measures. The Habitats Directive does not define how compensatory measures should address the adverse effects, however Commission guidance (3) sets out priorities and principles. The Directive sets out the requirement to protect coherence and therefore presumes that the original network was coherent. Commission guidance states that measures should:

- a) address in comparable proportions the habitats and species negatively affected
- b) provide functions comparable to those which had justified the selection of the original site, particularly regarding the adequate geographical distribution of the features concerned.

This is often referred to as 'like for like' compensation.

Commission guidance also sets out priorities for the location of compensatory measures which are in order:

- 1) Compensation within the Natura 2000 site.
- 2) Compensation outside the Natura 2000 site concerned but within a common topographical or landscape unit provided the same contribution to the ecological structure and/or network function is feasible.
- 3) Compensation outside the Natura 2000 site in a different topographical or landscape unit.

Topographical and landscape unit is not precisely defined. In the UK the established practice has been to locate compensation within the same geographical area or ecological system (following priorities 1 and 2 above). This reduces the risk that the measures will fail to protect coherence, as they are acting within the same part of the geographical distribution of the habitat or species. It is relatively straightforward

with this approach to show that proposed measures will make an equivalent contribution to the coherence of Natura 2000. The third option of compensation in a different area (topographic or landscape unit in the words of the Commission guidance) has not been widely applied in the UK.

2.3 Additionality

Commission guidance also states that measures must be additional in relation to the Natura 2000 network to which the Member State should have contributed in conformity with the Directives. The Commission guidance also says that measures should be additional to those already required by other European legislation. The question of additionality requires particular attention for possible measures for migratory fish. This is considered further later in this report.

2.4 Timing of measures

Commission guidance states that timing of measures demands a case by case approach. The guidance states that the site must not be irreversibly damaged before compensation is in place and that time lags might be admissible only in certain circumstances in which case 'overcompensation' would be required for interim losses. The guidance does not preclude time lags but states that these must avoid compromising the objective of no net loss of coherence and should be avoided if they would lead to population losses for any species protected in the site under Annex II of Directive 92/43/EEC or Annex I of Directive 79/409/EEC.

2.5 Effectiveness of measures

Commission guidance states that Measures with no reasonable guarantee of success should not be considered under Article 6 (section 1.5.2 of Article 6(4) Guidance (3)). Measures that are novel or untested at the scale required by an STP will be relatively less well evidenced in terms of their effectiveness. Assessment of their effectiveness would depend much more on expert judgement. A strict application of this principle might preclude some measures that have been identified within this report. They have been retained but with a caveat that development would be needed to establish their effectiveness and reduce their uncertainty.

2.6 Role of the competent authority, agencies etc

Under the Habitats Regulations (which give effect to the Directive in UK law) the term competent authority is used to indicate the decision making or consenting body. The competent authority is responsible for the Appropriate Assessment under Regulation 61. Within Wales, nature conservation is a matter devolved to the Welsh Assembly Government. If notwithstanding an adverse effect on integrity, a plan or project is agreed to, it falls to the Secretary of State or the Welsh Ministers where appropriate, to secure any necessary compensatory measures to protect the coherence of Natura 2000.

Defra provides UK representation to the Commission for the implementation of the Habitats Directive. In the few cases where compensatory measures are required, Defra channels details of these to the Commission. In those cases of compensation

arising from a decision within the devolved administrations it might be expected that these would also involve Defra.

The competent authority must consult with the appropriate conservation body in relation to the Appropriate Assessment, and have regard to any representations made. Where a competent authority proposes to proceed with a plan or project requiring compensatory measures the statutory conservation agencies have provided advice on the formulation of and effectiveness of the proposed compensatory measures. The agencies have specialist ecological expertise and experience of Habitats Directive casework which helps the competent authority consider what would constitute adequate compensation. Definition of compensatory measures is often a three way dialogue involving developer, competent authority and statutory agencies. Following agency advice gives the competent authority reassurance that the compensation they propose should be effective and therefore reduce the risk of non-compliance.

3 Study approach

3.1 Supporting work

Detailed supporting studies and reports were developed based on phase 1 study recommendations, advice from the STP Environmental Workstream (which comprised experts from the statutory agencies and Government Departments) and emerging findings from the SEA study, particularly the Hydraulics and Geomorphology modelling. A DECC chaired Habitats Regulations Assessment and compensatory measures expert group was established within the Environmental Workstream to steer and advise. This involves representatives from the statutory agencies including the Joint Nature Conservation Committee, WAG and Defra.

Studies and papers that have been produced to inform this work are listed in the table 1.

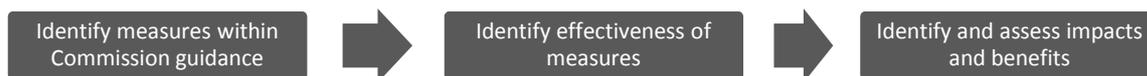
Table 1 Compensatory Measures Reports and papers

Subject	Produced by	Purpose
Managed re-alignment study – outside Severn Estuary.	PB/BV/ABPmer	Generates information on the feasibility of scaling up managed re-alignment, including costs, impacts and possible benefits to create inter-tidal habitat outside the Severn Estuary.
Managed re-alignment study – Severn Estuary (presented as annex to the above report)	PB/BV/ABPmer	Uses modelling from STP options to quantify potential for creating inter-tidal habitat adjoining the Severn Estuary.
Fish – Migratory and estuarine fish, measures to offset STP plan alternative effects. Published as Annex 3 of the SEA Fish Topic Paper	PB/BV/APEM	Review and assessment of effectiveness of compensatory measures for migratory fish. (Note includes Habitats Directive as part of more general consideration of SEA offsetting.)
Birds – Strategic review of issues surrounding potential for mitigation and compensation of SPA waterbirds.	PB/BV/BTO	To identify a series of ‘species guilds’ with similar ecological requirements. To identify the scope for mitigation / compensation provision for waterbirds in the same or different ecological functional units (i.e. within or close to the Severn or at distance) To identify the likely responses of species to the provision of new habitat ‘in unit’ and ‘out of unit’. To identify the barriers to successful provision of compensatory habitat.
New site designation as a compensatory measure under Article 6 of Habitats Directive	Led by JNCC for the HRA group; produced as an expert technical contribution to the STP Study.	Considers the potential for designation of existing habitats as a compensation measure.
Severn Tidal Power Feasibility Study Working Paper: Compensatory Measures – Application of Compensation Ratios under Article 6 (4).	Produced for the HRA group as an expert technical contribution to the STP Study.	Reviews compensation ratios

3.2 Identifying measures within Commission guidance

Measures that are considered for inclusion within the toolkit are drawn from the recommendations in the STP phase 1 study and the supporting studies for this report. Measures are included that are considered to be within Commission guidance and are thought to be effective or might have the potential to become effective compensation. **This is an inclusive approach which retains some measures that might subsequently be found to be ineffective or implausible for adoption.** This approach was taken so as not to exclude measures that might not be possible now but which if developed might provide assistance in compensating an STP.

A sequential approach might be applied to test compensatory measures and meet the principles of the Commission guidance and be capable of being adopted.



The criteria used to identify measures for inclusion within the toolkit reflect these three steps.

Some compensatory measures may result in significant land use change depending on the scale at which they are applied and in additional regulation for owners of the areas where they might be applied. The possibility of significant environmental, economic and social effects accounts for two of the criteria used in the selection of compensatory measures. These criteria are included to highlight these effects not as a filter to exclude them at this stage.

Compensation would be a significant programme or project in its own right. The impacts would need to be assessed and a judgement made on their acceptability within the overall context of an STP. These effects would be substantial and unprecedented for a compensation scheme. A high level consideration of the possible impacts and benefits of applying large scale managed re-alignment have been included in that study. This gives an indication of the possible scale and complexity that committing to compensation on this scale would involve which are extremely challenging.

3.3 Delivery

To be effective as compensation a measure that is theoretically feasible must also be capable of being effectively delivered. Compensation could involve substantial civil engineering and other projects with many complex delivery and supply chain issues that would need to be investigated. This study has generally looked at the practical delivery issues at a high level. The report on managed re-alignment looks at delivery in most detail based on interpretation of case studies. For other measures such as migratory fish an expert judgement has been applied saying whether the measure is deliverable by 2020. This assessment is generally conditional upon further investigation. Hence this strategic study is not a detailed investigation of the 'deliverability' of measures but a sample of the scale of difficulty that could apply.

4 Scope

The introduction to this report notes that this study is strategic and does not cover all features that might be affected by an STP. It can only give an indication of the feasibility of compensation for those features for which compensatory measures have been considered. **Any conclusions based on this study about the feasibility of compensating for an STP is therefore limited to those features.**

4.1 Far field effects

The study has looked at measures for the Natura 2000 features of the Severn Estuary and the migratory fish features of the River Wye/Afon Gwyi, River Usk/Afon Wysg and River Tywi/Afon Tywi.

For two options, the SEA has identified the potential for changes in water levels to occur at distance to the Severn Estuary. These ‘far field’ effects could result in adverse effects on sites that are dependent upon sea water levels. This study has not looked at the requirement and potential for providing compensation for these sites or at the requirements for habitats and species occurring there but not found within the Severn.

The risk of far field effect on SPA bird sites requires particular attention. The screening for the Report to inform an Appropriate Assessment has identified the risk of adverse effect on integrity within 97 SPA within the UK. The potential for adverse effect outside the UK has also been noted, although not related to sites. A strategy for bird compensation would need to minimise the risk of adverse effect to distant bird sites.

4.2 Geographical scope

This report assumes that measures would be applied within the UK and has not considered the potential for applying measures elsewhere within Europe. Some of the supporting studies refer to this theoretical possibility as did the Sustainable Development Commission in their work referred to in Part 2 of this report. The possibility of a State meeting its obligations under the Habitats Directive within another Member State would raise complex issues which were outside our scope.

Measures such as managed re-alignment have been treated as two compensation options depending on whether they are applied close to the Severn or at distance.

4.3 Features and sub-features

As noted in the introduction this report looks at compensation at the feature level as being most appropriate for a strategic level study. This reflects the overall design and work plan for the environmental study which notes that: *The assessment, being strategic in nature, will be at the level of resolution that is achievable within the limitations of the techniques, resources and time available for the SEA, HRA and underpinning technical studies.*

The purpose of the sub-features is explained in the JNCC publication on common standards monitoring:

The marine features are very broadly defined habitats that are often represented by large sites. To describe, monitor and manage such features effectively, it has often been necessary to divide the features into smaller units called sub-features. Sub-features are distinctive biological communities (e.g. eelgrass beds, common mussel beds, cockle beds), or particular structural or geographical elements of the feature (see Figure 1). It has often proved helpful, both in the development of conservation objectives and of monitoring programmes, to separate the feature into a number of constituent sub-features, and then to identify attributes and targets for the sub-features. The use of sub-features permits a level of flexibility in the application of the UK's Common Standards Monitoring which has been found necessary when applying the standards at the site level. (5)

The sub-features reflect the factors which led to the selection of the feature within the Natura 2000 series although the term sub-feature does not appear in that process. The sub-features are covered by the conservation objectives for a site.

Sub-features have not been covered and an appropriate compensation approach would need to be developed as part of more detailed studies.

Some features are listed in the designation of a SAC as primary reasons for selection, whereas other features may be included as nationally significant features that are not the primary reason for selection. Features that are not primary reasons for selection of the Severn Estuary are sandbanks slightly covered by seawater and Sabellaria reef. For the River Wye/Afon Gwyi SAC and River Usk/Afon Wysg SAC, Allis shad is not a primary reason for selection. All features contribute to the classification of the Natura 2000 site and to the coherence of the Natura 2000 network and would require compensation. While this does not affect their importance it might allow for greater flexibility in providing alternative representatives within the coherent network of Natura 2000 sites. **However this is likely to require selection of new SACs as all suitable examples within the sites that are notified would be expected to be already identified as part of the SAC designation process.**

5 Compensatory Measures Toolkit

This section identifies measures that could form part of a compensation toolkit for an STP option and that are thought to be within Commission guidance. This is organised by the SAC and SPA features considered in this study. Each section clarifies the scope of the features covered, the possible range of compensation need and then describes the measures within the toolkit. Key findings and uncertainties are then discussed.

The range of possible compensation need studied comes from a judgement based on the earlier STP study findings. For inter-tidal habitat creation, the range of possible compensation need takes account of compensation ratios that might be applied. Compensation ratios are discussed later in this report.

Criteria and selection of measures.

Potential measures were judged against the criteria in table 2 which were developed for this study.

Table 2 Criteria for evaluating measures

Criterion	Definition
Objective for measure	The adverse effect which the measure is intended to partially or entirely offset. The objective against which the effectiveness of measure is addressed. Note that protection of overall coherence is not specifically tested here
1 Effectiveness of measure	Assessment whether the measure is likely to be effective in addressing the effect. This is not a judgement on the ability of a measure to fully offset the effects of an STP.

Criterion	Definition
2 Established practice	Whether this measure has previously been applied as Habitats Directive compensation. Established practice involves lower risk and is more likely to meet legal, policy and consenting requirements.
3 Established method	Extent to which a measure relies on established technologies or techniques or requires innovation when applied to the feature under consideration.
4 Delivery by 2020 is judged feasible.	Judgement on whether a measure could reasonably be developed (where additional research and investigation is needed) and/or delivered for a scheme by 2020.
5 Significant adverse effect on another environmental feature	Extent to which a measure has significant negative environmental effects.
6 Significant adverse effect on society and economy	Extent to which a measure has significant adverse effect on society or economy.
7 Sustainability	Extent to which a measure is self-sustaining or requires ongoing intervention for it to continue acting.
8 Located within ecological functional unit	Those measures that are located adjoining or close to and actually or potentially ecologically linked to the affected site. This is a measure of the extent to which measures are within the same 'topographical or landscape unit' in Commission guidance terms.
9 Ecological function matched	The extent to which the measure directly replicates the ecological functions that have been lost. An assessment of how 'like for like' the measure is.
GREEN	Measure clearly meets criterion
AMBER	Measure partially meets criterion; and/or is capable of meeting the criterion in some circumstances.
RED	Measure clearly fails to meet criterion or is unknown effect.

Possible measures are evaluated against these criteria and shown as red or green depending on whether they clearly meet or clearly fail each criterion. Measures are recorded as amber if they partially meet the criterion or might meet the criterion only in some circumstances. For example, a measure might be considered to be partially effective in addressing an impact, or capable of being effective at certain levels of application, in which case it was recorded as amber against the criterion 3

(effectiveness). The measures for migratory fish follow the assessment in Annex 3 of the fish topic paper.

The scoring against the criteria is judgement based and relies on expert opinion. Assessment against some criteria will be less precise as it may depend upon several linked assumptions about different areas that are unknown or uncertain. For example, when anticipating whether measures that are novel and have not previously been used as compensation might be developed in time for a 2020 project (criterion 4). The scoring against the criteria should therefore be seen as indicative and of use in informing a decision on including or excluding a measure.

A significant environmental, social or economic effect (criteria 5 and 6) is an informal judgement unlike the application of significance in the SEA process. The judgement on significance is made to highlight possible negative effects at a scale that is appropriate to the strategic scale of an STP. An overall judgement was made to include (green) or conditionally include (amber) a measure in the toolkit. This was a judgement based on criteria 1, 2, 8 and 9. Measures are generally not screened out on the grounds of significant environmental, social or economic effects or overall sustainability. The impacts of possible compensation would need to be assessed as part of the further development and consenting of compensatory measures.

Measures that have been excluded at this stage from the toolkit (red) may have been excluded because they are within Commission guidance but are not thought to be sufficiently effective. One measure has also been excluded at this stage because although it may be effective (or partially effective) it is arguably not within Commission guidance. This measure (compensation for birds at distance from the Severn) is further considered in the reporting of measures outside Commission guidance.

The last two criteria on the location of measures and the matching of ecological function are seen as more or less limiting for the selection of measures within Commission guidance. These the guidance that measures should preferably be within the same topographical or landscape unit and should reflect the conservation objectives of the sites that have been negatively affected. This is applied more restrictively for SPAs than for SACs reflecting differences in the Commission guidance. This states that locating measures within the same landscape or topographical unit is preferred; however for SPAs measures should not be far away from the site affected.

Most of the measures that are included in the toolkit have been scored as amber – conditionally included – rather than green. This reflects the large number of measures that would be novel and untested as Habitats Directive compensation on the scale that is likely to be required. Reasons why a measure can only be conditionally included are:

- It is not clear at this stage whether they would be fully within Commission guidance.
- Their effect on social, environmental and economic objectives and policies might be unacceptable.

- They may require significant additional study or investigation before they could be quantitatively applied.
- They may have potential to provide compensation but are novel and would require development to establish if they really could be fully developed.

Conditionally included measures would require further investigation to determine whether they could be applied as compensation. Some conditionally included measures may be identified as technically feasible at this stage but could be found to be unrealistic or too risky when investigated further

The analysis and list of measures is shown in Annex A.

5.1 Estuary

This covers the Severn Estuary/ Môr Hafren SAC Interest Feature 1, the estuary feature. The JNCC Natura 2000 Standard Data Form which summarises the importance of the SAC refers to the Severn as 'one of the best areas in the United Kingdom'. The form goes on to note that the conservation of the features depends upon the tidal regime and that the tidal range is the second highest in the world. The Severn contributes about 30% by area of the UK SAC estuary resource.

Change in the extent of the estuary feature is relatively small in comparison with the change in the characteristic ecology of the feature. This would result in failure to meet most of the conservation objectives for the estuary feature within an impoundment. The extreme tidal range is referred to explicitly in the Natura 2000 Data Form and is used here to stand for the uniqueness of the Severn Estuary.

There are no areas with comparable tidal range within the UK or elsewhere within the NE Atlantic biogeographic region that could be designated or in which hyper-tidal estuary could be re-created. A loss in the extent of hyper-tidal estuary could not be compensated for on a like for like basis.

5.2 Sub-tidal sandbank (slightly covered by seawater)

5.2.1 Scope

This covers the Severn Estuary/ Môr Hafren SAC Interest Feature 2, sandbanks which are slightly covered by sea-water at all times, for which the area is considered to hold a significant presence. The Natura 2000 Data Sheet records this feature as covering about 16% of the SAC area.

5.2.2 Range of possible compensation need

It is possible that measures might not be needed if the sub-tidal sandbank that occurs following an STP could make a similar contribution to overall coherence. If this is not the case then compensation might be required for two effects – loss in the extent of the feature and change in its ecological character and function.

The likely effects include potential changes to the shape of existing sandbanks due to changes in sediment fluxes and flow speeds and a predicted move towards flatter and wider sandbanks. Within the impoundment finer sediment will tend to be deposited over the sand resulting in changes to this feature.

Change in the total extent of habitat might range from no net loss to significant areas 'lost' by being covered by finer sediments. Reporting is likely to be uncertain about whether the newly formed sandbank would be likely to qualify as SAC feature.

5.2.3 Measures

Creation of new sub-tidal sandbank is not thought to be feasible. Designation of other examples of sub-tidal sandbank within other estuaries would depend upon finding sufficient areas that were of sufficient quality.

5.2.4 Discussion

This feature is likely to be significantly different following an STP scheme within the impoundment even if the total extent is similar. The outputs from the strategic Appropriate Assessment are uncertain about how post-STP conditions would provide comparable ecological functions to the current situation. Assessing the contribution that the modified feature might make to coherence would require further investigation in developing a project.

5.3 Intertidal Habitat Features

5.3.1 Scope

This includes two SAC interest features of the Severn Estuary - inter-tidal mudflats and sandflats (SAC Interest Feature 3) and Atlantic salt-meadow (SAC Interest Feature 4). For this study, the feasibility of providing a mix of inter-tidal habitats within an overall scheme of inter-tidal habitat creation has been considered. This reflects practical experience of delivering mixtures of habitats and the dynamic character of coastal and estuarine processes. Within coastal systems habitats are subject to natural processes and change, with for example, saltmarsh building and saltmarsh erosion taking place.

'Like for like' compensation would require the proportion of saltmarsh and mudflat created to reflect the areas lost. A more flexible approach would be to accept some change in the overall proportions of these habitats. This might be linked to climate change adaptation and the relative vulnerability of mudflat and saltmarsh to sea level rise. This is discussed further in part 2.

The inter-tidal mudflat within the Severn Estuary is highly unusual. The existing physical and chemical conditions give rise to atypical invertebrate communities which could not be re-created elsewhere. Replacement inter-tidal habitats would not therefore be 'like for like' compensation for the loss of these characteristics. This section considers the potential for compensating for the loss in the extent of the Habitats Directive Annex II feature rather than all the effects on the conservation objectives for the feature as it occurs in the Severn Estuary.

The inter-tidal habitats are a supporting habitat for the SPA bird features as well as being a SAC habitat feature. The extent to which habitat compensation for the SAC feature is also able to serve as new supporting habitat for SPA bird populations is a key issue. This is discussed further in the section on migratory birds. The area of inter-tidal habitat loss that is most significant as supporting habitat for birds is less than the total area of inter-tidal habitat defined as the SAC feature.

5.3.2 Range of possible compensation need

The potential need for compensation for saltmarsh depends on whether this is based on the loss of saltmarsh immediately following closure of a scheme or the net change taking account of predicted losses and gains in habitat. Depending on which approach is adopted and applying compensation ratios between 1:1 and 3:1 there could be a requirement for up to 690ha of saltmarsh habitat creation.

A range of possible inter-tidal habitat loss was taken from Version 2 of the Option Definition Report of between 1,600-13,000ha. These figures do not take account any application of topographic modification as a mitigation measure. Applying the same range of compensation ratios this gives a possible range of 1,600-39,000ha of inter-tidal habitat creation. The saltmarsh requirement is a relatively small proportion of the overall inter-tidal requirement.

5.3.3 Measures

This assessment and selection of measures is based on the findings of the re-alignment report.

Inter-tidal habitat may be created by managed re-alignment. This involves building a new flood defence inland (where there is no naturally rising ground), then breaching the old defence to create new coastal habitat by allowing the sea to flood the land in between. Regulated tidal exchange may be considered as an option within areas suitable for managed re-alignment. This involves the use of structures such as sluices or pipes through a maintained defence to control or regulate tidal flooding of land behind the defence. Topographic modification is another approach, which would be applied to raise sub-tidal land within the Severn Estuary to become inter-tidal. This might be applied to land that is currently sub-tidal or to land that becomes sub-tidal as a result of an STP scheme. This approach has been classed as a mitigation (prevent/reduce) measure in the STP study and is not considered in detail within this report. However the potential relationship with topographic modification is further discussed in the section on bird measures because of the particular importance to birds of the location of measures.

Managed re-alignment is an established technique. It has been applied by the Environment Agency as compensation for flood risk management programmes and by the ports industry to facilitate ports expansion. Managed re-alignment within the Severn Estuary, and managed re-alignment at distance to the Severn Estuary are considered separately.

5.3.4 Managed re-alignment adjoining the Severn

The coastal floodplain adjoining the Severn Estuary includes areas where there is potential for managed re-alignment. A plausible area within which re-alignment might be possible was estimated as part of the studies supporting the Phase One Consultation on Severn Tidal Power (1). However the STP schemes reduce the potential area because they reduce the tidal range inside the impoundment. The reduction in the plausible area has therefore been modelled using the SEA studies and the results presented in as an annex to the managed re-alignment study. (6)

This study indicates that there is no significant potential for mudflat creation adjoining the Severn and that the area of plausible re-alignment is significantly reduced by the different options with virtually no remaining potential in the case of the Cardiff-Weston option. The reduction in the height of the tides within an impoundment means that potential areas are too high relative to the new high tide levels.

More detailed site assessment (as part of a site selection process for example) would reveal that only a proportion of this plausible area is likely to be readily achievable. A correction for likely yield has been applied based on Environment Agency experience in developing Coastal Habitat Management Plans to reflect that a significant proportion of sites identified through the initial constraints mapping and modelling are not found to be workable options following more detailed site investigation.

Although schemes to date have been on a far smaller scale than those potentially required for Severn Tidal Power, their experience is that as much as half of the area initially identified is not realisable once more detailed site based assessments are carried out. A scaling factor of 2:1 for potential to realisable habitat is therefore applied in table 3. Some of the existing plausible area could also be required to create habitat for compensation schemes associated with the Severn Estuary Flood Risk Management Strategy. Although an STP scheme is likely to result in the need for a review of current Flood Risk Management Strategy, which might change the Environment Agency requirements.

Table 3 Inter-tidal habitat creation adjoining the Severn effect of options

Scheme	Modelled area of managed saltmarsh potential within Severn (ha) after option effects and excluding coastal floodplain SSSIsh	Contribution after applying a correction of 50% (ha)
B3 Cardiff Weston	300	150
B4 Shoots	4,400	2,200
B5 Beachley	4,000	2,000
L2 Welsh Grounds	5,000	2,500
L3 Bridgwater Bay	3,100	1,550

Managed re-alignment would result in mainly saltmarsh being formed because the areas involved would be too high in the tidal frame to support mudflat. Managed re-alignment in the Severn Estuary is not a feasible measure for mudflat creation and the potential for saltmarsh creation is constrained by the effects of the options. The potential upper plausible limit for this measure is between 150-2,500ha depending

on the option. The potential area for managed re-alignment would in broad terms also be suitable for Regulated Tidal Exchange.

5.3.5 Managed re-alignment at distance from the Severn Estuary

In the UK managed re-alignment has been applied to relatively small areas and the total area of all re-alignments is less than 2000ha. Expert advice strongly suggested that scaling up individual site size would be essential to achieve the large total areas of habitat creation that might be required by an STP. This was a key issue therefore for the managed re-alignment study.

The preliminary study (in phase 1 of the STP) on compensation and mitigation measures calculated the area of relatively unconstrained coastal floodplain in England and Wales within which managed re-alignment might be undertaken. A correction factor was applied to account for the likely yield when delivering schemes to report a plausible area of 110,000ha (1). Exceeding that area might require re-routing infrastructure such as railway lines and main roads.

The possible compensation requirement for the larger schemes represents a significant and challenging proportion of the 110,000 ha. The managed re-alignment study was based on three case study areas and shows that large scale re-alignments (areas in excess of 1,500ha) appear technically feasible. The combined area of inter-tidal habitat that might be created from a combination of all three case studies is about 20,000ha. The study found that scaling up appears to add relatively few new technical issues although a large site will tend to incorporate more complex issues than single small site.

Across all the case studies, about half of their total area is likely to develop as mudflat – although there is great variation between individual case studies. Many sites that might initially form as mudflat will progress to saltmarsh over time. Hence the area over which mudflat can be created and maintained for the life of an STP option will be significantly less than the plausible area for managed re-alignment. It is uncertain whether it would be feasible to find sufficient area over which mudflat could be created and maintained for the life on an STP for all options. **This is a key finding as the loss of mudflat is many times greater than the reduction in saltmarsh area.**

The managed re-alignment study concentrated on the feasibility of creating large re-alignments. It is possible to consider two approaches, a ‘small sites approach’ and a ‘large sites approach’. An area of 20,000ha might be achieved using sites of 200-500ha would require an unfeasibly large number of individual projects, although it might allow for more flexibility in terms of site selection and programming. The switching point to a ‘large sites approach’ would need to be considered as part of the detailed site selection as part of a project. The implications for meeting different possible increments of compensation are illustrated in table 4.

Table 4 Implications of meeting possible increments of requirement

Inter-tidal habitat at distance from the Severn					
Possible compensation requirement	Feature implications		Delivery implications		
1,600 ha inter-tidal habitat	↓	Flexibility to define mudflat:saltmarsh proportion.	↓	Conventional 'small sites approach' possible.	
3,000 ha inter-tidal habitat					
10,000ha inter-tidal habitat					Increasing challenge to find sites that enable mudflat creation at high compensation ratios.
20,000ha inter-tidal habitat					Mudflat:saltmarsh proportions may be constrained.
39,000ha inter-tidal habitat					
				Novel 'large sites approach' essential.	

The creation of areas of inter-tidal habitat exceeding 150-3,000ha through managed re-alignment would need to be at distance to the Severn Estuary. Large sites are most likely to be found more than 100-150km from the Severn Estuary in the East and North of England. It is uncertain whether sufficient areas could be found where mudflat could be created and subsequently maintained as mudflat over the long term.

Commission guidance gives a higher priority to measures within the Natura 2000 site or within a 'common topographical or landscape unit'. Established practice is to compensate close to the area affected. Providing compensation at distance would therefore be novel and would have a greater effect on the geographic distribution of the habitat within the UK.

The social, environmental and economic costs and benefits of very large coastal re-alignments would be unprecedented. The largest STP might require an area 60 times greater than the largest re-alignment previously undertaken in the UK. While this might be technically feasible the delivery and impact assessment issues would be challenging. Managed re-alignment at distance to the Severn Estuary has been conditionally included as a measure within the toolkit. The conditions relate to:

- accepting that compensation 'at distance' would not be fully 'like for like' as they would not replicate the unique mudflat habitats of the Severn Estuary;
- the environmental, social and economic effects being publicly acceptable.

5.3.6 Coastal flood risk management and costs, impacts and benefits of re-alignment

The established practice is to identify compensation areas that have little or no infrastructure and to avoid domestic dwellings. This approach will not be possible within large scale re-alignments. The large scale re-alignment study identified at a high level a range of possible impacts and benefits that might occur. Issues include

the loss of productive farmland, the impact on farm businesses and the need to purchase and demolish domestic dwellings. There would be an impact on individuals and communities arising from the need to acquire domestic dwellings. The re-alignment study suggests that a 'large sites approach' might entail the purchase of up to 200 houses for a re-alignment area of 10,000ha (100sq km).

The loss of such assets is potentially controversial and would represent a significant social and economic cost of an STP project. In the context of climate change some areas where this measure might be applied could be vulnerable in the long term to sea level rise. The sustainability of an area in the long term may be considered in as depending in part on the public policy for and commitment to maintaining the current alignment. This is only partly the case however, because public resources are limited and therefore require higher not simply positive cost:benefit ratios.

Strategic implementation of Government's policy for flood risk management in coastal areas is achieved through Shoreline Management Plans (SMP). The Shoreline Management Plans identify policies for three time periods – 0-20, 20-50 and 50-100 years. The policy options for sections of coastal defence may be to 'hold the line', 'advance the line', undertake 'managed retreat' or to offer 'no active intervention'. Since June 2007, in England the Environment Agency has had the Coastal Strategic Overview and is responsible therefore for ensuring a long term, robust and strategic approach to coastal flood risk management. In Wales, the Welsh Assembly Government retains this overview.

The Environment Agency delivers coastal flood defence activities across England and Wales. In England, the Government funds the Environment Agency to deliver a programme of flood risk management activities. In Wales, the Welsh Assembly Government sets flood risk management policy and funds the majority of flood and coastal activities. In both England and Wales, the Environment Agency is funded by Governments to maintain, upgrade or replace flood defences for which it has responsibility. Work to coastal flood defences is managed as part of capital programme and maintenance programmes.

In England, the Environment Agency undertakes plan and project appraisal in accordance with Defra guidance on Appraisal of Flood and Coastal Erosion Risk Management, A Policy Statement June 2009. In addition Ministers have agreed nine outcome measures which will increasingly inform targets for flood risk management activities in England. In Wales investment decisions for coastal flood defence are guided by an appraisal process adopted by the Welsh Assembly Government.

The Environment Agency assesses risk and priorities, produces 3 year work plans, and allocates funding based on the priorities in England and Wales. System Asset Management Plans (SAMPs) are being produced to help manage each asset system. An asset system is a collection of individual assets that provide flood or coastal erosion risk protection to properties in a defined geographical area. The aim is to prioritise investment to those areas of greatest need.

Large scale re-alignment for habitat compensation would have to be closely integrated with flood risk management opportunities and policies to ensure that options for future flood protection are not compromised. Areas of saltmarsh also

contribute positively to flood risk management. A successful managed re-alignment could therefore provide benefits by working with a built defence to improve its performance, or by enabling a less substantial structure. With the scale of re-alignment potentially required it would be inevitable that existing flood risk management strategies for the areas and regions would be reviewed and probably amended. Possible flood risk management benefits of re-alignment might be assessed and quantified on a site by site basis as part of a site selection process.

5.3.7 Summary

Table 5 Managed re-alignment measures.

Measure	Included in toolkit	How much is feasible?
Managed re-alignment to create saltmarsh adjoining the Severn Estuary.	Yes	150-3,000ha outside the impoundments and therefore dependent upon the option.
Managed re-alignment to create mudflat and saltmarsh at distance from the Severn Estuary.	Conditional. Would not duplicate the habitats found within the Severn. Areas where long term mudflat is possible likely to be constrained. Significant environmental, social and economic costs and benefits would need to be acceptable and the credibility of practical delivery determined for larger targets.	20,000-40,000ha might be achievable although flexibility in terms of mix of habitats created is likely to be required.

5.4 Reef (*Sabellaria alveolata*)

5.4.1 Scope

This covers reefs formed by the tube-dwelling polychaete worm *Sabellaria alveolata* SAC interest feature 5. An unusual feature of the Severn Estuary is the presence of both inter-tidal and sub-tidal *Sabellaria* reef.

5.4.2 Range of possible compensation need.

This is likely to range from little or no effect through to total loss of the feature from the Severn Estuary. There is a lot of uncertainty about the distribution of the feature although it is known to be more prevalent in the outer part of the estuary.

5.4.3 Measures

It is thought unlikely that conditions for *Sabellaria* reef could be easily created. *Sabellaria alveolata* reefs in the UK are predominantly an intertidal habitat but the Severn Estuary is one of the few places where *Sabellaria alveolata* reefs occur extensively in the subtidal, as well as in the intertidal.

5.4.4 Discussion

The Natura 2000 Standard Data Form records this as covering 2% of the area and as a significant presence rather than best example. As there is insufficient known about its requirements to support habitat creation, the only measure that is conditionally included is new designation of existing areas not currently SAC. It would also require accepting that an alternative site would not be fully 'like for like' because of the unusual characteristics of Sabellaria reef in the Severn Estuary.

5.5 Migratory Fish

5.5.1 Scope

There are five species of migratory fish that are features of the Severn Estuary/ Môr Hafren SAC and/or one of the tributary SAC rivers. This report deals only with these species of fish as a conservation feature and not as a resource for recreational or commercial fishing.

Table 6 Fish features of SAC sites

Species	FEATURE OF:				
	Severn Estuary/ Môr Hafren SAC	Severn Estuary Ramsar	River Usk/Afon Wysg SAC	River Wye/Afon Gwyi SAC	River Tywi/Afon Tywi SAC
Atlantic Salmon	X	√	√	√	X
Allis Shad	X	√	√	√	√
Twaite Shad	√	√	√	√	√
Sea Lamprey	√	√	√	√	√
River Lamprey	√	√	√	√	√
Sea Trout	X	√	X	X	X
Eel	X	√	X	X	X

Allis shad is not a primary reason for selection for the Severn or any of its tributaries as an SAC and the lampreys are not a primary reason for selection of the River Tywi/Afon Tywi.

5.5.2 Range of possible compensation needs

The conservation objectives for three Severn Estuary/ Môr Hafren SAC species refer to unobstructed passage; population size; availability of prey items and water quality. For example the population of twaite shad is said to be favourable when:

- i. the migratory passage of both adult and juvenile twaite shad through the Severn Estuary between the Bristol Channel and their spawning rivers is not obstructed or impeded by physical barriers, changes in flows or poor water quality;
- ii. the size of the twaite shad population within the Severn Estuary and the rivers draining into it is at least maintained and is at a level that is sustainable in the long term.
- iii. the abundance of prey species forming the twaite shad's food resource within the

estuary, in particular at the salt wedge, is maintained.

iv. Toxic contaminants in the water column and sediment are below levels which would pose a risk to the ecological objectives described above.

Adverse effects on fish populations could range from population declines to complete loss of one or more SAC fish population. Compensating for the complete loss of a fish species from a SAC site would be unprecedented. There is also a risk of a UK extinction for twaite shad.

5.5.3 Identification of measures

Within the strategic study, measures that are located within the Severn Estuary and the SAC rivers have been defined as mitigation. Compensatory measures for migratory fish are therefore limited to those that might be applied at distance to the Severn. Possible measures could either act to create new self-sustaining fish populations in areas not currently occupied; or to increase the size of an existing population by reducing factors that currently limit their numbers.

The identification of compensatory measures for migratory fish is based on Annex 3 of the Fish Topic Paper which covers offsetting measures for the Strategic Environmental Assessment. The same criteria are used in that report to select compensatory measures. To simplify presentation measures for migratory fish have been grouped into the following headings in this report. Although the measures are listed individually here, they are most likely to be used together rather than in isolation. The Fish Topic paper should be referred to for the supporting detail.

Translocation and species introduction

This involves establishing a self-sustaining breeding population into a river where it is not currently established. This is a possible measure for twaite shad and allis shad but would not be applied to salmon or the lampreys because they are already widely distributed. The effectiveness of this measure is uncertain. It is not an established compensation measure and would rely on techniques to handle and introduce shad that would be novel, although there is experience elsewhere in Europe in introducing shads. The Fish Topic Paper Annex 3 concludes that further feasibility studies would be required to develop this measure and that it is not achievable within a 2020 timescale. It has been conditionally included in the toolkit for **shads** as having potential for projects beyond 2020.

Stocking in rivers at distance to the Severn

This involves stocking fish into a river to increase the size of the population. It may be used as a measure to support a fishery or a population of a fish species. Stocking with fish does not necessarily address the factors that limit a self-sustaining population and is only likely to be successful if used together with other measures.

Stocking is conditionally included as a measure for **salmon** and the two **shad** species but is excluded for the two lamprey species. Stocking is well established as a technique for salmon although not as a compensatory measure. As a technique it would be novel and require development for the shads. Quantifying the contribution

that stocking might make to compensation and developing the infrastructure to enable it to be delivered is not thought feasible by 2020.

Freshwater habitat enhancement at distance to the Severn

This covers a range of possible measures to address factors that limit the size of fish populations within a river including improvements to habitat quality and removal of barriers. This is an established approach to restoring or recovering populations that are negatively affected or not reaching their conservation target. It is included as a measure for all five species. However it is only a well established technique for salmon. There would be much greater uncertainty about applying this to the shads and lampreys. Quantifying the potential effect of this measure to show the extent to which it addresses the residual impact on a species would be challenging and the extent to which it might address an impact needs further study. This measure is considered as possible for some levels of compensation requirement within a 2020 timescale, subject to a feasibility study. This measure has been conditionally included as its application would also depend on whether it was additional to measures that are already required by other environmental regulation and therefore meet the principle of additionality.

Estuarine habitat enhancement at distance to the Severn

This would involve enhancing or creating estuarine habitat including new inter-tidal habitat at sites distant to the Severn Estuary. It is only considered as a potentially feasible option for **shads** because the juveniles are thought to spend more time resident within estuaries than other species. The measure is not thought to have as much potential for salmon and the two lamprey species and has therefore been excluded. It is not an established technique and would require further investigation to develop and demonstrate that it was achievable for a 2020 project. It would also require better understanding of the behaviour and ecology of shads in the estuary. Quantifying the effect of this measure would require additional development.

New notification of existing populations

As defined here, this measure covers the notification within the Natura 2000 series of new sites of existing populations of the species. The Commission guidance presents the case for this approach which might protect the coherent network by providing a comparable level of representation and protection of the SAC feature at a UK level. The issues and possible drawbacks of this approach are discussed further in the paper prepared for the HRA group by JNCC (7).

The measure is conditionally included as having some potential for Atlantic salmon and the two species of lamprey. This measure is thought achievable for 2020. It is less likely to apply to the two shad species as they have very restricted populations and it would depend upon finding suitable populations to increase and notify.

This measure would not maintain any genetically distinct populations that occur within the Severn Estuary and its tributaries. This approach has not previously been applied within the UK and would have implications in terms of policy and risk that would need to be considered acceptable before it could be applied with confidence.

Migratory Fish, the Water Framework Directive and Additionality

Commission guidance states that compensatory measures must be additional to measures that would normally be undertaken. The Commission guidance on Article 6(4) of the Habitats Directive issued in January 2007 contains three references to additionality: (3)

Compensatory measures should be additional to the actions that are normal practice under the Habitats and Birds Directives or obligations laid down in EC law. For example, the implementation of a management plan, or the proposal/designation of a new area, already inventoried as of Community importance, constitute "normal" measures for a Member State. Thus, compensatory measures should go beyond the normal/standard measures required for the protection and management of Natura 2000 sites.

The compensatory measures constitute measures specific to a project or plan, additional to the normal practices of implementation of the "Nature" Directives. They aim to offset the negative impact of a project and to provide compensation corresponding precisely to the negative effects on the species or habitat concerned.

...that the compensation must be additional in relation to the Natura 2000 network to which the Member State should have contributed in conformity with the Directives.

Many possible measures for migratory fish involve improving existing habitats (principally rivers) so that they support a larger population. The extent to which these habitat improvements are already required by existing obligations laid down in EC Law would need to be established. For example under the Water Framework Directive WFD all water bodies, other than those classified as heavily modified, have to reach an ecological status of at least "good" by 2015 – where this is not possible, extension may be allowed until 2021, or 2027, if sufficient justification can be given for the extension of deadlines. In the case of heavily modified water bodies, the requirement is to obtain "good ecological potential". Standards for good ecological potential will include requirements for fish biology as this forms part of good ecological status. The implementation of the WFD is still being developed and interpretation is therefore limited. The extent to which measures might be additional could depend upon the extent to which measures are planned, programmed or funded within the delivery of the WFD.

It is possible that there might be scope to apply measures that go beyond those that are planned to deliver the requirements of WFD. For example, there are a significant number of artificial barriers to fish passage which may not be priorities for action. Only a proportion of these would be on rivers where removal might benefit the species that are of concern.

Conclusion

Only two compensatory measures are identified as developable for a 2020 project, with other measures having potential to be developed over a longer timescale. The

two 2020 measures are freshwater habitat enhancement (removing factors limiting populations) and notification of replacement sites.

Measures such as freshwater habitat enhancement for fish might be considered additional if they could pass two tests:

- They are applied to rivers that are not SAC for the species subject to the compensatory measure.
- They are additional to measures that might reasonably be expected to be undertaken as part of WFD implementation and to meet WFD requirements.

The potential for applying compensatory measures for fish that are demonstrably additional to the requirements of WFD would need to be subject to further investigation to establish what might be possible for the species concerned.

5.6 Migratory birds – SPA

5.6.1 Scope

Sites may be designated for the numbers of an individual species using a site, or for a combination of species exceeding a threshold population size. This section covers the six species that are features of the Severn Estuary SPA and a further thirteen that are present in nationally significant numbers and form part of the SPA bird assemblage.

SAC designated inter-tidal habitats are also supporting habitat for the SPA bird features. Inter-tidal habitat creation at distance from the Severn would not be supporting habitat for the Severn Estuary SPA and would not be acting to protect the Severn Estuary SPA populations.

The review of mitigation and compensation implications for birds (8) considers the needs of species within three guilds. The guilds contain species that have similar habitat requirements.

Table 7 SPA bird species guild (based on review of mitigation and compensation implications)

BTO Guild	SPA interest features 1-6	SPA interest feature 7 – nationally important populations occurring within the assemblage
Primarily intertidal mudflat invertebrate feeders (except bivalve specialists)	Shelduck, Dunlin, Redshank	Ringed Plover, Grey Plover, Spotted Redshank
Primarily freshwater species	Gadwall	
Generalist wetland species	Bewick's Swan, European White-fronted Goose	Wigeon, Teal, Pintail, Pochard, Tufted Duck, Whimbrel, Curlew, (Shoveler, Mallard, Lapwing*)
* These three species are referred to in the Conservation Objectives: The JNCC website also lists lapwing, mallard and shoveler as qualifying for future inclusion as part of this assemblage (Stroud, DA, et al., 2001. <i>The UK SPA network: its scope and content</i> . JNCC, Peterborough)		

5.6.2 Range of possible compensation need.

The range of effect might range from minor for some species under some options to 50% reductions for some species with some options. The compensation requirement could be creation of sufficient habitat to accommodate a 50% decline in the population of one or more species. The two different bird assessment tools generate different model outputs and expert judgement is needed to interpret them. The Individual Behaviour Model generally predicts lower impacts than the Habitat Association Model. The Appropriate Assessment considers the application of these models.

The change in bird numbers will be related to, but not necessarily directly proportional to the change in inter-tidal habitat area. The total area of habitat required to compensate for loss of bird feeding habitat might be different to the area of habitat lost. As with most estuaries, not all areas of supporting inter-tidal habitat within the Severn have the same level of ecological functionality or will be uniformly distributed. Hence it is possible that some options might be found to have a proportionately greater effect on less productive areas and therefore less of an effect on their supporting function for birds. Replacement of less productive habitats with more productive habitat might also reduce the compensation requirement. However, understanding of the detailed ecological needs of the species and what constitutes optimal or best habitat is incomplete.

Compensation ratios for habitat creation for SPA birds might take account of the functionality of the habitat that has been lost and the likely functionality of the replacement habitat. There is potential for engineered habitats such as those created through topographic modification to be optimised for target bird species. However these are novel measures and predicting the effectiveness of such measures and therefore their potential contribution would need further investigation.

Nevertheless these could reduce amount of habitat compensation that is required if they can be practically delivered.

5.6.3 Measures

Two measures have been identified as included within Commission guidance.

Table 8 Measures for migratory birds

Measure	Included in Guidance based toolkit	Species guild
Managed re-alignment to create saltmarsh for birds adjoining the Severn Estuary.	Conditionally included	Primarily freshwater specialists and generalist wetland species. Effectiveness will vary between species and would require further investigation.
Freshwater wetland habitat creation for birds close to the Severn Estuary	For some species.	Freshwater and freshwater and estuarine species. (Effectiveness will vary between species.)

Species within the primarily freshwater species guild and species within the generalist wetland species guild might benefit from creation of freshwater wetland close to the Severn. Reference to the Wetland Vision Project website which covers coastal and floodplain Biodiversity Action Plan habitats for England indicates considerable potential wetland creation within the floodplain of the Severn. (<http://www.wetlandvision.org.uk>, accessed 20 February 2010.)

5.6.4 Discussion

The managed re-alignment study shows that there is virtually no potential to create mudflat adjacent to the estuary as supporting habitat for species that are primarily mudflat invertebrate feeders. This covers three SPA interest features shelduck, dunlin and redshank and other mudflat feeders that contribute to the overall assemblage of waterbirds. These are the species most likely to be affected by an STP. **This leaves mitigation through topographic modification as the only realistic approach for mudflat creation within the estuary, although this is not an established approach and is therefore uncertain.**

Managed re-alignment to create saltmarsh adjoining the Severn Estuary may benefit some species guilds although this may be mainly as roosting rather than feeding habitat. The possible extent of this measure is option constrained, with virtually none possible for a Cardiff-Weston Barrage.

Regulated Tidal Exchange (RTE) can be considered as an option within managed re-alignment areas. It has the potential to provide habitats that might be tailored to specific bird requirements. It could also be used in combination with freshwater wetland management and topographic modification to provide additional flexibility. A more detailed study would be necessary as part of project development to determine the potential for this variant and/or the optimal mix.

Managed re-alignment to create inter-tidal habitat (mudflat and saltmarsh) at distance to the Severn Estuary might arguably be excluded from measures because of Commission guidance which states that:

For instance, if an SPA which has a specific function to provide resting areas for migratory bird species in their way towards the north is negatively affected by a project, the compensatory measures proposed should focus on the specific function played by the site. Therefore, compensating with measures that could recreate the necessary conditions for resting of the same species in an area out of the migratory path or within the migratory path but far away would not be sufficient to ensure the overall coherence of the network. In this case, compensation should provide for suitable resting areas for the targeted species correctly located in the migratory path so that they will be realistically accessible to the birds which would have used the original site affected by the project. (3)

Compensation at distance to the Severn Estuary SPA would not be supporting habitat for the bird populations using that SPA.

The requirement for measures at distance to the Severn depends on the extent to which the compensation requirement can be reduced by the application of topographic modification mitigation (especially for inter-tidal feeders), managed re-alignment adjoining the Severn and by freshwater wetland habitat creation close to the Severn for those species that can use those habitats. The loss of mudflat for mudflat feeders such as dunlin is a particular challenge. Topographic modification is reported elsewhere in the STP study as it is a mitigation measure. However, it should be noted that it is not an established approach at the scale that might be applied to an STP scheme.

5.7 New designation

Consideration of the potential for developing an approach to new designation as a compensatory measure was recommended by the preliminary review of mitigation and compensation measures. The JNCC led the production of a paper (7) on new designations as a technical contribution to this work area. The paper was produced for and with the advice of the Habitats Regulations Assessment and Compensation Expert Group. The paper considers aspects of site selection and suggests a process which might be applied to assess a new site's contribution to coherence. The paper does not consider practical, policy and legal issues which would also need to be addressed to be confident that this was a workable approach.

The paper discusses two types of new notification, which it calls 'type a' and 'type b'. 'Type a' is new designation as an accompaniment to compensatory measures that enhance or create habitat. This is established practice. 'Type b' is new site designation as the main compensatory measure, i.e. adding an **existing** (not newly created/enhanced) habitat into the Natura 2000 network. This might be used to provide compensation without any specific habitat or species enhancement by finding an undesignated site with the right ecological characteristics.

The paper then concentrates on this second form of compensation and proposes criteria that might be applied if this form of new site designation was considered acceptable as part of a compensation strategy. It is suggested that the selection of sites would need to include an assessment of the contribution that the site would make to the coherence of the network. Commission guidance notes that : *New designations as part of compensation measures shall be submitted to the Commission before those are implemented and before the realisation of the project but after its authorisation. The new designations should be made available to the Commission through the established channels and procedures as in the process of adoption of the SCI lists and SPA designations*

This form of compensation has not been applied in the UK and the implications of this approach would need to be examined in greater depth before it could be taken forward. It is the only measure that has been identified within Commission guidance for the reef feature. It might also be applied as a measure for migratory fish and for sub-tidal sandbank. There are significant arguments for not adopting this measure. Commission guidance states that: While designations of new Natura 2000 sites can be part of a compensation package under Article 6(4), the designations on their own are insufficient without the accompanying measures.

The acceptability of new designation as a mechanism may be different for features that are not primary reasons for designation of the SAC. The argument would be that it is more likely that other sites might be found that are of equivalent value to the coherence of the network for features that are not primary.

The paper concludes that this approach would not be legitimate as a measure for compensating for loss of SPA supporting habitat.

Type a) designation also requires further consideration. There is a presumption that habitat that is created as compensation will eventually be added to the SAC network. The purpose of the compensation is to protect the coherence of the network of Natura 2000 sites, therefore there it is logical that the areas involved might be added through designation. Past habitat creation compensation (eg Newport Wetlands, Defra's Wallasea project) are based a presumption that they will be designated in due course. The migratory fish measures identified are unprecedented and there is no experience of applying this type of new notification to rivers.

Commission guidance notes that: new designation as part of compensation measures shall be submitted to the Commission before those are implemented and before the realisation of the project but after its authorisation. The new designations should be made available to the Commission through the established channels and procedures as in the process of adoption of the SCI lists and SPA designations (business as usual).

In conclusion, some compensatory measures raise potentially novel issues in relation to new designation. The practical, legal, political and policy implications of this approach would need further consideration if new designation were to be adopted as a measure. This would need to involve the devolved administrations as nature conservation is a devolved matter.

5.8 Compensation ratio

Choice of a compensation ratio requires an assessment of the loss of ecological functionality associated with the measures. Ultimately this is linked to the choice of option, the choice of compensatory measures and the time available for them to be delivered and achieving ecological function. These issues are reviewed in a technical contribution to the study, produced by members of the HRA and Compensatory Measures Expert Group. This forms Annex C of this report.

There are three possible applications of a compensation ratio.

- Choosing a ratio to use within the feasibility study to inform the overall cost estimates of an STP option (ODR3).
- Applying a ratio if a strategic plan to develop an option were to be adopted (eg following a public consultation).
- Determining a ratio that would be applied to a project.

The ratio for a project would depend upon the findings of a detailed EIA and AA at a project level. It is necessary therefore to be cautious when considering possible compensation ratios at this stage.

For intertidal habitat creation through managed re-alignment a basecase for the costing measures within the feasibility study of 2:1 has been applied for inter-tidal habitat with sensitivity testing at ratios of 1:1 and 3:1. This ratio reflects increasing experience of managed re-alignment being successful and findings from the large scale re-alignment study which indicate that there is no reason to suppose that scaled up sites will have lower inter-tidal habitat functionality than smaller sites. It also takes into consideration the point that a proportion of the inter-tidal within the Severn is extremely dynamic sandflats. Applying a high compensation ratio for loss of features which are essentially in an ongoing process of re-mobilisation and re-formation would appear inconsistent with the purpose of the ratio.

Compensation ratios for supporting habitat creation for SPA birds would need to be based on an assessment of the functionality of the habitat that has been lost and the likely functionality of the replacement habitat. This might justify a lower compensation ratio for supporting habitat for birds than that used for SAC habitat creation.

Quantification of fish impacts and of the effects of possible compensation has largely not been possible within the STP study. In the absence of quantifiable information on the risk of measures not achieving required levels of functionality application it is uncertain how to approach deciding a compensation ratio for migratory fish. It is likely that a different approach to managing risk would be required.

6 Delivery of compensatory measures

6.1 Assessment and consenting of Compensatory Measures

Most of the measures that have been identified may have significant environmental, social or economic effects that would need to be assessed and found to be acceptable.

Projects such as managed re-alignment are substantial civil engineering projects with all that entails in terms of site investigation, environmental assessment and consenting. Managed re-alignment projects would generally require an Environmental Impact Assessment. The managed re-alignment report considers the potential cost of delivering site investigations and environmental assessment.

Previous compensation has involved application of measures on at most one or two sites. An STP could involve a substantial number of projects and locations which would need to be assessed and consented. A programme of measures could involve effects such as large scale coastal re-alignment, land use change, loss of farmland, effects on local businesses and communities, flood risk benefit, effects on coastal and estuarine processes, sedimentation, erosion, navigation, widespread river enhancement measures, intervention to modify or remove river barriers, and possible establishment of new fish hatcheries.

The re-alignment study highlights some of the consents and licences that might need to be considered in addition to planning consent:

- Marine and Coastal Access Act
- Environmental Permitting (England and Wales) Regulations 2010.
- Land Drainage Act
- Flood Defence (Land Drainage) Bylaws and Sea Defence Bylaws.
- Harbours Act
- Marine Works (EIA) Regulations
- The Environment Impact Assessment Regulations
- Highways Acts
- Listed Buildings Consent
- Wildlife and Countryside Act 1981 (as amended) (depending upon proximity to SSSI)
- Habitats Regulations (proximity to SPA/SAC designated sites may require the need for Appropriate Assessment)
- Waste Management Licences and Exemptions
- Abstraction Licences and Exemptions.

Consenting of compensatory measures could depend upon how an STP project was consented. The practical effects of a choice of STP consenting route could affect how issues such as land assembly, environmental assessment and authorisation of compensation is approached. Issues that would need to be considered are whether compulsory purchase powers would be required and the extent to which different mechanisms can be applied across England and Wales.

6.2 Project Delivery and Timelines

The practical aspects of planning for and achieving delivery of a compensatory measures programme for a project as significant as an STP is a significant task. Scoping the best strategy for delivery would need to be an early priority.

Past compensation has generally involved selecting, procuring, planning, consenting and delivering one or at most two sites (for example in the case of the Thames Gateway ports development). By comparison even the smallest STP is hugely more complex than anything previously undertaken. Many aspects of a compensation plan would be a matter of scaling up past approaches, however there will be additional levels of complexity and novelty to address. A substantial project planning structure would need to be put in place with the access to appropriate skills and resources.

A possible timeline for planning and implementation of managed re-alignment is considered in the managed re-alignment study. This suggested 2 years for site selection, 5-7 years for design, planning, land purchase and consenting, 3 years for construction and a further 2-5 years to develop ecosystem function. Hence from start of process until physical completion could take 10-12 years or 12-17 years to achieve ecosystem function.

The link between timeline and scale may have a bearing if it was possible to buy into pre-existing or pre-planned habitat creation projects. For example it may be that some organisations have assembled areas 'in principle' that could be rolled out as STP compensation. This approach is referred to in the commercialisation study as a form of biodiversity banking. It is likely that it would only have a very limited application for smaller increments of requirement. However further investigation of a possible supply chain would be needed in order to better understand the potential of this approach. Biodiversity banking is an established approach in some parts of the world, for example in Australia and parts of the United States. This involves establishing a system of biodiversity credits which can be traded to offset the loss of biodiversity. The credits usually take the form of measures such as habitat creation and species enhancement provided by a supplier (the biodiversity bank). This approach is not established in Europe but is attracting some interest in among academics and policy advisers. A recent report to the European Commission considered the potential for habitat banking.

[<http://ec.europa.eu/environment/enveco/studies.htm#2>.]

6.3 Cost

The work on managed re-alignment provides an indication of the scale of compensation that might be required and the effect on cost and timeline. This reflects the evidence that is available and the difficulty in obtaining any quantitative predictions of impact and of the effectiveness of mitigation and compensation measures for fish. It also reflects the importance inter-tidal habitat as it comprises:

- Two of the three habitat features (saltmarsh and mudflat and sandbank) that are primary reasons for the selection of the Severn Estuary as an SAC.
- Is the supporting habitat for the SPA bird populations.
- Is relatively costly to re-create.

There would therefore be an additional and unknown cost associated with other compensation, particularly for migratory fish. This is likely to be most significant for options that result in lower inter-tidal losses but have relatively large effects on migratory fish.

The managed re-alignment study provides new information on the possible cost of coastal re-alignment schemes. This looked at the potential cost of scaling up managed re-alignment for sites up to 11,500ha (115 sq km) in extent. The study reported a wider variation in possible cost. Site specific issues have more effect on cost than the absolute size of a large re-alignment. For the purpose of the STP feasibility study a standard cost of £71,596 per ha including optimism bias has been applied to calculate the cost of managed re-alignment. This represents the average of 11 separate site studies at three locations covering a range of size of managed re-alignments between 500ha and 11,500ha. (5 sq km to 115 sq km).

The re-alignment study presented costs for 11 hypothetical re-alignments at three broad locations. Results were presented for a baseline scenario and for an high cost and a lower cost scenario. The approach taken is not to exclude outliers from the range of costs presented but assume a preference for the **low intervention scenario**. This scenario assumes the lower range of construction costs and not applying expensive options such as rock armour. This choice reflects feedback from some experts involved in the study that the level of intervention in the baseline scenario seemed on the high side. Validation of this choice would depend upon the site selection process finding sufficient areas where the low intervention scenario approach could be implemented.

7 Conclusions

7.1 Discussion and general conclusions

Criteria were applied to identify a toolkit of those compensatory measures that are within Commission guidance. This analysis is presented in annex A.

Measures that might be considered as being within Commission guidance have been identified for all Natura 2000 features within the scope of the study except for the hyper-tidal character of the estuary feature of the Severn Estuary SAC. The approach has been to screen in measures as included or conditionally included. Conditionally included measures may require further technical development or policy to be determined with respect to additionality, new notifications and the acceptability of their impact.

Measures have been considered in relation to their location – whether close to or at distance from the Severn Estuary and tributary rivers. This represents a step in the priorities within the Commission guidance or in the compensation hierarchy. Measures at distance might still be considered as being within the Commission guidance for SAC features provided they protect the overall coherence of Natura 2000. The UK has always sought to provide measures within what Commission guidance refers to as ‘a common topographical or landscape unit’. There is therefore no precedent for evaluating and applying such measures. They approach would have to be decided as a ‘special case’ for the Severn Estuary, or an agreed framework developed that might be applied in future cases.

For fish, the compensatory measures identified would be applied outside the Severn Estuary and would be outside the topographical or landscape unit. For inter-tidal

mudflat, compensation would have to be 'outside unit' as there is limited potential for mudflat creation adjoining the Severn Estuary under any conditions. The STP options reduce the potential for saltmarsh creation adjoining the Severn. In the case of a B3 Cardiff-Weston barrage, the potential is entirely lost. Creation of inter-tidal areas as supporting habitat for the SPA birds close to the Severn is also option constrained. This has implications for possible strategies for compensating for birds.

Commission guidance for SPA compensation measures is more tightly defined and in explaining that: 'compensating with measures in an area out of the migratory path or within the migratory path but far away would not be sufficient to ensure the overall coherence of the network'. The upper limit for compensating within Commission guidance therefore depends on the extent to which mitigation and compensation for birds can be delivered within or close to the Severn Estuary.

7.2 Quantification

Many measures which might be possible within Commission guidance are very uncertain in terms of their effectiveness. Quantification of potential measures has only been possible in this strategic study for inter-tidal habitat creation.

Quantification of the contribution to SPA bird populations from the creation of supporting habitats adjacent to the Severn and at distance from the Severn would also need to be developed as part of studies to inform project development. Modelling the possible effects of habitat creation adjacent to the Severn would be a relatively straightforward addition to the modelling undertaken for the SEA. Assessing the effect on bird distributions of habitat creation at distance to the Severn would require a different approach. This would be a substantial investigation and was outside the scope of what could be achieved within this study.

7.3 Scale and impact

Application of some measures within Commission guidance would depend on a judgement about their acceptability in terms of the scale of their possible impact and benefit when applied to the unprecedented scale of the compensation requirement for an STP. This particularly applies to scaling up managed re-alignment to meet large compensation targets. The re-alignment case study indicates that delivering an area of 10,000ha might involve acquisition of up to 200 houses. There are potential benefits of large scale re-alignment in terms of coastal flood risk management and ecosystem services, however these are highly site specific and would need to be evaluated as part of a site selection process.

7.4 Estuary

The estuary extent would remain more or less the same. Compensation for the effect on the coherence of Natura 2000 of the loss of hyper-tidal features would need to comprise measures that were not 'like for like'. The portion of the estuary inside the impoundment that was modified might continue to be designated as a SAC as it is unclear whether a site can be de-notified because of degradation due to human action rather than natural processes. If it remained as an SAC it would no longer

fulfil the same role within the coherent network. The extent to which it would develop ecological characteristics that would be of SAC quality is uncertain.

7.5 Sub-tidal sandbank slightly covered by seawater

These features will be substantially modified by an STP. Whether they would remain as a SAC feature is uncertain. If compensation was required it is likely that this could only be achieved through additional designation and management of an existing (currently undesignated) feature.

7.6 Inter-tidal habitat

The re-alignment study results suggest that it should be possible to achieve substantial areas of inter-tidal habitat creation through managed re-alignment. Scaling up of managed re-alignment is likely to depend on increasing individual site size. Very large sites are most likely to be found in the north and east of England. Compensation for loss of mudflat would have to be outside the Severn Estuary. Such compensation may be judged as being within Commission guidance. The replacement habitats would acquire the ecological function of inter-tidal habitats although they would be contributing that function to a different part of the biogeographic zone and a different Natura 2000 site.

7.7 Sabellaria reef

Compensation by notification of another existing example is unlikely to be within strict application of Commission guidance as other sub-tidal examples are unlikely to be found. Compensation for loss of reef is likely to require measures outside Commission guidance or very flexible interpretation of the guidance.

7.8 Migratory fish

Only two measures are identified as feasible for a 2020 project. These are freshwater habitat enhancement to increase species populations by removing factors that limit their numbers, and new notification of existing sites. Other measures have been identified that might be developed for a project beyond 2020.

The possible interaction between the Habitats Directive and the Water Framework Directive would need to be tested for those measures that act to increase a species population to ensure they would be additional to existing requirements. This would require an extensive investigation with the Environment Agency to identify whether there would be sufficient potential to practically apply such measures.

7.9 Migratory birds

Measures within Commission guidance include creation of compensatory supporting habitats through managed re-alignment or freshwater wetland creation adjoining or close to the Severn Estuary. Quantification of the effect of these measures has not been undertaken. The value of these habitats as supporting habitat for SPA birds varies between species. Provision of supporting habitat for those species that are

primarily mudflat invertebrate feeders is likely to be most limiting as they make use of mudflat or to some extent creeks in highly structured saltmarsh.

Provision of inter-tidal mudflat at distance is arguably outside Commission guidance and is outside UK experience. This measure would require the bird populations to adjust to a different distribution of habitat. This might have climate change adaptation benefits if it was judged that increasing the relative area of inter-tidal habitat in the east of the UK was beneficial and could still protect coherence. This approach would be most applicable for those species with predominantly east-west migration routes. Fundamental research to understand the effect of changing the distribution of bird habitats in relation to their flyways would be required to assess the consequences of such an approach.

7.10 Requirement for measures outside Commission guidance

Compensation for declines in migratory bird populations might not be possible within Commission guidance because of the limited potential for habitat creation within the Severn in some circumstances.

Compensation for migratory fish (shad, lamprey, salmon) within Commission guidance is uncertain.

Measures outside Commission guidance might be required as compensation for sub-tidal sandbank and Sabellaria reef if new designation was ruled out as not being sufficiently 'like for like' or acceptable in policy terms.

Like for like compensation for changes to the 'hyper-tidal' character of the estuary feature is not feasible. Compensation for this change would depend upon accepting that this aspect of the estuary feature was not replaced within the UK contribution to the Natura 2000 network (or elsewhere within the NE Atlantic biogeographic region).

This would mean that changes in the conservation objectives that depend upon the physical, chemical and ecological conditions generated by the extreme tidal range and shape of the Severn Estuary could not be addressed on a like for like basis.

PART 2

1 Background

Part 1 identified a toolkit of possible compensatory measures within Commission guidance that might be applied to compensate for the effects of a Severn Tidal Power option. This was 'option neutral' as it considered the potential of a measure and not its application to the impacts predicted for each of the scheme options.

The purpose of Part 2 is to consider possible measures outside Commission guidance, and the potential to address the outstanding impacts anticipated by the strategic study to inform an Appropriate Assessment.

2 Equivalence and Measures outside Commission Guidance

The purpose of compensation is to provide measures that offset a negative effect that cannot be avoided or mitigated through other means. Compensation therefore requires a way of determining the equivalence of measures – how much compensation is equivalent to the negative effect. The approach within the Commission guidance addresses this by using a site's conservation objectives to guide the development of compensation measures.

The scope of this study was to consider measures within Commission guidance where possible and where it is not, to look at whether there might be alternative ways of providing compensation outside Commission guidance that would be of equal value. In examining measures outside Commission guidance alternative approaches to equivalence might be need considered. To establish equivalence, damage from the STP and the benefits from the compensatory measures would need to be estimated using common units of measurement.

Ecosystem Valuation is an approach to measuring the value of environmental goods and services. An ecosystem valuation was undertaken as part of the STP feasibility study (9). This noted three possible ways of analysing equivalency. These are:

- Resource equivalency.
- Habitats equivalency.
- Value equivalency.

Resource equivalency looks at ecological units as the measure of exchange. For example, will an area of compensatory habitat support an equivalent number of birds of the same species and same populations as those displaced by an STP option? This form of compensation should achieve equivalence in terms of areas of habitat created (or managed) and their ecological function. Habitats equivalency would use both resource and ecosystem service concepts to measure the change in all ecosystem services expected in areas affected by potential STP implementation. This approach might require compensation to deliver equivalence in terms of habitat area and ecological function, and for the compensatory measures to deliver similar ecosystem services. Value equivalency analysis could use the change in value of ecosystem services as the budget for compensatory options (a value to cost approach), or repeat the valuation steps in full for compensatory measures to

estimate the benefits from habitats and services from compensatory options and require them to deliver an equivalent value of ecosystem services (a value to value approach).

The European Commission guidance on Habitats Directive compensation follows a resource equivalency approach as it is concerned with ensuring that the coherence of the Natura 2000 network of sites is protected. The network of sites has been selected for their ecological characteristics and not for the ecosystem services provided. The Commission guidance in effect seeks to restore a state of coherence by replacing losses in a way that is like for like. The value of ecosystem services provided by possible compensation areas could be used as an additional criterion when choosing measures within Commission guidance. For example, an objective might be to promote compensation measures that offer the widest possible benefits, such as carbon storage or flood protection. However, it should be noted that including such an approach might act to further constrain the areas available for compensation with possible effects on cost and deliverability. The ecosystem valuation study identifies which ecosystem services affected by STP Options can be expressed in value (monetary) terms.

The STP study approach is to look at measures within Commission guidance where possible and where it is not, to look at whether there are acceptable ways of providing compensation outside Commission guidance that would be of equivalent value. The Sustainable Development Commission was invited to look at whether it would be feasible to develop measures outside Commission guidance that would be of equal value in protecting coherence and to report their conclusions to the STP study. Their approach has been to look at network coherence and the contribution it makes to favourable conservation status and therefore at novel approaches to determining resource equivalency. (This includes whether a different ecological resource might be substituted as compensation for an adverse effect on a feature.)

It is thought that it would be difficult to demonstrate that a value equivalency approach would address the requirement for compensation to protect the coherence of Natura 2000 and it is not therefore considered further in this report.

3 Sustainable Development Commission and Equal Value

The Sustainable Development Commission (SDC) ran a participatory process around the concept of Equal Value which has been carried out in two phases:

- Phase 1 – deliberative process with experts (attending in their capacity as individuals and not representing organisational views) contributing to two workshops.
- Phase 2 - consultancy research to develop thinking. The full technical report on this stage is available through the SDC website [Reference to be confirmed on publication].

The SDC reported their conclusions from this process in recommendation to the STP Feasibility Study Project Board in March 2010 (10). They said that:

- *Our (SDC) conclusion at this stage is that such an approach might be feasible, albeit involving an unprecedented level of challenge. We have proposed a set of principles and tests which could begin to form the basis of a new methodology for compensation outside EU guidance but compliant with the Directives themselves. Crucially, these principles include strict adherence to sequencing – in other words the sorts of measures discussed should only be considered once all other existing approaches to mitigation and compensation have been fully explored.*
- The public debate about Severn Tidal Power is very robust, with strongly held views on both sides, and any decision will be of huge interest and has the potential to set precedents both in the UK and across Europe. Since the handling of biodiversity impacts is one of the areas that will rightly be subject to intense scrutiny, *the SDC recommends that far more thorough research, coupled with open and transparent public and stakeholder engagement is necessary before these new approaches could be adopted with confidence.*

4 Report to Inform an Appropriate Assessment

A tidal power option that was taken forward as a plan or project would need to be tested against the requirements of the European Community (EC) Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora) and Birds Directive (Council Directive 79/409/EEC on the conservation of wild birds). As part of the strategic study into the feasibility of an STP scheme a study was undertaken to produce a report to inform a strategic Appropriate Assessment.

The approach taken follows best practice for assessing the effects of plans or projects under the Habitats Regulations. The overall process is referred to as a Habitats Regulations Assessment (HRA). Stage 1 of the HRA produced a screening report to establish the scope of the stage 2 HRA which is Appropriate Assessment. The Report to Inform a Stage 2 (Appropriate Assessment) Habitat Regulations Assessment should be referred to for more information about the procedures followed and the results of that assessment (2).

A strategic Appropriate Assessment would need to be completed if and when a plan to develop an STP was adopted. A more detailed project level Appropriate Assessment would be undertaken as part of the development of a project. Hence the level of detail within the strategic Appropriate Assessment reflects the strategic level of the STP study.

As required by the Directive, a strategic Appropriate Assessment would take a precautionary approach in assessing whether there would be an adverse effect on site integrity. An adverse effect on site integrity arises if there is a significant negative effect on a Natura 2000 feature when judged against the conservation objectives for the site. Adverse effect on site integrity may be reported either because a negative effect has been demonstrated by the assessment, or the assessment has shown a risk of likely significant effect and it cannot be demonstrated that this will not have an adverse effect on site integrity. If in spite of a negative effect on site integrity a plan or project is to be adopted (because other

Habitats Directive tests can be met), then compensatory measures would be required.

The extent to which an effect can be demonstrated and quantified within the Appropriate Assessment has implications for the consideration of possible compensatory measures should a plan be adopted. There are for example a range of effects reported that are not certain and not quantified in the Report to inform an Appropriate Assessment and that could give rise to the need for compensation. **The possible need for compensation for these features is therefore uncertain and is not considered further at this stage.**

A negative effect on one or more Natura 2000 feature is demonstrated for the Severn Estuary/Mor Hafren SAC and SPA, the River Wye/Afon Gwyi/Afon Gwy SAC, River Usk/Afon Wysg/Afon Wysg SAC for all STP options. A negative effect due to displacement of birds is demonstrated for the Burry Inlet SPA and Chew Valley Lake SPA for a Cardiff-Weston Barrage, and for Somerset Levels and Moors SPA for a Cardiff-Weston Barrage and a Shoots Barrage.

A quantitative assessment against relevant conservation objectives was carried out where it was possible to do so from the information available within the SEA studies. Quantitative reporting was possible for changes in the extent of habitats or attributes such as inter-tidal mudflat and sandflat; saltmarsh; sub-tidal sandbank; and for changes in some bird populations. Reporting for effects on migratory fish features was qualitative and is mainly reported as uncertain declines or (risk of) population collapse or extinction. **The Report to Inform an Appropriate Assessment includes a mixture of quantitative and qualitative reporting. This limits the extent to which a quantitative consideration of compensation is possible.**

A reported negative effect for a Natura 2000 feature level may reflect negative effects on one or more conservation objectives for that feature. Within this compensation study the focus has been on the feasibility of compensating for change in extent of a feature in terms of habitat area or population size.

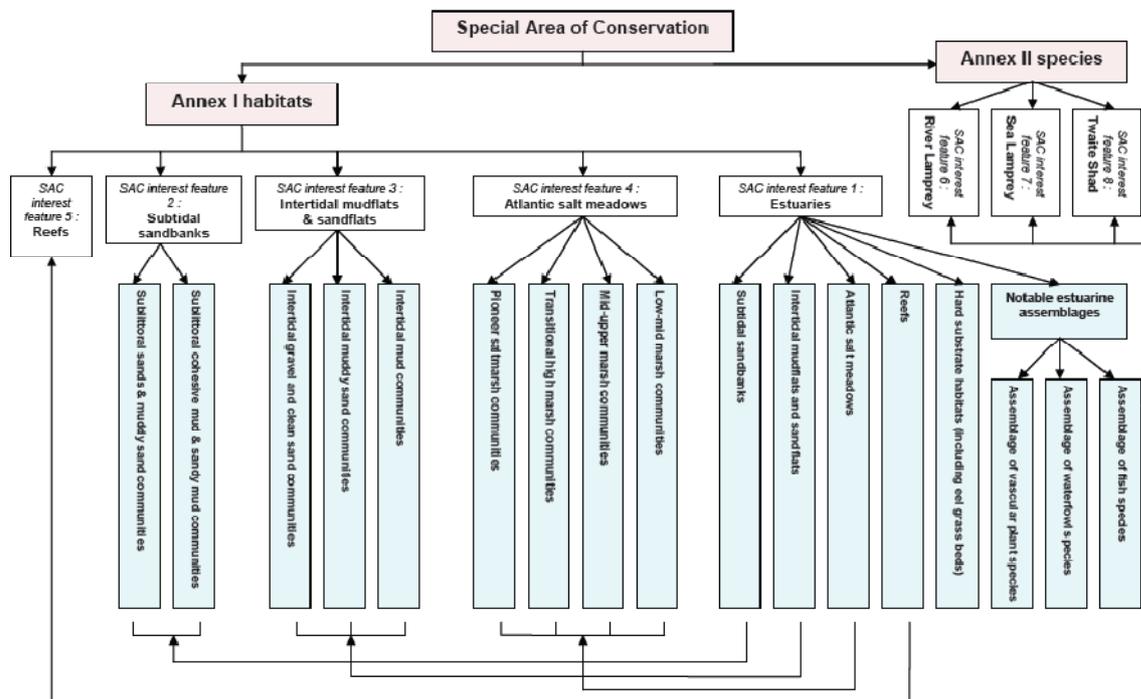
5 Application of Compensation Measures

This section considers the possible application of compensatory measures identified within the toolkit to selected features based on the assessments in the Report to Inform an Appropriate Assessment. This is to indicate possible approaches to compensation and their possible limitations and is not a comprehensive listing of all possible compensatory measures.

5.1 Severn Estuary SAC Conservation Objectives and Coherence

The ecological conditions found within the Severn Estuary are highly unusual and essentially unique within the UK. The conservation objectives for the Severn Estuary define favourable condition in terms of the existing tidal conditions and physical processes and the nature conservation features that they give rise to. Hence the tidal range and estuary shape influences the sediments within the estuary which in turn affect the character and ecology of the habitats that have formed.

The SAC has been classified for the estuary feature, inter-tidal saltmarsh, inter-tidal mudflat and sandbank, sub-tidal sandbank and reef. The inter-tidal and sub-tidal habitats are also sub-features of the estuary feature, so that their extent and character also contribute to the conservation objectives for the estuary feature. The relationship between these features is shown in the extract from the conservation objectives advice from the conservation agencies for the Severn Estuary/Mor Hafren SAC. (11)



All STP options would dramatically change the characteristic ecology of the Severn Estuary inside the impoundment. For the ebb only options this would include loss of the extreme tidal range with only the area outside the impoundment remaining hyper-tidal. The characteristic invertebrate communities within the mudflat would be changed as their composition is influenced by the extreme environment of the Severn. Sub-tidal sandbanks would also change in composition and shape within an impoundment so that they were different to the features that were classified.

A consequence of this atypical or unique ecology is that many of the characteristics of the estuary feature and the inter-tidal and sub-tidal habitats could not be replicated by compensation at distance from the Severn as there is nowhere else where such extreme conditions occur. Habitat creation outside the Severn as a compensatory measure would substitute habitats of more typical estuary or coastal conditions for the atypical. Hence it would not be strictly 'like for like'. In terms of the overall coherence of the Natura 2000 network this would require trading off representation of habitat that had an unusual position in an ecological range for habitat that was more typical. It would also involve trading off representation in terms of geographical range if for example lost habitats were replaced in the north or east of England.

It would need to be argued that the overall benefits to a coherent network of a compensation proposal outweighed such losses. For example, if compensation was acting to improve the overall resilience of the Natura 2000 network in the face of climate change. There is no precedent for such an approach and the benefits would need to be developed as part of the further development of a compensatory measures proposal.

5.2 Estuary Feature

5.2.1 Compensation requirement

The hyper-tidal range of the Severn would be largely lost within an impoundment. The Report to Inform an Appropriate Assessment suggests that the loss of hyper-tidal range within the SAC area for the options could be:

- Up to 100% for a Cardiff-Weston Barrage .
- 10-50% for a Shoots Barrage.
- 1-10% for a Beachley Barrage and Welsh Grounds Lagoon.

The effect for a Bridgwater Bay Lagoon is harder to interpret. There would be a change in tidal regime over 50% or more of the SAC, however it is arguable that all of the SAC would still have a hyper-tidal regime because of the ebb-flood operation of this option.

The estuary sub-features have not been considered and would need to be assessed as part of a more detailed level study.

5.2.2 Potential for compensation

No like for like measures were identified in Part 1. Compensation would depend upon a re-interpretation of coherence.

There appears to be no process for removing SAC designation due to human development, hence the Severn Estuary would remain an SAC in its modified form. Within the Natura 2000 network an area of hyper-tidal estuary would have been replaced by an area of modified estuary. Measures to optimise the way the ecology of the impounded area develops and therefore the future contribution to the Natura 2000 network might be considered.

5.3 Sub-tidal sandbank

5.3.1 Compensation requirement

The extent of sub-tidal sandbank is reported as increasing for all options. The characteristic composition of the surface of the sandbanks is however predicted to change as a result of fine sediment being deposited. The assessment is uncertain what proportion if any of the newly formed sandbank might be of SAC quality. This would need to be clarified as part of further study development.

5.3.2 Potential for compensation

New notification was identified in Part 1 as a possible but uncertain measure. No conclusion can be reached about the potential of this measure to meet an uncertain compensation requirement.

5.4 Intertidal Habitats (Saltmarsh and intertidal mudflat and sandflat).

5.4.1 Compensation requirement

The Report to Inform an Appropriate Assessment identifies the reduction in the extent of inter-tidal habitat on scheme closure. This takes into account the potential area of inter-tidal habitat that might be created through mitigation by topographic modification. The residual effect and therefore the compensation need is expressed as a range of values for each option.

The reductions in saltmarsh and inter-tidal mudflat and sandflat habitats are reported as well as a combined area for inter-tidal loss. For all schemes the losses by area for mudflat are many times greater than for saltmarsh. Consideration of how habitats change over time can complicate the overview. There are likely to be additional losses of inter-tidal habitat over time as a result of increased erosion caused by an STP scheme. Saltmarsh will be lost on closure of a scheme but new saltmarsh is predicted to form relatively soon after the impoundment is created. For clarity this report only considers the compensation requirement at the time of scheme closure.

Initial losses of saltmarsh (after taking into account mitigation) range between 31-37ha for a Shoots Barrage and 77-145ha for a Cardiff-Weston Barrage. The overall reduction of inter-tidal habitats is many times greater because of the loss of inter-tidal mudflat and sandflat. For example, for a Cardiff-Weston Barrage the area of intertidal habitat lost is between 11,400-15,800 ha after mitigation is applied.

5.4.2 Potential for compensation

The requirement for compensatory inter-tidal habitat depends on whether compensation is needed for loss in extent of habitat or for loss in extent and also for the change in its attributes. It also depends on the choice of compensation ratio that is applied to take into account the reduced ecological functionality of newly created habitat. It also depends on the compensation ratio that is applied. In exceptional circumstances this might be close to 1:1 where the compensation is being provided so far in advance that it has achieved ecological functionality by the time it is required. The following table compares the conclusions from part 1 with the possible need for compensation using a 2:1 ratio as a basecase. The use of a 2:1 ratio does not prejudge what compensation ratio might be required for a project which would need to be informed by more detailed investigation.

Scheme	Potential area of managed re-alignment (compensation) adjoining the Severn Estuary. (Assumes that 50% of the possible area could be developed.)	Reduction in extent of saltmarsh on scheme closure after taking account of mitigation. Shown as maximum and minimum values.	Reduction in extent of inter-tidal habitat on scheme closure after taking account of mitigation. Shown as minimum and maximum values. (Taken from Report to Inform an Appropriate Assessment)	Requirement for inter-tidal habitat compensation assuming a 2:1 compensation ratio
Cardiff Weston Barrage	150	77-145ha	11,400 - 15,800 ha	22,800 – 31,600 ha
Shoots Barrage	2,200	31-37ha	2,400 – 3,300 ha	4,800 – 6,600 ha
Beachley Barrage	2,000	28-46ha	1,900 – 2,800 ha	2,800 – 5,600 ha
Welsh Grounds Lagoon	2,500	56-68ha	5,300 – 7,400 ha	10,600 – 14,800 ha
Bridgwater Bay Lagoon	1,550	51-63ha	1,200 – 2,200 ha	2,400 – 4,400 ha

This indicates that compensation through managed re-alignment to create inter-tidal habitat within the Severn Estuary is likely to be possible as a compensatory measure for saltmarsh at compensation ratios of 2:1 for all options except for Cardiff-Weston Barrage. **However for overall inter-tidal habitat losses compensation within the Severn does not appear to be possible at a 2:1 compensation ratio for any option.** It might only be feasible at a 1:1 compensation ratio for Bridgwater Bay Lagoon and a Beachley Barrage. This would also entail substituting saltmarsh as compensation for the loss of mudflat .

As noted in part 1 of this report, the compensation requirement for inter-tidal mudflat could only be met by measures outside the Severn Estuary.

Conclusions

Applying the measures from part 1 of this report:

- Reductions in the extent of saltmarsh might be compensated for through managed re-alignment within the Severn Estuary for all options except a Cardiff-Weston Barrage.
- Reductions in the extent of intertidal mudflat and sandflat could not be compensated for within the Severn Estuary for any option.
- Some of the reductions in the extent of intertidal mudflat and sandflat might be compensated for within the Severn Estuary by saltmarsh creation, although this would not be 'like for like' compensation within Commission guidance.
- The reduction in the extent of inter-tidal habitat might be compensated for at distance to the Severn Estuary for all options.

- For a Cardiff-Weston Barrage finding sufficient area of managed re-alignment at distance that could be maintained as mudflat for the life of an STP might overly restrict choice of site and require a more flexible approach.

For larger options such as Cardiff-Weston Barrage it is unlikely that sufficient area could be found to deliver mudflat and saltmarsh in the same proportions as the habitat lost. This is not necessarily a barrier to protecting the coherence of the network. For example, it may be argued that a relative increase in saltmarsh could benefit coherence as saltmarsh has been more affected by coastal squeeze than inter-tidal mudflat. Saltmarsh losses in southern and eastern England for example have been cited as between 10-44% over a 25 year period in Natural England's State of Natural Environment Report (12).

5.5 Reef (*Sabellaria alveolata*)

5.5.1 Compensation requirement

A complete loss of the reef feature is thought likely for a Cardiff-Weston Barrage with uncertain reductions in extent for the other options.

5.5.2 Potential for compensation

New notification was conditionally identified as a measure in part 1 although it may not be possible to find comparable areas of SAC quality. If this was the case then there may be no potential to compensate within Commission guidance.

5.6 Migratory Fish

5.6.1 Compensation requirement

The assessment of effects on SAC fish features is uncertain. The Report to Inform an Appropriate Assessment identifies uncertain population declines or a potential for a population collapse or extinction of a species within an SAC. The term extinction is used here for the loss of a species within the SAC for which it has been designated.

Risk of population collapse and therefore loss of a sustainable population of Atlantic salmon is predicted for the River Wye/Afon Gwyi and River Usk/Afon Wysg SACs for all options. Potential losses (or collapse) of a population from at least one SAC are predicted for twaite shad, allis shad, river lamprey, and sea lamprey depending on the option. In terms of coherence the effect of a population collapse may be similar to extinction as it would be a loss of a sustainable population from the network. Compensation would need to address these losses from the network of Natura 2000 sites.

There are 17 fish populations that are designated features of the Severn Estuary, River Wye/Afon Gwyi, River Usk/Afon Wysg and River Tywi/Afon Tywi SACs. The number of these SAC fish populations at risk of extinction or collapse is shown in the following table.

Table 9 Individual SAC fish populations at risk of extinction or population collapse

Option	Number of individual SAC fish populations at risk of extinction or population collapse
Cardiff-Weston Barrage	7
Shoots Barrage	13
Beachley Barrage	13
Welsh Grounds Lagoon	8
Bridgwater Bay Lagoon	7

Compensation could be needed for the loss of between 7 and 13 SAC fish feature populations and for uncertain population declines in the remaining SAC fish feature populations. (Two SAC populations may be two species in one SAC or on species in 2 SACs.)

5.6.2 Potential for compensation

Compensation for this type and scale of loss of SAC populations is unprecedented. The underpinning science does not enable a quantitative assessment of impacts and of the effectiveness of compensatory measures. A firm conclusion about the extent to which these effects could be addressed by the measures described in part 1 is not possible.

Measures have been identified that might increase populations of Atlantic salmon, and the two lampreys at distance to the Severn. This involves increasing a fish population in a different river with a view to notifying it as a replacement within the Natura 2000 network. This might be put forward as compensation for the complete loss of a SAC population. This is likely to depend upon the following conditions being satisfied:

- That the measures undertaken to remove factors limiting a target population outside the Severn are additional to other requirements of European legislation for that population.
- That designation of substitute sites within Natura 2000 for the SAC fish features lost would be acceptable, especially at the scale likely to be required.
- That the replacement sites made a similar overall contribution to the coherence of the Natura 2000 network.
- That it was possible to find sufficient locations to practically implement measures on the scale likely to be required.

Demonstrating that these conditions could be met would be demanding for the scale of losses that the studies suggest could occur.

It would require clarification of the relationship between Water Framework Directive implementation and Habitats Directive compensation, and on the application of new designations to existing populations as a compensatory measure. It would also require extensive investigation to establish whether there were sufficient rivers where it was practical to increase populations of fish species through these measures to meet a required target.

The above approach could not be applied to the two shad species as it is unlikely that there are significant populations outside the Severn or the River Tywi/Afon Tywi that could be increased in this way. Hence compensation within Commission guidance for the shads is likely to depend upon developing a species introduction programme to establish new populations. This would require feasibility study and site investigations and would need to be based on sound science. It is uncertain whether such an approach could be developed and it is thought not to be possible for a 2020 project.

Notification of existing populations within without increasing their population size is also considered as a possible approach. Annex 3 of the Fish Topic Paper includes a preliminary review of possible populations of the migratory fish species outside the current SAC series and that might be considered as new notifications.

The above measures are arguably within the flexibility that the Commission guidance allows for.

Conclusion

Compensating for the effects on migratory fish within Commission guidance for a 2020 project may not be feasible for any option because of the limited measures available and their uncertainty. Compensation for a 2020 project would be likely to depend on measures outside Commission guidance (such as those investigated by the SDC) being developed and considered acceptable. Further investigation of possible measures and their quantification would be necessary to establish the extent to which compensation within Commission guidance was feasible for a project beyond 2020.

5.7 Migratory Birds

5.7.1 Compensation requirement

Of the seven Severn Estuary SPA bird features quantitative estimates are made for changes in populations of dunlin, redshank, gadwall and shelduck. An uncertain (and unquantified) population decline is reported for the assemblage (overall population) of over-wintering waterbirds. An uncertain population change is reported for Bewick's swan and white-fronted goose. Although construction stage impacts are significant for some bird populations under some options the greatest effect is due to the loss of intertidal habitat that supports the SPA bird numbers on closure of a scheme. This section focuses the operational stage impacts.

The conservation objectives for the SPA bird features set targets for the size of the population to be maintained and for the extent and quality of the habitats that support the species. A target for compensation might be set as the area of habitat required to support the number of birds that are negatively affected, or in terms of replacing (with appropriate compensation ratio) the loss of SPA supporting habitat.

The first approach would aim to maintain the same bird numbers but not necessarily the same area of supporting habitat. It would depend upon being confident in our assumptions about the ecology and behaviour of species affected and our modelling

of bird requirements. This would be almost certain to give rise to a lower compensation requirement, but would involve much greater risk. The second approach would be to replace supporting habitat at an appropriate ratio which would result in a greater compensation requirement.

The Report to Inform an Appropriate Assessment has reported residual impact or compensation need in terms of a change in the current populations of the SPA features. These results are shown in table 9 for the four SPA features for which declines have been quantitatively assessed.

Table 10 Range of declines after mitigation is applied (taken from table 9 of the Appropriate Assessment)

Feature	Cardiff-Weston Barrage	Shoots Barrage	Beachley Barrage	Welsh Grounds Lagoon	Bridgwater Bay Lagoon
Dunlin	7,235-8,402	3,737-4,340	1,252-1,454	4,425-5,139	1,538-1,786
Redshank	745-865	484-563	369-428	518-601	80-93
Shelduck	923-1,072	413-480	136-158	349-405	236-274
Gadwall	38-44	4-5	33-38	Approx 2	No change predicted

If the first approach was adopted, additional modelling and investigation would be needed to translate the predicted declines into an area of habitat that would support equivalent population numbers. This would need to consider the likely functionality of habitat created adjoining the Severn Estuary in terms of the density of birds that could be supported. This would require the development of modelling to a level at which gave sufficient confidence that the predictions were robust.

Adopting the second approach would entail replacing lost SPA supporting habitat on an area for area basis. This would be a similar approach to the provision of SAC habitat with an appropriate compensation ratio being applied. This would be a more precautionary approach as it might take more account of changes in the way birds make use of different parts of the estuary at different times.

5.7.2 Potential for compensation

For past developments affecting relatively small areas of supporting habitat for SPA birds the established approach has been to create comparable replacement habitat within the same topographic or landscape unit. This approach is not feasible because there are no significant opportunities for mudflat creation adjoining the Severn Estuary.

Applying bird compensation on an area for area basis would require at least some of the compensation to be delivered at distance to the Severn for all options. In the case of a Cardiff-Weston scheme most of this compensation would need to be at distance. Any application of this approach would therefore involve measures outside the Commission guidance. Applying area for area compensation at distance would require development of modelling and fundamental research to show how areas might be used and their effects on flyway populations. It might therefore converge with an approach based on modelling of habitat requirement.

Applying bird compensation as a habitat area calculated from modelling of bird behaviour or habitat association might enable less compensation and therefore more of it to be delivered close to the Severn Estuary. Further consideration of how far a modelled approach could be relied upon as the basis for calculating compensation would be needed. However given the likely need for measures outside the Severn Estuary further work in this area would be needed. The review of effects of potential effects of habitat creation waterbirds (8) provides further information on potential approaches to assessing the effects on flyway populations.

Whichever approach is developed the following points would apply.

- As a primarily freshwater species the negative effects on gadwall might be compensated for close to the Severn Estuary for all options through freshwater wetland habitat creation.
- The Report to Inform an Appropriate Assessment is uncertain about the effects on Bewick's swan and European white-fronted goose. These species are generalist wetland species and are mainly concentrated within the upper part of the Severn Estuary and may not be significantly affected by an STP. Some negative effects for these species might be compensated for by a combination of freshwater wetland and (for some options) saltmarsh creation.
- For all options there is virtually no potential to create compensatory habitat for specialist mudflat feeders through managed re-alignment adjoining the Severn Estuary. Compensation for dunlin, redshank and shelduck adjoining the Severn Estuary does not therefore appear possible.
- Compensation for loss of mudflat as supporting habitat for the SPA would therefore depend on the creation of inter-tidal habitat at distance to the Severn Estuary; or on other measures outside Commission guidance, for example based on the principles suggested by the Sustainable Development Commission.

The extent to which sufficient mudflat supporting habitat might be required outside the Severn Estuary depends upon whether compensation requirement is expressed on a modelled habitat area or an area to area basis. **However on both approaches it appears likely that at least some habitat creation at distance to the Severn Estuary would be required for all options. This would be least for Bridgwater Bay or Beachley Barrage and greatest for a Cardiff-Weston Barrage.**

Defining the compensation requirement on the basis of modelled habitat requirements the area outside the Severn would be sensitive to changes in the application of the bird modelling outputs and to different assumptions about the potential yield and effectiveness of topographic modification. Further development of bird modelling techniques to improve certainty in predicting change, and investigation of topographic modification might be considered. There are for example wide differences between the outputs from the Habitat Association Model and the Individual Behaviour Model for dunlin and redshank. This might indicate a potential to establish that population declines could be less than those shown by the assessment.

The effect of compensation at distance to the Severn Estuary is considered within the review of the potential effects of habitat creation (8). This suggests that:

Colonisation of sites created to the east of the UK may be aided in the long-term by eastward distribution changes of some species in response to climate change. However, many of the intertidal invertebrate feeders, intertidal bivalve specialists and generalist wetland species that would benefit from these measures are very site-faithful. These include key SPA species such as Dunlin, Redshank, Ringed Plover, Grey Plover, Whimbrel and Curlew. The re-distribution of these species to new sites could take many years, with risk of population declines in the interim period and the possibility that these populations could take years to recover from such declines. Furthermore, sites created on the east coast of the UK would be unlikely to fulfil the current role of the Severn as a refuge for waterbirds in severe weather, because winter temperatures broadly tend to be milder in the south west UK but colder further east.

The effect of compensation at distance to the Severn Estuary might be different in the future if bird populations continue to be re-distributed in response to climate change. Hence it is possible that the compensation requirement for a project developed for a 2050 timescale would be different to the compensation requirement for a project in 2020.

Switching to a strategy involving compensation for birds at distance to the Severn Estuary could require revisiting the Report to Inform an Appropriate Assessment as the risk of negative effects on flyway sites might not be able to be discounted. Consideration of what level of displacement of a population of birds from the Severn might give rise to a *significant* effect to another site within the flyway might be used to set a threshold that was able to discount significant effect for some species. The population of dunlin when the SPA was classified was about 40,000 individuals although it is now closer to 20,000 individuals. The predicted reductions therefore represent between 7% and 40% of the current population.

The potential for interim losses of populations of some species as populations adjust to a new distribution of habitat would also be challenging. The risk of effects on a flyway population being permanent rather than temporary and reversible would need to be assessed. Studies would need to consider whether the scale of possible interim losses and displacement was significant when considered within the context of the flyway population. The Severn Estuary also functions as a cold weather refuge during sustained periods of cold temperatures. This could not be replicated in the north or east of England.

For those species that can be effectively compensated for within the Severn Estuary a likely significant effect on flyway sites should not arise.

Compensation at distance to the Severn Estuary might be linked to a climate change adaptation strategy for birds. This would require investigation and development to identify which species were priorities for such a strategy in terms of benefits to their future conservation status and contribution to the coherence of the Natura 2000 network. This approach would be unprecedented as it would be compensating

against a possible future baseline state rather than the state at the time of site designation (as reflected in the conservation objectives).

Compensation for changes in the bird assemblage feature is not considered here as the assessment in the Report to Inform an Appropriate Assessment does not quantify the effect on this feature.

If compensation at distance was to be considered as a measure for possible reductions in bird numbers, then the approach might involve:

- Development of an evidence base to show that this could be effective in protecting the overall coherence of the Natura 2000 Network.
- A judgement on the acceptability of applying a measure that is arguably borderline, or outside Commission Guidance.
- Undertaking as much compensation within or close to the Severn as possible.
- Identifying those species where measures at distance might be capable of protecting their populations.
- Developing site selection criteria for managed re-alignment that linked SAC habitat and bird habitat requirements.
- Developing a sites database and population modelling to show how species might be expected to respond.
- Establishing that the areas that might be created were realistically accessible to birds even if they were judged to be 'far away'.

6 Key Findings and Conclusions

- The compensation study looked selectively at the potential to compensate for adverse effects on features within the Severn Estuary and for migratory fish using the River SACs flowing into the Severn. There are therefore significant gaps within the findings.
- Few of the compensation measures looked at are established practice and none have been used at the scale that a STP would require. As a result there are many gaps and uncertainties in their reporting. Further investigation and study would reduce the associated risk.
- Assessment of possible compensation measures depends on the accuracy and robustness of all the preceding assessment processes with the potential for uncertainties to become magnified.
- The SEA and Report to Inform an Appropriate Assessment has been able to provide a largely quantitative assessment of changes in the extent of inter-tidal habitats. This is not the case for all migratory bird features of the SPA or for the migratory fish features of the SAC.
- Limitations in quantification of impact assessment, mitigation measures and the effects of compensation reduce certainty for those features considered.

- A toolkit of 14 compensatory measures that are potentially within Commission guidance has been identified.
- Managed re-alignment to create inter-tidal habitat is the most established compensation measure considered. This might provide compensation for loss of SAC habitats and partial compensation for loss of supporting habitat for birds.
- Compensatory measures would be likely to involve unprecedented interventions in terms of the area of land and river affected and the scale of engineering and other works undertaken. There could be significant environmental, social and economic costs associated with compensation on this scale. There would also be the potential for benefits. Communities affected by or benefiting from these measures would be largely outside the area of the Severn. The acceptability of such an approach with stakeholders and the wider public would need to be tested.
- For migratory fish these include measures that are thought unfeasible for a 2020 scheme but which might be feasible on a longer timescale. Only two compensation measures for migratory fish are thought to be achievable by 2020, subject to further study. It is reported that the fish compensation measures are unlikely to completely offset all negative effects. Fish compensation is likely therefore to require measures outside Commission guidance for any option.
- The inter-relationship between Habitats Directive and Water Framework Directive legislation requires further consideration. The extent to which fish measures are additional to other requirements and are a sustainable form of compensation is uncertain. It is uncertain how much compensation might be achieved through the fish measures that are identified and further work involving the Environment Agency may help increase the confidence and scope for these options.
- Our studies have been positive in indicating that it may be possible to create very large areas of inter-tidal habitat through managed re-alignment, although this would be challenging and would not be fully 'like for like' compensation for any option. This is potentially least challenging for Bridgwater Bay Lagoon which has the least loss of inter-tidal habitat.
- Most compensatory measures have been conditionally identified (amber rated) for inclusion and would require further consideration and investigation to demonstrate that they were achievable.
- The compensation requirement for any option is extraordinary. The loss of fish populations which are features of the River SACs is unprecedented as is the effects on migratory bird populations
- Two approaches to determining the compensation requirement for birds were considered. The simplest would be based on replacing the area of supporting

habitat that had been lost (adopting an appropriate compensation ratio). An alternative would be to base compensation need on modelling of bird behaviour or habitat association. This is likely to give a lower compensation requirement but is potentially more risky. This approach would not be possible without further development as the Report to Inform an Appropriate Assessment could not generate modelled changes for all bird features.

- Based on the assessments, the loss of mudflat is a key issue for birds particularly dunlin and redshank which specialise in feeding on mudflat. It would not be possible to compensate within the area of the Severn Estuary for these birds for all options. This finding is sensitive to assumptions about the amount of topographic modification that might be possible and to the assessment of bird impacts. If the amount of topographic modification could be substantially increased and/or additional development of bird modelling was able to demonstrate a lower impact than our findings, then it might become feasible to compensate within the Severn for some options.
- Switching to a strategy involving compensation for birds at distance to the Severn Estuary could require revisiting the Report to Inform an Appropriate Assessment as the risk of negative effects on flyway sites might not be able to be discounted. Consideration of what level of displacement of a population of birds from the Severn might give rise to a *significant* effect to another site within the flyway might be used to set a threshold that was able to discount significant effect for some species.
- Habitat creation for birds at distance to the Severn might be justified perhaps, if it was applied as part of the development of a climate change adaptation strategy for waterbirds. If used as part of compensatory measures such a strategy would need to be backed with further study and modelling. Even if successful there would be a risk of interim declines in species such as dunlin and redshank which are very site faithful. The assessment issues posed by such an approach would need to be considered further, including whether the scale of possible interim losses and displacement were significant when considered against the flyway population. The risk of effects on a flyway population being permanent rather than temporary and reversible would also need to be assessed.
- The potential to develop novel approaches to compensation outside Commission guidance has been investigated by the Sustainable Development Commission. They have identified a number of principles and tests backed by technical studies and believe that it could be feasible to develop a new methodology for compensation outside EU guidance but compliant with the Directives themselves.
- The effect on some migratory fish and birds is reported as uncertain or unknown and cannot therefore be quantified at this stage. Better knowledge of these effects when assessing a project and the need for compensation. A project level assessment would need to be able quantify these impacts in order to quantify and demonstrate compensation. The extent to which

assessment techniques can be further developed to enable more certain and quantitative assessments for these features is a significant issue.

- It is reasonably clear that compensation would require novel approaches that are outside current practice and Commission guidance for all schemes. In the case of a B3 Cardiff-Weston scheme, unconventional and riskier measures would be needed for inter-tidal habitats, migratory fish and migratory birds.
- Some effects of a scheme on the estuary cannot be directly compensated for, including the loss of extreme hyper-tidal range and dynamic ecology within the impoundments of ebb only schemes. The loss of these features would have an effect on the range of ecological conditions within the UK network of Natura 2000 sites. This does not mean that compensation for a 2020 scheme is necessarily impossible but it may require a new approach to protecting the coherence of Natura 2000. A different approach might be justifiable in the context of climate change and the need for the network to adapt.
- The overall contribution to the coherence of the Natura 2000 network would comprise a modified Severn Estuary SAC and SPA (which would still be internationally designated) together with the range of measures adopted as compensation whether within or outside Commission guidance. This is a novel and unprecedented situation.
- Alternative ways of considering equivalence and a new way of defining the overall coherence of the network would be likely to be required. Different approaches to coherence might be justifiable in the context of the potential changes to Natura 2000 features that might arise from climate change. Alternative approaches possibly based on the SDC's study findings might be developed. In conclusion it is not impossible that compensation might be achievable for an STP but this would require unprecedented measures and a re-interpretation of Commission guidance.
- A strategic compensation proposal to adopt a plan has not been produced as part of this work. If a plan to progress an STP were to be adopted a proposal would need to be developed.

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